Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

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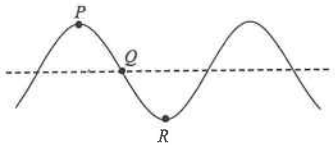
Part A : HKCE examination questions

1. < HKCE 1983 Paper II - 26 >

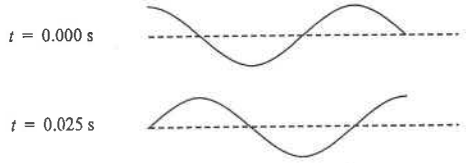


A transverse wave is travelling steadily from left to right through a series of particles. At a certain instant the wave form is as shown in the figure. Which of the following statements about the particles is/are correct ?

(1) Particle P is moving down.
(2) Particle Q is moving up.
(3) Particle R is momentarily at rest.

A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

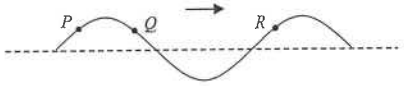
2. < HKCE 1987 Paper II - 11 >



The above figures show a wave in the same section of string at two different instants. What is the greatest possible period of the wave ?

A. 0.025 s
B. 0.050 s
C. 0.100 s
D. 0.200 s

3. < HKCE 1988 Paper II - 12 >

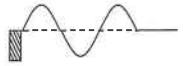


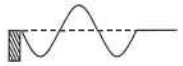
The above diagram shows a progressive transverse wave at a certain instant when travelling from left to right. Which of the following correctly shows the direction of motion of the particles at P, Q and R ?

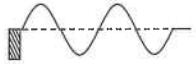
	P	*Q*	*R*
A.	→	→	→
B.	↓	↓	↓
C.	↓	↑	↓
D.	↑	↓	↑

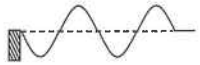
4. < HKCE 1991 Paper II - 23 >

A vibrator of frequency 5 Hz generates waves on a string. The above diagram shows the shape of the string at the instant when the vibrator has made one complete vibration. Which of the following best shows the waveform 0.1 s later ?

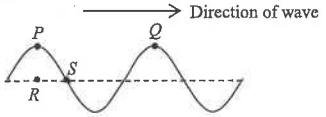
A.


B.


C.


D.


5. < HKCE 1991 Paper II - 21 >

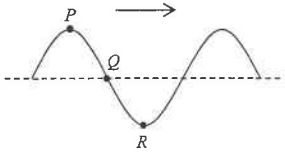


The above diagram shows a water wave travelling to the right. Which of the following statements is/are true ?

(1) PQ is equal to the wavelength.
(2) PR represents the amplitude.
(3) The particle at P will move to S after a quarter of a period.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

6. < HKCE 1992 Paper II - 22 >



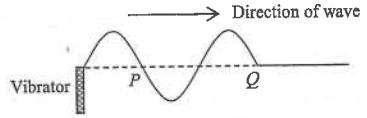
A water wave travels towards the right. The above diagram shows the waveform at a certain instant. Which of the following statements is/are true ?

(1) Particle P is moving downwards.
(2) Particle Q is moving upwards.
(3) Particle R is momentarily at rest.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

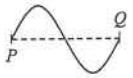
7. **< HKCE 1993 Paper II - 22 >**



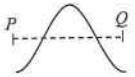
A vibrator generates a travelling wave on a string. The above diagram shows the shape of the string at a certain instant. Which of the following shows the shape of the string between PQ after a quarter of a period ?

A.

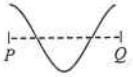
B.



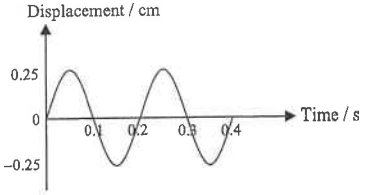
C.



D.



8. **< HKCE 1995 Paper II - 24 >**



A train of water waves is generated in a ripple tank. The graph above shows the variation of the displacement of a cork placed in the water with time. Find the frequency of the waves.

A. 0.2 Hz
B. 0.25 Hz
C. 4 Hz
D. 5 Hz

9. **< HKCE 1996 Paper II - 24 >**

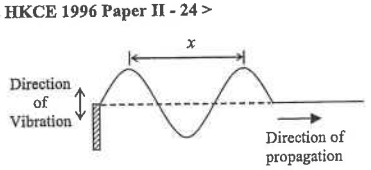


Figure (a)

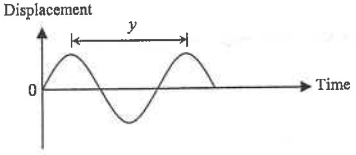


Figure (b)

A vibrator generates a travelling wave on a string. Figure (a) shows the shape of the string at a certain instant. Figure (b) shows the variation of the displacement of a certain particle on the string with time. Which of the following expressions represents the speed of the travelling wave ?

A. x
B. y
C. $\frac{x}{y}$
D. $\frac{y}{x}$

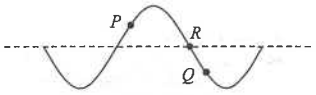
10. **< HKCE 1999 Paper II - 20 >**

A cork in the water vibrates up and down 4 times in 2 s when a wave passes through it. The distance between two successive crests of the wave is 10 cm. Find the speed of the water wave.

A. 0.05 m s^{-1}
B. 0.1 m s^{-1}
C. 0.2 m s^{-1}
D. 0.4 m s^{-1}

11. **< HKCE 1999 Paper II - 21 >**

The diagram shows a transverse wave travelling along a string. At the instant shown, particle P is moving upwards. Which of the following statements is **incorrect** ?



A. The wave is travelling towards the left.
B. Particles P and Q vibrate with the same frequency.
C. Particle Q is moving downwards at this instant.
D. Particle R is at rest at this instant.

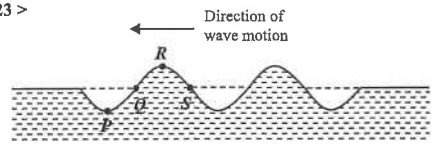
12. **< HKCE 2000 Paper II - 24 >**

Which of the following statements correctly describe(s) the meaning of the frequency of a wave ?

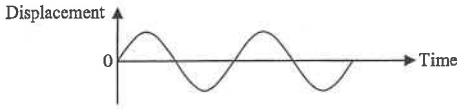
(1) the time taken for the wave to make one complete vibration
(2) the distance travelled by the wave in one second
(3) the number of waves produced in one second

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

13. **< HKCE 2001 Paper II - 23 >**



Four corks are moving up and down on the surface of a pond as a water wave passes through them. At time $t = 0$, the positions of the corks are shown above. The figure below shows the displacement-time graph of one of the four corks. (Note : Displacement is positive when the cork is above the still water surface.)



Which cork has the motion represented by the graph ?

A. P
B. Q
C. R
D. S

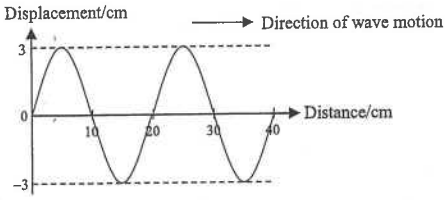
14. **< HKCE 2002 Paper II - 25 >**

A wave source generates waves of frequency 50 Hz. How long does it take for the waves to travel 100 m ?

A. 0.5 s
B. 2 s
C. 5000 s
D. It cannot be determined as insufficient information is given.

Provided by dse.life

Questions 15 and 16 : A transverse wave travels along a string with a speed of 1.2 m s^{-1}. The diagram below shows the shape of the string at a certain instant.



15. **< HKCE 2003 Paper II - 25 >**

Which of the following statements about the transverse wave are correct ?

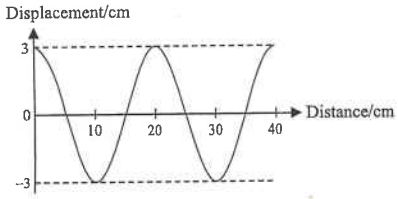
(1) Its wavelength is 20 cm.
(2) Its frequency is 6 Hz.
(3) Its amplitude is 6 cm.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

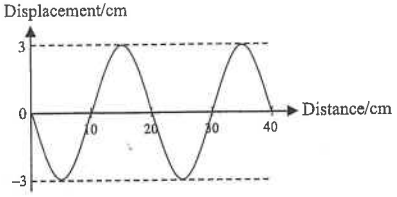
16. **< HKCE 2003 Paper II - 26 >**

Which of the following diagrams shows the shape of the string at a quarter of a period later ?

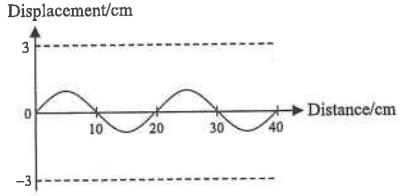
A.



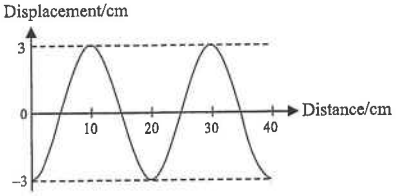
B.



C.

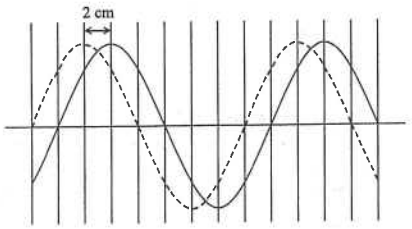


D.



17. **< HKCE 2004 Paper II - 22 >**

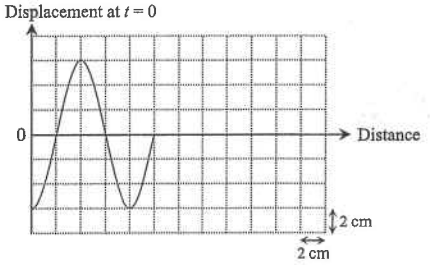
The solid curve in the diagram shows a transverse wave at a certain instant. After 0.05 s, the wave has travelled a distance of 2 cm and is indicated by the dashed curve. Find the wavelength and frequency of the wave.

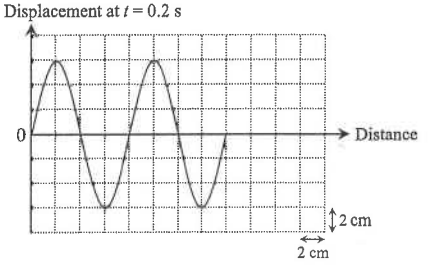


	Wavelength / cm	Frequency / Hz
A.	8	2.5
B.	8	5
C.	16	2.5
D.	16	5

Questions 18 and 19 :

The displacement-distance graphs of the particles along a travelling wave at time $t = 0$ and $t = 0.2$ s are shown below.





18. **< HKCE 2005 Paper II - 34 >**

Which of the following statements about the wave are correct ?

(1) Its amplitude is 6 cm.
(2) Its wavelength is 8 cm.
(3) Its frequency is 5 Hz.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

19. **< HKCE 2005 Paper II - 35 >**

What is the speed of the wave ?

A. 0.2 m s^{-1}
B. 0.3 m s^{-1}
C. 0.4 m s^{-1}
D. 0.8 m s^{-1}

20. **< HKCE 2006 Paper II - 16 >**

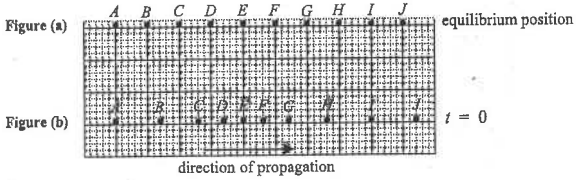
In December 2004, an earthquake in the Indian Ocean caused a tsunami which produced water waves having wavelength about 100 m and frequency about 2 Hz. What was the approximate time taken for these water waves to travel from the earthquake centre to Sri Lanka across a distance of about 1500 km ?

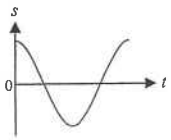
A. 1 hour
B. 2 hours
C. 3 hours
D. 4 hours

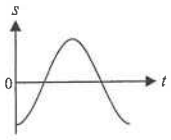
Provided by dse.life

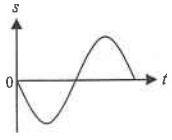
21. **< HKCE 2007 Paper II - 38 >**

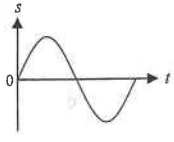
A longitudinal wave is travelling from left to right in a medium. Figure (a) shows the equilibrium positions of particles A to J in the medium. At time $t = 0$, the positions of the particles are shown in Figure (b). Which of the following correctly shows the displacement-time graph of particle I ? (Note: displacement to the right is taken to be positive)



A. 

B. 

C. 

D. 

22. **< HKCE 2008 Paper II - 37 >**

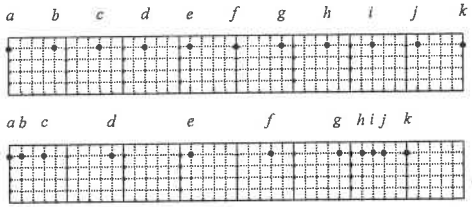
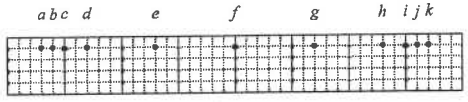
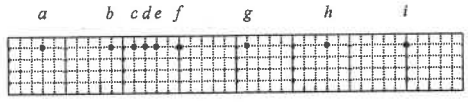


Figure (a) shows a series of particles which is uniformly distributed along a slinky spring. Figure (b) shows their positions at a certain instant when a travelling wave passes through the slinky spring from left to right. Which of the following diagrams shows the correct positions of the particles after half a period from the instant shown in Figure (b) ?

A. 

B. 

C. 

D. 

23. **< HKCE 2009 Paper II - 36 >**

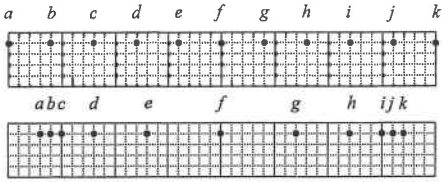
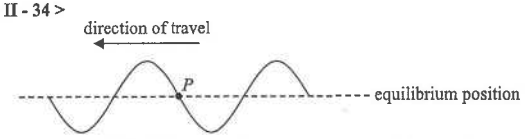


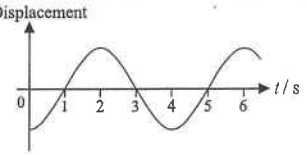
Figure (a) shows a series of particles ($a - k$) at their equilibrium positions. Figure (b) shows the positions of the particles at a certain instant when a longitudinal wave travels to the right passes through the particles. Which are the directions of the motion of the particles c and f at the instant shown in Figure (b) ?

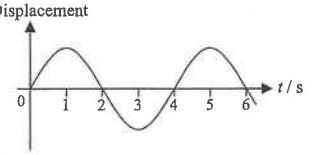
	particle c	particle f
A.	to left	to left
B.	to left	to right
C.	to right	to left
D.	to right	to right

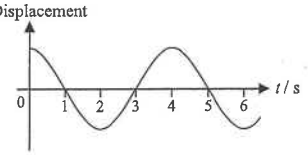
24. **< HKCE 2010 Paper II - 34 >**

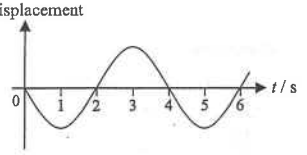


A wave travels along a string to the left. The figure above shows its waveform at time $t = 1$ s. Which of the following displacement-time graphs best represents the motion of particle P ? (Take displacement upwards to be positive.)

A. 

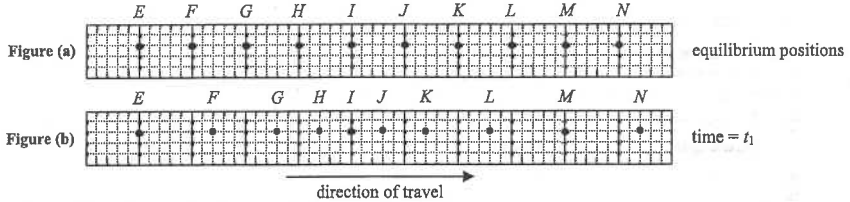
B. 

C. 

D. 

25. **< HKCE 2010 Paper II - 35 >**

Figure (a) shows the equilibrium positions of particles E to N in a medium. A longitudinal wave is travelling from left to right. At time t_1, the positions of the particles are shown in Figure (b).



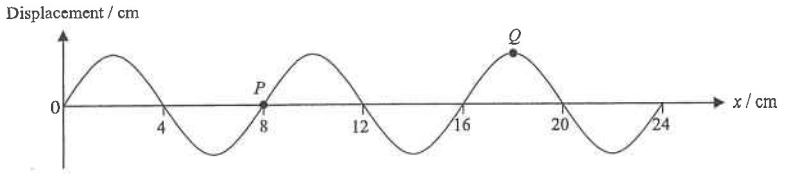
Which of the following particles is momentarily at rest at t_1 ?

A. K B. L C. M D. N

Provided by dse.life

Questions 26 and 27 :

The figure below shows the displacement-distance graph of a wave travelling to the right with speed 2 cm s^{-1} at a certain instant. P and Q are two particles at distances $x = 8$ cm and 18 cm respectively.



26. **< HKCE 2011 Paper II - 34 >**

What is the period of the wave ?

A. 0.25 s
B. 4 s
C. 8 s
D. 18 s

27. **< HKCE 2011 Paper II - 35 >**

What is the shortest time for P to have the same displacement as Q at the instant shown ?

A. 1 s
B. 3 s
C. 4 s
D. 5 s

28. **< HKCE 2011 Paper II - 36 >**

Figure (a) shows a series of particles ($E - O$) at their equilibrium positions. Figure (b) shows the positions of the particles at a certain instant when a longitudinal wave travelling to the right passes through the particles.

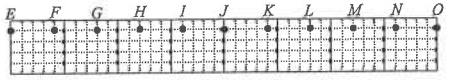


Figure (a)

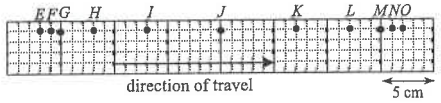


Figure (b)

Which of the following statements is **incorrect** ?

A. The separation between F and N equals to the wavelength of the wave.
B. The amplitude of the wave is 4 cm.
C. J is momentarily at rest at the instant shown in Figure (b).
D. N is at the centre of compression at the instant shown in Figure (b).

Part B : HKAL examination questions

29. **< HKAL 1992 Paper I - 20 >**

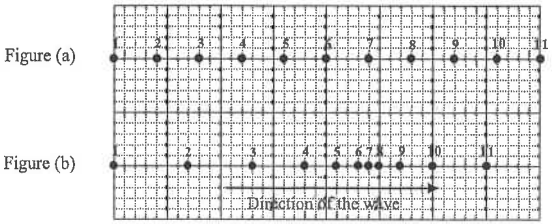
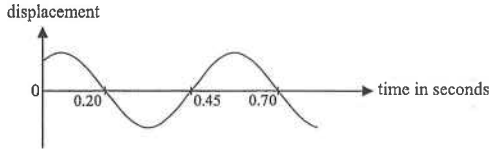


Figure (a) shows the equilibrium positions of equally spaced particles in a medium. A longitudinal wave travels from left to right through the medium. At a certain instant, the positions of the particles are shown in Figure (b). What will be the directions of motion of particle 1 and particle 7 at this instant ?

	Particle 1	Particle 7
A.	to the right	to the right
B.	to the right	to the left
C.	to the left	to the right
D.	to the left	to the left

30. **< HKAL 1993 Paper I - 24 >**



A displacement-time graph of a particle in a travelling wave is shown. What is the frequency of this wave ?

A. 1.43 Hz
B. 2.00 Hz
C. 2.22 Hz
D. 4.00 Hz

31. **< HKAL 1994 Paper IIA - 14 >**

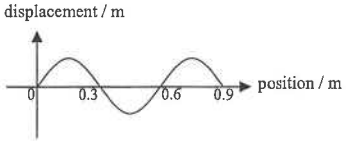


Figure (a)

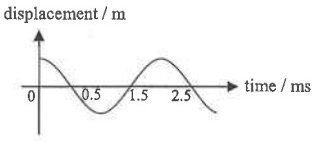


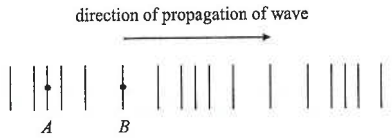
Figure (b)

Figure (a) represents the displacement-position graph of a travelling wave at a certain instant and Figure (b) represents the displacement-time graph of a particle in the wave. Calculate the speed of the wave.

A. 300 m s^{-1}
B. 150 m s^{-1}
C. 1.2 m s^{-1}
D. 0.6 m s^{-1}

Provided by dse.life

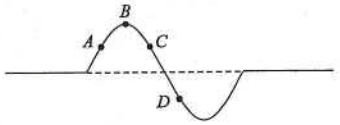
32. **< HKAL 1995 Paper IIA - 12 >**



The above figure shows a longitudinal wave travelling to the right. The particles A and B are at the centre of a compression and a rarefaction respectively. Which of the following gives correctly the directions of motion of A and B at the moment shown ?

	Particle *A*	**Particle *B***
A.	to the right	to the left
B.	to the right	at rest
C.	to the right	to the right
D.	at rest	to the right

33. **< HKAL 1998 Paper IIA - 13 >**



The above figure shows a transverse wave propagating along a string. At the instant shown, the particle D on the string is moving downward. Which of the following deductions is/are correct ?

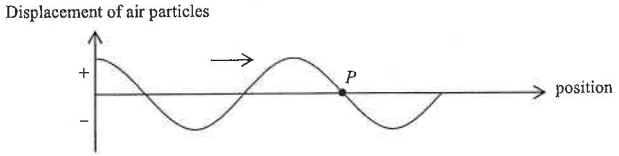
(1) The wave is propagating to the left.

(2) Particle B takes longer time to reach its equilibrium position than that of particle A.

(3) Particles C and D are moving in opposite directions at the instant shown.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

34. **< HKAL 2000 Paper IIA - 17 >**



The above figure shows the displacement – position graph of a longitudinal wave at a certain instant. Take the displacement towards the right as positive, which of the following statements about particle P at this instant are correct ?

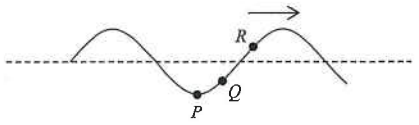
(1) P is a centre of compression.

(2) P has the greatest kinetic energy.

(3) P is moving towards the right.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

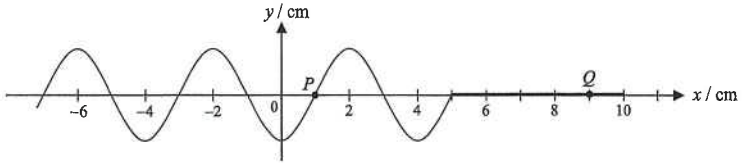
35. **< HKAL 2003 Paper IIA - 14 >**



The figure shows three particles P, Q and R on a transverse wave travelling towards the right. The three particles will reach their own equilibrium positions at different times in the sequence of

A. R, P, Q
B. R, Q, P
C. P, R, Q
D. P, Q, R

36. **< HKAL 2009 Paper IIA - 16 >**



The above figure shows the displacement y against the position x of a transverse wave travelling to the right at time $t = 0$. P and Q are two particles at $x = 1$ cm and $x = 9$ cm respectively. Next time when P reaches its crest position is at $t = 0.3$ s. Which of the following statements are correct ?

(1) The speed of the transverse wave is 10 cm s^{-1}.

(2) Particle Q first reaches its crest position at $t = 0.5$ s.

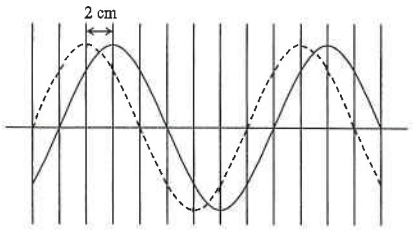
(3) When Q reaches its crest position, P also reaches its crest position.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part C : HKDSE examination questions

37. **< HKDSE Sample Paper IA - 17 >**

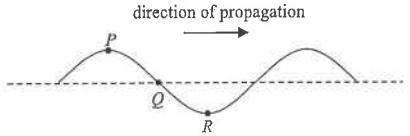
The solid curve in the above diagram shows a transverse wave at a certain instant. After 0.05 s, the wave has travelled a distance of 2 cm and is indicated by the dashed curve. Find the wavelength and frequency of the wave.



	Wavelength / cm	**Frequency / Hz**
A.	8	2.5
B.	16	2.5
C.	8	5
D.	16	5

Provided by dse.life

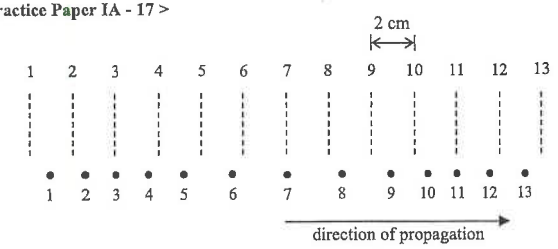
38. **< HKDSE Sample Paper IA - 18 >**



The figure shows the shape of a transverse wave travelling along a string at a certain instant. Which statements about the motion of the particles *P*, *Q* and *R* on the string at this instant is correct ?

A. Particle *P* is moving downwards.
B. Particle *Q* is stationary.
C. Particle *R* attains its maximum acceleration.
D. *P* and *Q* are in phase.

39. **< HKDSE Practice Paper IA - 17 >**

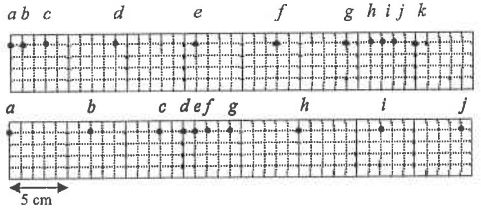


A longitudinal wave travels to the right through a medium containing a series of particles. The figure above shows the positions of the particles at a certain instant. The dotted lines indicate the equilibrium positions of the particles. Which of the following statements about the wave at the instant shown is/are correct ?

(1) The wavelength of the longitudinal wave is 16 cm.
(2) Particles 8 and 10 are moving in the same direction.
(3) Particle 3 is momentarily at rest.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

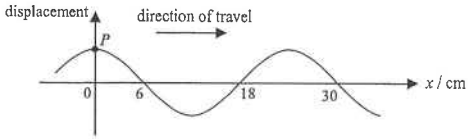
40. **< HKDSE 2012 Paper IA - 15 >**



A series of particles is uniformly distributed along a slinky spring initially. Figure (a) shows their positions at a certain instant when a travelling wave propagates along the slinky spring from left to right. Figure (b) shows their positions 0.1 s later. Which statement is correct ?

A. Particle *e* is always stationary.
B. Particles *a* and *i* are in phase.
C. The wavelength of the wave is 16 cm.
D. The frequency of the wave is 10 Hz.

41. **< HKDSE 2013 Paper IA - 16 >**



The figure shows a snapshot of a section of a continuous transverse wave travelling along the *x*-direction at time $t = 0$. At $t = 1.5$ s, the particle *P* just passes the equilibrium position for a *second* time at that moment. Find the wave speed.

A. 20 cm s^{-1}
B. 12 cm s^{-1}
C. 6 cm s^{-1}
D. 4 cm s^{-1}

42. **< HKDSE 2013 Paper IA - 17 >**

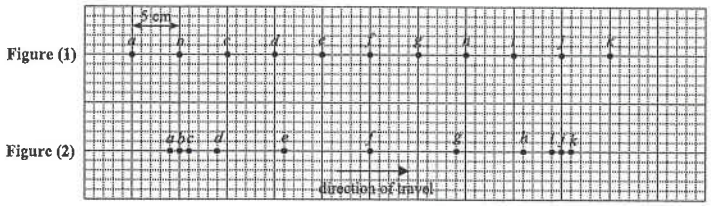
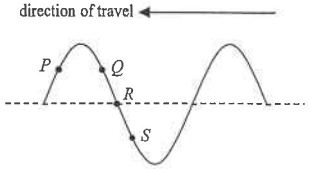


Figure (1) shows the equilibrium positions of particles *a* to *k* separated by 5 cm from each other in a medium. A longitudinal wave is travelling from left to right with a speed of 80 cm s^{-1}. At a certain instant, the positions of the particles are shown in Figure (2). Determine the amplitude and frequency of the wave.

	amplitude	**frequency**
A.	6 cm	2 Hz
B.	6 cm	4 Hz
C.	9 cm	2 Hz
D.	9 cm	4 Hz

43. **< HKDSE 2014 Paper IA - 14 >**



A transverse wave travels towards the left on a long string. *P*, *Q*, *R* and *S* are particles on the string. Which of the following statements correctly describe(s) their motions at the instant shown ?

(1) *P* is moving upwards.
(2) *Q* and *S* are moving in opposite directions.
(3) *R* is momentarily at rest.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

44. < HKDSE 2015 Paper IA - 12 >

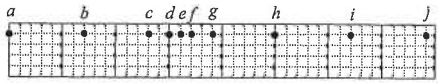


Figure (a)

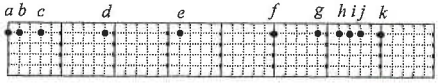


Figure (b)

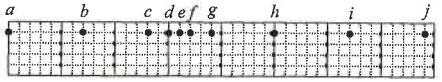


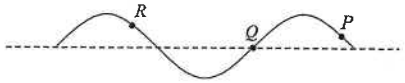
Figure (c)

A series of particles is uniformly distributed along a slinky spring initially. When a travelling wave propagates along the slinky spring from left to right, Figure (a) shows the positions of the particles at a certain instant. Figures (b) and (c) respectively show their positions 0.05 s and 0.1 s later. Which of the following is/are a possible frequency of the wave ?

(1) 10 Hz
(2) 20 Hz
(3) 40 Hz

A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

45. < HKDSE 2016 Paper IA - 15 >

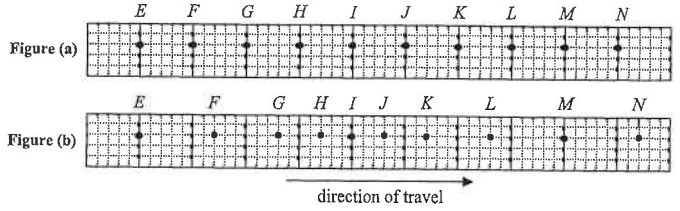


The above figure shows a snapshot of a transverse wave which travels along a string. Which statement is correct ?

A. The wave is travelling to the left if particle P is moving upwards at this instant.
B. Particles P and R are moving in the same direction at this instant.
C. Particle Q is at rest at this instant.
D. Particle R vibrates with an amplitude larger than that of particle Q.

46. < HKDSE 2017 Paper IA - 14 >

Figure (a) shows the equilibrium positions of particles E to N in a medium. At time $t = 0$, a longitudinal wave starts travelling from left to right. At time $t = 1$ s, the positions of the particles are shown in Figure (b).

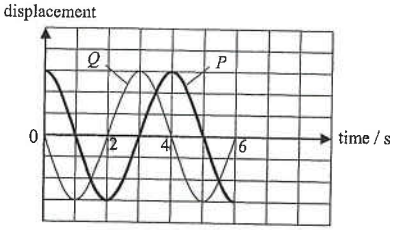


Which of the following statements **MUST BE** correct ?

A. The distance between particles F and N is equal to the wavelength of the wave.
B. The period of the wave is 1 s.
C. Particle E is always at rest.
D. Particle I is momentarily at rest at $t = 1$ s.

47. < HKDSE 2018 Paper IA - 15 >

The figure below shows the displacement-time graph of particles P and Q on the same transverse travelling wave of wavelength λ.



Which of the following statements **MUST BE** correct ? Upward displacement is taken to be positive.

(1) At time $t = 2$ s, P is momentarily at rest.
(2) At time $t = 4$ s, Q is moving downwards.
(3) The separation between the equilibrium positions of P and Q is 0.25 λ.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

8. <HKDSE 2019 Paper IA-1 >

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49. <HKDSE 2020 Paper IA-11>

Figure (1)

Figure (2)

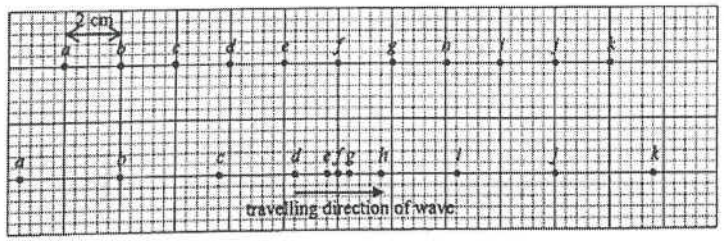
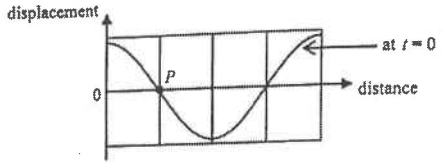


Figure (1) shows the equilibrium positions of particles a to k in a medium. The particles are separated by 2 cm from each other. A longitudinal wave of frequency 5 Hz is travelling from left to right. At a certain instant, the positions of the particles are shown in Figure (2). Determine the amplitude and speed of the wave.

	amplitude	speed
A.	3.6 cm	40 cm s^{-1}
B.	3.6 cm	80 cm s^{-1}
C.	2.4 cm	40 cm s^{-1}
D.	2.4 cm	80 cm s^{-1}

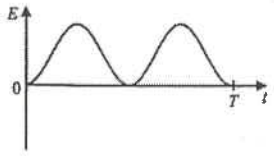
50. <HKDSE 2020 Paper IA-12>

The figure shows part of the displacement-distance graph of a travelling wave of period T at time $t = 0$. P is a particle on the wave.

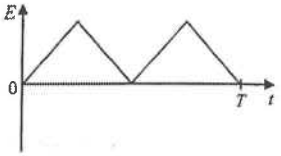


Which graph below correctly shows the variation of the particle's kinetic energy E within a period starting from $t = 0$?

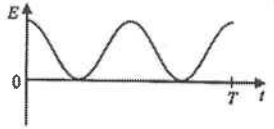
A.



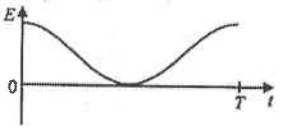
B.



C.



D.



Provided by dse.life

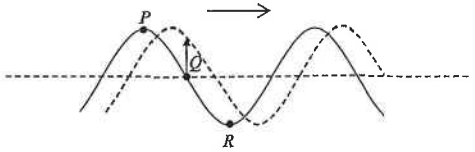
HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. D	21. C	31. A	41. B
2. C	12. B	22. C	32. A	42. A
3. C	13. B	23. C	33. A	43. A
4. A	14. D	24. C	34. D	44. A
5. C	15. A	25. A	35. A	45. B
6. D	16. D	26. B	36. B	46. A
7. D	17. C	27. B	37. B	47. C
8. D	18. A	28. C	38. C	48. C
9. C	19. B	29. C	39. A	49. D
10. C	20. B	30. B	40. B	50. C

M.C. Solution

1. D



× (1) P is at the crest position, thus it must be momentarily at rest.

✓ (2) Draw the dotted line representing the wave at a later instant, Q is moving upwards

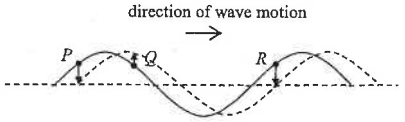
✓ (3) R is at the trough position, thus it must be momentarily at rest.

2. C

In 0.025 s, the waveform propagates by $\frac{1}{4}$ of its wavelength.

∴ Period = $0.025 \times 4 = 0.1$ s

3. C



∴ P : ↓ Q : ↑ R : ↓

4. A

$T = \frac{1}{f} = \frac{1}{5} = 0.2$ s

∴ After 0.1 s which is $\frac{1}{2}T$, the wave should propagate by $\frac{1}{2}\lambda$.

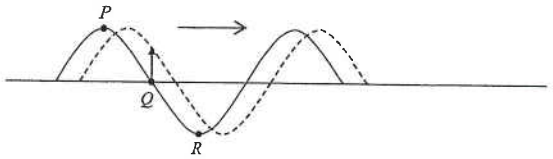
5. C

✓ (1) P and Q are two particles in phase with minimum separation ⇒ $PQ = \lambda$

✓ (2) P is in maximum displacement ⇒ PR = amplitude

× (3) Particle P vibrates vertically about its equilibrium position, thus P will move to position R.

6. D

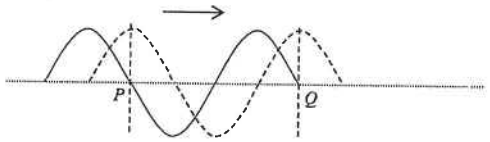


× (1) P is at its maximum displacement and is momentarily at rest

✓ (2) Q is moving upwards as shown by the above diagram

✓ (3) R is at the instant of maximum displacement and is momentarily at rest

7. D



After a quarter of a period, the wave would travel towards the right a distance of a quarter of wavelength.

8. D

From the graph, $T = 0.2$ s.

$f = \frac{1}{T} = \frac{1}{0.2} = 5$ Hz

9. C

From figure (a), $\lambda = x$.

From figure (b), $T = y$.

$v = f\lambda = \frac{\lambda}{T} = \frac{x}{y}$

Provided by dse.life

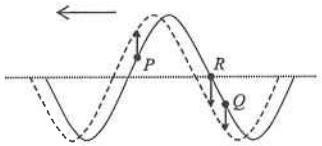
10. C

$f = \frac{4}{2} = 2$ Hz

$\lambda = 10$ cm $= 0.1$ m

$\therefore\ v = f\lambda = (2)(0.1) = 0.2$ m s^{-1}

11. D



✓ A. P moves upward $\Rightarrow$ the wave is travelling to the left

✓ B. All particles in same wave must have the same frequency

✓ C. Q is moving downwards at the instant shown

× D. R is moving downwards as shown by the above diagram

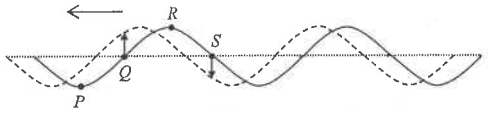
12. B

× (1) The time taken for the wave to make one complete vibration is the period.

× (2) The distance travelled by the wave in one second is the speed.

✓ (3) The number of waves produced in one second is the frequency.

13. B



As shown in the above diagram, particles P, and R are momentarily at rest at $t = 0$

while Q is moving upwards and S is moving downwards.

Since the Displacement - time graph shows that the motion of cork is moving upwards at $t = 0$ $\therefore$ Q is the answer.

14. D

Time taken should be found by $t = d / v$.

However, $v = f\lambda$.

As λ is unknown, v cannot be determined, so time taken to travel 100 m cannot be determined.

15. A

✓ (1) The distance that the wave repeats itself in 1 cycle is 20 cm. This is the wavelength.

✓ (2) By $v = f\lambda$ $\therefore$ $(1.2) = f\,(0.20)$ $\therefore$ $f = 6$ Hz.

× (3) The amplitude should be 3 cm from the graph.

16. D

After a quarter of a period, the waveform should propagate $\frac{1}{4}$ wavelength towards the right.

Thus the crest initially at 5 cm should move to the point at 10 cm.

17. C

Wavelength : $\lambda = 2$ cm $\times 8 = 16$ cm

As the wave travels 2 cm, i.e. $\frac{1}{8}\lambda$ in 0.05 s which is $\frac{1}{8}T$, thus period $T = 0.05$ s $\times 8 = 0.40$ s

Frequency : $f = \frac{1}{T} = \frac{1}{0.40} = 2.5$ Hz

18. A

✓ (1) Amplitude is the maximum displacement, thus $A = 3 \times 2$ cm $= 6$ cm

✓ (2) Wavelength is the minimum distance to repeat itself, thus $\lambda = 4 \times 2$ cm $= 8$ cm

× (3) Since at $t = 0.2$ s, the wave has propagated $\frac{3}{4}\lambda$, thus 0.2 s $= \frac{3}{4}T$ $\therefore$ $T = 0.267$ s

Frequency $f = \frac{1}{T} = \frac{1}{0.267} = 3.75$ Hz $\neq 5$ Hz

19. B

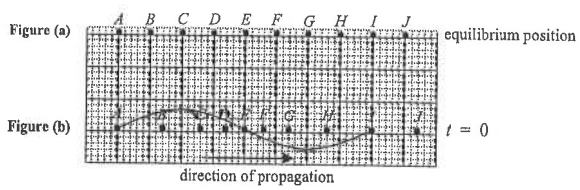
$v = \frac{d}{t} = \frac{3 \times 2}{0.2} = 30$ cm s^{-1} $= 0.3$ m s^{-1}

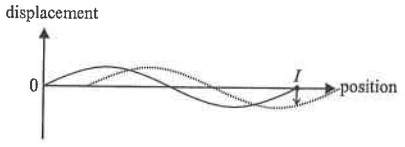
20. B

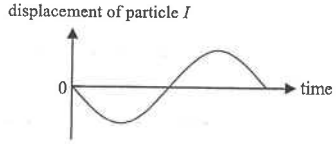
By $v = f\lambda$ $\therefore$ $v = (2)(100) = 200$ m s^{-1}

By $d = vt$ $\therefore$ $(1500 \times 10^3) = (200)\,t$ $\therefore$ $t = 7500$ s ≈ 2 hours

21. C







Since the particle I is initially at the equilibrium position.

At a later time, it would move towards the left, i.e. it would have a negative displacement.

Provided by dse.life

22. C

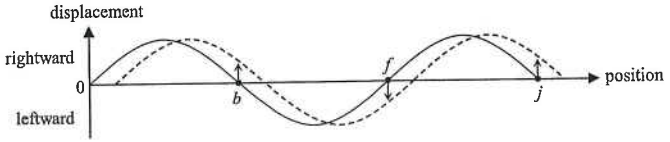
In Figure (b), particle a is at the centre of compression, thus it must be at the equilibrium position.

After half a period, particle a should perform half a cycle,

thus it must be still at the same equilibrium position but it then becomes at the centre of rarefaction.

The graph in option C shows that particle a is at the rarefaction and at the same position, thus it is the answer.

23. C



Particle b and j are at the centre of compression and particle f is at the centre of rarefaction.

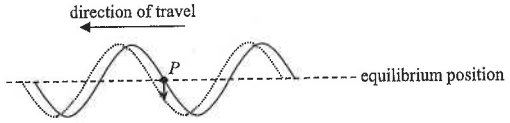
They are at the equilibrium positions.

After a small time interval, the wave travels towards the right and is represented by the dotted line.

Particle b and together with particle c nearby are moving towards the right.

Particle f is moving towards the left.

24. C

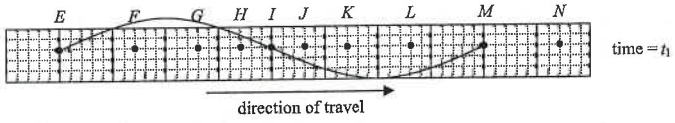


The wave would travel towards the left after $t = 1$ s as shown by the dotted line.

It shows that particle P is at the equilibrium position and is moving downwards at $t = 1$ s.

Thus, option C shows the correct $y - t$ graph for particle P. Note that position of P at $t = 1$ s.

25. A



From the graph, E and M are at the centre of rarefaction and I is at the centre of compression.

Centre of rarefaction and centre of compression must be at the equilibrium positions and are moving at greatest speed.

For a particle to be momentarily at rest, it must be at the extreme point,

and its position should be at the middle of the compression and rarefaction.

From the graph shown, particle K is at the leftmost position and must be momentarily at rest at t_1.

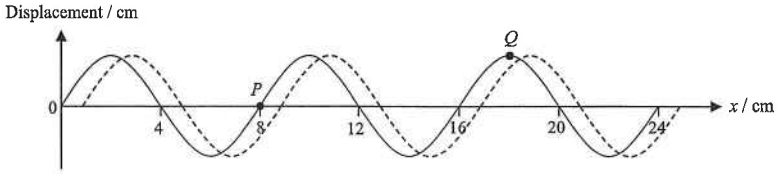
26. B

Wavelength : $\lambda = 8$ cm

By $v = f\lambda$ $\therefore$ $(2) = f(8)$ $\therefore$ $f = 0.25$ Hz

Period : $T = \frac{1}{f} = \frac{1}{0.25} = 4$ s

27. B



The wave is moving towards the right, thus particle P is moving downwards.

To reach the position of Q, that is the crest, particle P has to move through $\frac{3}{4}$ cycle. Thus, the time taken is $\frac{3}{4}T$.

$\therefore$ $t = \frac{3}{4} \times 4 = 3$ s

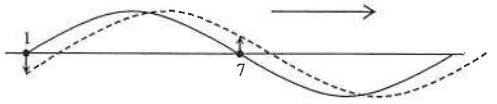
28. C

Particle J is at the position of rarefaction, thus it must be at the equilibrium position.

At equilibrium point, it must move with the maximum speed, not at rest. Thus option C is **incorrect**.

29. C

Take the rightward direction as (+) :



Particle 1 is moving towards the negative direction, thus it is moving to the left.

Particle 7 is moving towards the positive direction, thus it is moving to the right

30. B

Period : $T = 0.70 - 0.20 = 0.5$ s

$\therefore$ $f = \frac{1}{T} = \frac{1}{0.5} = 2$ Hz

31. A

From Figure (a), particles separated by 0.6 m are in the same phase, thus the wavelength : $\lambda = 0.6$ m

From Figure (b), a particle takes 2 ms to complete a cycle

$\therefore$ $T = 2 \times 10^{-3}$ s

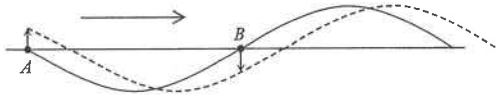
$\therefore$ $f = \frac{1}{T} = \frac{1}{2 \times 10^{-3}} = 500$ Hz

$\therefore$ $v = f\lambda = (0.6)(500) = 300$ m s^{-1}

Provided by dse.life

32. A

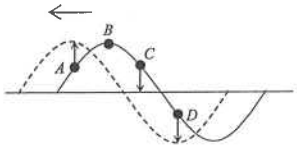
Take the rightward direction as (+) :



Particle A is moving towards the positive direction, thus it is moving to the right.

Particle B is moving towards the negative direction, thus it is moving to the left.

33. A



✓ (1) Particle D moves downward $\Rightarrow$ the wave moves to the left

× (2) A moves upward before going downward but B moves downward only
$\Rightarrow$ A : takes a longer path to reach the equilibrium position

× (3) C and D both move downward.

34. D

✓ (1) P is a centre of compression
since the particles at the left hand side of P have positive displacement, i.e. moves to the right ;
while the particles at the right hand side of P moves to the left.

✓ (2) P : at equilibrium position $\Rightarrow$ maximum KE

✓ (3) P : has (+) displacement later $\Rightarrow$ moving to the right

35. A

At the instant shown, particle P is momentarily at rest, particle Q and R are moving downwards.

Time for P to reach the equilibrium point $= \frac{1}{4}T$

Time for Q to reach the equilibrium point $> \frac{1}{4}T$

Time for R to reach the equilibrium point $< \frac{1}{4}T$

36. B

✓ (1) At this instant, P is moving downwards.
As it takes 0.3 s for P to reach the crest position that performs $\frac{3}{4}$ cycle, the period is 0.4 s.
Wavelength of the wave is 4 cm. Speed $= \lambda / T = (4) / (0.4) = 10$ cm s^{-1}

× (2) At $t = 0.5$ s, Q should reach its trough position.

✓ (3) The separation of P and Q is two wavelengths, thus their motions are in phase.

37. B

Wavelength : $\lambda = 2$ cm $\times 8 = 16$ cm

As the wave travels 2 cm, i.e. $\frac{1}{8}\lambda$ in 0.05 s which is $\frac{1}{8}T$,

Period $T = 0.05$ s $\times 8 = 0.40$ s

Frequency : $f = \frac{1}{T} = \frac{1}{0.40} = 2.5$ Hz

OR

As the wave travels 2 cm in 0.05 s, speed : $v = \frac{d}{t} = \frac{2}{0.05} = 40$ cm s^{-1}

By $v = f\lambda$ $\therefore$ $(40) = f\,(16)$ $\therefore$ $f = 2.5$ Hz

38. C

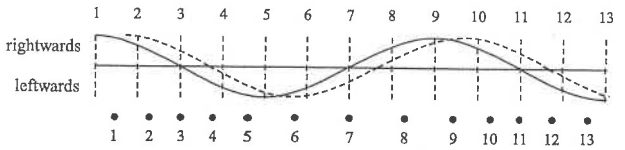
× A. As P is at the crest, it must be momentarily at rest.

× B. As Q is at the equilibrium position, it must have the maximum speed and must be moving.

✓ C. As R is at the extreme position, its acceleration is the maximum.

× D. As the separation between P and Q are not $n\,\lambda$, they cannot be in phase.

39. A



Draw the displacement - position graph as shown in the above figure.
Note that particles 3 and 11 are at the compression and particle 7 is at the rarefaction.

✓ (1) The separation between two compressions is 1 wavelength. $\therefore$ $\lambda = 8 \times 2 = 16$ cm

× (2) After a short time, the wave would move rightwards to the dotted position.
Thus, particle 8 is moving leftwards and particle 10 is moving rightwards.
They are moving in opposite directions.

× (3) Particle 3 is at the equilibrium position, it must have the maximum speed, but not at rest.

40. B

× A. For a travelling wave, particles may be momentarily at rest. There is no particle that is always at rest.

✓ B. In Figure (a), particles a and I are both at the compression, thus they are in phase.

× C. The separation between a and i is one wavelength, which is 32 cm.

× D. Particle a is at the compression in Figure (a) and at the rarefaction in Figure (b),
that is, particle a has moved through half cycle of the oscillation, thus the time taken is half period.
$\therefore$ $\frac{1}{2}T = 0.1$ s $\therefore$ $T = 0.2$ s $\therefore$ $f = 1 / T = 1 / 0.2 = 5$ Hz

Provided by dse.life

41. B

From the graph, wavelength : $\lambda = 30 - 6 = 24$ cm

In 1.5 s, particle P performs $\frac{3}{4}$ cycle, thus it takes a time of $\frac{3}{4}T$, where T is the period.

$\therefore \frac{3}{4}T = 1.5 \quad \therefore T = 2$ s

Frequency : $f = \frac{1}{T} = \frac{1}{2} = 0.5$ Hz

Speed : $v = f\lambda = (0.5)(24) = 12$ cm s^{-1}

42. A

From Figure (2), particles b and j are at the centres of compression.

Separation between them is the wavelength.

$\therefore \lambda = 8 \times 5 = 40$ cm

By $v = f\lambda \quad \therefore (80) = f(40) \quad \therefore f = 2$ Hz

From Figure (2), as particle b is at the compression and particle f is at the rarefaction, they are at equilibrium positions.

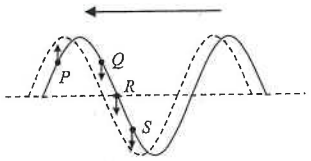
Particle d should then be at the extreme position.

Displacement of particle d is the amplitude.

$\therefore$ Amplitude = 6 cm

43. A

After a while, the wave would shift to the left shown as the dotted curve.



✓ (1) Particle P is moving upwards.

× (2) Particles Q and S should move in the same direction.

× (3) Particle R is not momentarily at rest, but moving downwards.

44. A

In Figure (a), particle e is at the centre of compression.

✓ (1) If $f = 10$ Hz, then $T = \frac{1}{f} = \frac{1}{10} = 0.1$ s. After a time of 0.05 s : $t = \frac{0.05}{0.1}T = \frac{1}{2}T$,
particle e should travel $\frac{1}{2}$ cycle to the position of the centre of rarefaction as shown in Figure (b).
Thus, $f = 10$ Hz is possible.

× (2) If $f = 20$ Hz, then $T = \frac{1}{f} = \frac{1}{20} = 0.05$ s. After a time of 0.05 s : $t = 1T$,
particle e should travel 1 cycle to the position of the centre of compression,
but not the rarefaction as shown in Figure (b). Thus, $f = 20$ Hz is impossible.

× (3) If $f = 40$ Hz, then $T = \frac{1}{f} = \frac{1}{40} = 0.025$ s. After a time of 0.05 s : $t = 2T$,
particle e should travel 2 cycles to the position of the centre of compression,
but not the rarefaction as shown in Figure (b). Thus, $f = 40$ Hz is impossible.

45. B

× A. If particle P is moving upwards, the wave should be travelling to the right.

✓ B. If the wave is moving to the right, then both P and R are moving upwards.
If the wave is moving to the left, then both P and R are moving downwards.
Thus, they must be moving in the same direction at this instant.

× C. Particle Q is at the equilibrium position that has the greatest speed, it must be moving.

× D. Particle R and Q should be moving with the same amplitude since it is a travelling wave.

46. A

✓ A. From Figure (b), both E and M are at the centre of rarefaction,
thus distance between E and M is one wavelength.
Therefore, distance between the next particles, F and N, is also one wavelength.

× B. There is no information concerning the period or frequency of the wave.

× C. In a travelling wave, there is no particle that is always at rest.

× D. Particle I is at the centre of compression, it is moving towards the right at this instant.

47. C

✓ (1) At $t = 2$ s, P is at the position of trough, thus it must be momentarily at rest.

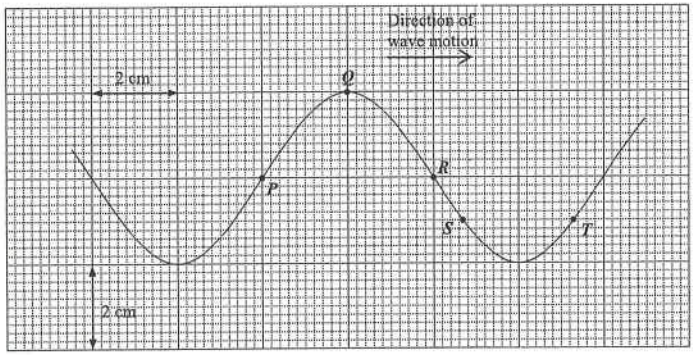
✓ (2) At $t = 4$ s, Q is at equilibrium positon and later at a lower position, thus it must be moving downwards.

× (3) P and Q are neither in phase nor anti-phase, there is no phase relation concerning their separation.

Provided by dse.life

Part A : HKCE examination questions

1. **< HKCE 1981 Paper I - 6 >**



A transverse wave is travelling steadily from left to right through a series of particles. At a certain instant the wave form is as shown in the above figure. Each of the vibrating particles is observed to perform four complete oscillations in 16 s.

(a) Find the following quantities : (4 marks)

(i) the amplitude of the wave,

(ii) the wavelength,

(iii) the period,

(iv) the frequency.

(b) At the instant shown, which of the particles P, Q, R, S, T is/are (5 marks)

(i) moving upwards,

(ii) moving downwards,

(iii) momentarily at rest ?

(c) What will be the position of particle Q a quarter of a period later ? (2 marks)

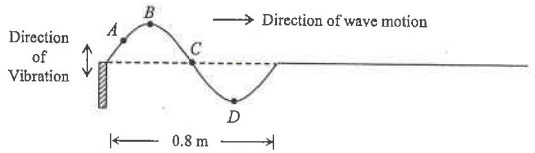
2. **< HKCE 1990 Paper I - 5 >**

A vertical vibrator generates waves on a string. It takes 0.25 s to produce a complete wave of wavelength 0.8 m on the string.

(a) Find the frequency and speed of the waves on the string. (3 marks)

(b) How long does it take for the wave to propagate a distance of 2 m ? (2 marks)

(c) The figure below shows the shape of the string at the instant when the vibrator has made one complete vibration.



(i) At the instant shown, which of the particles A, B, C, D is/are

(1) moving downwards,

(2) at rest ? (2 marks)

(ii) Sketch the shape of the string after 0.125 s. In your figure show the positions of the particles A, B, C and D. (4 marks)

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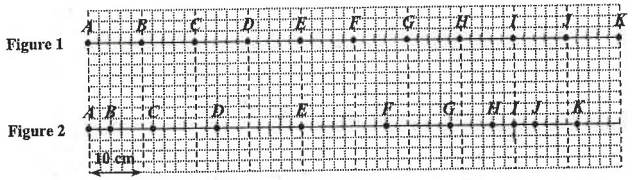
3. **< HKCE 1998 Paper I - 7 >**



A longitudinal wave is travelling from left to right in a medium. Figure 1 shows the equilibrium positions of some particles A to K in the medium. Figure 2 shows the positions of the particles at a certain time t when the wave is passing through them.

(a) What is meant by a longitudinal wave ? Give an example of a longitudinal wave. (2 marks)

(b) Point out a particle in Figure 2 which is

(i) at the centre of a compression,

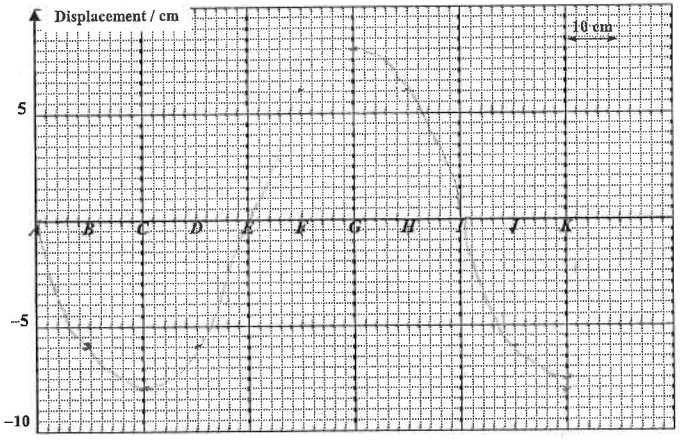
(ii) at the centre of a rarefaction. (2 marks)

(c) The table below shows the displacements of particles A and B at time t. (Note : Displacement to the right is taken to be positive.)

(i) Using Figures 1 and 2, find the displacements of the other particles and complete the Table below. (2 marks)

Particle	A	B	C	D	E	F	G	H	I	J	K
Displacement / cm	0	– 6									

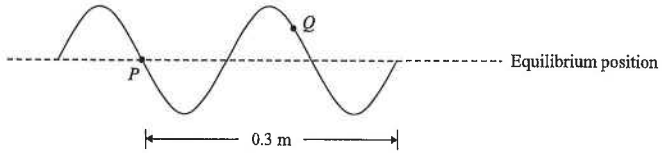
(ii) In the figure below, draw a graph showing the displacements of the particles along the wave at time t. (2 marks)



3. (c) (iii) Find the amplitude and wavelength of the wave. (2 marks)

(iv) If each particle takes 0.25 s to complete one oscillation, find the speed of the wave. (2 marks)

4. **< HKCE 2002 Paper I - 4 >**



A wave is generated on a string. The figure above shows the shape of the string at a certain instant. At this instant, both particles P and Q are moving downwards.

(a) State the type of wave generated on the above string. (1 mark)

(b) What is the direction of travel of the above wave ? (1 mark)

(c) At the instant shown, which particle (P or Q) has a greater speed ? Explain briefly. (2 marks)

(d) Find the wavelength of the wave. (1 mark)

(e) Describe the motions of particles P and Q at a quarter of a period later. (2 marks)

Provided by dse.life

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) $A = 2$ cm [1]

(ii) $\lambda = 8$ cm [1]

(iii) $T = 4$ s [1]

(iv) $f = 0.25$ Hz [1]

(b) (i) R, S [2]

(ii) P, T [2]

(iii) Q [1]

(c) Q is at 2 cm below its present position [2]

2. (a) Frequency = 4 Hz [1]

Speed $= \frac{d}{t} = \frac{0.8}{0.25} = 3.2\ \text{m s}^{-1}$ **OR** $v = f\lambda = 4 \times 0.8 = 3.2\ \text{m s}^{-1}$ [2]

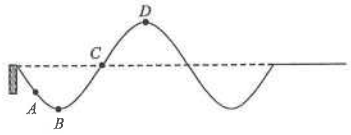
(b) By $d = vt$ [1]

$\therefore (2) = (3.2)t \quad \therefore t = 0.625$ s [1]

(c) (i) (1) A [1]

(2) B and D [1]

(ii)



< For wave form > [2]

< 0.5 mark for each particle > [2]

3. (a) A longitudinal wave is a wave in which the vibrations are parallel to the direction of travel of the wave. [1]

Example : (Any **ONE** of the following) [1]

* Sound waves
* Ultrasonic waves
* Waves generated in a slinky spring

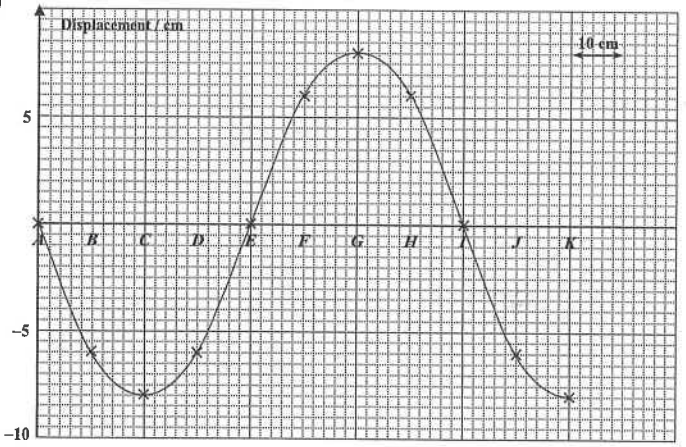
(b) (i) Particle A (**OR** I) is at a centre of compression. [1]

(ii) Particle E is at a centre of rarefaction. [1]

3. (c) (i) [2]

Particle	C	D	E	F	G	H	I	J	K
Displacement / cm	– 8	– 6	0	6	8	6	0	– 6	– 8

(ii)



< Correct points > [1]

< Correct curve > [1]

(iii) Amplitude = 8 cm [1]

Wavelength = 80 cm [1]

(iv) speed $= f\lambda$ [1]

$= \frac{1}{0.25} \times 0.8 = 3.2\ \text{m s}^{-1}$ [1]

4. (a) It is a transverse wave [1]

(b) The direction is towards the left. [1]

(c) Particle P has a greater speed, [1]

since it is at the equilibrium position. [1]

(d) Wavelength $= \frac{0.3}{1.5} = 0.2$ m [1]

(c) Particle P is momentarily at rest. [1]

Particle Q is moving downwards. [1]

Provided by dse.life

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普遍氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

DSE Physics - Section C : M.C. PC - WA2 - M / 01
WA2 : Wave Phenomena

Part A : HKCE examination questions

1. **< HKCE 1982 Paper II - 12 >**

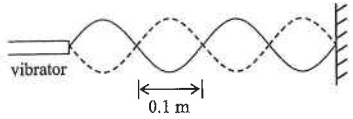
A train of water waves is travelling from a deep water region to a shallow water region. Which of the following properties of the water waves will be changed ?

(1) wavelength
(2) frequency
(3) velocity

A. (1) only
B. (3) only
C. (1) & (3) only
D. (2) & (3) only

2. **< HKCE 1982 Paper II - 13 >**

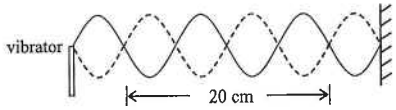
A stationary wave is obtained by attaching one end of a string to a 50 Hz vibrator as shown in the diagram. The velocity of the waves propagated in the string is



A. 0.1 m s^{-1}
B. 0.2 m s^{-1}
C. 5 m s^{-1}
D. 10 m s^{-1}

3. **< HKCE 1983 Paper II - 23 >**

A stationary wave is set up along a string by a vibrator as shown in the diagram. If the frequency of the vibrator is 5 Hz, what is the velocity of the wave set up in the string ?



A. 25 cm s^{-1}
B. 50 cm s^{-1}
C. 75 cm s^{-1}
D. 100 cm s^{-1}

4. **< HKCE 1984 Paper II - 22 >**

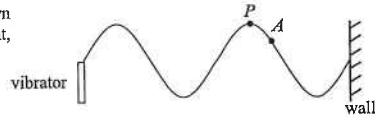
In a ripple tank experiment, a series of plane water waves are sent through a narrow slit. Which of the following will have changed when the water waves emerge from the slits ?

(1) wave speed
(2) wave pattern
(3) frequency

A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

5. **< HKCE 1985 Paper II - 25 >**

A stationary wave is produced in a string by a vertical vibrator as shown in the diagram. If P is at the crest of an antinode at a certain instant, what is the direction of motion of the point A at that instant ?



A. upwards
B. downwards
C. to the right
D. momentarily at rest

Provided by dse.life

6. **< HKCE 1986 Paper II - 24 >**

Straight waves in a ripple tank are observed using a hand stroboscope with a single slit. The maximum frequency of rotation of the stroboscope where a stationary pattern can be observed is 2 revolutions per second. The distance between the first crest and the eleventh crest is found to be 0.2 m. What is the speed of the wave ?

A. $\frac{0.2}{11}$ m s^{-1} B. $\frac{0.2}{10}$ m s^{-1}

C. $\frac{0.4}{11}$ m s^{-1} D. $\frac{0.4}{10}$ m s^{-1}

7. **< HKCE 1987 Paper II - 12 >**

The figure shows a stationary water wave at its maximum vibration. What is the direction of the motion of a particle P at this instant ?

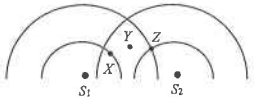
A. towards the right
B. upwards
C. downwards
D. momentarily at rest

8. **< HKCE 1988 Paper II - 24 >**

In a ripple tank, when water waves pass through a narrow gap in a barrier, what happens to its frequency and wavelength ?

	Frequency	Wavelength
A.	increases	decreases
B.	decreases	increases
C.	decreases	remains unchanged
D.	remains unchanged	remains unchanged

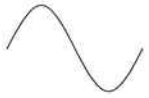
9. **< HKCE 1989 Paper II - 25 >**



The figure above shows the wave pattern in a ripple tank from coherent point sources S_1 and S_2. What kind of interference occurs at X, Y and Z ?

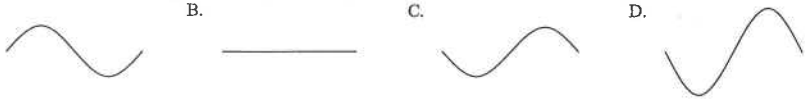
	X	Y	Z
A.	destructive	constructive	constructive
B.	no interference	constructive	constructive
C.	no interference	destructive	no interference
D.	no interference	destructive	constructive

10. **< HKCE 1989 Paper II - 26 >**



A stationary wave is formed in a string. The above diagram shows the string at the instant of maximum displacement. What will be the shape of the wave pattern one quarter of a period later ?

A. B. C. D.



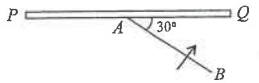
11. **< HKCE 1990 Paper II - 26 >**

In a ripple tank experiment, a series of plane water waves passes through a narrow slit. Which of the following properties of the waves will remain unchanged ?

(1) speed
(2) direction of travel
(3) frequency

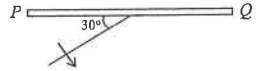
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

12. **< HKCE 1990 Paper II - 23 >**



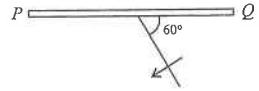
A straight pulse AB is travelling towards a straight barrier PQ in a ripple tank as shown above. Which of the following figures best shows the reflected pulse ?

A.



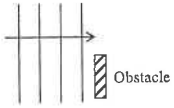
B.

C.



D.

13. **< HKCE 1991 Paper II - 24 >**

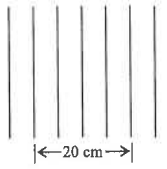


A series of water waves, generated in water of uniform depth, is travelling towards an obstacle as shown above. Which of the following diagrams best shows the wave pattern after passing the obstacle ?

A. B. C. D.

14. **< HKCE 1992 Paper II - 24 >**

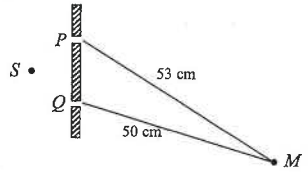
In a ripple tank experiment, the pattern of plane water waves is frozen by using a stroboscopic lamp flashing at a frequency of 50 Hz as shown in the above diagram. If the frequency of the vibrator is 50 Hz, find the wavelength and speed of the waves.



	Wavelength	Speed
A.	4 cm	2 m s^{-1}
B.	4 cm	12.5 m s^{-1}
C.	5 cm	2.5 m s^{-1}
D.	5 cm	10 m s^{-1}

Provided by dse.life

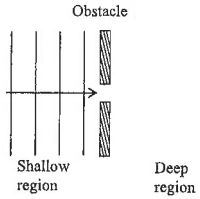
15. < HKCE 1992 Paper II - 25 >



In a double-slit experiment, a source S sends waves towards two slits P and Q, which are equidistant from S. The distances of a point M from P and Q are 53 cm and 50 cm respectively. If constructive interference occurs at M, the possible wavelength of the waves is

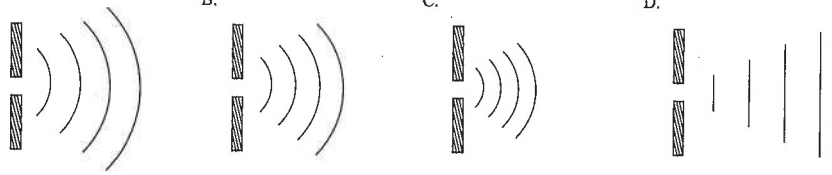
A. 1 cm.
B. 2 cm.
C. 4 cm.
D. 6 cm.

16. < HKCE 1992 Paper II - 26 >

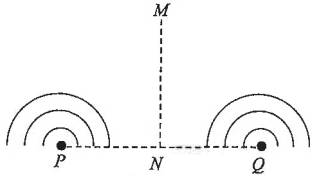


The figure above shows a series of plane water waves travelling in a shallow region of water. The waves pass through a small slit to a deep region of water. Which of the following diagrams shows the wave pattern in the deep region ?

A. B. C. D.



17. < HKCE 1993 Paper II - 25 >

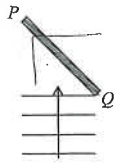


Two vibrators P and Q are set to vibrate in phase in a ripple tank. MN is the perpendicular bisector of PQ as shown above. Which of the following statements is/are true ?

(1) Constructive interference occurs along MN.
(2) Destructive interference occurs along PQ.
(3) A crest is always formed at M.

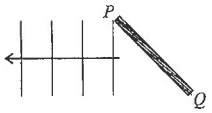
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

18. < HKCE 1993 Paper II - 23 >

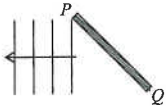


Plane water waves travel towards a straight barrier PQ as shown in the figure above. Which of the following diagrams best shows the reflected waves ?

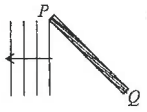
A.



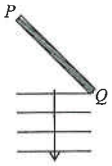
B.



C.



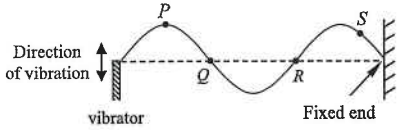
D.



19. < HKCE 1994 Paper II - 20 >

A vibrator generates a stationary wave on a string. The diagram shows the string at an instant of maximum displacement. Which of the following statement is correct ?

A. Particle P is moving towards the right.
B. Particle Q is moving upwards.
C. Particle R always remains at rest.
D. All particles in the string move with the same amplitude.



20. < HKCE 1996 Paper II - 25 >

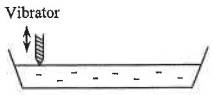


Figure (a)

Figure (b)

A vibrator generates continuous plane waves in a ripple tank (see Figure (a)). Figure (b) shows the wave pattern observed.

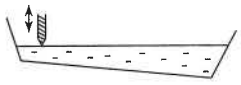
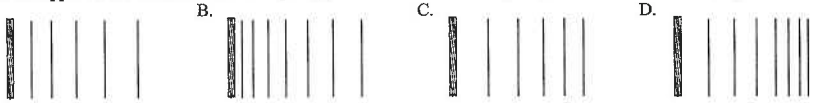


Figure (c)

Now the ripple tank is tilted as shown in Figure (c). Which of the following diagrams best shows the wave pattern observed ?

A. B. C. D.



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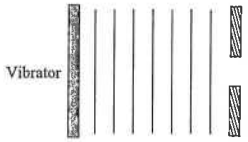
21. < HKCE 1997 Paper II - 25 >

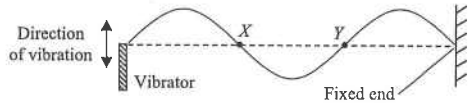


A vibrator generates continuous plane waves in a ripple tank. The waves undergo diffraction when they pass through a slit. Which of the following can increase the degree of diffraction of the waves ?

(1) Increasing the width the slit
(2) Placing the vibrator closer to the silt
(3) Increasing the wavelength of the water waves

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Questions 22 and 23 : A vibrator generates a stationary wave on a string. The diagram below shows the string at a certain instant.



22. < HKCE 1997 Paper II - 23 >

Which of the following statements is **incorrect** ?

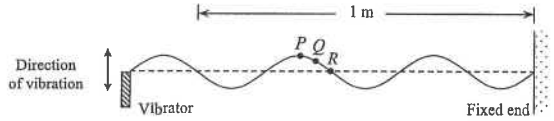
A. The distance between *X* and *Y* is equal to half the wavelength of the stationary wave.
B. All particles between *X* and *Y* on the string vibrate in the same direction.
C. All particles between *X* and *Y* on the string vibrate with the same frequency.
D. All particles between *X* and *Y* on the string vibrate with the same amplitude.

23. < HKCE 1997 Paper II - 24 >

The vibrating string also sets the neighbouring air into vibration. Which of the following statements about the waves on the string and those in air must be correct ?

A. They are both stationary.
B. They have the same speed.
C. They have the same wavelength.
D. They have the same frequency.

24. < HKCE 1998 Paper II - 27 >



A vibrator generates a stationary wave on a string. The above diagram shows the string at the instant of maximum displacement. Which of the following statements is **incorrect** ?

A. Particles *P* and *Q* move with the same amplitude.
B. The motions of particles *P* and *Q* are in phase.
C. Particle *Q* is momentarily at rest at this instant.
D. The wavelength of the stationary wave is 0.4 m.

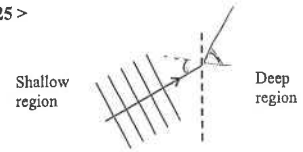
25. < HKCE 1998 Paper II - 26 >

A series of plane water waves travel towards an obstacle in a ripple tank. When the waves pass the obstacle, they bend around the corners of the obstacle. Which of the following statements is/are correct ?

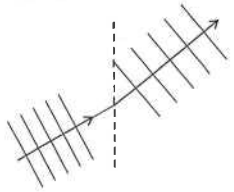
(1) The phenomenon is called diffraction.
(2) The speed of the waves remains unchanged as they bend round the corners.
(3) The degree of bending of the waves depends on the size of the obstacle relative to the wavelength of the waves.

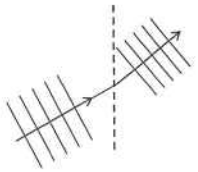
A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

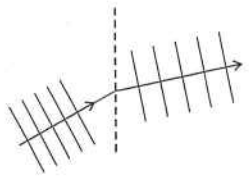
26. < HKCE 1998 Paper II - 25 >

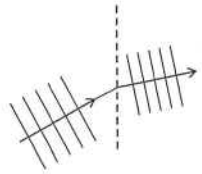


The diagram above shows a series of plane water waves travelling from a shallow region to a deep region of water. Which of the following diagrams best shows the wave pattern in the deep region ?

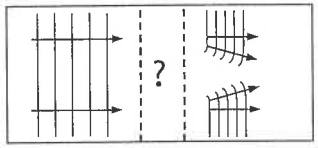
A.


B.


C.


D.


27. < HKCE 1999 Paper II - 22 >



A series of straight water waves travels towards the right in a ripple tank as shown above. In order to obtain the waves as shown in the right hand side, what kinds of phenomenon have the straight waves undergone ?

A. reflection only
B. refraction only
C. diffraction only
D. refraction and diffraction only

Provided by dse.life

28. **< HKCE 1999 Paper II - 23 >**

A plane water wave travels from a deep region to a shallow region of water. If the wavelength, frequency and speed of the wave in the deep region are λ_1, f_1 and v_1 respectively, while the corresponding values in the shallow region are λ_2, f_2 and v_2 respectively. Which of the following relations is/are correct ?

(1) $\lambda_1 > \lambda_2$
(2) $v_1 > v_2$
(3) $f_1 > f_2$

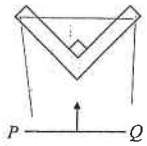
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

29. **< HKCE 2000 Paper II - 26 >**

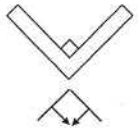
A water wave of frequency 30 Hz travels in a deep region of water. When the wave enters a shallow region, its wavelength is reduced to one-third of its original value. Find the frequency of the water wave in the shallow region.

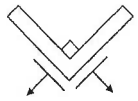
A. **30 Hz**
B. 60 Hz
C. 90 Hz
D. It cannot be determined since the speed of the water wave is not given.

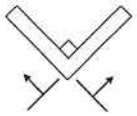
30. **< HKCE 2000 Paper II - 27 >**

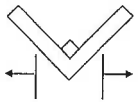


A straight pulse PQ travels towards a V-shaped barrier in a ripple tank as shown above. Which of the following diagrams best shows the reflected pulse(s) ?

A.


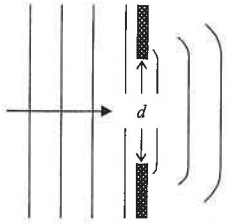
B.


C.


D.


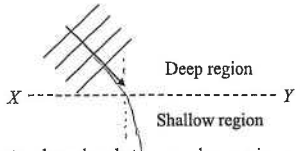
31. **< HKCE 2001 Paper II - 26 >**

Water waves of wavelength λ are diffracted as they pass through a gap of width d as shown in the figure above. Which of the following changes would produce the most significant diffraction effect ?

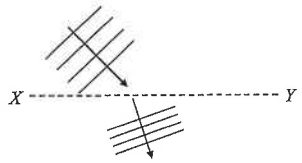


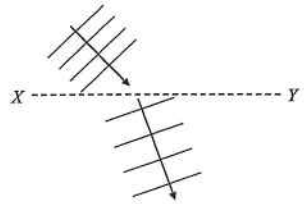
	λ	d
A.	remains unchanged	halved
B.	remains unchanged	doubled
C.	halved	halved
D.	halved	doubled

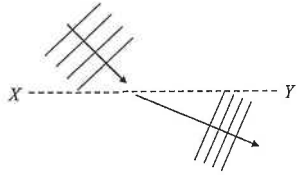
32. **< HKCE 2001 Paper II - 25 >**

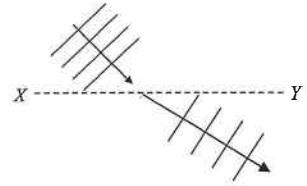


In the above diagram, XY represents a boundary between a deep region and a shallow region of water in a ripple tank. A series of straight water waves in the deep region travels towards XY. Which of the following diagrams best shows the wave pattern in the shallow region ?

A.


B.


C.


D.


