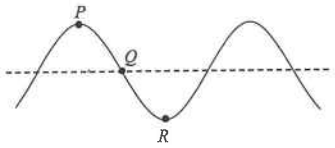
Part A : HKCE examination questions

1. < HKCE 1983 Paper II - 26 >

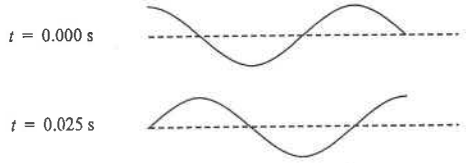


A transverse wave is travelling steadily from left to right through a series of particles. At a certain instant the wave form is as shown in the figure. Which of the following statements about the particles is/are correct ?

(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

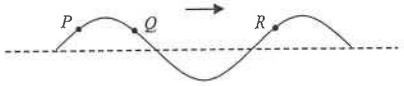
2. < HKCE 1987 Paper II - 11 >



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 >

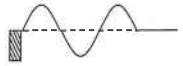


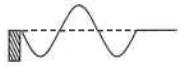
The above diagram shows a progressive transverse wave at a certain instant when travelling from left to right. Which of the following correctly shows the direction of motion of the particles at P, Q and R ?

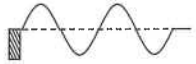
	P	*Q*	*R*
A.	→	→	→
B.	↓	↓	↓
C.	↓	↑	↓
D.	↑	↓	↑

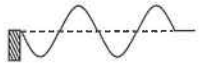
4. < HKCE 1991 Paper II - 23 >

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 ?

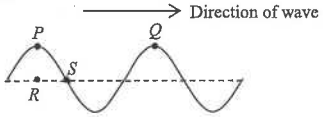
A.


B.


C.


D.


5. < HKCE 1991 Paper II - 21 >

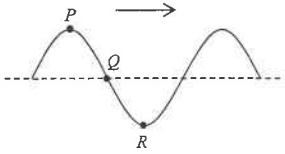


The above diagram shows a water wave travelling to the right. Which of the following statements is/are true ?

(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 >

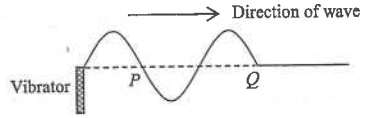


A water wave travels towards the right. The above diagram shows the waveform at a certain instant. Which of the following statements is/are true ?

(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

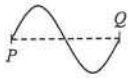
7. **< HKCE 1993 Paper II - 22 >**



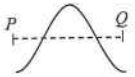
A vibrator generates a travelling wave on a string. The above diagram shows the shape of the string at a certain instant. Which of the following shows the shape of the string between PQ after a quarter of a period ?

A.

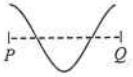
B.



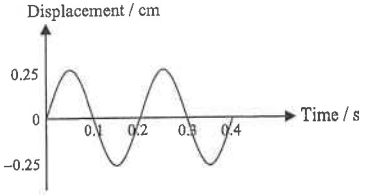
C.



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 >**

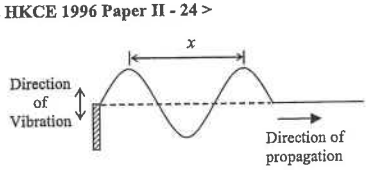


Figure (a)

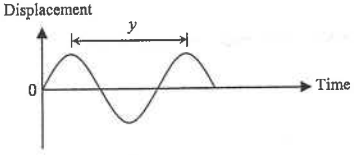


Figure (b)

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. $\frac{y}{x}$

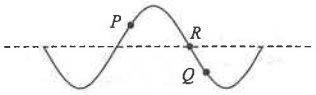
10. **< HKCE 1999 Paper II - 20 >**

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.

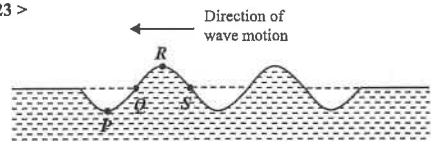
12. **< HKCE 2000 Paper II - 24 >**

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

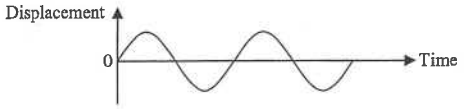
(1) the time taken for the wave to make one complete vibration
(2) the distance travelled by the wave in one second
(3) the number of waves produced in one second

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 ?