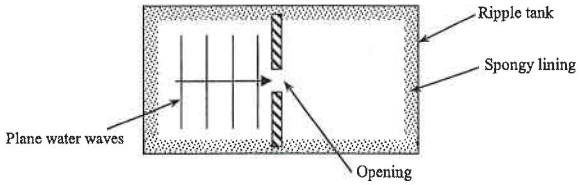
33. **< HKCE 2002 Paper II - 24 >**

In a ripple tank experiment, a series of water waver travels towards a barrier. Which of the following quantities would remain unchanged after the waves are reflected by the barrier ?

(1) **wavelength**
(2) **frequency**
(3) **speed**

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

34. **< HKCE 2002 Paper II - 26 >**

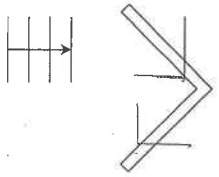


Which of the following phenomena would be observed when the water waves pass through the opening in the above set-up ?

A. reflection
B. refraction
C. diffraction
D. interference

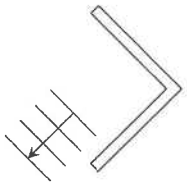
Provided by dse.life

35. < HKCE 2003 Paper II - 27 >

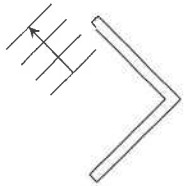


Plane water waves travels towards an L-shaped barrier in a ripple tank as shown above. Which of the following diagrams best shows the reflected wave pattern ?

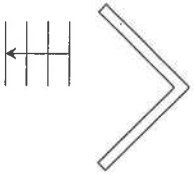
A.



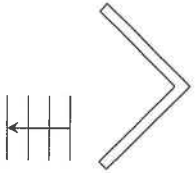
B.



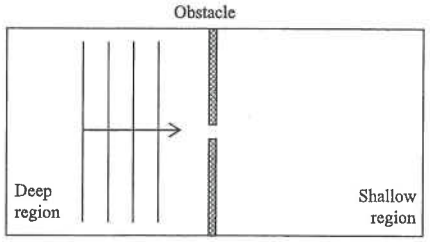
C.



D.



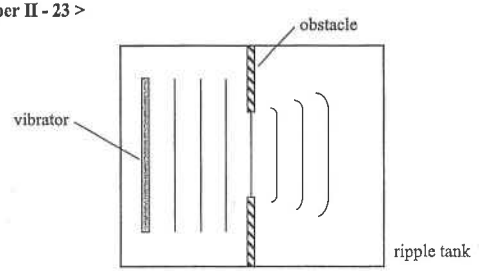
36. < HKCE 2003 Paper II - 28 >



Plane water waves travel from a deep region to a shallow region of water through a narrow gap as shown above. Which of the following properties of the waves remains unchanged ?

A. direction of travel
B. speed
C. wavelength
D. frequency

37. < HKCE 2004 Paper II - 23 >

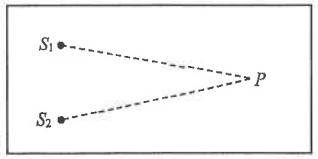


A student uses the above set-up to study the diffraction of water waves. Which of the following changes can make the diffraction effect more significant ?

(1) reducing the width of the gap between the obstacles
(2) increasing the frequency of the vibrator
(3) adding more water to the ripple tank

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

38. < HKCE 2004 Paper II - 25 >

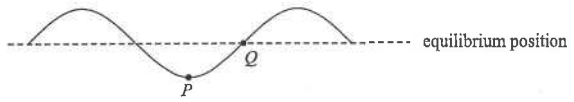


Two dippers S_1 and S_2 are connected to the same vibrator and produce identical waves in a ripple tank. P is a point such that $S_1P - S_2P = \lambda$, where λ is the wavelength of the water waves generated. Which of the following statements is/are correct ?

(1) Constructive interference occurs at P.
(2) A crest is always formed at P.
(3) If the wavelength of the waves generated by the dippers is doubled, destructive interference will occur at P.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

39. < HKCE 2004 Paper II - 21 >



The figure shows the waveform of a transverse stationary wave at a certain instant. If particle P is at its lowest position at this instant, what will be the instantaneous motion of particles P and Q after a quarter of a period ?

	P	Q
A.	moving upwards	at rest
B.	moving upwards	moving upwards
C.	at rest	at rest
D.	at rest	moving upwards

Provided by dse.life

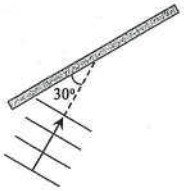
40. **< HKCE 2005 Paper II - 36 >**

An interference pattern is formed by two coherent point sources of water waves. Which of the following variations can change the positions of constructive interference ?

(1) changing the amplitude of the waves
(2) changing the wavelength of the waves
(3) changing the separation between the point sources

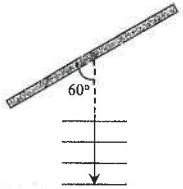
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

41. **< HKCE 2005 Paper II - 14 >**

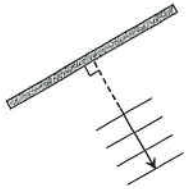


Straight water waves travel towards a barrier as shown above. Which of the following diagrams best shows the reflected wave pattern ?

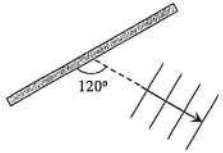
A.



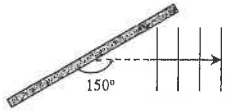
B.



C.



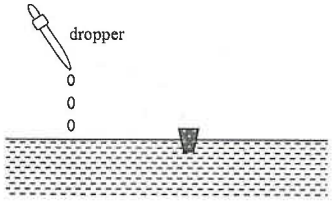
D.



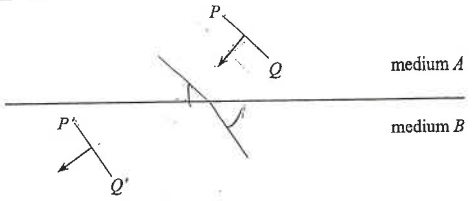
42. **< HKCE 2005 Paper II - 15 >**

A cork floats in water and a dropper is used to produce circular waves as shown in the diagram. Which of the following describes the motion of the cork when the waves pass through it ?

A. moves towards the dropper
B. moves away from the dropper
C. vibrates vertically about its original position
D. moves away from the dropper and vibrates vertically at the same time



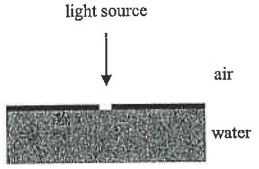
43. **< HKCE 2006 Paper II - 15 >**



A series of plane waves travel from medium *A* into medium *B*. The figure above shows the positions, *PQ* and *P'Q'*, of a wavefront before and after entering the medium *B*. What would happen to the speed and the wavelength of the wave when it travels from medium *A* to medium *B* ?

	Speed	Wavelength
A.	increases	increases
B.	increases	remains unchanged
C.	decreases	decreases
D.	decreases	remains unchanged

44. **< HKCE 2007 Paper II - 16 >**

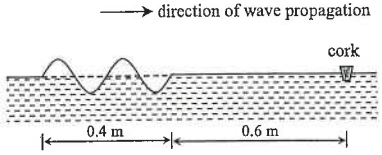


Light travels from air to water through a slit as shown above. Which of the properties of the light in water remain(s) unchanged ?

(1) direction of travel
(2) speed
(3) frequency

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

45. **< HKCE 2009 Paper II - 14 >**

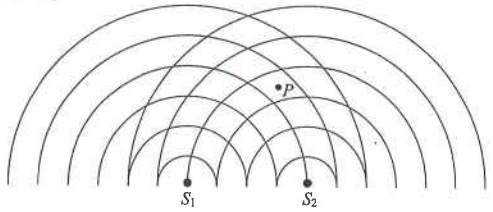


A cork is floating on a calm water surface as shown in the above figure. At time $t = 0$, a water wave is travelling towards the cork with a speed of 0.2 m s^{-1}. When will the cork rise to its highest position for the first time ?

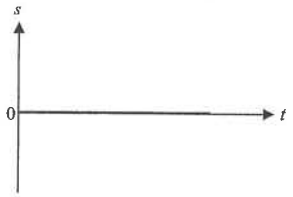
A. 3.00 s
B. 3.50 s
C. 3.75 s
D. 4.00 s

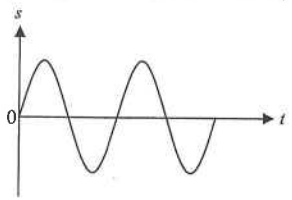
Provided by dse.life

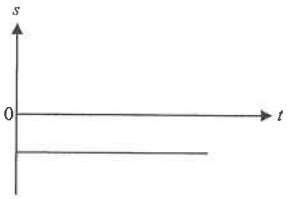
46. **< HKCE 2009 Paper II - 38 >**

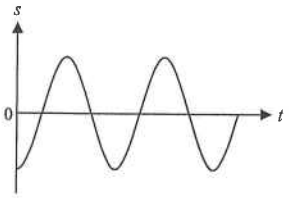


The figure above shows the circular wavefronts produced by two identical dot vibrators, S_1 and S_2, in a ripple tank at time $t = 0$. Solid lines represent crests. A cork is placed at point P on the water surface. Which of the following graphs best represents the variation of the displacement s of the cork with time t ? (Take upward as the positive direction.)

A.


B.


C.


D.


47. **< HKCE 2009 Paper II - 37 >**

A musical note is produced by a guitar string. Which of the following properties about the sound wave produced and the wave in the string is/are the same ?

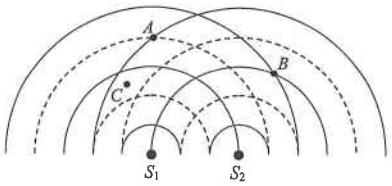
(1) wavelength
(2) frequency
(3) wave speed

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

48. **< HKCE 2010 Paper II - 36 >**

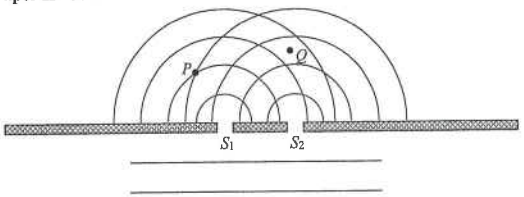
Two point sources S_1 and S_2 are producing circular water waves in a ripple tank. The figure shows the wave pattern at a certain instant. Solid lines represent crests and dotted lines represent troughs. Which of the following statements is/are correct ?

(1) The water particle at A is always at rest.
(2) The water particle at B is always at a crest.
(3) The interference at C is neither constructive nor destructive.



A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

49. **< HKCE 2011 Paper II - 37 >**

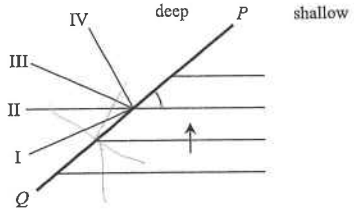


The figure above shows the wavefronts formed in a ripple tank. Solid lines represent crests. S_1 and S_2 are two narrow gaps allowing water waves to pass through and interfere. Which of the following statements is correct ?

A. Refraction occurs when water waves pass through S_1 and S_2.
B. The displacement of the water particles at P and Q are the same at the moment shown above.
C. Constructive interference occurs at Q.
D. The water particle at P is always at a crest.

Part B : HKAL examination questions

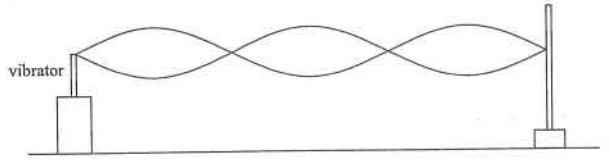
50. **< HKAL 1990 Paper I - 16 >**



The figure shows wave crests moving in the direction of the arrow towards the interface PQ between a shallow region and a deep region as shown in the figure. Which of the lines shown may represent one of the wave crests in the deep region ?

A. I
B. II
C. III
D. IV

51. **< HKAL 1994 Paper IIA - 20 >**



In the above figure, a stationary wave is set up on an elastic string by adjusting the frequency f of the vibrator. Which of the following statements is/are correct ?

(1) If f increases so that another stationary wave is set up, the number of antinodes in the wave pattern increases.
(2) If f increases, the speed of the waves on the string increases.
(3) The waves produced in air by the string have the same speed as the waves on the string.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

52. **< HKAL 1996 Paper IIA - 12 >**

The waves from two coherent sources must have
(1) the same amplitude
(2) the same wavelength
(3) a constant phase relationship

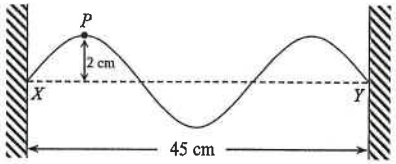
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

53. **< HKAL 2001 Paper IIA - 12 >**

In which of the following cases can the principle of superposition be applied to two overlapping waves of the same nature ?
(1) Two waves that have the same amplitude.
(2) Two waves that travel in opposite directions.
(3) Two waves that are coherent.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

54. **< HKAL 2005 Paper IIA - 29 >**

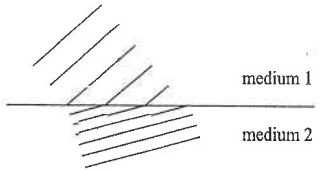


Two identical transverse waves, travelling in opposite directions along string XY fixed at both ends, form a stationary wave. The separations between X and Y is 45 cm. Particle P is an antinode with an amplitude of 2 cm. The above figure shows the shape of the string at an instant when P is at its maximum displacement from the equilibrium position. What is the amplitude and the wavelength of each of the **travelling waves** on the string ?

	Amplitude	Wavelength
A.	1 cm	30 cm
B.	1 cm	15 cm
C.	2 cm	30 cm
D.	2 cm	15 cm

55. **< HKAL 2009 Paper IIA - 15 >**

The diagram shows the wavefronts of a wave passing the boundary of two different media. Which of the following combinations about the type of wave and the two media is/are possible ?



	type of wave	medium 1	medium 2
(1)	light waves	air	water
(2)	sound waves	water	air
(3)	water waves	shallow water	deep water

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

56. **< HKAL 2010 Paper IIA - 14 >**

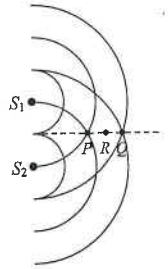


Figure (a)

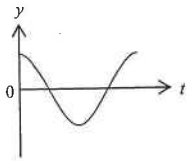
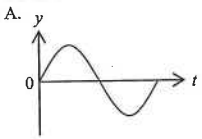
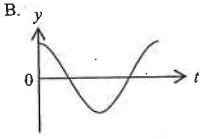
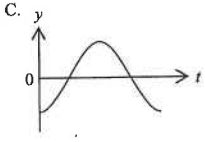


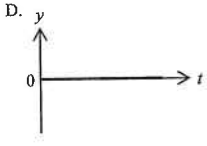
Figure (b)

In a ripple tank, S_1 and S_2 are two coherent sources vibrating with the same frequency. Figure (a) shows the pattern of water waves at time $t = 0$. The solid lines represent the crests of the water waves. Figure (b) shows the displacement-time graph of the particle P. Which of the following displacement-time graphs is correct for the particle R at mid-way between PQ as shown ?

A. 

B. 

C. 

D. 

57. **< HKAL 2012 Paper IIA - 15 >**

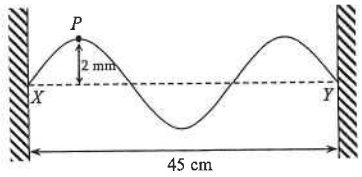
The principle of superposition can be applied to two overlapping waves of the same nature :
(1) only if they have the same frequency.
(2) only if they have the same amplitude.
(3) only if they travel in the same direction.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. None of the above conditions is necessary.

Part C : HKDSE examination questions

58. **< HKDSE Sample Paper IA - 19 >**

String XY is fixed at both ends. The distance between X and Y is 45 cm. Two identical sinusoidal waves travel along XY in opposite directions and form a stationary wave with an antinode at point P. The figure shows the string when P is 2 mm, its maximum displacement, from the equilibrium position. What is the amplitude and wavelength of each of the **travelling waves** on the string ?

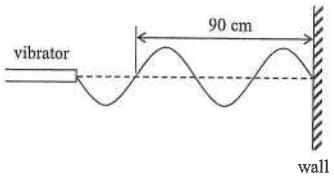


	Amplitude	Wavelength
A.	1 mm	30 cm
B.	1 mm	15 cm
C.	2 mm	30 cm
D.	2 mm	15 cm

Provided by dse.life

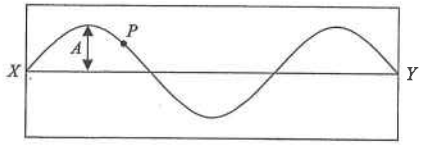
59. **< HKDSE Practice Paper IA - 19 >**

A stationary wave is set up along a string by a vibrator. The waveform at a certain instant is shown. If the frequency of the vibrator is 50 Hz, what is the wave speed along the string ?

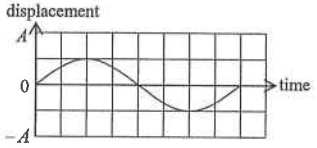


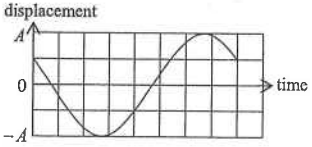
A. 15 m s^{-1}
B. 30 m s^{-1}
C. 45 m s^{-1}
D. 55 m s^{-1}

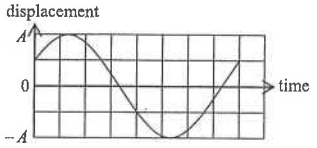
60. **< HKDSE 2012 Paper IA - 18 >**

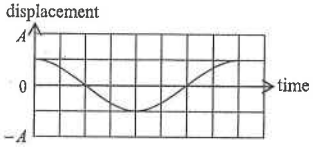


A stationary wave is formed on string fixed at both ends X and Y. The above figure is a snapshot of the string at time $t = 0$. The amplitude of vibration at an antinode is A. If upward displacement is taken as positive, which of the following shows the displacement-time graph of point P on the string for one period ?

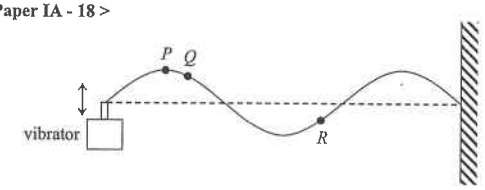
A.


B.


C.


D.


61. **< HKDSE 2013 Paper IA - 18 >**



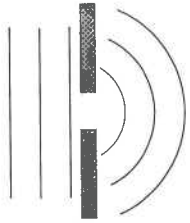
A vibrator generates a stationary wave on a string which is fixed at one end. The figure shows the appearance of the string at a certain instant. Which of the following descriptions about the motion of particles P, Q and R must be correct ?

(1) P and Q are momentarily at rest at this instant.
(2) Q and R take the same time to reach their respective equilibrium positions.
(3) P and R are always in antiphase.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

62. **< HKDSE 2014 Paper IA - 16 >**

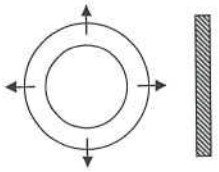
The photograph shows a series of plane sea waves travelling through a gap in a sea wall which exhibits diffraction. Assuming that the frequency of the waves remains unchanged, which of the following will increase the degree of diffraction ?



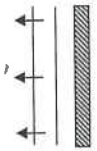
(1) The gap in the sea wall becomes narrower.
(2) The wavelength of the waves increases.
(3) The amplitude of the waves becomes larger.

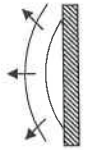
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

63. **< HKDSE 2014 Paper IA - 13 >**

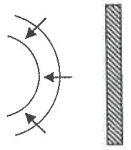


The above figure shows two circular pulses produced by drops of water falling in a ripple tank. The pulses are then reflected by a straight barrier. Which diagram best shows the reflected pulses ?

A.


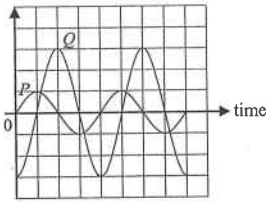
B.


C.


D.


64. **< HKDSE 2015 Paper IA - 13 >**

Two waves P and Q travel in the same direction and meet at a point. The graph shows the variation of the displacement of each wave with time at that point. Which of the following statements is/are correct ?

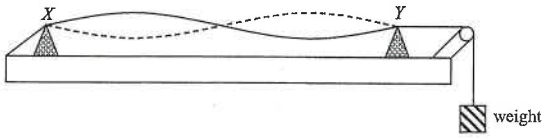
displacement


(1) P and Q have the same frequency.
(2) The oscillation due to P is in anti-phase with that due to Q.
(3) The amplitude of the resultant wave at that point is four times the amplitude of P.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

65. < HKDSE 2015 Paper IA - 18 >



A string is set to vibrate at frequency f such that a standing wave is formed between two fixed supports X and Y as shown in the above figure.

If the tension in the string is increased by adding weight gradually while the frequency is kept at f, which of the following is a possible mode of vibration at a steady state ?

A.


B.

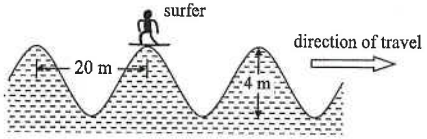

C.


D.


66. < HKDSE 2016 Paper IA - 16 >

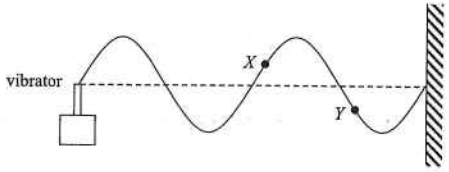
The surfer in the figure reaches a crest at the moment shown. The crests of the water wave are 20 m apart and the surfer descends a vertical distance of 4 m from a crest to a trough in a time interval of 2 s. What is the speed of the wave ?

A. 1 m s^{-1}
B. 2 m s^{-1}
C. 5 m s^{-1}
D. 10 m s^{-1}



67. < HKDSE 2016 Paper IA - 18 >

A string is tied to a vibrator while the other end is fixed to a wall. A stationary wave is formed as shown.

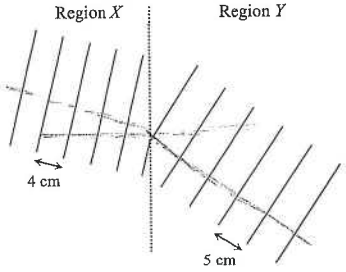


Which statement is correct when the frequency of the vibrator doubles ?

A. The wavelength will double.
B. The wave speed will double.
C. The amplitude will be halved.
D. Particles X and Y will become vibrating in phase.

68. < HKDSE 2017 Paper IA - 16 >

The figure shows plane water waves travelling from region X to region Y. The wavelengths of the water waves in regions X and Y are 4 cm and 5 cm respectively.



Which of the following statements is correct ?

A. The speed of the water waves in region X is higher than that in region Y.
B. The direction of travel of the water waves bends towards the normal as they enter region Y.
C. The frequency of the water waves is the same in both regions.
D. If plane water waves of wavelength 5 cm travel from region Y to region X, the wavelength becomes 6 cm after the waves enter region X.

69. < HKDSE 2017 Paper IA - 17 >

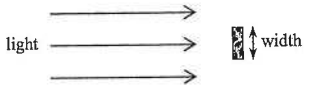
In which of the following situations **MUST** the direction of travel of a wave change ?

(1) when a wave is reflected by a barrier
(2) when a wave enters from one medium to another medium
(3) when a wave travels through a gap smaller than its wavelength

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

70. < HKDSE 2018 Paper IA - 16 >

Light undergoes diffraction round an obstacle.



The angle of diffraction would increase when

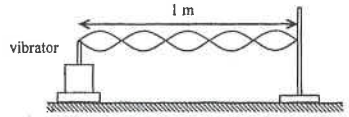
(1) the amplitude of the incident light is increased.
(2) the width of the obstacle is increased.
(3) the wavelength of the incident light is increased.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

Provided by dse.life

71. **< HKDSE 2018 Paper IA - 18 >**

The figure shows a string with one end fixed and the other end tied to a vibrator. A stationary wave is formed as shown at a certain frequency.

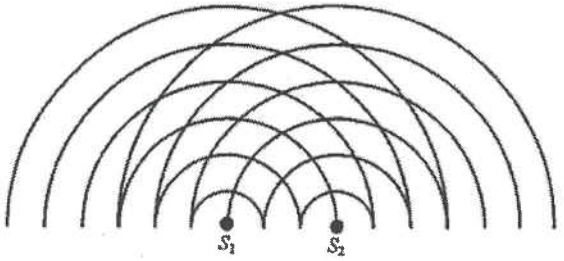


If the speed of the wave along the string is 7 m s^{-1}, what is the frequency of the wave ?

A. 2.8 Hz
B. 7 Hz
C. 17.5 Hz
D. 35 Hz

72. <HKDSE 2019 Paper IA-15>

7 . <HKDSE 2019 Paper IA-16>



The figure shows the circular water waves generated by two dippers S_1 and S_2 vibrating in phase. The lines represent wave crests. What is the number of nodal lines (i.e. minimum amplitude) formed ?

A. 3
B. 4
C. 6
D. 7

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. C	11. C	21. B	31. A	41. D
2. D	12. D	22. D	32. A	42. C
3. B	13. B	23. D	33. D	43. A
4. B	14. C	24. A	34. C	44. B
5. D	15. A	25. D	35. D	45. C
6. D	16. A	26. A	36. D	46. D
7. D	17. A	27. D	37. C	47. B
8. D	18. B	28. C	38. C	48. A
9. B	19. C	29. A	39. A	49. C
10. B	20. B	30. D	40. C	50. C

51. A	61. D	71. C
52. D	62. A	**72. A**
53. D	63. B	**7 .**
54. A	64. A	**7 . A**
55. C	65. D	
56. C	66. C	
57. D	67. D	
58. A	68. C	
59. B	69. B	
60. D	70. B	

M.C. Solution

1. C

✓ (1) From deep to shallow water region, the wavelength would decrease.

× (2) The frequency would remain unchanged during refraction.

✓ (3) The velocity would decrease when water wave travels from deep to shallow water region.

2. D

$\lambda = 0.1 \times 2 = 0.2$ m

$v = f\lambda = (50)(0.2) = 10$ m s^{-1}

Provided by dse.life

3. B

Distance between 2 adjacent nodes is equal to half of a wavelength.

$\therefore (4) \times \frac{\lambda}{2} = (20) \qquad \therefore \lambda = 10 \text{ cm}$

$\therefore v = f\lambda = (5)(10) = 50 \text{ cm s}^{-1}$

4. B

× (1) Same medium gives the same speed.

✓ (2) When the wave passes through narrow slit, diffraction occurs, giving a change in wave pattern.

× (3) Frequency is unchanged during diffraction.

5. D

P is at the crest, thus P is momentarily at rest.

For a stationary wave, all particles within the same loop are in phase, thus A is also momentarily at rest.

6. D

Distance between the 11 crests $= 10\lambda$

$\therefore \lambda = \frac{0.2}{10} \text{m}$

$v = f\lambda = (2) \times \left(\frac{0.2}{10}\right) = \frac{0.4}{10} \text{ m s}^{-1}$

7. D

As the stationary wave is at its maximum vibration,

each particle is at their extreme positions with maximum displacement, thus each particle is momentarily at rest.

8. D

Frequency : no change in source $\Rightarrow$ no change in frequency

Wavelength : no change in medium $\Rightarrow$ no change in speed $\Rightarrow$ no change in wavelength

9. B

X : $\Delta = 1\frac{3}{4}\lambda - 1\lambda = \frac{3}{4}\lambda$ $\therefore$ No interference

Y : $\Delta = 1\frac{1}{2}\lambda - 1\frac{1}{2}\lambda = 0\lambda$ $\therefore$ Constructive interference

Z : $\Delta = 2\lambda - 1\lambda = 1\lambda$ $\therefore$ Constructive interference

10. B

For stationary wave, after $\frac{1}{4}$ period, the particles at antinodes will be at the equilibrium positions.

Therefore, the waveform will become a horizontal line.

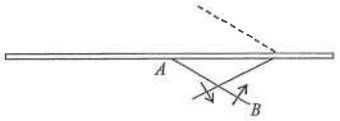
11. C

✓ (1) For the same medium, the same speed is unchanged.

× (2) Diffraction occurs when the wave passes through the slit and spreads out to give a change of direction.

✓ (3) Frequency is unchanged during diffraction.

12. D



Draw the dotted line that the incident pulse appears to be.

Then reflect the dotted line to give the reflected pulse. The reflected pulse should be at the right side of the barrier.

13. B

All the figures in A, B, C give proper diffraction pattern.

However, since it is uniform depth, there is no change in speed, thus no change in wavelength

$\therefore$ B is correct since the wavelength remains the same.

14. C

Wavelength : $\lambda = \frac{20}{4} = 5 \text{ cm}$

Speed : $v = f\lambda = (50)(0.05) = 2.5 \text{ m s}^{-1}$

15. A

$\Delta = 53 - 50 = 3 \text{ cm}$

For constructive interference to occur, $\Delta = n\lambda$ where $n = 0, 1, 2, \ldots$.

A. If $\lambda = 1$ cm, then $\Delta = 3 \text{ cm} = 3\lambda$, thus constructive interference occurs.

B. If $\lambda = 2$ cm, then $\Delta = 3 \text{ cm} = 1.5\lambda$, thus destructive interference should occur.

C. If $\lambda = 4$ cm, then $\Delta = 3 \text{ cm} = 0.75\lambda$, thus neither constructive nor destructive interference occurs.

D. If $\lambda = 6$ cm, then $\Delta = 3 \text{ cm} = 0.5\lambda$, thus destructive interference should occur.

16. A

A, B, C give proper diffraction pattern.

After the wave passes through the slit, it is a deep region, thus the wave speed increases, and the wavelength increases.

17. A

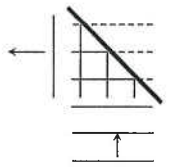
✓ (1) Path difference at any point on $MN = 0$, thus constructive interference occurs along MN.

× (2) Alternate constructive and destructive interference occurs along PQ .

× (3) Crest and trough can both be formed at points of constructive interference.

Provided by dse.life

18. B



No change in medium, thus no change in speed and no change in wavelength.

19. C

× A. Particle P vibrates vertically about its equilibrium position only; at this instant, P is momentarily at rest
× B. Q is a node, thus it is always at rest
✓ C. R is a node, thus it is always at rest
× D. P has the maximum amplitude while Q has zero amplitude.

20. B

Tilting ⇒ at middle is the same depth but increasing depth to the right and decreasing depth to the left
⇒ increasing wave speed to the right and decreasing wave speed to the left
⇒ increasing wavelength to the right and decreasing wavelength to the left

21. B

× (1) Increase of width gives smaller degree of diffraction.
× (2) Degree of diffraction is independent of the position of the source.
✓ (3) Increase of the wavelength gives greater degree of diffraction

22. D

✓ A. The distance between X and Y, i.e. distance between 2 nodes, is half of the wavelength.
✓ B. All the particles within the same loop vibrate in phase, thus vibrate in the same direction.
✓ C. All particles in the same wave vibrate with the same frequency.
× D. Different particles have different amplitudes in a stationary wave.

23. D

The wave on the string and the wave in air have the same frequency as they come from the same source.

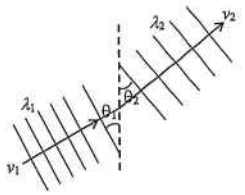
24. A

× A. At this instant, P is the antinode which has the maximum amplitude. Q has smaller amplitude.
✓ B. Particles in the same loop must move in the same phase
✓ C. Q is at maximum displacement and must be momentarily at rest
✓ D. Since distance between 2 nodes is half of the wavelength which is 0.2 m $\therefore \lambda = 0.4$ m

25. D

✓ (1) Bending around the corners is diffraction
✓ (2) No change in depth of water, thus no change in medium, giving no change in speed
✓ (3) The increase of wavelength gives greater degree of diffraction

26. A



Shallow → deep ⇒ speed increases
⇒ wavelength increases
⇒ angle made with the boundary increases

27. D

Wavelength decreases ⇒ speed decreases ⇒ refraction occurs
The wave bends round corner ⇒ diffraction occurs

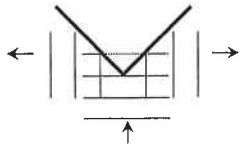
28. C

Water wave travels faster in deep region ⇒ $v_1 > v_2$ ∴ (2) is correct
No change in source ⇒ $f_1 = f_2$ ∴ (3) is not correct
By $v = f\lambda$ ⇒ $\lambda_1 > \lambda_2$ ∴ (1) is correct

29. A

The change of medium results in refraction, but in refraction, there is no change in frequency
Frequency remains the same of 30 Hz

30. D



31. A

The most significant diffraction effect occurs when
① wavelength is greater
② slit size is smaller
∴ A is the best choice.

Provided by dse.life

32. A

Water wave in shallow region travels with a smaller speed, thus the wavelength is decreased.

When entering the shallow region, it moves a shorter distance, thus bending occurs.

33. D

✓ (1) By $v = f\lambda$ as v and f remain unchanged, λ is unchanged.

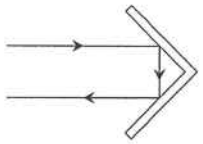
✓ (2) Frequency depends on source only, so it is unchanged.

✓ (3) Speed depends on medium only, so it is unchanged.

34. C

Diffraction occurs when water waves passes through a small opening.

35. D



Consider the direction of travel of the wave, the wave reflects two times and travels backwards.

36. D

× A. During diffraction through the narrow slit, the direction of travel changes from one direction to many direction by spreading out from the slit.

× B. The speed decreases when the water waves travel from deep region to shallow region.

× C. The wavelength decreases when the water waves travel from deep region to shallow region.

✓ D. The frequency remains unchanged during diffraction and refraction.

37. C

✓ (1) A smaller gap can give greater degree of diffraction.

× (2) By increasing the frequency, the wavelength is decreased. Thus, the degree of diffraction is decreased.

✓ (3) By adding more water, depth is increased, thus speed is increased, wavelength is then increased. Therefore, the degree of diffraction is increased.

38. C

✓ (1) Since the path difference at P is equal to 1 λ, constructive interference occurs at P.

× (2) At points of constructive interference, crest or trough may form.

✓ (3) If the wavelength is doubled, path difference : $\Delta = \frac{1}{2}(2\lambda)$, thus destructive interference occurs.

39. A

P is an antinode. After a quarter of a period, it is at the equilibrium position. At that instant, it should move upwards.

Q is a node. It is always at rest.

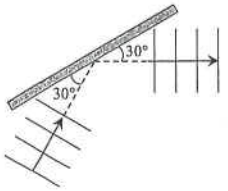
40. C

× (1) Changing the amplitude of the waves would not affect the positions of constructive interference

✓ (2) $\lambda \uparrow \Rightarrow$ separation between two lines of constructive interference $\uparrow$

✓ (3) Separation between the point sources $\downarrow \Rightarrow$ separation between two lines of constructive interference $\uparrow$

41. D



During reflection, incident angle = reflected angle

Note that both the incident angle and the reflected angle equal 60°.

42. C

Since water wave is a transverse wave,

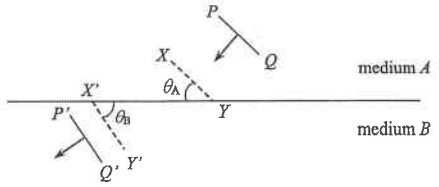
the cork would oscillate vertically up and down about its original position.

43. A

As shown in the above diagram, $\theta_B > \theta_A$

During refraction : $\sin\theta \propto v \propto \lambda$.

$\therefore v_B > v_A$ and $\lambda_B > \lambda_A$



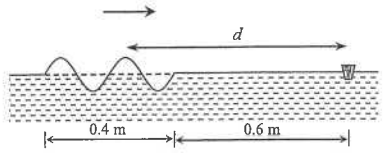
44. B

× (1) Direction of travel would change after diffraction from the slit.

× (2) Speed would change after refraction as the light travels from air to water.

✓ (3) Frequency depends on the source only, it remains unchanged during refraction and diffraction.

45. C



Distance d between the nearest crest and the cork = 0.15 + 0.6 = 0.75 m

By $d = vt$ $\therefore$ $(0.75) = (0.2)\,t$ $\therefore$ $t = 3.75$ s

Provided by dse.life

46. D

At the time instant shown, point P is at the trough position of wave 1 and also trough position of wave 2.

Thus it is at the lowest position.

Moreover, trough and trough gives constructive interference, thus P is at constructive interference.

47. B

As the wave speed depends on the medium, sound wave in air and the wave in the string should have different speeds.

As the two waves come from the same source, they must have the same frequency.

By $v = f\lambda$, they must have different wavelength.

48. A

✓ (1) At A, crest meets trough to give destructive interference, thus the particle there is always at rest.

× (2) At B, crest meets crest to give constructive interference, B then vibrates with the greatest amplitude. However, B would be sometimes at the crest and sometimes at the trough as it vibrates up and down.

× (3) From the graph, $S_1 C = 1.25\,\lambda$ and $S_2 C = 2.25\,\lambda$.
Path difference at $C = 2.25\,\lambda - 1.25\,\lambda = 1\,\lambda$. Thus C is at constructive interference.

49. C

× A. When water waves pass through S_1 and S_2, diffraction occurs.

× B. P is at the crest, with positive displacement; Q is at the trough, with negative displacement.

✓ C. Q is at the position of trough on trough, thus give greater trough to have constructive interference.
The path difference at $Q = 3.5\,\lambda - 2.5\,\lambda = 1\,\lambda$ ∴ constructive interference occurs at Q

× D. At this instant, P is at the crest, but later the displacement of P would vary, it may be at the trough later.

50. C

Water wave in deeper region moves with a greater speed.

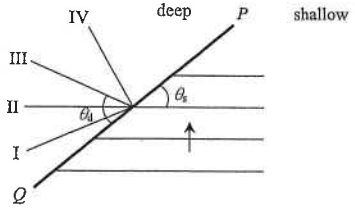
∴ $v_d > v_s \Rightarrow \theta_d > \theta_s$

∴ III is the possible wavefront

IV is not correct

since the wavefront makes a refracted angle greater than 90°

with the boundary, which is impossible.



51. A

✓ (1) $f\uparrow \Rightarrow \lambda\downarrow \Rightarrow$ number of loops increases $\Rightarrow$ number of antinodes on the string ↑

× (2) Speed on the same medium is constant, not affected by the change of frequency.

× (3) The two waves are in different medium, they have different speed.

52. D

× (1) Waves from two coherent sources may have similar amplitude, due to different path lengths.

✓ (2) Two coherent sources must have same frequency, thus same wavelength.

✓ (3) Two coherent sources must have constant phase relationship.

53. D

Principle of Superposition can be applied to :

all types of waves with different frequency, amplitude, directions and phase.

54. A

① Amplitude of each travelling wave $= \frac{1}{2}A = 1$ cm

② Wavelength of each travelling wave $= 45 \times \frac{2}{3} = 30$ cm

55. C

As the wavelength in medium 1 is longer, the wave in medium 1 has greater speed.

✓ (1) light waves travel with greater speed in air than in water

✓ (2) sound waves travel with greater speed in water than in air

× (3) water waves travel with smaller speed in shallow water than in deep water

56. C

P has crest on crest and R has trough on trough, both of them have constructive interference.

At $t = 0$, displacement of R is negative since it is at the trough position.

57. D

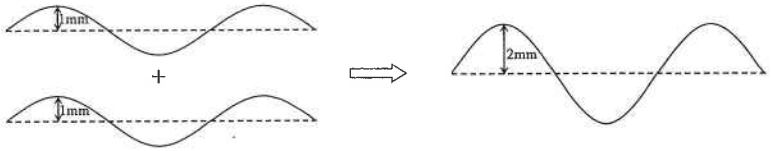
× (1) Two waves with different frequency can be superposed.

× (2) Two waves with different amplitude can be superposed.

× (3) Two waves in opposite directions can be superposed.

The principle of superposition can be applied to any two waves of the same nature.

58. A



① Amplitude

The stationary wave is formed by two travelling waves in opposite direction superpose together.

The amplitude of each travelling wave should be 1 mm so that they add together to give the antinode of 2 mm.

② Wavelength $= 45 \times \frac{2}{3} = 30$ cm

59. B

Wavelength : $\lambda = 90 \times \frac{2}{3} = 60$ cm $= 0.6$ m

Speed : $v = f\lambda = (50)(0.6) = 30$ m s^{-1}

Provided by dse.life

60. D

P is at the extreme point, that is, the crest of its oscillation at $t = 0$.

61. D

× (1) P and Q may not reach the extreme positions, thus they may not be momentarily at rest.

✓ (2) Q and R are in antiphase (opposite phase), they reach their own equilibrium positions at the same time.

✓ (3) P and R are at adjacent loop, they must always be in antiphase.

62. A

✓ (1) If the gap is narrower, the degree of diffraction will increase.

✓ (2) As the wavelength of the waves increases, the degree of diffraction will increase.

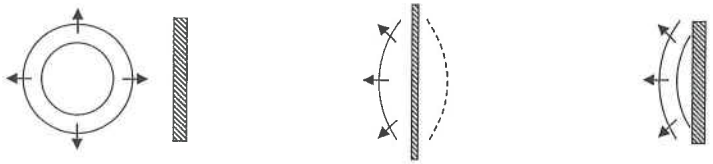
× (3) The degree of diffraction is not affected by the amplitude of the waves.

63. B

The wave grows until it is reflected by the walls.

Use dotted line to show the incident pulse behind the walls.

The reflection of the dotted pulse gives the reflected pulse.



64. A

✓ (1) As shown in the figure, the period T of the two waves are both 4 divisions,
by $f = \frac{1}{T}$, they have the same frequency f.

× (2) When P is at the crest, Q is not at the trough, thus they are no in anti-phase.

× (3) The amplitude of P is 1 division and the amplitude of Q is 3 divisions.
Since the two waves are not in phase,
the amplitude of their resultant wave would not be the sum of their individual amplitudes,
thus the amplitude of their resultant wave would not be 4 divisions, that is, not 4 times of that of P.

65. D

As the tension in the string is increased, speed of the transverse wave along the string increases.

Since the frequency is unchanged,

by $v = f\lambda$, the wavelength increases.

The only option that shows an increase of wavelength of standing wave is D.

66. C

$\lambda = 20$ m

From crest to trough, it is $\frac{1}{2}$ cycle, thus it takes a time of $\frac{1}{2}$ period.

$\therefore \frac{1}{2}T = 2$ s $\quad \therefore T = 4$ s

Speed of the wave :

$$v = \frac{\lambda}{T} = \frac{20}{4} = 5 \text{ m s}^{-1}$$

OR

$$f = \frac{1}{T} = \frac{1}{4} = 0.25 \text{ Hz}$$

$$v = f\lambda = (0.25)(20) = 5 \text{ m s}^{-1}$$

67. D

× A. When the frequency doubles, the wavelength should become halved.

× B. The wave speed is not affected by the frequency, thus it should be unchanged.

× C. The amplitude is not affected by the frequency, thus it should be unchanged.

✓ D. When frequency doubles, the wavelength becomes halved.
The number of loops in the stationary wave changes from 4 loops to 8 loops.
Particle X is 5th loop and particle Y is in the 7th loop, counted from the vibrator.
Particles in these two loops are all vibrating in phase.

68. C

× A. During refraction, speed v is proportional to wavelength λ.
As the wavelength in X is smaller, the speed of water wave in X should be smaller than that in Y.

× B. As shown in the figure, the direction of travel in region Y should be bent away from the normal.

✓ C. The frequency of wave must remain unchanged during refraction.

× D. The ratio of wavelengths in the two regions should remain unchanged.
Thus, the ratio should be 4 : 5, but not 5 : 6.

69. B

✓ (1) When a wave is reflected, it direction must change.

× (2) When a wave enters from one medium to another medium, refraction occurs.
During refraction, the direction may not change if the angle of incidence is 0° along the normal.
Thus, the direction may not change during refraction.

✓ (3) When a wave travels through a gap, diffraction occurs.
The wave spreads out through the gap, thus the direction must change.

70. B

× (1) Degree of diffraction is not affected by the amplitude of the wave.

× (2) To increase the degree of diffraction, width of obstacle should be decreased.

✓ (3) Longer wavelength gives greater degree of diffraction.

Provided by dse.life

71. C

There are 5 loops in the stationary wave. The length of each loop is 0.5 λ.

$\therefore$ $5 \times 0.5\ \lambda = 1$

$\therefore$ $\lambda = 0.4$ m

By $v = f\lambda$

$\therefore$ $(7) = f\ (0.4)$

$\therefore$ $f = 17.5$ Hz

Part A : HKCE examination questions

1. **< HKCE 1979 Paper I - 6 >**

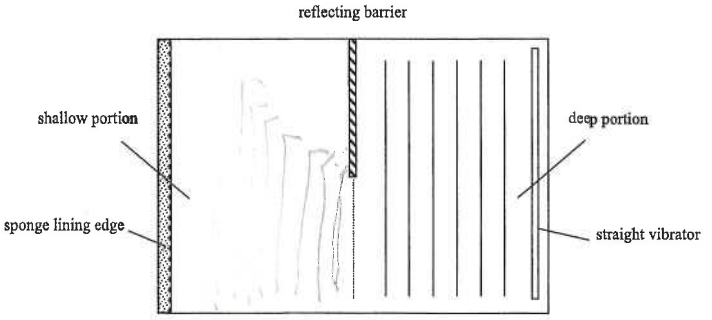
(a) What are the uses of the following parts of a ripple tank in wave experiments ?

(i) a dot vibrator, (1 mark)

(ii) the shallow portion of the tank, (1 mark)

(iii) the spongy lining around the edges of the tank. (1 mark)

(b) In a ripple tank experiment, waves are generated by a straight vibrator as shown below.



(i) In the above figure, sketch the wave pattern at the shallow portion of the tank. (3 marks)

(ii) What phenomena occur in the shallow portion of the tank ? (2 marks)

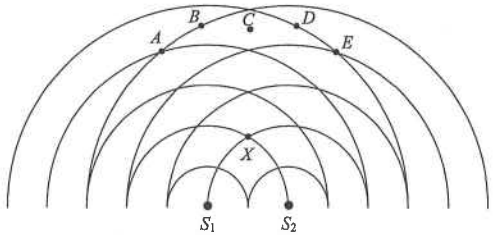
Provided by dse.life

2. **< HKCE 1984 Paper I - 5 >**

In a ripple tank experiment, a generator produces a train of straight waves travelling towards a barrier with two narrow slits. The distance between two successive wave crests is found to be 2 cm.

(a) The ripple tank is illuminated by a stroboscope lamp. The wave motion appears to be stationary when the frequency of the stroboscope lamp is 10 Hz. What is the speed of the train of waves ? (3 marks)

(b)



Two sources S_1 and S_2 vibrating in phase give out water waves. The above figure shows the pattern of water waves at a certain instant.

(i) Explain why the energy of the water waves is at a maximum at points A and E and is at a minimum at points B and D. (4 marks)

(ii) Since very little or no wave motion is seen at points B and D, a student concludes that energy disappears there. Explain briefly where the energy goes. (2 marks)

(iii) Sketch the water level along the line XC at the above instant. (2 marks)

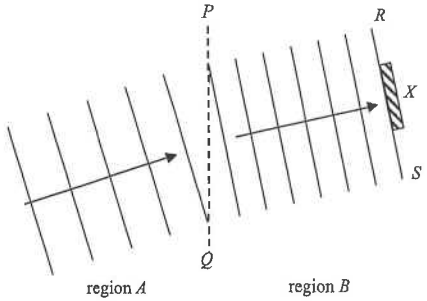
(iv) How would the separation between A and C change if

(1) the frequency of the generator increases, and

(2) the separation between the two sources increases ? (2 marks)

3. **< HKCE 1985 Paper I - 5 >**

In a ripple tank experiment, a train of water waves are produced by a straight vibrator of frequency 10 Hz. The train of waves goes from region A to another region B through a straight boundary PQ as shown in the figure below. The two regions are of different depths. The distance between two successive crests of the waves in region A is 0.03 m while that of the waves in the region B is 0.02 m.



(a) Describe briefly how to set up two regions of different depths in a ripple tank. (2 marks)

(b) Describe briefly how to measure the distance between the crests of two successive wavefronts. (4 marks)

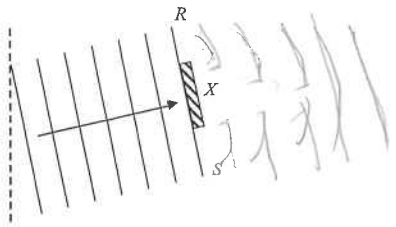
(c) Find the speeds of the trains of water waves in

(i) region A, and

(ii) region B. (4 marks)

(d) Which of the regions, A or B, is deeper ? (1 mark)

(e) If a barrier X is now placed in position RS as shown in the figure, which wave phenomenon would occur ? Sketch the wave pattern that you expect to observe. (2 marks)



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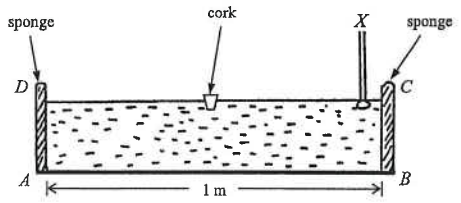
4. **< HKCE 1989 Paper I - 5 >**



A glass tank is filled with a liquid. A cork is placed at the mid-point of the tank as shown above. A vibrator X is moving up and down at the surface producing straight waves.

(a) Describe the motion of the cork. (1 mark)

(b) Suggest a simple method of measuring the wavelength of the wave using a stroboscope. (3 marks)

(c) It takes 2 s for the waves generated by X to reach the opposite end AD of the tank. During this time interval, the vibrator makes 5 'up' and 'down'. Find

(i) the frequency,

(ii) the wavelength, and

(iii) the speed of the wave. (6 marks)

(d) If another vibrator placed at the opposite end AD is also moving in exactly the same way as X, what will be the change in the amplitude of the movements of the cork ? Explain briefly. (3 marks)

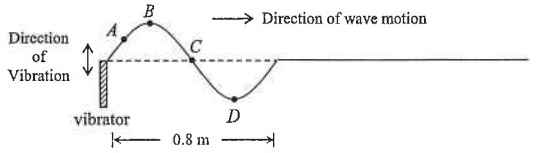
(e) If the tank is tilted so that A is higher than B and X is moving as before, sketch a diagram to show the wave form that would be observed when viewed from the side $ABCD$. (2 marks)

5. **< HKCE 1990 Paper I - 5 >**

A vertical vibrator generates waves on a string. It takes 0.25 s to produce a complete wave of wavelength 0.8 m on the string.

(a) Find the frequency and speed of the waves on the string. (3 marks)

(b) The figure below shows the shape of the string at the instant when the vibrator has made one complete vibration.



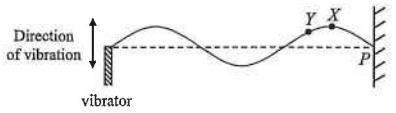
(i) At the instant shown, which of the particles A, B, C, D is/are

(1) moving downwards,

(2) at rest ? (2 marks)

(ii) Sketch the shape of the string after 0.125 s. In your figure show the positions of the particles A, B, C and D. (4 marks)

(c) A certain point P on the string is fixed to the wall so that a stationary wave is formed. The figure below shows the string at the instant of maximum displacement.



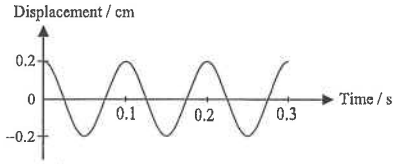
(i) Describe the motion of particles X and Y at this instant.

(ii) Sketch the shape of the string after one quarter on a cycle. (4 marks)

(d) The vibrating string in (c) also sets the neighbouring air vibrating. List two differences between the waves in air and those on the string. (2 marks)

Provided by dse.life

6. **< HKCE 1994 Paper I - 5 >**

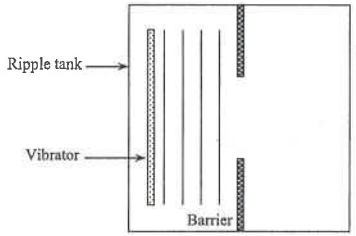


A train of straight waves is generated in a ripple tank. The figure above shows the displacement-time graph of a cork placed in the water. The waves take 0.5 s to travel a distance of 12 cm.

(a) Find the amplitude, frequency, speed and wavelength of the waves. (5 marks)

(b) Suggest one method to prevent water waves from bouncing back at the edges of the tank. (2 marks)

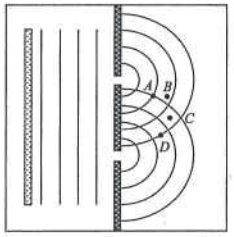
(c) A barrier with an opening is placed in the ripple tank and the waves travel towards it as shown in the figure below.



(i) On the above figure, sketch the wave pattern formed on the other side of the barrier. (2 marks)

(ii) Name this wave phenomenon. (1 mark)

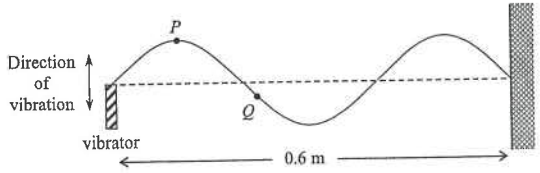
(d) The barrier in (c) is replaced by one with two smaller openings.



(i) The figure above shows the wave pattern at a certain instant. Among the 4 points A, B, C and D, state a point of constructive interference and a point of destructive interference. (2 marks)

(ii) A student says that at a point of constructive interference, a crest is always formed. Is the student correct ? Explain briefly. (3 marks)

7. **< HKCE 1996 Paper I - 4 >**

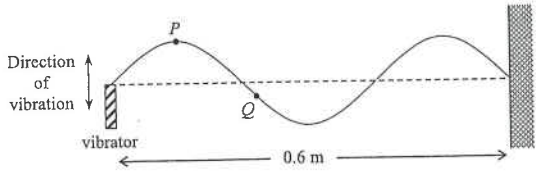


A string is fixed at one end to a wall and a vibrator generates a stationary wave on the string. The distance between the ibrator and the wall is 0.6 m. The figure above shows the string at the instant of maximum displacement.

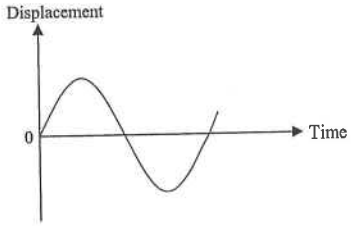
(a) Find the wavelength of the stationary wave. (1 mark)

(b) Describe the motion of particles P and Q at this instant. (2 marks)

(c) In the below figure, mark in the positions of the nodes (labelled as N) and antinodes (labelled as A). (2 marks)



(d) The figure below shows the displacement ~ time graph of particle P.

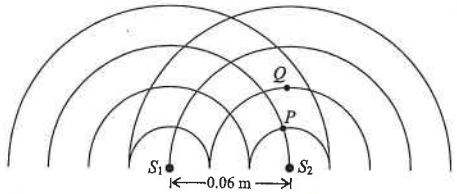


In the above figure, sketch the displacement-time graph of particle Q. (2 marks)

(e) The vibrating string also sets the neighbouring air into vibration. State two differences between the waves on the string and those in air. (2 marks)

Provided by dse.life

8. **< HKCE 1997 Paper I - 2 >**



Two dippers S_1 and S_2 vibrate in phase producing identical circular water waves in a ripple tank. The Figure above shows the wave pattern at a certain instant. (Note : The dark lines represent crests.) The distance between S_1 and S_2 is 0.06 m and it is known that the water waves travel with a speed of 0.4 m s^{-1}.

(a) Find the wavelength and frequency of the water waves. (3 marks)

(b) The ripple tank has a spongy lining at its edges. Explain the function of the spongy lining. (2 marks)

(c) P and Q are two points at the water surface as shown in the above Figure. Find the path difference at

(i) point P, and

(ii) point Q

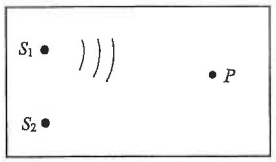
from S_1 and S_2, giving the answers in terms of the wavelength λ of the water waves.

Hence state the types of interference occurring at P and Q. (4 marks)

(d) How would the interference at Q be affected if the frequency of vibration of the two dippers is doubled ? Explain your answer. (Note : You may assume that the speed of the water waves remains unchanged.) (3 marks)

(e) If only one dipper is available, suggest a method of producing an interference pattern in the ripple tank. Illustrate your answer with a diagram. (2 marks)

9. **< HKCE 2001 Paper I - 4 >**



A dipper S_1 is connected to a vibrator and produces circular water waves in a ripple tank. A cork is placed at a point P on the water surface as shown in the above figure.

(a) Describe the motion of the cork as the water waves pass through it. (1 mark)

(b) Suppose another dipper S_2 is connected to the same vibrator and produces identical water waves. It is known that $S_1P = 6.0$ cm, $S_2P = 7.8$ cm and the wavelength of the water waves is 1.2 cm.

(i) Name the wave phenomenon that occurs when both dippers vibrate. (1 mark)

(ii) How would the motion of the cork be affected ? Explain your answer. (3 marks)

10. **< HKCE 2004 Paper I - 5 >**

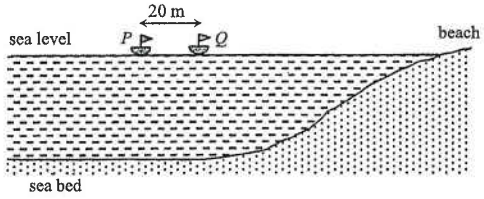


Figure 1

Figure 1 above shows a sectional view of a beach. Two boats are located at positions P and Q as shown, where PQ = 20 m. Straight water waves travel towards the beach. The waves take 4 s to travel from P to Q.

(a) Find the average speed of the waves between P and Q. (2 marks)

Provided by dse.life

10. (b)

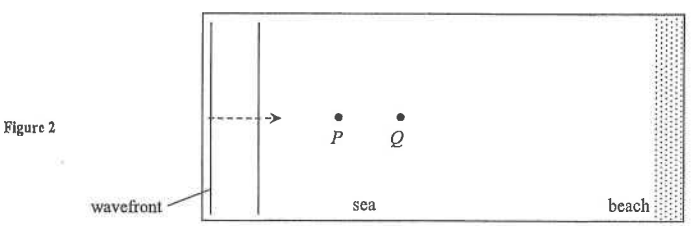


Figure 2 shows the view of the beach from above. In Figure 2, draw the wave pattern observed when the waves travel towards the beach. (2 marks)

(c) Name the wave phenomenon that occurs as the waves travel towards the beach. (1 mark)

11. **< HKCE 2005 Paper I - 5 >**

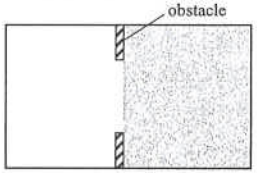


Figure 1

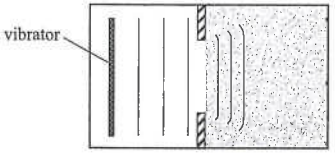


Figure 2

Figure 1 shows a ripple tank with a deep region P and a shallow region Q.

(a) Suppose that two obstacles are added in the ripple tank as shown in Figure 1.

(i) Name two wave phenomena that may occur if water waves travel from P to Q. (2 marks)

(ii) Figure 2 shows the wave pattern observed when straight water waves are generated in P. Compare the wavelength and speed of the waves travelling in Q with those in P. (2 marks)

(b)

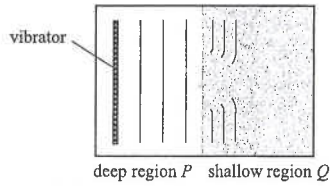


Figure 3

Suggest one method of obtaining the wave pattern in Q as shown in Figure 3. Illustrate your answer by completing Figure 3. (2 marks)

12. **< HKCE 2008 Paper I - 5 >**

Figure 1 shows a plastic box floating on the water surface of a pool which has a deep region and a shallow region. A boy tries to get the box back. He throws a stone into the water to produce waves and he expects that the water waves will "push" the box towards the poolside.

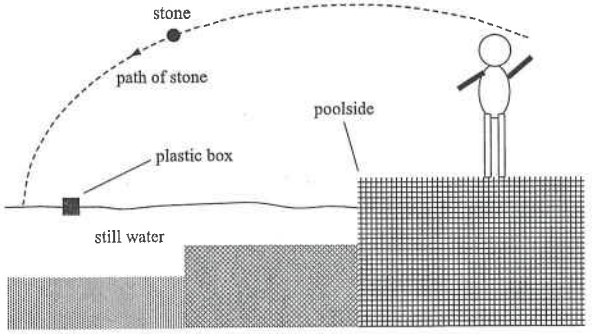


Figure 1

(a) According to the direction of motion of the water molecules, state the kind of wave produced on the water surface. (1 mark)

(b) Explain whether the water waves can "push" the box to the poolside. (2 marks)

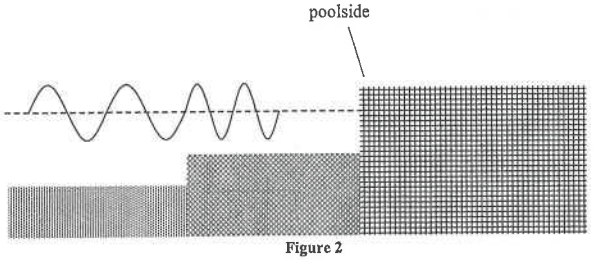


Figure 2

(c) Figure 2 shows a continuous water wave traveling towards the poolside. Deduce the relationship between the velocity of the water wave and the depth of water on the pool. Show your reasoning. (3 marks)

Provided by dse.life

13. **< HKCE 2009 Paper I - 10 >**

In a ripple tank, initially five tiny plastic beads (P, Q, R, S, T) float on the calm water surface. A vibrator begins to produce straight waves at time $t = 0$. Figure 1 shows the positions of beads on the waves at $t = 7$ s. Figure 2 shows the displacement-time graph of S.

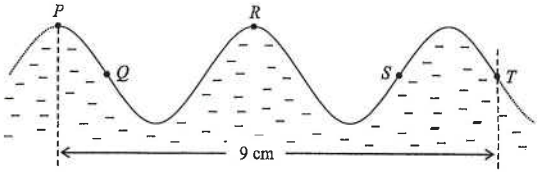


Figure 1

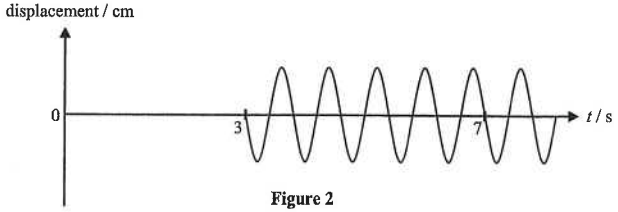


Figure 2

(a) (i) Find the wavelength of the wave. (1 mark)

(ii) Find the frequency of the wave. (2 marks)

(iii) Find the distance between the vibrator and S. (3 marks)

(b) State the bead(s) that is/are moving

(i) in the same direction with T at time $t = 7$ s, (1 mark)

(ii) in the opposite direction with T at time $t = 7$ s. (1 mark)

(c) In Figure 1, sketch the waveform between P and T at a quarter of period after $t = 7$ s. Mark the position of S. (2 marks)

14. **< HKCE 2010 Paper I - 11 >**

Figure 1 shows three points, A, B and X, in a ripple tank where $AX = 15$ cm and $BX = 25$ cm.

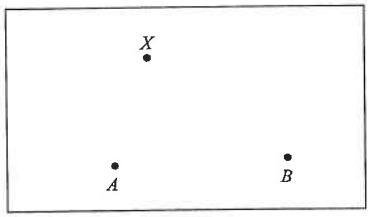


Figure 1

A dipper placed at A vibrates and produces circular water waves of wavelength 10 cm. Figure 2 shows the displacement-time graph for a water particle at X. (Take displacement upward as positive.)

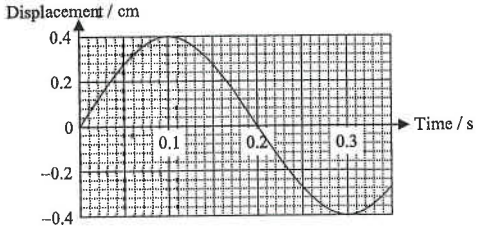


Figure 2

(a) (i) Find the amplitude of the water wave at X. (1 mark)

(ii) Find the speed of the water wave. (3 mark)

(iii) In Figure 3, sketch the waveform along the straight line AX at time $t = 0.2$ s. (Take displacement upward as positive.) (2 marks)

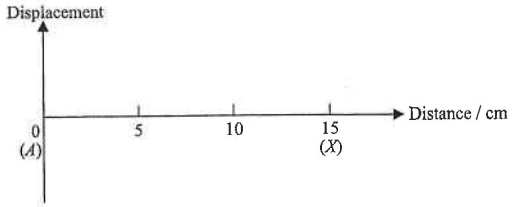


Figure 3

(b) Another dipper is now placed at B and always moves in the same direction as the dipper at A. Determine the type of interference occurring at X. (3 marks)

Provided by dse.life

15. **< HKCE 2011 Paper I - 3 >**

Read the following passage about tsunamis and answer the questions that follow.

Tsunami

When earthquakes occur under the sea, the water above is vertically displaced and waves are formed as water attempts to regain equilibrium. When large areas of sea floor rise or sink, a tsunami can be produced. Other than earthquakes, landslides and undersea volcanic eruptions can also cause tsunamis.

Tsunamis are different from wind-generated waves. Wind-generated waves we usually see at beaches may have a wavelength of 150 m and a period of about 10 s. A tsunami, however, can have a wavelength exceeding 100 km and a period of a few hours.

As a result of their long wavelengths, tsunamis behave as shallow-water waves. Shallow-water waves move at a speed given by the equation $v = \sqrt{g\,d}$
where g is the acceleration due to gravity and d is water depth.

Tsunamis can travel great distances with limited energy losses. As tsunamis leave the deep water of the open sea and approach the coast, their wave speed decreases but their height grows. Tsunamis may reach a height onshore above sea level of 20 m or more and cause serious destruction.

(a) Name two natural phenomena that can cause tsunamis. (2 marks)

(b) The typical water depth is about 4000 m in the Pacific Ocean. Estimate the speed of a tsunami generated there. (1 mark)

(c) As shown in the map in the figure below, an undersea earthquake occurs at S and produces tsunamis. Both islands Q and R are struck by the tsunamis.

(i) Although island R is sheltered from S by island Q, why is it still struck by the tsunamis ? (1 mark)

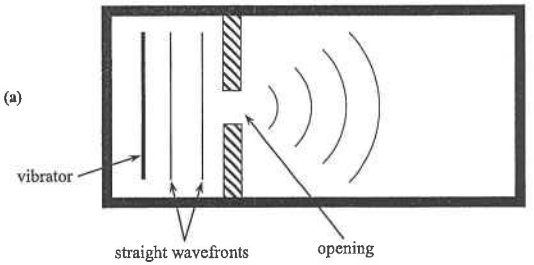
(ii) When the undersea earthquake occurs, a ship is at point P which is in the open sea deep water area as shown in the above figure. On receiving the tsunami warning, the captain of the ship decides to stay at P rather than going back to island Q. Referring to the given passage, comment on whether the captain's decision is correct or not. (2 marks)

Part B : HKDSE examination questions

16. **< HKDSE Practice Paper IB - 5 >**

(a) Two rectangular barriers are put into a ripple tank. A vibrator vibrating at 25 Hz produces water waves with straight wavefronts. The wavelength of the water waves is 0.8 cm. Circular wavefronts are observed after the water waves pass through the opening between the two barriers. Figure (a) shows the top view of the set-up.

Figure (a)



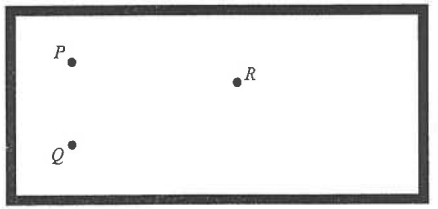
(i) Name the wave phenomenon that takes place when the water waves pass through the opening. (1 mark)

(ii) Calculate the speed of the water waves in the ripple tank. (2 marks)

(iii) If the experiment is repeated using a higher vibrator frequency, describe the changes, if any, in the wave pattern shown in Figure (a). (2 marks)

(b) Figure (b) shows three points, P, Q and R, in a ripple tank such that $PR = 8$ cm and $QR = 10$ cm. A dipper is put at P to produce circular water waves of wavelength 0.8 cm.

Figure (b)



Another identical dipper, vibrating in phase with the one at P, is later put at Q. Explain the change, if any, in the amplitude of the water wave at R. (3 marks)

Provided by dse.life

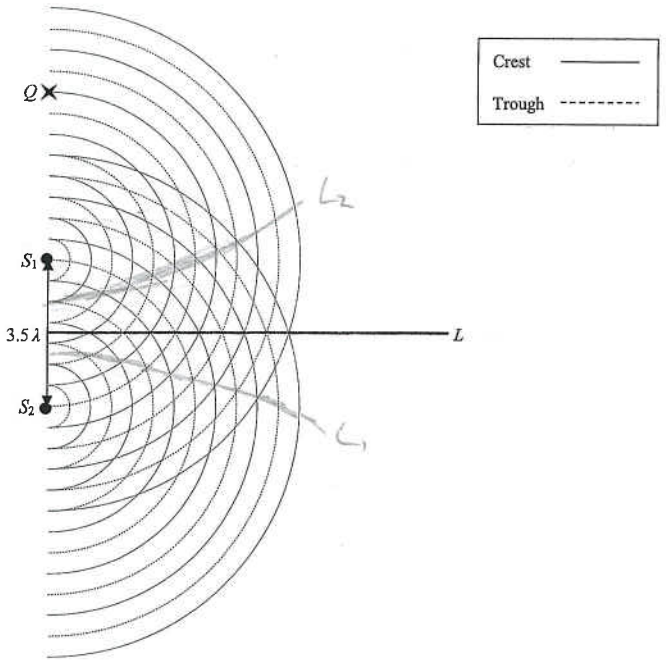
17. **< HKDSE 2012 Paper IB - 6 >**

In a ripple tank, circular water waves are produced by two vibrators S_1 and S_2 of the same frequency vibrating in phase. Their separation is 3.5 λ, where λ is the wavelength of the waves.

Figure (a) shows the two circular waves propagating on the water surface at a certain moment.

Line L is a line connecting all points P which have path difference $S_1P - S_2P = 0$.

Figure (a)



(a) (i) Draw and label a line in Figure (a) connecting all points P which have path difference

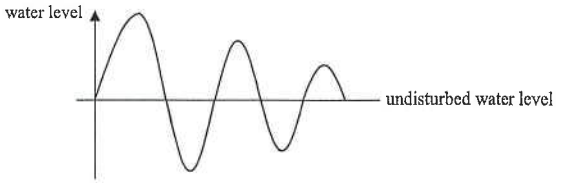
(1) $S_1P - S_2P = \lambda$ (label it as L_1)

(2) $S_1P - S_2P = -\frac{3}{2}\lambda$ (label it as L_2) (2 marks)

(ii) What would happen to L_1 and L_2 if the separation between S_1 and S_2 is reduced slightly ? (1 mark)

17. (b) Figure (b) shows the profile of the water level along line L at a certain instant. Sketch on the same figure the profile at a time $\frac{1}{2}T$ later, where T is the period of the water waves. (1 mark)

Figure (b)

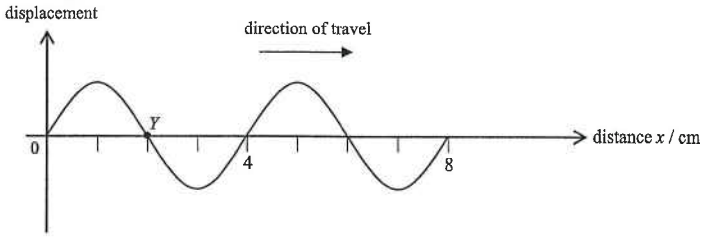


(c) Q is a point on the line joining S_1 and S_2 as shown in Figure (a). State the kind of interference that occurs at Q and give a reason for this occurrence. (2 marks)

18. **< HKDSE 2017 Paper IB - 6 >**

(a) A dipper vibrating with a frequency of 5 Hz is put in a water tank. Figure 1 shows the displacement-distance graph of the water wave at time $t = 0$. Y is a particle in the water tank.

Figure 1

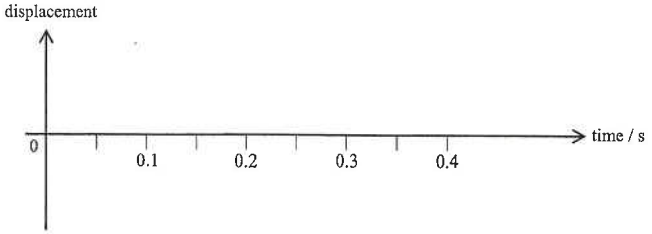


(i) Determine the wave speed of the water wave. (2 marks)

(ii) State the direction of motion of particle Y at $t = 0$. (1 mark)

(iii) Sketch the displacement-time graph of particle Y between $t = 0$ and $t = 0.4$ s in Figure 2. (2 marks)

Figure 2



Provided by dse.life

18. (b) In Figure 3, A and B are two dippers vibrating in phase in a water tank. The distance between A and B is 6 cm. OP is the perpendicular bisector of AB. Q is a second minimum from P, where $AQ = 12$ cm and $BQ = 15$ cm.

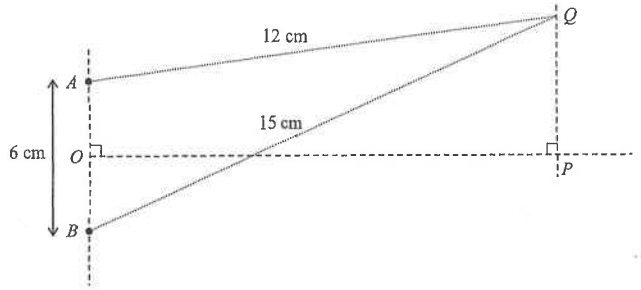


Figure 3

(i) Explain why a minimum occurs at Q. (2 marks)

(ii) Determine the wavelength of the water wave. (2 marks)

(iii) Sketch in Figure 4 how the **AMPLITUDE** of the water wave varies along the line OP. (1 mark)

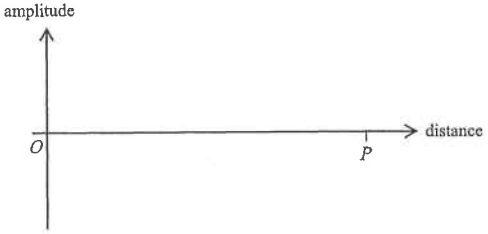


Figure 4

there is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

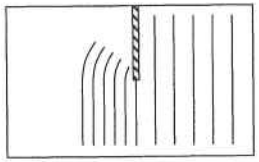
Question Solution

1. (a) (i) To act as a point source for producing circular wavefront. [1]

(ii) To show the phenomenon of refraction. [1]

(iii) To absorb the waves and prevent the rebounding of waves at the edges. [1]

(b) (i)



< wavefronts closer together > [1]

< waves spread out > [1]

< circular wavefronts shown > [1]

(ii) Diffraction and refraction occurs [2]

2. (a) f = 10 Hz [1]

$v = f\lambda = 10 \times 2$ [1]

$= 20$ cm s^{-1} [1]

(b) (i) At A and E, constructive interference occurs [2]

At B and D, destructive interference occurs [2]

(ii) Energy goes to the points of constructive interference [2]

(iii)

[2]

(iv) (1) separation would decrease [1]

(2) separation would decrease [1]

3. (a) Place a transparent plastic sheet totally immersed in water to give a shallow region [2]

(b) Freeze the wave pattern using a stroboscope [1]

Place a metre rule closed to the ripple tank. [1]

The position of 2 successive crests is marked on the metre rule. [1]

The length between the two marks is the wavelength. [1]

Provided by dse.life

5. A ripple tank has a shallow region P and a deep region Q. Straight water wave of frequency 10 Hz is travelling in the shallow region as shown in Figure 5.1 when viewed from above.

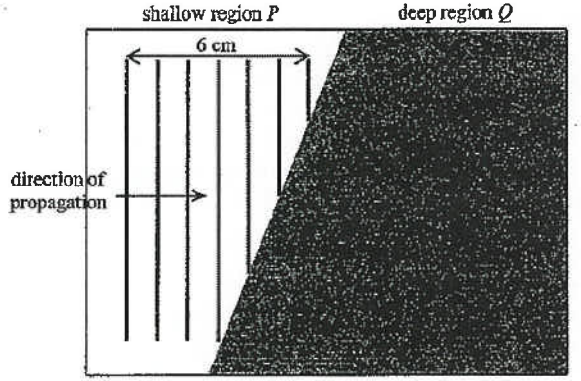


Figure 5.1 Top view

(a) The separation between seven crests in the shallow region is found to be 6 cm as shown.

(i) Find the wavelength of the wave in the shallow region. (1 mark)

(ii) What is the wave speed in the shallow region ?

(b) The water wave then propagates into the deep region where the wavelength of the wave is double that in the shallow region.

(i) State the frequency of the water wave in the deep region. (1 mark)

(ii) On Figure 5.1, sketch the wave pattern in the deep region. (2 marks)

(iii) Name the phenomenon occurred across the boundary and explain its cause. (2 marks)

Provided by dse.life

3. (c) (i) $v = f\lambda = 10 \times 0.03$ [1]

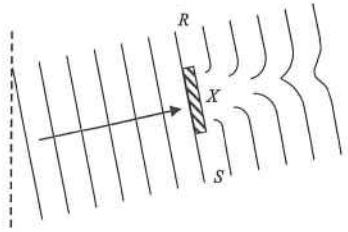
$= 0.3 \text{ m s}^{-1}$ [1]

(ii) $v = 10 \times 0.02$ [1]

$= 0.2 \text{ m s}^{-1}$ [1]

(d) Region A [1]

(e) Diffraction occurs [1]



[1]

4. (a) The cork moves up and down. [1]

(b) The wave motion can be frozen by viewing through a stroboscope. [1]

A metre rule is placed close to the tank. [1]

The wavelength is measured by marking the position of 2 successive wave crests on the meter rule. [1]

(c) (i) $f = \frac{5}{2}$ [1]

$= 2.5 \text{ Hz}$ [1]

(ii) $\lambda = \frac{1}{5}$ [1]

$= 0.2 \text{ m}$ [1]

(iii) $v = f\lambda = 2.5 \times 0.2$ **OR** $v = \frac{d}{t} = \frac{1}{2}$ [1]

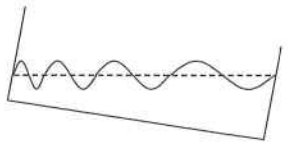
$= 0.5 \text{ m s}^{-1}$ $= 0.5 \text{ m s}^{-1}$ [1]

(d) Since the path difference at the cork is zero, [1]

constructive interference occurs. [1]

The cork will move up and down with greater amplitude. [1]

(e) [2]



5. (a) Frequency = 4 Hz [1]

$v = \frac{d}{t} = \frac{0.8}{0.25} = 3.2 \text{ m s}^{-1}$ [2]

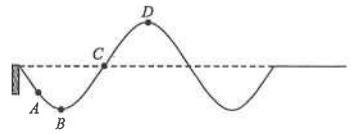
OR

$v = f\lambda = 4 \times 0.8 = 3.2 \text{ m s}^{-1}$ [2]

(b) (i) (1) A [1]

(2) B and D [1]

(ii)



< For wave form > [2]

< 0.5 mark for each particle > [2]

(c) (i) X and Y are both at rest. [2]

(ii)

[2]

(d) **Any TWO of the followings :** [2]

* Waves in air are longitudinal waves but waves on string are transverse waves.
* Waves in air are travelling waves but waves on the string are stationary waves.
* Waves in air and waves on string have different wavelengths (**OR** speeds).