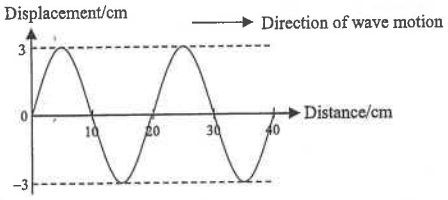
A. P
B. Q
C. R
D. S

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.

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 ?

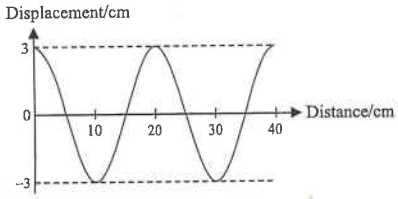
(1) Its wavelength is 20 cm.
(2) Its frequency is 6 Hz.
(3) Its amplitude is 6 cm.

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

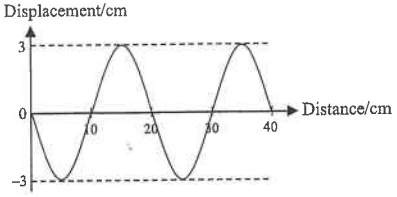
16. **< HKCE 2003 Paper II - 26 >**

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

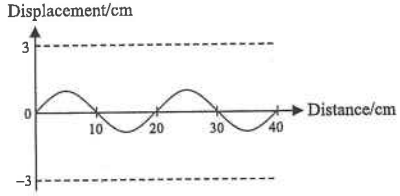
A.



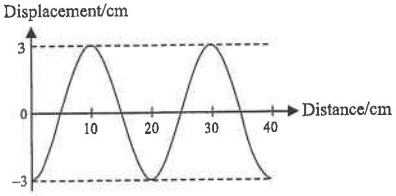
B.



C.

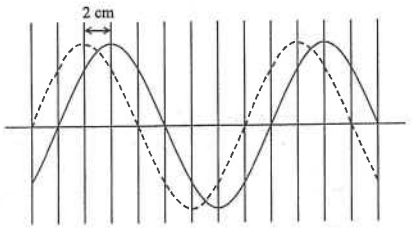


D.



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

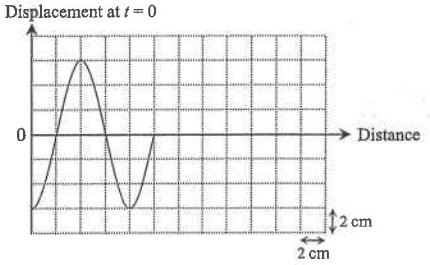
The solid curve in the diagram shows a transverse wave at a certain instant. After 0.05 s, the wave has travelled a distance of 2 cm and is indicated by the dashed curve. Find the wavelength and frequency of the wave.

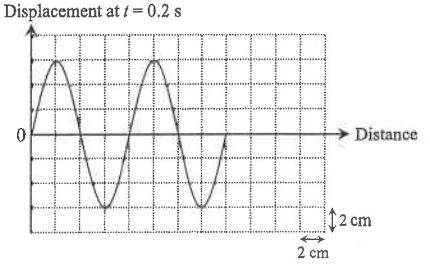


	Wavelength / cm	Frequency / Hz
A.	8	2.5
B.	8	5
C.	16	2.5
D.	16	5

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}

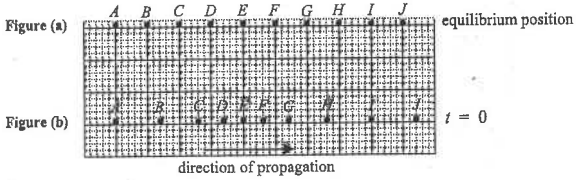
20. **< HKCE 2006 Paper II - 16 >**

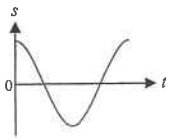
In December 2004, an earthquake in the Indian Ocean caused a tsunami which produced water waves having wavelength about 100 m and frequency about 2 Hz. What was the approximate time taken for these water waves to travel from the earthquake centre to Sri Lanka across a distance of about 1500 km ?

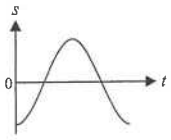
A. 1 hour
B. 2 hours
C. 3 hours
D. 4 hours

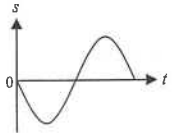
21. **< HKCE 2007 Paper II - 38 >**

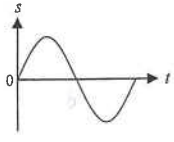
A longitudinal wave is travelling from left to right in a medium. Figure (a) shows the equilibrium positions of particles A to J in the medium. At time $t = 0$, the positions of the particles are shown in Figure (b). Which of the following correctly shows the displacement-time graph of particle I ? (Note: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



A. 

B. 

C. 

D. 

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

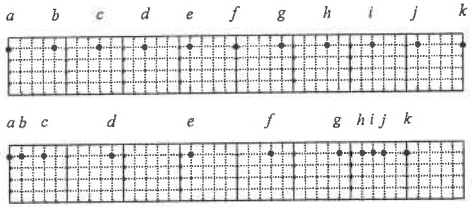
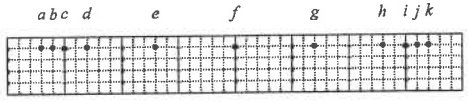
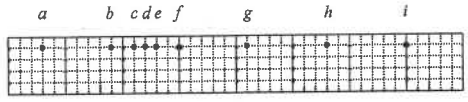


Figure (a) shows a series of particles which is uniformly distributed along a slinky spring. Figure (b) shows their positions at a certain instant when a travelling wave passes through the slinky spring from left to right. Which of the following diagrams shows the correct positions of the particles after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

A. 

B. 

C. 

D. 

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

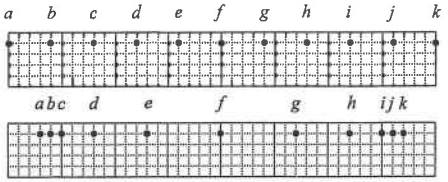
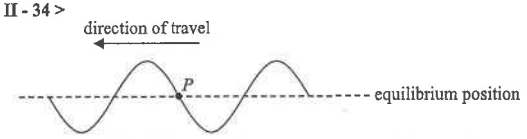


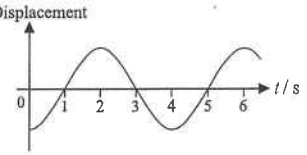
Figure (a) shows a series of particles ($a - k$) at their equilibrium positions. Figure (b) shows the positions of the particles at a certain instant when a longitudinal wave travels to the right passes through the particles. Which are the directions of the motion of the particles c and f at the instant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

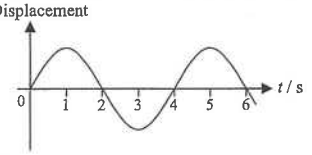
	particle c	particle f
A.	to left	to left
B.	to left	to right
C.	to right	to left
D.	to right	to right

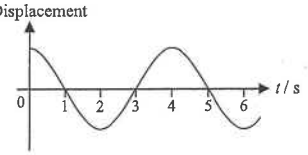
24. **< HKCE 2010 Paper II - 34 >**

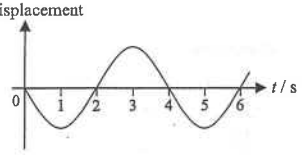


A wave travels along a string to the left. The figure above shows its waveform at time $t = 1$ s. Which of the following displacement-time graphs best represents the motion of particle P ? (Take displacement upwards to be positive.)

A. 

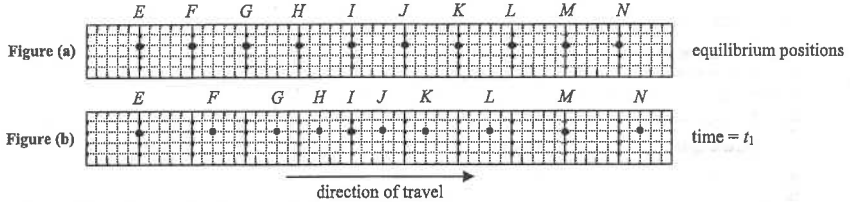
B. 

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).

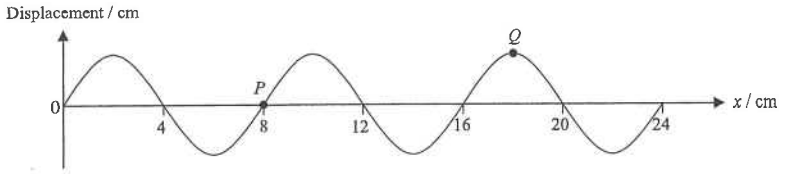


Which of the following particles is momentarily at rest at t_1 ?

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

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.