6. (a) Amplitude = 0.2 cm [1]

Frequency $= \frac{1}{10} = 10 \text{ Hz}$ [1]

Speed $= \frac{d}{t} = \frac{0.12}{0.5} = 0.24 \text{ m s}^{-1}$ [1]

Wavelength $\lambda = \frac{v}{f} = \frac{0.24}{10}$ [1]

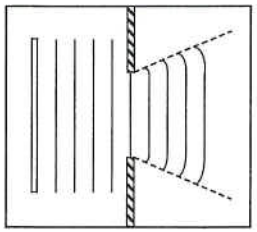
$= 0.024 \text{ m}$ [1]

(b) **Any ONE of the following :** [2]

* Insert spongy plastic (cotton wool) around the edge of the tank.
* Use water tanks that have sloping edges.

Provided by dse.life

6. (c) (i)



[2]

(ii) Diffraction. [1]

(d) (i) A (or C) is a point of constructive interference. [1]

D is a point of destructive interference. [1]

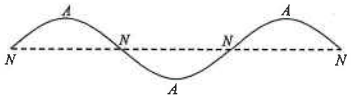
(ii) No. [1]

A trough can also be formed at points of constructive interference. [2]

7. (a) $\lambda = 0.4$ m [1]

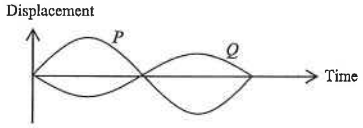
(b) Both P and Q are at rest at this instant. [2]

(c)



[2]

(d)



< Q and P are in opposite phase > [1]

< Amplitude of Q less than that of P > [1]

(e) **Any TWO of the following :** [2]

- Waves in air are travelling waves but waves on string are stationary waves
- Waves in air are longitudinal waves but waves on string are transverse wave
- Waves in air and waves on string have different wavelengths (or speeds)

8. (a) Wavelength = 0.02 m [1]

Frequency $= \frac{v}{\lambda} = \frac{0.4}{0.02} = 20$ Hz [2]

(b) To prevent water waves from bouncing back at the edges of the tank. [2]

OR

To absorb the water waves. [2]

8. (c) (i) Path difference at $P = 2\lambda$ [1]

$\therefore$ Constructive interference occurs at P. [1]

(ii) Path difference at $Q = 1\frac{1}{2}\lambda$ [1]

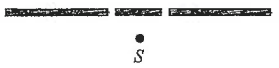
$\therefore$ Destructive interference occurs at Q. [1]

(d) If the frequency of vibration is doubled, the wavelength of the water waves would become halved. [1]

The path difference at Q would then be equal to 3 times the wavelength of the water waves, [1]

so the interference at Q becomes constructive. [1]

(e) Place a barrier with two small openings in front of the dipper. [1]



[1]

9. (a) The cork will move up and down. [1]

(b) (i) It is called interference. [1]

(ii) Path difference at $P = S_2P - S_1P$

$= 7.8 - 6.0 = 1.8$ cm [1]

$= 1\frac{1}{2}\lambda$ [1]

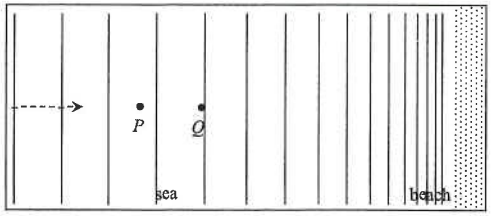
Since destructive interference occurs at P, the amplitude of vibration would decrease (**OR** become zero). [1]

10. (a) $v = \frac{d}{t}$ [1]

$= \frac{20}{4}$

$= 5\ \text{m s}^{-1}$ [1]

(b)



< wavelength shorter at right hand side > [1]

< correct pattern > [1]

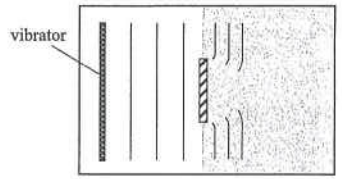
(c) Refraction [1]

Provided by dse.life

11. (a) (i) diffraction and [1]
refraction [1]

(ii) wavelength in Q is smaller than that in P [1]
speed in Q is smaller than that in P [1]

(b) Add an obstacle into the ripple tank. [1]



[1]

12. (a) transverse wave [1]

(b) As the water wave travels to the pool deck, the water particles only move up and down. [1]
Therefore, the water wave cannot push the box to the pool deck. [1]

(c) The wavelength decreases as the wave travels to the shallow region. [1]
As the frequency remains unchanged, [1]
the velocity of the water wave decreases as the depth decreases. [1]

13. (a) (i) $\lambda = \dfrac{9}{2.25} = 4$ cm [1]

(ii) $T = \dfrac{7-3}{5} = 0.8$ s [1]

$f = \dfrac{1}{T} = 1.25$ Hz [1]

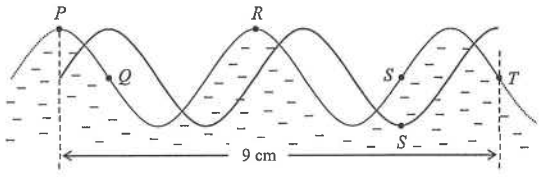
(iii) $v = f\lambda = (1.25)(4) = 5$ cm s^{-1} [1]

$d = vt = (5) \times (3)$ [1]
$= 15$ cm [1]

(b) (i) Q [1]

(ii) S [1]

(c)



< correct waveform > [1]
< correct position of S > [1]

14. (a) (i) Amplitude = 0.4 cm [1]

(ii) $T = 0.4$ s

$f = \dfrac{1}{T} = \dfrac{1}{0.4} = 2.5$ Hz [1]

$v = f\lambda$ [1]

$= (2.5)(0.1) = 0.25$ m s^{-1} < accept 25 cm s^{-1} > [1]

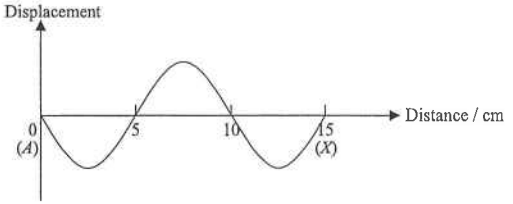
OR

$v = \dfrac{d}{t}$ [1]

$= \dfrac{0.1}{0.4}$ [1]

$= 0.25$ m s^{-1} [1]

(iii)



< zero displacement at A, X > [1]
< 1.5 waves drawn correctly > [1]

(b) Path difference = 25 – 15 [1]
= 10 cm = 1 λ [1]

Constructive interference occurs at X. [1]

15. (a) **Any TWO of the followings :** [1+1]
- ✶ earthquakes
- ✶ landslides
- ✶ volcanic eruptions

(b) $v = \sqrt{g\,d} = \sqrt{9.81 \times 4000} = 198$ m s^{-1} [1]

(c) (i) The tsunamis undergo diffraction and get around island Q. [1]

(ii) **Any ONE of the following reason :** [1]
- ✶ The height of the tsunami grows as it travels near to the coast.
- ✶ The height of the tsunami is small in open sea.
- ✶ The tsunami may cause serious damage near the shore.

So, the captain's decision is correct. [1]

Provided by dse.life

16. (a) (i) Diffraction [1]

(ii) $v = f\lambda = (25) \times (0.8)$ [1]

$= 20 \text{ cm s}^{-1}$ [1]

(iii) The wavelength of the water wave decreases. [1]

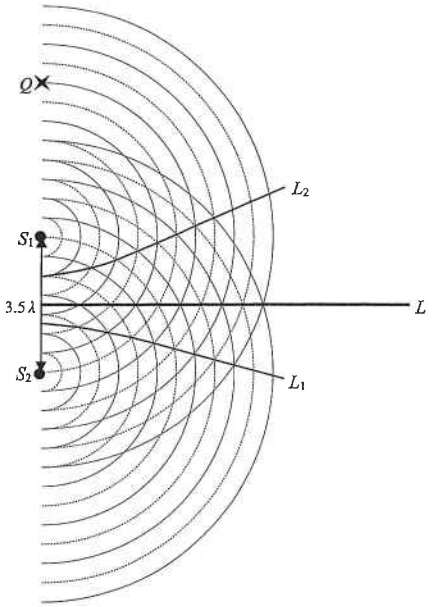
The degree of diffraction decreases. [1]

(b) Path difference at R = 2.0 cm = 2.5 λ [1]

Destructive interference occurs at R. [1]

Amplitude of the water wave at R decreases when another dipper is placed at Q. [1]

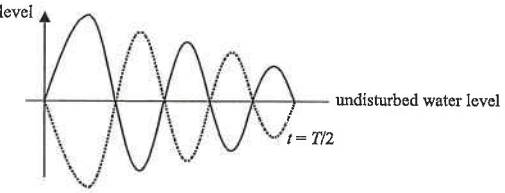
17. (a) (i)



[1]

(ii) L_1 and L_2 will be further away from L. [1]

(b)



[1]

(c) The path difference at Q is 3.5 λ. ($QS_1 = 4\lambda$ and $QS_2 = 7.5\lambda$) [1]

Thus, destructive interference occurs at Q. [1]

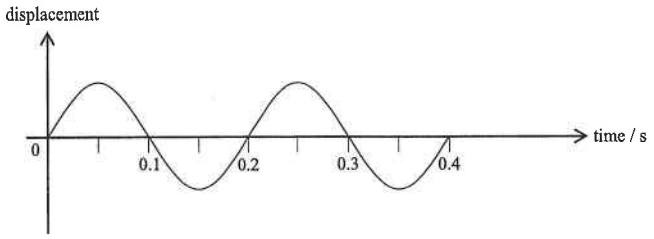
18. (a) (i) $v = f\lambda$

$= 5 \times 4$ [1]

$= 20 \text{ cm s}^{-1}$ < accept 0.2 m s^{-1} > [1]

(ii) Y is moving upwards [1]

(iii)



< Two waves drawn > [1]

< All the shapes are correct > [1]

(b) (i) The water waves from A and B meeting at Q are in opposite phase. [1]

OR

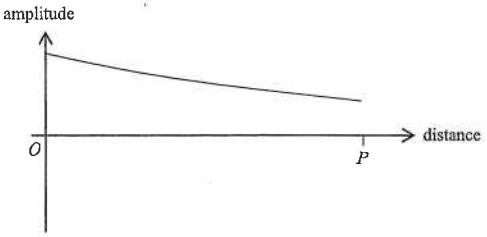
The path difference at Q is equal to 1.5 λ. [1]

Thus, destructive interference occurs to form a minimum. [1]

(ii) Path difference at Q = 1.5 λ = 3 cm [1]

Wavelength : λ = 2 cm [1]

(iii)



< a line (curve or straight line) gradually decreases in amplitude > [1]

Provided by dse.life

19. (a) (i) wavelength $\lambda = \frac{0.06}{7-1}$

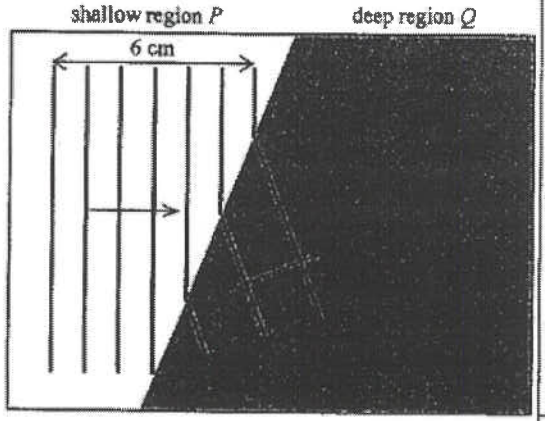
$= 0.01$ m ($= 1$ cm) — 1A — 1

(ii) speed $v = f\lambda = 10 \times 0.01$

$= 0.1$ m s^{-1} ($= 10$ cm s^{-1}) — 1M/1A — 1

(b) (i) frequency = 10 Hz — 1A — 1

(ii)



1A

1A

2

(iii) Refraction.
It is due to the change in wavelengths / wave speeds in different media / depths.

1A
1A

2

Provided by dse.life

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

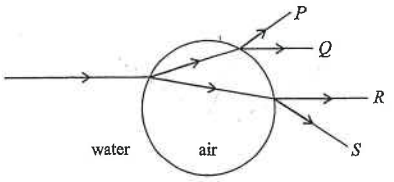
DSE Physics - Section C : M.C. PC - WA3 - M / 01
WA3 : Reflection and Refraction of Light

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8$ m s^{-1}

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 16 >**



A light ray passes through a spherical air bubble in water. Which of the following represents the path of the emergent ray ?

A. *P*
B. *Q*
C. *R*
D. *S*

2. **< HKCE 1980 Paper II - 28 >**

A fixed object is placed in front of a plane mirror. If the mirror is moved 0.10 m away from the fixed object, how far will the image move ?

A. 0.05 m
B. 0.10 m
C. 0.20 m
D. 0.40 m

3. **< HKCE 1980 Paper II - 17 >**

When light enters from one medium into another, which of the following will be changed ?

(1) The frequency of the light
(2) The wavelength of the light
(3) The velocity of the light

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

4. **< HKCE 1980 Paper II - 18 >**

A point light source is placed in a liquid. Rays from the source leave the liquid surface through a circular area of diameter 24 cm. The refractive index of the liquid is 1.25. The depth of the source below the liquid surface is

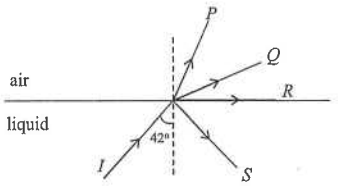
A. 9 cm
B. 15 cm
C. 16 cm
D. 18 cm

Provided by dse.life

5. **< HKCE 1982 Paper II - 21 >**

A ray of light I passes from a liquid L into air makes an angle of incidence of 42°. If the refractive index of the liquid L is 1.35, the most probable emergent ray of light is

A. P
B. Q
C. R
D. S



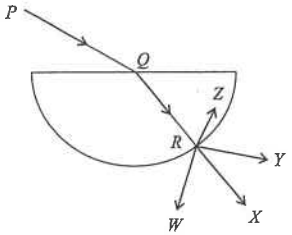
6. **< HKCE 1983 Paper II - 18 >**

Which of the following statements about the properties of light is/are correct ?

(1) The speed of light in vacuum is independent of its wavelength.
(2) The wavelength of light will change when it enters a less dense medium.
(3) The frequency of light will change when it enters a less dense medium.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

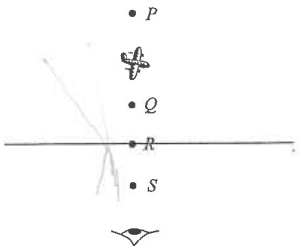
7. **< HKCE 1983 Paper II - 16 >**



In the diagram, PQR represents the path of a ray of light incident on a semi-circular glass slab. Q is the centre of the slab. Which of the directions W, X, Y or Z correctly indicates the subsequent path of the refracted ray ?

A. W
B. X
C. Y
D. Z

8. **< HKCE 1984 Paper II - 19 >**



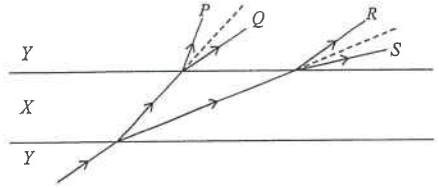
As shown in the diagram, the apparent position of the aeroplane seen by the diver at the bottom of the small pond is at

A. P
B. Q
C. R
D. S

9. **< HKCE 1985 Paper II - 18 >**

In the diagram shown, a light ray passes from medium Y to medium X and emerges to medium Y again. The refractive index of medium X is smaller than that of medium Y. Which of the following represents the path of the emergent ray ?

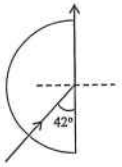
A. P
B. Q
C. R
D. S



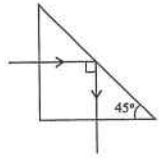
10. **< HKCE 1987 Paper II - 18 >**

A ray of light passes from air into a glass block. Which of the following ray diagrams is/are correct ? (Given that the critical angle of glass is 42°.)

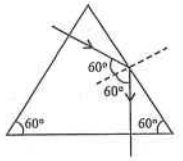
(1)



(2)



(3)

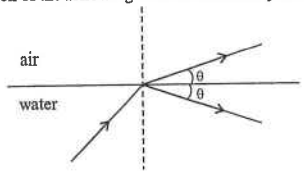


A. (2) only
B. (3) only
C. (2) & (3) only
D. (1), (2) & (3)

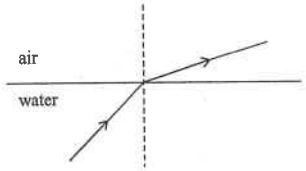
11. **< HKCE 1988 Paper II - 19 >**

Which of the following best describes a ray of light travelling from water to air ?

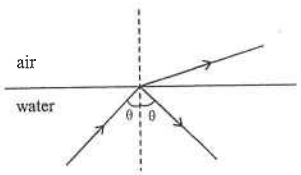
A.



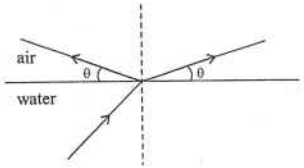
B.



C.



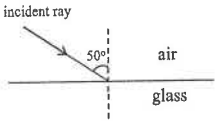
D.



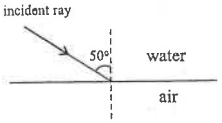
12. **< HKCE 1992 Paper II - 16 >**

The refractive indices of water and glass are 1.33 and 1.5 respectively. In which of the following cases will total internal reflection occur ?

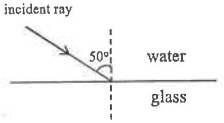
(1)



(2)



(3)



A. (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

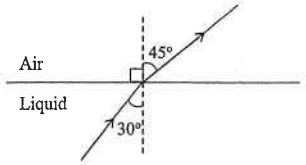
13. **< HKCE 1993 Paper II - 11 >**

Which of the following phenomena is/are caused by refraction of light ?
(1) A swimming pool appears shallower than it really is.
(2) A metre rule appears bent when dipped in water.
(3) A spectrum is formed when white light passes through a prism.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

14. **< HKCE 1993 Paper II - 13 >**

The diagram shows a light ray travelling from liquid to air.
Find the refractive index of the liquid.



A. 0.71
B. 1.33
C. 1.41
D. 1.50

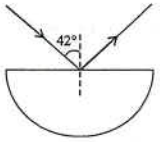
15. **< HKCE 1994 Paper II - 13 >**

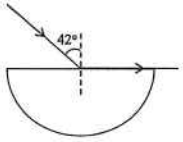
Which of the following devices involve(s) total internal reflection of light as they work ?
(1) Optical fibres
(2) A prismatic periscope
(3) A plane mirror

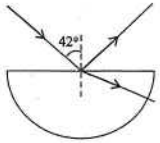
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

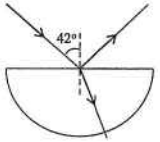
16. **< HKCE 1994 Paper II - 14 >**

A ray of light travels in air and strikes a semi-circular glass block at an angle of incidence 42°. The critical angle of the glass is 42°. Which of the following diagrams best shows the subsequent path(s) of the ray ?

A.


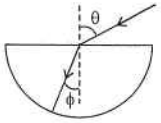
B.


C.


D.


17. **< HKCE 1996 Paper II - 17 >**

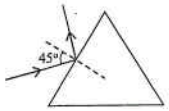
A ray of light travelling in air enters a semi-circular glass block as shown. Different values of the angle of incidence θ and the corresponding values of the angle of refraction ϕ are measured. Which of the below expressions represents the refractive index of the glass ?

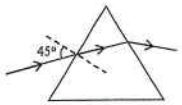


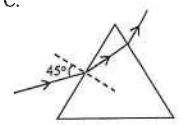
A. the slope of the graph of sin θ against sin ϕ
B. the slope of the graph of sin ϕ against sin θ
C. the slope of the graph of θ against ϕ
D. the slope of the graph of ϕ against θ

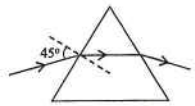
18. **< HKCE 1996 Paper II - 14 >**

A ray of red light travels in air and strikes a triangular glass prism at an angle of incidence 45°. The critical angle of red light for the glass is 42°. Which of the following diagrams best shows the path of the ray ?

A.


B.


C.


D.


19. **< HKCE 1997 Paper II - 15 >**

Which of the following phenomena involve(s) total internal reflection of light ?
(1) The sparkling of a diamond.
(2) The formation of a mirage.
(3) A ruler appearing bent when dipped in water.

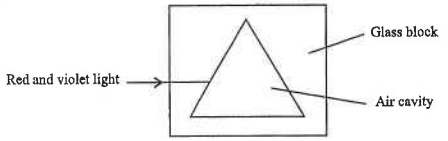
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

20. **< HKCE 1998 Paper II - 18 >**

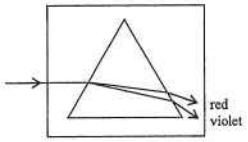
Which of the following phenomena is/are caused by the refraction of light ?
(1) If a man who is spear-fishing aims his spear at where the fish appears to be, he will miss it.
(2) A spectrum is formed when white light passes through a prism.
(3) A light ray is transmitted through a curved glass fibre.

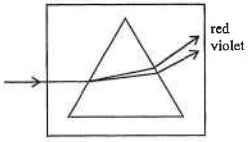
A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

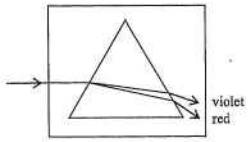
21. **< HKCE 1998 Paper II - 16 >**

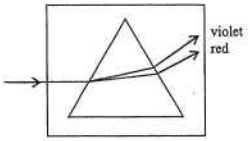


A beam consisting of red and violet light travels in a glass block with an air cavity. The cavity is in the shape of a prism as shown above. Which of the following diagrams best shows the subsequent path of the beam ?

A.


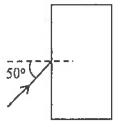
B.


C.


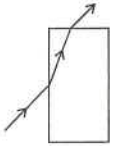
D.


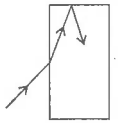
Provided by dse.life

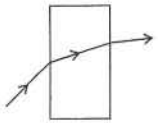
22. < HKCE 1999 Paper II - 13 >

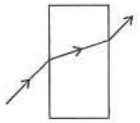


A ray of light travels in air and strikes a rectangular glass block at an angle of incidence 50°. The critical angle of the glass is 42°. Which of the following diagrams best shows the path of the ray ?

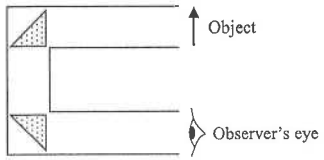
A.


B.


C.


D.


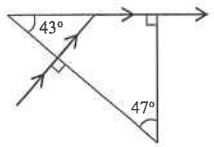
23. < HKCE 2000 Paper II - 18 >



A student uses two triangular prisms to construct a periscope as shown above. Which of the following shows the image of the object as seen by the observer ?

A. B. C. D.

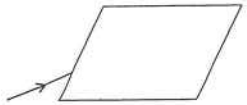
24. < HKCE 2000 Paper II - 16 >



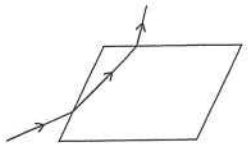
A ray of light enters a glass prism and travels along the path as shown above. Find the refractive index of the glass.

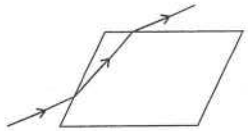
A. 1.07
B. 1.37
C. 1.47
D. 1.50

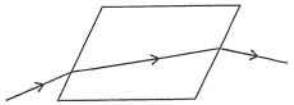
25. < HKCE 2002 Paper II - 14 >

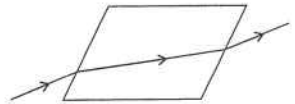


A ray of light travels in air and strikes a glass block as shown above. Which of the following diagrams best shows the path of the ray ?

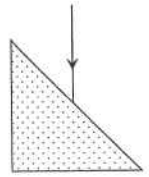
A.


B.


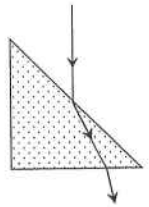
C.


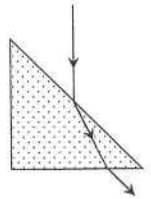
D.


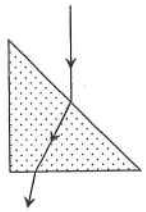
26. < HKCE 2003 Paper II - 13 >

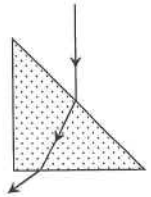


A ray of light travels in air and strikes a glass prism as shown above. Which of the following diagrams best shows the path of the ray ?

A.


B.


C.


D.


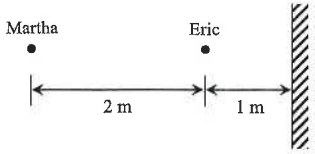
Provided by dse.life

27. **< HKCE 2004 Paper II - 14 >**

The photograph shows the image of a tree formed by the surface of a pool of calm water. Which of the following phenomena explains the formation of the image ?

A. reflection
B. total internal reflection
C. refraction
D. diffraction

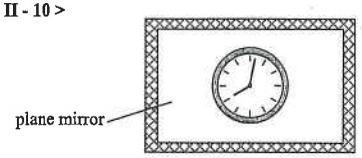
28. **< HKCE 2004 Paper II - 13 >**



Eric stands 1 m in front of a plane mirror. Martha stands 2 m behind Eric as shown above. Find the distance between Eric and the image of Martha formed by the mirror.

A. 2 m
B. 3 m
C. 4 m
D. 6 m

29. **< HKCE 2005 Paper II - 10 >**



The diagram shows the image of a clock formed in a plane mirror. What is the time displayed by the clock at this instant ?

A. 3:58
B. 4:02
C. 7:58
D. 8:02

30. **< HKCE 2006 Paper II - 19 >**

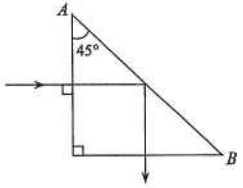
Which of the following surfaces produce diffuse reflection when parallel light rays fall on them ?

(1) a blackboard in the classroom
(2) a polished metal surface
(3) a page in this question book

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. **< HKCE 2006 Paper II - 32 >**

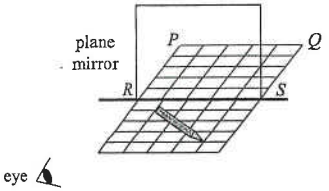
A light ray enters normally from the air into a right-angled prism and is totally internally reflected at face *AB* as shown below. Based on this optical phenomenon, which of the following is/are the possible value(s) for the refractive index of the material of the prism ?



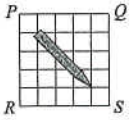
(1) 1.35
(2) 1.45
(3) 1.55

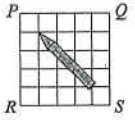
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

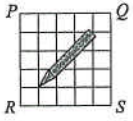
32. **< HKCE 2007 Paper II - 11 >**

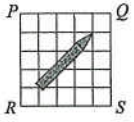


A pencil is placed in front of a vertical plane mirror as shown in the figure above. Which of the following shows the correct position of the image ?

A.


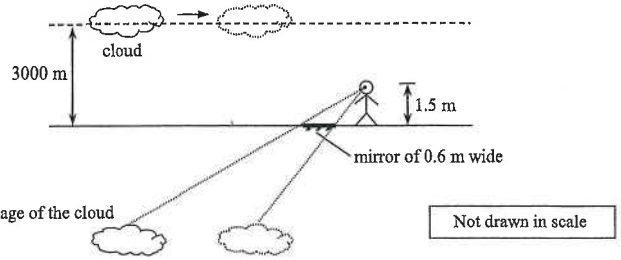
B.


C.


D.


33. **< HKCE 2007 Paper II - 35 >**

John wants to estimate the speed of a cloud in the following experiment. The cloud is moving horizontally at a height of 3000 m above the ground. He looks at the image of the cloud in a mirror of 0.6 m wide placed on the horizontal ground 1.5 m below his eye level. He finds that the image of the cloud takes 20 s to move across the mirror.

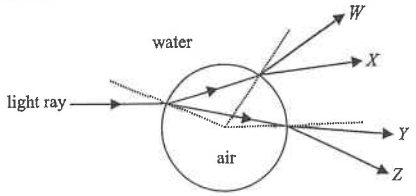


What is the approximate speed of the cloud ?

A. 0.03 m s^{-1}
B. 0.06 m s^{-1}
C. 60 m s^{-1}
D. 150 m s^{-1}

Provided by dse.life

34. < HKCE 2007 Paper II - 13 >



A light ray is incident from water onto an air bubble as shown above. Which light ray best represents the emergent ray ?

A. W
B. X
C. Y
D. Z

35. < HKCE 2007 Paper II - 14 >

Figure (a) shows a light ray travelling from air into medium X. The angle of incidence is 50° and the angle of refraction is r. Another light ray travelling from medium X to air is shown in Figure (b). The angle of incidence is 35° and the angle of refraction is also equal to r. What is angle r ?

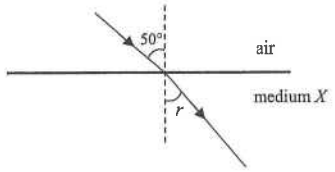


Figure (a)

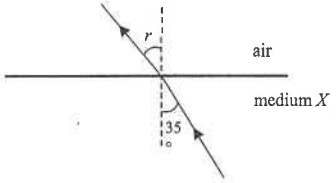
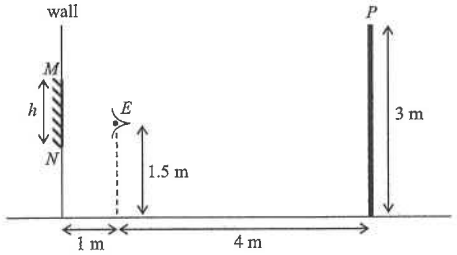


Figure (b)

A. 26.1°
B. 41.5°
C. 42.5°
D. 48.5°

36. < HKCE 2008 Paper II - 13 >

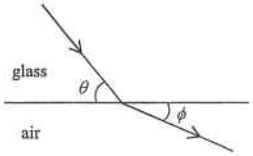


In the figure, a plane mirror MN of height h is mounted in an adjustable vertical position on a vertical wall. E is an observer's eye which is 1 m from the wall and 1.5 m above the ground. PQ is a vertical post of height 3 m and is 4 m behind the observer. Looking into the mirror the observer can see the whole image of the post. What is the minimum value of h ?

A. 0.5 m
B. 0.6 m
C. 1.5 m
D. 2.0 m

37. < HKCE 2008 Paper II - 17 >

A ray of light is traveling from glass to air as shown in the figure. Which of the following ratios is the refractive index of glass ?



A. $\dfrac{\sin\theta}{\sin\phi}$
B. $\dfrac{\sin\phi}{\sin\theta}$
C. $\dfrac{\sin(90°-\theta)}{\sin(90°-\phi)}$
D. $\dfrac{\sin(90°-\phi)}{\sin(90°-\theta)}$

38. < HKCE 2008 Paper II - 38 >

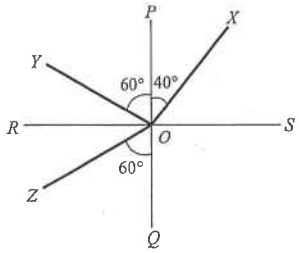
Which of following statements about total internal reflection is/are correct ?

(1) The angle of incidence is less than the critical angle.
(2) Both reflected and refracted rays appear.
(3) The ray is travelling from an optically denser medium to an optically less dense medium.

A. **(1)** only
B. **(3)** only
C. **(1)** & (2) only
D. **(2)** & (3) only

39. < HKCE 2008 Paper II - 16 >

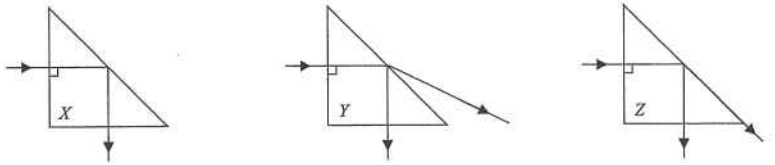
A light ray undergoes reflection and refraction at an air-glass boundary as shown. PQ is perpendicular to RS. OX, OY and OZ are the paths of the light rays. Which of the following deductions is/are correct ?



(1) OX is the path of the incident ray.
(2) RS is the air-glass boundary.
(3) The light ray travels from glass to air.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

40. < HKCE 2009 Paper II - 34 >

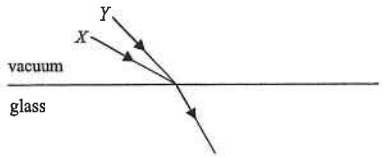


X, Y and Z are three 45° – 90° – 45° triangular prisms made of different transparent materials. A ray incident normally at one face is found to undergo refraction and reflection in each prism as shown in the figures above. Which of the following is the correct order of the refractive indices of the prisms ?

A. $X > Y > Z$
B. $X > Z > Y$
C. $Y > Z > X$
D. $Z > Y > X$

Provided by dse.life

41. **< HKCE 2009 Paper II - 15 >**



Two coloured lights, *X* and *Y*, travel from vacuum to glass. They undergo refraction and travel along the same path in glass. Which of the following descriptions about the two coloured lights is correct ?

A. Glass has a greater refractive index for *X* and *X* travels with the same speed as *Y* in vacuum.
B. Glass has a greater refractive index for *X* and *X* travels slower than *Y* in vacuum.
C. Glass has a smaller refractive index for *X* and *X* travels with the same speed as *Y* in vacuum.
D. Glass has a smaller refractive index for *X* and *X* travels faster than *Y* in vacuum.

42. **< HKCE 2010 Paper II - 13 >**

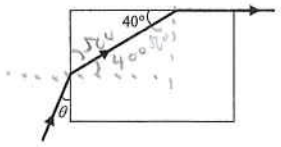
A student performs an experiment to find the refractive index of a material and the result is shown below. Which of the following set of data is likely to be wrong ?

	P	*Q*	*R*	*S*
Angle of incidence	20°	40°	60°	80°
Angle of refraction	14°	22°	38°	44°

A. *P*
B. *Q*
C. *R*
D. *S*

43. **< HKCE 2010 Paper II - 38 >**

A ray of light enters a transparent rectangular block and travels along the path as shown in the figure above. Find angle θ.



A. 33°
B. 57°
C. 59°
D. 75°

44. **< HKCE 2011 Paper II - 38 >**

Telecommunication companies nowadays use optical fibres to transmit data. What are the advantages of using optical fibres over copper wires in transmitting data ?

(1) Less data loss in the transmission.
(2) Data can be transmitted at a higher rate.
(3) For the same data transmission rate, optical fibres take up less space.

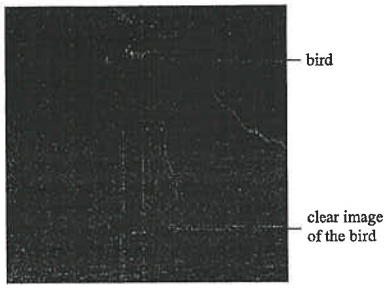
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

45. **< HKCE 2011 Paper II - 15 >**

When a light ray travels from air to glass, which of the following descriptions about the changes of the speed, the frequency and the wavelength of the ray is correct ?

	Speed	Frequency	Wavelength
A.	remains unchanged	increases	decreases
B.	remains unchanged	decreases	increases
C.	decreases	remains unchanged	decreases
D.	increases	remains unchanged	increases

46. **< HKCE 2011 Paper II - 14 >**



A clear image of a bird is formed by a calm water surface as shown in the above figure. Which of the following statements about the image is/are correct ?

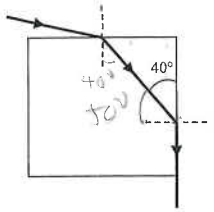
(1) The image is real.
(2) A clear image is formed as regular reflection occurs.
(3) If the bird is closer to the water surface, the size of the image increases.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

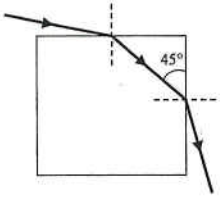
47. **< HKCE 2011 Paper II - 39 >**

A ray of light enters a transparent rectangular block from air and emerges. Which of the following ray diagrams is/are **impossible** ? The dotted lines represent normal to the surfaces.

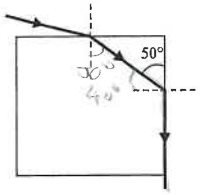
(1)



(2)



(3)



A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

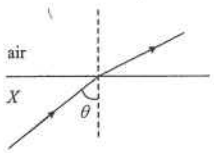
Part B : HKAL examination questions

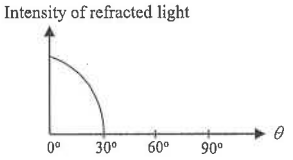
48. < HKAL 1994 Paper IIA - 15 >

The speed of light in a transparent material is 1.6×10^8 m s^{-1}. Find the critical angle for that material.

A. 28.1°
B. 32.2°
C. 41.8°
D. 48.0°

49. < HKAL 1995 Paper IIA - 13 >





A beam of light travels from a medium X to air. When the incident angle θ varies from 0° to 90°, the light intensity of the refracted ray varies as shown in the graph. What is the ratio of the speed of light in air to that in medium X ?

A. 1 : 2
B. 1 : 3
C. 2 : 1
D. 2 : 3

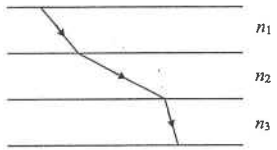
50. < HKAL 1996 Paper IIA - 12 >

When a beam of light travels from glass to air, the emergent light in air shows an increase in

(1) frequency.
(2) speed.
(3) wavelength.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

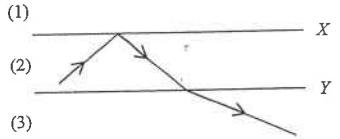
51. < HKAL 1997 Paper IIA - 13 >



A light ray passes through three media of refractive indexes n_1, n_2 and n_3 respectively as shown. The boundaries between the three media are parallel. Which of the following relations for n_1 , n_2 and n_3 is correct ?

A. $n_1 > n_3 > n_2$
B. $n_3 > n_1 > n_2$
C. $n_1 > n_2 > n_3$
D. $n_2 > n_1 > n_3$

52. < HKAL 2003 Paper IIA - 15 >



X and Y are two parallel boundaries separating media (1), (2) and (3). A light ray undergoes total internal reflection at the boundary X and then refracts at Y as shown. Arrange the speeds of light in the three media in descending order.

A. (1) > (2) > (3)
B. (1) > (3) > (2)
C. (2) > (3) > (1)
D. (3) > (1) > (2)

53. < HKAL 2006 Paper IIA - 9 >

The refractive indices of water and glass are 1.33 and 1.50 respectively. Which of the following statements is/are correct ?

(1) Light travels faster in water than in glass.
(2) The frequency of light is reduced when it travels from water to glass.
(3) Light bends away from the normal when it travels from water to glass.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

54. < HKAL 2007 Paper IIA - 9 >

A diver at a depth of d below the water surface looks up and finds that the sky appears to be within a circle of radius r. Which of the correctly gives the expression for the critical angle of water ?

A. $\tan c = \frac{r}{d}$
B. $\sin c = \frac{r}{d}$
C. $\tan c = \frac{d}{r}$
D. $\sin c = \frac{d}{r}$

55. < HKAL 2013 Paper IIA - 15 >

A point source of light is situated at the bottom of a swimming pool. It is found that a circular patch of radius 1.7 m is illuminated on the water surface. Find the depth of water in the pool.

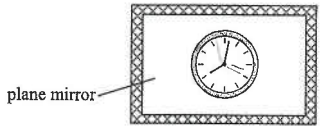
Given : refractive index of water = 1.33

A. 1.2 m
B. 1.3 m
C. 1.4 m
D. 1.5 m

Provided by dse.life

Part C : HKDSE examination questions

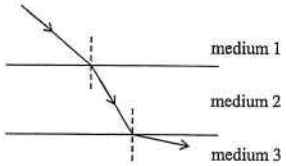
56. < HKDSE Sample Paper IA - 15 >



The diagram shows the image of a clock formed in a plane mirror. What is the time displayed by the clock ?

A. 3:58
B. 4:02
C. 7:58
D. 8:02

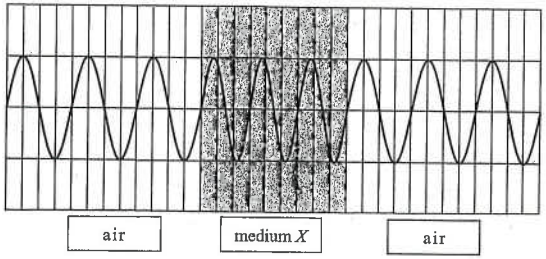
57. < HKDSE Practice Paper IA - 20 >



As shown in the figure, a ray of light travels from medium 1 to medium 2, and then enters medium 3. The boundaries are parallel to each other. Arrange the speed of light, c, in the three media in **ascending** order.

A. $c_3 < c_2 < c_1$
B. $c_3 < c_1 < c_2$
C. $c_2 < c_3 < c_1$
D. $c_2 < c_1 < c_3$

58. < HKDSE 2012 Paper IA - 17 >

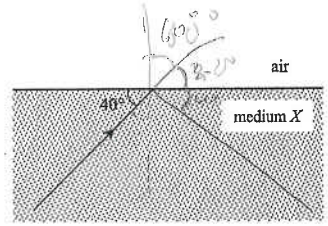


A certain monochromatic light passes through medium X as shown above. What is the refractive index of medium X ?

A. 1.25
B. 1.33
C. 1.50
D. 1.65

59. < HKDSE 2013 Paper IA - 20 >

A ray of light is travelling from a transparent medium X to air making an angle of 40° with the boundary plane as shown. If the angle between the refracted ray in air and the reflected ray in medium X is 70°, find the refractive index of medium X.



A. $\frac{\sin 40°}{\sin 30°}$
B. $\frac{\sin 30°}{\sin 40°}$
C. $\frac{\sin 60°}{\sin 50°}$
D. $\frac{\sin 50°}{\sin 60°}$

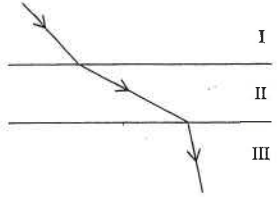
60. < HKDSE 2013 Paper IA - 21 >

White light can be resolved into its component colours by using a glass prism. Which of the following statements is/are correct ?

(1) The refractive indices of glass for different component colours are not the same.
(2) Red light travels faster than violet light in a vacuum.
(3) The frequencies of all the component colours are reduced when entering the prism.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

61. < HKDSE 2014 Paper IA - 15 >



The figure shows the path of a light ray travelling from medium I to medium III separated by parallel boundaries. Arrange in **ascending order** the speed of light in the respective media.

A. I < III < II
B. II < III < I
C. III < I < II
D. III < II < I

62. < HKDSE 2016 Paper IA - 20 >

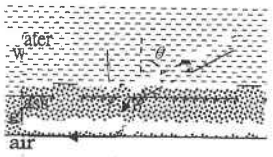
A beam of white light is separated into different colours after entering a glass prism because lights of different colours

A. are diffracted to different extents by the prism.
B. undergo total internal reflection at different angles inside the prism.
C. travel at different speeds in vacuum.
D. travel at different speeds in glass.

Provided by dse.life

63. **< HKDSE 2016 Paper IA - 17 >**

A parallel-sided glass sheet separates water from air. A ray of light in water is incident at an angle θ on the glass sheet and finally emerges into air along the glass-air interface as shown. Find θ.

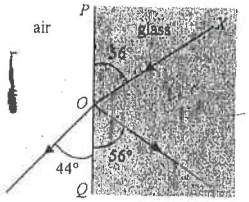


Given : refractive index of water is 1.33.

A. 41.2°
B. 48.8°
C. 53.1°
D. It depends on the refractive index of glass.

64. **< HKDSE 2018 Paper IA - 17 >**

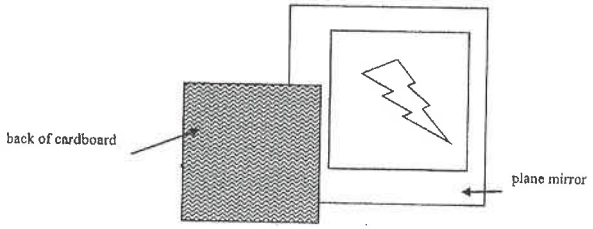
In the figure above, XO is a light ray incident on the glass-air boundary plane PQ. Which of the following gives the refractive index of glass ?



A. sin 56° / ~~sin 44°~~
B. sin 44° / ~~sin 34°~~
C. sin 56° / ~~sin 46°~~
D. sin 46° / ~~sin 34°~~

65. **< HKDSE 2018 Paper IA - 20 >**

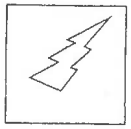
The figure shows the image seen when a plane mirror is placed in front of a cardboard with a design on its front surface.



Which diagram below shows the design on the cardboard ?

A.


B.


C.


D.


HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. A	11. C	21. D	31. D	41. A
2. C	12. A	22. D	32. D	42. B
3. D	13. D	23. A	33. C	43. A
4. A	14. C	24. C	34. A	44. D
5. B	15. B	25. D	35. B	45. C
6. C	16. D	26. D	36. A	46. B
7. B	17. A	27. A	37. D	47. B
8. A	18. D	28. C	38. B	48. B
9. C	19. B	29. A	39. B	49. C
10. C	20. B	30. B	40. B	50. D
51. B	61. C			
52. B	62. D			
53. A	63. B			
54. A	64. D			
55. D	65. D			
56. A	66. **B**			
57. D	67. C			
58. B	68. A			
59. C				
60. A				

M.C. Solution

1 A

Normal is the line passing through the contact point and the centre of sphere.

From water to air : denser medium to less dense medium ⇒ bend away from normal ⇒ the upper light ray is correct

From air to water : less dense medium to denser medium ⇒ bend towards normal ⇒ ray P is correct

2. C

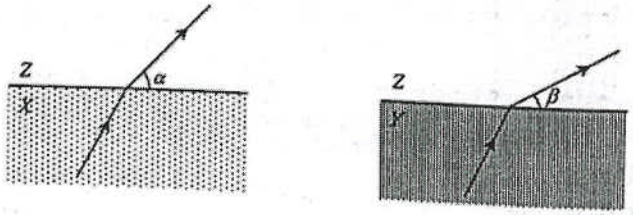
Mirror is moved 0.10 m away ⇒ Object distance increases by 0.10 m and image distance increases by 0.10 m
⇒ Distance between object and image increases by 0.20 m
⇒ Image moves by 0.20 m (for a fixed object)

Provided by dse.life

66. <HKDSE 2019 Paper IA-17>

67. <HKDSE 2020 Paper IA-13>

Monochromatic light travels with the same incident angle from media X and Y respectively to another medium Z as shown.



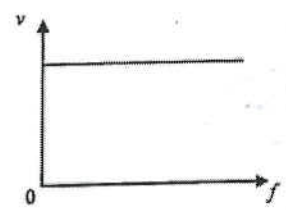
The corresponding refracted rays in Z make angles α and β respectively with the boundary plane (with $\alpha > \beta$). Which medium, X or Y, has a greater refractive index ? In which medium, X or Y, does light travel faster ?

	medium with a greater refractive index	medium in which light travels faster
A.	X	X
B.	X	Y
C.	Y	X
D.	Y	Y

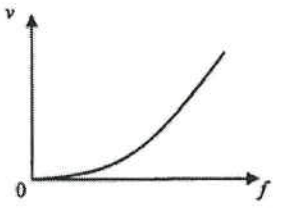
68. <HKDSE 2020 Paper IA-16>

A transverse wave propagates along a stretched string. Which graph below correctly shows the variation of the speed v of the wave with its frequency f ?

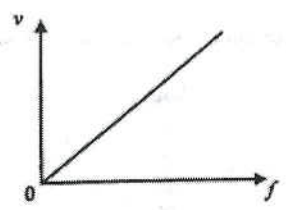
A.



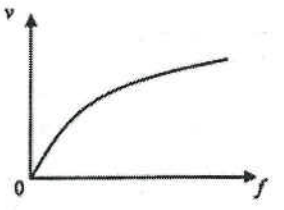
B.



C.



D.



Provided by dse.life

3. D

× (1) Frequency remains unchanged during the refraction of light from one medium into another.

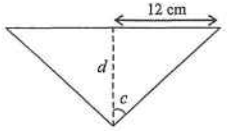
✓ (2) Wavelength must change during the refraction.

✓ (3) Since velocity depends on medium, velocity must change when light travels from one medium to another.

4. A

$\sin c = \frac{1}{1.25}$ $\therefore$ $c = 53.1°$

$\tan(53.1°) = \frac{12}{d}$ $\therefore$ $d = 9$ cm



5. B

$\sin c = \frac{1}{1.35}$ $\therefore$ $c = 48°$

$i = 42°$ $\Rightarrow$ $i < c$ $\therefore$ total internal reflection does not occur

Liquid $\rightarrow$ air $\Rightarrow$ denser medium to less dense medium $\Rightarrow$ light ray bends away from normal

$\therefore$ Ray Q is the correct emergent light ray under refraction

6. C

✓ (1) The speed of light in vacuum is a universal constant, not affected by any factors.

✓ (2) When light enters a less dense medium, e.g. from glass to air, the wavelength must increase.

× (3) Frequency must be unchanged when light enters a less dense medium.

7. B

Incident ray passes through centre of circle $\therefore$ incident ray lies on the normal

$\Rightarrow$ $i = 0°$ $\therefore$ $r = 0°$

$\Rightarrow$ emerged ray does not change direction from glass to air

8. A

The observer is in water

$\therefore$ apparent height of the aeroplane is greater than the real height due to refraction

$\therefore$ image of aeroplane should be above the object, thus it appears at the position P

9. C

From Y to X : optical denser medium to less dense medium

$\Rightarrow$ bend away from normal $\Rightarrow$ the right ray is correct

From X to Y : optical less dense medium to denser medium

$\Rightarrow$ bend towards normal $\Rightarrow$ ray R is correct

10. C

× (1) angle between incident ray and normal = 48° $\therefore$ $i > c$
$\Rightarrow$ total internal reflection occurs $\therefore$ no refracted ray

✓ (2) Incident angle : $i = 45°$ $\therefore$ $i > c$ $\Rightarrow$ total internal reflection occurs

✓ (3) Incident angle : $i = 60°$ $\therefore$ $i > c$ $\Rightarrow$ total internal reflection occurs

11. C

× A. refracted angle $\neq$ reflected angle

× B. There must be a reflected ray.

✓ C. incident angle = reflected angle and refracted ray bends away from normal

× D. There exists no top left light ray.

12. A

× (1) Glass is a optically dense medium than air, thus total internal reflection would never occur.

✓ (2) From water to air, light travels from denser to less dense medium.
For water, $\sin c = \frac{1}{1.33}$, critical angle $c = 48.8°$, thus, $i > c$, total internal reflection occurs.

× (3) Glass is a denser medium than water as its refractive index is greater,
thus total internal reflection would never occur.

13. D

✓ (1) due to refraction of light ray from water to air bends away from normal

✓ (2) due to refraction of light ray from water to air bends away from normal

✓ (3) due to refraction of different colours of light having different refractive index in glass

14. C

$n = \frac{\sin\theta_{air}}{\sin\phi} = \frac{\sin 45°}{\sin 30°} = 1.41$

15. B

✓ (1) Optical fibres make use of total internal reflection for transmission of signal without loss of energy

✓ (2) A prismatic periscope uses two prisms to reflect light,
light rays under total internal reflection so that no multiple images are formed

× (3) Plane mirror makes use of reflection, but not total internal reflection.

16. D

From air to glass $\Rightarrow$ from less dense medium to denser medium

$\Rightarrow$ refracted ray bends towards the normal

Some of the incident ray undergoes reflection to give the reflected ray

Provided by dse.life

17. A

$$n = \frac{\sin\theta_{air}}{\sin\theta_{medium}} = \frac{\sin\theta}{\sin\phi}$$

$\therefore$ slope of the graph of sin θ against sin ϕ = refractive index of the glass n

18. D

Air → glass : less dense to denser ⇒ bend towards normal ⇒ either A or D is correct

Glass → air : denser to less dense ⇒ bend away from normal ⇒ D is correct

19. B

✓ (1) Diamond cutting makes use of total internal reflection to give sparkling effect

✓ (2) Mirage occurs when light in air undergoing total internal reflection.

× (3) The ruler that seems bent involves refraction only

20. B

✓ (1) Due to refraction of light, the actual position of the fish is different from the image of the fish

✓ (2) Different colours of light undergo different degree of refraction to give the spectrum

× (3) A glass fibre makes use of total internal reflection to transmit the light ray.

21. D

Direction of travel :

(1) Enter into air cavity ⇒ denser → less dense ⇒ bends away from normal

(2) Leave the air cavity ⇒ less dense → denser ⇒ bends towards the normal

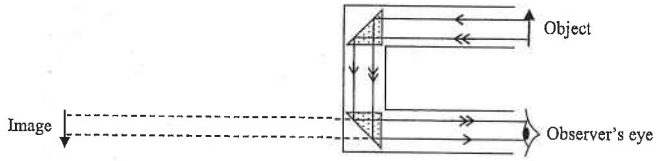
In addition, red light should have the least deviation.

22. D

Air → glass : The light bends towards the normal.

Glass → air : The light bends away from normal.

23. A



As shown in the figure, the image observed by the eye is inverted.

24. C

Angle between edge of the glass block and incident light = 47°

$\therefore$ $i = 90° - 47° = 43°$

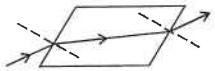
As the emergent angle is 90°, the incident angle 43° is the critical angle of glass

$\therefore$ $n = \frac{1}{\sin 43°} = 1.47$

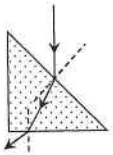
25. D

air → glass, more optically denser, the ray will bend towards normal.

glass → air, optically less dense, the ray will bend away from normal.



26. D



When light travels from air into glass, it bends towards the normal.

When light travels from glass to air, it bends away from the normal.

27. A

The pool of calm water acts as a plane mirror to give the image.

28. C

Images of Martha and Eric are at the same distance behind the mirror as the objects.

Thus, image of Martha is at 3 m behind the mirror.

Distance between Eric and image of Martha = 1 + 3 = 4 m

29. A

Since the image formed by a plane mirror is laterally inverted, the object should be as shown in the figure.

Thus the actual time is 3:58.

30. B

✓ (1) The blackboard has rough surface and thus gives diffuse reflection.

× (2) A polished metal surface has very smooth surface and thus gives regular reflection, not diffuse reflection.

✓ (3) The paper surface of a page in this book is rough and thus gives diffuse reflection.

Provided by dse.life

31. D

Since the incident angle is 45°, as total internal reflection occurs, the incident angle must be greater than the critical angle,

$\therefore\ i > c \qquad \therefore\ 45° > c \qquad$ or $\qquad c < 45°$

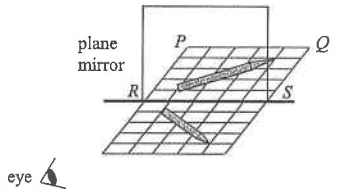
By $\sin c = \frac{1}{n}$, critical angle of different materials can be found.

× (1) A refractive index of 1.35 gives a critical angle of 47.8°, that is greater than 45°.

✓ (2) A refractive index of 1.45 gives a critical angle of 43.6°, that is smaller than 45°.

✓ (3) A refractive index of 1.55 gives a critical angle of 40.2°, that is smaller than 45°.

32. D



The image formed by a plane mirror is virtual, erect and same size.

33. C

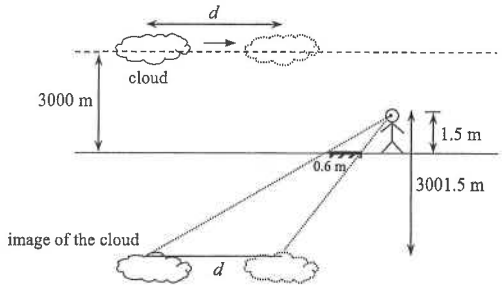
By use of the two similar triangles,

$\frac{d}{0.6} = \frac{3001.5}{1.5}$

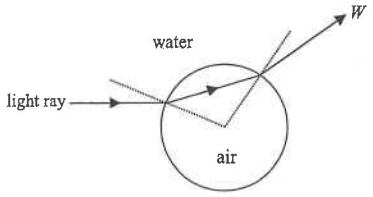
$\therefore\ d = 1200.6 \approx 1200$ m

Speed of the cloud :

$v = \frac{d}{t} = \frac{1200}{20} = 60\ \text{m s}^{-1}$



34. A



The light bends away from the normal from water to air.

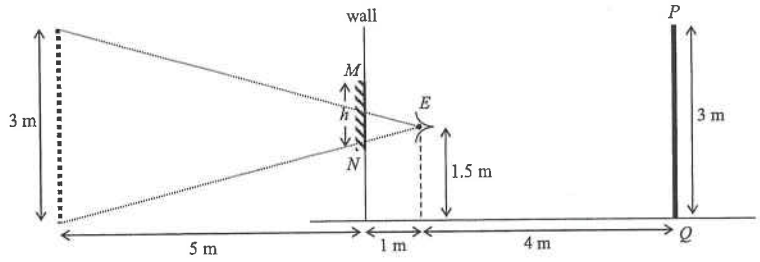
The light then bends towards the normal from air to water.

35. B

$n_X = \frac{\sin\theta_{air}}{\sin\theta_X}$

$\therefore\ \frac{\sin 50°}{\sin r} = n_X = \frac{\sin r}{\sin 35°} \qquad \therefore\ r = 41.5°$

36. A



Consider the image at the same distance behind the mirror.

The image height is 3 m and the image distance is 5 m.

By similar triangles, $\frac{h}{3} = \frac{1}{1+5} \qquad \therefore\ h = 0.5$ m

37. D

$n = \frac{\sin\theta_{air}}{\sin\theta_{glass}} = \frac{\sin(90° - \phi)}{\sin(90° - \theta)}$

38. B

× (1) The angle of incidence should be greater than the critical angle for total internal reflection to occur.

× (2) No refracted ray appears if total internal reflection occurs.

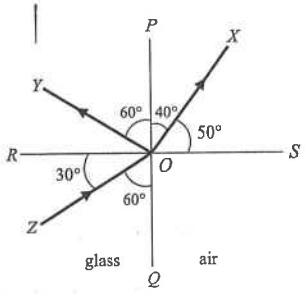
✓ (3) Total internal reflection occurs only if the ray travels from an optically denser medium to an optically less dense medium

39. B

× (1) OZ should be the incident ray with incident angle of 30°.

× (2) PQ should be the air-glass boundary.

✓ (3) The light ray travels from glass to air as shown, OX is the refracted ray and OY is the reflected ray.



Provided by dse.life

40. B

In X, total internal reflection occurs at the incident angle of 45°, thus $i > c$, the critical angle is less than 45°

In Y, total internal reflection does not occur at the incident angle of 45°, thus $i < c$, the critical angle is greater than 45°

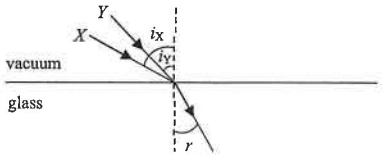
In Z, total internal reflection just occurs at the incident angle of 45°, thus the critical angle is 45°.

The critical angles are in the order of $Y > Z > X$.

By $n = 1 / \sin c$, the greater the critical angle, the smaller is the refractive index.

Thus, the refractive indices are in the order of $X > Z > Y$.

41. A



As shown in the figure, both of the rays have the same refracted angle but the incident angle of X is greater than that of Y.

By $n = \sin i / \sin r$, greater incident angle i gives greater refractive index n, thus X has greater refractive index in glass.

Since both X and Y are electromagnetic waves, they must have the same speed in vacuum.

42. B

	P	Q	R	S
$\sin i$	0.342	0.643	0.866	0.985
$\sin r$	0.242	0.375	0.616	0.695
$\sin i / \sin r$	1.41	1.71	1.41	1.42

In refraction, the ratio of $\sin i / \sin r$ should be approximately constant.

The data of Q gives a different ratio, thus it should be wrong.

43. A

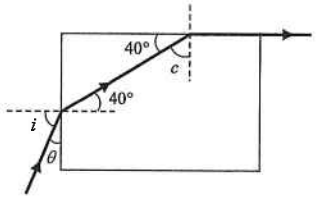
From the figure, critical angle c is 50°.

By $n = \dfrac{1}{\sin c} = \dfrac{1}{\sin 50°} = 1.305$

When light ray enters the block from air,
incident angle is i and refracted angle is 40°.

By $n = \dfrac{\sin i}{\sin r}$ $\quad \therefore \ (1.305) = \dfrac{\sin i}{\sin 40°}$

$\therefore \ i = 57°$ $\quad \therefore \ \theta = 90° - 57° = 33°$



44. D

✓ (1) Since total internal reflection occurs along the optical fibre, less data is lost in transmission.

✓ (2) Light waves can carry more data than radio waves, thus data can be transmitted at a higher rate.

✓ (3) Optical fibres are thinner than copper wires, thus they take up less space.

45. C

When light travels from air to glass, speed decreases, frequency remains unchanged, and wavelength decreases.

46. B

× (1) The image is virtual since the calm water surface acts as a plane mirror that can only give virtual image.

✓ (2) If the water surface is calm, then regular reflection occurs to give a clear image.

× (3) The size of the image must be always same as the object, and is not affected by the object distance.

47. B

✓ (1) This is possible as the critical angle is 50°, the refracted angle is 40° when light enters the block.

✓ (2) This is possible as the refracted angle is 45° when light enters the block,
the incident angle is also 45° when light leaves the block.

× (3) This is **impossible** as the critical angle is 40°, but the refracted angle is 50° when light enters the block.

48. B

$n = \dfrac{v_a}{v_m}$ $\quad \therefore \ n = \dfrac{(3\times10^8)}{(1.6\times10^8)}$ $\quad \therefore \ n = 1.875$

$n = \dfrac{1}{\sin c}$ $\quad \therefore \ (1.875) = \dfrac{1}{\sin c}$ $\quad \therefore \ c = 32.2°$

49. C

Intensity of refracted beam drops to zero when $\theta = 30°$, thus the critical angle $c = 30°$

Refractive index of the medium X: $n_X = \dfrac{1}{\sin c} = \dfrac{1}{\sin 30°} = 2$

Refractive index can be defined as the ratio of speed of light in air to that in the medium.

$n_X = \dfrac{v_{air}}{v_X}$ $\quad \therefore \ \dfrac{v_{air}}{v_X} = 2$

50. D

× (1) Frequency remains unchanged when light travels from glass to air.

✓ (2) Light travels with a greater speed in air than in glass.

✓ (3) Wavelength must increase when light travels from glass to air, as $\lambda \propto v$ during refraction.

51. B

By $n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$

$\therefore \ n \propto \dfrac{1}{\sin\theta}$

$\therefore \ \theta_2 > \theta_1 > \theta_3 \Rightarrow n_3 > n_1 > n_2$

Provided by dse.life

52. B

Since total internal reflection occurs when light travels from (2) to (1), there is no refraction in medium (1),

thus, $\sin\theta_1 > 1$.

From the figure, $\theta_3 > \theta_2$

$\therefore \sin\theta_1 > \sin\theta_3 > \sin\theta_2$

As $v \propto \sin\theta$

$\therefore v_1 > v_3 > v_2$

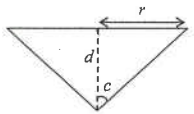
53. A

✓ (1) Since $v \propto \frac{1}{n}$, water has smaller refractive index, thus speed of light in water is faster.

× (2) When light travels from one medium to another medium during refraction, frequency is unchanged.

× (3) Since $\sin\theta \propto \frac{1}{n}$, glass has greater refractive index, thus angle of refraction in glass is smaller, light should bend towards the normal from water to glass.

54. A



This is the fisheye's view, which is a daily life examples of total internal reflection.

The semi-vertical angle is the critical angle.

Thus, $\tan c = \frac{r}{d}$.

55. D

$\sin c = \frac{1}{n} = \frac{1}{1.33}$ $\therefore c = 48.8°$

$\tan c = \frac{r}{d}$ $\therefore \tan 48.8° = \frac{(1.7)}{d}$ $\therefore d = 1.5$ m

56. A

image object

Since the image formed by a plane mirror is erect but laterally inverted, the object should be as shown in the figure.

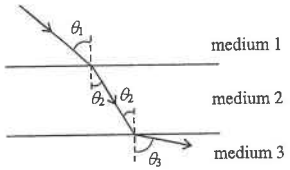
Thus the actual time is 3:58.

57. D

During refraction, speed $v \propto \sin\theta$

As $\theta_2 < \theta_1 < \theta_3$

$\therefore c_2 < c_1 < c_3$



OR

By $n_1\sin\theta_1 = n_2\sin\theta_2 = n_3\sin\theta_3$

As $\theta_2 < \theta_1 < \theta_3$

Thus, $n_2 > n_1 > n_3$

Since the speed of light in medium : $c \propto \frac{1}{n}$ $\therefore c_2 < c_1 < c_3$

58. B

Wavelength in air = 4 units

Wavelength in the medium X = 3 units

Refractive index : $n = \frac{\lambda_{air}}{\lambda_X} = \frac{4}{3} = 1.33$

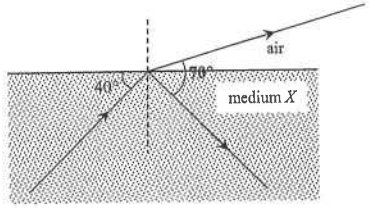
59. C

Incident angle in the medium X = 90° – 40° = 50°

By Law of reflection, reflected angle = incident angle

Reflected angle in medium X = 50°

Refracted angle in air = 180° – 70° – 50° = 60°



Refractive index of medium X :

$n = \frac{\sin\theta_{air}}{\sin\theta_X} = \frac{\sin 60°}{\sin 50°}$

60. A

✓ (1) Different colours of light have different speeds in glass, thus the refractive indices of glass for different colours are different.

× (2) In vacuum, all colours travel with the same speed.

× (3) The frequencies remain unchanged during the refraction when light travels from air to glass.

61. C

In the graph, draw the normal lines.

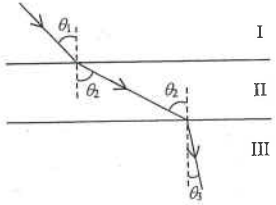
Make down the angles as shown.

From the graph,

$\theta_3 < \theta_1 < \theta_2$

As $\sin\theta \propto v$

$\therefore v_3 < v_1 < v_2$



Provided by dse.life

62. D

Different colours have different speeds in glass,
thus different colours have different refractive index in glass
and undergo different degrees of refraction
to split (disperse) into a visible light spectrum.

63. B

By $n_w \sin\theta_w = n_g \sin\theta_g = n_a \sin\theta_a$

$\therefore$ $(1.33)\sin\theta = (1)\sin 90°$ < refractive index of air is equal to 1 >

$\therefore$ $\theta = 48.8°$

64. D

Refractive index :

$$n = \frac{\sin\theta_{air}}{\sin\theta_{glass}} = \frac{\sin(90°-44°)}{\sin(90°-56°)} = \frac{\sin 46°}{\sin 34°}$$

65. D

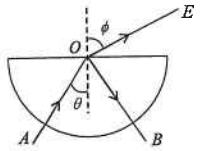
Since the image formed by a plane mirror must be erect and laterally inverted,
the object should be the one shown in option D.

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8\ m\ s^{-1}$

Part A : HKCE examination questions

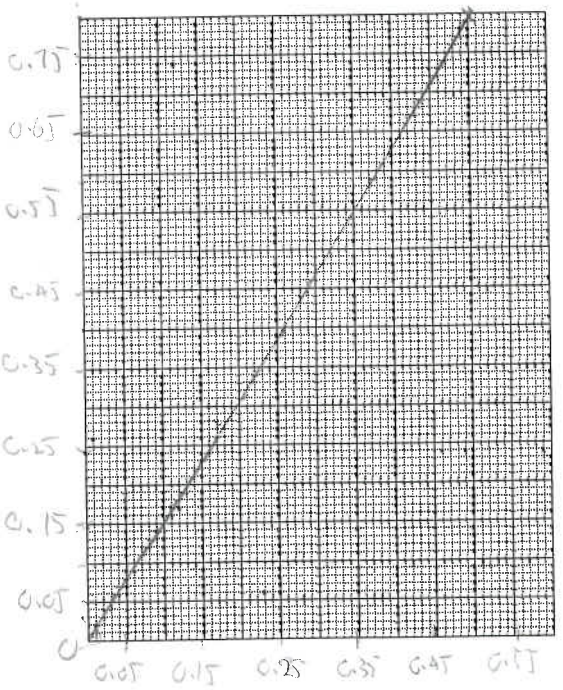
1. **< HKCE 1988 Paper I - 6 >**



The figure above shows a ray of light entering a semi-circular plastic block in direction AO and is refracted into the air along OE. Part of the light is then reflected along OB. A set of readings for different angles θ and ϕ are measured. The results are tabulated as follows :

θ	10°	15°	20°	25°	30°
ϕ	16.1°	24.5°	33.2°	42.5°	53.1°

(a) (i) Plot the graph of $\sin\phi$ (vertical axis) against $\sin\theta$ (horizontal axis) on a piece of graph paper using a scale of 1 cm to 0.05. (5 marks)



Provided by dse.life

1. (a) (ii) Find the slope of the graph and state its physical meaning. (3 marks)

(iii) Calculate the critical angle of the plastic. (2 marks)

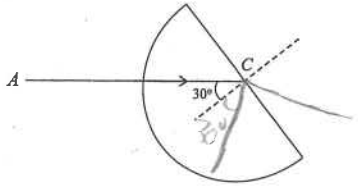
(b) Briefly describe the change in brightness of

(i) the refracted ray *OE* and

(ii) the reflected ray *OB*, as angle θ is gradually increased from 0° to nearly 90°. (3 marks)

(c) Describe briefly ONE application of total internal reflection in everyday life. (2 marks)

2. **< HKCE 1991 Paper I - 3 >**



The figure above shows a ray of red light entering a semi-circular glass block in the direction *AC*. The angle of incidence at *C* is 30°. The critical angle of red light for the glass block is 39°.

(a) How would the frequency, wavelength and speed of the ray be affected when it enters the glass block ? (3 marks)

(b) When the ray reaches *C*, it splits into two. On the above figure, sketch the two rays. (3 marks)

(c) Calculate

(i) the refractive index of the glass block, and (2 marks)

(ii) the angle of refraction of the ray on leaving the glass block. (2 marks)

2. (d) What happens if the ray reaches *C* with an angle of incidence greater than 39° ? (1 mark)

(e) A periscope consists of two right-angled prisms.

(i) Draw a ray diagram to show how the periscope works. (3 marks)

(ii) State one advantage of using right-angled prisms over plane mirrors. (1 mark)

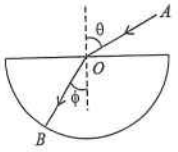
3. **< HKCE 1993 Paper I - 3 >**

Thin glass fibres can be used as a light guide.

(a) Explain, with the aid of a diagram, how a light ray is transmitted along a curved glass fibre. (3 marks)

(b) State one application of light guides. (1 mark)

4. **< HKCE 1993 Paper I - 3 >**



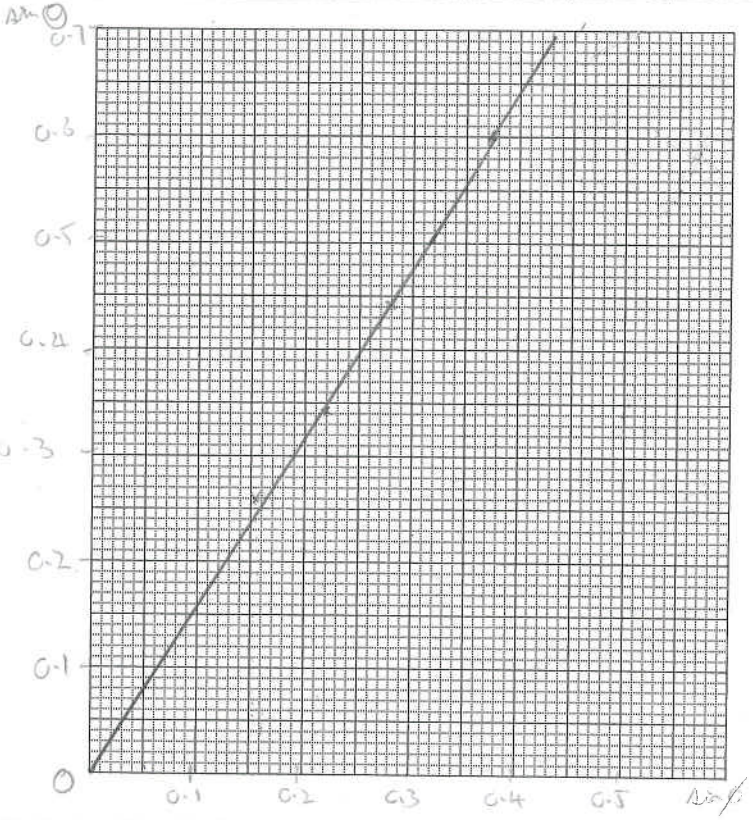
A ray of light travelling in the direction *AO* in air enters a semi-circular glass block as shown in the figure above. The ray is refracted along *OB* in the glass block. Different values of the angle of incidence θ are used and the corresponding values of the angle of refraction ϕ are measured. The following result is obtained :

θ	15°	20°	25°	30°	35°	40°
ϕ	9.0°	12.9°	16.3°	19.0°	22.3°	25.1°

Provided by dse.life

4. (a) Using a scale of 1 cm to 0.05, plot the graph of sin θ (vertical axis) against sin ϕ (horizontal axis) on graph paper. (5 marks)

sin θ	0.259	0.342	0.443	0.5	0.574	0.643
sin ϕ	0.156	0.223	0.281	0.326	0.379	0.424



(b) Find the slope of the graph and state its physical meaning. (3 marks)

(c) A student predicts that total internal reflection will occur when θ = 45°. Is he right or wrong ? Explain briefly. (3 marks)

5. **< HKCE 1995 Paper I - 3 >**

A boy 1.5 m tall stands a few metres in front of a plane mirror *AB* which is hung on a vertical wall. The boy's eyes are 1.4 m above the ground. He can see all of himself in the mirror. In Figure 1, *PQ* represents the boy and *E* is his eyes.

Figure 1

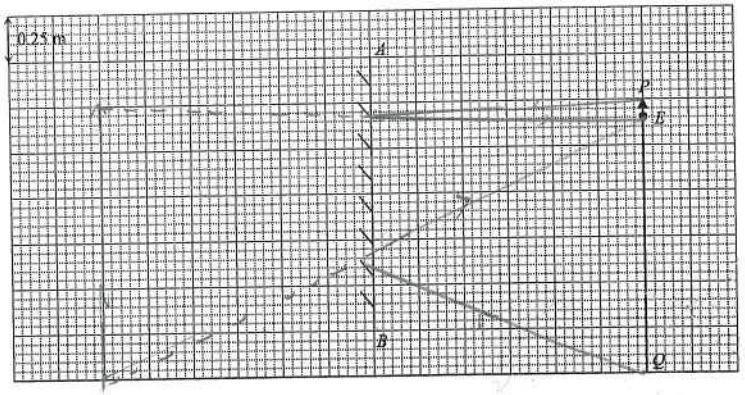
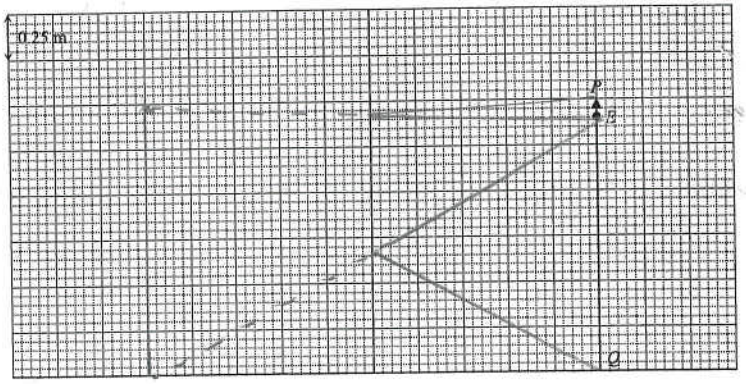


Figure 2



(a) State three properties of the boy's image as formed by the mirror. (2 marks)

(b) In Figure 1, draw

(1) the image of the boy formed by the mirror,

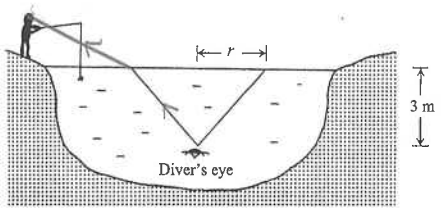
(2) the paths of two rays, one from *P* and one from *Q*, to show how the rays reach his eyes. (4 marks)

(c) Using (b), or otherwise, find the minimum length of the mirror *AB* for the boy to see all of himself. (2 marks)

(d) If the boy moves a few steps towards the mirror and the length of the mirror is equal to that found in part (c), can the boy still see all of himself in the mirror ? In Figure 2, draw a ray diagram to illustrate your answer. (3 marks)

Provided by dse.life

6. **< HKCE 1995 Paper I - 5 >**



A diver stays at a depth of 3 m under water in a lake. When the diver looks upwards, the scene above the water surface is compressed into a circular patch of radius r at the water surface as shown in the above figure. The refractive index of water is 1.33.

(a) Calculate

(i) the critical angle of the water, (2 marks)

(ii) the radius r. (2 marks)

(b) A fisherman stands beside the lake as shown in the above figure. Can the diver see the fisherman ? Draw a ray diagram in the above figure to illustrate your answer. (2 marks)

7. **< HKCE 2001 Paper I - 7 >**

(a)

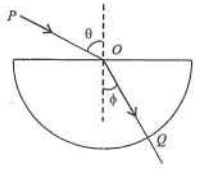


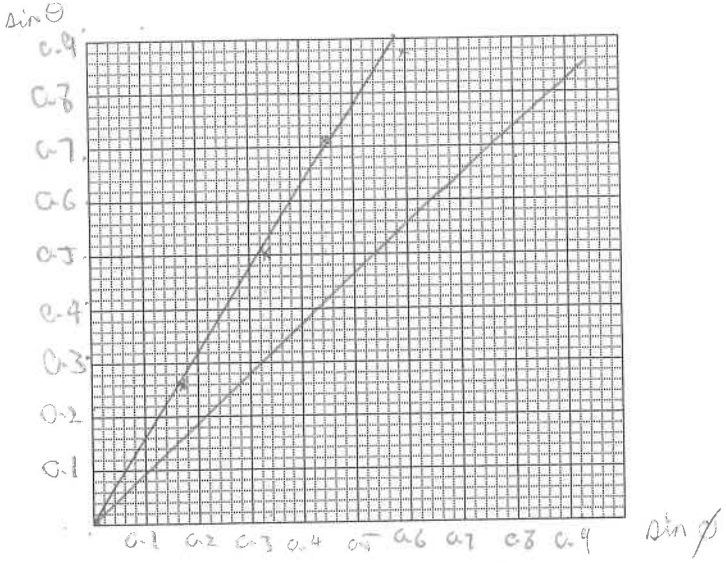
Figure 1

A ray of light travelling in air in the direction PO enters a semi-circular glass block as shown in Figure 1 above. The ray travels along the direction OQ inside the block. Different values of the angle of incidence θ and the corresponding values of ϕ, the angle between OQ and the normal, are measured. The following results are obtained :

θ	0	15°	30°	45°	60°
ϕ	0	9.5°	19.0°	27.0°	34.0°

(i) Name the wave phenomenon shown in the above figure. (1 mark)

7. (a) (ii) Using a scale of 1 cm to 0.1, plot a graph of sin θ against sin ϕ on graph paper. (5 marks)



(iii) Using the graph in (ii), find the critical angle of the glass. (3 marks)

(iv) If the glass block is replaced with a Perspex block with a **smaller** refractive index, on the same graph in (ii), draw the graph of sin θ against sin ϕ you expect to obtain. (2 marks)

(b) Given that the refractive index of diamond is 2.4 and the refractive index of glass is about 1.6, explain why a diamond sparkles more than a piece of glass of similar shape.

[Hint : You may consider the paths of rays entering the diamond and the glass from the top (see Figure 2).]

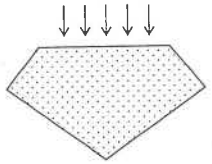


Figure 2

(3 marks)

Provided by dse.life

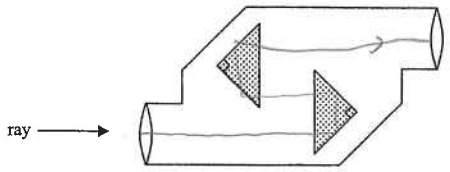
8. **< HKCE 2002 Paper I - 1 >**

(a) A plane mirror can be used as a rear-view driving mirror. State one advantage and one disadvantage of using the plane mirror as a driving mirror. (2 marks)

(b)

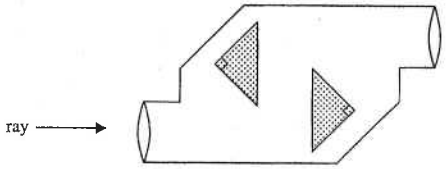
The Figure above shows an ambulance. Explain why the word AMBULANCE is printed in the form as shown in the figure. (2 marks)

9. **< HKCE 2002 Paper I - 1 >**



The Figure above shows the structure of part of a pair of binoculars, which consists of two triangular prisms.

(a) In the figure below, complete the path of the ray. (1 mark)



(b) Give one advantage of using triangular prisms over plane mirrors in making binoculars. (1 mark)

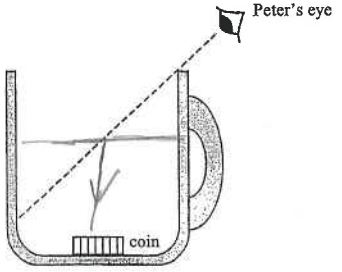
10. **< HKCE 2003 Paper I - 2 >**

(a) A ray of light travels from water to air with an angle of incidence 30°. The refractive index of water is 1.33.

(i) Find the angle of refraction of the ray in air. (2 marks)

(ii) Find the critical angle of water. (2 marks)

(b)



Peter places a coin in an empty cup. As shown in the above Figure, he **cannot** see the coin. After pouring some water into the cup, he finds that he can see the coin without changing the position of the cup or his eyes. In the above Figure, draw a ray diagram to illustrate how Peter can see the coin. (2 marks)

Provided by dse.life

11. < HKCE 2004 Paper I - 1 >

Figure 1

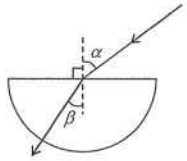
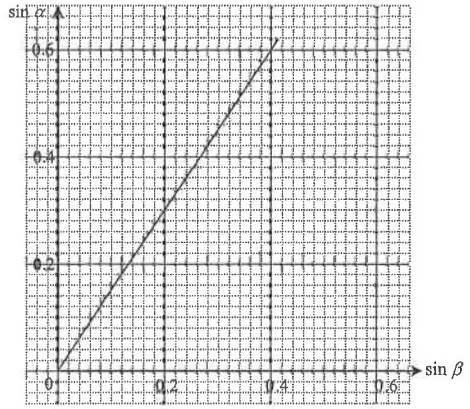


Figure 1 show a set-up used to study the relationship between the angle of incidence α and the angle of refraction β of a ray of light travelling from air into a semi-circular glass block. Figure 2 shows a graph of sin α against sin β.

Figure 2



(a) Find the slope of the graph in Figure 2 and state its physical meaning. (3 marks)

(b) Philip predicts that if α is increased to 50°, total internal reflection will occur. Explain whether he is correct or not. (2 marks)

12. < HKCE 2005 Paper I - 10 >

Optical fibres are widely used in telephone communication. The voice signals are transmitted in the form of light through optical fibres.

(a) Figure 1 shows a light ray travelling towards an optical fibre.

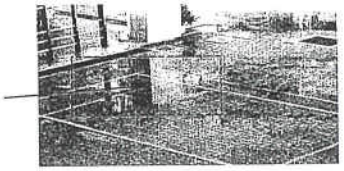
(i) In Figure 1, sketch the subsequent path of the ray. (2 marks)

(ii) Name the wave phenomenon that occurs as the ray travels inside the fibre. (1 mark)

(b) State two advantages of using optical fibres over copper wires in telephone communication. (2 marks)

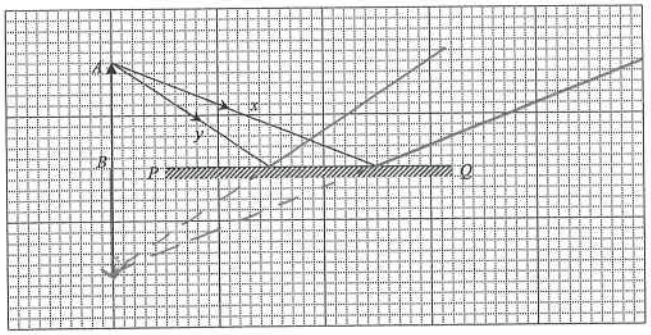
13. < HKCE 2007 Paper I - 5 >

The Figure below shows a playground after raining. Images can be seen on the calm water surface of the wet ground.



(a) Explain why images can be seen on the calm water surface. (2 marks)

(b) The Figure below shows an object AB above the water surface PQ.



In the Figure,

(i) draw the reflected rays of the incident rays x and y;

(ii) hence, draw the image of AB. (4 marks)

Provided by dse.life

14. **< HKCE 2008 Paper I - 10 >**

A teacher performs an experiment by directing a red light beam from air normally to the straight edge of a semi-circular glass block with centre O (see Figure 1). The refractive index of glass is 1.48.

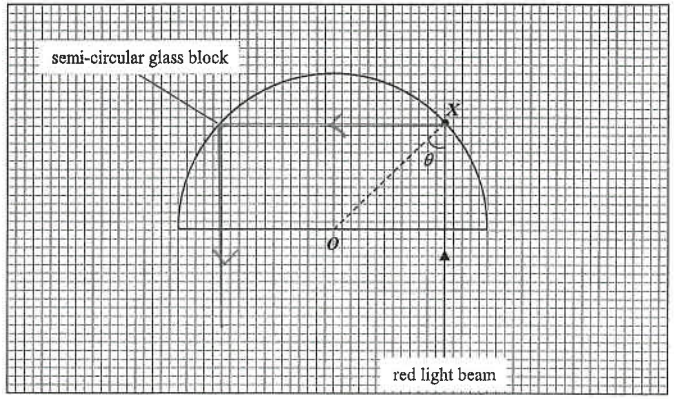


Figure 1

(a) Find the critical angle of the glass block. (2 marks)

(b) If $\theta = 45°$,

(i) describe and explain what happens when the light beam hits point X. (2 marks)

(ii) complete the path of the light beam in Figure 1 until it finally emerges from the glass block to the air. (2 marks)

(c) If the light beam travels in the same direction but with a shorter distance from O, with $\theta < 40°$, sketch the path of the refracted beam at Y and mark the angle of refraction as r in Figure 2. (2 marks)

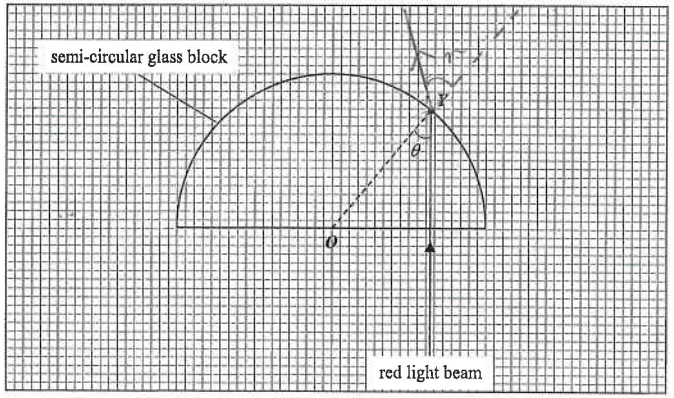


Figure 2

15. **< HKCE 2011 Paper I - 4 >**

It is known that the refractive index of glass is different for light of different wavelengths. Figure (a) shows a blue light ray passing through a glass prism. Some angles are measured as shown.

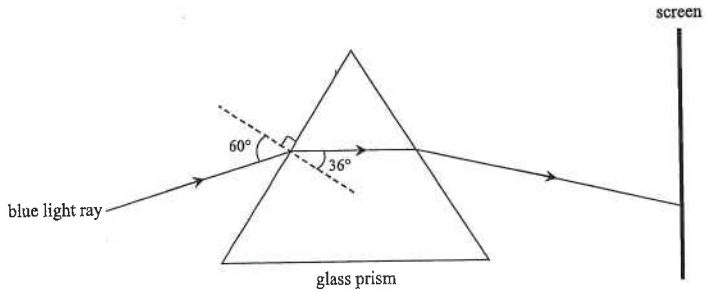


Figure (a)

(a) Determine the refractive index of glass for blue light. (2 marks)

It is known that the refractive index of glass for red light is smaller than that for blue light.

(b) Now, the blue light ray is replaced by a red light ray as shown in Figure (b). The dotted line (– · – · – · –) shows the original path of the blue light ray. Sketch the path of the red light ray in Figure (b). (2 marks)

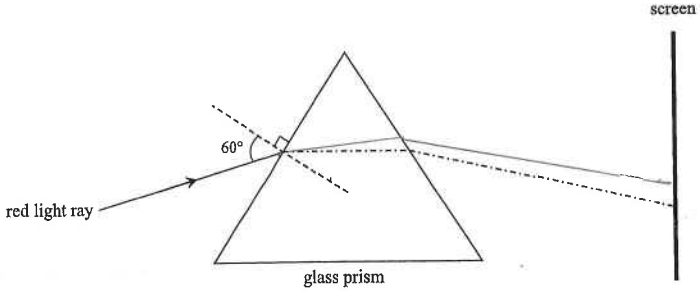


Figure (b)

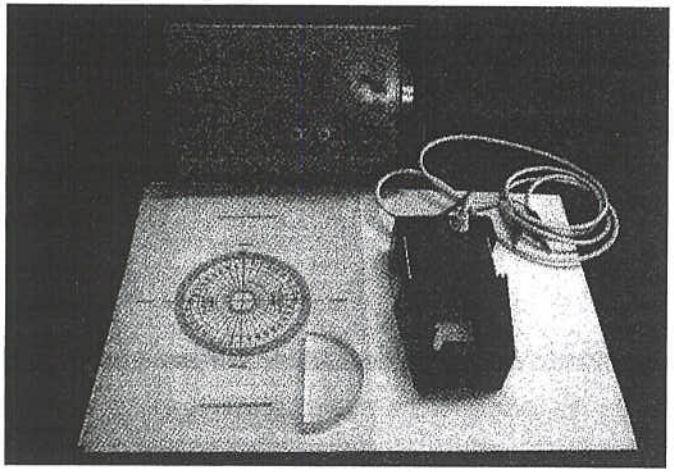
Provided by dse.life

Part B : HKDSE examination questions

16. < HKDSE Practice Paper IB - 6 >

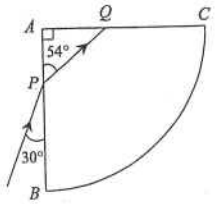
The Figure below shows the following apparatus :

A low voltage power supply, a ray box with a single slit, a full scale protractor and a semi-circular glass block.



Describe how to use the above apparatus to measure the critical angle of the semi-circular glass block. (5 marks)

17. < HKDSE 2014 Paper IB - 5 >

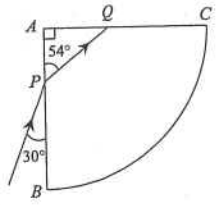


The Figure above shows the cross-section of glass block ABC. ABC is a quarter circle with its centre at A. A ray of red light is incident at P on face AB and the refracted ray strikes the face AC at Q as shown.

(a) Calculate the refractive index of the glass for red light. (2 marks)

(b) Explain why the ray is totally reflected when it strikes the face AC at Q. (2 marks)

(c) In the Figure, sketch the subsequent path of the ray until it finally emerges from the block to the air. (2 marks)



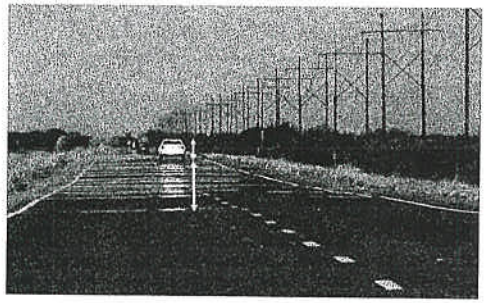
(d) If the incident ray is a ray of white light, what can be observed when it finally emerges from the block ? (1 mark)

Provided by dse.life

18. **< HKDSE 2015 Paper IB - 6 >**

Read the following description about a **mirage** and answer the questions that follow.

A mirage is often seen on highways during hot summers. Pools of water seem to cover the roadway far ahead. Distant objects appear to be reflected by the surface of the 'water'. The phenomenon is caused by the difference in refractive index between the hot air near the road surface and the cooler air above it. The refractive index of cool air is greater than that of hot air, but the differences are so small that the subsequent deviations of light rays are tiny. Sufficiently large temperature difference between the hot air near the road surface and the above cooler air over a short height (i.e. high temperature gradient) and light rays travelling along sufficient long path lengths are required to form a mirage.



The Figure above shows the mirage seen on a highway. This photo was taken with a telephoto lens which gives the perception that the viewer is very close to the car ahead.

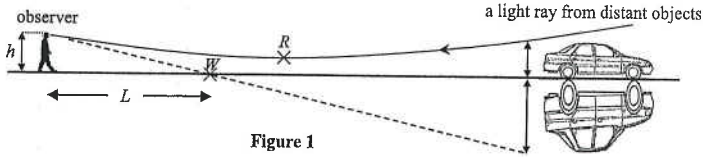


Figure 1

Figure 1 and 2 illustrate the principle of the phenomenon. Air of different temperature is simplified to several layers and modeled as parallel slabs as shown in Figure (b). The bending of the light ray from distant objects is much exaggerated. θ_1, θ_2, θ_3 and θ_4 denote the angles of incidence at various boundaries of air layers.

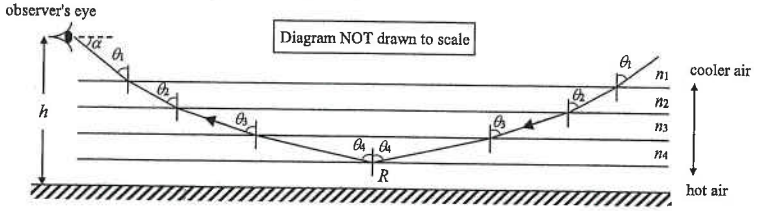


Figure 2

(a) State ONE essential condition for a mirage to be observed. (1 mark)

18. (b) (i) Referring to Figure 2, deduce the relationship between θ_1, θ_4 and refractive index n_1, n_4. For total internal reflection just to occur at R, θ_4 can be taken as 90°. Hence, find the corresponding value of θ_1 if $n_1 = 1.000261$ and $n_4 = 1.000221$. (3 marks)

(ii) Find L in Figure 1 if $h = 1.5$ m. (Note : $\alpha + \theta_1 = 90°$ in Figure 2.) (2 marks)

(c) A thirsty traveller in a vast desert sees similar mirages such that a 'water source' appears at W which is distance L away like the one in Figure 1. If he walks a distance L towards the 'water source', how far would the 'water source' appear to him ? Explain your answer. (2 marks)

19. **< HKDSE 2017 Paper IB - 7 >**

(a) A light ray enters a rectangular plastic block $ABCD$ from air at point E, and the angle of incidence is θ. The light ray emerges along face BC as shown in Figure (a). The refractive index of the plastic is 1.36.

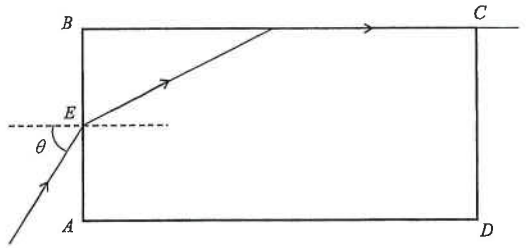


Figure (a)

(i) Find the critical angle of the plastic. (2 marks)

Provided by dse.life

19. (a) (ii) Find the value of θ. (3 marks)

(iii) If the light ray enters the plastic block at point E with an angle of incidence larger than θ, sketch the path of the light ray in Figure (a). (2 marks)

(b) A student designs a periscope using two plastic prisms, the refractive index of the plastic is 1.36. As shown in Figure (b), an object is placed in front of the periscope.

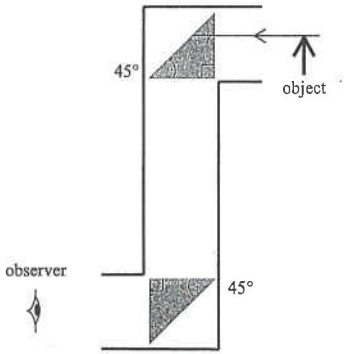


Figure (b)

(i) Complete the path of the light ray from the object in Figure (b), and explain why the periscope fails to work. (3 marks)

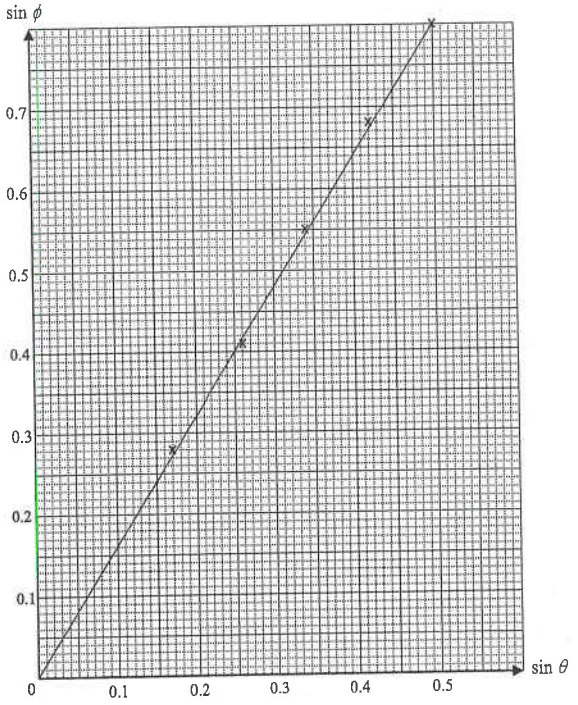
(ii) What can be used to replace the two plastic prisms so that the periscope can work properly ? (1 mark)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i)

$\sin\theta$	0.17	0.26	0.34	0.42	0.5
$\sin\phi$	0.28	0.41	0.55	0.68	0.80



< Correct label of axis > [1]

< Correct scale > [1]

< Correct points > (1/2 mark each, up to maximum of 2 marks) [2]

< Straight line > [1]

(ii) Slope $= \frac{0.8}{0.5}$ [1]

$= 1.6$ < from 1.58 to 1.66 is accepted > [1]

The slope is equal to the **refractive index** of the plastic. [1]

Provided by dse.life

1. (a) (iii) $\sin c = \frac{1}{n} = \frac{1}{1.62}$ [1]

$\therefore \quad c = 38.1°$ < from 36.5° to 39.7° is accepted > [1]

(b) (i) Brightness of *OE* gradually decreases and [1]

the brightness becomes zero after $\theta = c$ [1]

(ii) Brightness of *OB* gradually increases

and then becomes very bright after $\theta = c$ [1]

(c) Optical fibres [1]

used in telecommunication [1]

OR

Endoscope [1]

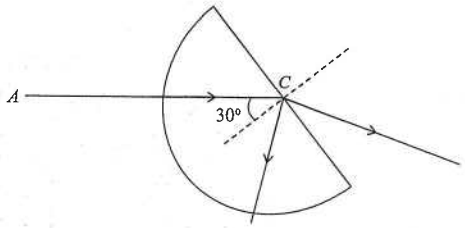
to examine the internal organs of patient [1]

2. (a) The frequency remains unchanged. [1]

The speed of the ray decreases. [1]

The wavelength of the ray decreases. [1]

(b)



< reflected ray drawn correct > [1]

< refracted ray drawn > [1]

< refracted ray bent away from normal > [1]

(c) (i) $n = \frac{1}{\sin c} = \frac{1}{\sin 39°}$ [1]

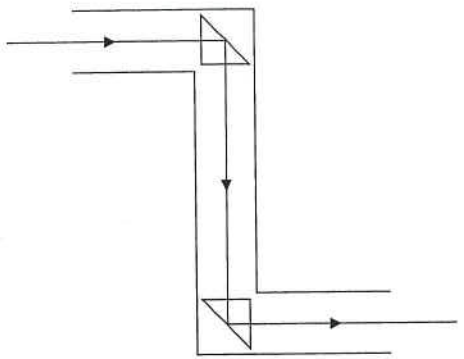
$\therefore \quad n = 1.59$ [1]

(ii) $\frac{\sin \theta}{\sin 30°} = 1.59$ [1]

$\therefore \quad \theta = 52.7°$ [1]

2. (d) Total internal reflection occurs [1]

(e) (i)



< Correct position of prisms > [1]

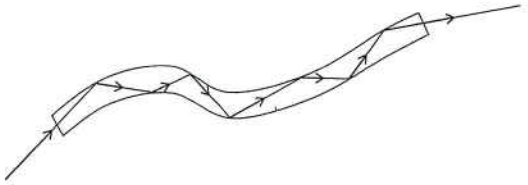
< Correct orientation of prisms > [1]

< Correct light ray > [1]

(ii) Any **ONE** of the following : [1]

* Prisms do not have multiple reflections.
* Prisms do not give multiple images.
* The image will be clearer.
* The image will be brighter.

3. (a)



[2]

< light ray travels from end to the other end > [1]

< a few total internal reflection occurs > [1]

The ray travels along the glass fibre by total internal reflection. [1]

(b) Any **ONE** of the following [1]

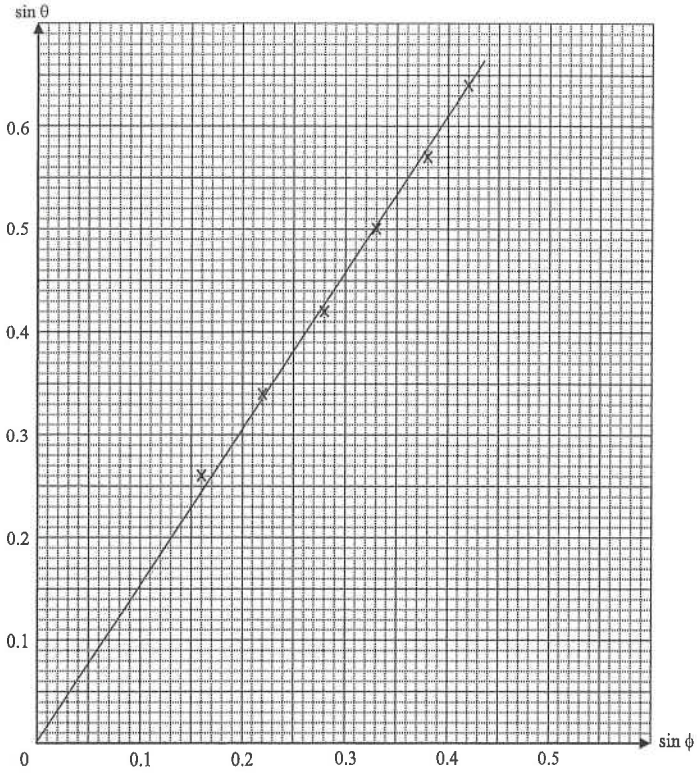
* Telecommunications
* Endoscope for internal examination of patients

Provided by dse.life

4. (a)

$\sin\theta$	0.26	0.34	0.42	0.50	0.57	0.64
$\sin\phi$	0.16	0.22	0.28	0.33	0.38	0.42

[1]



< Correct labelled axes > [1]

< Correct scale > [1]

< Correct points > [1]

< Straight lines > [1]

(b) Slope $= \dfrac{0.64}{0.42}$ [1]

$= 1.52$ < from 1.48 to 1.56 is acceptable > [1]

The slope represents the refractive index of glass. [1]

4. (c) He is wrong [1]

because total internal reflection would not happen [1]

when light travels from air to glass (OR from a less dense medium to a denser medium) [1]

< OR >

He is wrong [1]

because total internal reflection can only occur [1]

when light travels from a denser medium to a less dense medium [1]

5. (a) Any **THREE** of the following : [2]

- virtual
- erect
- same size as the object
- laterally inverted
- image distance is equal to the object distance

(b)

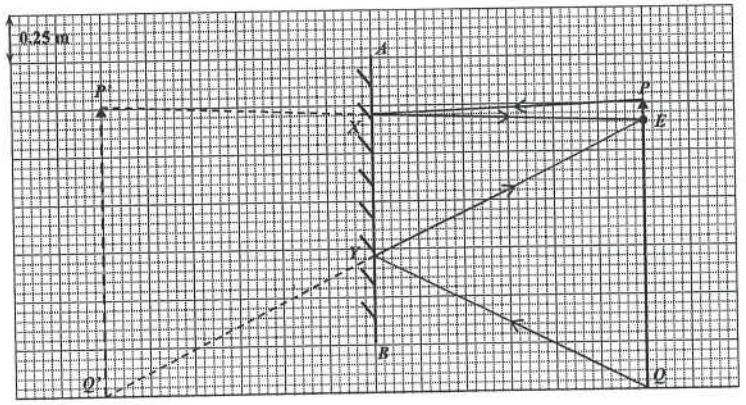


Figure 1

< Position of image correct > [1]

< Height of image correct > [1]

< Ray from P correctly reflected > [1]

< Ray from Q correctly reflected > [1]

(c) From the above diagram,

minimum length of mirror = distance between points X and Y

= 0.75 m (± 0.03 m) [2]

Provided by dse.life

5. (d) Yes, the boy can still see all of himself. [1]

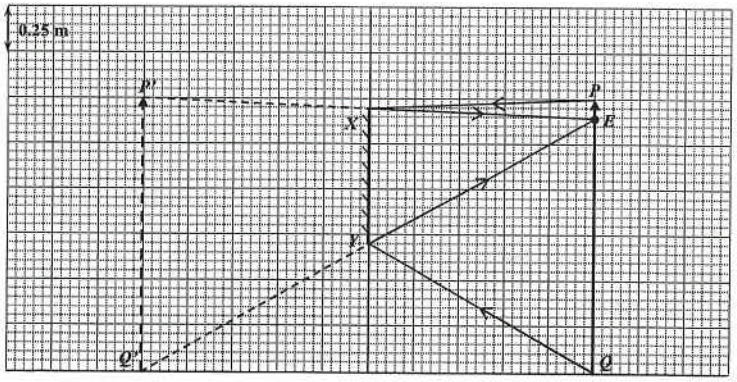


Figure 2

< Ray from P correctly reflected from P' > [1]

< Ray from Q correctly reflected from Q' > [1]

6. (a) (i) $\sin c = \frac{1}{n} = \frac{1}{1.33}$ [1]

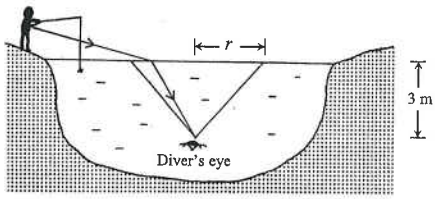
$\therefore\ c = 48.8°$ [1]

(ii) $\because\ \tan c = \frac{r}{d}$

$\therefore\ \tan 48.8° = \frac{r}{3}$ [1]

$\therefore\ r = 3.43$ m < accept 3.42 m > [1]

(b) As shown in the diagram below, the diver **can see** the fisherman. [1]



< a ray should be drawn from the body of the fisherman into the diver's eye > [1]

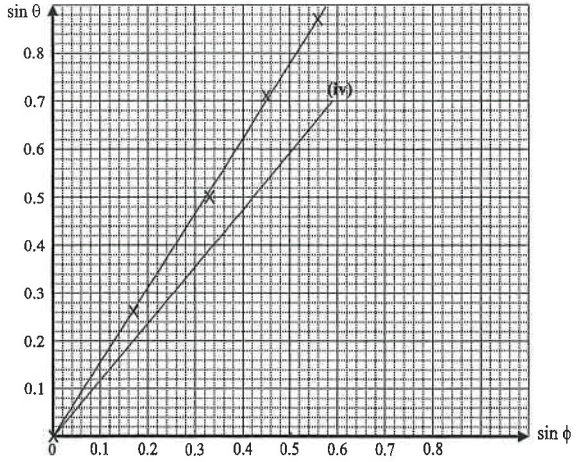
(Note that the light ray should not be along the circular path)

(No mark is given if the arrow is in the reverse direction)

7. (a) (i) refraction [1]

(ii)

$\sin\theta$	0	0.26	0.50	0.71	0.87
$\sin\phi$	0	0.17	0.33	0.45	0.56



< 2 axes labeled correctly > [1]

< Correct scale > [1]

< Correct points > [2]

< A best straight line through the origin > [1]

(iii) Slope of the line $= n = \frac{0.62-0}{0.40-0} = 1.55$ < accept 1.52 to 1.58 > [1]

$\sin c = \frac{1}{n} = \frac{1}{1.55}$ [1]

$\therefore\ c = 40.2°$ < accept 39° to 41° > [1]

(iv) Graph drawn on part (ii)

< A straight line through the origin. > [1]

< Slope of the line should be smaller than that in (ii) but must be greater than 1 > [1]

(b) As the refractive index of diamond is larger than that of glass,

the critical angle of diamond is smaller than that of glass. [1]

Therefore, more light would have total internal reflection inside the diamond than inside the glass. [1]

So more light would leave the upper surface and make diamond more sparkling. [1]

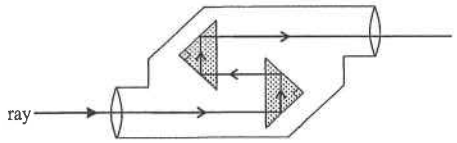
Provided by dse.life

8. (a) **Advantage** : the plane mirror can give same size images. [1]

Disadvantage : the plane mirror has multiple reflection that makes the image not clear. [1]

(b) The drivers of cars in front can see the word "AMBULANCE" in the right way [1]
through the rear-view driving mirror. [1]

9. (a) [1]



(b) **Advantage** : (any **ONE** of the following) [1]

* Using prisms can prevent multiple reflection. (**OR** prevent formation of multiple images)
* The image formed is clearer. (**OR** brighter)

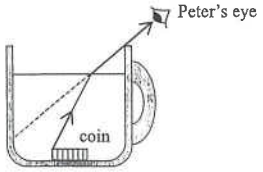
10. (a) (i) By $n = \dfrac{\sin\theta_{air}}{\sin\theta_{water}}$ [1]

$\therefore\ (1.33) = \dfrac{\sin\theta_{air}}{\sin 30^\circ}$ $\therefore\ \theta_{air} = 41.7^\circ$ [1]

(ii) $\sin c = \dfrac{1}{n} = \dfrac{1}{1.33}$ [1]

$\therefore\ c = 48.8^\circ$ [1]

(b)



[2]

11. (a) slope $= \dfrac{0.62}{0.4}$ [1]

$= 1.55$ (1.50 to 1.60 are acceptable) [1]

The slope is the refractive index of the glass. [1]

(b) He is not correct. [1]

Total internal reflection will not occur when light travels from a less dense medium to a denser medium. [1]

12. (a) (i)

< reflected angle = incident angle during internal reflection > [1]

< all correct > [1]

(ii) total internal reflection [1]

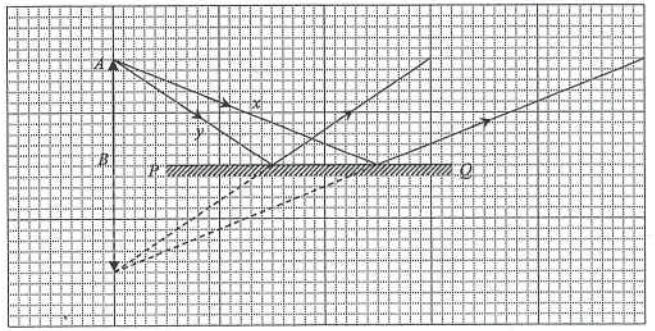
(b) Any **TWO** of the followings : [2]

* Optical fibres can transmit the signals with little loss than copper wires.
* Optical fibres can carry more information than copper wires.
* Optical fibres are much lighter and thinner than copper wires.

13. (a) The calm water surface gives a smooth reflecting surface. [1]

Regular reflection occurs at the water surface. [1]

(b)



< Reflected ray of x drawn correctly > [1]

< Reflected ray of y drawn correctly > [1]

< Dotted lines extended correctly > [1]

< Image drawn correctly > [1]

14. (a) $n = \dfrac{1}{\sin c}$ [1]

$\therefore\ 1.48 = \dfrac{1}{\sin c}$

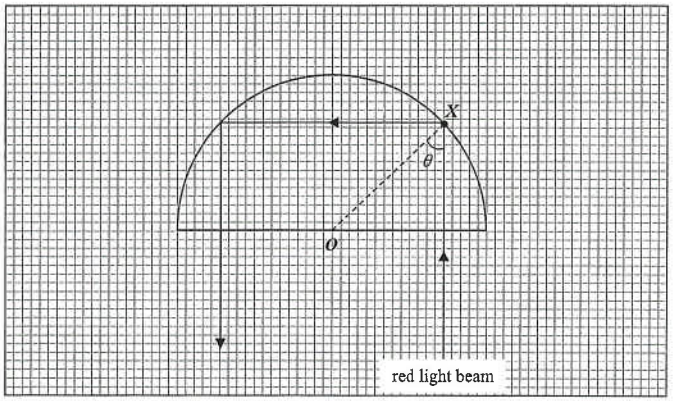
$\therefore\ c = 42.5^\circ$ [1]

(b) (i) The angle of incident θ (45°) is greater than the critical angle, [1]

thus, total internal reflection occurs at X. [1]

Provided by dse.life

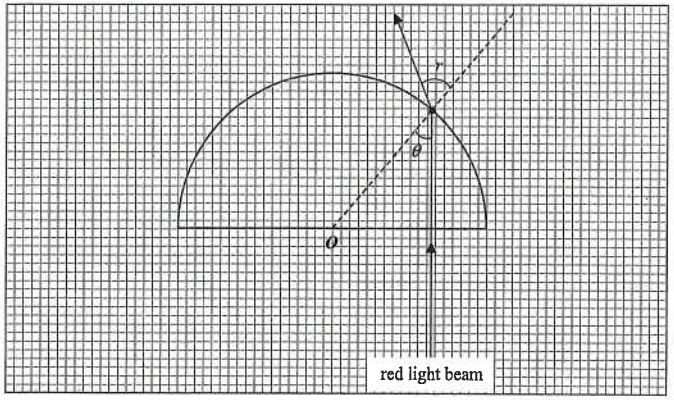
14. (b) (ii)



< total internal reflection drawn at X > [1]

< all rays are correct > [1]

(c)



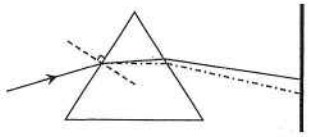
< refracted ray comes out from Y and bends away from the normal > [1]

< angle r marked correctly > [1]

15. (a) $n = \dfrac{\sin i}{\sin r} = \dfrac{\sin 60°}{\sin 36°}$ [1]

$= 1.47$ [1]

(b)



[2]

16. Connect the ray box to the power supply (and switch it on). [1]

Put the semi-circular glass block onto the protractor.

The centre of the semi-circular glass block should coincide with the centre of the paper protractor. [1]

Direct a light ray into the glass block through the curved side towards its centre. [1]

Vary the incident angle in the glass block until the refracted ray is parallel to the straight edge of the glass block. [1]

Read the incident angle from the protractor and the critical angle of the glass block can be obtained. [1]

< accept using diagrams >

17. (a) $n_g = \dfrac{\sin \theta_{air}}{\sin \theta_g}$

$= \dfrac{\sin(90° - 30°)}{\sin(90° - 54°)}$ [1]

$= 1.47$ [1]

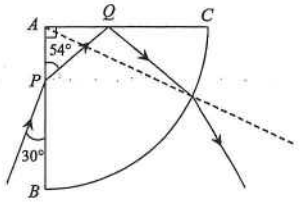
(b) $\sin c = \dfrac{1}{n_g} = \dfrac{1}{1.47}$

$\therefore\ c = 42.9°$ < accept $42.7°$ > [1]

At Q, the incident angle $i = 54°$

Since the incident angle i > critical angle c, total internal reflection occurs at Q. [1]

(c)



< the ray is totally reflected at Y, with reflected angle = incident angle > [1]

< the ray bends away from normal (dotted line) at the curved surface (no dotted line drawn is accepted) > [1]

(d) The white light dispersed into a spectrum. [1]

OR

The white light splits into different colours. [1]

18. (a) Any **ONE** of the following : [1]

* Total internal reflection occurs.
* High temperature gradient near the road surface.
* Light rays travel sufficient long path lengths.

Provided by dse.life

18. (b) (i) $n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3 = n_4 \sin\theta_4$ [1]

$\therefore n_1 \sin\theta_1 = n_4 \sin\theta_4$

$\therefore (1.000261)\sin\theta_1 = (1.000221)\sin 90°$

$\therefore \theta_1 = 89.5°$ <accept 89.488°> [1]

(ii) $\alpha = 90° - \theta_1 = 90° - 89.5° = 0.5°$ <**OR** 0.512°>

$\frac{h}{L} = \tan\alpha$ [1]

$\therefore \frac{(1.5)}{L} = \tan 0.5°$ $\therefore L = 172$ m <accept 167.7 m to 172.0 m> [1]

(c) The water source still appears the same distance away [1]

because the image is caused by the reflection of light of distant objects at the same angle. [1]

19. (a) (i) $\sin c = \frac{1}{n} = \frac{1}{1.36}$ [1]

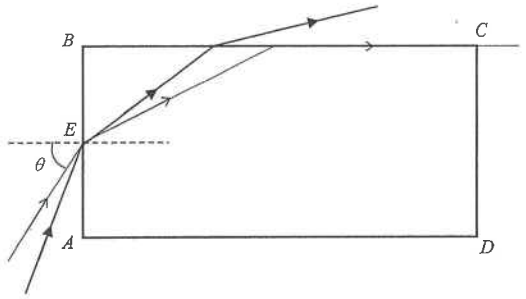
$\therefore c = 47.3°$ [1]

(ii) Angle of refraction at E: $r = 90° - 47.3° = 42.7°$ [1]

By $(1.36) = \frac{\sin\theta}{\sin 42.7°}$ [1]

$\therefore \theta = 67.3°$ <accept 62.7°> [1]

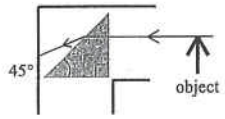
(iii)



<correct refraction at E> [1]

<correct refraction at BC> [1]

(b) (i)



[1]

The angle of incidence of the light ray from the object is less than the critical angle of the plastic prism. [1]

Total internal reflection will not occur. [1]

(ii) Glass prism **OR** Plane mirror [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

Provided by dse.life

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8 \text{ m s}^{-1}$

The following list of formulae may be found useful :

Equation for a single lens $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

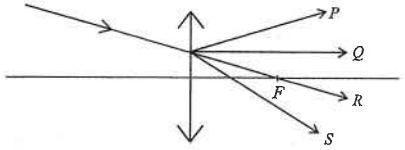
Part A : HKCE examination questions

1. < HKCE 1980 Paper II - 26 >

A convex lens is used to form an image of a bright object on a screen. The effect of covering the top half of the lens with a card is to

A. remove the top half of the image.
B. remove the bottom half of the image.
C. make the image smaller.
D. make the image dimmer.

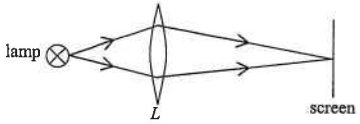
2. < HKCE 1981 Paper II - 16 >



A ray of light falls on a convex lens as shown in the figure. F is the principal focus of the lens. Which of the following represents the path of the emergent ray ?

A. P
B. Q
C. R
D. S

3. < HKCE 1982 Paper II - 25 >

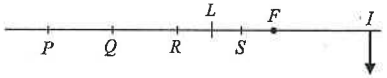


A convex lens L is placed between a screen and a lamp. A sharp image is formed on the screen as shown in the above figure. Which of the following statements concerning the image are correct ?

(1) The image is larger than the object.
(2) The image is real.
(3) The image is inverted.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

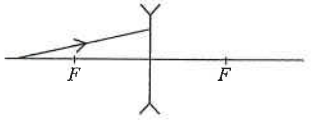
4. < HKCE 1982 Paper II - 24 >



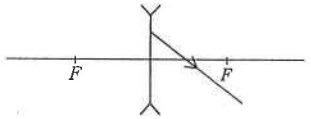
A real image of an object is formed at I by a lens placed at L. If the focus of the lens is at F, the object must have been placed near to

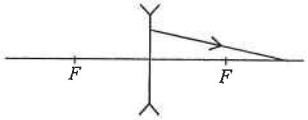
A. P
B. Q
C. R
D. S

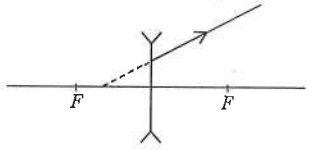
5. < HKCE 1982 Paper II - 19 >

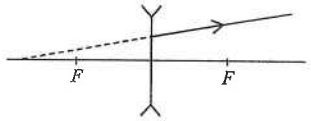


A ray of light is incident at a concave lens. F is the focus of the lens. Which of the following diagrams correctly shows the path of the emergent ray ?

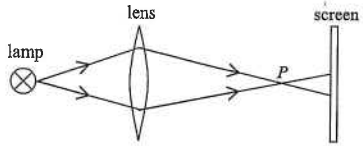
A.


B.


C.


D.


6. < HKCE 1983 Paper II - 17 >



A lens gives a sharp image of the lamp at P as shown in the figure above. Which of the following methods could give a sharp image of the filament on the screen ?

(1) Move the screen towards the lens.
(2) Move the lamp closer to the lens.
(3) Replacing the lens by another lens of longer focal length.

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

7. **< HKCE 1983 Paper II - 19 >**

Which of the following statements concerning the properties of virtual images formed by a lens is/are correct ?

(1) Virtual images can be seen by the naked eye.

(2) Virtual images can be formed on a screen.

(3) Virtual images can be photographed with a camera.

A. (1) only
B. (3) only
C. (1) & (3) only
D. (2) & (3) only

8. **< HKCE 1983 Paper II - 20 >**

An object is placed 20 cm in front of a converging lens of focal length 30 cm. Which of the following statements about its image is/are correct ?

(1) The image is real.

(2) The image is magnified.

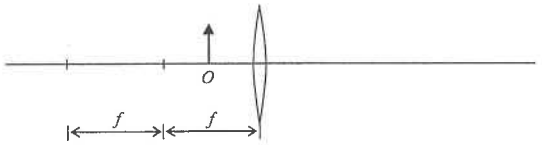
(3) The image is erect.

A. (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

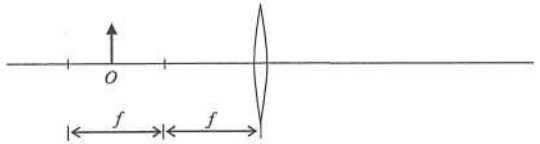
9. **< HKCE 1984 Paper II - 18 >**

Which of the following will produce a diminished image of an object O ? (f is the focal length)

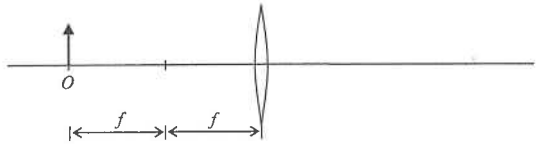
A.



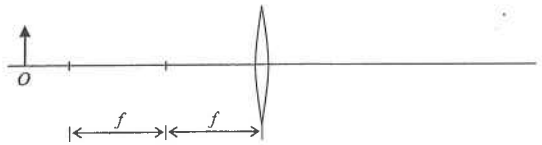
B.



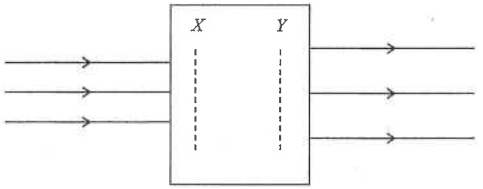
C.



D.



10. **< HKCE 1984 Paper II - 14 >**

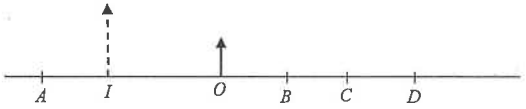


As shown in the diagram, a narrow parallel beam of light is converted to a wider parallel beam by placing two lenses X and Y in the positions shown. Which of the combinations below when correctly chosen and installed could produce the effect required ?

	Lens X	Lens Y
(1)	convex	concave
(2)	concave	concave
(3)	concave	convex

A. (2) only
B. (3) only
C. (1) & (3) only
D. (2) & (3) only

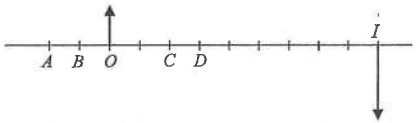
11. **< HKCE 1985 Paper II - 17 >**



In the above figure, the image I of an object placed at O is produced by a single lens. If the magnification is 2, what kind of lens has been used and where must it have been placed ?

A. a concave lens placed at A
B. a concave lens placed at B
C. a convex lens placed at C
D. a convex lens placed at D

12. **< HKCE 1986 Paper II - 11 >**



In the diagram shown, the image I is produced by a lens. The object is placed at O. What is the nature and position of this lens ?

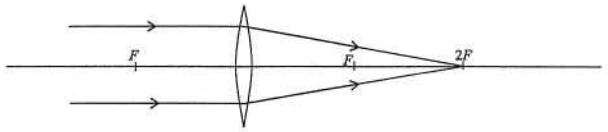
A. concave and placed at A
B. convex and placed at B
C. concave and placed at C
D. convex and placed at D

Provided by dse.life

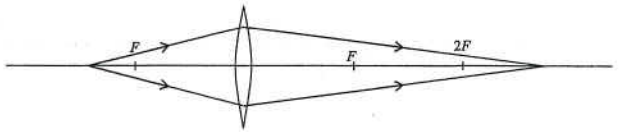
13. **< HKCE 1986 Paper II - 12 >**

Which of the following ray diagrams correctly show(s) the paths of light rays through the lens ?

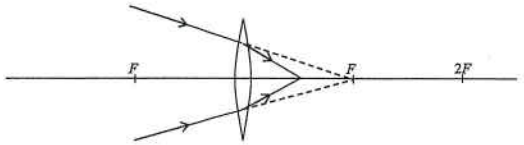
(1)



(2)



(3)

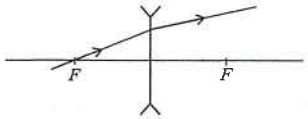


A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

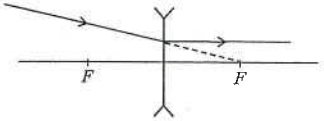
14. **< HKCE 1986 Paper II - 14 >**

If points F and F' represent the focal points of a concave lens, which of the following ray diagrams correctly shows the path of a light ray through the lens ?

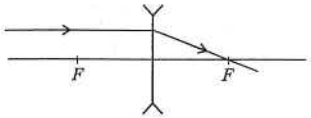
A.



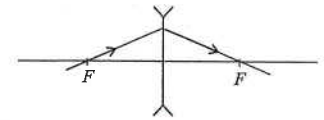
B.



C.



D.



15. **< HKCE 1987 Paper II - 21 >**

d

A concave lens is placed above the letter " d " which has the size shown in the above figure. The image of the letter " d " appears as

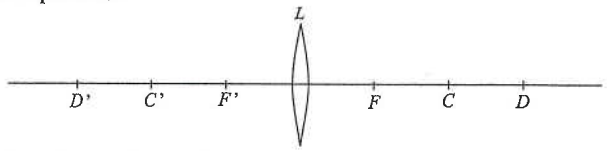
A. **d**

B. **p**

C. **d**

D. **p**

16. **< HKCE 1987 Paper II - 19 >**



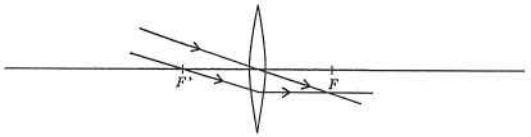
An object is placed in front of a convex lens L in the region $D'C'$, as shown in the diagram. If F is the focus of the lens, where should the image lie ?

A. between C' and F'
B. between F' and L
C. between L and F
D. between F and C

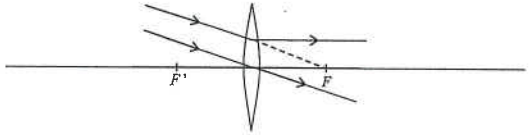
17. **< HKCE 1987 Paper II - 22 >**

Which of the following ray diagrams is/are correct ?

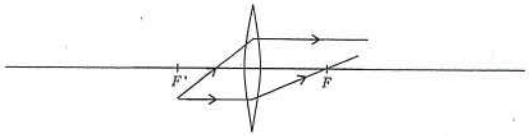
(1)



(2)

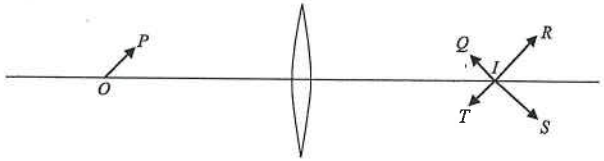


(3)



A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

18. **< HKCE 1988 Paper II - 19 >**

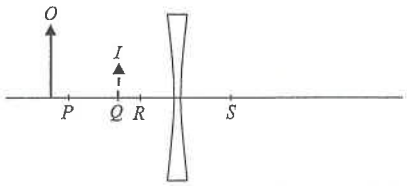


The figure shows an object OP placed in front of a convex lens. Which of the following should be its most probable image ?

A. IQ
B. IR
C. IS
D. IT

Provided by dse.life

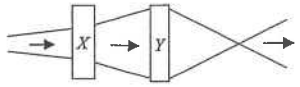
19. **< HKCE 1988 Paper II - 21 >**



The figure shows an object *O* placed in front of a concave lens to give an image *I*. What is the most probable position of the focus ?

A. *P*
B. *Q*
C. *R*
D. *S*

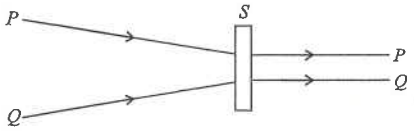
20. **< HKCE 1988 Paper II - 22 >**



The above figure shows a beam of light passing through devices *X* and *Y*. What could *X* and *Y* be ?

	X	*Y*
A.	concave lens	concave lens
B.	concave lens	convex lens
C.	convex lens	concave lens
D.	convex lens	convex lens

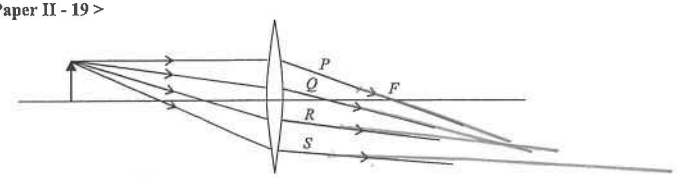
21. **< HKCE 1989 Paper II - 18 >**



Two light rays *P* and *Q* pass through an optical system *S* as shown in the figure above. *S* probably is

A. 
B.
C. 
D.

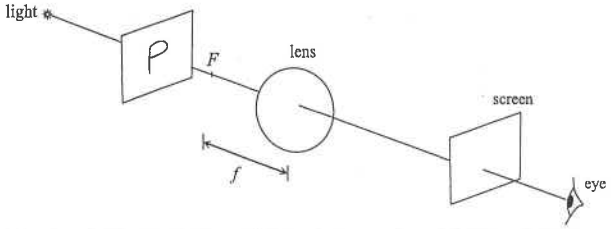
22. **< HKCE 1989 Paper II - 19 >**



Which of the 4 light rays *P*, *Q*, *R* and *S* drawn above is **NOT** possible ?

A. *P*
B. *Q*
C. *R*
D. *S*

23. **< HKCE 1989 Paper II - 20 >**



A slide illuminated by a light source is placed in front of a convex lens of focal length *f* as shown in the figure above. The image seen on the translucent screen is probably

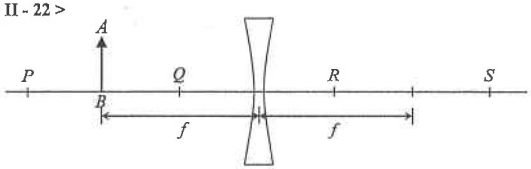
A. 

B. 

C. 

D. 

24. **< HKCE 1989 Paper II - 22 >**

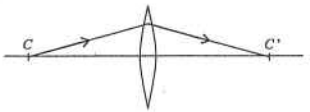


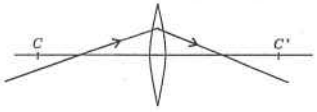
An object *AB* is placed at a distance of one focal length *f* in front of a concave lens as shown in the figure above. What is the position and the nature of the image ?

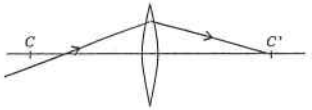
	Position	**Nature**
A.	at *P*	virtual and erect
B.	at *Q*	virtual and erect
C.	at *R*	real and inverted
D.	at infinity	-----

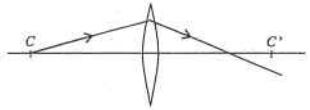
25. **< HKCE 1989 Paper II - 23 >**

If *C*, *C'* are both at a distance of 2 times the focal length from a convex lens, which of the following ray diagrams is correct ?

A. 

B. 

C. 

D. 

26. **< HKCE 1990 Paper II - 15 >**

A convex lens is used as a magnifying glass to read small printing in a book. Which of the following statements is/are true ?

(1) The image distance is greater than the object distance.
(2) The image of the printing is real.
(3) The image of the printing is erect.

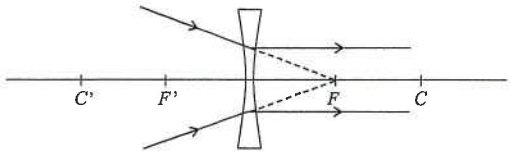
A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

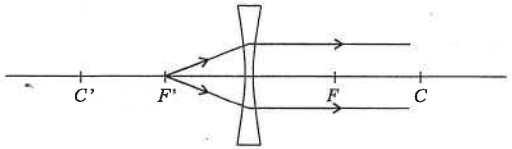
27. **< HKCE 1990 Paper II - 14 >**

If F, F' are foci and C, C' are both at a distance of two times the focal length from the lens, which of the following ray diagrams is/are correct ?

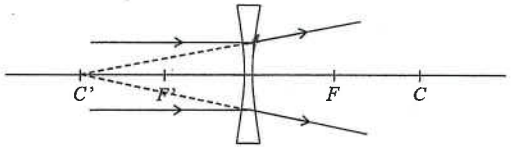
(1)



(2)

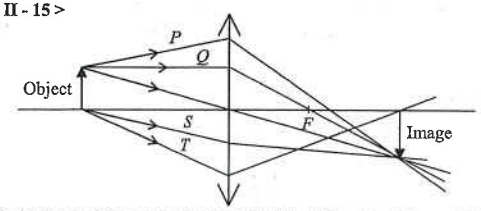


(3)



A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

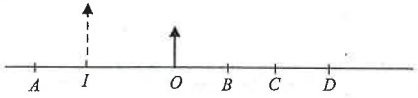
28. **< HKCE 1991 Paper II - 15 >**



In the figure above, F is the focus of the converging lens. Which of the refracted rays is INCORRECTLY drawn ?

A. P
B. Q
C. S
D. T

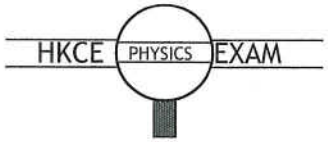
29. **< HKCE 1991 Paper II - 13 >**



In the diagram, the image I of an object O is produced by a lens. What is the nature and position of this lens ?

A. concave and placed at A
B. concave and placed at B
C. convex and placed at C
D. convex and placed at D

30. **< HKCE 1993 Paper II - 12 >**



A lens is used to look at some print on a paper. The image of the word "PHYSICS" is shown above. Which of the following statements is/are true ?

(1) The lens is a converging lens.
(2) The image lies between the paper and the lens.
(3) The image is real.

A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

31. **< HKCE 1994 Paper II - 11 >**

Which of the following statements concerning real images formed by a lens is/are correct ?

(1) Real images are always diminished.
(2) Real images can be photographed with a camera.
(3) Without a screen, real images cannot be seen by the eye.

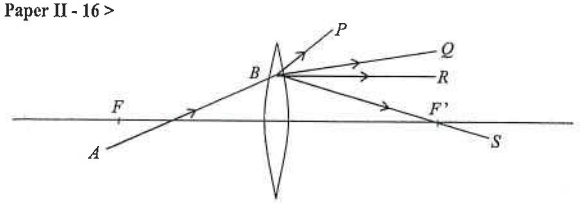
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

32. **< HKCE 1995 Paper II - 13 >**

A convex lens is used as a magnifying glass to read some small print in a book. The glass is placed 3 cm from the book and the magnification is 3. What is the distance between the book and the image of the print ?

A. 3 cm
B. 6 cm
C. 9 cm
D. 12 cm

33. **< HKCE 1995 Paper II - 16 >**

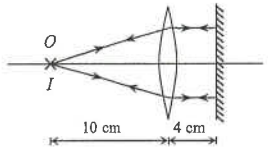


In the above diagram, F, F' are the foci of the convex lens and AB is an incident ray. Which of the following paths best represents the emergent ray ?

A. P
B. Q
C. R
D. S

Provided by dse.life

34. **< HKCE 1996 Paper II - 15 >**



When an object O is placed in front of a convex lens and a plane mirror as shown above, an image I is formed at the same positions as the object. Which of the following statements is/are correct ?

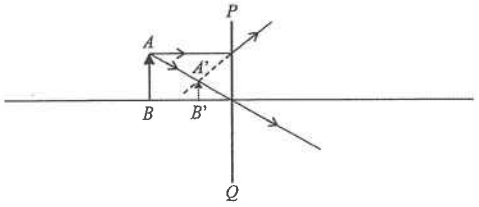
(1) The image I is real.

(2) The focal length of the lens is 10 cm.

(3) If the distance between the lens and the plane mirror is changed to 2 cm, the position of the image I would remain unchanged.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (1), (2) & (3)

35. **< HKCE 1997 Paper II - 12 >**



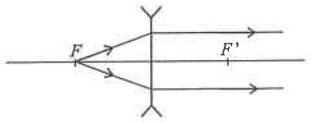
In the above diagram, $A'B'$ is the image of an object AB formed by an optical device PQ. What is PQ ?

A. a plane mirror
B. a glass block
C. a concave lens
D. a convex lens

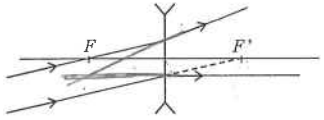
36. **< HKCE 1998 Paper II - 15 >**

If F and F' are the foci of the concave lens, which of the following ray diagrams is **incorrect** ?

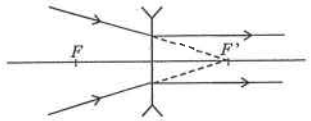
A.



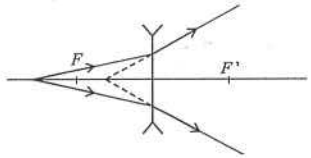
B.



C.

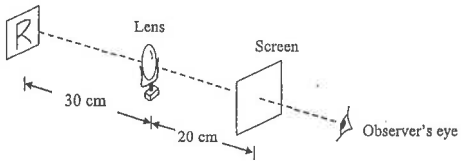


D.



For questions 37 and 38

An illuminated letter 'R' is placed in front of a lens as shown below and an image is formed on a translucent screen. The object distance is 30 cm and the image distance is 20 cm.



37. **< HKCE 1999 Paper II - 11 >**

Which of the following statements is/are correct ?

(1) The lens is a converging lens.

(2) The image is diminished.

(3) The shape of the image seen by the observer is 'Ꞵ'.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

38. **< HKCE 1999 Paper II - 12 >**

If a piece of paper is used to cover one-half of the lens, which of the following describes the change in the image as seen by the observer ?

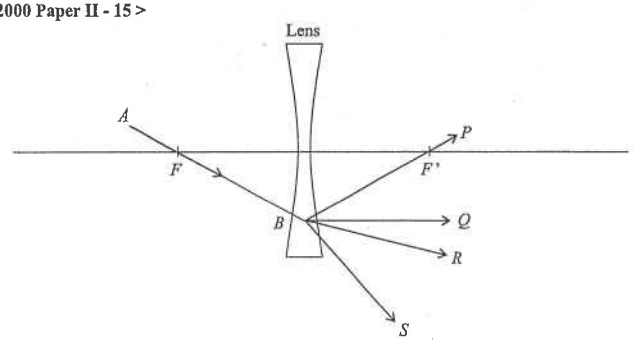
A. The whole image can still be seen but the image becomes dimmer.

B. The whole image can still be seen and its brightness remains unchanged.

C. Only half of the image can be seen and the image becomes dimmer.

D. Only half of the image can be seen but its brightness remains unchanged.

39. **< HKCE 2000 Paper II - 15 >**



In the above figure, F and F' are the foci of the above lens and AB is an incident ray. Which of the following paths best represents the emergent ray ?

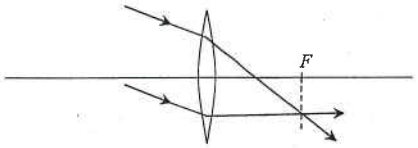
A. P
B. Q
C. R
D. S

Provided by dse.life

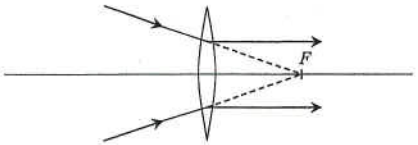
40. **< HKCE 2003 Paper II - 15 >**

Which of the following ray diagrams concerning the refraction of light ray by a converging lens is/are **incorrect** ? F denotes the focus of the lens.

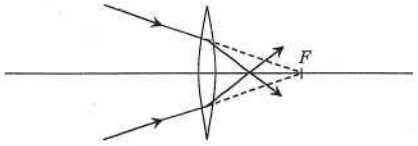
(1)



(2)



(3)



A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

41. **< HKCE 2003 Paper II - 16 >**

The photograph shows a student using a convex lens of focal length 20 cm to view a distant object. Which of the following statements about the image formed is/are correct ?

(1) The image will be erect.

(2) The image will be diminished.

(3) The student must use a screen in order to see the image.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

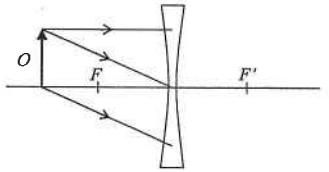
42. **< HKCE 2004 Paper II - 17 >**

The photograph shows a watch with a lens positioned over the date-display. Which of the following statements are correct ?

(1) The lens is a convex lens.
(2) The image of the date-display formed by the lens is virtual.
(3) The date-display and its image lie on the same side of the lens.

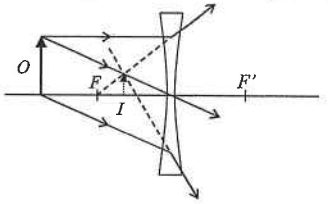
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

43. **< HKCE 2004 Paper II - 16 >**

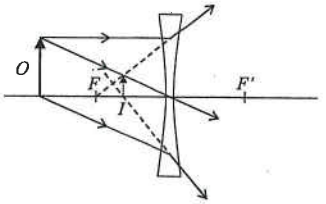


An object O is placed in front of a concave lens. F and F' are the foci of the lens. Which of the following diagrams shows the refracted rays of the three incident rays and the image I formed ?

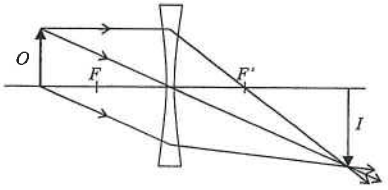
A.



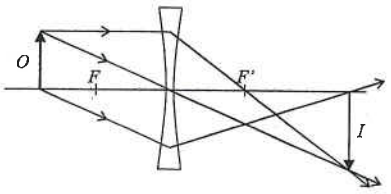
B.



C.



D.



44. **< HKCE 2004 Paper II - 15 >**

An object is placed in front of a concave lens. Which of the following statements about the properties of the image formed in the lens must be correct ?

(1) The image is diminished.
(2) The image is virtual.
(3) The image distance is smaller than the focal length of the lens.

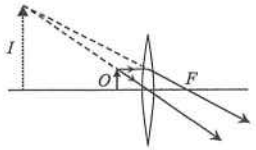
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

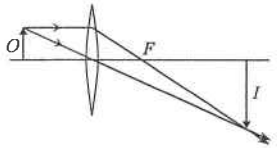
45. **< HKCE 2005 Paper II - 11 >**

Cecilia uses a magnifying glass to read some small print. Which of the following diagrams shows how the image of the print is formed ?

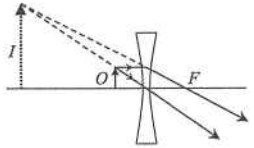
A.



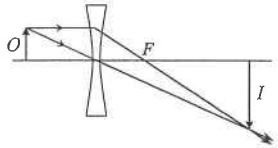
B.



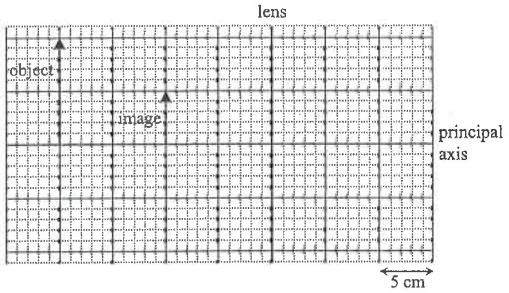
C.



D.



46. **< HKCE 2005 Paper II - 12 >**



An object is placed near a lens and an image is formed as shown. Which of the following statements are correct ?

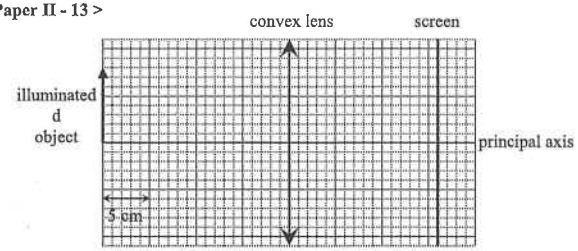
(1) The height of the image is half that of the object.

(2) The lens is a concave lens.

(3) The focal length of the lens is 20 cm.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

47. **< HKCE 2006 Paper II - 13 >**



As shown above, an illuminated object is placed at a distance 20 cm in front of a convex lens and a sharp image is formed on a screen at a distance of 16 cm from the lens. The focal length of the convex lens is

A. less than 8 cm.
B. between 8 cm and 10 cm.
C. between 10 cm and 16 cm.
D. between 16 cm and 20 cm.

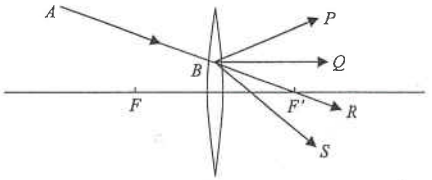
48. **< HKCE 2006 Paper II - 14 >**

Which of the following examples illustrate(s) a real image ?

(1) a fish in a pond being observed from above the water
(2) a fingerprint left at a crime scene being observed through a magnifying glass
(3) a motion picture on the screen being watched in a cinema

A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

49. **< HKCE 2007 Paper II - 12 >**



F and *F'* are the foci of the above lens and *AB* is an incident ray. Which light ray best represents the emergent ray ?

A. *P*
B. *Q*
C. *R*
D. *S*

50. **< HKCE 2007 Paper II - 15 >**

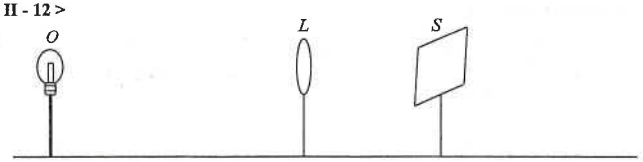
The figure shows a web cam. A web cam typically includes a lens and an image sensor.
The function of the image sensor is similar to that of a film in a conventional camera.
The image is formed on the sensor and is then digitised.
Which of the following statements is/are correct ?

(1) The lens is a convex lens.
(2) The lens is a concave lens.
(3) Image formed on the image sensor is real.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

Provided by dse.life

51. **< HKCE 2008 Paper II - 12 >**



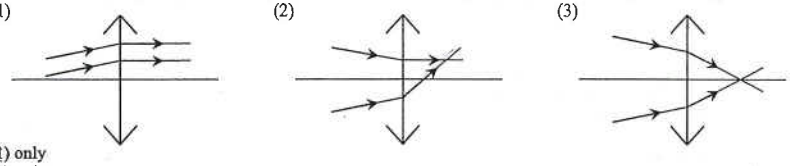
A light bulb O is placed in front of a lens L as shown above. A sharp and diminished image is formed on the screen S. With the position of L fixed, which of the following methods can form a sharp and magnified image on the screen ?

A. Move O and S towards L.
B. Move O and S away from L.
C. Move O towards L and move S away from L.
D. Move O away from L and move S towards L.

52. **< HKCE 2008 Paper II - 15 >**

Which of the following ray diagrams concerning the refraction of two light rays by a converging lens is/are possible ?

(1) (2) (3)



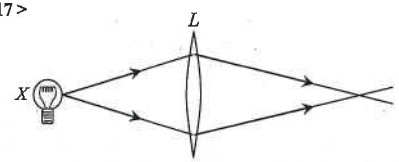
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

53. **< HKCE 2009 Paper II - 13 >**

A student puts a lens at a certain distance above a paper with the word "TEST" written on it as shown in the figure. What is the lens ? If the student moves the lens further away from the paper, what will be the change in the size of the image ?

	lens	change in size of the image
A.	convex	increases
B.	convex	decreases
C.	concave	increases
D.	concave	decreases

54. **< HKCE 2009 Paper II - 17 >**

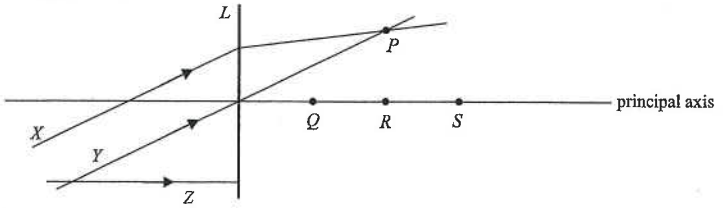


In the above figure, X is a light bulb and L is a convex lens. Which of the following ways can be used to produce a parallel beam of light rays ?

(1) Moving L closer to X.
(2) Replacing L with another convex lens of longer focal length
(3) Replacing L with another concave lens of shorter focal length

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

55. **< HKCE 2010 Paper II - 14 >**



Two parallel rays X and Y meet at P after passing through lens L as shown. Another ray Z parallel to the principal axis is directed to lens L. Which point in the figure will ray Z pass through ?

A. P
B. Q
C. R
D. S

56. **< HKCE 2011 Paper II - 16 >**

An object is placed in front of a concave lens. Which of the following descriptions about the image formed by the lens is **incorrect** ?

A. It is always virtual.
B. It is always diminished.
C. It is always between the object and the lens.
D. It will be formed at infinity if the object is placed at the focus of the lens.

57. **< HKCE 2011 Paper II - 17 >**

The figure above shows an object O and its image I formed by a lens. Which of the following about the lens used and its position is correct ?

	Type of lens	Position of lens
A.	concave	X
B.	concave	Y
C.	convex	X
D.	convex	Y

Part B : HKAL examination questions

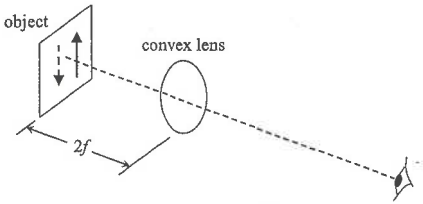
58. **< HKAL 1980 Paper I - 15 >**

An object is placed in front of a converging lens of focal length 30 cm. For which of the following object distances would the image be real and magnified ?

A. 10 cm
B. 20 cm
C. 40 cm
D. 80 cm

Provided by dse.life

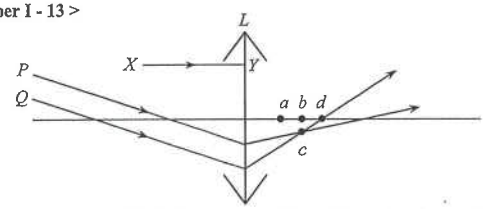
59. **< HKAL 1983 Paper I - 15 >**



An object with two arrows drawn on a screen is placed at a distance $2f$ from a convex lens of focal length f. Which of the following diagrams correctly represents the image seen by the eye when the object is viewed through the lens ?

A. 
B. 
C. 
D. 

60. **< HKAL 1984 Paper I - 13 >**



Two parallel light rays P and Q are incident onto a convex lens. After refraction, the two light rays meet at the point c. The ray XY parallel to the principal axis after passing through the lens will pass through the point

A. *a*.
B. *b*.
C. *c*.
D. *d*.

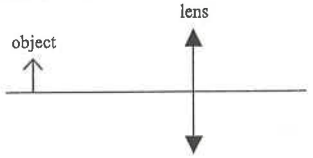
61. **< HKAL 2007 Paper IIA - 12 >**

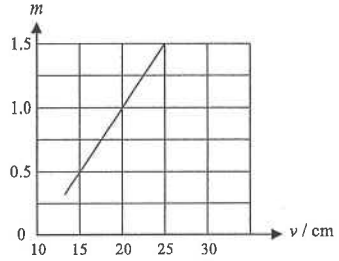
An object is placed at the focus of a diverging lens of focal length 10 cm. What is the magnification of the image formed ?

A. 0.5
B. 1.0
C. 2.0
D. infinite

62. **< HKAL 2009 Paper IIA - 20 >**

An object is placed at different distances in front of a converging lens. The image is formed on the other side of the lens. The graph shows the variation of the linear magnification m of the image with the image distance v. Find the focal length of the converging lens.





A. 10 cm
B. 15 cm
C. 20 cm
D. 30 cm

63. **< HKAL 2011 Paper IIA - 17 >**

An object is placed at 15 cm from a lens. A virtual image magnified 2 times is produced. The lens is a

A. concave lens of focal length 10 cm.
B. convex lens of focal length 10 cm.
C. concave lens of focal length 30 cm.
D. convex lens of focal length 30 cm.

64. **< HKAL 2013 Paper IIA - 18 >**

An object is placed 12 cm in front of a converging lens. An image is formed 24 cm from the lens. Find the focal length of the converging lens if the image is

(1) real ;
(2) virtual ?

	image is real	**image is virtual**
A.	24 cm	8 cm
B.	12 cm	8 cm
C.	8 cm	12 cm
D.	8 cm	24 cm

Part C : Supplemental exercise

65. An object is placed at 15 cm from a lens. A real image magnified 2 times is produced. The lens is a

A. concave lens of focal length 10 cm.
B. convex lens of focal length 10 cm.
C. concave lens of focal length 30 cm.
D. convex lens of focal length 30 cm.

66. An object is placed in front of a convex lens of focal length 20 cm. For which of the following object distances would the image be erect ?

A. 10 cm
B. 30 cm
C. 40 cm
D. 60 cm

67. An object is moving at constant speed away from a convex lens of focal length 20 cm. At the moment when it is at 30 cm from the lens, which of the following descriptions of the image is correct ?

	direction of image movement	**speed of the image**
A.	away from the lens	faster than that of the object
B.	towards the lens	faster than that of the object
C.	away from the lens	slower than that of the object
D.	towards the lens	slower than that of the object

Part D : HKDSE examination questions

68. **< HKDSE Sample Paper IA - 21 >**

An object is placed at the focus of a concave lens of focal length 10 cm. What is the magnification of the image formed ?

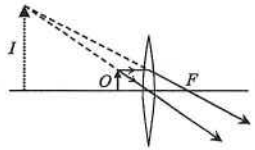
A. 0.5
B. 1.0
C. 2.0
D. infinite

Provided by dse.life

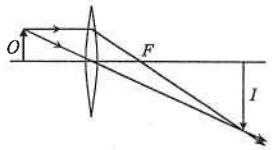
69. **< HKDSE Sample Paper IA - 16 >**

Cecilia uses a magnifying glass to read some small print. Which of the following diagrams shows how the image of the print is formed ?

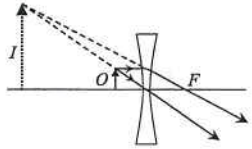
A.



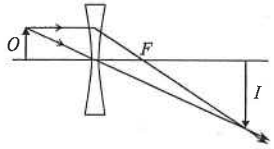
B.



C.



D.