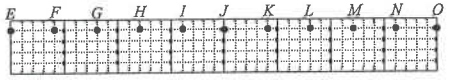


Figure (a)

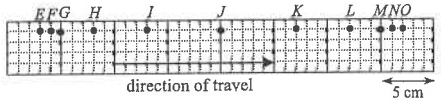


Figure (b)

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 >**

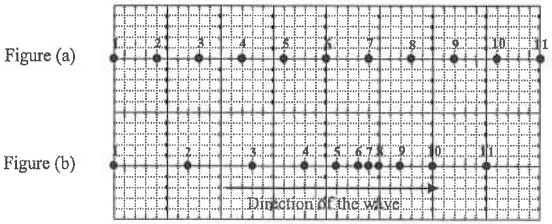
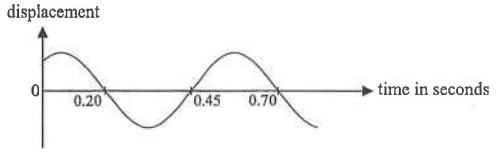


Figure (a) shows the equilibrium positions of equally spaced particles in a medium. A longitudinal wave travels from left to right through the medium. At a certain instant, the positions of the particles are shown in Figure (b). What will be the directions of motion of particle 1 and particle 7 at this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

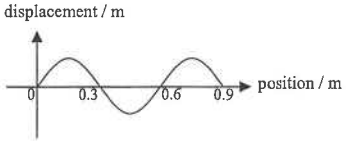


Figure (a)

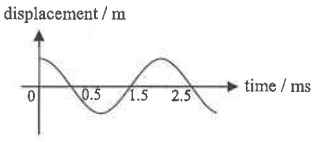
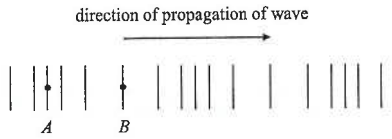


Figure (b)

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}

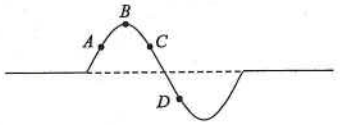
32. **< HKAL 1995 Paper IIA - 12 >**



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 ?

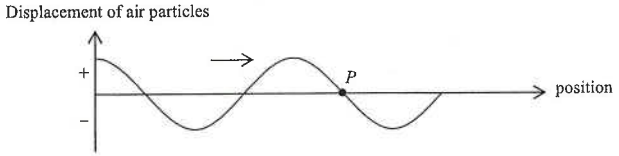
(1) The wave is propagating to the left.

(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 ?

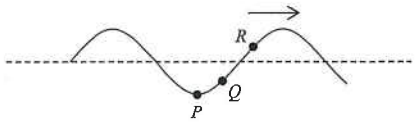
(1) P is a centre of compression.

(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)

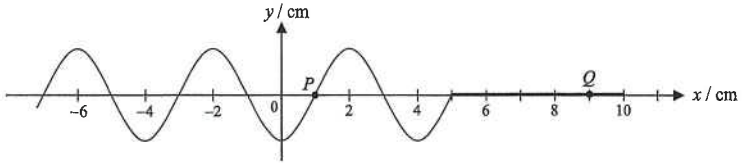
35. **< HKAL 2003 Paper IIA - 14 >**



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.

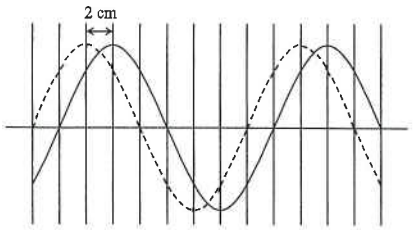
(3) When Q reaches its crest position, P also reaches its crest position.

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

Part C : HKDSE examination questions

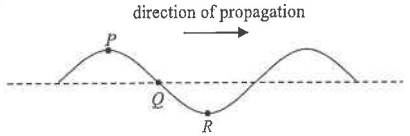
37. **< HKDSE Sample Paper IA - 17 >**

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

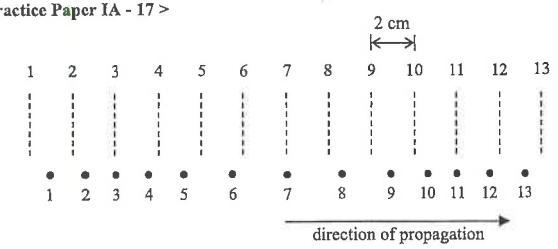
38. **< HKDSE Sample Paper IA - 18 >**



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 >**

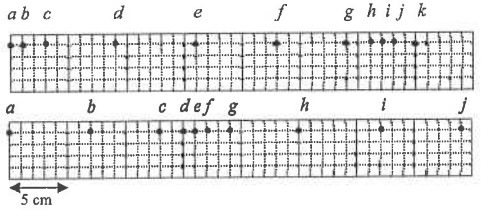


A longitudinal wave travels to the right through a medium containing a series of particles. The figure above shows the positions of the particles at a certain instant. The dotted lines indicate the equilibrium positions of the particles. Which of the following statements about the wave at the instant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