70. **< HKDSE Practice Paper IA - 21 >**

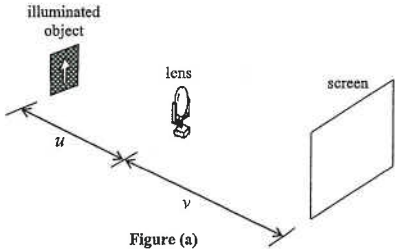


Figure (a)

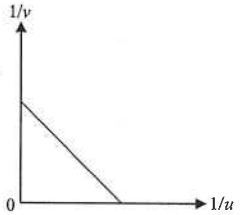
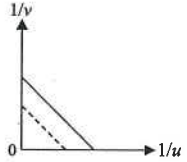


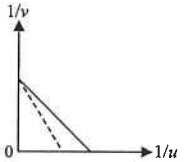
Figure (b)

A student uses the set-up in Figure (a) to study the relationship between the object distance u and the image distance v of a convex lens. A graph of $1/v$ against $1/u$ is plotted in Figure (b). If the lens is replaced by another convex lens of shorter focal length, which of the following graphs (in dotted lines) would be obtained ?

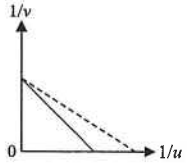
A.



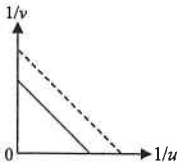
B.



C.



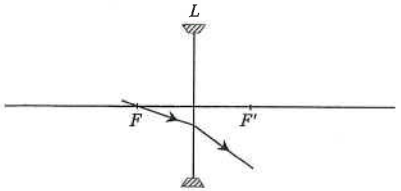
D.



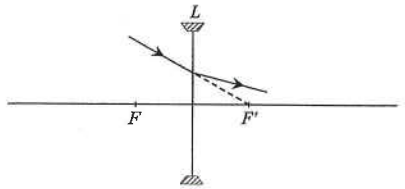
71. **< HKDSE 2012 Paper IA - 21 >**

In each of the following diagrams, L is a concave lens and its two principal foci are denoted by F and F'. Which of the ray diagrams is/are possible ?

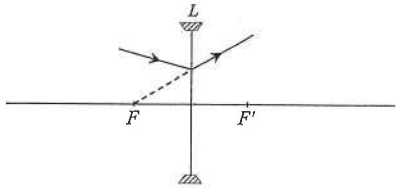
(1)



(2)

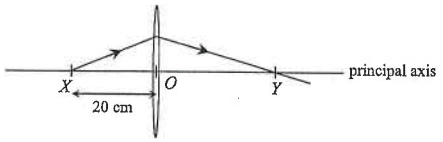


(3)



A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

72. **< HKDSE 2013 Paper IA - 22 >**



A point light source at X on the principal axis of a thin convex lens emits a ray of light. The ray passes through the lens and reaches the principal axis at point Y as shown. O is the optical centre of the lens such that $OX = 20$ cm and $OY > OX$. Which of the following statements is/are correct ?

(1) The focal length of the lens is shorter than 20 cm.

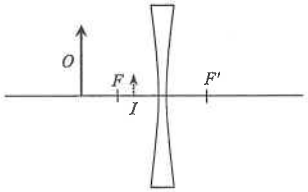
(2) If the point light source is shifted away from the lens, separation OY would increase.

(3) An object placed at Y would give a diminished image at X.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

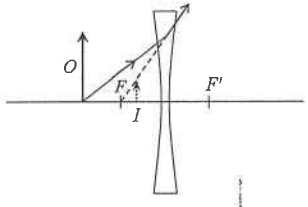
Provided by dse.life

73. **< HKDSE 2015 Paper IA - 15 >**

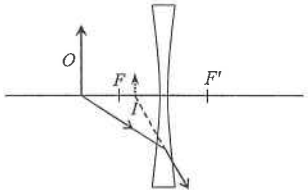


An object O placed in front of a concave lens forms an image I as shown. F and F' are the foci of the lens. Which ray diagram is correct ?

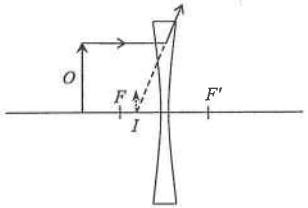
A.



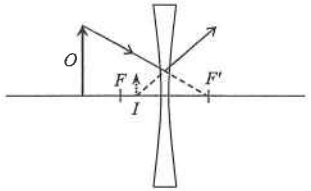
B.



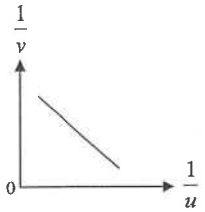
C.



D.

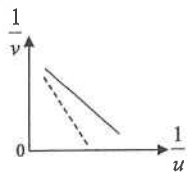


74. **< HKDSE 2015 Paper IA - 16 >**

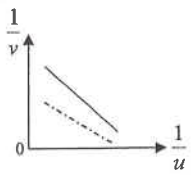


A student uses a convex lens to investigate the variation of image distance v with object distance u for real image. The graph of $\frac{1}{v}$ plotted against $\frac{1}{u}$ is shown above. If a convex lens of longer focal length is used, what would be the expected result (in dotted lines) ?

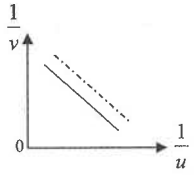
A.



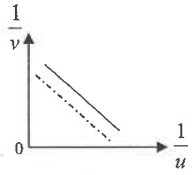
B.



C.



D.



75. **< HKDSE 2016 Paper IA - 22 >**

An object is moving at constant speed towards a convex lens of focal length 10 cm. At the moment when it is at 100 cm from the lens, which of the following descriptions of the image is correct ?

	direction of image movement	speed of the image
A.	away from the lens	faster than that of the object
B.	towards the lens	faster than that of the object
C.	away from the lens	slower than that of the object
D.	towards the lens	slower than that of the object

76. **< HKDSE 2017 Paper IA - 19 >**

When an object is placed 30 cm in front of a concave lens, an image is formed 20 cm away from the lens. If the concave lens is replaced by a convex lens of the same focal length and the object distance remains unchanged, which of the following descriptions about the image formed is correct ?

	nature of the image	image distance
A.	real	20 cm
B.	real	60 cm
C.	virtual	20 cm
D.	virtual	60 cm

77. **< HKDSE 2018 Paper IA - 19 >**

An object placed 25.0 cm in front of a lens forms a virtual image at a distance 11.1 cm from the lens. The lens is a

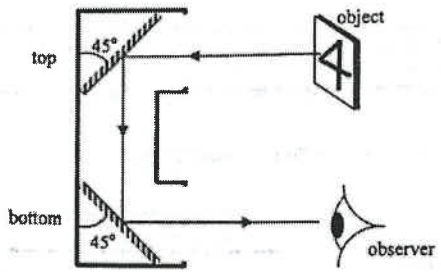
A. concave lens of focal length 7.7 cm.
B. concave lens of focal length 20 cm.
C. convex lens of focal length 7.7 cm.
D. convex lens of focal length 20 cm.

78. **<HKDSE 2019 Paper IA-20>**

Provided by dse.life

79. <HKDSE 2019 Paper IA-17>

The figure shows a periscope designed by a student. An object is observed via the periscope.



Which image will the observer see ?

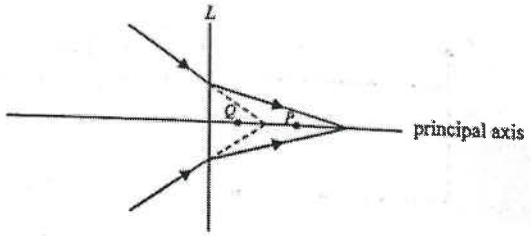
A. 

B. 

C. 

D. 

80. <HKDSE 2020 Paper IA-18>

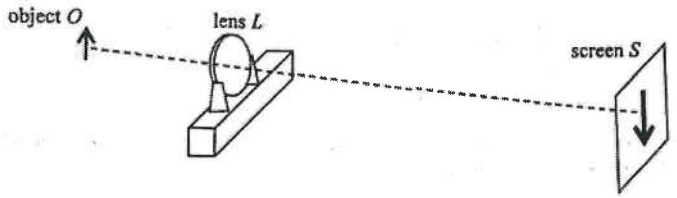


Referring to the above ray diagram, what kind of lens is represented by L ? Which point, P or Q, can be its focus ?

	lens L	focus
A.	concave	P
B.	convex	P
C.	concave	Q
D.	convex	Q

81. <HKDSE 2020 Paper IA-20>

The figure shows an enlarged sharp image of an object O formed on a screen S by a convex lens L.



Which of the following can give a diminished sharp image on the screen ?

(1) Keeping the positions of O and L unchanged, move S suitably closer to L.
(2) Keeping the positions of L and S unchanged, move O suitably farther away from L.
(3) Keeping the positions of O and S unchanged, move L suitably closer to S.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

Provided by dse.life

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. C	21. C	31. B	41. B	51. C
2. D	12. D	22. D	32. B	42. D	52. B
3. D	13. C	23. C	33. B	43. B	53. D
4. B	14. B	24. B	34. D	44. D	54. A
5. C	15. A	25. A	35. C	45. A	55. C
6. D	16. D	26. B	36. A	46. D	56. D
7. C	17. A	27. A	37. B	47. B	57. D
8. C	18. C	28. C	38. A	48. C	58. C
9. D	19. A	29. D	39. D	49. D	59. D
10. B	20. B	30. A	40. A	50. C	60. B
61. A	71. A	81. B			
62. A	72. C				
63. D	73. B				
64. D	74. D				
65. B	75. C				
66. A	76. D				
67. B	77. B				
68. A	78. A				
69. A	79. D				
70. D	80. A				

M.C. Solution

1. D

Covering top half of the lens means that only half of the lens can refract light to form the image.

Therefore, less light passes through the lens, thus the image becomes dimmer.

However, the shape and size of image remain unchanged, that is, the whole image can still be seen.

2. D

Since convex lens is a converging lens, the ray after refraction must bend towards the principal axis.

3. D

✓ (1) Since the image distance is larger than the object distance, the image is larger than the object.

✓ (2) Since the image can form on the screen, it must be a real image

✓ (3) Since the image is real, it must be inverted.

4. B

Since the position of image is beyond $2F$,

thus the position of object should be between F and $2F$ ∴ the object is placed near to Q

5. C

Since concave lens is a diverging lens, the ray after refraction must bend away from the principal axis.

6. D

✓ (1) If the screen is moved towards the lens until it is at P, the sharp image would be formed at the screen.

✓ (2) Since image and object move at the same distance, if the object is moved to the right, the image would also move to the right and formed at the screen.

✓ (3) If the focal length is increased, then the refracted light would be converged to a less extent and the image may form on the screen.

7. C

✓ (1) naked eye can see virtual images directly

× (2) light rays diverging from virtual images cannot be captured by screen

✓ (3) camera can take a picture of virtual image directly

8. C

× (1) Object placed between convex lens and focus ⇒ image is virtual

✓ (2) Object placed between convex lens and focus ⇒ image is magnified

✓ (3) Virtual image ⇒ image is erect

9. D

× A. Object placed between the lens and F will give a magnified and virtual image

× B. Object placed between F and $2F$ will give a magnified and real image

× C. Object placed at $2F$ will give a same size and real image

✓ D. Object placed beyond $2F$ will give a diminished and real image

10. B

Lens X should be concave to give a divergent beam of rays.

Lens Y must be convex so that the divergent beam of light bends towards the principal axis to give a parallel beam of rays.

∴ (3) is the only correct answer.

Provided by dse.life

11. C

Draw a line joining the head of the object and the image.

The intersection point of the line with the principal axis gives the position of the lens.

Thus C is the correct position of the lens.

On the other hand, since the image is magnified, the lens must be convex.

12. D

Draw a line joining the head of the object and the image.

The intersection point of the line with the principal axis gives the position of the lens.

Thus D is the correct position of the lens.

On the other hand, since the image is inverted, the lens must be convex.

13. C

× (1) Parallel beam of light should converge to the focus F, not to $2F$.

✓ (2) Object between F and $2F$ give the image beyond $2F$.

✓ (3) Light rays after refracted by a converging lens must bend towards the principal axis.

14. B

× A. Light passing through the lens bends to the principal axis ⇒ property of converging lens

✓ B. Incident light through focus on the other side of lens ⇒ emerge as ray parallel to principal axis

× C. Light parallel to principal focus converges to focus ⇒ property of converging lens

× D. Light passing through the lens bends to the principal axis ⇒ property of converging lens

15. A

The image formed by a concave lens must be erect and diminished.

16. D

For a convex lens, if the object is placed beyond $2F$,

the image must form between F and $2F$ at the other side of the lens.

17. A

✓ (1) Parallel incident rays must converge to a focus on the focal plane.

× (2) The two rays should not diverge after passing through a convex lens, which is a converging lens.

× (3) Since the upper ray does not come from the focus, it should not emerge as light ray parallel to the axis.

18. C

As real image must be inverted, thus IS and IT may be possible.

When point P of the object is shifted closer to the lens,

the image should be shifted in the same direction, that is, further away from the lens.

Thus, IS is the possible one.

19. A

By drawing light ray parallel to principal axis from object, the light ray should diverge from image.

By extending this line, it would meet the principal axis at P, thus P is the focus.

20. B

Light rays diverge after passing through X, thus X is a concave lens.

Light rays converge after passing through Y, thus Y is a convex lens.

21. C

Treat right side parallel rays as **incident** rays, they diverge after passing the lens.

Thus the lens must be a diverging lens, that is, a concave lens.

22. D

All the light rays emitting from the same point must meet also at the same point after passing through the lens.

Extending rays P, Q and R would meet at a point to give the image,

but ray S would not meet at that point.

23. C

As the object is placed between F and $2F$,

the image must be real, inverted and magnified.

24. B

Nature : Concave lens ⇒ image must be virtual and erect

Position : Concave lens

⇒ image must be virtual ⇒ on the same side as object

⇒ image must be diminished ⇒ $v < u$ ⇒ Q is the position

25. A

✓ A. Light ray emitted from C should converge to C'

× B. Incident light ray from a point between C and F
⇒ refracted ray should converge to a point beyond C'

× C. Incident light ray from a point between C and F
⇒ refracted ray should converge to a point beyond C'

× D. Light ray emitted from C should converge to C'

26. B

✓ (1) $v > u \Rightarrow h_i > h_o$ ∴ image is magnified

× (2) Image formed behind the lens ⇒ virtual image

✓ (3) Virtual image ⇒ erect

Provided by dse.life

27. A

✓ (1) Treat right side as parallel incident lights, they should diverge from focus.

× (2) Light rays should not converge after passing a concave lens, which is a diverging lens.

× (3) Parallel incident lights should diverge from focus, not C'.

28. C

The incident light ray S comes from the bottom of the object,

thus it must refract towards the bottom of the image, not towards the head of the image.

29. D

Nature of lens : Since the image is magnified, thus the lens must be convex.

Position of lens : Draw a line joining the head of the object and the image.

The intersection point of the line with the principal axis gives the position of the lens.

Thus D is the correct position of the lens.

30. A

× (1) As the image is erect and diminished, the lens must be a concave lens, that is, diverging lens.

✓ (2) As the image is diminished, magnification $m < 1$,
thus $v < u$, the image distance is shorter than the object distance, the image is closer than the object.

× (3) Since the image is erect, it must be virtual.

31. B

× (1) Real images may be magnified or diminished

✓ (2) Camera can take picture for both real and virtual images

× (3) Human eye can see real images directly

32. B

$v = mu = 3 \times 3 = 9$ cm

$\therefore$ Distance between the book and the print $= v - u = 9 - 3 = 6$ cm

33. B

× A. P is not correct since it bends away from the principal axis

✓ B. Q is correct since it bends towards the principal axis

× C. R is not correct since the incident ray does not pass through the focus F

× D. S is not correct since the incident ray is not parallel to the principal axis.

34. D

✓ (1) Since refracted light rays actually pass through the image, thus the image is real.

✓ (2) Parallel incident rays converge to focus $\Rightarrow f = 10$ cm

✓ (3) Light rays between lens and mirror is still parallel, regardless of the distance between mirror and lens.

35. C

As the image is virtual, erect and diminished,

the lens must be a concave lens.

36. A

× A. Light ray parallel to principal axis diverge from focus

✓ B. Light ray extension passes through F' $\Rightarrow$ emerge as parallel ray $\Rightarrow$ lower light ray is correct

✓ C. Light ray extension passes through F' $\Rightarrow$ emerge as parallel ray

✓ D. Emerged light ray bends away from the side of the principal axis.

37. B

✓ (1) Real image formed from lens $\Rightarrow$ converging lens

✓ (2) $u > v \Rightarrow m < 1 \Rightarrow$ image diminished

× (3) Real image $\Rightarrow$ inverted $\Rightarrow$ image seen on the screen is Ꙅ

38. A

If half of the lens is covered,

only half of the lens can refract light to form the image,

thus the image must become dimmer.

39. D

For concave lens which is diverging lens, the refracted ray must bend away from the principal axis.

Rays P, Q and R bend towards the principal axis.

Only ray S bends away from the principal axis.

40. A

✓ (1) The two parallel light rays converge to a point on the focal plane.

× (2) It is not correct since the light rays diverge after passing through the convex lens.

✓ (3) The two light rays converge after passing through the convex lens.

[Note that the question asks you to find out the ray diagram which is NOT correct]

41. B

For a distant object, the image must be real, inverted and formed at the focus of the convex lens.

× (1) The image should be inverted.

✓ (2) The image must be diminished since the image distance is less than the object distance.

× (3) The student can see the real image directly without the use of screen.

Provided by dse.life

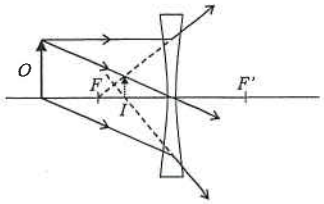
42. D

✓ (1) Since the image is magnified, it must be a convex lens. Only convex lens can give magnified image.

✓ (2) Since the image is erect, the image must be virtual.

✓ (3) Since the image is virtual, it must be at the same side as the object.

43. B



A ray parallel to the principal axis should be diverged from the focus F.

A ray through the optical centre should pass without bending.

A ray emitted from the bottom of the object should seem to be emitted from the bottom of the image.

44. D

Images formed by a concave lens have the following properties :

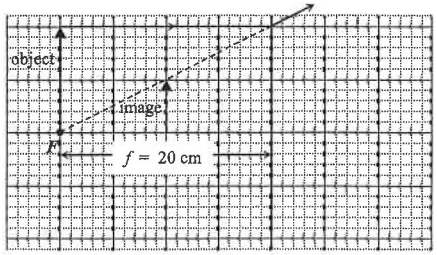
* virtual
* erect
* diminished
* form in the region between the focus and the lens

45. A

A magnifying glass is a convex lens.

The image formed is virtual, erect and magnified.

46. D

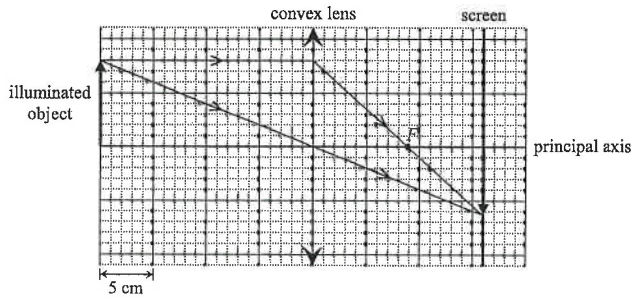


✓ (1) Height of image is half of that of object, giving a magnification of 0.5.

✓ (2) Only concave lens can give a diminished and virtual image.

✓ (3) Draw a ray parallel to the principal axis and diverge from the image, the intersection with the axis gives the focus. The focal length is 20 cm.

47. B



From the above figure, the focal length is about 9 cm, i.e. between 8 cm and 10 cm.

48. C

× (1) The image of the fish at the apparent depth is a virtual image.

× (2) The image given by a magnifying glass must be virtual, erect and magnified.

✓ (3) The image formed on the screen is a real image.

49. D

The lens is a convex lens, i.e. a converging lens. Only ray S bends towards the principal axis.

50. C

✓ (1) Only convex lens can form real image onto the film.

× (2) Concave lens cannot form real image onto the film.

✓ (3) The image is real since the sensor (film) has to receive light to record the information.

51. C

To give a magnified image, the linear magnification $m > 1$, and image distance $v >$ object distance u.

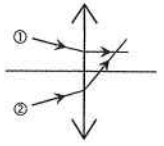
Thus, the distance LS should be increased and the distance OL should be decreased.

Therefore, move O towards L and move S away from L can achieve this.

52. B

× (1) The parallel rays should converge to a point at the focal plane after passing through the converging lens.

× (2) In this figure, ray ① is not correct since it bends away from the principal axis.
However, ray ② is correct since it bends towards the principal axis.



✓ (3) Both two rays are correct since they bend towards the principal axis after refraction.

Provided by dse.life

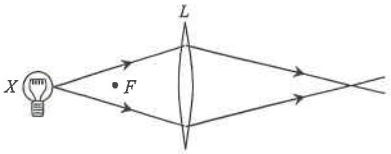
53. D

As the image is erect (virtual) and diminished, the lens must be a concave lens.

If the lens is moves away from the paper, object distance increases, image distance would also increase.

As the image moves closer to the focus, the image size would decrease.

54. A



✓ (1) The light bulb is now beyond the focus F.
If the lens L is moved closer to X, X can then be at the focus and gives a parallel beam of light rays.

✓ (2) If the convex lens has a focal length longer so that the light bulb X is at the focus, then a parallel beam of light rays can be produced.

× (3) Concave lens is a diverging lens, and it can never produce a parallel beam of light rays.

55. C

The two parallel rays X and Y meet at P, thus P is one of the focus on the focal plane, and R is the principal focus.

For a light ray parallel to the principal axis, the refracted ray must pass the principal focus R, thus ray Z will pass through R.

56. D

✓ A. The image of a concave lens must always be virtual and erect.

✓ B. The image of a concave lens must always be diminished.

✓ C. Since the image must be diminished, $m < 1$, $v < u$, thus the image distance must be shorter than the object distance.

× D. Even the object is placed at the focus, the image is still between the lens and the focus.

57. D

Since the image is magnified, the lens must be convex since only convex lens can give a magnified image.

Since the image is virtual, it must be at the same side as the object, thus the lens must be at position Y.

58. C

For a converging lens, $f < u < 2f$ gives a real and magnified image.

Thus, object distance 40 cm that is greater than f of 30 cm but less than $2f$ of 60 cm will give a real and magnified image.

59. D

A real image formed by the convex lens must be inverted.

Thus, the dotted arrow shifts from the left to the right and the head of the dotted arrow shifts from the bottom to the top.

60. B

As the two incident rays are parallel, the two refracted rays must meet at the focal plane.

Thus, the vertical plane containing b and c is the focal plane and b is the principal focus.

As the ray XY is parallel to the principal axis, the refracted ray must pass through the principal focus b.

61. A

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\therefore \frac{1}{(-10)} = \frac{1}{(10)} + \frac{1}{v}$

$\therefore v = -5\text{ cm}$

$\therefore m = \frac{v}{u} = \frac{(5)}{(10)} = 0.5$

62. A

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\therefore \frac{v}{f} = \frac{v}{u} + \frac{v}{v} \quad \therefore \frac{v}{f} = m + 1 \quad \therefore m = \frac{1}{f}v - 1$

By slope-intercept form : $y = mx + c$, slope of the graph is $\frac{1}{f}$.

$\therefore$ slope $= \frac{1}{f} = \frac{1.5 - 0.5}{25 - 15} \quad \therefore f = 10\text{ cm}$

OR

When $m = 1$, $v = 20$ cm.

When $m = 1$, $u = v = 2f \quad \therefore f = 10\text{ cm}$

63. D

By $v = mu = (2)(15) = 30$ cm

For a virtual image, v is (–) in the lens formula.

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \therefore \frac{1}{f} = \frac{1}{(15)} + \frac{1}{(-30)} \quad \therefore f = +30\text{ cm}$

The lens is convex with focal length 30 cm.

64. D

Image is real : $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(12)} + \frac{1}{(24)} \quad \therefore f = +8\text{ cm}$

Image is virtual : $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(12)} + \frac{1}{(-24)} \quad \therefore f = +24\text{ cm}$

Provided by dse.life

65. B

By $v = m u = (2)(15) = 30$ cm

For a real image, the image distance is (+) in the lens formula.

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{f} = \frac{1}{(15)} + \frac{1}{(30)}$ $\therefore f = +10$ cm

The lens is convex with focal length 10 cm.

66. A

For a convex lens, $u < f$ gives a virtual, erect and magnified image.

Thus, object distance 10 cm that is less than f of 20 cm will give a virtual, erect and magnified image.

67. B

Assume the object is at the left hand side of the convex lens.

Since the object distance $2f > u > f$, the image is real, inverted, magnified and at the right hand side of the lens.

When the object moves leftwards away from the lens,

① the real image at the other side also moves leftwards, that is, towards the lens

② as the image is magnified, the speed of the image is faster than that of the object

68. A

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{(-10)} = \frac{1}{(10)} + \frac{1}{v}$ $\therefore v = -5$ cm

$\therefore m = \frac{v}{u} = \frac{(5)}{(10)} = 0.5$

69. A

A magnifying glass is a convex lens. The image formed is virtual, erect and magnified.

70. D

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{v} = -\frac{1}{u} + \frac{1}{f}$

Compared with the slope-intercept form of a straight line : $y = mx + c$

The slope of the line must be equal to – 1 and the y-intercept is $1/f$.

If the lens is replaced by another lens of shorter focal length, the slope is still equal to – 1.

As f is decreased, $1/f$ is increased, therefore, the y-intercept should increase, as shown in option D.

71. A

✓ (1) Concave lens is a diverging lens, thus the light ray bends away from the principal axis.

× (2) Since the ray is incident towards the focus F', the refracted ray should be parallel to the principal axis.

× (3) If the refracted ray is diverged from the focus F, the incident ray should be parallel to the principal axis.

72. C

✓ (1) If an object is placed at X, the image is real and formed at Y.
To give a real image, the object must be placed beyond the focus.
Thus, OX is longer than the focal length, that is, f is shorter than 20 cm.

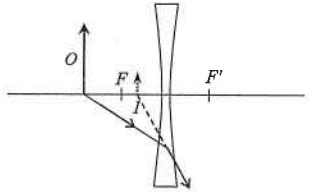
× (2) If the object is shifted towards the left, the image would also shift towards the left,
thus OY should decrease.

✓ (3) If an object is placed at Y, the image would form at X.
As the image distance OX is shorter than the object distance OY,
that is, $v < u$, thus $m < 1$, the image is diminished.

73. B

× A. The incident ray emitting from the bottom of the object should diverge from the bottom of the image,
not from the top of the image.

✓ B. The incident ray emitting from the bottom of the object correctly diverge from the bottom of the image.



× C. The incident ray emitting from the top of the object should diverge from the top of the image,
not from the bottom of the image.

× D. The incident ray emitting from the top of the object should diverge from the top of the image,
not from the bottom of the image.

74. D

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{v} = -\frac{1}{u} + \frac{1}{f}$

Compared with the slope-intercept form of a straight line : $y = mx + c$

The slope of the line must be equal to – 1 and the y-intercept is $1/f$.

If the lens is replaced by another lens of longer focal length, the slope is still equal to – 1.

As f is increased, $1/f$ is decreased, therefore, the y-intercept should decrease, as shown in option D.

75. C

Assume the object is at the left hand side of the convex lens.

Since the object distance $u > 2f$, the image is real, inverted, diminished and at the right hand side of the lens.

When the object moves rightwards towards the lens,

① the real image at the other side also moves rightwards, that is, away from the lens

② as the image is diminished, the speed of the image is slower than that of the object

Provided by dse.life

76. D

For a concave lens, the image must be virtual, thus v is negative.

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{f} = \frac{1}{(30)} + \frac{1}{(-20)}$ $\therefore f = -60$ cm

For a convex lens, the focal length must be positive, thus f is + 60 cm.

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{(60)} = \frac{1}{(30)} + \frac{1}{v}$ $\therefore v = -60$ cm

Since v is negative, the image is virtual, and the image distance is 60 cm.

77. B

By $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\therefore \frac{1}{f} = \frac{1}{(25)} + \frac{1}{(-11.1)}$ $\therefore f = -20$ cm

Since the focal length is (–), it is a concave lens.

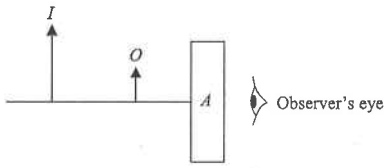
The following list of formulae may be found useful :

Equation for a single lens $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Part A : HKCE examination questions

1. **< HKCE 1979 Paper I - 5 >**

The box A in the Figure below represents an optical device capable of forming an image I of a given object O as shown.



(a) What is the optical device as represented by A ? (1 mark)

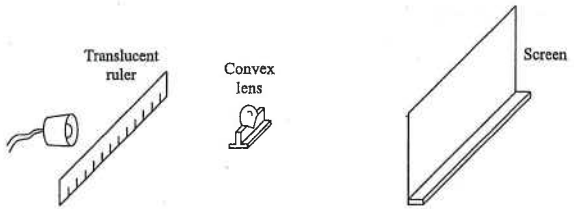
(b) State whether the image formed is real or virtual. (1 mark)

2. **< HKCE 1984 Paper I - 6 >**

(a) Describe briefly with the aid of a ray diagram, a simple laboratory method that can be used to determine the focal length of a convex lens. (4 marks)

Provided by dse.life

2. (b)



The figure shown above is a simple experimental set-up to study the image formed by a convex lens. The translucent ruler is an illuminated object, the position of which remains unchanged throughout the experiment. The position of the lens is adjusted so that a sharp image of the ruler is formed on the screen.

(i) Suppose that the distance between the lens and the ruler is 25 cm and that the focal length of the lens is 20 cm. What must be the distance between the lens and the screen? Draw a scaled diagram in the figure below to find the answer. What is the magnification of the image ? (4 marks)

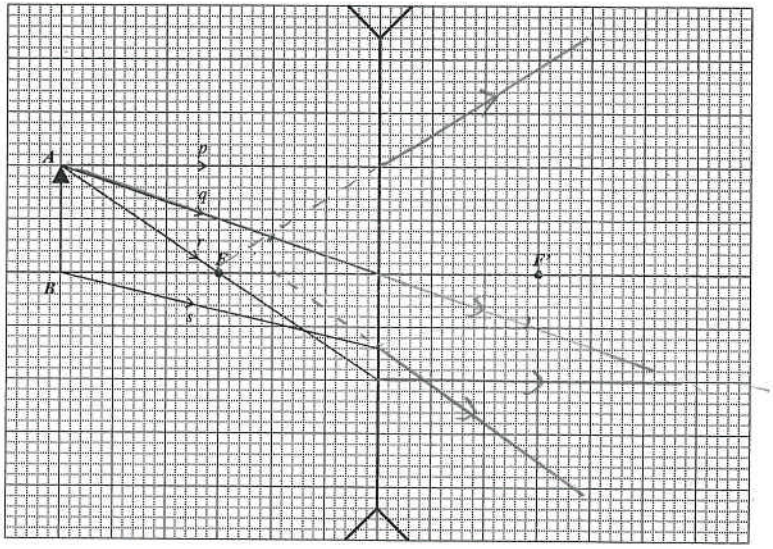
(ii) If the screen is now moved a few centimetres towards the object, how would you adjust the position of the lens to give a sharp image on the screen again ? (2 marks)

(iii) Keeping its position unchanged, the lens is now replaced by another convex lens of shorter focal length, and the screen is adjusted to give a sharp image. How would the magnification of the image be affected ? Explain briefly. (2 marks)

2. (b) (iv) Explain, with the aid of a ray diagram, why an image cannot be formed on the screen when the distance between the lens and the ruler is smaller than the focal length of the lens. (3 marks)

3. **< HKCE 1987 Paper I - 5 >**

The figure below shows an object AB in front of a concave lens with foci F and F'. p, q, r and s are incident rays.



(a) Draw the refracted rays of p, q, r and s and the image of AB on the above figure. (5 marks)

(b) State the nature (real or virtual, erect or inverted) of the image. (2 marks)

(c) Find the magnification. (2 marks)

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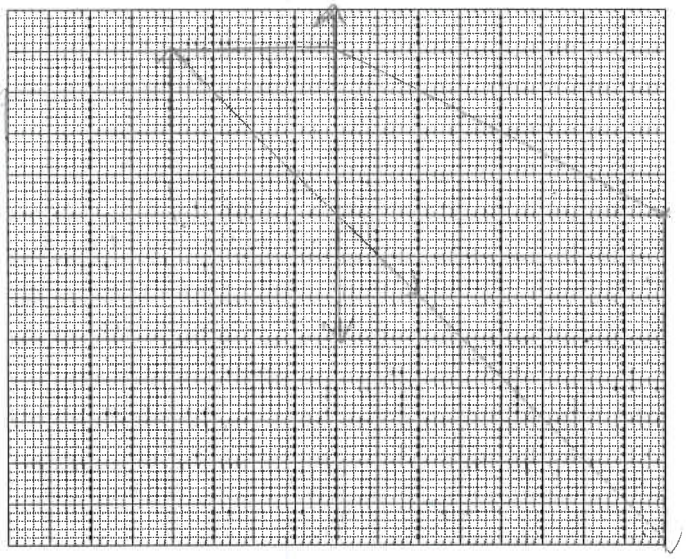
4. **< HKCE 1989 Paper I - 6 >**

An object of height 4 cm placed in front of a lens produces an image of height 8 cm on a screen. The object and the image are 60 cm apart.

(a) (i) Draw a ray diagram on a graph paper, using a scale of 1 cm representing 5 cm for the object and image distances and a scale of 1 cm representing 1 cm for the object and image heights to show TWO rays between the object and the image. (3 marks)



(ii) From the ray diagram, measure (3 marks)

(1) the object distance,

(2) the image distance, and

(3) the focal length of the lens.

(iii) What is the

(1) magnification and

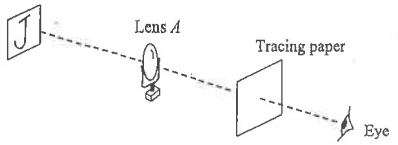
(2) nature

of the image? (3 marks)

(b) Describe the change in the magnification and nature of the image when the object is moving from nearly touching the lens to far away from the lens. (6 marks)

5. **< HKCE 1990 Paper I - 6 >**

The figure below shows an experimental set-up to study image formation by convex lens *A* of focal length 40 cm. The object is an illuminated letter 'J' placed a few metres away. The tracing paper is moved to catch a sharp image.



(a) (i) What is the approximate distance between lens *A* and the image ? Explain briefly. (2 marks)

(ii) Sketch the shape of the image seen by the observer. (2 marks)

(b) If the experiment is repeated with a convex lens of longer focal length, what will be the change in the size of the image ? Illustrate your answer with a ray diagram. (4 marks)

6. **< HKCE 1992 Paper I - 3 >**

A student holds a lens close to his eye to look at some small print on a paper. The image of the letters "EX" is shown in the Figure below. The magnification is 3.

(a) What kind of lens is used in the above figure ? Explain briefly. (2 marks)

(b) State the nature (real or virtual, erect or inverted) of the image. (2 marks)

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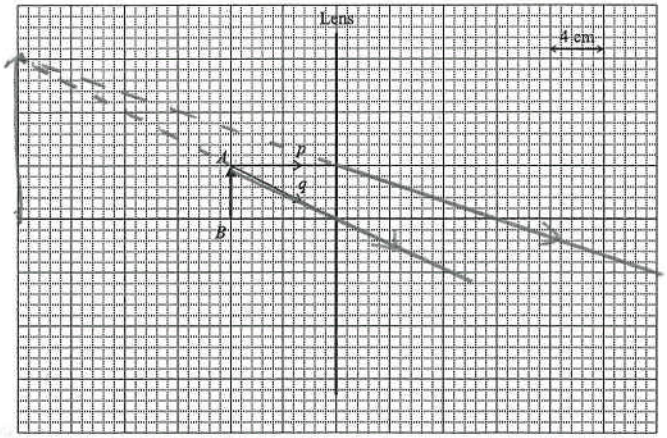
6. (c) The paper is placed at a distance of 8 cm from the lens. In the figure below, *AB* represents the object, and *p*, *q* are two incident rays. A scale of 1 cm representing 4 cm for the object distance is used.



(i) Draw the refracted rays of *p* and *q* and the image of *AB* in the above figure. (4 marks)

(ii) From the ray diagram, measure

(1) the image distance,

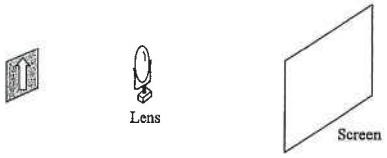
(2) the focal length of the lens. (2 marks)

(d) If the paper is placed closer to the lens, how would the size of the image and the image distance be affected ? Illustrate your answer with a ray diagram. (4 marks)

(e) If the paper is moved away from the lens to a position beyond the focus, the student finds that a clear image cannot be observed. Explain briefly. (2 marks)

7. **< HKCE 1994 Paper I - 3 >**

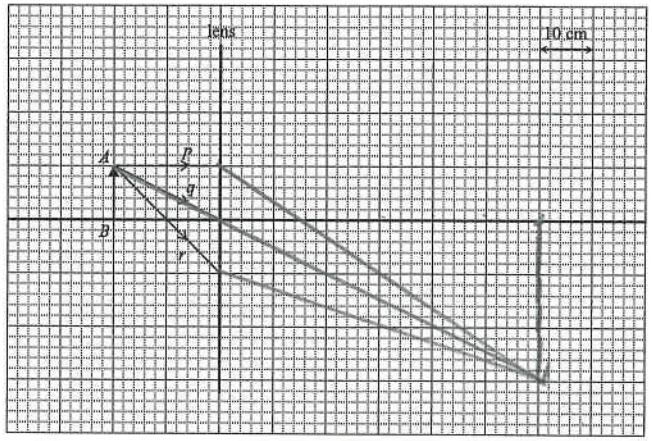
A student uses the set-up shown below to study the image formation of a lens. An illuminated object is placed a distance of 20 cm from the lens. A screen is placed on the other side of the lens. When the screen is moved to a point 60 cm from the lens, a sharp image is formed on the screen.



(a) What kind of lens is used in the experiment ? (1 mark)

(b) Is the image real or virtual ? (1 mark)

(c) In the Figure shown below, *AB* represents the illuminated object and *p*, *q* and *r* represents the incident rays.



(i) Draw the refracted rays of *p*, *q* and *r* and the image of *AB* in the figure above. (4 marks)

(ii) Find the magnification of the image. (2 marks)

(iii) Find the focal length of the lens. (1 mark)

(d) How would the image formed on the screen be affected when the upper half of the lens is covered by opaque paper ? (2 marks)

(e) Describe briefly a simple laboratory method to measure directly the focal length of the lens. Illustrate your answer with a ray diagram. (4 marks)

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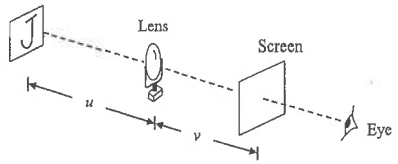
8. **< HKCE 1996 Paper I - 1 >**

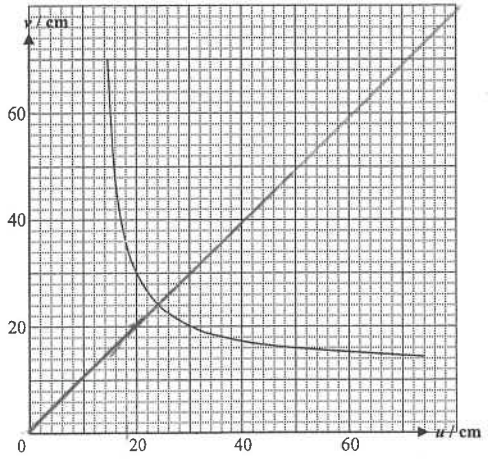


In Figure 1, the image of an illuminated letter 'J ' formed by a lens is caught by a translucent screen.

(a) (i) What kind of lens is being used ? Explain your answer. (2 marks)

(ii) Sketch the shape of the image seen by the observer. (2 marks)

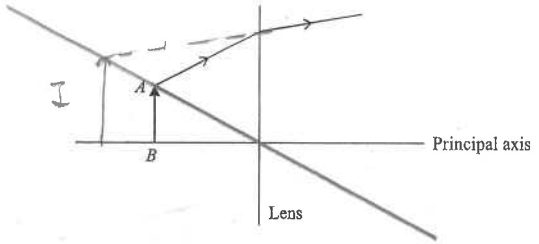
(b) Figure 2 shows the relation between the image distance v and the object distance u.



(i) Find the magnification of the image when $u = 18$ cm. (2 marks)

(ii) Find the value of u when $u = v$. Hence find the focal length of the lens. (3 marks)

8. (c) The illuminated letter is now placed closer to the lens. In the Figure below, AB represents the letter and the path of a ray from A through the lens is shown.



(i) In the above Figure, draw the path of ray from A which passes through the optical centre of the lens and construct the image of AB. (3 marks)

(ii) State an application of the lens in which an image like that shown in the above Figure is formed. (1 mark)

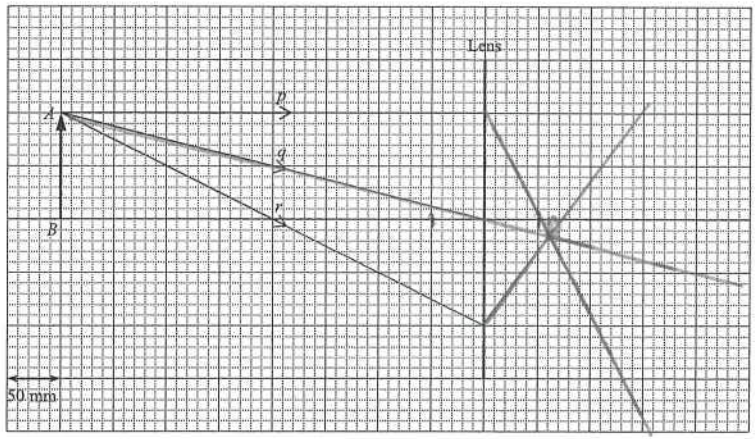
(iii) Comment on the following statement :

After adjusting the position of the screen, the image formed in the above Figure can still be caught. (2 marks)

9. **< HKCE 1999 Paper I - 8 >**

An object is placed 40 cm in front of a convex lens of focal length 50 mm. In the following figure, AB represents the object and p, q and r are incident rays. A scale of 1 cm representing 50 mm is used.

(a) Draw the refracted rays of p, q and r and the image of AB in the below figure. (4 marks)



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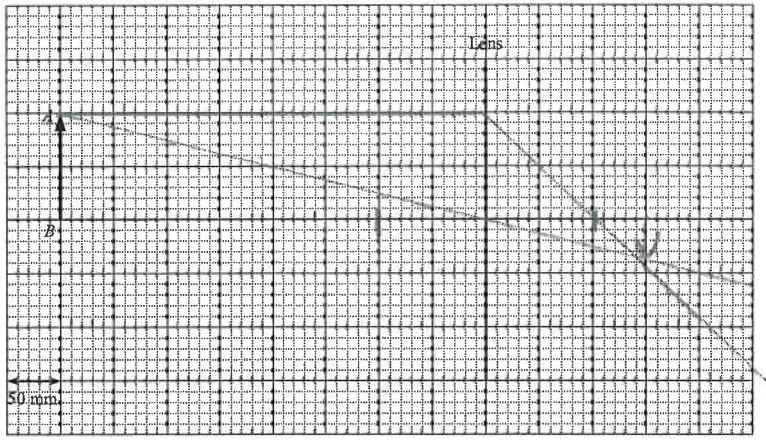
9. (b) If the convex lens is replaced by another convex lens of focal length 100 mm and the object remains at 40 cm from the lens, how would the size of the image be affected ? Illustrate your answer with a ray diagram. (4 marks)

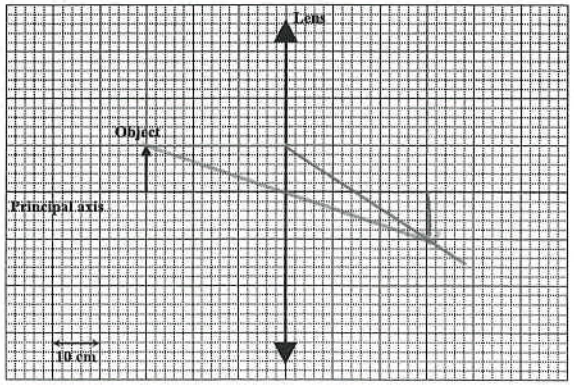


10. **< HKCE 2000 Paper I - 1 >**

An illuminated object is placed 30 cm in front of a convex lens and a sharp image is formed on a screen on the other side of the lens. The image is of the same size as the object.

(a) Is the image real or virtual ? Explain your answer. (2 marks)

(b) In the below figure, draw a ray diagram to show how the image of the illuminated object is formed.



Hence, or otherwise, determine the focal length of the lens. (4 marks)

11. **< HKCE 2001 Paper I - 3 >**

A student holds a lens above a picture and the image observed is shown in the above figure.

(a) What kind of lens is used by the student ? Explain your answer. (2 marks)

(b) Sketch a ray diagram to show how the image in the above figure is formed. (3 marks)

12. **< HKCE 2002 Paper I - 11 >**

Kitty designs a simple peephole as shown in the above figure which is installed at an entrance door to identify visitors. The peephole consists of a metal tube with a concave lens of focal length 10 cm fixed inside.

(a) A visitor stands at a distance 30 cm in front of the peephole (see Figure 1).

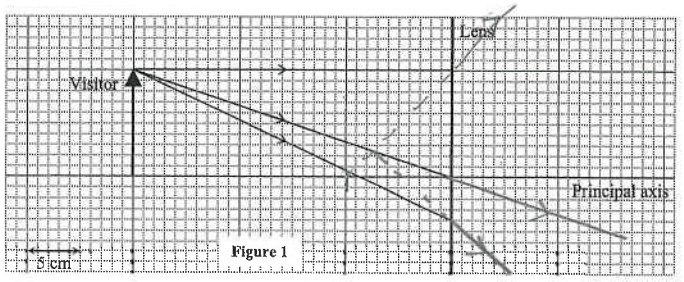


Figure 1

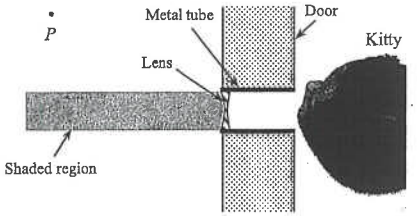
(i) In Figure 1, draw the refracted rays of the three incident rays and the image formed. (4 marks)

Provided by dse.life

12. (a) (ii) Find the magnification of the image formed. (2 marks)

(b) Suggest one reason to explain why the concave lens inside peephole cannot be replaced by a convex lens. (2 marks)

(c)



The Figure above shows the top-view of the peephole. The metal tube will only allow Kitty to see those images formed in the shaded region. Now a visitor stands at a point *P* and Kitty cannot see him through the peephole.

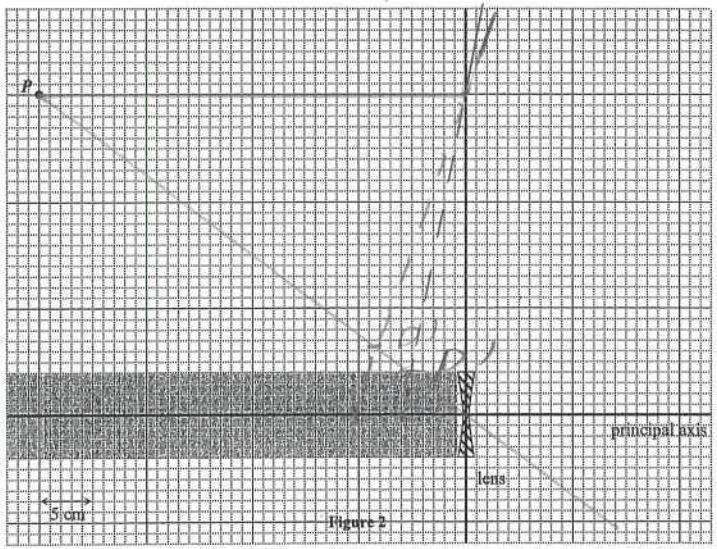


Figure 2

(i) Explain, by drawing a ray diagram in Figure 2, why Kitty cannot see the visitor. (3 marks)

(ii) The lens is now replaced by another concave lens of a shorter focal length and Kitty can **just** see the visitor at *P*. In Figure 2, locate the image observed and find the focal length of this lens. (4 marks)

13. **< HKCE 2004 Paper I - 11 >**

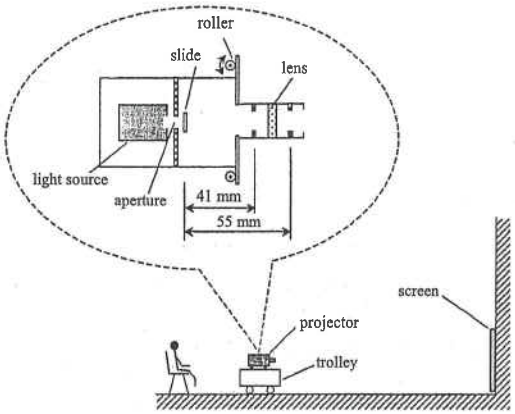


Figure 1

Peter designs a simple slide projector (see Figure 1). A slide is placed in front of a bright light source. A sharp image of the slide formed by a lens is projected onto a screen. The focal length of the lens is 40 mm and the distance between the slide and the lens can be adjusted within the range of 41 to 55 mm.

(a) What kind of lens is used in the projector ? Explain your answer. (2 marks)

(b) The projector is placed on a trolley in front of a screen (see Figure 1). The lens is placed at 50 mm from the slide.

(i) In Figure 2, draw a ray diagram to show how the image of the slide is formed by the lens. (4 marks)

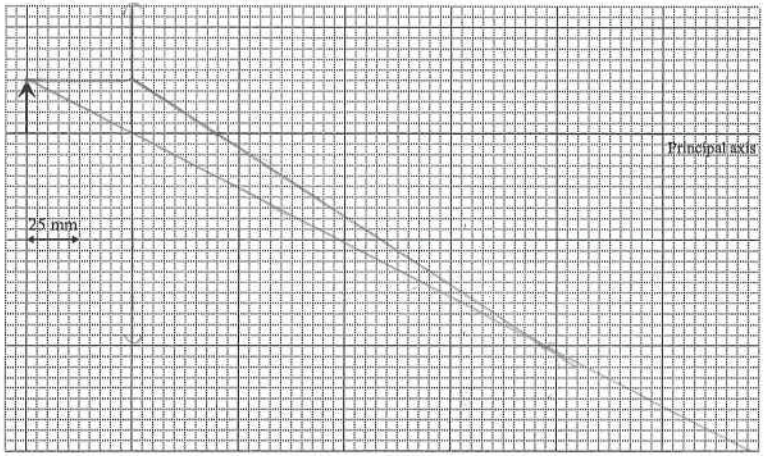


Figure 2

Provided by dse.life

13. (b) (ii) Find the magnification of the image formed. (2 marks)

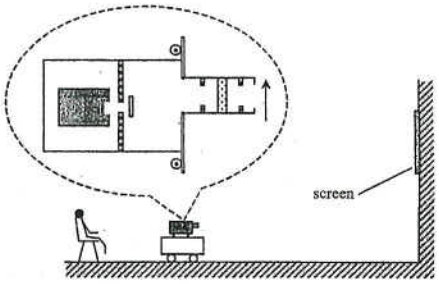
(iii) Peter finds that the size of the image formed on the screen is too small.

(1) Without replacing the lens, describe a method to increase the size of the image formed on the screen. (2 marks)

(2) Karen suggests that the size of the image can also be increased by replacing the lens with one that has a focal length of 60 mm. Explain whether Karen's suggestion will work or not. (2 marks)

(c)

Figure 3



The projector is designed so that the lens can be moved up and down by adjusting the rollers. The screen is now hung at a higher position. In order to project the image onto the screen again, Karen suggests that the lens should be moved up (see Figure 3). Is Karen correct ? Sketch a ray diagram to illustrate your answer. (3 marks)

14. **< HKCE 2005 Paper I - 4 >**

Figure 1

Figure 2

Figure 1 shows a paper with some letters 'J' printed on it. The paper is placed behind a glass filled with water. Figure 2 shows the image of the letters formed by the glass of water.

(a) State the nature of the image formed (erect or inverted, magnified or diminished, real or virtual). (2 marks)

(b) Jason holds a lens in front of the paper in Figure 1 and finds that the image formed is of the same nature as that formed by the glass of water.

(i) What kind of lens is held by Jason ? (1 mark)

(ii) Sketch a ray diagram to show how the image of the letters is formed by the lens. (3 marks)

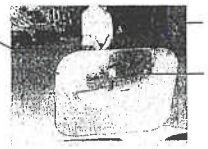
Provided by dse.life

15. **< HKCE 2006 Paper I - 5 >**

Figure 1 below shows a plastic lens L mounted on the rear window of a car. The driver can view his friend David, and the surroundings at the back of the car through either the rear window or lens L as shown in Figure 2.

Figure 1

lens L



David and the surroundings viewed through the rear window of the car

David and the surroundings viewed through lens L

Figure 2

(a) What kind of lens is L ? Explain your answer. (2 marks)

(b) Suppose that David in Figure 2 stands at 60 cm from lens L of focal length 30 cm. In Figure 3, David is plotted as AB. Draw a ray diagram to show how the image of David is formed by lens L. Use a horizontal scale of 1 cm to 10 cm. (4 marks)

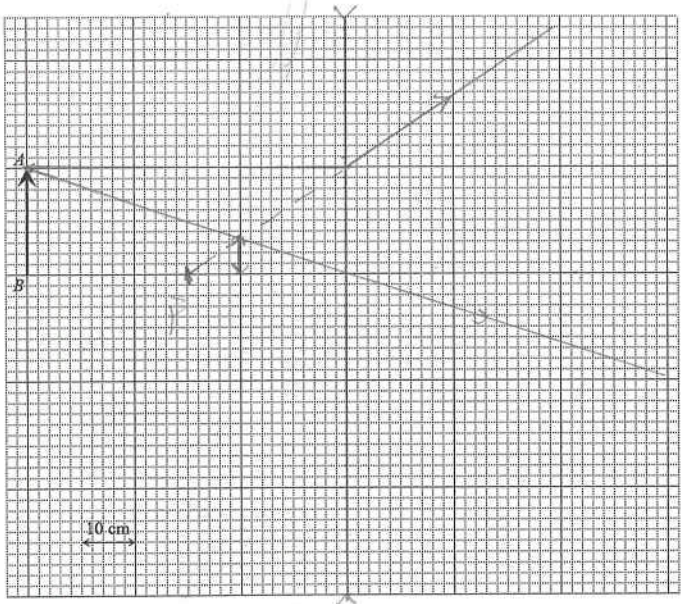


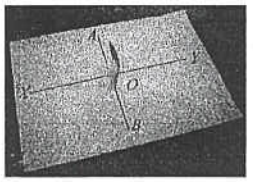
Figure 3

(c) State one advantage of using lens L. (1 mark)

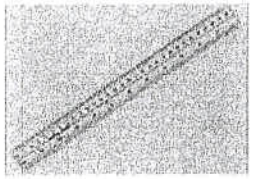
16. **< HKCE 2008 Paper I - 6 >**

Using the apparatus in the following figures, describe the procedures of an experiment to find the focal length of a cylindrical convex lens. (4 marks)

ray box with a **single slit** connected to a 12 V power supply



cylindrical convex lens on a paper with its optical centre at the intersection O of two perpendicular lines AB and XY, the line XY is the principal axis of the lens

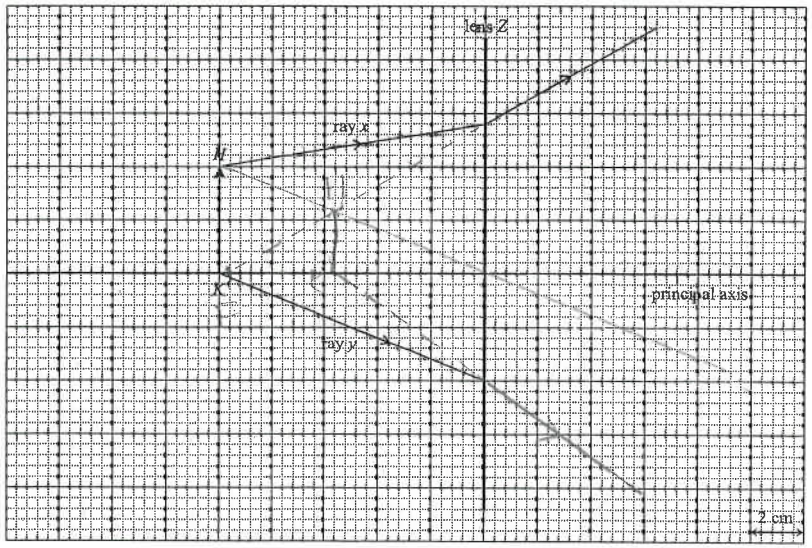


ruler

Provided by dse.life

17. **< HKCE 2009 Paper I - 5 >**

An object *HK* is placed in front of a lens *Z*. A light ray *x* from *H* passes through the lens as shown in the Figure below.



(a) Explain whether the lens is convex or concave. (2 marks)

(b) (i) Construct the image of *HK* in the above Figure. (3 marks)

(ii) Hence, find the linear magnification of the image. (1 mark)

(c) Mark the position of the principal focus *F* in the above Figure. (1 mark)

(d) Draw the refracted ray of ray *y* in the above Figure. (1 mark)

18. **< HKCE 2010 Paper I - 5 >**

Identical letters are printed on a paper. One of the letters is observed under a lens as shown in Figure 1.

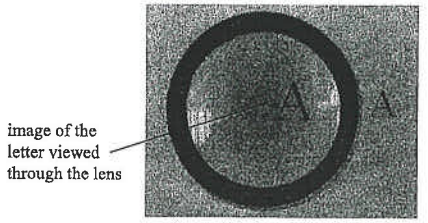


Figure 1

(a) What kind of lens is used ? Explain you answer. (2 marks)

(b) The height of the printed letter "A" is 2 cm. The lens is placed 4 cm above the paper. The linear magnification of the image is found to be 1.5. In Figure 2, *O* and *L* show the positions of the printed letter "A" and the lens respectively.

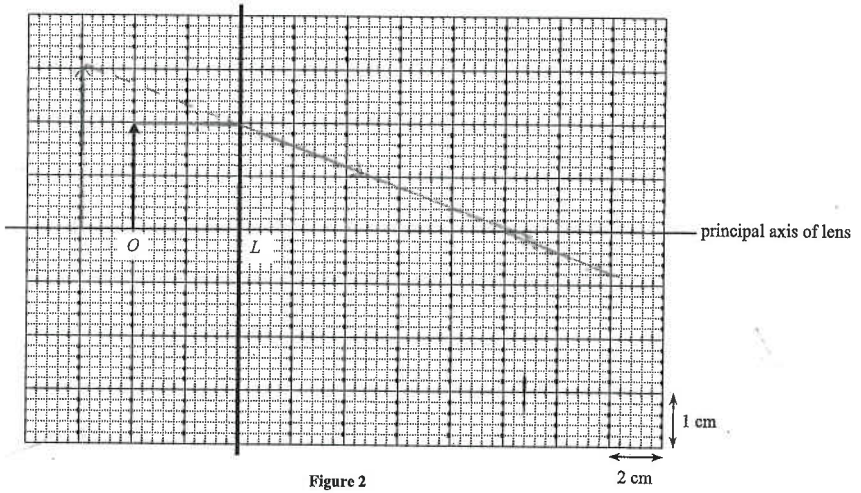


Figure 2

In Figure 2,

(i) draw an arrow to show the image of *O*. (2 marks)

(ii) add one suitable light ray to find the focal length of the lens. (2 marks)

Focal length = _____ cm.

(c) The lens is then placed at a distance twice the focal length above the paper. State the nature of the Image. (2 marks)

Provided by dse.life

19. **< HKCE 2011 Paper I - 4 >**

It is known that the refractive index of glass is different for light of different wavelengths. Figure (a) shows a blue light ray passing through a glass prism. Some angles are measured as shown.

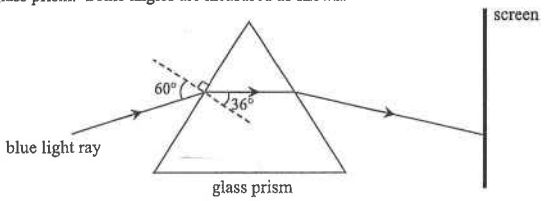


Figure (a)

(a) Determine the refractive index of glass for blue light. (2 marks)

(b) Now, the blue light ray is replaced by a red light ray as shown in Figure (b). The dotted line (– · – · – · –) shows the original path of the blue light ray. It is known that the refractive index of glass for red light is smaller than that for blue light. Sketch the path of the red light ray in Figure (b). (2 marks)

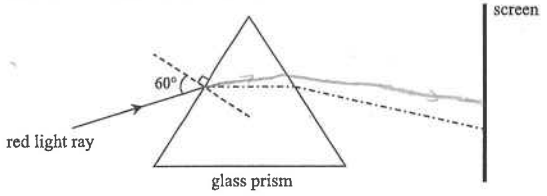


Figure (b)

(c) An object emitting red light is placed in front of a convex lens as shown in Figure (c). The lens is made of glass. A sharp image is formed on the screen. The positions of the object and the lens remain unchanged.

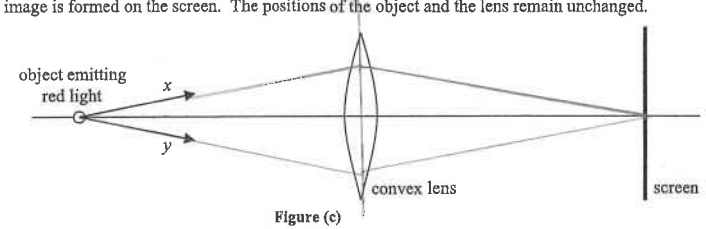


Figure (c)

(i) Complete the paths of rays *x* and *y* in Figure (c). (1 mark)

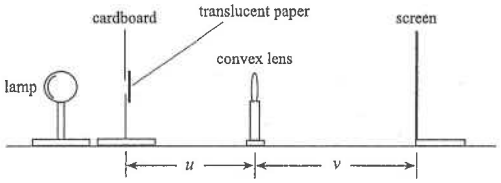
(ii) When the object is replaced by one emitting blue light, the image on the screen becomes blurred. Explain in which direction should the screen be moved in order to form a sharp image. (2 marks)

(iii) Now the object is replaced by one emitting white light. Theoretically, it is impossible to form a sharp image on the screen. Explain why. (2 marks)

Part B : HKAL examination questions

20. **< HKAL 2007 Paper IA - 5 >**

A student performs an experiment on an optical bench to measure the focal length of a convex lens. He places a lamp behind a sheet of cardboard with a circular hole covered by a piece of translucent paper and tries to locate a sharp image of the edge of the hole on a screen. The object distance and image distance are denoted by *u* and *v* respectively.



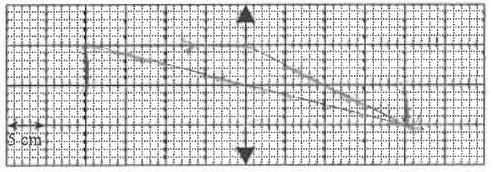
(a) Suggest **ONE** way to make it easier to focus the image on the screen. (1 mark)

(b) For a certain object distance, the student cannot obtain an image on the screen no matter how he adjusts the screen's position. What would most likely be the reason ? Explain briefly. (2 marks)

(c) If the centre of the lens is covered by a small coin, what would be the effect on the image formed on the screen ? Explain briefly. (2 marks)

(d) Suppose the object distance is exactly equal to the image distance and the separation between the object and the real image is 40 cm.

(i) Draw a ray diagram to show the formation of the image by the object. (2 marks)



(ii) From the ray diagram, write down the focal length of the lens. (1 mark)

Provided by dse.life

Part C : HKDSE examination questions

21. < HKDSE Practice Paper IB - 7 >

A drop of liquid is placed on a thin glass slide above a plastic ruler. The side view of the set-up is shown in Figure (a). Looking through the liquid drop, a magnified image of the number '9' on the ruler is seen as shown in Figure (b).

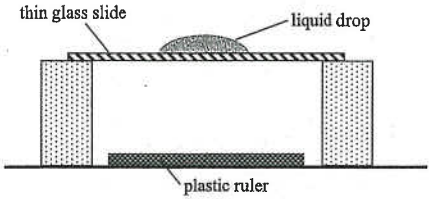


Figure (a)

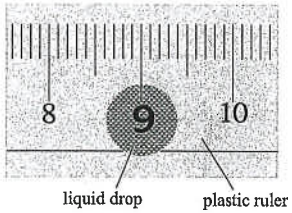


Figure (b)

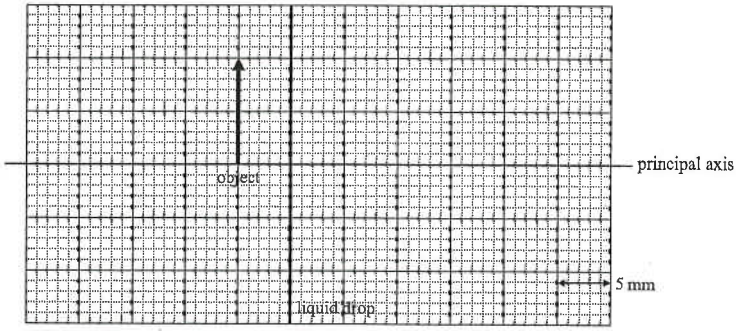
(a) A lens can be used to produce an image with the same nature as that produced by the liquid drop. State the type of lens and explain your answer. (2 marks)

(b) The linear magnification of the number '9' is 1.4. Take the number '9' as the object, use the graph paper below to

(i) draw the image of the object, and

(ii) draw **one** light ray to find the focal length of the liquid drop.

You may neglect the effect due to the thin glass slide. (3 marks)



Focal length of the liquid drop = _____ mm

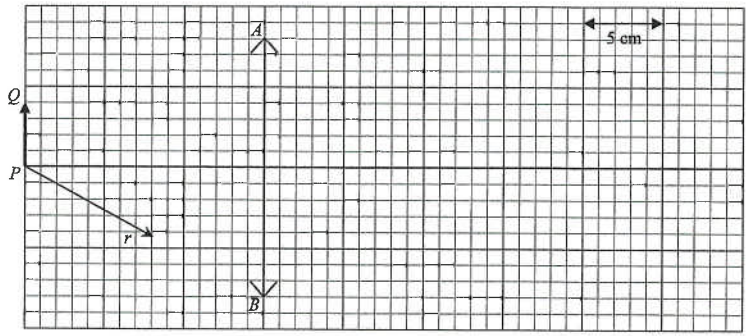
(c) If the refractive index of the liquid becomes smaller, explain the change, if any, in the focal length of the liquid drop. (2 marks)

22. < HKDSE 2012 Paper IB - 7 >

A luminous object *PQ* is placed 15 cm in front of a convex lens *AB* as shown in the Figure below.

(a) The focal length of the lens is 5 cm.

(i) Use a graphical method to find the location of the image of the object. Clearly draw all the construction lines on the Figure and state the nature of the image. (4 marks)



(ii) Complete the path of ray *r* on the Figure to show how it travels after passing through the convex lens. (1 mark)

(b) Suppose that a lens of focal length 10 cm is used instead while the size of the lens and the object distance of *PQ* from the lens remain unchanged.

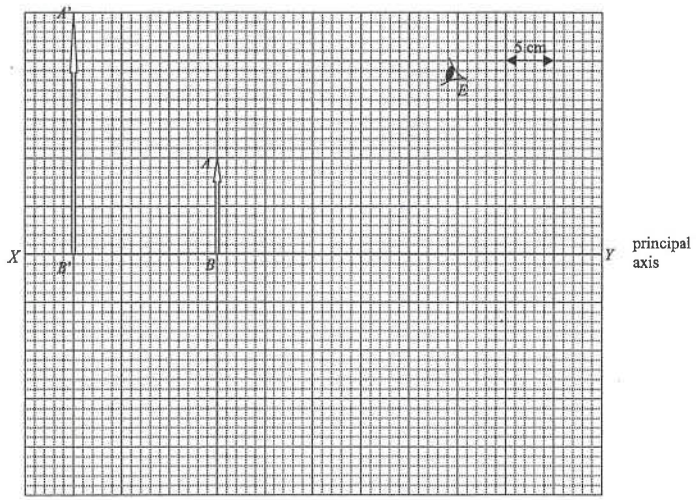
(i) Use the lens formula to find the image distance. Find also the linear magnification of the image. (3 marks)

(ii) Compare the brightness of this image with that in (a). Explain. (2 marks)

Provided by dse.life

23. **< HKDSE 2013 Paper IB - 8 >**

In the Figure below, *A'B'* represents the image of an object *AB* formed by a lens *L* (not shown) where *XY* is the principal axis of the lens.



(a) (i) Is the image real or virtual ? (1 mark)

(ii) What kind of lens is used ? Explain your answer. (2 marks)

(b) (i) Locate the optical centre *O* of lens *L* and draw on the above Figure the position of lens *L*. (1 mark)

(ii) By drawing an additional light ray, mark the principal focus *F* of the lens and find its focal length. The horizontal scale is 1 cm to 5 cm. (2 marks)

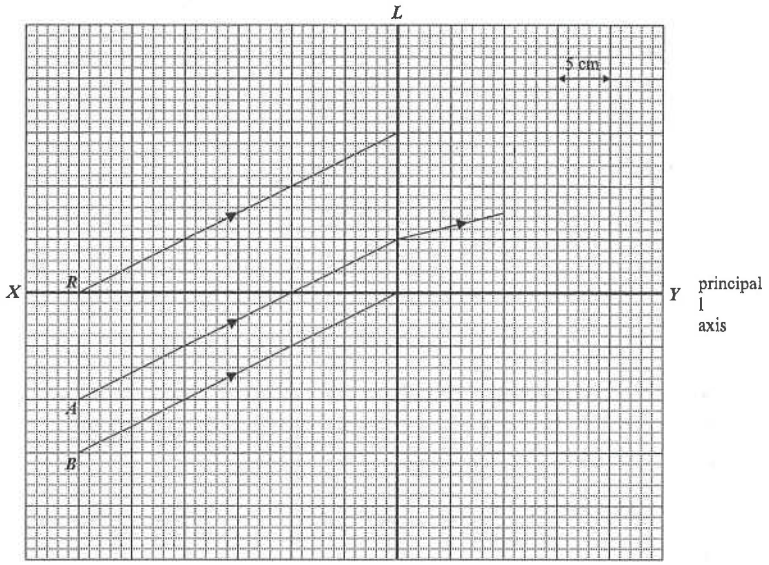
Focal length = _____

(c) Draw a light ray to show how the eye *E* shown can see the image of head *A* through lens *L*. (2 marks)

(d) State an application of lens *L* in the situation as shown above. (1 mark)

24. **< HKDSE 2014 Paper IB - 6 >**

In the below Figure, *XY* is the principal axis of a thin spherical lens *L* while *A*, *B* are two parallel rays coming from a *point P* of a distant object (**NOT** shown).



(a) What kind of lens is *L* ? Explain. (2 marks)

(b) (i) Locate the image of *P* (denoted it as point *P'*). (2 marks)

(ii) Hence, determine the focal length of the lens. (1 mark)

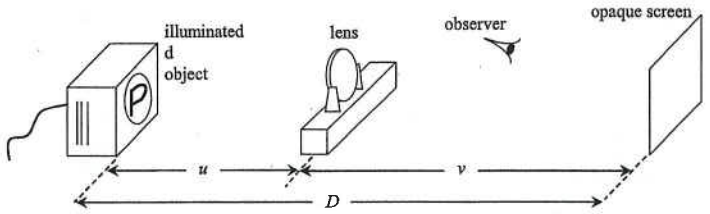
Focal length = _____

(c) *R* is a ray coming from the same point *P* ; complete its path after passing through the lens. (1 mark)

(d) Based on the situation shown in the ray diagram above, describe a simple experimental method to determine the focal length of lens *L*. (2 marks)

Provided by dse.life

25. **< HKDSE 2016 Paper IB - 5 >**



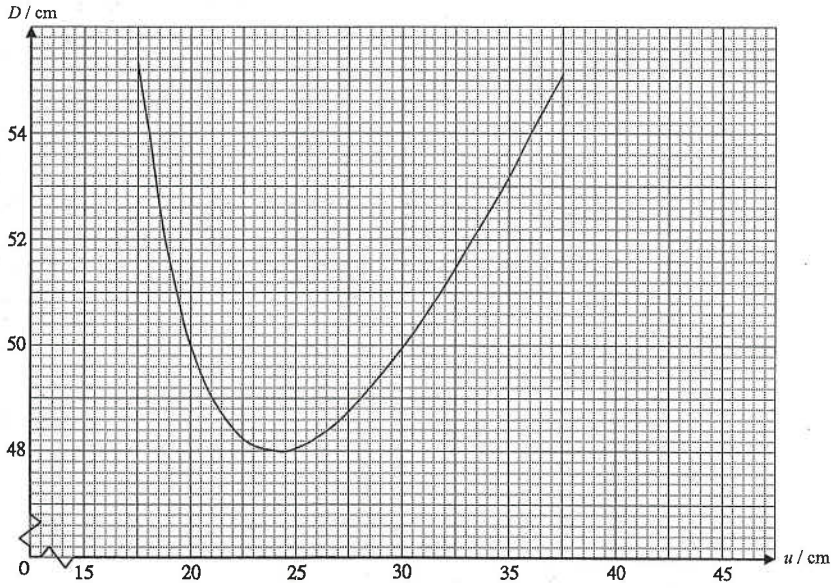
Kitty uses the set-up in the above Figure to study the image formation of a lens. The lens is placed at a distance u from an illuminated object (letter 'P'). An opaque screen is placed at a distance D from the object so as to capture the image.

(a) (i) State the kind of lens used. Explain your answer. (2 marks)

(ii) Sketch the image on the screen seen by the observer. (1 mark)

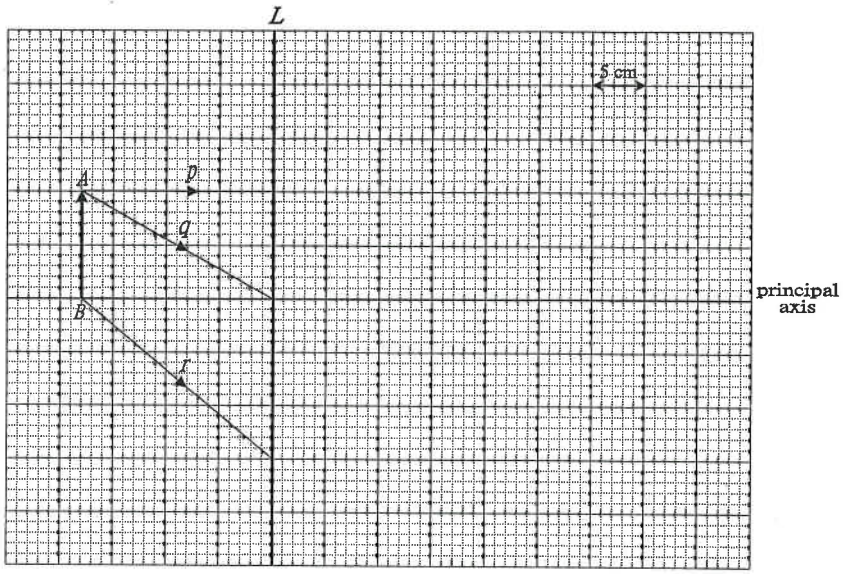
opaque screen

(b) The separation D is varied while the position of the lens is adjusted to form an image once again on the screen. The corresponding object distance u is obtained for plotting a graph of D against u as shown below.



25. (b) (i) When the lens is placed at 18 cm from the object, use the graph to find the corresponding separation between the lens and the screen. Hence calculate the magnification of the image. (2 marks)

In the Figure below, AB represents the illuminated object which is at 18 cm from the lens L. p, q and r are light rays from AB.



(ii) Indicate the image formed by AB (denote it as I) and draw the refracted rays of p, q and r. (3 marks)

(iii) Hence find the focal length of the lens. The horizontal scale is 1 cm to 5 cm. (1 mark)

Focal length = _____

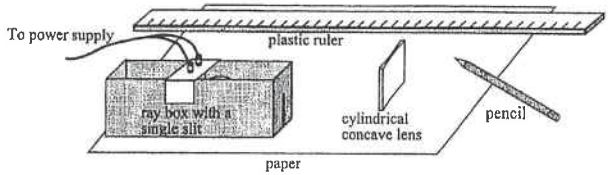
(iv) Keeping the object and screen fixed in position, suggest where Kitty should move the lens to such that an image can be formed again on the screen.

State the ratio $\frac{\text{height of this new image}}{\text{height of the original image}}$. (2 marks)

Provided by dse.life

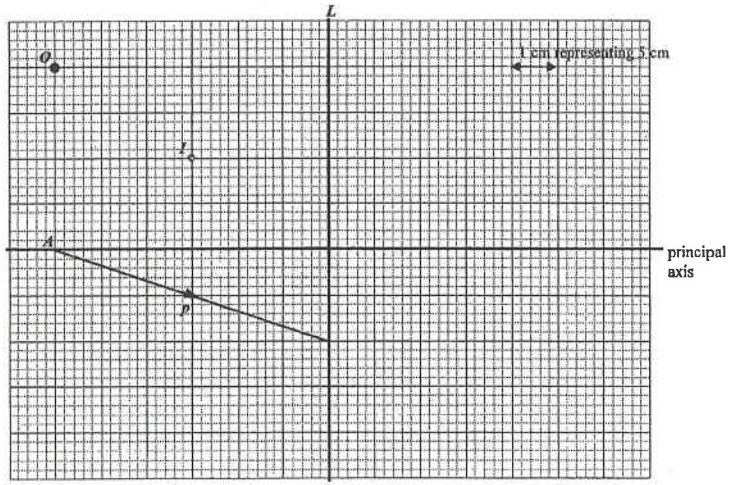
26. **< HKDSE 2018 Paper IB - 6 >**

(a) You are given a ray box with a single slit (producing a fine light beam), a cylindrical concave lens, a plastic ruler, a pencil and a piece of paper as shown in the Figure.



Describe how you would use the above apparatus to find the focal length of the lens and state **ONE** possible source of error in the experiment. (5 marks)

(b) In the figure below, L represents another cylindrical lens. A vertical pin used as the object is placed at O, the image is formed at I by the lens. The horizontal scale is 1 cm to 5 cm.



(i) What kind of lens is used ? Explain. (2 marks)

(ii) Draw a suitable light ray to locate the principal focus F of lens L. Find its focal length.

Focal length = _____ (2 marks)

(iii) Complete the path for the ray p from point A. (1 mark)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

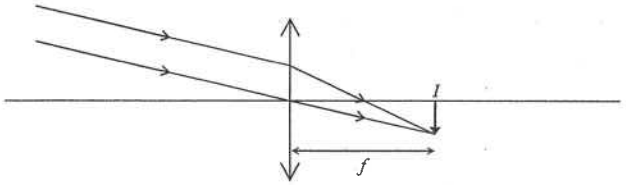
1. (a) A is a convex lens. < **OR** converging lens > [1]

(b) The image is virtual. [1]

2. (a) The convex lens is used to face a distant object [1]

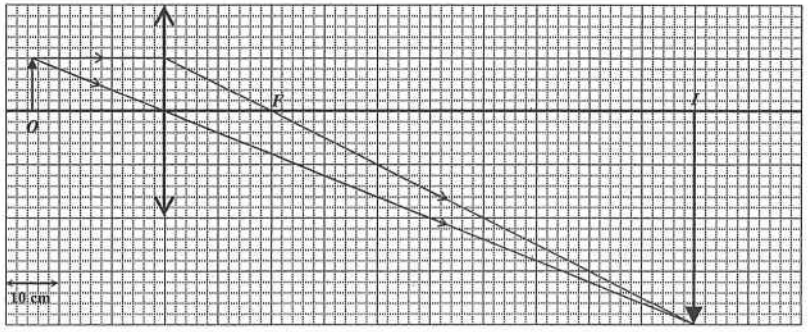
and the image is captured by a screen. [1]

The distance between the lens and the screen is equal to the focal length of the lens. [1]



[1]

(b) (i)



< a light ray parallel to principal axis refracts to F correctly drawn > [1]

< a light ray passing through optical centre without change of direction correctly drawn > [1]

< if any one arrow is missed, deduct one mark >

Distance between the lens and the screen = 100 cm < accept 90 cm to 110 cm > [1]

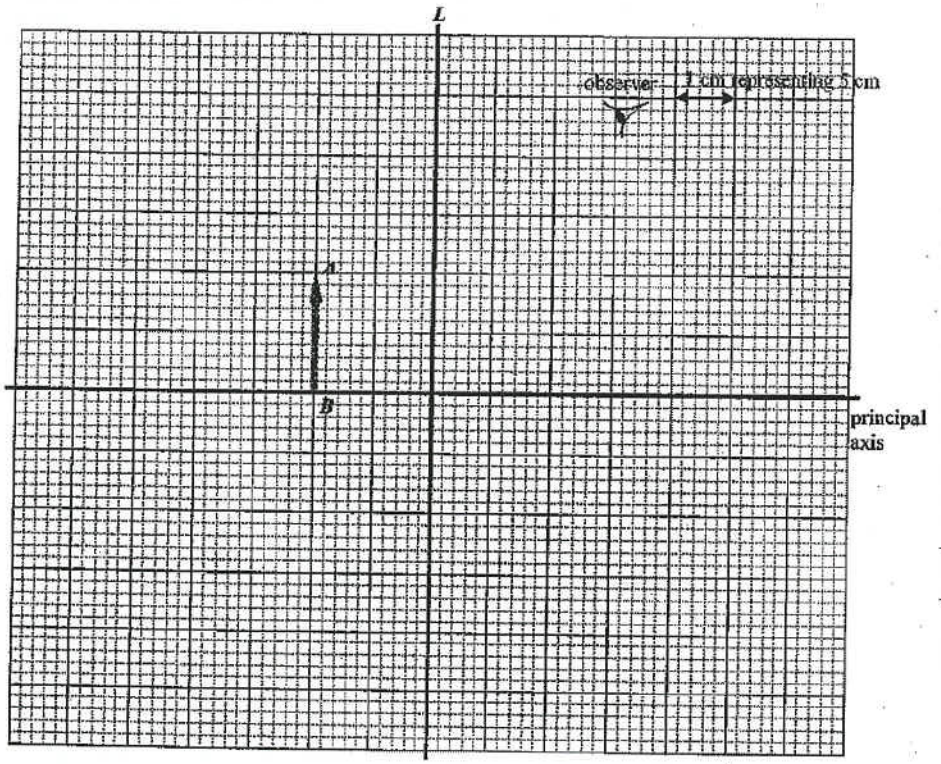
Magnification of the image = 4 < accept 3.5 to 4.5 > [1]

(ii) The lens should be moved away from the ruler. [2]

Provided by dse.life

27. <HKDSE 2019 Ppaper-IB-6>

In Figure 6.1, AB represents the virtual image of an object formed by lens L. The magnification of the image is 0.4. The horizontal scale is 1 cm to 5 cm.



(a) What kind of lens is used ? Explain. (2 marks)

.....

.....

.....

(b) Indicate on Figure 6.1 the position and height of the object. (2 marks)

(c) By drawing a suitable light ray, locate and mark the position of the focus, F, of the lens. Find the focal length of the lens. (3 marks)

Focal length = ...

(d) Draw a light ray emerging from the object to illustrate how the observer in the figure can see the tip A of the image. (2 marks)

28. < HKDSE 2020 Paper 1B -7>

Figure 7.1 shows an optical fibre which consists of a cylindrical glass core of refractive index n_g enclosed by a transparent cladding of refractive index n_c.

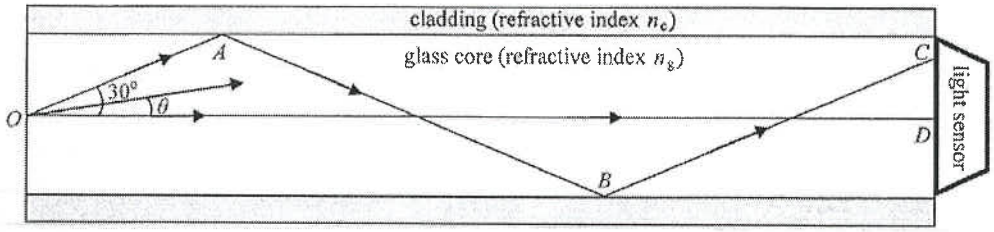


Figure 7.1

As shown in Figure 7.1, a point light source at O emits monochromatic light in all directions. Inside the fibre, light can reach the right end of the fibre through many different paths making angles θ with the axis OD. Two of these paths, OD and $OABC$, have been drawn for reference. Light ray OA makes an angle of 30° with the axis OD and is incident at the core-cladding boundary at A with an angle of incidence i_A.

(a) (i) Find i_A. (1 mark)

.....

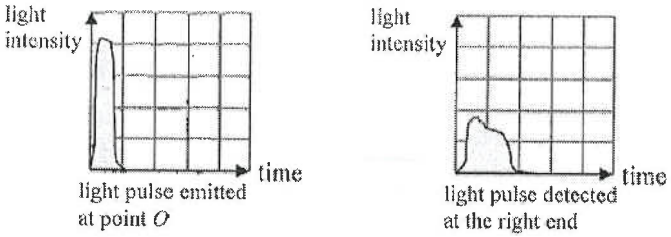
.....

(ii) If i_A is just greater than the critical angle of that boundary, estimate $\frac{n_g}{n_c}$. (2 marks)

(iii) What phenomenon occurs at point A ? State the condition needs to be satisfied by θ such that this phenomenon **fails to occur**. (2 marks)

(b) A narrow monochromatic light pulse (i.e. of a short duration) emitted at point O propagates with its energy within $\theta = \pm 30°$ towards a light sensor located at the right end of the optical fibre. The respective emitted and detected light pulses are represented below using the same scales.

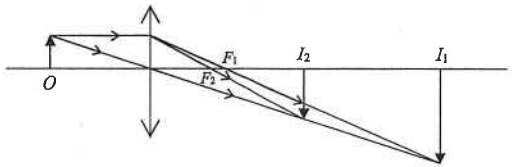
gure 7.2



(i) Explain why the light pulse detected is **broader** (i.e. of a longer duration) and with **lower intensity**. Assume that the loss of energy of the light pulse due to absorption by glass is negligible. (2 marks)

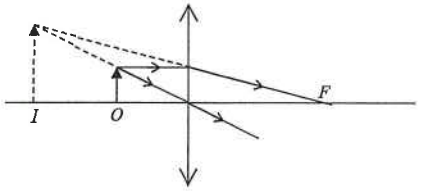
Provided by dse.life

2. (b) (iii) The magnification decreases. [1]



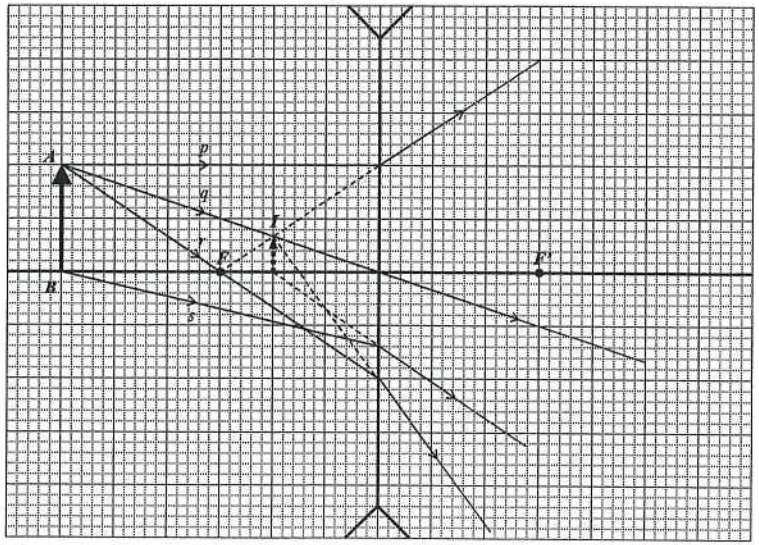
[1]

(iv) The image becomes virtual. [1]



[2]

3. (a)



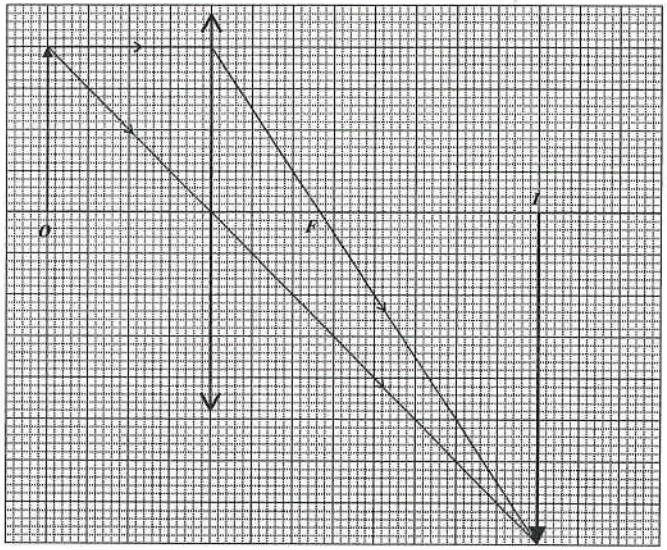
< Each correct ray 1 mark × 4 > [4]

< Correct position of image > [1]

(b) The image is virtual and erect. [2]

(c) Magnification m = 0.33 (± 0.03) [2]

4. (a) (i)



< Correct scale > [1]

< Light ray passing through the optical centre correctly drawn > [1]

< Light ray passing through the focus F correctly drawn > [1]

(ii) (1) object distance = 20 cm [1]

(2) image distance = 40 cm [1]

(3) focal length = 13.3 cm [1]

< accept 13.0 cm to 14.0 cm >

(iii) (1) magnification = 2 [1]

(2) natures of the image are real [1]
and inverted [1]

(b) The magnification increases first [1]
and then decreases finally. [1]

The nature of image is virtual [1]
and erect at first [1]

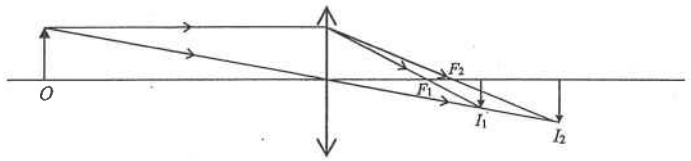
and then become real [1]
and inverted finally. [1]

Provided by dse.life

5. (a) (i) The approximate distance is 40 cm. [1]

For a distant object, image is formed at the focal plane of the lens. [1]

(ii)  [2]

(b) 

[3]

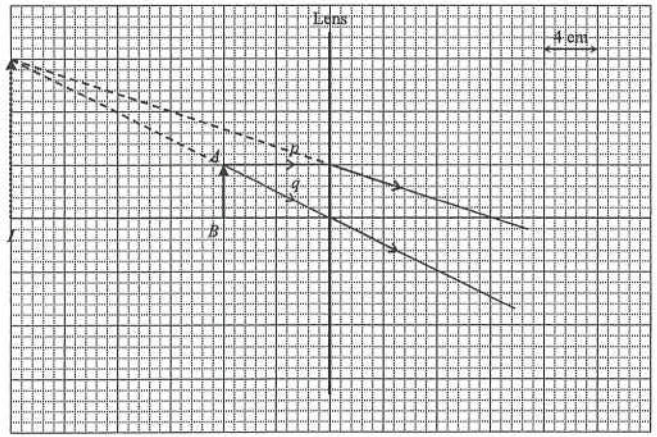
Image size increases. [1]

6. (a) Convex lens (**OR** Converging lens) [1]

Since only a convex lens can give a magnified image. [1]

(b) The image is virtual [1]

and erect [1]

(c) (i) 

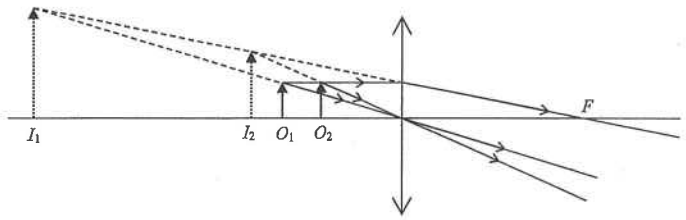
< Image behind object > [1]

< Magnification = 3 > [1]

< 2 correct rays > [2]

(ii) (1) Image distance = 24 cm [1]

(2) Focal length = 12 cm [1]

6. (d) 

[2]

Size of image decreases [1]

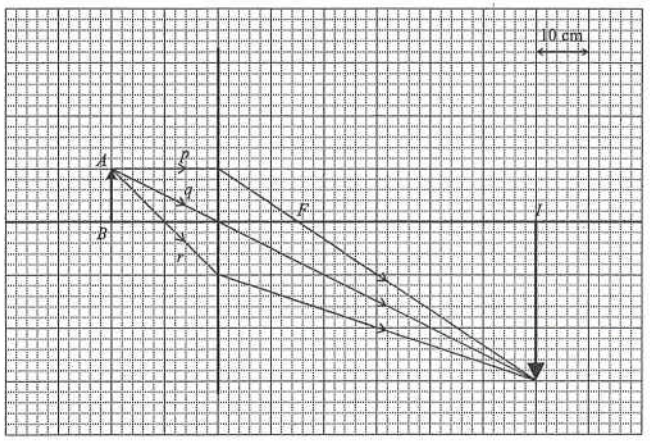
Image distance decreases [1]

(e) When object distance is greater than the focal length, the image becomes real [1]

and forms behind the observer's eye. [1]

7. (a) A convex lens is used. [1]

(b) The image is real. [1]

(c) (i) 

< 1 mark for each ray (solid line) > [3]

< Image at right position (solid inverted arrow) > [1]

(ii) $m = \frac{v}{u}$ (**OR** $m = \frac{h_i}{h_o}$) [1]

$= 3$ [1]

(iii) Focal length = 15 cm < from 14 cm to 16 cm is acceptable > [1]

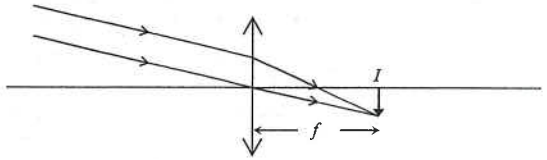
Provided by dse.life

7. (d) The brightness of the image decreases. [2]

OR

The image becomes dimmer. [2]

(e)



[1]

The lens is used to view a distant object and [1]

the image is caught by a screen. [1]

The distance from the lens to the screen is equal to the focal length of the lens. [1]

8. (a) (i) Convex lens [1]

Only convex lens can form real image [1]

(ii)  [2]

(b) (i) When $u = 18$ cm, $v = 36$ cm [1]

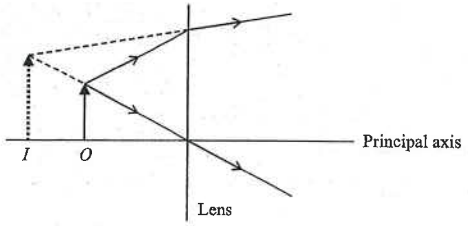
$m = \frac{v}{u} = \frac{36}{18} = 2$ [1]

(ii) $u = 24$ cm [1]

$f = 24 \times \frac{1}{2}$ [1]

$= 12$ cm [1]

(c) (i)



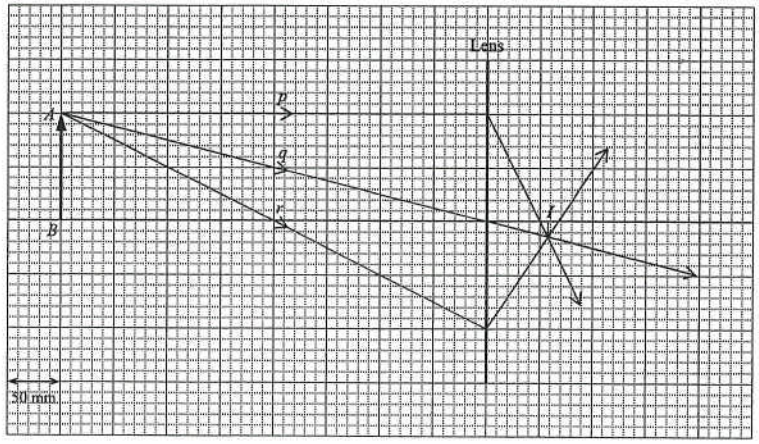
[3]

(ii) Magnifying glass [1]

(iii) False [1]

The image is virtual and cannot be formed on a screen. [1]

9. (a)



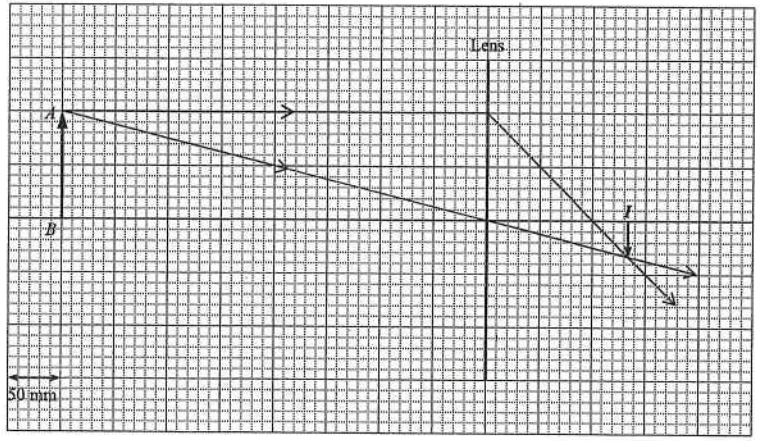
< ray p correctly drawn > [1]

< ray q correctly drawn > [1]

< ray r correctly drawn > [1]

< image correctly drawn > [1]

(b) As shown in the ray diagram, the size of the image is increased. [1]



< ray diagram correct > [1]

< two rays correctly drawn > [1]

< image correctly drawn > [1]

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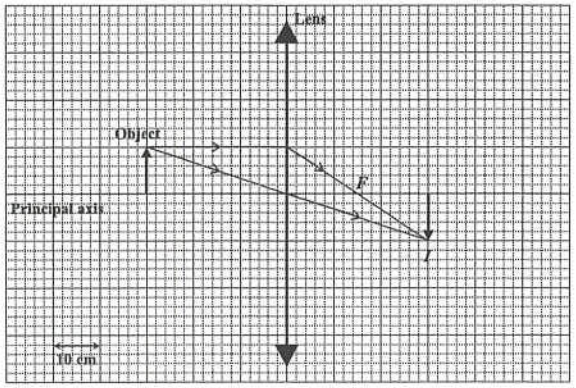
10. (a) The image is real [1]

because it can be formed on the screen [1]

(b)



< Image correctly drawn > [1]

< The ray passing through optical centre drawn > [1]

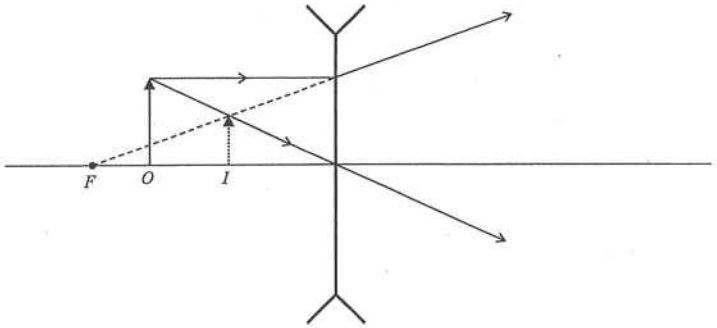
< The ray parallel to the principal axis drawn > [1]

The focal length of the lens is 15 cm. [1]

11. (a) It is a concave lens. [1]

The image is erect and diminished. [1]

(b)



< A ray passing through the optical centre correctly drawn > [1]

< A ray parallel to the principal axis correctly refracted > [1]

< Image correctly shown > [1]

12. (a) (i)

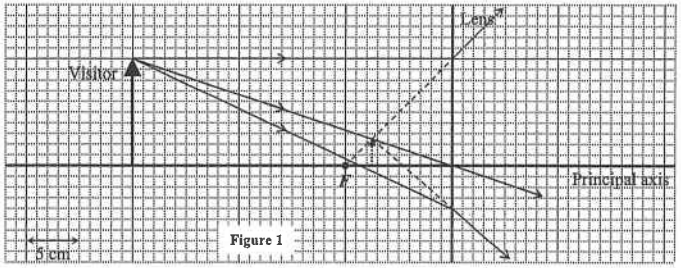


Figure 1

< 3 correct rays > (no mark for dotted rays or wrong direction) [3]

< image correct > (no mark for solid lines or inverted image) [1]

(ii) $m = \frac{v}{u} = \frac{7.5}{30}$ **OR** $m = \frac{h_i}{h_o} = \frac{2.5}{10}$ [1]

$= 0.25$ $= 0.25$ [1]

< m = 0.2 to 0.3 are acceptable >

(b) (i) Any **ONE** of the following : [2]

- The image formed by a convex lens may be inverted.
- The image formed may be magnified and it is difficult for Kitty to observe the image.
- The image formed may be real and forms behind Kitty and thus difficult for Kitty to observe the image.
- The field of view of the peephole would become narrower when a convex lens is used.

(c)

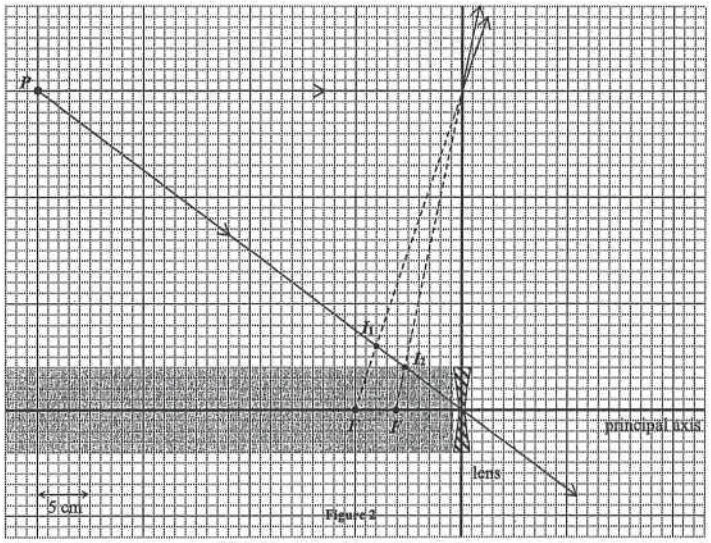


Figure 2

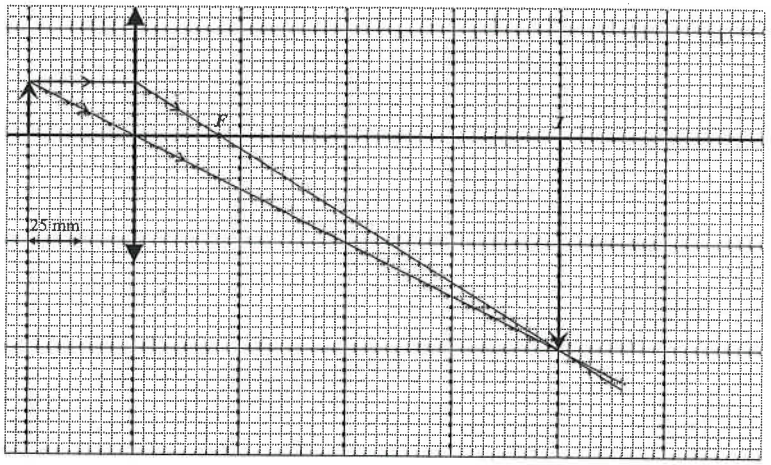
Provided by dse.life

12. (c) (i) Since the image I_1 is outside the shaded region, Kitty cannot see the visitor. [1]
< Two correct rays > [1]
< Position of the image I_1 correctly marked > [1]

(ii) Focal length of the lens = 6 cm < 5 cm to 7 cm is acceptable > [2]
< The image I_2 should be formed at the boundary of the shaded region > [1]
< Correct ray to locate the point of focus F' > [1]

13. (a) It is a convex lens. [1]
Since only convex lens can give a real image that can form on the screen. [1]

(b) (i)



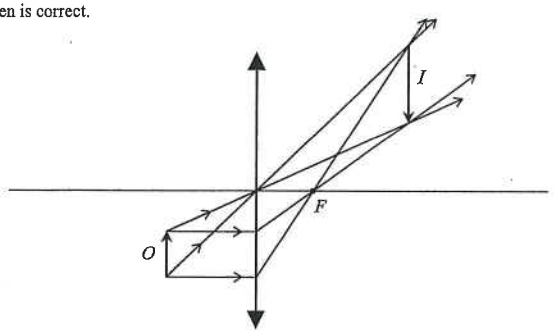
< Correct position of the lens > [1]
< 2 refracted rays correctly drawn > [1]
< Rays use solid line with arrows > [1]
< Image correctly drawn > [1]

(ii) $m = \frac{v}{u}$ (**OR** $m = \frac{h_i}{h_o}$) [1]
$= 4$ (Accept 3.2 to 4.5) [1]

(iii) (1) The projector should be moved away from the screen. [1]
The lens-to-slide distance should be decreased to re-focus the image onto the screen. [1]

(2) Since the focal length is larger than the object distance (41-55 mm) [1]
the image will become virtual that cannot be captured by the screen, thus it does not work. [1]

13. (c) Karen is correct. [1]

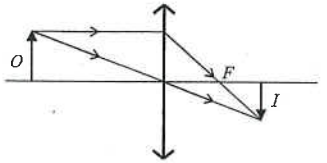


[2]

14. (a) The image is inverted, diminished [1]
and real. [1]

(b) (i) convex lens < **OR** converging lens > [1]

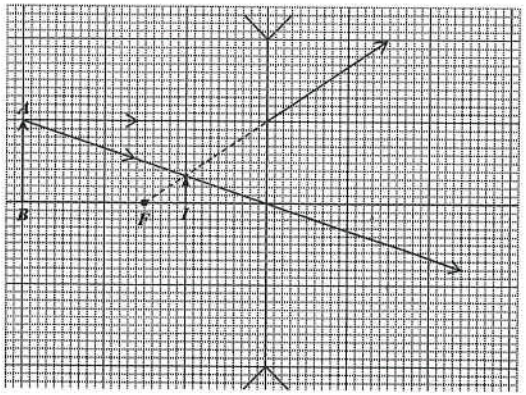
(ii)



[3]

15. (a) L is a concave lens. [1]
Since the image is erect and diminished. [1]

(b)



Provided by dse.life

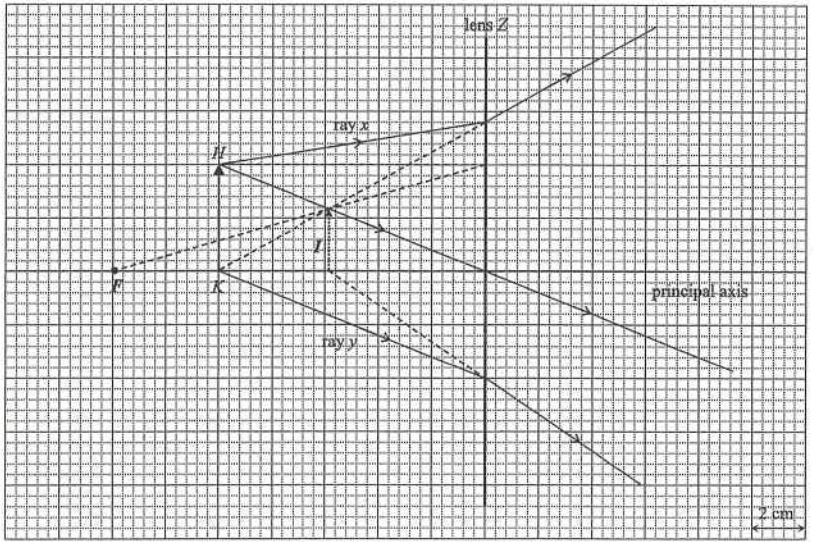
15. (b) < correct position of the lens and the its correct symbol > [1]
< correct ray passing through the optical centre > [1]
< correct ray parallel to the principal axis > [1]
< correct position of the image at about 20 cm (no mark if solid line is used) > [1]

(c) It can increase the field of view of the driver. [1]

16. Direct a light ray to the lens [1]
which is parallel to *XY*. [1]
Mark on the blank paper the point of intersection of the emerged light ray and the principal axis. [1]
Measure the distance between the point of intersection and the optical centre by the ruler to give the focal length. [1]

17. (a) Since the ray *x* diverges from the principal axis, [1]
it is a concave lens. [1]

(b) (i)



< refracted ray of *x* extended backwards > [1]
< ray passing through optical centre is drawn > [1]
< correct image marked > [1]

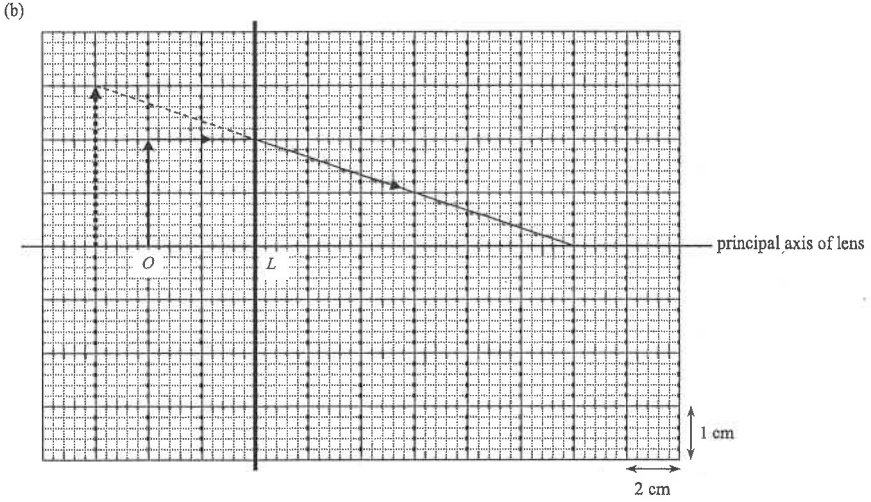
(ii) m = 0.58 < accept 0.50 to 0.62 > [1]

(c) < *F* marked at the left side of the lens, at around 13 to 15 cm > [1]

(d) < The refracted ray correctly drawn > [1]

18. (a) Convex lens [1]
Only convex lens can produce magnified image. [1]

(b)



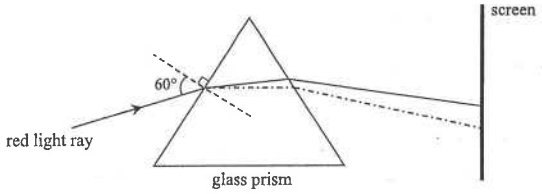
(i) < correct image distance and image size > [1]
< erect, same side as the object > [1]

(ii) < correct light ray > [1]
Focal length = 12 cm < accept 10.8 – 13.2 cm > [1]

(c) Real, inverted [1]
same size [1]

19. (a) $n = \frac{\sin i}{\sin r}$ [1]
$= \frac{\sin 60°}{\sin 36°}$
$= 1.47$ [1]

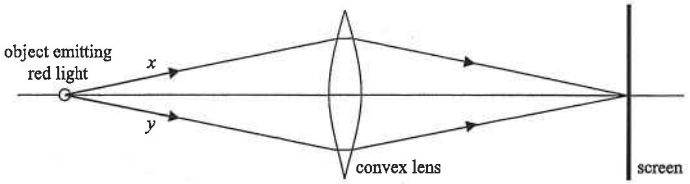
(b)



[2]

Provided by dse.life

19. (c) (i)



< after refraction, the two light rays meet at a point at the principal axis on the screen > [1]

< no mark is given if there is no arrow >

(ii) It is because blue light bends more in glass, the focal length of blue light is shorter. [1]

The screen should be moved towards the lens. [1]

(iii) White light consists of light of different colours. [1]

Image positions for light of different colours are different. [1]

20. (a) Add a mark, e.g. a cross, on the translucent paper. [1]

(b) The object distance is less than the focal length of the lens. [1]

The image would be virtual and cannot be formed on the screen. [1]

OR

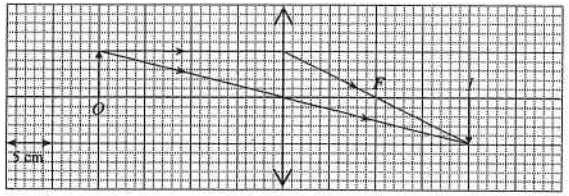
The object distance is equal to the focal length of the lens. [1]

The image would be at infinity and cannot be formed on the screen. [1]

(c) The whole image can be seen but become dimmer (less bright), [1]

since less light is refracted by the lens. [1]

(d) (i)



< object and image correctly drawn > [1]

< two rays correctly drawn > [1]

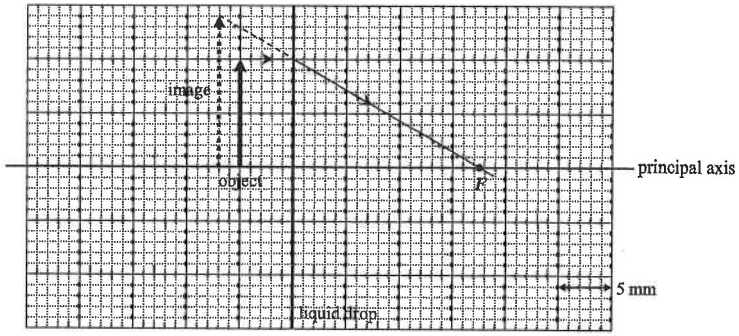
< if any one arrow is missed, deduct one mark >

(ii) f = 10 cm [1]

21. (a) Convex lens < **OR** converging lens > [1]

Only a convex lens can produce magnified image. [1]

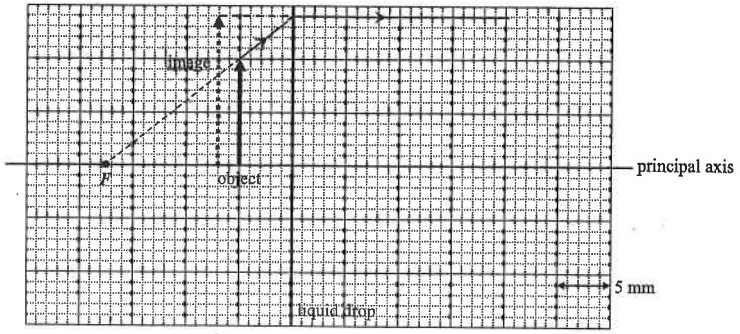
(b)



(i) < image position and height correct > [1]

(ii) < construction ray correct drawn > [1]

< the following construction ray is also acceptable to find the focal length >

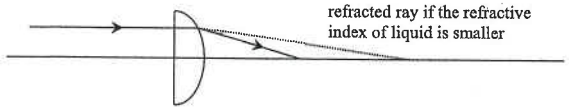


Focal length = 17.5 mm < accept 17 – 18 mm > [1]

(c) The focal length of the liquid will increase, [1]

since an incident ray parallel to the principal axis of the liquid will bend towards the principal axis less after passing through the liquid. [1]

< accept the explanation by drawing >

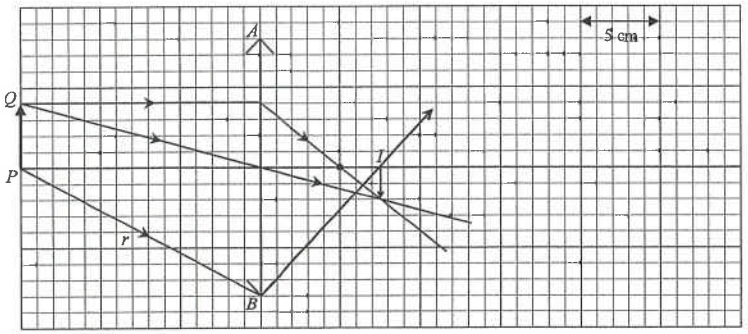


Provided by dse.life

22. (a) (i) Nature of image :

real [1]

inverted, diminished [1]



< A light ray passing through the optical centre > [1]

< A light ray parallel to the principal axis converges to the focus > [1]

(ii) < ray *r* correctly completed > [1]

(b) (i) $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\therefore \frac{1}{(10)} = \frac{1}{(15)} + \frac{1}{v}$ [1]

$\therefore v = 30$ cm [1]

$m = \frac{v}{u}$

$= \frac{30}{15} = 2$ [1]

(ii) Same amount of light is refracted by the lens in both cases.

For the magnified image in (b) (i), same amount of light is distributed over a larger image, [1]

thus, the image is dimmer compared to that in (a). [1]

OR

Same amount of light is refracted by the lens in both cases.

For the image in (b) (i), the image distance is greater, light intensity decreases as distance increases, [1]

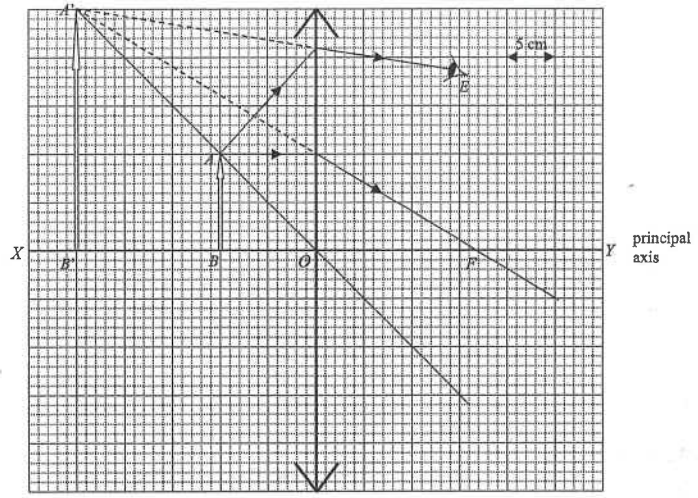
thus, the image is dimmer compared to that in (a). [1]

23. (a) (i) Virtual [1]

(ii) It is a convex lens. < **OR** converging lens > [1]

Only convex lens can give a magnified image. < virtual and erect image is **NOT** accepted > [1]

(b)



(i) < correct position of *O* marked in the figure and lens drawn correctly > [1]

(ii) < correct light ray drawn to locate *F* > [1]

Focal length = 17 cm < accept 16.0 to 17.5 cm > [1]

(c) < correct light ray drawn from *A'* to *E* > [1]

< incident light drawn from *A*, all correct, including solid line and dotted line > [1]

(d) Any **ONE** of the following : [1]

* magnifying glass
* glasses for long-sighted eye
* simple microscope

24. (a) *L* is a convex lens < accept converging lens > [1]

Reason (any **ONE** of the following) [1]

* since the ray *A* converged (**OR** bent) to the principal axis after refracted by *L*
* a real image (**OR** inverted image) can be formed
* the object and the image are at the opposite sides of the lens

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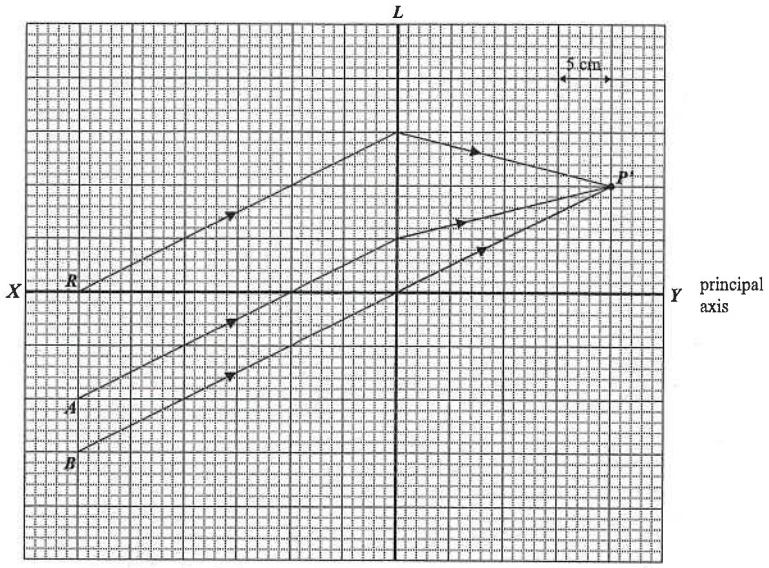
24. (b)



(i) < the ray A passing through the lens without bending > (no mark is awarded if no arrow) [1]

< the position of P' correctly marked > [1]

(ii) Focal length = 20 cm [1]

(c) < refracted ray of R travels to P' > [1]
(no mark is awarded if no arrow)

(d) Face the convex lens towards a distant object. Capture the sharp image onto a screen. [1]

The distance between the lens and the screen is the focal length of the lens. [1]

25. (a) (i) Convex lens [1]

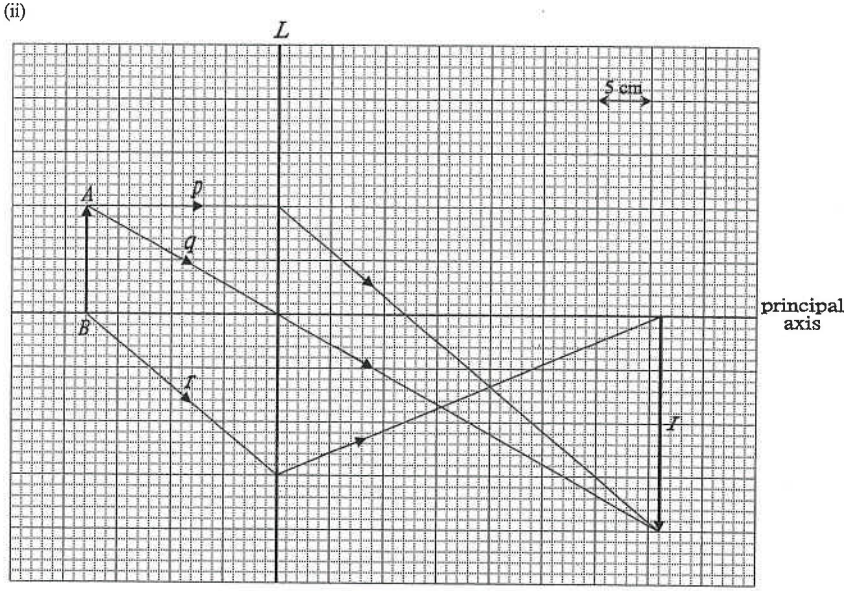
Only convex lens can form real image that can be captured by the screen [1]

(ii) b [1]

(b) (i) image distance : $v = 54 - 18 = 36$ cm [1]

Magnification : $m = \frac{v}{u} = \frac{36}{18} = 2$ [1]

25. (b) (ii)



< Image I correctly drawn > [1]

< Rays p and q correctly drawn with arrows > [1]

< Ray r correctly drawn with arrow > [1]

(iii) f = 12 cm < accept 11.5 cm to 12.5 cm > [1]

(iv) Move the lens 18 cm farther away from the object (**OR** towards the screen). [1]

Height ratio = 1 : 4 [1]

26. (a) On the paper, draw a straight line to represent the principal axis, mark a point O to represent the optical centre.
Place the lens on the paper so that the lens is perpendicular to the principal axis and its optical centre on O. [1]
Direct a light ray parallel to the principal axis to the lens and trace the path of the emergent ray on the paper. [1]
Extend the path of the emergent ray backwards and locate the intersection point F on the principal axis. [1]
Measure the distance of F from O, which gives the focal length of the lens. [1]

< accept using diagram to simplify the description >

Source of error (Any **ONE** of the following) : [1]

* The light ray may not be parallel to the principal axis.
* Due to the thickness of the beam of light, the path of ray may not be marked correctly.
* There is uncertainty in the reading of the focal length by using the plastic ruler.

< accept other reasonable answer >

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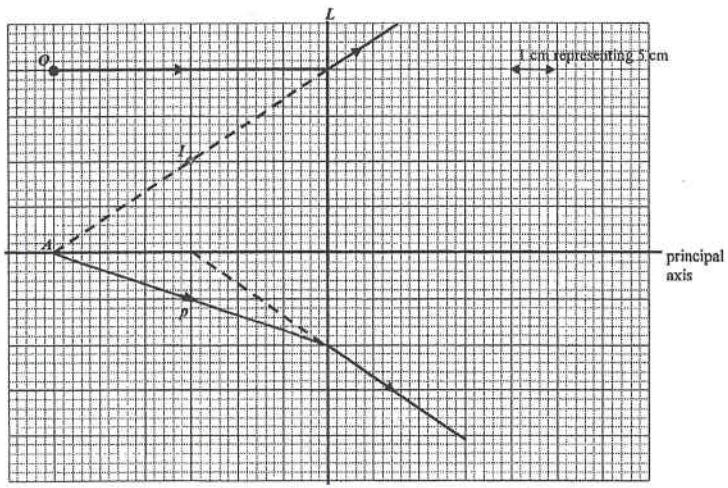
WA4 : Lenses

26. (b)



(i) *L* is a concave lens (**OR** divergent lens) [1]

Since the image is erect (**OR** virtual) and diminished. [1]

(ii) Focal length = 30 cm < accept 29 to 31 cm > [1]

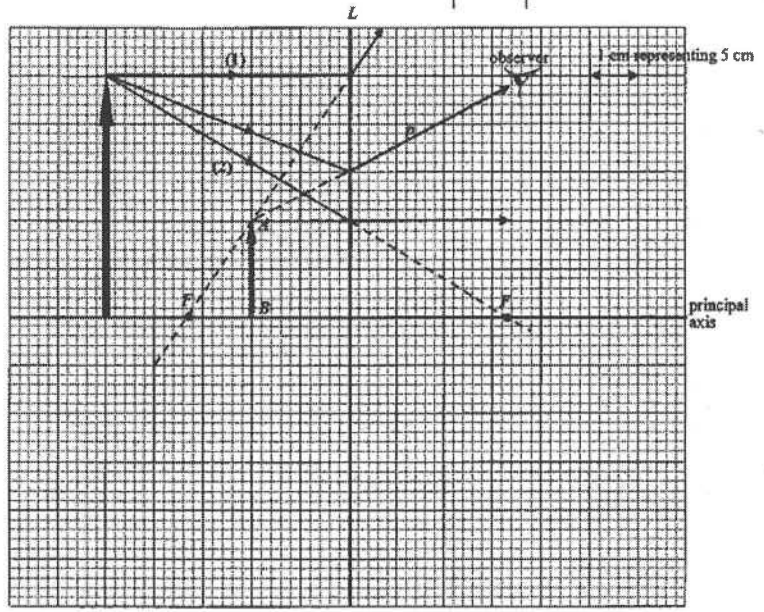
< ray to find *F* correctly drawn > [1]

(iii) < refracted light ray of *p* correctly drawn and extended backwards > [1]

27.

27. (a) *L* is diverging / concave. 1A
Only diverging / concave lens forms diminished, virtual image. 1A
2

(b)



Correct position and height of object 2A
2

(c) Correct ray to locate *F* and focus *F* correctly marked. 2M
Focal length = 16.5 cm 1A
Accept: (15.5 ~ 17.5) cm
3

(d) Correct ray *p* from tip of object 2A
2

Provided by dse.life

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8 \text{ m s}^{-1}$

The following list of formulae may be found useful :

Fringe width in double-slit interference $\Delta y = \frac{\lambda D}{a}$

Diffraction grating equation $d \sin \theta = n \lambda$

Part A : HKCE examination questions

1. < HKCE 1980 Paper II - 35 >

An electromagnetic wave has a frequency of the order of 10^{16} Hz. What should be the type of the electromagnetic wave ? Given that the speed of light in vacuum is $3 \times 10^8 \text{ m s}^{-1}$.

A. infra-red rays
B. visible light
C. ultra-violet rays
D. X-rays

2. < HKCE 1981 Paper II - 23 >

Given the following types of electromagnetic waves :

(1) radio waves
(2) yellow light
(3) green light

The waves listed in ascending order of their wavelengths are :

A. (1) , (3) , (2)
B. (2) , (1) , (3)
C. (3) , (1) , (2)
D. (3) , (2) , (1)

3. < HKCE 1982 Paper II - 14 >

Arrange the following electromagnetic waves in descending order of their wavelengths :

(1) visible light
(2) X-rays
(3) radio waves

A. (1) , (2) , (3)
B. (1) , (3) , (2)
C. (2) , (3) , (1)
D. (3) , (1) , (2)

4. < HKCE 1983 Paper II - 18 >

Which of the following statements about the properties of light is/are correct ?

(1) The speed of light in vacuum is independent of its wavelength.
(2) The wavelength of light will change when it enters a less dense medium.
(3) The frequency of light will change when it enters a less dense medium.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

5. < HKCE 1983 Paper II - 21 >

Given that the approximate wavelength of red light is 7×10^{-7} m, what is the approximate wavelength of an FM radio wave ?

A. 3×10^2 m
B. 3×10^{-3} m
C. 3×10^{-7} m
D. 3×10^{-9} m

6. < HKCE 1985 Paper II - 22 >

When light travels from air to glass, which of the following statements is/are true ?

(1) The speed of the light changes.
(2) The wavelength of the light increases.
(3) The frequency of the light remains unchanged.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

7. < HKCE 1985 Paper II - 23 >

A short pulse of microwave travelling at $3 \times 10^8 \text{ m s}^{-1}$ was used to detect the position of a stationary weather balloon. It was found that the microwaves reflected from the balloon were picked up 2×10^{-4} s after the pulse had been emitted from the station. The distance of the balloon from the station was

A. 1.5×10^4 m
B. 3.0×10^4 m
C. 1.5×10^{12} m
D. 3.0×10^{12} m

8. < HKCE 1985 Paper II - 24 >

Which of the following is in the correct order of increasing wavelengths ?

A. infra-red rays, X-rays, radio waves
B. infra-red rays, radio waves, X-rays
C. X-rays, radio waves, infra-red rays
D. X-rays, infra-red rays, radio waves

9. < HKCE 1986 Paper II - 26 >

Which of the following is/are transverse wave(s) ?

(1) water waves
(2) sound waves
(3) X-rays

A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (2) & (3) only

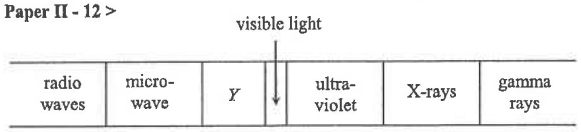
Provided by dse.life

10. **< HKCE 1987 Paper II - 15 >**

Which of the following has the shortest wavelength ?

A. X-rays
B. Microwaves
C. Radio waves
D. Visible light

11. **< HKCE 1988 Paper II - 12 >**



The figure above shows the electromagnetic spectrum. Which of the following statements about *Y* is/are true ?

(1) The frequency of *Y* is lower than that of visible light.
(2) *Y* is emitted by hot bodies.
(3) *Y* can be deflected by electric and magnetic field.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

12. **< HKCE 1988 Paper II - 28 >**

If the speed of radio waves in air is v_1 and the speed of light in air is v_2, which of the following is correct ?

A. $v_2 > 2v_1$
B. $2v_1 > v_2 > v_1$
C. $v_1 = v_2$
D. $2v_2 > v_1 > v_2$

13. **< HKCE 1988 Paper II - 29 >**

When a light ray travels from air to water, how do the speed, the frequency and the wavelength change ?

	Speed	Frequency	Wavelength
A.	remains the same	remains the same	remains the same
B.	becomes smaller	becomes greater	remains the same
C.	becomes smaller	remains the same	becomes smaller
D.	becomes greater	remains the same	becomes smaller

14. **< HKCE 1989 Paper II - 13 >**

A pulse of microwave of speed 3×10^8 m s^{-1} is sent out to detect the position of a stationary weather balloon. The reflected microwave was picked up in 2×10^{-4} s after emission. What is the distance of the balloon from the station ?

A. 1.5×10^4 m
B. 3.0×10^4 m
C. 6.0×10^4 m
D. 1.5×10^{12} m

15. **< HKCE 1989 Paper II - 27 >**

Which of the following descriptions about the nature of light is/are correct ?

(1) The speed of light in a vacuum is independent of its wavelength.
(2) There cannot be total internal reflection when light is travelling from air to water.
(3) Light travels faster in glass than in air.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

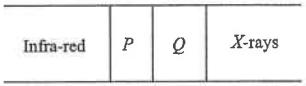
16. **< HKCE 1989 Paper II - 28 >**

Arrange the following in ascending order of wavelengths.

(1) X-rays
(2) Microwaves
(3) Visible light
(4) Ultra-violet rays

A. (1), (2), (3), (4)
B. (2), (3), (4), (1)
C. (1), (4), (3), (2)
D. (2), (1), (3), (4)

17. **< HKCE 1990 Paper II - 29 >**



The diagram shows part of the electromagnetic spectrum. Which of the following statements is/are true ?

(1) The wavelength of *P* is longer than that of *Q*.
(2) The velocity of *P* in a vacuum is smaller than that of *Q*.
(3) *Q* can be deflected by an electric field.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

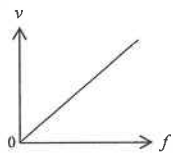
18. **< HKCE 1990 Paper II - 11 >**

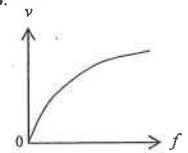
What happens to the wavelength and frequency of a ray of light if it passes from water to air ?

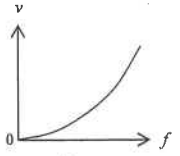
	Wavelength	Frequency
A.	increases	decreases
B.	decreases	remains unchanged
C.	remains unchanged	increases
D.	increases	remains unchanged

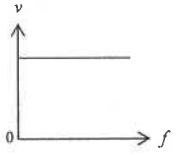
19. **< HKCE 1991 Paper II - 25 >**

Which of the following graphs correctly shows the variation of speed v against frequency f of the electromagnetic waves in vacuum ?

A. 

B. 

C. 

D. 

20. **< HKCE 1992 Paper II - 28 >**

Which of the following is an application of microwaves in everyday life ?

A. Radar
B. Carbon-14 dating
C. Radiotherapy
D. Detecting cracks in railway track

Provided by dse.life

21. **< HKCE 1992 Paper II - 27 >**

Given that the wavelengths of visible light range from 4×10^{-7} m to 7×10^{-7} m, which of the following combinations of wavelengths for infrared, red and violet lights is possible ?

	Infrared	Red light	Violet light
A.	1×10^{-4} m	7×10^{-7} m	4×10^{-7} m
B.	1×10^{-7} m	7×10^{-7} m	4×10^{-7} m
C.	1×10^{-4} m	4×10^{-7} m	7×10^{-7} m
D.	1×10^{-7} m	4×10^{-7} m	7×10^{-7} m

22. **< HKCE 1993 Paper II - 26 >**

Which of the following statements is/are true ?
(1) Light is a transverse wave.
(2) Light does not undergo diffraction.
(3) Light transmits energy.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

23. **< HKCE 1993 Paper II - 24 >**

A radio station broadcasts at a frequency of 94 MHz. Find the wavelength of the radio waves.
A. 0.31 m
B. 3.19 m
C. 31.91 m
D. 3191 m

24. **< HKCE 1994 Paper II - 22 >**

Which of the following statements concerning infra-red radiation is correct ?
A. Infra-red is red in colour.
B. Infra-red can be detected by a Geiger-Muller counter.
C. Infra-red can be used to sterilize drinking water.
D. Warm objects emit infra-red.

25. **< HKCE 1994 Paper II - 21 >**

Arrange the following electromagnetic waves in ascending order of frequencies.
(1) X-rays
(2) Ultra-violet rays
(3) Radio waves

A. (1), (2), (3)
B. (2), (1), (3)
C. (3), (1), (2)
D. (3), (2), (1)

26. **< HKCE 1996 Paper II - 28 >**

Which of the following is **not** an application of the corresponding electromagnetic wave ?

	Electromagnetic wave	Application
A.	Ultra-violet	Camera autofocusing
B.	Infra-red	Detecting survivors buried in landslides
C.	Microwaves	Satellite communication
D.	X-rays	Detecting weapons hidden in suitcases

27. **< HKCE 1996 Paper II - 26 >**

X-rays	*P*	Visible light	*Q*	Microwaves

Part of the electromagnetic spectrum is shown above. Which of the following statements is/are correct ?
(1) *P* is ultra-violet and *Q* is infra-red.
(2) The wavelength of *P* is shorter than that of *Q*.
(3) The speed of *P* in vacuum is higher than that of *Q*.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

28. **< HKCE 1997 Paper II - 26 >**

Which of the following is an application of ultra-violet radiation ?
A. Camera auto-focusing
B. Detecting cracks in railway tracks
C. Detecting survivors buried in landslides
D. Sterilization of drinking water

29. **< HKCE 1999 Paper II - 24 >**

Which of the following equipment emit(s) waves which are electromagnetic in nature ?
(1) a television remote control
(2) a microwave oven
(3) an ultrasonic scanner for examining foetuses (babies not yet born)

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

30. **< HKCE 2000 Paper II - 25 >**

Scientists have discovered that ozone molecules in the earth's atmosphere are being destroyed. Which of the following electromagnetic waves is mainly responsible for causing hazard to human health as a result of the damaging of the ozone layer ?
A. gamma radiation
B. visible light
C. infra-red
D. ultra-violet

31. **< HKCE 2002 Paper II - 27 >**

Which of the following is/are the reason(s) for **not** over-using ultra-violet lamps to produce a suntan effect ?
(1) Ultra-violet radiation is highly penetrating and will damage body tissue.
(2) Ultra-violet radiation has a strong heating effect and will damage body tissue.
(3) Over exposure to ultra-violet radiation may cause skin cancer.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

Provided by dse.life

32. **< HKCE 2003 Paper II - 30 >**

The photograph shows a digital video camera recorder. The recorder has a night-shot function of capturing images in the dark. Which of the following electromagnetic waves is employed by the recorder in capturing images in the dark ?

A. radio waves
B. infra-red
C. ultra-violet
D. X-rays

33. **< HKCE 2004 Paper II - 24 >**

A ship is equipped with certain devices. Which device is **not** an application of electromagnetic waves ?

A. the radar system
B. the sonar system
C. the infra-red system for night navigation
D. the wireless telecommunication system

34. **< HKCE 2005 Paper II - 16 >**

Which of the following shows the correct order of the relative positions of five electromagnetic waves in the electromagnetic spectrum, in the order of decreasing wavelength ?

A. microwaves, infra-red, visible light, ultra-violet, X-rays
B. microwaves, ultra-violet, visible light, infra-red, X-rays
C. X-rays, infra-red, visible light, ultra-violet, microwaves
D. X-rays, ultra-violet, visible light, infra-red, microwaves

35. **< HKCE 2007 Paper II - 17 >**

Which of the following phenomena demonstrate(s) that light is an electromagnetic wave ?

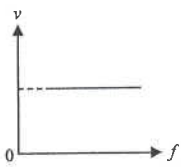
(1) Light bends when it travels across a boundary from one medium into another.
(2) Light reflects when it meets a polished metal surface.
(3) Light can travel from the Sun to the Earth.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

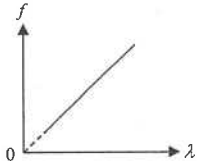
36. **< HKCE 2009 Paper II - 16 >**

Which of the following graphs showing the relationship among velocity (v), frequency (f) and wavelength (λ) of electromagnetic waves in vacuum is/are correct ?

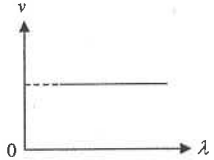
(1)



(2)

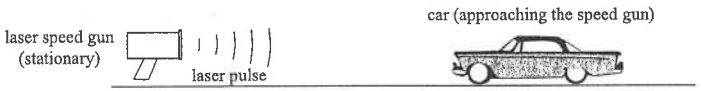


(3)



A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

37. **< HKCE 2010 Paper II - 37 >**



In the figure, a laser speed gun is used to check for speeding. A car is approaching the speed gun. The speed gun emits a laser pulse. The speed gun receives the reflected pulse from the car after 3.6×10^{-7} s. After 0.2 s, the speed gun emits another laser pulse. The speed gun receives the reflected pulse from the car after 3.1×10^{-7} s. What is the estimated speed of the car ? Given that speed of the laser pulse is 3×10^8 m s^{-1}.

A. **15.0 m s^{-1}**
B. 20.1 m s^{-1}
C. 37.5 m s^{-1}
D. 40.2 m s^{-1}

38. **< HKCE 2011 Paper II - 13 >**

Compare the time taken for the following waves to travel a distance of 100 m.

T_1 Water waves with frequency 0.5 Hz and wavelength 2 m
T_2 Sound waves travelling at 340 m s^{-1}
T_3 Microwaves emitted by an artificial satellite

The time taken in **descending** order is

A. $T_1 > T_2 > T_3$
B. $T_2 > T_3 > T_1$
C. $T_3 > T_2 > T_1$
D. $T_1 > T_3 > T_2$

Part B : HKAL examination questions

39. **< HKAL 1981 Paper I - 43 >**

In Young's double slit experiment, which of the following can increase the separation of the interference fringes on the screen ?

(1) Increase the distance between the double slits and the screen.
(2) Increase the wavelength of the light.
(3) Increase the distance between the light source and the double slits.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

40. **< HKAL 1989 Paper I - 22 >**

When light of wavelength λ is incident normally on a diffraction grating with p lines per millimetre, the second-order maximum is at an angle θ from the central position. When light of wavelength $5\lambda/4$ is incident normally on another grating with $3p$ lines per millimetre, the first-order maximum is formed at an angle ϕ from the central position. Which of the following relations is correct ?

A. $\sin \phi = (5 \sin \theta) / 12$
B. $\sin \phi = \sin (5\theta / 12)$
C. $\sin \phi = \sin (15\theta / 4)$
D. $\sin \phi = (15 \sin \theta) / 8$

Provided by dse.life

41. **< HKAL 1995 Paper IIA - 14 >**

In Young's double-slit experiment, which of the following combinations of monochromatic light, the slit-separation and the slit-to-screen distance would produce the greatest fringe separation on the screen ?

	Monochromatic light	Slit-separation	Slit-to-screen distance
A.	red light	1 mm	1 m
B.	red light	1 mm	2 m
C.	red light	2 mm	1 m
D.	blue light	1 mm	2 m

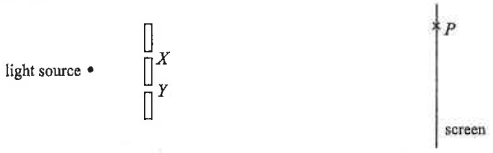
42. **< HKAL 1996 Paper IIA - 12 >**

When light travels from glass to air, the emergent light would show an increase in

(1) frequency.
(2) wavelength.
(3) velocity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

43. **< HKAL 1997 Paper IIA - 15 >**

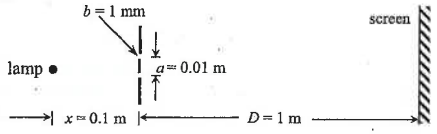


In a Young's double-slit experiment, the light source gives out a monochromatic light of wavelength 400 nm. If the path difference of light from the two slits X and Y at point P on the screen is 3000 nm, which of the following is/are correct ?

(1) At point P, the 7th dark fringe is observed.
(2) If the light source is moved closer to the slits, the fringe separation on the screen will increase.
(3) If light of wavelength 500 nm is used, point P will become a bright fringe.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

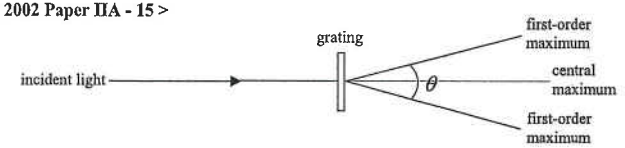
44. **< HKAL 2001 Paper IIA - 13 >**



A student prepares a double-slit interference experiment as shown. a is the slit separation and b is the slit width. However, no interference fringe can be observed on the screen. Which of the following improvements should be taken ?

A. decrease x
B. decrease D
C. increase b
D. decrease a

45. **< HKAL 2002 Paper IIA - 15 >**



When a monochromatic light passes through a diffraction grating, a pattern of maxima and minima is observed as shown. Which of the following combinations would produce the largest angle θ between the two first-order maxima ?

	Grating (lines per mm)	Colour of light used
A.	200	green
B.	200	red
C.	400	green
D.	400	red

46. **< HKAL 2003 Paper IIA - 19 >**

A plane diffraction grating having a ruling of 5000 lines per cm. When monochromatic light of wavelength 500 nm is incident normally onto it, which of the following descriptions is/are correct ?

(1) The spacing between the rulings is 2000 nm.
(2) The second-order maximum occurs at an angle of 30° from the central line.
(3) There is no third-order maximum in the diffracted pattern.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

47. **< HKAL 2004 Paper IIA - 11 >**

In a Young's double-slit experiment, a monochromatic light source is used. Which of the following methods would increase the fringe separation on the screen ?

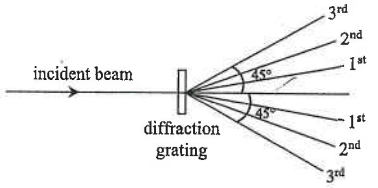
(1) Use a monochromatic light source of longer wavelength.
(2) Use a double slit with greater slit separation.
(3) Use a double slit with larger slit width.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

48. **< HKAL 2007 Paper IIA - 10 >**

A beam of monochromatic light is incident normally on a diffraction grating. The third-order maxima are found at angles of 45° from the central line. What is the highest order of diffracted maximum that can be observed ?

A. 3rd order
B. 4th order
C. 5th order
D. 6th order



49. **< HKAL 2007 Paper IIA - 11 >**

In a Young's double-slit experiment, monochromatic light of wavelength 550 nm is used. The fringes are formed on a screen placed at 1.0 m from the double slits. If the separation between the first and the fifth dark fringes is 5.0 mm, calculate the slit separation of the double slits.

A. 0.3×10^{-4} m
B. 1.1×10^{-4} m
C. 4.4×10^{-4} m
D. 5.5×10^{-4} m

Provided by dse.life

50. **< HKAL 2011 Paper IIA - 15 >**

Which of the following statements about a transmission diffraction grating are correct when monochromatic light is incident onto **the grating ?**

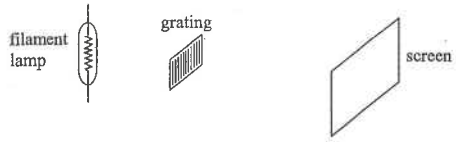
(1) The grating produces diffraction pattern on both sides of the central line.

(2) The angle of diffraction of the same order is directly proportional to the wavelength of the incident light.

(3) A grating with smaller grating spacing gives greater diffracted angle of the first maxima.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

51. **< HKAL 2012 Paper IIA - 13 >**



A student used the above set-up to produce a diffraction pattern on a screen. The filament lamp gives out white light. It was found that part of the second-order spectrum overlapped with the third-order one. The student suggested the following changes to eliminate the overlapping so as to obtain a pure second-order spectrum. Which of the following may be possible ?

(1) Move the screen closer to the grating.

(2) Replace the grating by one with smaller grating spacing.

(3) Insert a single slit between the filament lamp and the grating.

A. (1) only
B. (2) only
C. (3) only
D. None of the above

Part C : Supplemental exercise

52. A diffraction grating ruled with 500 lines per mm is illuminated normally by white light. If the wavelengths for yellow light and violet light are 600 nm and 400 nm respectively, which of the following statements are correct ?

(1) In the first order spectrum, the violet end is closer to the central bright fringe than the red end.

(2) The second-order image of yellow light coincides with the third-order image of violet light.

(3) There is no fourth-order image for violet light.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

53. Which of the following correctly gives the order of magnitude of the wavelengths of infra-red radiation and ultra-violet radiation in air ?

	Infra-red radiation	**ultra-violet radiation**
A.	10^{-2} m	10^{-8} m
B.	10^{-5} m	10^{-8} m
C.	10^{-2} m	10^{-10} m
D.	10^{-5} m	10^{-10} m

54. Two identical monochromatic light sources cannot give interference pattern. The reason(s) is/are

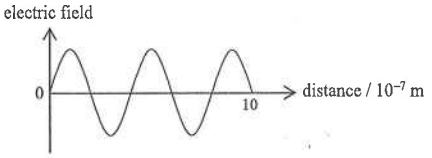
(1) the two light sources have different amplitudes.

(2) the two light sources have different frequency.

(3) the two light sources do not have constant phase relationship.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

55.



The above figure shows how the electric field of a monochromatic light wave varies with distance in air. Which description about the colour of the light and its frequency is correct ?

	colour	**frequency / Hz**
A.	violet	5.0×10^{14}
B.	violet	7.5×10^{14}
C.	orange	5.0×10^{14}
D.	orange	7.5×10^{14}

56. A diffraction grating of 4000 lines per cm is placed at a distance of 0.75 m from a screen. A monochromatic light is directed perpendicularly onto the grating. The two second-order fringes on the screen are at a separation of 68.6 cm. Calculate the wavelength of the monochromatic light.

A. 460 nm
B. 520 nm
C. 545 nm
D. 572 nm

Part D : HKDSE examination questions

57. **< HKDSE Sample Paper IA - 20 >**

A Young's double-slit experiment was performed using a monochromatic light source. Which change would result in a greater fringe separation on the screen ?

(1) Using monochromatic light source of longer wavelength

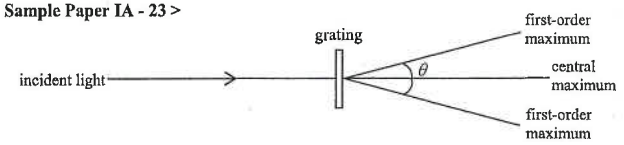
(2) Using double slit with greater slit separation

(3) Using double slit with larger slit width

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

58. **< HKDSE Sample Paper IA - 23 >**



When monochromatic light is passed through a diffraction grating, a pattern of maxima and minima is observed as shown. Which combination would produce the largest angle θ between the first-order maxima ?

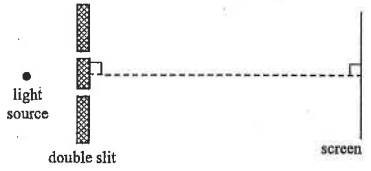
	Grating (lines per mm)	Colour of light used
A.	200	blue
B.	200	red
C.	400	blue
D.	400	red

59. **< HKDSE Practice Paper IA - 23 >**

Yellow light of wavelength 590 nm is incident normally on a diffraction grating with 400 lines per mm. Find the difference in angular positions for the third order and the fourth order bright fringes.

A. 13.7°
B. 25.7°
C. 45.1°
D. 70.7°

60. **< HKDSE Practice Paper IA - 22 >**



In a Young's double slit experiment, a monochromatic light source of wavelength 600 nm is used. The fringe separation is 5 mm on the screen. If the slit separation is halved and a monochromatic light source of wavelength 450 nm is used instead, what is the new fringe separation ?

A. 1.9 mm
B. 3.3 mm
C. 7.5 mm
D. 13.3 mm

61. **< HKDSE Practice Paper IA - 16 >**

Which of the following phenomena demonstrates that light is an electromagnetic wave ?

A. Light carries energy.
B. Light reflects when it meets a polished metal surface.
C. Light bends when it travels across a boundary from one medium into another.
D. Light can travel from the Sun to the Earth.

62. **< HKDSE 2012 Paper IA - 19 >**

Which of the following statements is INCORRECT ?

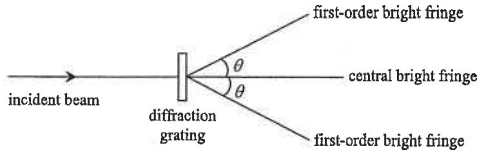
A. In air, the wavelength of infra-red radiation is shorter than that of ultra-violet radiation.
B. Visible light travels faster in air than in glass.
C. Microwaves travel at the speed of light in a vacuum.
D. Both light and sound exhibit diffraction.

63. **< HKDSE 2012 Paper IA - 20 >**

For a diffraction grating of 600 lines per mm, the diffracted red light (657 nm) coincides with the diffracted violet light (438 nm) at an angle of diffraction of 52°. What are the respective orders of the diffracted red light and violet light ?

	red	violet
A.	2	3
B.	3	4
C.	3	2
D.	4	3

64. **< HKDSE 2013 Paper IA - 23 >**



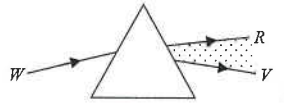
When monochromatic light passes through a diffraction grating, a pattern of bright fringes is formed. Which arrangement would produce the greatest angle θ between the central and first-order bright fringes ?

	grating (lines per mm)	colour of light
A.	400	green
B.	400	blue
C.	200	green
D.	200	blue

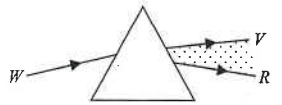
65. **< HKDSE 2015 Paper IA - 17 >**

Which diagrams below correctly show the spectra formed from white light by a glass prism and a diffraction grating respectively ? It is known that red light travels faster than violet light in glass.
(R = red, V = violet, W = white)

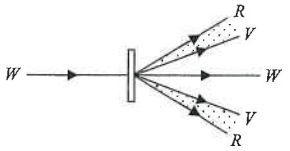
(1)



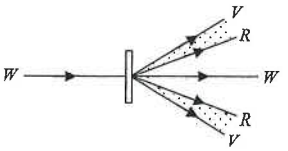
(2)



(3)



(4)



A. (1) & (3) only
B. (1) & (4) only
C. (2) & (3) only
D. (2) & (4) only

Provided by dse.life

66. **< HKDSE 2015 Paper IA - 20 >**

Which of the following gives the order of magnitude of the wavelengths of ultra-violet radiation and microwave in a vacuum ?

	ultra-violet radiation	microwave
A.	10^{-8} m	10^{-2} m
B.	10^{-8} m	10^{-5} m
C.	10^{-10} m	10^{-2} m
D.	10^{-10} m	10^{-5} m

67. **< HKDSE 2016 Paper IA - 19 >**

Diffraction will occur when light

(1) passes through a pinhole.

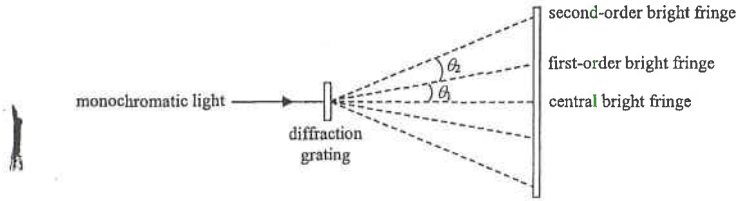
(2) passes by a sharp edge.

(3) passes through a slit.

A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

68. **< HKDSE 2017 Paper IA - 20 >**

The figure below shows some of the bright fringes formed when monochromatic light passes through a diffraction grating.



Which of the following is/are correct ?

(1) $\theta_1 = \theta_2$

(2) The maximum order of bright fringe is 4 if $\theta_1 = 20°$.

(3) θ_1 will decrease if the experiment is performed in water but not in air.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. C	11. C	21. A	31. B	41. B
2. D	12. C	22. D	32. B	42. D
3. D	13. C	23. B	33. B	43. B
4. C	14. B	24. D	34. A	44. D
5. A	15. C	25. D	35. B	45. D
6. C	16. C	26. A	36. C	46. C
7. B	17. A	27. C	37. C	47. A
8. D	18. D	28. D	38. A	48. B
9. C	19. D	29. C	39. C	49. C
10. A	20. A	30. D	40. D	50. B
51. D	61. D	71. C		
52. A	62. A	72. A		
53. B	63. A			
54. B	64. A			
55. B	65. A			
56. B	66. A			
57. A	67. D			
58. D	68. B			
59. B	69. D			
60. C	70. A			

M.C. Solution

1. C

$v = f\lambda$

$\therefore\ (3 \times 10^8) = (10^{16})\,\lambda \qquad \therefore\ \lambda = 3 \times 10^{-8}$ m

$\therefore$ The wave is in the range of ultra-violet rays.

2. D

Wavelengths in ascending order are : green light, yellow light, radio waves

Provided by dse.life

69. <HKDSE 2019 Paper IA-19>

70. <HKDSE 2019 Paper IA-22>

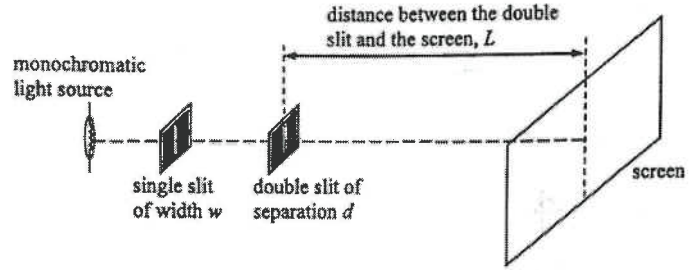
71. <HKDSE 2020 Paper IA-14>

A light beam consisting of wavelengths λ_1 and λ_2 is incident normally on a diffraction grating. The third-order diffraction of wavelength λ_1 coincides with the fourth-order diffraction of wavelength λ_2 in the resulting pattern. If λ_1 is 680 nm, find λ_2.

A. 510 nm
B. 680 nm
C. 907 nm
D. It cannot be determined because the grating spacing is unknown.

72. <HKDSE 2019 Paper IA-15>

The figure shows a typical set-up of Young's double slit experiment.



Which combination below is the best setting for displaying an observable fringe pattern on the screen ?

	w	d	L
A.	0.1 mm	1 mm	10 m
B.	0.1 mm	1 mm	1 m
C.	1 mm	0.1 mm	1 m
D.	1 mm	0.1 mm	0.1 m

Provided by dse.life

3. D

Wavelengths in descending order are : radio waves, visible light, X-rays

4. C

✓ (1) Speed of light depends on medium only.

✓ (2) Change in medium results in change of speed, thus give the change in wavelength.

× (3) Frequency must remain unchanged during refraction.

5. A

The wavelength of FM radio wave is the order of 10^2 m.

6. C

✓ (1) From air to glass, speed of light would decrease.

× (2) When speed decreases, wavelength would also decrease, by $v = f\lambda$.

✓ (3) Frequency must be unchanged during refraction.