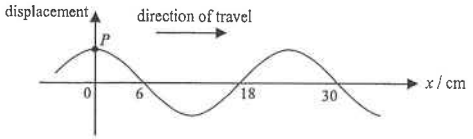
40. **< HKDSE 2012 Paper IA - 15 >**



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 >**

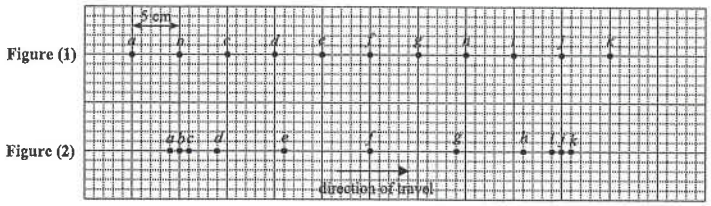
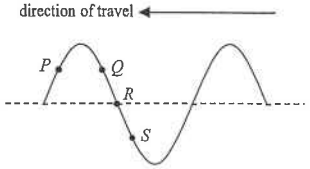


Figure (1) shows the equilibrium positions of particles *a* to *k* separated by 5 cm from each other in a medium. A longitudinal wave is travelling from left to right with a speed of 80 cm s^{-1}. At a certain instant, the positions of the particles are shown in Figure (2). Determine the amplitude and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

44. < HKDSE 2015 Paper IA - 12 >

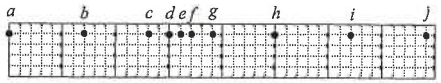


Figure (a)

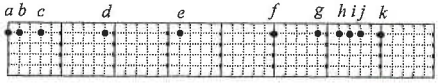


Figure (b)

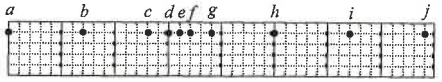


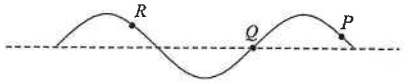
Figure (c)

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 >

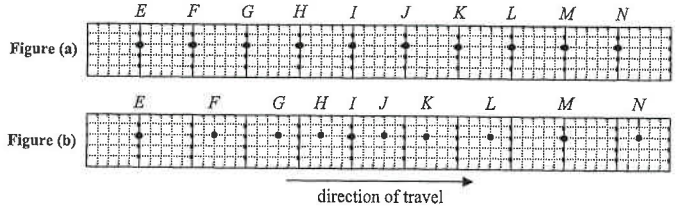


The above figure shows a snapshot of a transverse wave which travels along a string. Which statement is correct ?

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).

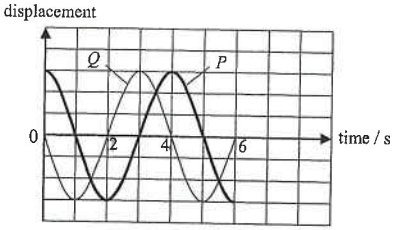


Which of the following statements **MUST BE** correct ?

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 >

49. <HKDSE 2020 Paper IA-11>

Figure (1)

Figure (2)

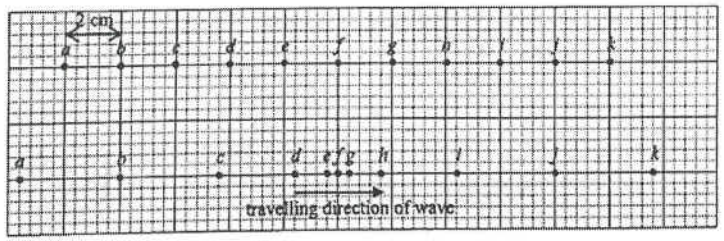
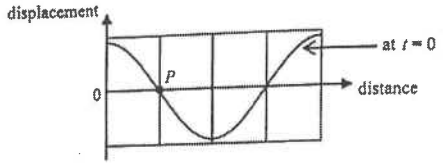


Figure (1) shows the equilibrium positions of particles a to k in a medium. The particles are separated by 2 cm from each other. A longitudinal wave of frequency 5 Hz is travelling from left to right. At a certain instant, the positions of the particles are shown in Figure (2). Determine the amplitude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

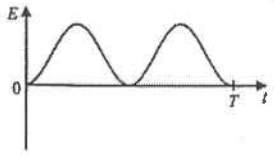
50. <HKDSE 2020 Paper IA-12>

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.