7. B

By $d = \frac{1}{2} v t$

$\therefore\ d = \frac{1}{2} (3 \times 10^8) (2 \times 10^{-4}) = 3 \times 10^4$ m

8. D

× A. wavelength of infra-red rays > wavelength of X-rays

× B. wavelength of radio waves > wavelength of X-rays

× C. wavelength of radio waves > wavelength of infra-red rays

✓ D. it is the correct ascending order of wavelengths

9. C

Sound wave is the only example of longitudinal wave.

10. A

Wavelength of X-rays is shorter than microwaves, radio waves and visible light

11. C

✓ (1) Frequency decreases towards the left

✓ (2) *Y* is infra-red which is emitted by hot or warm bodies

× (3) Electromagnetic waves cannot be deflected by electric field or magnetic field.

12. C

Both radio waves and visible light are electromagnetic waves, they have the same speed,

$\therefore\ v_1 = v_2$.

13. C

Speed : Speed decreases when light travels from air to water

Frequency : Frequency remains unchanged when light travels from one medium to another medium

Wavelength : Wavelength decreases when light travels from air to water, by $v = f\lambda$.

14. B

$d = \frac{1}{2} v t = \frac{1}{2} (3 \times 10^8) (2 \times 10^{-4}) = 3 \times 10^4$ m

15. C

✓ (1) Speed of light depends on medium.

✓ (2) Total internal reflection can only occur when light travels from a denser medium to a less dense medium, e.g. from water to air.

× (3) Light travels slower in glass than in air.

16. C

The correct ascending order of wavelengths :

gamma rays, X-rays, ultra-violet, visible light, infra-red, microwave, radio waves.

17. A

✓ (1) Wavelength decreases towards the right of the spectrum, thus *P* has longer wavelength.

× (2) All electromagnetic waves travel with the same velocity in vacuum.

× (3) Electromagnetic waves cannot be deflected by an electric field.

18. D

Wavelength : Speed of light increases when it travels from water to air, by $v = f\lambda$, wavelength also increases.

Frequency : Frequency must remain unchanged when light travels from one medium to another medium.

19. D

Speeds of all the electromagnetic waves are the same and do not depend on the frequency of the wave.

20. A

✓ A. Radar uses microwaves to send pulses to detect flying objects.

× B. Carbon-14 dating uses β radiation.

× C. Radiotherapy uses γ-rays.

× D. Detecting cracks in railway track uses ultrasound.

Provided by dse.life

21. A

Infrared : Wavelength is longer than that of visible light, thus it should be 1×10^{-4} m

Red light : Red light has the longest wavelength among the range of visible light, thus it is 7×10^{-7} m

Violet light : Violet light has the shortest wavelength among the range of visible light, thus it is 4×10^{-7} m

22. D

✓ (1) Light is a type of transverse wave.

× (2) All waves, including electromagnetic waves, posses all phenomena of waves, including diffraction.

✓ (3) Light wave carries light energy.

23. B

$v = f \lambda$

$\therefore \ (3 \times 10^8) = (94 \times 10^6) \lambda$

$\therefore \ \lambda = 3.19$ m

24. D

× A. Infra-red is invisible.

× B. Geiger-Muller counter can only detect α, β or γ radiation, but not infra-red radiation.

× C. Ultra-violet is used to sterilize drinking water.

✓ D. Warm or hot bodies emit infra-red radiation.

25. D

Frequencies in ascending order are :

radio waves, ultra-violet rays, X-rays

26. A

Infra-red radiation OR ultrasonic wave can be used for camera autofocusing.

27. C

✓ (1) Ultra-violet is between X-rays and visible light while infra-red is between microwaves and visible light

✓ (2) Wavelength increases towards the right of this spectrum, thus wavelength of *P* is shorter.

× (3) All electromagnetic waves travel with same speed in vacuum

28. D

× A. Camera autofocusing : both ultrasound or infra-red radiation can be used

× B. Detecting railway cracks : use ultrasound

× C. Detecting survivors : use infra-red radiation

✓ D. Sterilize drinking water : use ultra-violet radiation

29. C

✓ (1) Remote control : Infrared radiation

✓ (2) Oven : Microwave

× (3) Scanning foetuses : ultrasonic waves – sound waves with frequency higher than 20000 Hz

30. D

Ozone layer in the atmosphere can absorb most of the ultra-violet radiation from the sun so that the intensity of the ultra-violet radiation reaching the Earth's surface is much reduced and causes less hazard to human being, as over-exposure to ultra-violet radiation may cause skin cancer.

31. B

× (1) The penetrating power of ultra-violet radiation is not high enough to penetrate through the human body (X-rays and gamma radiation can penetrate through human body)

× (2) Ultra-violet radiation does not have heating effect (Infra-red has heating effect)

✓ (3) Ultra-violet radiation has sun-tan effect and over-exposure may cause skin cancer

32. B

Infra-red can enable the images to be captured in the dark.

33. B

✓ A. The radar system makes use of microwave which is an electromagnetic wave.

× B. The sonar system makes use of ultrasound which is NOT an electromagnetic wave.

✓ C. The infra-red system makes use of infra-red radiation which is an electromagnetic wave.

✓ D. The wireless telecommunication system makes use of radio wave which is an electromagnetic wave.

34. A

The electromagnetic wave spectrum in order of decreasing wavelength :

① radio waves
② microwaves
③ infra-red
④ visible light
⑤ ultra-violet
⑥ X-rays
⑦ gamma rays

35. B

× (1) This can only shows that wave has refraction.

× (2) This can only shows that wave has reflection.

✓ (3) Since the space between the Sun and the Earth is vacuum, this can show that light is an electromagnetic wave that can travel in vacuum.

Provided by dse.life

36. C

✓ (1) Speed v of electromagnetic waves is independent of the frequency f, thus it is a horizontal line.

× (2) As the velocity is constant, by $v = f\lambda$,
the frequency f and the wavelength λ should be inversely proportional, thus the graph should be a curve.

✓ (3) Speed v of electromagnetic waves is independent of the wavelength λ, thus it is a horizontal line.

37. C

Initial distance of the car $= \frac{1}{2} \times (3 \times 10^8) \times (3.6 \times 10^{-7}) = 54$ m

Final distance of the car $= \frac{1}{2} \times (3 \times 10^8) \times (3.1 \times 10^{-7}) = 46.5$ m

Speed of the car $= \frac{\Delta d}{\Delta t} = \frac{54 - 46.5}{0.2} = 37.5 \text{ m s}^{-1}$

38. A

Speed of water waves < speed of sound waves < speed of microwaves

Time to travel a distance of 100 m $= \frac{100 \text{ m}}{\text{speed of the wave}}$

Thus, the smaller the speed, the longer is the time taken $\therefore T_1 > T_2 > T_3$

39. C

✓ (1) By $\Delta y = \frac{\lambda D}{a}$ $\therefore D \uparrow \Rightarrow \Delta y \uparrow$

✓ (2) By $\Delta y = \frac{\lambda D}{a}$ $\therefore \lambda \uparrow \Rightarrow \Delta y \uparrow$

× (3) Separation between fringes is independent of the distance between the light source and the double slits, thus Δy is unchanged.

40. D

As $d \sin\theta = n\lambda$

$\therefore (\frac{10^{-3}}{p})\sin\theta = (2)\lambda$ and $(\frac{10^{-3}}{3p})\sin\phi = (1)\frac{5\lambda}{4}$

$\therefore \frac{(1/p)}{(1/3p)} \cdot \frac{\sin\theta}{\sin\phi} = \frac{(2)}{(1)} \frac{\lambda}{(5\lambda/4)}$ $\therefore \sin\phi = \frac{15}{8}\sin\theta$

41. B

By $\Delta y = \frac{\lambda D}{a}$

Monochromatic light : $\lambda \uparrow \Rightarrow \Delta y \uparrow$ $\therefore$ red light

Slit-separation : $a \downarrow \Rightarrow \Delta y \uparrow$ $\therefore$ 1 mm

Slit-to-screen distance : $D \uparrow \Rightarrow \Delta y \uparrow$ $\therefore$ 2 m

42. D

× (1) Frequency remains unchanged during refraction

✓ (2) For light : $v_{glass} < v_{air} \Rightarrow \lambda_{glass} < \lambda_{air}$

✓ (3) For light : $v_{glass} < v_{air}$

43. B

× (1) $\Delta = 3000 \text{ nm} = \frac{3000}{400}\lambda = 7.5\lambda$ $\therefore P$: 8th dark fringe

× (2) The fringe separation is independent of the distance between the source and slits, thus same s

✓ (3) $\Delta = 3000 \text{ nm} = \frac{3000}{500}\lambda = 6\lambda$ $\therefore$ constructive interference occurs, it is a bright fringe

44. D

The wavelength of light is very small (about 10^{-7} m).

In order to have observable interference, slit separation a should be much decreased to give observable interference.

45. D

By $d \sin\theta = 1\lambda$ $\therefore$ To have greater θ, d should be smaller and λ should be greater

① grating in lines per mm should be greater so that grating spacing d is smaller $\therefore$ 400 is better

② red light has longer wavelength than green light $\therefore$ red light is better

46. C

✓ (1) Grating spacing $d = \frac{1 \times 10^{-2}}{5000} = 2 \times 10^{-6} \text{ m} = 2000 \text{ nm}$

✓ (2) By $d \sin\theta = n\lambda$ $\therefore (2 \times 10^{-6}) \sin\theta_2 = (2)(500 \times 10^{-9})$ $\therefore \theta_2 = 30°$

× (3) $\sin\theta_3 = 3 \sin\theta_1 = 1.5 \sin\theta_2 = 1.5 \sin 30°$ $\therefore \theta_3 = 48.6°$ $\therefore$ Third order spectrum exists.

47. A

By using fringe separation : $\Delta y = \frac{\lambda D}{a}$

✓ (1) $\lambda \uparrow \Rightarrow \Delta y \uparrow$

× (2) $a \uparrow \Rightarrow \Delta y \downarrow$

× (3) Larger slit width gives the same fringe separation Δy

48. B

By $d \sin\theta = n\lambda$

① $d \sin 45° = 3\lambda$

② $d \sin 90° = n\lambda$

$\therefore n = 4.24$

Thus the highest order is the 4th order.

Provided by dse.life

49. C

Fringe separation : $\Delta y = 5.0\text{ mm} \times \frac{1}{4} = 1.25\text{ mm}$

By $\Delta y = \frac{\lambda D}{a}$

$\therefore\ (1.25\times10^{-3}) = \frac{(550\times10^{-9})\cdot(1)}{a}$

$\therefore\ a = 4.4\times10^{-4}\text{ m}$

50. B

✓ (1) The diffraction pattern is symmetrical on both sides of the central line.

× (2) For the same order, it should be the sin of the angle proportional to the wavelength, i.e. $\sin\theta \propto \lambda$

✓ (3) For smaller d, the angle θ is greater, thus the first maxima are separated at greater angles.

51. D

For grating or interference pattern, the second order and the third order must be overlapped.

The overlapping cannot be changed by any methods.

52. A

✓ (1) For the first-order spectrum : $d\sin\theta = 1\lambda$.
$\therefore\ \lambda_{violet} < \lambda_{yellow} \Rightarrow \theta_{violet} < \theta_{yellow}$ $\therefore$ violet is closer.

✓ (2) By $d\sin\theta = n\lambda$
For 2nd order image of yellow light : $d\sin\theta = (2)(600) = 1200$ nm
For 3rd order image of violet light : $d\sin\theta = (3)(400) = 1200$ nm
Same value of $d\sin\theta \Rightarrow$ the 2 lights coincide at the same diffracted angle θ

× (3) Consider the 4th order image for violet light.
By $d\sin\theta = n\lambda$ $\therefore\ (\frac{10^{-3}}{500})\sin\theta = (4)(400\times10^{-9})$ $\therefore\ \theta = 53.1°$
$\therefore$ 4th order violet maximum exists.

53. B

Typical order of wavelength of infra-red radiation in air is 10^{-5} m.

Typical order of wavelength of ultra-violet radiation in air is 10^{-8} m.

54. B

× (1) Since the two light sources are identical, they should have same amplitudes.

× (2) Since the two light sources are identical, they should have the same wavelength and frequency.

✓ (3) Two independent light source cannot have constant phase relationship.
Thus, they are not coherent sources, and therefore, no interference pattern can be observed.

55. B

From the figure, the wavelength : $\lambda = 10\times10^{-7}\times\frac{2}{5} = 4\times10^{-7}\text{ m}$

The colour is violet since violet has the shortest wavelength among the visible light that has range of 400 nm to 700 nm.

By $c = f\lambda$

$\therefore\ (3\times10^{8}) = f\times(4\times10^{-7})$ $\therefore\ f = 7.5\times10^{14}\text{ Hz}$

56. B

① $\tan\theta_2 = \frac{x}{d} = \frac{0.686/2}{0.75}$ $\therefore\ \theta_2 = 24.58°$

② $d\sin\theta = n\lambda$ $\therefore\ (\frac{1\times10^{-2}}{4000})\sin24.58° = (2)\lambda$ $\therefore\ \lambda = 520\text{ nm}$

57. A

Fringe width in double-slit interference : $\Delta y = \frac{\lambda D}{a}$

✓ (1) $\lambda\uparrow \Rightarrow \Delta y\uparrow$

× (2) $a\uparrow \Rightarrow \Delta y\downarrow$

× (3) Larger slit width gives the same fringe separation Δy, as Δy is not affected by the slit width.

58. D

By $d\sin\theta = 1\lambda$ $\therefore$ To have greater θ, d should be smaller and λ should be greater

① grating in lines per mm should be greater so that grating spacing d is smaller $\therefore$ 400 is better

② red light has longer wavelength than blue light $\therefore$ red light is better

59. B

By $d\sin\theta = n\lambda$

① $(\frac{1\times10^{-3}}{400})\sin\theta_4 = (4)(590\times10^{-9})$ $\therefore\ \theta_4 = 70.73°$

② $(\frac{1\times10^{-3}}{400})\sin\theta_3 = (3)(590\times10^{-9})$ $\therefore\ \theta_3 = 45.07°$

$\therefore\ \Delta\theta = 70.73 - 45.07 = 25.7°$

60. C

By $\Delta y = \frac{\lambda D}{a}$

① $(5\times10^{-3}) = \frac{(600\times10^{-9})D}{a}$ ② $\Delta y = \frac{(450\times10^{-9})D}{(a/2)}$

Combine ① and ② : $\Delta y = 7.5\times10^{-3}\text{ m} = 7.5\text{ mm}$

Provided by dse.life

61. D

× A. All waves carry energy. Carry energy cannot prove that light is an electromagnetic wave.

× B. All waves reflect. Reflection cannot prove that light is an electromagnetic wave.

× C. All waves bend to give refraction. Refraction cannot prove that light is an electromagnetic wave.

✓ D. Light can travel in space (vacuum) is a proof for electromagnetic wave.

62. A

× A. The wavelength of the infra-red radiation is longer than that of ultra-violet radiation.

✓ B. Visible light travels at the greatest speed in air or vacuum. In glass, the speed is smaller.

✓ C. Microwaves are electromagnetic waves, which must be travel at the speed of light in a vacuum.

✓ D. Since light and sound are waves, they exhibit diffraction.

63. A

By $d \sin\theta = n\lambda$

Red light : $(\frac{1\times10^{-3}}{600})\sin 52° = n(657\times10^{-9})$ $\therefore n = 2$

Violet light : $(\frac{1\times10^{-3}}{600})\sin 52° = n(438\times10^{-9})$ $\therefore n = 3$

64. A

By $d \sin\theta = n\lambda$

For the first order bright fringe, $n = 1$ $\therefore \sin\theta = \frac{\lambda}{d}$

To give greatest angle θ,

d should be smaller, thus the grating should have more line per mm, that is, 400

λ should be greater, thus the colour of light should be green, since wavelength of green light is longer than blue light

65. A

① When white light passes through a prism, it is dispersed into its component colours.
Red (R) light is least deviated from the original direction.

② When white light passes through a diffraction grating, the first order consists of continuous spectrum.
Red (R) light with longest wavelength has the largest diffracted angle from the central line.

66. A

Order of magnitude of wavelength of ultra-violet radiation = 10^{-8} m

Order of magnitude of wavelength of microwaves = 10^{-2} m

67. D

✓ (1) When light passes through a pinhole, light spreads out from the hole to give diffraction.

✓ (2) When light passes by a sharp edge, light bends round the corner to give diffraction.

✓ (3) When light passes through a slit, light spreads out from the slit to give diffraction.

68. B

× (1) The bright fringes produced by a diffraction grating is not evenly distributed, thus θ_2 must not equal θ_1, actually, $\theta_2 > \theta_1$.

× (2) By $d \sin\theta = n\lambda$
① $d \sin 20° = (1)\lambda$ ② $d \sin 90° = n\lambda$
$\therefore n = 2.92$
The maximum order of bright fringe should be 2.

✓ (3) If the experiment is performed in water, λ will decrease.
By $d \sin\theta = n\lambda$, θ will decrease.

Provided by dse.life

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8 \text{ m s}^{-1}$

The following list of formulae may be found useful :

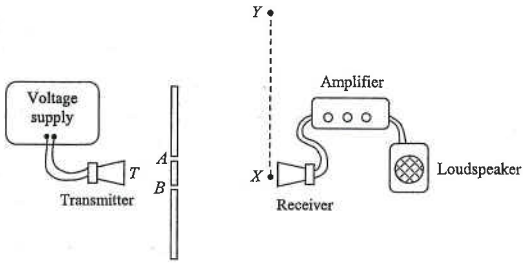
Fringe width in double-slit interference $\Delta y = \frac{\lambda D}{a}$

Diffraction grating equation $d \sin\theta = n\lambda$

Part A : HKCE examination questions

1. < HKCE 1986 Paper I - 6 >

(a) The below figure shows an experimental set-up to study the interference of 3 cm microwave. Microwaves emitted from a transmitter at T pass through two narrow slits A and B where $TA = TB$. The microwaves are picked up by a receiver at X where $XA = XB$. The receiver is connected to a loudspeaker through an amplifier. The loudness of sound from the loudspeaker indicates the intensity of the microwaves received.



(i) What is the frequency of the microwaves ? (3 marks)

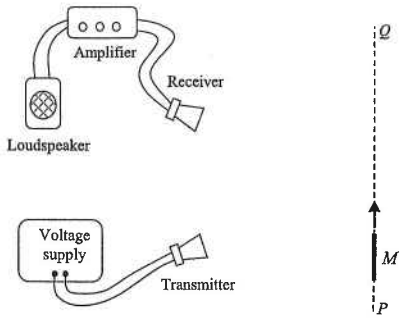
(ii) What is the path difference of the microwaves from A and B at X ? (1 mark)

(iii) Are the waves at constructive or destructive interference at X ? (1 mark)

(iv) Would the sound from the loudspeaker be loud or soft ? (1 mark)

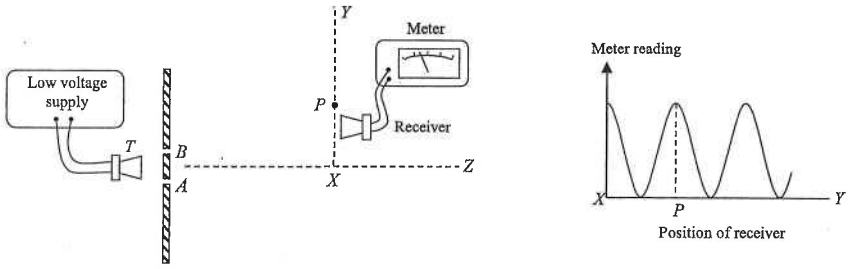
(v) Describe briefly the variation of the loudness of the sound from the loudspeaker when the receiver is being moved along XY. (2 marks)

1. (b) The following figure shows another experimental set-up using the same microwave transmitter and receiver. 3 cm-microwaves are emitted from the transmitter. A metal plate M is then moved from P to Q. Describe the variation of the loudness of the sound from the loudspeaker. Explain briefly with the aid of a diagram. (5 marks)



(c) Give two examples of applications of microwaves. (2 marks)

2. < HKCE 1995 Paper I - 4 >



The figure above shows a set-up to investigate the interference of microwaves. Microwaves emitted from a transmitter T pass through two narrow slits A and B, which are equidistant from T. The receiver is then connected to a meter, which indicates the intensity of microwaves received.

The graph above then shows the variation of the meter reading as the receiver is moved from X to Y. X is equidistant from A and B.

(a) Explain briefly why the meter shows maximum and minimum readings. (3 marks)

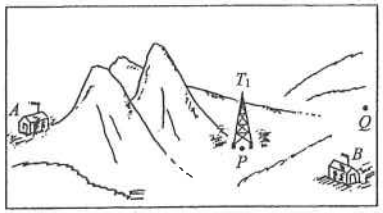
Provided by dse.life

2. (b) What type of interference is observed at P ? (1 mark)

(c) If $AP = 36$ cm, $BP = 33$ cm, find the wavelength and frequency of the microwaves. (4 marks)

(d) Sketch a graph to show the variation of the meter reading as the receiver is moved from X to Z (XZ is perpendicular to XY). Explain briefly why the reading varies in this way. (4 marks)

3. **< HKCE 1999 Paper I - 10 >**



Peter lives in a house A on one side of a hill. A transmitting station T_1 is located at site P on the other side of the hill. (See the above figure.) The station transmits radio waves of frequency 600 kHz and TV waves of frequency 500 MHz.

(a) Find the wavelengths of the radio waves and TV waves. (3 marks)

(b) (i) Name the wave phenomenon which enables the waves transmitted by T_1 to reach Peter's house. (1 mark)

3. (b) (ii) Peter finds that the radio reception is better than the TV reception. Explain this phenomenon. (2 marks)

(c) Peter is watching TV in his house. He finds that the reception is affected when an aeroplane flies overhead. Explain this phenomenon. (2 marks)

(d) Another transmitting station will be built at site Q. (See the above figure.) Mary lives in a house B such that $BP = 3.95$ km and $BQ = 3.20$ km.

(i) Find the path difference at B from P and Q. (1 mark)

(ii) Mary listens to the radio in her house. How will the reception be affected if both stations transmit identical radio waves at 600 kHz ? Explain your answer. (Neglect the reflection of waves from the hill.) (3 marks)

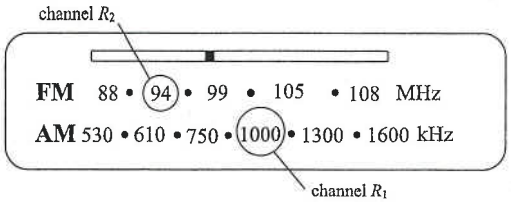
(e) The table below shows the broadcasting frequencies of RTHK Radio 1 (FM) in different districts :

District	Frequency / MHz
Hong Kong north	92.6
Hong Kong south	93.6
Kowloon east	94.4
Kowloon west	92.9
Shatin, Ma On Shan	93.5
Tai Po, Fanling	93.2
Tuen Mun, Yuen Long	93.4

State one advantage of broadcasting at different frequencies in different districts. (2 marks)

Provided by dse.life

4. **< HKCE 2004 Paper I - 4 >**



The Figure above shows the display panel of a radio and the broadcasting frequencies of two radio channels R_1 and R_2.

(a) Find the wavelength of the radio waves used by channel R_1. (2 marks)

(b) Anita's house is surrounded by hills and at her house, the reception of one of the two radio channels is better. For which radio channel is the reception better ? Explain your answer. (3 marks)

5. **< HKCE 2006 Paper I - 1 >**

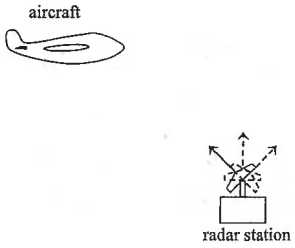


Figure 1

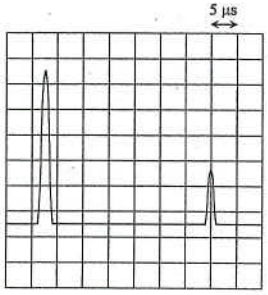


Figure 2

RADAR (RAdio Detecting And Ranging) is a useful device in air traffic control. In Figure 1, an aircraft is flying near a radar station. A pulse of electromagnetic wave with a speed of 3×10^8 m s^{-1} and a frequency of 1.2×10^9 Hz is emitted from the radar station towards the aircraft.

(a) Find the wavelength of the electromagnetic wave. (2 marks)

(b) The electromagnetic wave pulse emitted is reflected by the aircraft back to the radar station. The emitted and reflected pulses are displayed on the screen of a CRO as shown in Figure 2. The time-base setting of the CRO is 5 μs per division. Estimate the distance between the radar station and the aircraft. (3 marks)

6. **< HKCE 2006 Paper I - 2 >**

RADAR is a useful device to detect aircraft. However, the air-forces of many countries try to build aircraft that can hide away from their enemies. Read the following passage about a stealth bomber (see Figure 1).

Stealth Bomber

There are some special features in the design of the stealth bomber to make it invisible to enemy sensors. The aircraft needs to blend in with the background visually and its engine needs to be very quiet. Furthermore, it needs to hide from enemy radar and infrared sensors. Defending against radar detection, the surface of the stealth bomber is particularly good at absorbing radio waves. More importantly, the large flat areas on the top and bottom of the aircraft reflect most incoming radio waves away from the radar station in the same manner as plane mirrors usually reflect light rays away from light sources. In regard to infrared sensors typically picking up on hot engine exhaust, all of the exhausts in a stealth bomber pass through cooling vents before flowing out of the plane. With the designs mentioned above, a stealth bomber has the ability to fly almost undetected through enemy airspace.

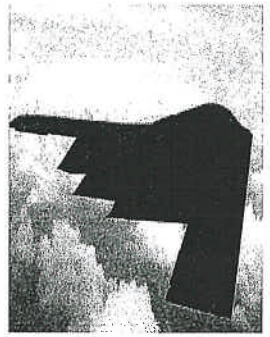


Figure 1

Source: http://science.howstuffworks.com/stealth-bomber3.htm

(a) (i) In Figure 2 below, draw a ray to show how a wave from the radar is reflected at the bottom of the stealth bomber. (1 mark)

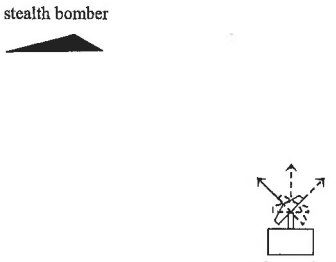


Figure 2

(ii) If the stealth bomber flies horizontally to a particular position around the radar, it can be detected by the radar. Mark this position with a symbol X in Figure 2. (1 mark)

(b) All of the exhausts in a stealth bomber pass through cooling vents before flowing out of the plane. Explain how this can help the stealth bomber to hide away from enemy detection. (2 marks)

(c) Apart from the above designs which help prevent the stealth bomber being detected by radar and infrared sensors, state two other essential features which are important in building the stealth bomber so that it can hide away from enemy detection. (2 marks)

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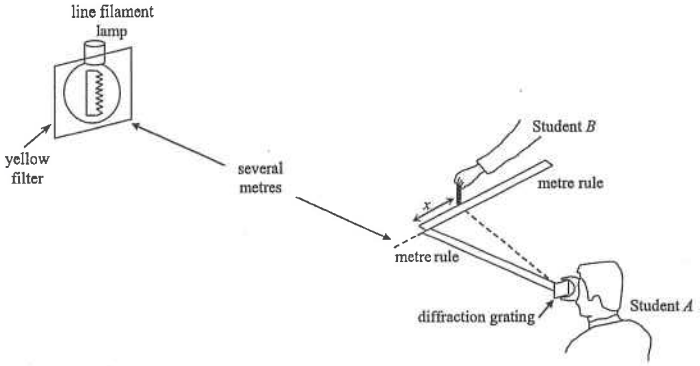
Part B : HKAL examination questions

7. **< HKAL 1981 Paper IIB - 3 >**

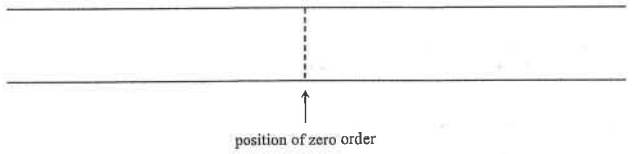


Student *A* views a line filament lamp with a yellow filter through a diffraction grating with its lines parallel to the filament as shown. The grating is held at one end of a metre rule which is directed towards the lamp. At the other end of the metre rule, a second rule is placed at right angles to the first rule. The diffraction grating has 6.0×10^5 lines per metre.

(a) Student *B* was told to move a pencil held vertically along the second rule until it coincides with the yellow band in the first image of the lamp as seen through the grating. If the distance between the first rule and the pencil is $x = 0.37$ m as shown in the figure, calculate the wavelength of the yellow light. (2 marks)

(b) If student *B* keeps moving the pencil along the second metre rule in the same direction, how many more yellow bands will be encountered ? Explain. (You may extend the length of the second metre rule by using more metre rules.) (2 marks)

(c) If the filter is removed, sketch the pattern seen by student *A* on both sides of the filament, up to the second order, on the figure below. Label the significant features. (4 marks)

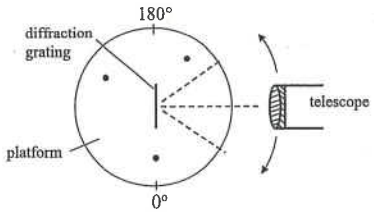


8. **< HKAL 1994 Paper I - 6 >**

(a) A student views a green light source through a double slit. The pattern observed is shown in the Figure below.

How would the pattern be affected if red light is used instead ? (1 mark)

(b)



To observe the light spectrum of the sodium lamp, a student places a diffraction grating on a platform such that the incident light falls normally on the grating. There is a protractor scale on the platform from 0° to 180°. The sodium lamp produces a yellow light of a certain wavelength. The student uses the second-order images and records the angular position readings of the yellow line on each side of the central line as follows :

	Left-hand side (second order)	Right-hand side (second order)
scale reading on protractor	45.67°	134.37°

(i) Give the grating spacing to be 1684 nm, calculate the wavelength of the yellow light produced by the sodium lamp. Give your answer to 4 significant figures. (2 marks)

(ii) Suggest ONE reason for making measurements by using the second-order images instead of the first-order ones. (1 mark)

Provided by dse.life

9. **< HKAL 2010 Paper I - 2 >**

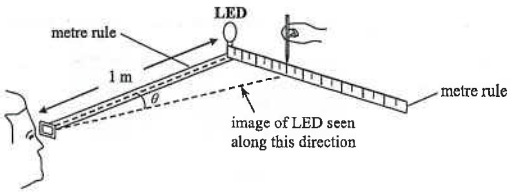


Figure 1

An LED (Light Emitting Diode) emitting monochromatic light of wavelength λ is viewed through a diffraction grating of 160 lines per mm as shown in Figure 1. With the aid of a pencil and two mutually perpendicular metre rules, several positions of images corresponding to the maxima are located in the way shown. Figure 2 shows the observation through the diffraction grating.

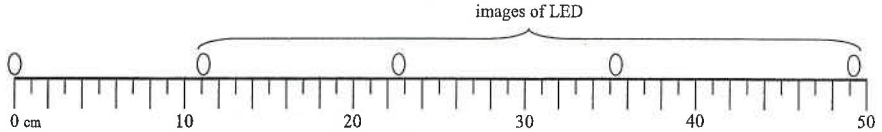
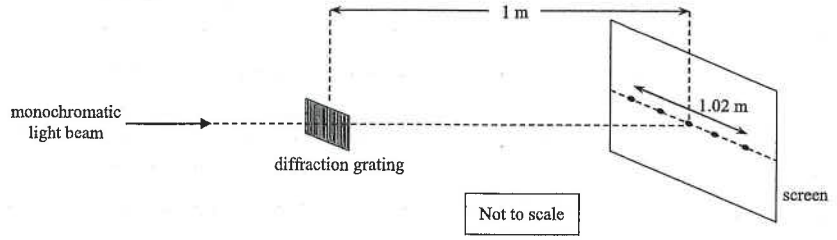


Figure 2

(a) Find the angular position θ of the image of the fourth maximum according to the above observation. Hence determine the wavelength λ of the light emitted by the LED. (3 marks)

(b) Calculate the maximum order of the LED image that may be observed for the above grating. (2 marks)

10. **< HKAL 2011 Paper I - 3 >**



Monochromatic light of wavelength 570 nm from a laser is directed normally onto a diffraction grating as shown. A screen is placed at a distance 1 m behind the grating. The central part of the resulting diffraction pattern is shown in the figure. The separation between the second-order bright spots on both sides of the pattern is 1.02 m.

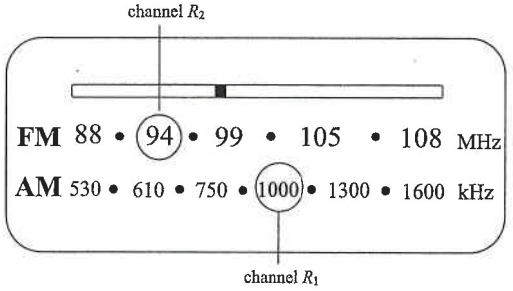
(a) Calculate the grating spacing d of the diffraction grating. (3 marks)

10. (b) State one safety precaution in using the laser light. (1 mark)

(c) State one precaution in performing the above experiment. (1 mark)

Part C : HKDSE examination questions

11. **< HKDSE Sample Paper IB - 5 >**



The Figure above shows the display panel of a radio and the broadcasting frequencies of two radio channels R_1 and R_2.

(a) Find the wavelength of the radio waves used by channel R_1. (1 mark)

(b) Anita's house is surrounded by hills and at her house, the reception of one of the two radio channels is better. For which radio channel is the reception better ? Explain your answer. (2 marks)

12. **< HKDSE 2012 Paper IB - 6 >**

A double-slit set-up is used for the demonstration of the interference of light in which the separation between slits S_1 and S_2 is 0.5 mm and the screen is at 2.5 m from the slits. Calculate the average separation between adjacent bright fringes on the screen for a monochromatic light of wavelength 550 nm. (2 marks)

Provided by dse.life

13. **< HKDSE 2013 Paper IB - 7 >**

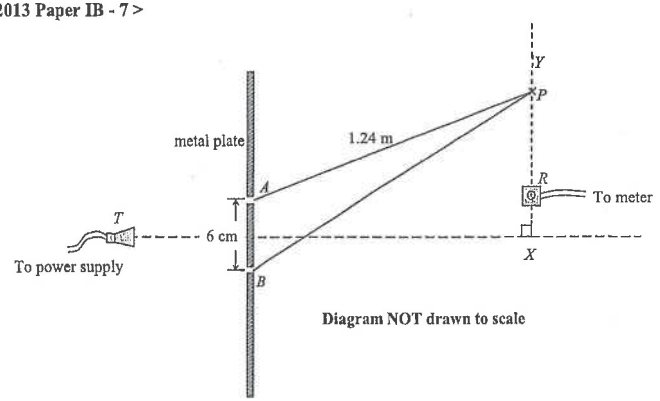


Diagram NOT drawn to scale

The Figure above shows a set-up for the study of interference of microwaves. Microwaves of wavelength 2 cm emitted from a transmitter T pass through two slits A and B formed by metal plates. The slits are separated by 6 cm as shown. A probe R connecting to a meter is moved from X to Y to detect the intensity of microwaves received. Transmitter T and point X are equidistant from A and B.

(a) Calculate the frequency of the microwaves. (2 marks)

(b) (i) The meter shows alternate maxima and minima when R moves along XY. Explain. (2 marks)

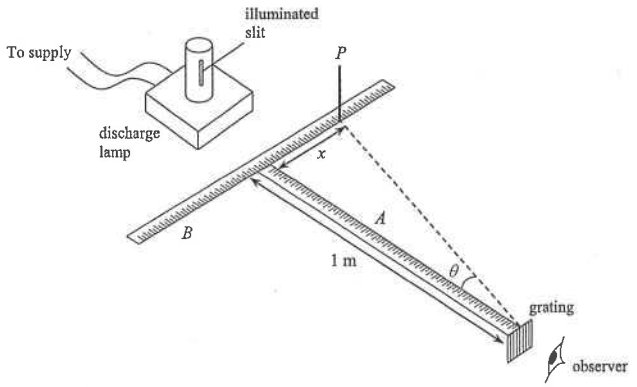
(ii) The second minimum is found at position P where $AP = 1.24$ m. Find BP. (2 marks)

(iii) When R is moved along XY from X towards Y and beyond, explain whether or not it is possible to detect more than three maxima. (2 marks)

(c) Microwaves can be used in radar. Why are radio waves of lower frequencies not suitable for use in radar ? (2 marks)

14. **< HKDSE 2014 Paper IB - 7 >**

The Figure below shows an experimental set-up to determine the wavelength of monochromatic light emitted from the vertical narrow slit of a discharge lamp. A, B are two mutually perpendicular metre rules on the bench with rule A pointing towards the lamp. A diffraction grating with vertical lines is placed at one end of rule A. A vertically mounted pin P is moved along rule B until the pin is in line with the diffracted image of the second-order to the observer. The corresponding distance x is measured for finding the diffraction angle θ.



The grating has 300 lines per mm and x is found to be 0.38 m for the **second-order** image.

(a) (i) Calculate the diffraction angle θ. (1 mark)

(ii) Hence find the wavelength of the light from the lamp. (3 marks)

(iii) Give ONE advantage of measuring the position of the second-order image instead of the first-order one. (1 mark)

(b) In the experiment, the illuminated slit may not be well aligned along metre rule A. Suggest one way to reduce this error. (2 marks)

Provided by dse.life

15. **< HKDSE 2015 Paper IB - 7 >**

(a) A laser light beam of wavelength 650 nm is incident normally on a pair of slits separated by $a = 0.325$ mm. Interference pattern is observed on a screen at a distance $D = 3.0$ m from the slits as shown in Figure 1. What is the separation between adjacent first- and second-order bright fringes ? (2 marks)

Figure 1

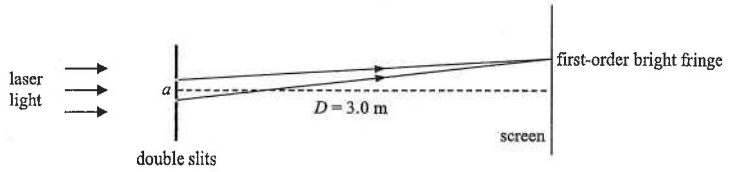


Diagram NOT drawn to scale

(b) Figure 2 shows a set-up with two small LEDs separated by 6 mm and both LEDs emit light of wavelength 650 nm. State and explain what you would expect to see on the screen. (2 marks)

Figure 2

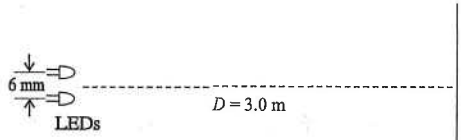
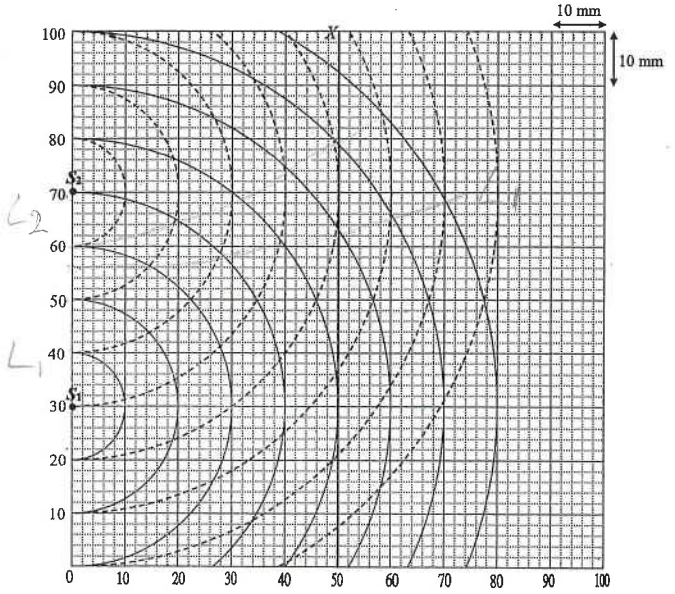


Diagram NOT drawn to scale

15. Figure 3 shows circular water waves in a ripple tank. The two point sources S_1 and S_2, separated by 40 mm, are driven by the same vibrator. The solid lines represent the wave crests from S_1 and the dotted lines represent the wave crests from S_2. The wavelength of the waves is 10 mm.

Figure 3



(c) Sketch on Figure 3 two lines to indicate all points P with path difference $PS_1 - PS_2$ equals to 10 mm (L_1) and 20 mm (L_2). State the kind of interference that occurs at these points P. (3 marks)

(d) (i) If the interference pattern is observed along line XY at 50 mm from the source as shown, measure the separation between adjacent first- and second-order maxima Δy. (1 mark)

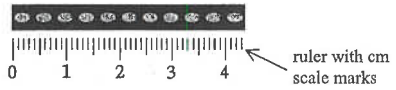
separation Δy = _____

(ii) However, using the calculation method in (a) would obtain 12.5 mm for this separation. Why does this calculated value differ with the measurement in (d) (i) ? (2 marks)

Provided by dse.life

16. **< HKDSE 2016 Paper IB - 6 >**

(a) A laser beam is directed perpendicularly towards a double slit of separation a = 0.3 mm. The pattern of bright spots projected on a screen 1.8 m away from the slits is shown in the Figure below.



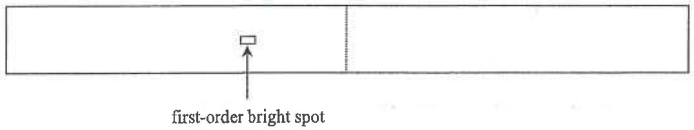
(i) Find the wavelength of the laser beam. (3 marks)

(ii) Explain why the slit width has to be very narrow in order for the above pattern to be observed. (2 marks)

(b) The double slit is now replaced by a diffraction grating of 500 lines per mm.

(i) Find the separation between the central bright spot and first-order bright spot of the pattern on the screen for the same experimental settings. (3 marks)

(ii) Sketch the pattern, up to the second-order, that you would expect to see on the screen when using this diffraction grating. A first-order bright spot has already been drawn for you. (2 marks)



17. **< HKDSE 2018 Paper IB - 7 >**

(a)

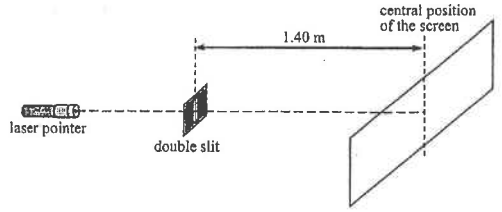


Figure 1

Figure 1 above shows a set-up for measuring the wavelength λ of light emitted by a laser pointer. Several bright dots of average separation about 2 mm can be seen on the screen.

(i) For the same set of apparatus, suggest a way to increase the average separation between the bright dots on the screen. (1 mark)

The double slit is now replaced by a diffraction grating with 400 lines per mm.

(ii) Briefly explain why the accuracy of the experiment can be improved. (1 mark)

(iii) Only five bright dots are observed on the screen such that the separation between the 1st and 5th dots is 1.56 m. Find λ. (3 marks)

(b) To measure the speed of sound in air, a student connects two loudspeakers, A and B, to a signal generator as shown in Figure 2.

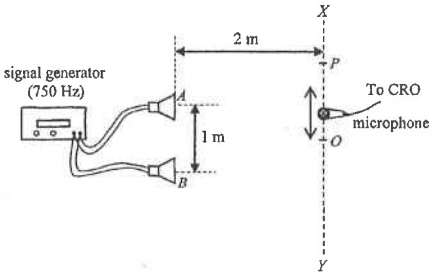


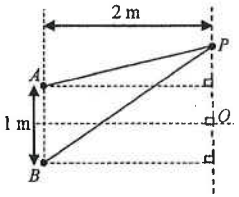
Figure 2

The separation of A and B is 1 m. A microphone is used to pick up the sound along the line XY at a distance of 2 m from the loudspeakers. The central maximum is at point O while the next maximum is at point P.

(i) With reference to the above settings, use the fringe separation equation $\Delta y = \frac{\lambda D}{a}$ in double-slit interference to find the wavelength λ of sound is not accurate. Explain briefly. (1 mark)

Provided by dse.life

17. (b) (ii) The distance between O and P is found to be 1 m when the signal generator is set at 750 Hz. By considering the path difference $PB - PA$, use the results of the experiment to find the speed of sound in air.



HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) $v = f\lambda$ [1]

$(3 \times 10^8) = f(0.03)$ [1]

$f = 10^{10}$ Hz [1]

(ii) path difference = 0 [1]

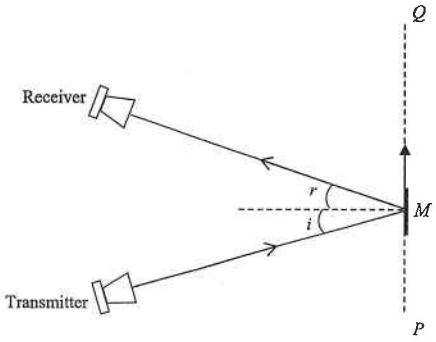
(iii) constructive interference [1]

(iv) loud [1]

(v) Along XY, loud and soft sounds are heard [1]

alternately [1]

(b)



[1]

As M moves, the intensity of sound increases to a maximum [1]

and then decreases again as it approaches Q. [1]

When M is mid-way between P and Q, (**OR** indication in the figure that $i = r$), [1]

microwaves emitted from the transmitter is reflected by M and collected by the receiver. [1]

(c) Any **TWO** of the following : [2]

* Radar
* Microwave oven
* Satellite communication
* Mobile phone

2. (a) Interference of microwaves from A and B occurs due to different path difference. [1]

The reading reaches a maximum at positions of constructive interference [1]

and a minimum at positions of destructive interference. [1]

Provided by dse.life

2. (b) Constructive interference occurs at P. [1]

(c) Path difference at $P = 1\ \lambda$ [1]

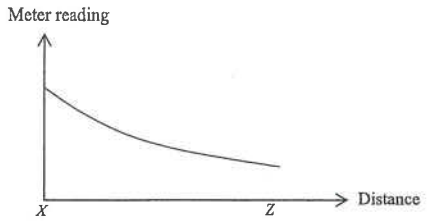
$\therefore\ \lambda = 36 - 33 = 3$ cm [1]

By $v = f\lambda$

$\therefore\ (3 \times 10^8) = f(0.03)$ [1]

$\therefore\ f = 10^{10}$ Hz [1]

(d) [2]



The interference is always constructive along XZ, so the reading is always at a maximum. [1]

However the intensity of the waves decreases with distance,

so the reading decreases as the probe moves away from X. [1]

3. (a) By $v = f\lambda$ [1]

For Radio waves :

$(3 \times 10^8) = (600 \times 10^3)\ \lambda$

$\therefore\ \lambda = 500$ m [1]

For TV waves :

$(3 \times 10^8) = (500 \times 10^6)\ \lambda$

$\therefore\ \lambda = 0.6$ m [1]

(b) (i) The phenomenon is diffraction. [1]

(ii) As the wavelength of the radio waves is longer than that of the TV waves, [1]

the radio waves are diffracted more by the hills, so the radio reception is better. [1]

(c) The aeroplane reflects the TV waves. [1]

The waves travelling directly to the aerial has interference with the waves reflected by the aeroplane. [1]

(d) (i) Path difference $= BP - BQ$

$= 3.95 - 3.20 = 0.75$ km

$= 750$ m [1]

3. (d) (ii) A path difference of 750 m is equal to $1\frac{1}{2}\lambda$. [1]

So the two signals give destructive interference. [1]

As a result, the radio reception will become poorer. [1]

(e) Destructive interference of signals from 2 neighbouring transmitters [1]

can be avoided. [1]

4. (a) By $v = f\lambda$

$\therefore\ (3 \times 10^8) = (1000 \times 10^3)\ \lambda$ [1]

$\therefore\ \lambda = 300$ m [1]

(b) The reception of channel R_1 is better. [1]

Since the wavelength of R_1 is longer than that of R_2, [1]

the radio waves of R_1 diffract more than that of R_2. [1]

5. (a) $v = f\lambda$

$\therefore\ (3 \times 10^8) = (1.2 \times 10^9)\ \lambda$ [1]

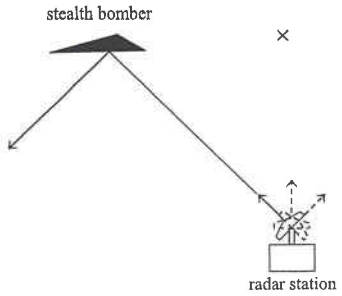
$\therefore\ \lambda = 0.25$ m [1]

(b) $\Delta t = 6.5 \times 5 \times 10^{-6} = 3.25 \times 10^{-5}$ s [1]

$d = \frac{1}{2} \times v \times \Delta t = \frac{1}{2} \times (3 \times 10^8) \times (3.25 \times 10^{-5})$ [1]

$= 4880$ m < accept 4875 m > [1]

6. (a)



(i) < The incident ray and the reflected ray drawn with reflected angle equals the incident angle > [1]

(ii) < The cross X marked vertically above the radar station > [1]

Provided by dse.life

6. (b) To lower the temperature of the exhausts [1]

and reduce the emission of infra-red radiation. [1]

(c) ① The engine is very quiet. [1]

② The aircraft blends in with the background visually. [1]

7. (a) $\tan\theta = \frac{0.37}{1} = 0.37$

$\therefore\ \theta = 20.3°$ [1]

By $d\sin\theta = n\lambda$

$\therefore\ \left(\frac{1}{6.0\times10^5}\right)\times\sin 20.3° = 1\times\lambda$

$\therefore\ \lambda = 5.78\times10^{-7}\ \text{m}$ [1]

(b) The maximum diffracted angle is 90°

By $d\sin\theta = n\lambda$

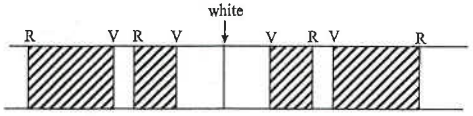
$\therefore\ \left(\frac{1}{6.0\times10^5}\right)\times\sin 90° = n\times(5.78\times10^{-7})$

$\therefore\ n = 2.9$ [1]

$\therefore$ No 3rd or higher order maximum can be observed.

$\therefore$ One more yellow band will be observed. [1]

(c)



Any **FOUR** of the following features in the diagram : [4]

* zero order image - white
* continuous spectra in each order
* violet / red ends marked correctly
* two orders shown on each side
* distance between 2nd and 1st order > distance between 1st and zeroth order
* spreading of colours greater in second order than the first order

8. (a) The fringe separation increases. [1]

8. (b) (i) By $d\sin\theta = n\lambda$

$\therefore\ (1684)\times\sin\left[\frac{134.37° - 45.67°}{2}\right] = (2)\lambda$ [1]

$\therefore\ \lambda = 588.6\ \text{nm}$ [1]

(ii) Larger diffraction angle gives smaller percentage error. [1]

9. (a) For the 4th order image : $x = 49.2\ \text{cm}$

$\therefore\ \tan\theta = \frac{49.2\times10^{-2}}{1}$

$\therefore\ \theta = 26.2°$ <accept 26.0° to 26.4°> [1]

By $d\sin\theta = n\lambda$

$\therefore\ (\frac{1\times10^{-3}}{160})\sin 26.2° = (4)\lambda$ [1]

$\therefore\ \lambda = 6.90\times10^{-7}\ \text{m}$ <accept 6.8×10^{-7} m to 7.0×10^{-7} m> [1]

(b) By $d\sin\theta = n\lambda$

$\therefore\ (\frac{1\times10^{-3}}{160})\sin 90° = n(6.90\times10^{-7})$ [1]

$\therefore\ n = 9.06$ $\therefore$ maximum order is 9 [1]

OR

By $\frac{n}{4} = \frac{\sin 90°}{\sin 26.2°}$ [1]

$\therefore\ n = 9.06$ $\therefore$ maximum order is 9 [1]

10. (a) Second order : $\tan\theta = \frac{1.02/2}{1.00}$ $\therefore\ \theta = 27.02°$ [1]

By $d\sin\theta = n\lambda$

$\therefore\ d\sin 27.02° = (2)(570\times10^{-9})$ [1]

$\therefore\ d = 2.51\times10^{-6}\ \text{m}$ <accept 2.5×10^{-6} m> [1]

<Do not accept answer by using $\Delta y = \lambda D / a$>

(b) Any **ONE** of the following [1]

* Do not view the laser light directly with eyes.
* Do not point laser light towards human bodies.

(c) Any **ONE** of the following [1]

* Grating should be perpendicular to the incident light.
* Screen should be parallel to the grating.

Provided by dse.life

11. (a) $v = f\lambda$

$\therefore\ (3 \times 10^8) = (1000 \times 10^3)\,\lambda$

$\therefore\ \lambda = 300$ m [1]

(b) The reception of channel R_1 is better. [1]

Since the wavelength of R_1 is longer than that of R_2,

the radio waves of R_1 diffract more than that of R_2. [1]

12. $\Delta y = \dfrac{\lambda D}{a} = \dfrac{(550\times10^{-9})(2.5)}{(0.5\times10^{-3})}$ [1]

$= 2.75 \times 10^{-3}$ m [1]

13. (a) $c = f\lambda$

$\therefore\ (3 \times 10^8) = f(0.02)$ [1]

$\therefore\ f = 1.5 \times 10^{10}$ Hz [1]

(b) (i) Path difference of the diffracted waves from slits A and B varies along XY. [1]

Constructive and destructive interference occur alternately to give maximum and minimum. [1]

(ii) $BP - AP = 1.5\,\lambda$ [1]

$BP - 1.24 = 0.03$

$BP = 1.27$ m [1]

(iii) Path difference along XY must be less than slit separation AB.

$AB = 6$ cm $= 3\,\lambda$

Thus the path difference can never reach 3λ along XY. [1]

Therefore, it is not possible to detect more than 3 maxima along XY. [1]

(Only $\Delta = 0\lambda, 1\lambda, 2\lambda$ can be detected.)

(c) Radio waves with lower frequencies and longer wavelength have greater diffraction effect. [1]

Radio waves by-pass small obstacles (**OR** Radio waves cannot be reflected by small obstacles). [1]

14. (a) (i) $\tan\theta = \dfrac{0.38}{1}$ $\therefore\ \theta = 20.8°$ [1]

(ii) Grating spacing : $d = (\dfrac{1\times10^{-3}}{300})$ [1]

By $d\sin\theta = n\lambda$ $\therefore\ (\dfrac{1\times10^{-3}}{300})\sin 20.8° = (2)\lambda$ [1]

$\therefore\ \lambda = 5.92 \times 10^{-7}$ m < accept 5.90×10^{-7} m to 5.97×10^{-7} m > [1]

14. (a) (iii) The diffracted angle θ is greater and thus the percentage error is reduced. [1]

OR

The value x is greater and thus the percentage error is reduced. [1]

(b) Locate the second order images at the other side of the central line. [1]

Take the average value of x obtained from both sides to find λ. [1]

OR

Measure the distance between the two images and divide it by 2 to give x. [1]

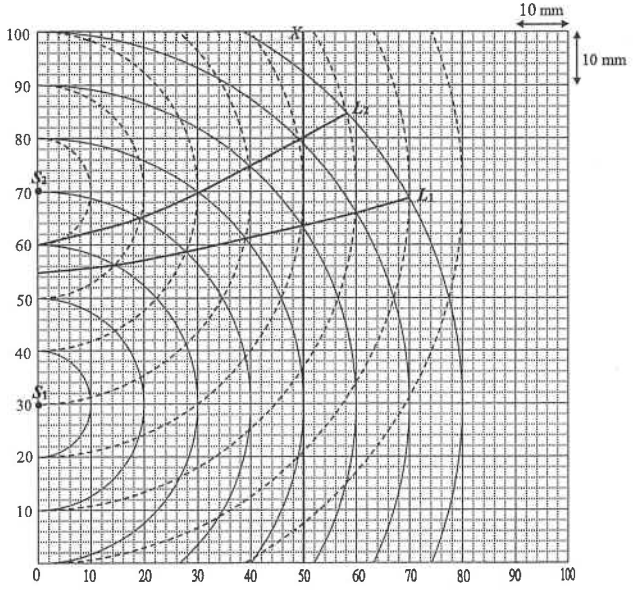
15. (a) $\Delta y = \dfrac{\lambda D}{a} = \dfrac{(650\times10^{-9})(3.0)}{(0.325\times10^{-3})}$ [1]

$= 6 \times 10^{-3}$ m (6 mm) [1]

(b) The screen is uniformly illuminated. < **OR** No alternate bright and dark fringes can be observed > [1]

The lights from the LEDs are not coherent. < **OR** No constant phase relationship > [1]

(c)



< $\Delta = PS_1 - PS_2 = 10$ mm $= 1\,\lambda$: drawn correctly > [1]

< $\Delta = PS_1 - PS_2 = 20$ mm $= 2\,\lambda$: drawn correctly > [1]

Constructive interference occurs at P. [1]

Provided by dse.life

15. (d) (i) $\Delta y = 17$ mm <accept 15 mm to 19 mm> [1]

(ii) The calculation is true only for small angle close to the central line. [1]

Moreover, the screen is too close to the sources, $D >> a$ cannot be satisfied. [1]

16. (a) (i) $\Delta y = \frac{(4.0-0)}{10} = 0.4$ cm <accept 0.39 to 0.41 cm> [1]

By $\Delta y = \frac{\lambda D}{a}$

$\therefore (0.4\times10^{-2}) = \frac{\lambda(1.8)}{(0.3\times10^{-3})}$ [1]

$\therefore \lambda = 6.67 \times 10^{-7}$ m <accept $6.5 - 6.7 \times 10^{-7}$ m> [1]

(ii) To ensure that light through the two slits have large diffraction [1]

so that the two diffracted light can interfere (**OR** overlap). [1]

(b) (i) By $d \sin\theta = n\lambda$

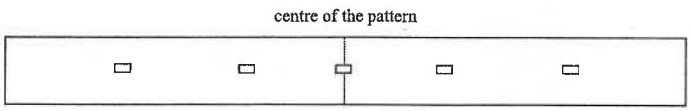
$\therefore (\frac{10^{-3}}{500}) \sin\theta = (1)(6.67 \times 10^{-7})$ [1]

$\therefore \theta = 19.5°$

By $\tan 19.5° = \frac{x}{(1.8)}$ [1]

$\therefore x = 0.637$ m <accept 0.633 m to 0.640 m> [1]

(ii)



<5 spots shown with symmetry about the centre> [1]

<separation between 1st and 2nd order spots is larger> [1]

17. (a) (i) Increase the separation D between the double slit and the screen. [1]

(ii) The separation of the bright dots on the screen becomes larger, thus the percentage error is smaller. [1]

(iii) Second order bright fringe : $\tan\theta_2 = \frac{(1.56/2)}{(1.40)}$ $\therefore \theta_2 = 29.1°$ [1]

Grating spacing : $d = \frac{(10^{-3})}{(400)} = 2.5 \times 10^{-6}$ m [1]

By $d \sin\theta = n\lambda$

$\therefore (2.5 \times 10^{-6}) \sin 29.1° = (2)\lambda$ $\therefore \lambda = 6.08 \times 10^{-7}$ m <accept 6.06 to 6.10 $\times 10^{-7}$ m> [1]

17. (b) (i) The equation can only be applied for $a << D$. [1]

(ii) Path difference at $P = 1\lambda$ [1]

$\Delta = \sqrt{(1+0.5)^2+2^2} - \sqrt{(1-0.5)^2+2^2} = 1\lambda$ [1]

$\therefore \lambda = 0.438$ m

By $v = f\lambda$

$\therefore v = (750)(0.438) = 329$ m s^{-1} <accept 328 to 330 m s^{-1}> [1]

Provided by dse.life

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

WA6 : Sound

Part A : HKCE examination questions

1. **< HKCE 1981 Paper II - 20 >**

Which of the following statements is/are correct ?
(1) Sound waves cannot be diffracted.
(2) A louder sound travels faster in air.
(3) Sound travels faster in water than in air.

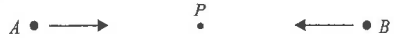
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. **< HKCE 1983 Paper II - 22 >**

An ultrasonic wave is sent from a ship to find the depth of the sea-bed. A signal is received 0.2 s later. Given that the speed of sound in sea water is 1500 m s^{-1}, what is the depth of the sea-bed ?

A. 75 m
B. 150 m
C. 300 m
D. 450 m

3. **< HKCE 1984 Paper II - 23 >**



Two sound waves of the same frequency are emitted from 2 sources *A* and *B* as shown in the diagram. What kind of interference will occur at the mid-point *P* when the 2 waves generated are (1) in phase; (2) anti-phase ?

	In phase	Anti-phase
A.	constructive	constructive
B.	constructive	destructive
C.	destructive	constructive
D.	cannot be determined	cannot be determined

4. **< HKCE 1985 Paper II - 21 >**

Which of the following are longitudinal waves ?
(1) sound waves transmitted through a solid
(2) sound waves transmitted through water
(3) waves in a vibrating string

A. (1) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

5. **< HKCE 1986 Paper II - 23 >**

Which of the following can be reflected and diffracted ?
(1) sound waves
(2) infra-red radiation
(3) X-rays

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

6. **< HKCE 1986 Paper II - 27 >**

The depth of a lake can be found by the method of echo-sounding. The depth of a short pulse sent vertically down to the bottom of the lake was received after 0.6 s. Given that the speed of sound in water is 1440 m s^{-1}, the depth of the lake will be

A. 7.2 m.
B. 14.4 m.
C. 432 m.
D. 864 m.

7. **< HKCE 1987 Paper II - 14 >**

The wavelength and velocity of a sound in air are 25 cm and 340 m s^{-1} respectively. When this sound enters a medium, its wavelength becomes 75 cm. Find the velocity of the sound in the medium.

A. 113 m s^{-1}
B. 340 m s^{-1}
C. 1020 m s^{-1}
D. 1130 m s^{-1}

8. **< HKCE 1988 Paper II - 22 >**

A signal of sound is sent vertically downwards from a ship. Its echo reflected from the sea bed is detected by a microphone on the ship 0.4 s later. What is the depth of the sea if the speed of sound in the sea is known to be 1500 m s^{-1} ?

A. 150 m
B. 300 m
C. 600 m
D. 3000 m

9. **< HKCE 1988 Paper II - 25 >**

The range of sound that a boy can hear is from 30 Hz to 16500 Hz. If it is given that the speed of sound in air is 330 m s^{-1}, what is the shortest wavelength of sound in air that the boy can hear ?

A. 0.02 m
B. 0.09 m
C. 11.0 m
D. 50.0 m

10. **< HKCE 1989 Paper II - 24 >**

The wavelength and velocity of a sound in air are 25 cm and 330 m s^{-1} respectively. When this sound enters a medium, its wavelength becomes 75 cm. Find the velocity of the sound in the medium.

A. 165 m s^{-1}
B. 330 m s^{-1}
C. 660 m s^{-1}
D. 990 m s^{-1}

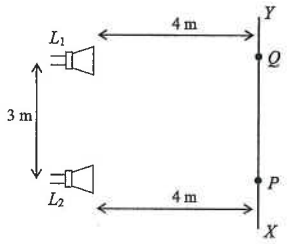
11. **< HKCE 1990 Paper II - 27 >**

Which of the following statements about sound is/are correct ?

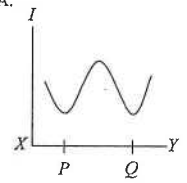
(1) Sound cannot travel through water.
(2) Loudness increases with the amplitude of the sound wave.
(3) Pitch increases with the wavelength of the sound wave.

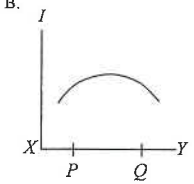
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

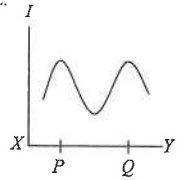
12. **< HKCE 1990 Paper II - 25 >**

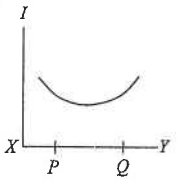


In the figure shown, the two loudspeakers L_1 and L_2 emit sound waves of wavelength 2 m. The waves emitted are exactly opposite in phase. Which of the following graphs best represents the variation of sound intensity I along the line XY ?

A.


B.


C.


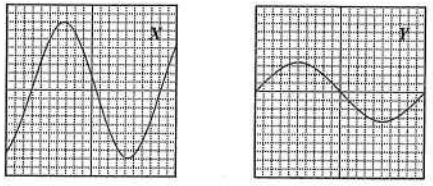
D.


13. **< HKCE 1990 Paper II - 28 >**

A bat emits sound waves of frequency 30 kHz and receives a reflected signal from an obstacle after 0.15 s. The speed of the sound in air is 340 m s^{-1}. How far is the obstacle away from the bat ?

A. 11.3 m
B. 25.5 m
C. 51.0 m
D. 88.2 m

14. **< HKCE 1991 Paper II - 27 >**



The diagrams above show the traces of two musical notes X and Y on an oscilloscope. Which of the following statements is/are true ?

(1) X has a higher pitch than Y.
(2) The loudness of X is greater than that of Y.
(3) X and Y are longitudinal waves.

A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

Provided by dse.life

15. **< HKCE 1991 Paper II - 26 >**

Which of the following is an application of ultrasonic in everyday life ?

A. Cooking
B. TV broadcasting
C. Camera autofocusing
D. Satellite telecommunication

16. **< HKCE 1992 Paper II - 23 >**

Which of the following is/are longitudinal waves ?

(1) Ultrasonic transmitted through air.
(2) Infrared transmitted through water.
(3) Gamma rays transmitted through outer space.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

17. **< HKCE 1993 Paper II - 27 >**

The frequencies of two musical notes X and Y are 256 Hz and 512 Hz respectively. If X and Y both have the same amplitude, which of the following statements is/are true ?

(1) Y has a higher pitch than X.
(2) The loudness of X is larger than that of Y.
(3) The wavelength of Y is longer than that of X.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

18. **< HKCE 1993 Paper II - 28 >**

Which of the following statements about ultrasonics is INCORRECT ?

A. Ultrasonics are longitudinal waves.
B. The frequency of ultrasonics is above 20 kHz.
C. Ultrasonics are deflected by a magnetic field.
D. Ultrasonics cannot travel through a vacuum.

19. **< HKCE 1994 Paper II - 23 >**

Which of the following is NOT an application of ultrasonics ?

A. Camera autofocusing
B. Satellite communication
C. Measurement of the depth of the sea-bed
D. Detection of cracks in railway tracks

20. **< HKCE 1995 Paper II - 25 >**

When a sound wave travels from air into water, its wavelength is increased by five times. If the speed of sound in air is 330 m s^{-1}, find the speed of the sound wave in water.

A. 66 m s^{-1}
B. 330 m s^{-1}
C. 1650 m s^{-1}
D. insufficient information

21. **< HKCE 1997 Paper II - 22 >**

Which of the following statements concerning microwaves and ultrasonic waves is/are correct ?

(1) Microwaves are electromagnetic waves while ultrasonic waves are not.
(2) Microwaves and ultrasonic waves travel with the same speed in air.
(3) Microwaves can be diffracted while ultrasonic waves cannot.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

22. **< HKCE 1998 Paper II - 28 >**

Which of the following statements about ultrasonic waves is correct ?

A. They are transverse waves.
B. They are electromagnetic waves.
C. They travel with a speed of 3×10 m s^{-1} in air.
D. They cannot travel through a vacuum.

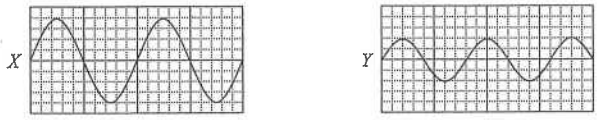
23. **< HKCE 1999 Paper II - 25 >**

Which of the following statements about light and sound is/are correct ?

(1) Both light and sound are transverse waves.
(2) Both light and sound travel faster in air than in water.
(3) Both light and sound can undergo refraction when travelling from one medium to another.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

24. **< HKCE 2000 Paper II - 28 >**



A microphone and a CRO are used to detect the sound emitted by two tuning forks X and Y in turn. The figures show the traces obtained, with the same setting of the CRO. Find the ratio of the frequency of the sounds emitted by X to that of Y.

A. 1 : 2
B. 2 : 1
C. 4 : 5
D. 5 : 4

25. **< HKCE 2001 Paper II - 24 >**

A sonar on a ship is used to find the depth of the sea. An ultrasonic wave pulse is sent downwards from the ship towards the sea bed. The pulse travels with a speed of 1500 m s^{-1} in sea water. If the reflected pulse is received after 0.16 s, find the depth of the sea.

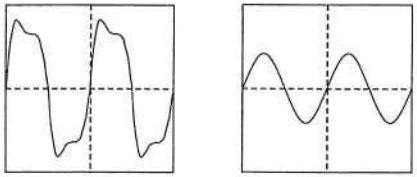
A. 120 m
B. 240 m
C. 480 m
D. 4688 m

Provided by dse.life

26. **< HKCE 2001 Paper II - 22 >**

Which of the following is **not** a transverse wave ?
A. radio waves
B. visible light
C. X-rays
D. ultrasonic waves

27. **< HKCE 2002 Paper II - 29 >**


Note *X* Note *Y*

The above figures show the CRO displays of two musical notes *X* and *Y*. The settings of the CRO for the two notes are identical. Which of the following statements are correct ?
(1) Notes *X* and *Y* are of different qualities.
(2) Note *X* is of a higher pitch than note *Y*.
(3) Note *X* is louder than note *Y*.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

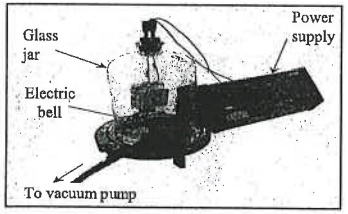
28. **< HKCE 2002 Paper II - 28 >**

The figure shows the image of a foetus (a baby not yet born) taken by a scanner. Which of the following waves should be used in the scanning process ?
A. infra-red
B. microwaves
C. ultrasonics
D. X-rays

29. **< HKCE 2003 Paper II - 29 >**

A ringing electric bell is placed inside a glass jar as shown. As air is pumped out of the jar, the sound will die away. Which of the following can explain this phenomenon ?

A. The hammer of the bell cannot vibrate in a vacuum.
B. Sound waves are internally reflected by the glass surface.
C. Sound waves cannot travel in a vacuum.
D. The frequency of sound waves in a vacuum exceeds the audible frequency range.



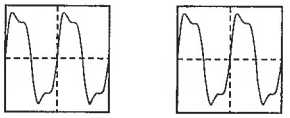
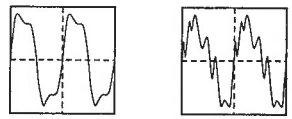
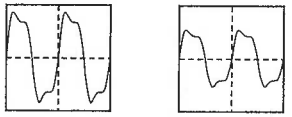
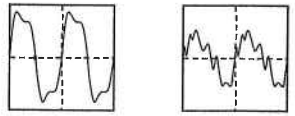
30. **< HKCE 2004 Paper II - 26 >**

Which of the following descriptions about microwaves and ultrasonic waves is correct ?
A. They can both travel in a vacuum.
B. They are both transverse waves.
C. They can both be deflected by magnetic fields.
D. They travel with different speeds in air.

31. **< HKCE 2005 Paper II - 38 >**

Two musical notes are produced by two different kinds of musical instruments. The two notes have the same pitch but different loudness. Which of the following combinations of notes satisfies the above description ?

Note : The settings of the CRO for displaying the notes are identical.

A. 
B. 
C. 
D. 

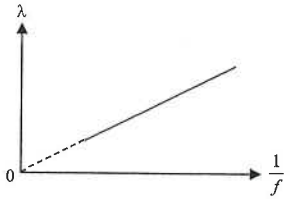
32. **< HKCE 2005 Paper II - 37 >**

Which of the following is a unit of sound intensity level ?
A. decibel
B. hertz
C. sievert
D. watt

33. **< HKCE 2005 Paper II - 13 >**

Which of the following statements about sound waves are correct ?
(1) Sound waves are longitudinal waves.
(2) Sound waves are electromagnetic waves.
(3) Sound waves cannot travel in a vacuum.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

34. **< HKCE 2006 Paper II - 17 >**



A loudspeaker is connected to a signal generator to produce sound waves. The frequency *f* is varied and the corresponding wavelength λ is measured. The wavelength is plotted against the reciprocal of the frequency as shown above. Which of the following are correct deductions obtained from the graph ?
(1) The wavelength of the sound is inversely proportional to its frequency.
(2) The slope of the graph is equal to the speed of the sound.
(3) The speed of the sound depends on its frequency
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Provided by dse.life

35. **< HKCE 2006 Paper II - 34 >**

The following data show the frequencies and sound intensity levels of some musical notes produced by a piano.

Note	Frequency / Hz	Intensity level / dB
C	256	64
D	288	68
E	320	65
F	341	63

Which of the following statements is/are correct ?

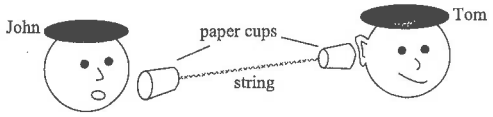
(1) The note F has the lowest pitch.

(2) The note D has the greatest loudness.

(3) The note C played on a guitar will sound differently from the same note produced by the piano.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

36. **< HKCE 2006 Paper II - 18 >**



John and Tom communicate with each other by using two paper cups connected with a string. Which of the following statements are correct ?

(1) The sound waves transmitted along the string are transverse waves.

(2) The speed of the sound waves along the string is faster than that in the air.

(3) When John whistles a note of 1000 Hz towards the paper cup, Tom will also hear a note of 1000 Hz.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

37. **< HKCE 2006 Paper II - 20 >**

Which of the following phenomena are due to the refraction of waves ?

(1) When water waves enter shallow water from deep water, the spacing between wavefronts decreases.

(2) A swimming pool appears shallower than it actually is.

(3) Mary can hear loud and soft sounds alternately when she walks across in front of two loudspeakers connected to a signal generator.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

38. **< HKCE 2006 Paper II - 33 >**

Flash lamps used by professional photographers can find object distances by using infrared waves so as to adjust the flash output. Which of the following is/are the reason(s) of using infrared waves instead of ultrasonic waves in such flash lamps ?

(1) Speed of infrared waves is much faster than that of ultrasonic waves making the time for finding object distances shorter.

(2) Objects to be photographed will usually emit infrared waves.

(3) The sound produced by ultrasonic waves makes photographers feel annoyed.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

39. **< HKCE 2007 Paper II - 36 >**

Which of the following descriptions about ultrasonic waves must be correct ?

A. In the same medium, the speed of the ultrasonic waves is higher than that of the audible sound waves.

B. In the same medium, the wavelength of the ultrasonic waves is longer than that of the audible sound waves.

C. In the same medium, the intensity of the ultrasonic waves is higher than that of the audible sound waves.

D. In the same medium, the frequency of the ultrasonic waves is higher than that of the audible sound waves.

40. **< HKCE 2007 Paper II - 37 >**

Two identical loudspeakers X and Y are connected in parallel to a signal generator. A microphone connected to a CRO detects a maximum when it is 0.2 m from X and 0.4 m from Y. It detects a minimum when it is 0.9 m from X and 0.4 m from Y. What is the possible wavelength of the sound wave ?

A. 0.1 m
B. 0.2 m
C. 0.4 m
D. 0.5 m

41. **< HKCE 2007 Paper II - 39 >**

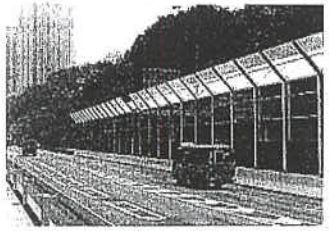
Noise barriers built along highways are used to block the noise generated by road traffic. Which of the following statements correctly explain how the noise barriers can block the noise ?

(1) The noise from vehicles is reflected.

(2) The noise is absorbed by the noise barriers.

(3) The noise is diffracted at the top edge of the noise barriers.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)



42. **< HKCE 2008 Paper II - 14 >**

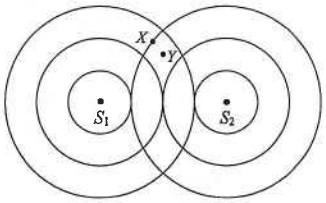
A ship uses a sonar system to detect the depth of the sea. A sound wave signal of frequency 30000 Hz is sent vertically downward from the sea surface and the reflected signal is received 5 s later. Which of the following is correct ?
(The speed of sound wave in sea water is 1400 m s^{-1}.)

	Wavelength of the sound wave in sea water (m)	Depth of the sea (m)
A.	4.67×10^{-2}	3500
B.	4.67×10^{-2}	7000
C.	9.33×10^{-2}	3500
D.	9.33×10^{-2}	7000

Provided by dse.life

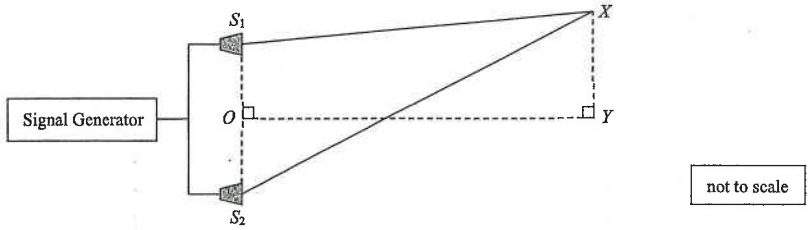
43. **< HKCE 2008 Paper II - 36 >**

In the figure, S_1 and S_2 are two identical loudspeakers connected in parallel to a signal generator. The circles represent the wavefronts of the sound wave produced. What are the changes to the loudness of the sound at X and Y if loudspeaker S_1 is turned off ?



	X	Y
A.	increases	increases
B.	decreases	decreases
C.	increases	decreases
D.	decreases	increases

44. **< HKCE 2009 Paper II - 35 >**



Sound waves of 660 Hz are produced from two identical loudspeakers S_1 and S_2 which are connected in parallel to a signal generator. The distances S_1X and S_2X are 2 m and 4 m respectively. O is the midpoint of S_1S_2. What kinds of interference occur at X and Y respectively ? Given that the speed of sound in air is 330 m s^{-1}

	X	Y
A.	constructive	constructive
B.	constructive	destructive
C.	destructive	constructive
D.	destructive	destructive

45. **< HKCE 2010 Paper II - 15 >**

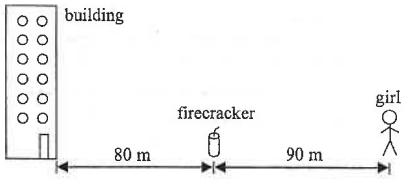
Which of the following statements about sound waves is **not** correct ?

A. Sound waves are longitudinal waves.
B. Sound waves diffract when travelling through a doorway.
C. Sound waves cannot pass through a vacuum.
D. All sound waves of frequencies above 20 Hz are audible.

46. **< HKCE 2010 Paper II - 12 >**

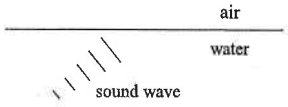
In the figure, a firecracker at a position 80 m away from a building explodes and produces a bang. A girl standing 90 m away from the firecracker hears two bangs. What is the time interval between the two bangs ?

Given : speed of sound in air = 340 m s^{-1}



A. 0.24 s
B. 0.26 s
C. 0.47 s
D. 0.50 s

47. **< HKCE 2010 Paper II - 39 >**

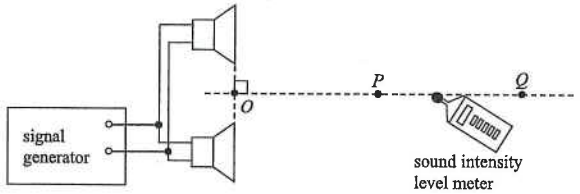


The figure shows a sound wave travelling in water. It is known that the sound waves travel faster in water than in air. After refraction, which of the following statements is/are correct ?

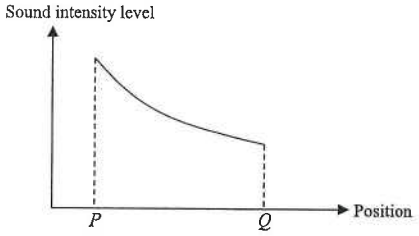
(1) The wavelength of the sound wave increases.
(2) The frequency of the sound wave remains unchanged.
(3) The sound wave bends away from the normal.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

48. **< HKCE 2010 Paper II - 40 >**



Two identical loudspeakers are connected in parallel to a signal generator, O is the midpoint between the loudspeakers. When a sound intensity level meter is moved from P to Q, the graph below shows the variation of the sound intensity level received with position.



Which of the following statements is/are correct ?

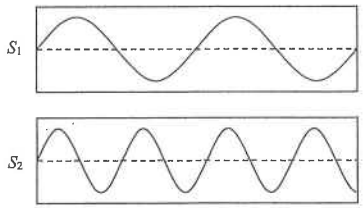
(1) The sound intensity level at Q is smaller because the amplitude of the sound wave decreases as it is further away from the loudspeakers.
(2) Constructive interference occurs at point P while destructive interference occurs at point Q.
(3) The result of the experiment shows that sound is a wave.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Provided by dse.life

Part B : HKAL examination questions

49. < HKAL 1982 Paper I - 41 >



Two tuning forks F_1 and F_2 are hit respectively to give sound notes. Their waveforms are displayed on a CRO connected to a microphone. The traces S_1 and S_2 observed on the screen of the CRO are given by F_1 and F_2 respectively. The time base of the CRO remains the same in each case. Which of the following statements is/are correct ?

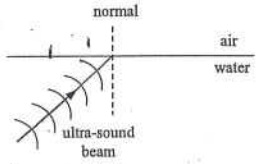
(1) The period of F_1 is greater than the period of F_2.

(2) The pitch of F_1 is greater than the pitch of F_2.

(3) The speed of sound from F_1 is greater than the speed of sound from F_2.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

50. < HKAL 1985 Paper I - 17 >



A beam of ultrasound is directed from water to air as shown in the above figure. Which of the following statements is true ?

A. The refracted beam leaving the surface will bend away from the normal.

B. The refracted beam will bend towards the normal.

C. The refracted beam will travel in the same direction as the incident beam.

D. Total internal reflection will occur.

51. < HKAL 1990 Paper I - 18 >

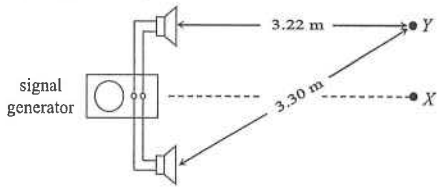
Which of the following represent the approximate noise levels

(1) in a quiet school library ?

(2) near the road with heavy traffic ?

	(1)	(2)
A.	30 dB	60 dB
B.	60 dB	90 dB
C.	30 dB	90 dB
D.	90 dB	60 dB

52. < HKAL 1992 Paper I - 22 >

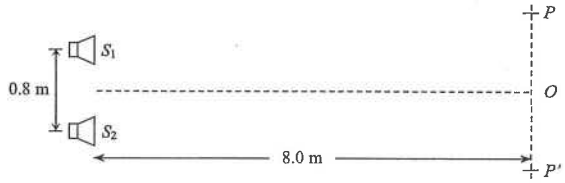


Two loudspeakers are connected to the same signal generator. A microphone placed at X detects a maximum sound intensity. When the microphone is moved upwards, maximum sound intensity is also detected at Y. Which of the following may give possible values of the wavelength of the sound emitted from the loudspeakers ?

(1) 0.04 m
(2) 0.08 m
(3) 0.16 m

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

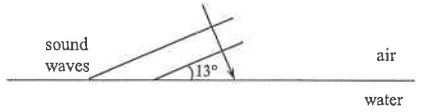
53. < HKAL 2008 Paper IIA - 11 >



Two loudspeakers S_1 and S_2 are connected to a signal generator to give out sound waves that are in phase. The separation between S_1 and S_2 is 0.8 m. A student moves a microphone along a line PP' 8.0 m away from the loudspeakers and parallel to S_1S_2. Loud sound is detected consecutively at P, O and P'. If PP' equals 2.0 m, estimate the wavelength of the sound produced by the loudspeakers.

A. 5 cm
B. 10 cm
C. 15 cm
D. 20 cm

54. < HKAL 2010 Paper IIA - 15 >

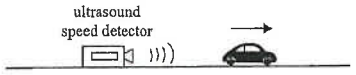


Sound waves of frequency 1000 Hz travel from air to water as shown. If the incident wavefront makes an angle of 13° with the interface, find the angle of refraction and the wavelength of sound in water.
(Given : speed of sound in air and that in water are 340 m s^{-1} and 1500 m s^{-1} respectively.)

	angle of refraction	wavelength in water
A.	2.9°	7.7 cm
B.	2.9°	1.5 m
C.	83°	7.7 cm
D.	83°	1.5 m

Provided by dse.life

55. **< HKAL 2011 Paper IIA - 12 >**



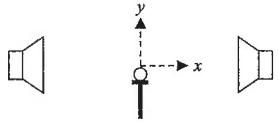
The above figure shows a speed detector used for measuring the speed of a toy car. The detector emits an ultrasound pulse P_1 towards the car, which is reflected back to the detector as pulse R_1 after 15 ms. Another pulse P_2 is emitted 0.5 s after P_1 is emitted and the reflected pulse R_2 is received 20 ms later.

Assume that the car is travelling directly away from the detector with uniform speed. Estimate its speed.

Given : speed of ultrasound in air = 340 m s^{-1}

A. 1.7 m s^{-1}
B. 2.1 m s^{-1}
C. 2.6 m s^{-1}
D. 3.4 m s^{-1}

56. **< HKAL 2011 Paper IIA - 11 >**

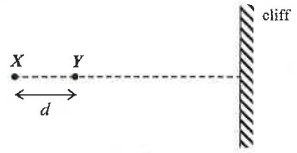


Two loudspeakers are connected to a signal generator and they gives out sound waves in anti-phase. A small microphone is placed midway between the two loudspeakers. The intensity of the sound detected by the microphone is close to zero. Which of the following changes can lead to a significant increase in the sound intensity detected ?

(1) Move the microphone along the x direction.
(2) Move the microphone along the y direction.
(3) Increase the frequency of the signal generator.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

57. **< HKAL 2013 Paper IIA - 16 >**



A boy claps his hands in front of a cliff at the position X as shown in the above figure. He hears the echo 0.8 s later. He then walks a distance d towards the cliff and claps again at the position Y. This time he hears the echo 0.6 s later. Find d if the speed of sound in air is 330 m s^{-1}.

A. 17 m
B. 33 m
C. 66 m
D. 132 m

Part C : Supplemental exercise

58. What is the approximate range of audible frequencies for a young adult ?

A. from 2 Hz to 2 000 Hz
B. from 20 Hz to 2 000 Hz
C. from 20 Hz to 20 000 Hz
D. from 200 Hz to 200 000 Hz

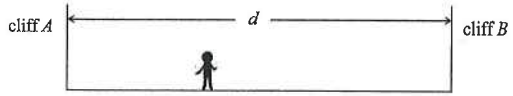
59. Which factors affect the quality of sound waves produced by a musical instrument ?

A. the amplitude of the sound waves
B. the frequency of the sound waves
C. the velocity of the sound waves
D. the waveform of the sound waves

60. Two boys both sing the same musical note "doh". However, the two notes can be distinguished to be sung by which boy since they have different

A. speed.
B. loudness.
C. pitch.
D. quality.

61.



Mary stands between two cliffs A and B as shown in the above figure. She claps her hands and hears the first echo after 1.2 s and the second echo after 1.8 s. If the speed of sound in air is 320 m s^{-1}, what is the distance d between the two cliffs ?

A. 192 m
B. 288 m
C. 480 m
D. 960 m

62. Peter sees a flash of lightning in the sky. After 6 s, he hears the bang of thunder. How far way is he from the thunderstorm ?
(Given : speed of light in air = 3×10^8 m s^{-1} ; speed of sound in air = 320 m s^{-1}.)

A. 960 m
B. 1920 m
C. 9×10^8 m
D. 18×10^8 m

63. Arrange the following in ascending order of frequency :

(1) the domestic mains voltage
(2) microwaves from a mobile phone
(3) a note of sound from a violin

A. (1) (2) (3)
B. (1) (3) (2)
C. (2) (1) (3)
D. (3) (2) (1)

Provided by dse.life

Part D : HKDSE examination questions

64. **< HKDSE Sample Paper IA - 22 >**

Which of the following statements about sound waves is/are correct ?
(1) Sound waves are longitudinal waves.
(2) Sound waves are electromagnetic waves.
(3) Sound waves cannot travel in a vacuum.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

65. **< HKDSE 2012 Paper IA - 22 >**

The figure shows the waveforms of sound notes generated by a violin, a piano and a tuning fork. The scale is the same in time and intensity axes for all three waveforms.

(X)

(Y)

(Z)

Which of the following about the sound notes are correct ?
(1) They all have the same pitch.
(2) The qualities of sound of (Y) and (Z) are different.
(3) (X) is generated by the tuning fork.

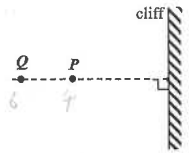
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (2) only
D. (1), (2) & (3)

66. **< HKDSE 2012 Paper IA - 23 >**

Which of the following about ultrasound is INCORRECT ?
A. Ultrasound is a longitudinal wave.
B. The frequency of ultrasound is greater than 20000 Hz.
C. In air, the speed of ultrasound is faster than the speed of audible sound.
D. In air, the diffraction effect of ultrasound is less prominent than that of audible sound.

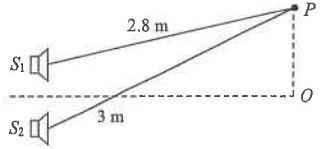
67. **< HKDSE 2013 Paper IA - 19 >**

Astronauts P and Q stand at 400 m and 600 m respectively from a vertical cliff on the surface of a planet. The figure shows the top view. P claps his hands once and Q hears two clapping sounds separated by 4 s. What is the speed of sound in the atmosphere of this planet ?



A. 100 m s^{-1}
B. 150 m s^{-1}
C. 200 m s^{-1}
D. 250 m s^{-1}

68. **< HKDSE 2014 Paper IA - 18 >**



S_1 and S_2 are two loudspeakers connected to a signal generator but the sound waves produced by them are in anti-phase. Point O is equidistant from the loudspeakers while point P is at the distances shown in the figure from the loudspeakers. What type of interference occurs at O and P if the wavelength of the sound waves is 10 cm ?

	O	*P*
A.	destructive	constructive
B.	constructive	constructive
C.	destructive	destructive
D.	constructive	destructive

69. **< HKDSE 2014 Paper IA - 17 >**

Figure (a) shows a car travelling with a uniform speed along a straight road away from a stationary ultrasound generator and detector at Y. When the car is 64 m from Y, the generator emits an ultrasound pulse towards the car.

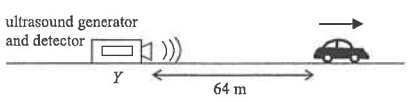


Figure (a)

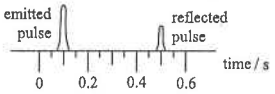


Figure (b)

The pulse is then reflected back to the detector at Y and displayed on a CRO as shown in Figure (b). Estimate the speed of the car. Given : speed of ultrasound in air is 340 m s^{-1}.

A. 16 m s^{-1}
B. 20 m s^{-1}
C. 24 m s^{-1}
D. 32 m s^{-1}

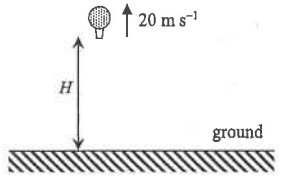
70. **< HKDSE 2014 Paper IA - 19 >**

Which of the following statements about sound waves is/are correct ?
(1) Sound waves are electromagnetic waves.
(2) Sound waves cannot travel in a vacuum.
(3) Sound waves cannot form stationary waves.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

71. **< HKDSE 2015 Paper IA - 19 >**

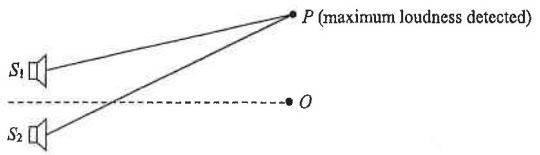
A balloon is rising at a uniform speed of 20 m s^{-1}. When the balloon is at an altitude H as shown, it sends a sound signal towards the ground. After 5 s, the balloon receives the echo of the signal. Estimate H.
Given : speed of sound in air = 340 m s^{-1}.



A. 1600 m
B. 850 m
C. 800 m
D. 750 m

Provided by dse.life

72. **< HKDSE 2016 Paper IA - 21 >**



Loudspeakers S_1 and S_2 connected to a signal generator emit sound waves which are in phase. Point O is equidistant from the loudspeakers while at point P maximum loudness is detected. The wavelength of the sound waves is λ. Which statement is INCORRECT ?

A. Both PS_1 and PS_2 must be integral multiples of wavelength λ.
B. The definite value of the path difference $PS_2 - PS_1$ cannot be determined from the information given.
C. At least one point of minimum loudness can be detected between O and P.
D. Minimum loudness will be detected at P if the sound waves from S_1 and S_2 are in antiphase.

73. **< HKDSE 2016 Paper IA - 23 >**

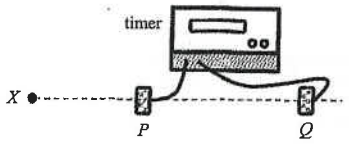
Which of the following are applications of ultrasound ?

(1) sterilizing drinking water
(2) detecting cracks in railway tracks
(3) breaking up kidney stones

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

74. **< HKDSE 2017 Paper IA - 15 >**

An experiment is set up to measure the speed of sound in air as shown. P and Q are two microphones connected to a timer. A sound is produced at X. The timer starts when P receives the sound, and stops when Q receives the sound. The timer shows the time taken for the sound to travel from P to Q. The distance PQ and the time shown can be used to calculate the speed of sound.



Which of the following statements is **INCORRECT** ?

A. X, P and Q must be along the same straight line.
B. The percentage error in the time measured will increase if the distance PQ is reduced.
C. The speed of sound determined should be independent of the distance between X and P.
D. The distance PQ must be equal to an integral multiple of wavelengths of the sound produced at X.

75. **< HKDSE 2017 Paper IA - 18 >**

Two musical notes of the same pitch and loudness are produced by two different musical instruments. They sound different to the human ears because they have different

A. amplitudes.
B. phases.
C. wave speeds.
D. waveforms.

76. **< HKDSE 2017 Paper IA - 21 >**

If the speed of sound in water is x and the speed of light in water is y, which of the following is correct ?

	speed of sound in air	**speed of light in air**
A.	$> x$	$> y$
B.	$> x$	$< y$
C.	$< x$	$> y$
D.	$< x$	$< y$

77. **< HKDSE 2018 Paper IA - 21 >**

Which of the following is **NOT** typical sound intensity level that occurs in daily life ?

A. 130 dB : when an airplane take-off
B. 110 dB : at a rock concert
C. 80 dB : having a normal conversation
D. 30 dB : inside a library

78. **< HKDSE 2018 Paper IA - 14 >**

Which of the following statements about waves is/are correct ?

(1) Longitudinal waves can transmit energy from one place to another but transverse waves cannot.
(2) Sound waves propagate faster in water than in air.
(3) Infra-red radiation is a kind of electromagnetic wave.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

79. <HKDSE 2019 Paper IA-21>

Provided by dse.life

80. <HKDSE 2020 Paper IA-19>

Which of the following phenomena provides conclusive evidence that sound is a wave ?

(1) reflection of sound from a wall
(2) refraction of sound at the boundary between two media
(3) interference of sound

A. (2) only
B. (3) only
C. (1) and (2) only
D. (1) and (3) only

81. <HKDSE 2020 Paper IA-21>

Which of the following statements about ultrasound is/are correct ?

(1) Ultrasound has a shorter wavelength than audible sound.
(2) Ultrasound cannot be produced by vibrating objects.
(3) Ultrasound cannot be heard as it cannot travel through air.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

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HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. B	21. A	31. D	41. A	51. C
2. B	12. C	22. D	32. A	42. A	52. C
3. B	13. B	23. B	33. B	43. C	53. B
4. C	14. D	24. C	34. A	44. A	54. D
5. D	15. C	25. A	35. D	45. D	55. A
6. C	16. A	26. D	36. C	46. C	56. A
7. C	17. A	27. B	37. A	47. B	57. B
8. B	18. C	28. C	38. A	48. A	58. C
9. A	19. B	29. C	39. D	49. A	59. D
10. D	20. C	30. D	40. B	50. B	60. D
61. C	71. C	81. A			
62. B	72. A				
63. B	73. C				
64. D	74. D				
65. D	75. D				
66. C	76. C				
67. C	77. C				
68. C	78. D				
69. B	79. D				
70. A	80. B				

M.C. Solution

1. B

× (1) All waves, including sound waves, possess all the four phenomena, including diffraction.

× (2) Speed of sound is independent of its intensity or loudness, but depends on medium only.

✓ (3) Sound wave travels faster in liquid than in gas or air

2. B

$$d = \frac{v \cdot \Delta t}{2} = \frac{(1500)(0.2)}{2}$$

$$= 150 \text{ m}$$

3. B

As P is the mid-point, the path difference at P is zero.

If the two sources vibrate in phase, P would undergo constructive interference.

If the two sources vibrate out of phase (anti-phase), P would undergo destructive interference.

4. C

✓ (1) Sound waves in solid are longitudinal waves.

✓ (2) Sound waves in water are longitudinal waves.

× (3) Waves in vibrating string are transverse waves.

5. D

Since sound waves, infra-red radiation and X-rays are waves, they possess all the phenomena of waves.

Thus, all of them can be reflected and diffracted.

6. C

$$d = \frac{1}{2} v \Delta t = \frac{1}{2}(1440)(0.6) = 432 \text{ m}$$

7. C

There is no change in frequency when sound waves enter another medium.

By $v = f\lambda$ $\therefore$ $v \propto \lambda$

$$\therefore \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

$$\therefore \frac{(340)}{v_2} = \frac{(25)}{(75)} \qquad \therefore v_2 = 1020 \text{ m s}^{-1}$$

8. B

$$d = \frac{1}{2} v \Delta t = \frac{1}{2}(1500)(0.4) = 300 \text{ m}$$

9. A

By $v = f\lambda$, the greatest frequency gives the shortest wavelength.

$\therefore$ $(330) = (16500)\lambda$

$\therefore$ $\lambda = 0.02$ m

10. D

There is no change in frequency when sound enters another medium.

By $v = f\lambda$ $\therefore$ $v \propto \lambda$ (for constant frequency f)

$$\therefore \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} \qquad \therefore \frac{(330)}{v_2} = \frac{(25)}{(75)}$$

$\therefore$ $v_2 = 990 \text{ m s}^{-1}$

Provided by dse.life

11. B

× (1) Sound wave can travel in any material medium, including water.

✓ (2) If the amplitude of sound increase, loudness increases.

× (3) If the wavelength increases, frequency decreases, thus pitch decreases.
Pitch should decrease with the wavelength.

12. C

For the two sources vibrating in **opposite** phase, type of interference is reverse :

(1) at the mid-point : $\Delta = 0\lambda$ $\therefore$ destructive interference occurs, intensity is minimum

(2) at Q : $\Delta = \sqrt{3^2+4^2} - 4 = 1\,\text{m} = \frac{1}{2}\lambda$ $\therefore$ constructive interference occurs, intensity is maximum

13. B

$d = \frac{1}{2} v \Delta t$

$= \frac{1}{2}(340)(0.15)$

$= 25.5\,\text{m}$

14. D

✓ (1) X has shorter period, thus it has higher frequency, therefore, X has higher pitch.

✓ (2) X has a greater amplitude, thus it has greater loudness

✓ (3) Both X and Y are musical notes, i.e. they are sound waves, thus they are longitudinal waves.

15. C

× A. Microwave oven cooking : microwaves

× B. TV broadcasting : radio waves

✓ C. Camera autofocusing : ultrasonic waves (OR infra-red radiation)

× D. Satellite telecommunication : microwaves

16. A

✓ (1) Ultrasonic waves are sound waves with frequency higher than 20000 Hz, they are longitudinal waves.

× (2) Infrared radiations are electromagnetic waves, they are transverse waves.

× (3) Gamma rays are electromagnetic waves, they are transverse waves.

17. A

✓ (1) Frequency of Y is higher than that of X, thus Y has a higher pitch.

× (2) As they have the same amplitude, they have the same intensity and thus same loudness.

× (3) By $v = f\lambda$, Y has the higher frequency, thus Y should have the shorter wavelength.

18. C

✓ A. Ultrasonics are sound waves with frequency higher than 20000 Hz, thus they are longitudinal waves.

✓ B. This is the definition of ultrasonics.

× C. Ultrasonics cannot be deflected by magnetic field.

✓ D. Sound wave requires a material medium to travel.

19. B

Satellite communication is an application of microwaves, not ultrasonics.

20. C

There is no change in frequency when sound enters another medium.

By $v = f\lambda$

$\therefore\ v \propto \lambda$

$\therefore\ v_{\text{water}} = 330 \times 5 = 1650\,\text{m s}^{-1}$

21. A

✓ (1) Ultrasonic waves are sound waves.

× (2) Ultrasonic waves are not electromagnetic waves, speed of ultrasonics is less than speed of microwaves.

× (3) Both are waves, thus both possess all wave phenomena, including diffraction.

22. D

× A. Ultrasonics are sound waves, thus they are longitudinal waves.

× B. Ultrasonics cannot travel in vacuum, they are not electromagnetic waves.

× C. Ultrasonics travel with the speed of sound, not the speed of light of $3 \times 10^8\,\text{m s}^{-1}$.

✓ D. Ultrasonics require a material medium to travel, they cannot travel in vacuum.

23. B

× (1) Sound is a longitudinal wave.

× (2) Sound travels faster in water than in air.

✓ (3) Both of them are waves, thus both possess all wave phenomena, including refraction.

24. C

For a certain interval of time displayed in the CRO,

X completes 2 cycles but Y completes 2.5 cycles.

$f_X : f_Y = 2 : 2.5 = 4 : 5$

25. A

$d = \frac{1}{2} c\, t = \frac{1}{2}(1500) \times (0.16) = 120\,\text{m}$

Provided by dse.life

26. D

× A. Radio waves are electromagnetic waves, they are transverse in nature.

× B. Visible light is electromagnetic wave, it is transverse in nature.

× C. X-rays are electromagnetic waves, they are transverse in nature.

✓ D. Ultrasonics waves are longitudinal waves, they are NOT transverse waves.

27. B

✓ (1) Notes *X* and *Y* are of different qualities as they have different waveforms.

× (2) Notes *X* and *Y* have the same pitch as they have the same frequency (same period).

✓ (3) Note *X* has larger amplitude than note *Y*, so note *X* is louder than note *Y*.

28. C

Ultrasonics can be used to examine foetus without causing harmful effect

X-rays cannot be used since X-rays would cause harmful effect to the foetus.

29. C

Since sound waves cannot travel in a vacuum,

the sound cannot be heard after the air has been pumped out.

30. D

× A. Microwaves can travel in vacuum but ultrasonic waves cannot.

× B. Microwaves are transverse waves but ultrasonic waves are longitudinal waves.

× C. Both microwaves and ultrasonic waves cannot be deflected by magnetic fields.

✓ D. Speed of microwaves equals speed of light but speed of ultrasonic waves equal the speed of sound. Thus they have different speeds in air.

31. D

× A. The two waves have different loudness, thus they should have different amplitudes, not the same.

× B. The two waves have different loudness, thus they should have different amplitudes, not the same.

× C. The two waves are produced by different musical instruments, they should have different quality, thus they should have different waveforms, not the same.

✓ D. These two notes have different amplitudes, representing different loudness.
These two notes have different waveforms, representing different quality from different instruments.

32. A

✓ A. Decibel (dB) is a unit of sound intensity level.

× B. Hertz (Hz) is a unit of frequency.

× C. Sievert (Sv) is a unit of radiation dose.

× D. Watt (W) is a unit of power.

33. B

✓ (1) Sound waves are longitudinal waves, with particles vibrate along the direction of travel.

× (2) Sound waves are mechanical waves, not electromagnetic waves.

✓ (3) Sound waves need a material medium for travelling, they cannot travel in vacuum.

34. A

✓ (1) Since the graph is a straight line passes through the origin, λ and $\frac{1}{f}$ are proportional,

i.e. the wavelength is inversely proportional to the frequency.

✓ (2) The slope of the graph $= \frac{\lambda}{1/f} = f\lambda = v$.

× (3) Since the slope is constant, the speed is independent of the frequency *f*.

35. D

× (1) Pitch depends on the frequency.
As note C has the lowest frequency, note C should have the lowest pitch.

✓ (2) Intensity level gives the loudness of sound.
As note D has the greatest intensity level, note D has the greatest loudness.

✓ (3) Different musical instruments give out sounds of different quality, and they will sound differently.

36. C

× (1) The sound waves transmitted along the string should be longitudinal waves.

✓ (2) Speed of sound waves in solid is faster than that in the air.

✓ (3) Frequency would not change when the sound travels along the string.

37. A

✓ (1) Since the spacing between wavefronts is the wavelength, as wavelength decreases, speed decreases. When speed changes, refraction occurs.

✓ (2) The swimming pool appears shallower is due to apparent depth, which is due to refraction of light.

× (3) Alternate loud and soft sounds are due to interference, not refraction.

38. A

✓ (1) Speed of infrared waves is the speed of light which is much greater than the speed of sound waves.

× (2) The flash lamps would emit infrared waves and then detect the infrared waves reflected by the object.
The objects emit infrared waves or not would not affect the reflected infrared waves.

× (3) Ultrasonic waves cannot be heard by human ears, and thus no annoyance would be caused.

Provided by dse.life

39. D

The definition of ultrasonic waves is sound waves with frequency higher than that of the audible sound waves,

or sound waves with frequency higher than 20 000 Hz.

Thus, ultrasound has frequency higher than that of audible sound.

40. B

At the point of maximum, path difference = 0.4 − 0.2 = 0.2 m = $n\lambda$

At the point of minimum, path difference = 0.9 − 0.4 = 0.5 m = $(m+\frac{1}{2})\lambda$

Suppose the wavelength is 0.2 m.

At the point of maximum, path difference = 0.2 m = (1) λ

At the point of minimum, path difference = 0.5 m = $(2\frac{1}{2})\lambda$

Since the wavelength 0.2 m satisfies the above conditions, this is the only possible wavelength among the four values.

41. A

✓ (1) The noise is reflected by the barrier and cannot transmit to the region behind the barriers.

✓ (2) The noise is absorbed at the lower part of the barriers to reduce the noise from spreading out.

× (3) If the noise is diffracted and spreads away, the noise cannot be blocked.

42. A

By $v = f\lambda$ $\therefore$ (1400) = (30000) λ $\therefore$ $\lambda = 4.67 \times 10^{-2}$ m

By $d = \frac{1}{2} v \Delta t = \frac{1}{2}(1400)(5) = 3500$ m

43. C

① X is a point under destructive interference since path difference at X is 0.5 λ. Loudness at X is minimum initially.
If S_1 is turned off, no destructive interference occurs, thus the loudness would increase.

② Y is a point under constructive interference since path difference at Y is 0 λ. Loudness at Y is maximum initially.
If S_1 is turned off, no constructive interference occurs, thus the loudness would decrease.

44. A

Wavelength of the sound wave :

By $v = f\lambda$ $\therefore$ (330) = (660) λ $\therefore$ $\lambda = 0.5$ m

Path difference at $X = 4 - 2 = 2$ m $= 4\lambda$ $\therefore$ Constructive interference occurs at X.

Path difference at $Y = 0$ m $= 0\lambda$ $\therefore$ Constructive interference occurs at Y.

45. D

Audible range of sound is from 20 Hz to 20000 Hz.

Sound waves above 20000 Hz are not audible.

46. C

The first bang is directly from the firecracker. $\therefore$ $t_1 = \frac{90}{340} = 0.265$ s

The second band is reflected from the building. $\therefore$ $t_2 = \frac{80+80+90}{340} = 0.735$ s

Time interval = 0.735 − 0.265 = 0.47 s

47. B

× (1) As the speed of sound wave in air is smaller, the wavelength of sound waves in air is shorter.

✓ (2) Frequency must be unchanged during refraction.

× (3) As the speed of sound waves in air is smaller, the refracted angle is smaller,
thus the sound waves should bend towards the normal.

48. A

✓ (1) Sound intensity decreases with distance.

× (2) As the path difference at Q is zero, Q has constructive interference.

× (3) This experiment only shows that the sound intensity decreases with distance.
To prove that sound is a wave, interference must be demonstrated.
Alternate loud and soft sound should be shown to demonstrate the phenomenon of interference.

49. A

✓ (1) S_1 takes a longer time to complete 1 cycle, thus the period of F_1 is greater.

× (2) As the period of F_1 is greater, the frequency of F_1 is smaller, thus the pitch of F_1 is lower.

× (3) Both are sound waves travelling in air, thus they should have the same speed.

50. B

When ultra-sound travels from water to air, it travels from a faster medium to a slower medium,

thus the refracted angle is smaller, the refracted beam bends towards the normal.

51. C

(i) In quiet school library, the sound level is very low, about 30 to 40 dB

(ii) Near a busy road with heavy traffic, the sound level is very high, about 90 to 100 dB

52. C

Path difference : $\Delta = 3.30 - 3.22 = 0.08$ m

✓ (1) If $\lambda = 0.04$ m, then $\Delta = 2\lambda$, thus constructive interference occurs.

✓ (2) If $\lambda = 0.08$ m, then $\Delta = 1\lambda$, thus constructive interference occurs.

× (3) If $\lambda = 0.16$ m, then $\Delta = 0.5\lambda$, thus destructive interference should occur.

Provided by dse.life

53. B

$S_1P = \sqrt{(8)^2+(1-0.4)^2} = 8.022$ m

$S_2P = \sqrt{(8)^2+(1+0.4)^2} = 8.122$ m

Path difference at $P = 8.122 - 8.022 = 0.1$ m

Since P is at the first maximum from O, path difference at P is 1 λ.

$\therefore \lambda = 0.1$ m $= 10$ cm

54. D

By $\frac{\sin\theta_{air}}{\sin\theta_{water}} = \frac{v_{air}}{v_{water}}$ $\therefore \frac{\sin 13^\circ}{\sin\theta_{water}} = \frac{340}{1500}$ $\therefore \theta_{water} = 83^\circ$

By $v_{water} = f\lambda_{water}$

$\therefore (1500) = (1000)\lambda_{water}$

$\therefore \lambda_{water} = 1.5$ m

55. A

$d_1 = \frac{1}{2}vt_1 = \frac{1}{2}(340)(15\times10^{-3}) = 2.55$ m

$d_2 = \frac{1}{2}vt_2 = \frac{1}{2}(340)(20\times10^{-3}) = 3.4$ m

$v = \frac{\Delta d}{\Delta t} = \frac{3.4-2.55}{0.5} = 1.7$ m s^{-1}

56. A

✓ (1) Moving along the x direction would change the path difference, thus vary the type of interference.

× (2) Moving along the y direction would keep the path difference remain as zero, thus no variation.

× (3) As the path difference is zero, destructive interference occurs, no matter what the frequency is.

57. B

When the boy walks a distance d, the echo is heard with an extra time of $(0.8 - 0.6) = 0.2$ s

$d = \frac{1}{2}\times330\times0.2 = 33$ m

58. C

Audible frequencies for a normal young adult are in the range of 20 Hz to 20 000 Hz.

59. D

Quality is determined by the waveform of the sound waves.

60. D

We distinguish different sources of sound by observing the different quality of the sound notes.

61. C

The first echo is due to the reflection of sound at cliff A.

Distance between Mary and cliff A : $d_1 = \frac{1}{2}(320)\times(1.2) = 192$ m

The second echo is due to the reflection of sound at cliff B.

Distance between Mary and cliff B : $d_2 = \frac{1}{2}(320)\times(1.8) = 288$ m

Therefore, distance between the two cliffs :

$d = d_1 + d_2 = 192 + 288 = 480$ m

62. B

Since the speed of light is very great, the time taken for the lightning to be seen is negligible.

Distance travelled by the sound $= vt = (320)(6) = 1920$ m

63. B

(1) frequency of domestic main voltage = 50 Hz

(2) typical order of wavelength of microwaves $= 10^{-2}$ m $\therefore$ typical order of frequency $= \frac{(3\times10^8)}{(10^{-2})} \approx 10^{10}$ Hz

(3) Frequency of a sound note from a violin $\approx$ 1000 Hz

Ascending order of frequency : (1) (3) (2)

64. D

✓ (1) Sound waves are longitudinal waves, with particles vibrate along the direction of travel.

× (2) Sound waves are mechanical waves, not electromagnetic waves.

✓ (3) Sound waves need a material medium for travelling, they cannot travel in vacuum.

65. D

✓ (1) Since they all have the same number of cycles in the same time interval, they have the same frequency.

✓ (2) Since the waveforms of (Y) and (Z) are different, they have different qualities.

✓ (3) Tuning fork would give the pure sinusoidal waveform as shown in (X).

66. C

In air, the speed of ultrasound is the same as the speed of audible sound.

$\therefore$ C is INCORRECT.

67. C

The sound produced at P travels a distance of PQ towards Q and Q hears the first sound.

The sound produced at P travels towards the cliff and reflected to Q and Q hears the second sound.

The extra distance travelled by the second sound is two times the distance between P and the cliff.

Speed of sound : $v = \frac{2\times400}{4} = 200$ m s^{-1}

Provided by dse.life

68. C

At O, the path difference is zero.

If the two waves emitted are in anti-phase, then destructive interference occurs at O.

At P, path difference $= 3 - 2.8 = 0.2$ m $= 20$ cm $= 2\lambda$

Since the two waves emitted are in anti-phase, thus destructive interference occurs at P.

69. B

The ultrasound is emitted at the time of 0.1 s and the reflected pulse is received at the time of 0.5 s.

The ultrasound pulse takes a time interval of 0.4 s to travel to the car and back to the detector.

Thus, the ultrasound pulse reaches the car after a time interval of 0.2 s.

At that instant, distance of the car from the generator $= vt = 340 \times 0.2 = 68$ m

Distance travelled by the car during this time interval of 0.2 s $= 68 - 64 = 4$ m

Speed of the car $= \frac{d}{t} = \frac{4}{0.2} = 20$ m s^{-1}

70. A

× (1) Sound waves are mechanical waves, not electromagnetic waves.

✓ (2) Sound waves need a material medium to travel, thus they cannot travel in vacuum.

× (3) All waves can form stationary waves, including sound waves.

71. C

By $d = vt$

$\therefore (H + H + 20 \times 5) = (340) \times (5)$ $\therefore H = 800$ m

72. A

× A. To give constructive interference, path difference $PS_2 - PS_1$ must be an integral multiples of λ.
However, PS_2 and PS_1 need not be integral multiples of λ, e.g. $\Delta = 2.5\lambda - 1.5\lambda = 1\lambda$.

✓ B. The path difference may be 1λ, 2λ, 3λ, …
The definite value cannot be determined.

✓ C. The path difference at P is at least equal to $1\ \lambda$.
Between O and P, there is a point that the path difference is $\frac{1}{2}\ \lambda$.
At this point, destructive interference occurs and minimum loudness is detected.

✓ D. If S_1 and S_2 are in antiphase, then the type of interference will be reversed,
thus, destructive interference will occur at P.

73. C

× (1) Ultrasound cannot sterilize drinking water, only ultraviolet radiation can sterilize drinking water.

✓ (2) Ultrasound can be used to detect cracks in railway or machines.

✓ (3) Ultrasound can be used to smash kidney stones, break them into smaller pieces.

74. D

✓ A. For sound travelling from X towards the right along a straight line,
P and Q should be along the same line.

✓ B. The speed of sound v is calculated by : $v = d / t$.
If the distance d is reduced, the percentage error of d will increase,
thus the percentage error of v will increase.

✓ C. If distance d increase, time t will also increase, the calculated value of v should be unchanged.

× D. The distance PQ can be any value, not necessary to be integral multiple of wavelength of sound.

75. D

Two musical notes having different waveforms can give different quality of sound,
and this can be distinguished as two different sounds by human ears.

76. C

Speed of sound in air is smaller than that in water, thus, speed of sound in air $< x$.

Speed of light in air is greater than that in water, thus, speed of light in air $> y$.

77. C

✓ A. When we are close to an airplane taking-off, the noise should exceed the threshold of pain.
Thus, 130 dB may be possible.

✓ B. At a rock concert, the noise may be very large and close to the threshold of pain.
Thus, 110 dB may be possible.

× C. Normal conversation between two persons should be around 60 dB.
Thus, 80 dB is **NOT** a typical level.

✓ D. Inside a library, it may be very quiet.
Thus, 30 dB may be possible.

78. D

× (1) Both longitudinal waves and transverse waves can transmit energy from one place to another.

✓ (2) Speed of sound waves in solid > speed of sound waves in liquid > speed of sound waves in air

✓ (3) Infra-red radiation is a kind of electromagnetic wave, with wavelength longer than visible light.

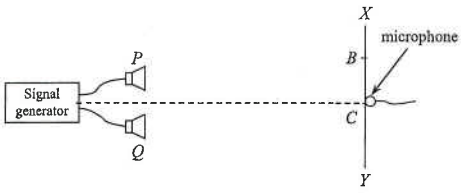
Provided by dse.life

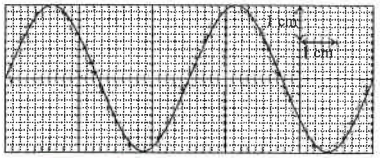
DSE Physics - Section C : Question PC - WA6 - Q / 01
WA6 : Sound

Part A : HKCE examination questions

1. **< HKCE 1988 Paper I - 5 >**

Two small loudspeakers P and Q emit sound wave of the same frequency and intensity. A microphone connected to a CRO is moved along the line YX as shown in the figure below. A trace on the screen is also shown in the figure.





(a) It is given that the time base setting is 0.1 ms cm^{-1}.

(i) What is the frequency of the sound ? (3 marks)

(ii) Is this frequency below, within or above audible range ? (1 mark)

(b) The amplitude of the trace shows a maximum when the microphone is at C (on the perpendicular bisector of PQ) and gradually decreases to a minimum at B.

(i) Explain briefly why this happens. (2 marks)

(ii) Write down an equation to show the relationship between the distance PB, QB and the wavelength λ. (2 marks)

(iii) If $PB = 3.04$ m and $QB = 3.12$ m, calculate the speed of sound in air. (3 marks)

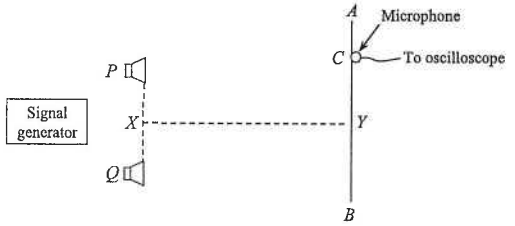
(iv) How would the distance CB be affected, when sound of a lower frequency is used ? (1 mark)

(c) If loudspeaker P is disconnected from the signal generator when the microphone is still at B, how would the period and amplitude of the trace be affected ? (2 marks)

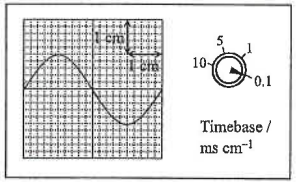
DSE Physics - Section C : Question PC - WA6 - Q / 02
WA6 : Sound

2. **< HKCE 1991 Paper I - 4 >**

The below figure shows the set-up to study the interference of sound. P, Q are two identical loudspeakers. $PC = 2.05$ m and $QC = 2.31$ m.



(a) Initially only P is connected to the signal generator and sound is emitted. A microphone connected to an oscilloscope is placed at point C. The below figure shows the trace on the oscilloscope. The speed of sound in air is 325 m s^{-1}. Find the frequency and wavelength of the sound. (5 marks)



(b) Now both P and Q are connected to the signal generator and they emit sound of the same frequency and intensity as in part (a). Interference is observed when the microphone is moved along AB.

(i) Is the interference of sound at C constructive or destructive ? Explain your answer. (3 marks)

(ii) Compared with (a), how do the pitch and loudness of the sound at C change ? (2 marks)

(iii) The amplitude of the trace on the oscilloscope is not zero at the positions of destructive interference. Suggest two possible reasons. (2 marks)

(iv) A student says that alternate constructive and destructive interference will also be observed along XY. (X is the mid-point of PQ.) State whether his statement is true or false. Explain briefly. (3 marks)

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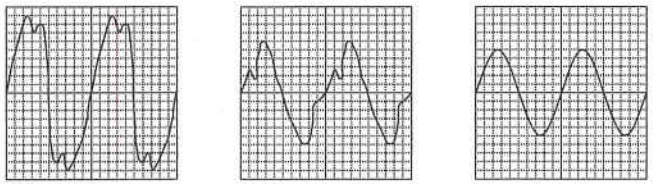
3. **< HKCE 1996 Paper I - 4 >**

The figures below show the traces on a CRO of three notes produced by different musical instrument.
(Note : The settings of the CRO remain unchanged.)



Note *X* Note *Y* Note *Z*

(a) Which of the notes is produced by a tuning fork ? (1 mark)

(b) Compare the pitch and loudness of the three notes. Explain briefly. (4 marks)

4. **< HKCE 2000 Paper I - 9 >**

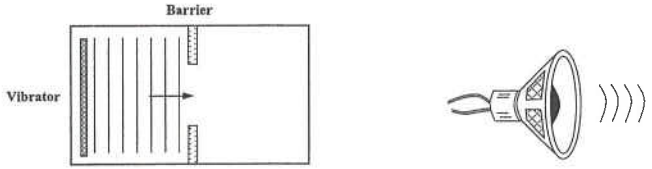


Figure 1

Figure 2

Figure 1 shows a vibrator producing straight water waves in a ripple tank. Figure 2 shows a loudspeaker which is emitting low-frequency sounds.

(a) You are given the following equipment :

a cork, a slinky spring, a candle and matches, a ruler.

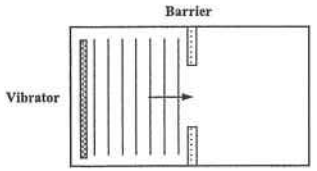
Select suitable equipment and describe

(i) a method to demonstrate that the water waves in Figure 1 are transverse, and (2 marks)

(ii) a method to demonstrate that the sound waves in Figure 2 are longitudinal. (2 marks)

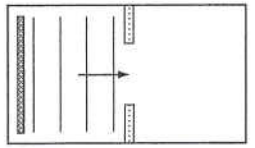
4. (b) A barrier with an opening is placed in the ripple tank as shown in Figure 1.

(i) In the figure below, draw the wave pattern formed on the other side of the barrier. Name this wave phenomenon. (3 marks)



(ii) The wavelength of the water waves is increased as shown in Figure 3.

Figure 3



(1) Suggest **two** methods which can be used to increase the wavelength of the water waves. (2 marks)

(2) On Figure 3, draw the wave pattern formed on the other side of the barrier. (2 marks)

(c)

Figure 4

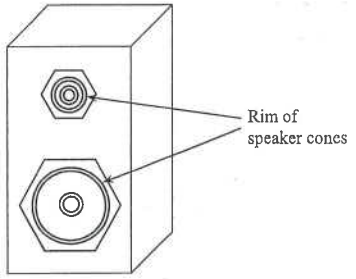


Figure 4 above shows a loudspeaker unit with two speaker cones, a big one and a small one. One speaker cone emits low-frequency sounds and the other emits high-frequency sounds. The sound waves generated by the speaker cones will bend around the rim of the cones in a way similar to water waves bending around corners of obstacles.

Which cone is more suitable for emitting high-frequency sounds ? Explain your answer. (3 marks)

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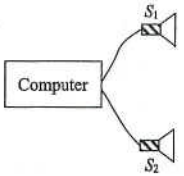
5. **< HKCE 2001 Paper I - 6 >**

Explain the following phenomena :

(a) In a thunderstorm, lightning is seen before thunder is heard. (1 mark)

(b) Sound waves can bend round a corner but light cannot. (2 marks)

6. **< HKCE 2002 Paper I - 5 >**



- P (Mary)
- Q (Susan)

Two identical loudspeakers S_1 and S_2 are connected to a computer. The set-up generates a sound of frequency 200 Hz. Mary and Susan stand at positions P and Q in front of the loudspeakers, where $PS_1 = 6.10$ m, $PS_2 = 8.65$ m and $QS_1 = QS_2$. The speed of sound in air is 340 m s^{-1}.

(a) Find the wavelength of the sound emitted by the loudspeakers. (2 marks)

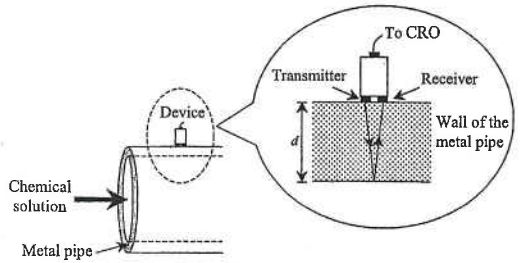
(b) (i) Find the path difference at P from S_1 and S_2. (1 mark)

(ii) Explain whether Mary will hear a loud or a soft sound. (2 marks)

(c) The set-up now generates sound of frequencies 200 Hz and 400 Hz alternately. Susan then predicts that constructive and destructive interference will occur alternately at Q. Explain whether Susan is correct or not. (2 marks)

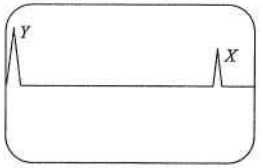
7. **< HKCE 2003 Paper I - 7 >**

Figure 1



In a factory, an engineer uses a device to monitor the thickness of the wall of a metal pipe used for conveying chemical solutions. The device consists of a transmitter and a receiver. During the test, the device is placed on the surface of the pipe. The transmitter emits an ultrasonic pulse of frequency 2×10^6 Hz. The pulse travels with a speed of 6×10^3 m s^{-1} inside the wall. The pulse is reflected from the other surface of the wall and is recorded by the receiver (see Figure 1). The device is connected to a CRO, which displays the transmitted and reflected pulses (see Figure 2).

Figure 2



(a) Find the wavelength of the pulse inside the wall. (2 marks)

(b) Which of the two pulses in Figure 2 is the reflected pulse ? Explain your answer. (2 marks)

(c) The engineer conducts the test every five weeks and measure the total time of travel of the pulse inside the wall. The results are shown in the below table.

Time t / weeks	0	5	10	15	20	25
Total time of travel / 10^{-6} s	14.5	14.0	13.3	12.8	12.2	11.5
Thickness of the wall d / mm						

(i) Show that the thickness of the wall at time $t = 0$ is 43.5 mm. (2 marks)

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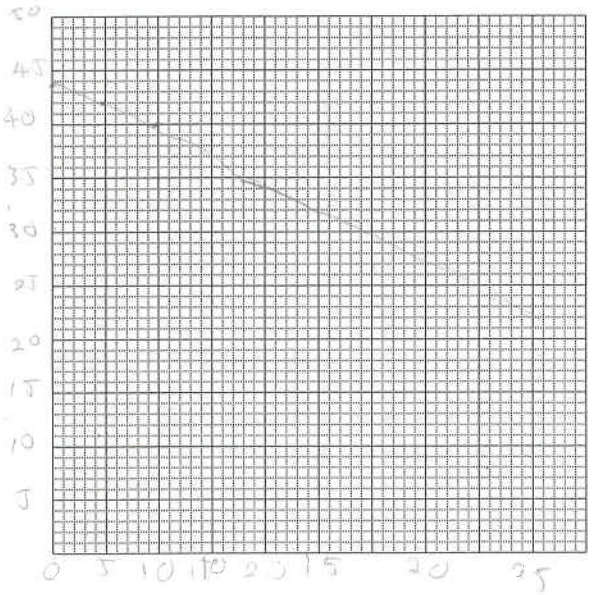
7. (c) (ii) Plot a graph of the thickness of the wall d against time t on the graph below, with d ranging from 0 to 50 mm and t ranging from 0 to 40 weeks. (5 marks)



(iii) The pipe has to be replaced when the thickness of the wall drops to 30 mm. Using the graph in (c) (ii), estimate the time at which the pipe has to be replaced. (2 marks)

(d)

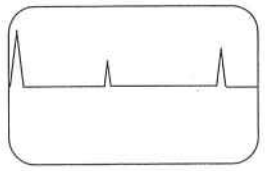
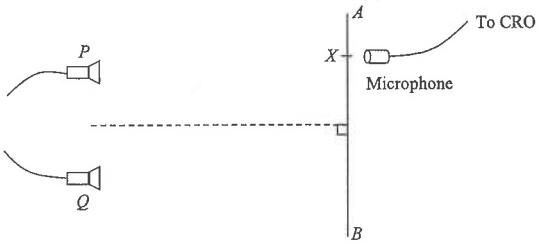


Figure 3

Figure 3 shows the CRO display of the test result on a certain day. The engineer points out that there may be a small crack in the wall of the pipe. Explain how the engineer arrives at such a conclusion. (2 marks)

8. **< HKCE 2003 Paper I - 5 >**



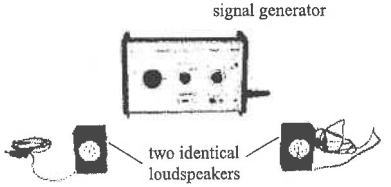
The Figure above shows two loudspeakers P and Q emitting sound waves which are of the same frequency and in phase. As a microphone is moved along the line AB, the amplitude of the trace displayed on the CRO is found to increase and decrease alternately.

(a) Name the wave phenomenon observed. (1 mark)

(b) The amplitude of the trace reaches a maximum when the microphone is placed at a point X, where $PX = 1.74$ m and $QX = 1.96$ m. A student says that one possible wavelength of the sound waves is 0.44 m. Explain whether the student is correct or not. (3 marks)

9. **< HKCE 2005 Paper I - 6 >**

You are provided with the apparatus shown in the Figure below.

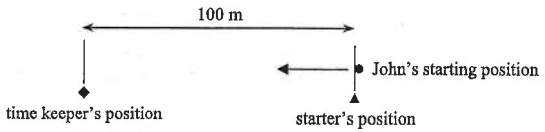


Describe how you should use the apparatus to conduct an experiment to demonstrate the interference of sound waves. You may use additional apparatus if necessary. (4 marks)

Provided by dse.life

10. **< HKCE 2007 Paper I - 6 >**

John wants to find out the time he takes to run 100 metres. A starter at the starting point uses a horn to emit a sound signal of frequency 425 Hz to notify John to start running. A time keeper presses a stop watch to record the time when he hears the sound signal as shown in the figure below. Given that the speed of sound in air is 340 m s^{-1}.



(a) Find the wavelength of the sound signal emitted by the horn. (2 marks)

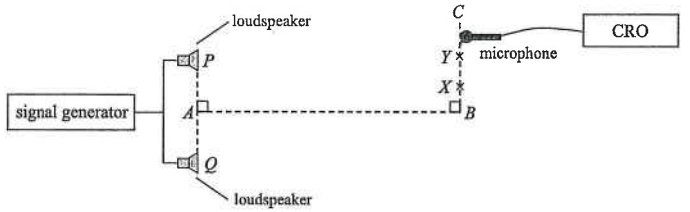
(b) (i) Find the time t taken by the sound signal to travel 100 metres. (1 mark)

(ii) As it takes time t for the sound signal to travel from the starter to the time keeper, David suggests the following ways to reduce the time delay t :

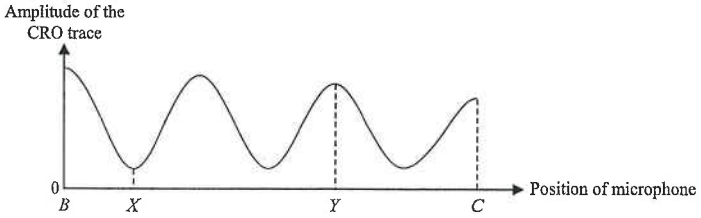
1. using a horn emitting sound of higher frequency;
2. lowering a flag instead of using a horn to notify the time keeper.

Explain whether each of the above suggestions will work. (4 marks)

11. **< HKCE 2007 Paper I - 10 >**



In the above Figure, two identical loudspeakers P and Q are connected to a signal generator. Position A is the midpoint of PQ. A microphone connected to a CRO is moved along BC to measure the loudness of the sound. The amplitude of the CRO trace increases as the loudness of the sound detected increases. The Figure below shows the result.



(a) (i) Explain why the loudness of the sound varies at different positions along BC. (2 marks)

(ii) State ONE reason why the amplitude of the CRO trace is NOT zero at position X. (1 mark)

(b) If $PY = 5.10$ m and $QY = 5.78$ m, find

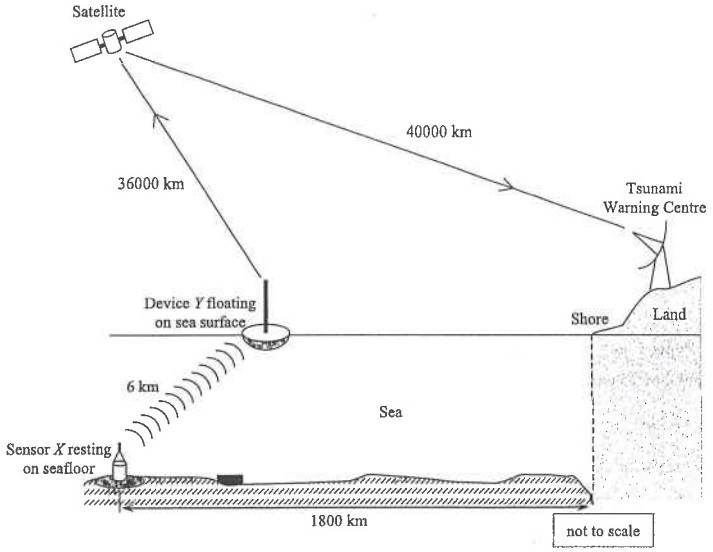
(i) the path difference at position Y from P and Q ; (1 mark)

(ii) the wavelength of the sound. (2 marks)

Provided by dse.life

12. **< HKCE 2009 Paper I - 11 >**

A tsunami is a kind of large-scale water wave that is commonly generated by earthquakes. The Figure below shows a simplified tsunami detection system. Sensor *X* on the seafloor can detect earthquakes and tsunamis. When a tsunami is detected, an ultrasound signal will be sent from Sensor *X* to Device *Y* on the sea surface. Device *Y* will immediately transmit a microwave signal to a satellite and the satellite will send the microwave signal to the Tsunami Warning Centre on land.



(a) What is ultrasound ? (1 mark)

(b) Given :

Distance from the Sensor *X* to the shore = 1 800 km

Distance from Sensor *X* to Device *Y* = 6 km

Distance from Device *Y* to the satellite = 36 000 km

Distance from the satellite to the Tsunami Warning Centre = 40 000 km

Speed of ultrasound in water = 1 500 m s^{-1}

Speed of microwave = 3×10^8 m s^{-1}

Average speed of tsunami on the sea surface = 250 m s^{-1}

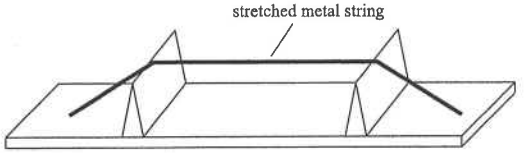
Can the Tsunami Warning Centre receive the signal one hour before the arrival of tsunami to the shore ? Show your calculations. (Assume that when a tsunami arrives at the water surface vertically above Sensor *X*, *X* sends a signal to Device *Y*.) (3 marks)

12. (c) Explain why ultrasound is not used to transmit signals from the satellite to the Tsunami Warning Centre. (1 mark)

(d) After receiving the signal from the satellite, the Tsunami Warning Centre will send a warning signal to the alarm stations in neighbouring cities. John suggests using ultrasound to transmit the warning signal, while Peter suggests using radio wave to transmit the warning signal. Explain which suggestion is more appropriate. (2 marks)

13. **< HKCE 2010 Paper I - 6 >**

The Figure below shows a metal string stretched over two wedges. Kathy plucks the string and a sound is heard.



(a) Describe how the sound is produced by the string. (3 marks)

(b) State one difference and one similarity in the **nature** of the wave on the string and the sound wave produced. (2 marks)

Difference :

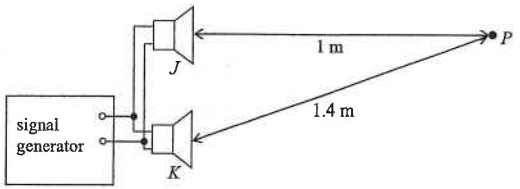
Similarity :

Provided by dse.life

14. **< HKCE 2011 Paper I - 8 >**

Two identical loudspeakers J and K are connected in parallel to a signal generator as shown in Figure (a). They are emitting sound waves of frequency 850 Hz. Point P is 1 m and 1.4 m away from J and K respectively.
Given : speed of sound = 340 m s^{-1}

Figure (a)

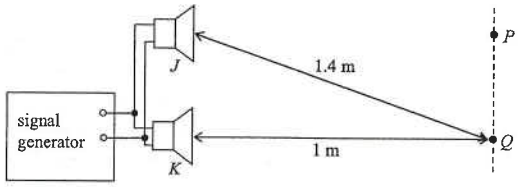


(a) Determine the wavelength of the sound produced. (2 marks)

(b) Determine the type of interference occurring at P. (3 marks)

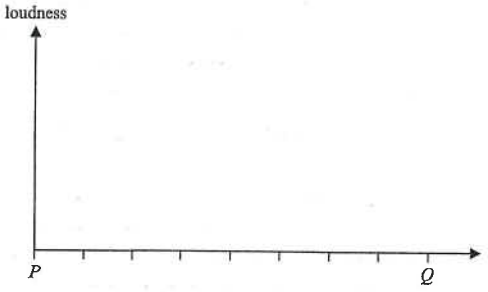
(c) Another point Q is 1.4 m and 1 m away from J and K respectively as shown in Figure (b). Mary walks along the straight line PQ.

Figure (b)



Sketch a graph in Figure (c) to show the variation of the loudness of the sound that Mary hears between P and Q. (2 marks)

Figure (c)

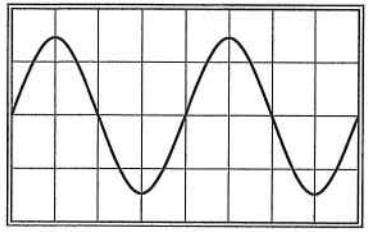


14. (d) Now loudspeaker K is disconnected and a microphone connected to a CRO is placed at P as shown in Figure (d). Loudspeaker J is emitting sound waves of frequency 850 Hz.

Figure (d)

The waveform of the sound received by the microphone is displayed on the CRO as shown in Figure (e).

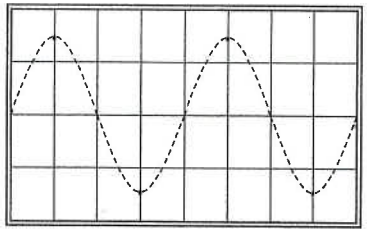
Figure (e)



The settings of the CRO remain unchanged.

(i) If the microphone is moved closer to loudspeaker J, describe the change of the waveform displayed on the CRO. (1 mark)

(ii) Now the microphone is returned to P and the sound emitted by loudspeaker J is changed to 425 Hz, sketch the waveform displayed on the CRO in the Figure below. (1 mark)



Provided by dse.life

Part B : HKAL examination questions

15. **< HKAL 1984 Paper IIB - 3 >**

In the figure below, a signal generator G is connected to two loudspeakers L_1 and L_2 placed 3 m apart. The signal generator gives out a frequency of 680 Hz to the two loudspeakers that give out the sound waves in phase. The speed of the sound waves is 340 m s^{-1}.

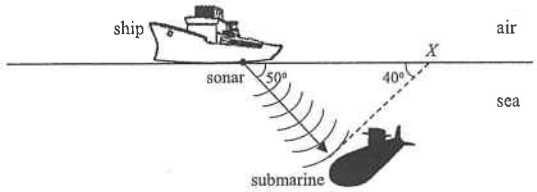
(a) A microphone is used to detect the sound intensity given out by the two loudspeakers.

(i) Describe the variation in the signal detected by the microphone when it moves along the line AB, which is the perpendicular bisector of L_1 L_2. (1 mark)

(ii) Describe the variation in the signal detected by the microphone when it moves slowly along line XY, which is parallel to L_1 L_2. (1 mark)

(b) Point Z in the above figure represents a point at which a minimum intensity sound is heard. When the loudspeaker L_2 is disconnected, explain the change of the intensity of the sound heard at Z. (2 marks)

16. **< HKAL 2004 Paper I - 3 >**



A ship equipped with a sonar system is used to detect objects in the sea. Ultrasound of frequency 25 kHz are sent towards the seabed. The ultrasound, which then propagate at an angle of 50° to the sea surface, are reflected from a submarine back to the ship after 0.15 s. (Given: speed of sound in air = 340 m s^{-1} ; speed of sound in sea water = 1500 m s^{-1})

(a) Find the wavelength of the ultrasound in sea water. (2 marks)

(b) Calculate the vertical distance of the submarine beneath the sea surface. (2 marks)

(c) Some of the ultrasound reflected by the submarine propagate along the dotted line and emerge into the air at X. Calculate the angle of refraction in air. (3 marks)

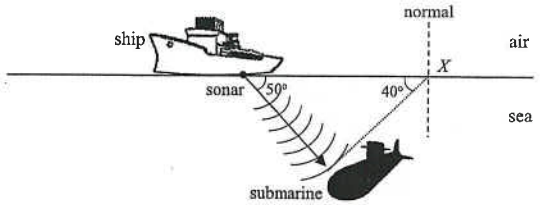
(d) Is it possible for the ultrasound, at certain angles of incidence, to undergo total internal reflection when it travels from sea water to the air ? Explain. (2 marks)

(e) Explain why radar using microwaves are not suitable for detecting objects in sea water. (1 mark)

Provided by dse.life

Part C : HKDSE examination questions

17. < HKDSE Sample Paper IB - 10 >



The figure above shows a ship equipped with sonar. The sonar emits ultrasonic waves of frequency 25 kHz into the sea. The waves propagate at an angle of 50° to the surface of the sea and are reflected from a submarine back to the ship after 0.15 s.

Given : speed of sound in air = 340 m s^{-1}

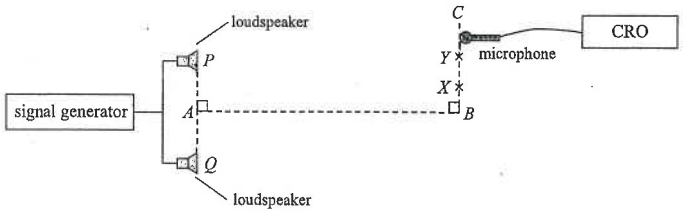
speed of sound in sea water = 1500 m s^{-1}

(a) Calculate the vertical distance of the submarine beneath the sea surface. (2 marks)

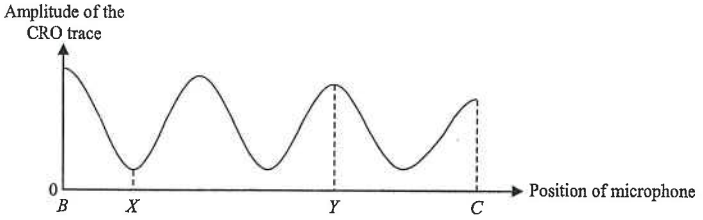
(b) Some of the reflected waves propagate along the dotted line and emerge into the air at *X*. Calculate the angle of refraction in air. (2 marks)

(c) Is it possible for ultrasonic waves, at certain angles of incidence, to undergo total internal reflection when they go from sea water to the air ? Explain. (2 marks)

18. < HKDSE Sample Paper IB - 6 >



The above Figure shows two identical loudspeakers *P* and *Q* connected to a signal generator. Position *A* is the mid-point of *PQ*. A microphone connected to a CRO is moved along *BC*. The amplitude of the CRO trace increases as the loudness of the sound detected increases. The Figure below shows how the amplitude of the CRO trace varies with the position of the microphone.



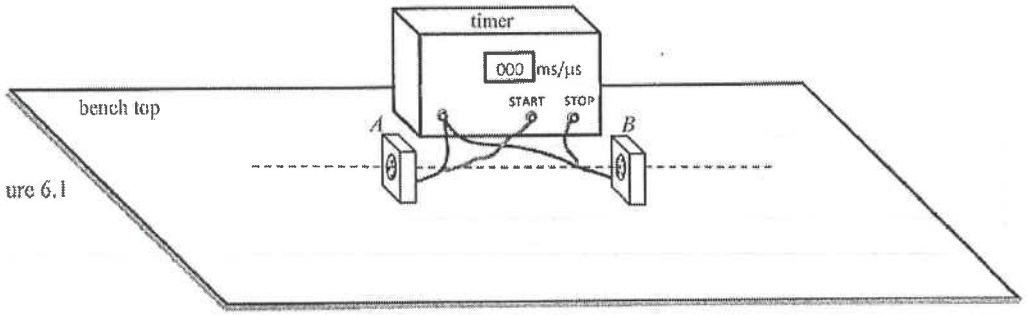
(a) (i) Explain why the loudness of the sound varies along *BC*. (2 marks)

(ii) State **ONE** reason why the amplitude of the CRO trace is **NOT** zero at position *X*. (1 mark)

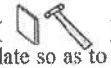
(b) If *PY* = 5.10 m and *QY* = 5.78 m, find the wavelength of the sound. (2 marks)

Provided by dse.life

The set-up in Figure 6.1 is to find the speed of sound in air. Two identical microphones *A* and *B* are connected to a timer and placed on a bench top as shown. The timer can be triggered to 'start' and 'stop' timing using the respective microphones to feed signals to the START and STOP terminals of the timer.



ure 6.1

(a) You are given a hammer and a metal plate (). Use 'X' to indicate a suitable location on Figure 6.1 where the hammer should hit the plate so as to generate a sharp loud sound to be received by the microphones in this experiment. State an additional piece of apparatus needed and the measurements to be made in this experiment. (3 marks)

(b) The separation between *A* and *B* is set at 0.280 m. The experiment is repeated to obtain a few readings of the timer as follows:

801 μs, 838 μs, 539 μs, 821 μs

(i) Find the speed of sound in air. Show how you would treat the data obtained in the calculation.

(ii) Suggest one adjustment to the experimental setting so as to obtain a more accurate result.

(3 marks)

Provided by dse.life

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) Period $T = 0.1 \times 5$ [1]
$= 0.5$ ms [1]
Frequency : $f = \frac{1}{T} = \frac{1}{0.5 \times 10^{-3}} = 2000$ Hz [1]

(ii) Within the audible range [1]

(b) (i) Constructive interference at C [1]
Destructive interference at B [1]

(ii) $QB - PB = \frac{1}{2}\lambda$ [2]

(iii) $\lambda = 2 \times (3.12 - 3.04) = 0.16$ m [1]
$v = f\lambda$ [1]
$= 2000 \times 0.16 = 320$ m s^{-1} [1]

(iv) larger [1]

(c) Period unchanged [1]
Amplitude increases [1]

2. (a) Period $= 4 \times 0.1 = 0.4$ ms [1]
Frequency $= \frac{1}{0.4 \times 10^{-3}} = 2500$ Hz [2]
Wavelength $\lambda = \frac{v}{f} = \frac{325}{2500} = 0.13$ m [2]

(b) (i) Path difference $= 2.31 - 2.05 = 0.26$ m $= 2\lambda$ [2]
$\therefore$ Constructive interference [1]

(ii) Pitch remains unchanged [1]
Loudness increases [1]

(iii) Any **TWO** of the following : [2]
- Noise from surrounding (OR background noise)
- Reflection of the loudspeaker's sound at the walls
- The intensities of the sound from P and Q reaching the microphone may not be equal.
- The microphone has finite size

2. (b) (iv) False [1]
The path difference along XY is always equal to zero.
The interference is always constructive along XY. [2]

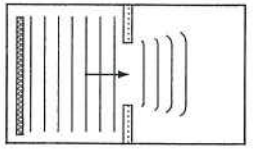
3. (a) Note Z [1]

(b) All of the notes X, Y and Z have the same pitch since they all have the same frequency. [2]
However, note X has the greatest loudness since note X has the greatest amplitude [1]
and note Z has the smallest loudness since note Z has the smallest amplitude. [1]

4. (a) (i) Place the cork in the ripple tank. [1]
The cork moves up and down. [1]

(ii) Place the candle which has been lighted up in front of the loudspeaker. [1]
The flame moves forward and backward. (**OR** The flame moves to and fro.) [1]

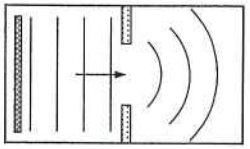
(b) (i)



< Correct shape > [1]
< Wavelength remains unchanged > [1]
The phenomenon is diffraction. [1]

(ii) (1) ① Increase the depth of the water in the ripple tank. [1]
② Decrease the frequency of the vibrator. [1]

(2)



< Correct shape > [1]
< Diffraction is larger than (b) (i) > [1]

(c) The smaller speaker cone is more suitable for emitting high-frequency sounds. [1]
Since the wavelength of high-frequency sounds is shorter, diffraction is less. [1]
Thus a smaller cone is used to increase its degree of diffraction. [1]

5. (a) The speed of light in air is much higher than that of sound. [1]

(b) The wavelength of light is much smaller than that of sound. [1]
Thus the degree of diffraction of light is much smaller. [1]

Provided by dse.life

6. (a) $v = f\lambda$ [1]

$(340) = (200)\,\lambda \quad \therefore\ \lambda = 1.7$ m [1]

(b) (i) Path difference at $P = 8.65 - 6.10 = 2.55$ m [1]

(ii) Path difference at $P = \dfrac{2.55}{1.7}\lambda = 1.5\,\lambda$ [1]

Destructive interference occurs; so Mary will hear a soft sound. [1]

(c) Susan is incorrect. The path difference at Q from S_1 and S_2 is zero, [1]

constructive interference will always occur at Q. [1]

7. (a) By $v = f\lambda$

$\therefore\ (6 \times 10^3) = (2 \times 10^6)\,\lambda$ [1]

$\therefore\ \lambda = 3 \times 10^{-3}$ m [1]

(b) X is the reflected pulse [1]

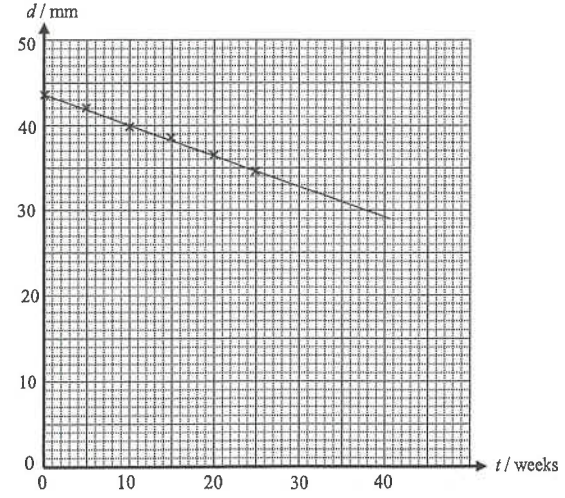
since the amplitude of the reflected pulse should be smaller. [1]

(c) (i) $d = \dfrac{v \cdot t}{2} = \dfrac{(6\times10^3)\cdot(14.5\times10^{-6})}{2}$ [1]

$= 0.0435$ m $= 43.5$ mm [1]

(ii)

Time t / weeks	0	5	10	15	20	25
Total time of travel / 10^{-6} s	14.5	14.0	13.3	12.8	12.2	11.5
Thickness of the wall d / mm	43.5	42.0	39.9	38.4	36.6	34.5



7. (c) (ii) < Two axes labelled > [1]

< Range of scale correct > [1]

< Points correctly plotted > [2]

< Straight line drawn > [1]

(iii) From the graph, d drops to 30 mm at $t = 37.5$ weeks [1]

Time at which the pipe has to be replaced = 37.5 weeks [1]

(d) Between the transmitted pulse and the pulse reflected from the wall, [1]

there is another pulse of smaller amplitude [1]

which should be reflected from the crack. [1]

8. (a) interference [1]

(b) Path difference at $X = 1.96 - 1.74$

$= 0.22$ m [1]

If the wavelength is 0.44 m, then the path difference is $\frac{1}{2}\lambda$ [1]

and thus the amplitude at X should be minimum but not maximum, so the student is not correct. [1]

9. Connect the two loudspeakers to the signal generator. [1]

Adjust the frequency of the signal generator to give a sound note that can be heard. [1]

Walking in front of the two loudspeakers, [1]

alternate loud and soft sound can be heard. [1]

< OR >

Connect the two loudspeakers to the signal generator. [1]

Adjust the frequency of the signal generator to give a suitable sound note. [1]

Connect a microphone to a CRO and move the microphone in front of the two loudspeakers, [1]

alternate maxima and minima can be observed on the CRO. [1]

10. (a) $v = f\lambda$ [1]

$(340) = (425)\,\lambda$

$\therefore\ \lambda = 0.8$ m [1]

(b) (i) $t = \dfrac{d}{v} = \dfrac{100}{340} = 0.294$ s [1]

(ii) 1. It does not work [1]

since the speed of sound is not affected by the frequency. [1]

2. It works [1]

since the speed of light is very high, time delay becomes negligible. [1]

Provided by dse.life

11. (a) (i) Along *BC*, interference occurs. [1]

Constructive interference gives loud sound and destructive interference gives soft sound. [1]

(ii) Any **ONE** of the following : [1]

* There is background noise.
* Sound is reflected by the surrounding walls.
* *P* and *Q* do not have the same amplitude.
* The microphone is not a point receiver.

(b) (i) Path difference = 5.78 – 5.10 = 0.68 m [1]

(ii) $\Delta = 0.68 = 2\lambda$ [1]

$\lambda = 0.34$ m [1]

12. (a) Ultrasound is sound wave of frequency higher than 20 000 Hz. [1]

(b) Time for tsunami to reach the shore $= \frac{1800 \times 10^3}{250} = 7200$ s [1]

Time required for the travel of the signals $= \frac{6000}{1500} + \frac{76000 \times 10^3}{3 \times 10^8} = 4.25$ s [1]

Time left for announcing warning signal = 7200 – 4.25 = 7195.75 s > 1 h [1]

The system can meet the requirement.

(c) Ultrasound cannot travel in outer space. [1]

(d) The speed of radio wave is higher. [1]

Therefore, Peter's suggestion is more appropriate. [1]

13. (a) When the string vibrates up and down, [1]

the air nearby will be forced to move [1]

and the sound wave travels outwards. [1]

(b) Difference : (any **ONE**) [1]

* Wave on the string is transverse but sound wave is longitudinal.
* Wave on the string is stationary but sound wave is travelling.

Similarity : (any **ONE**) [1]

* Both waves are mechanical waves.
* Both waves need material medium for propagation.

14. (a) $v = f\lambda$ [1]

$\therefore$ (340) = (850) λ

$\therefore$ $\lambda = 0.4$ m [1]

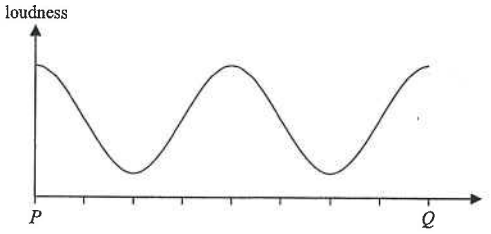
14. (b) Path difference at *P* = 1.4 – 1.0 [1]

= 0.4 m

= 1 λ [1]

Hence, constructive interference occurs at *P*. [1]

(c)

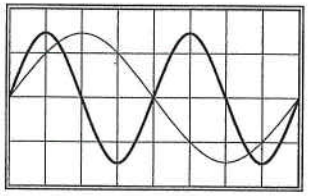


< maximum at *P* and *Q* > [1]

< all correct > [1]

(d) (i) The amplitude of the waveform will increase. [1]

(ii)



< same amplitude but with double period > [1]

15. (a) (i) Sound of maximum intensity is heard, and the intensity decreases along *AB*. [1]

(ii) Alternative maximum and minimum intensity is detected along *XY* [1]

(b) There is a minimum intensity sound at *Z* because destructive interference occurs there and the two waves arriving at *Z* exactly cancel. [1]

When L_2 is disconnected, no such cancellation occurs, as only one wave arrives.
Thus the intensity increases. [1]

16. (a) By $v = f\lambda$

$\therefore$ $(1500) = (25 \times 10^3)\lambda$ [1]

$\therefore$ $\lambda = 0.06$ m [1]

(b) Distance between the ship and the submarine $= \frac{1}{2} \times (1500) \times (0.15) = 112.5$ m [1]

Vertical distance = 112.5 × sin 50° = 86.2 m [1]

Provided by dse.life

DSE Physics - Section C : Question Solution PC - WA6 - QS / 07
WA6 : Sound

16. (c) The angle of incidence at $X = 50°$ [1]

$\therefore \frac{\sin 50°}{\sin r} = \frac{1500}{340}$ [1]

$\therefore r = 10°$ [1]

(d) No, the ultrasound refracts towards the normal [1]
since ultrasound travels faster in water than in air. [1]

(e) Microwaves would be absorbed by water effectively. [1]

17. (a) Vertical distance $= \frac{1}{2} \times (1500) \times (0.15) \times \sin 50°$ [1]

$= 86.2$ m [1]

(b) $\frac{\sin 50°}{\sin r} = \frac{1500}{340}$ [1]

$\therefore r = 10°$ [1]

(c) No, ultrasonic waves travel faster in sea water than in air, [1]
so they are refracted towards the normal and no total internal reflection is possible when they go from water to air. [1]

18. (a) (i) Along *BC*, interference occurs. [1]

Constructive interference gives loud sound and destructive interference gives soft sound. [1]

(ii) Any **ONE** of the following : [1]

- ✶ There is background noise.
- ✶ Sound is reflected by the surrounding walls.
- ✶ *P* and *Q* do not have the same amplitude.
- ✶ The microphone is not a point receiver.

(b) Path difference $= 2\lambda$

$\therefore 5.78 - 5.10 = 2\lambda$ [1]

$\therefore \lambda = 0.34$ m [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

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