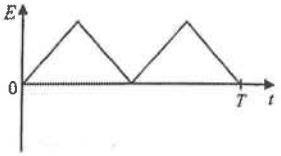


Which graph below correctly shows the variation of the particle's kinetic energy E within a period starting from $t = 0$?

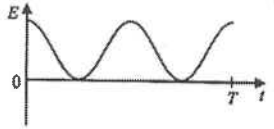
A.



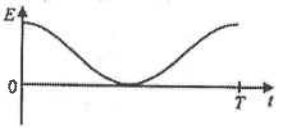
B.



C.



D.



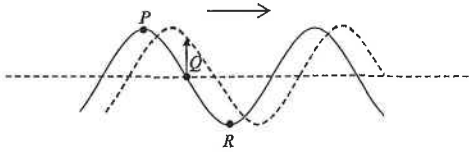
HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

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

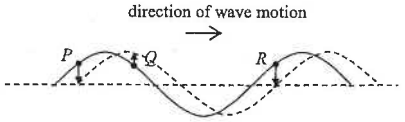
✓ (3) R is at the trough position, thus it must be momentarily at rest.

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 $\frac{1}{2}\lambda$.

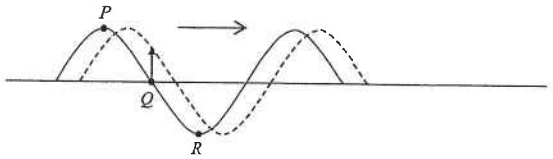
5. C

✓ (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

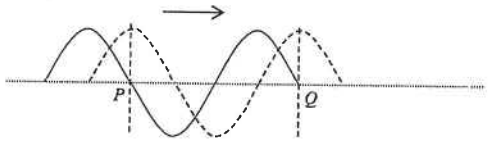


× (1) P is at its maximum displacement and is momentarily at rest

✓ (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), $T = y$.

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

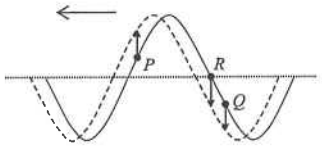
10. C

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

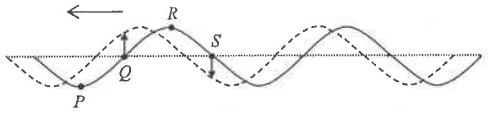
12. B

× (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

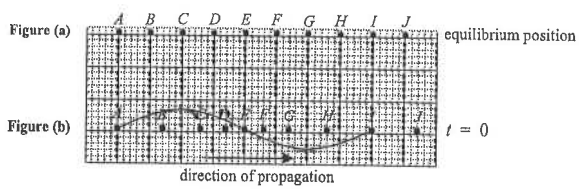
$v = \frac{d}{t} = \frac{3 \times 2}{0.2} = 30$ cm s^{-1} $= 0.3$ m s^{-1}

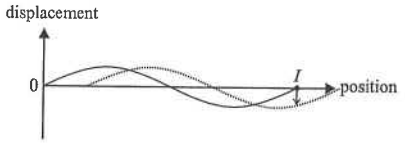
20. B

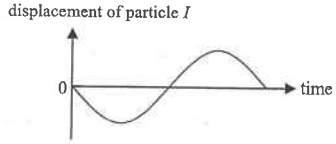
By $v = f\lambda$ $\therefore$ $v = (2)(100) = 200$ m s^{-1}

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.

22. C

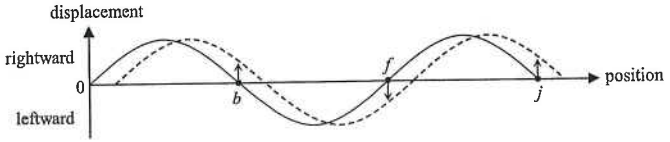
In Figure (b), particle a is at the centre of compression, thus it must be at the equilibrium position.

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.

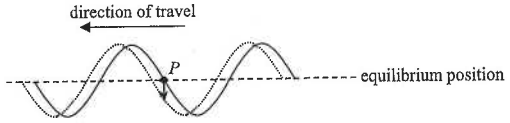
They are at the equilibrium positions.

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

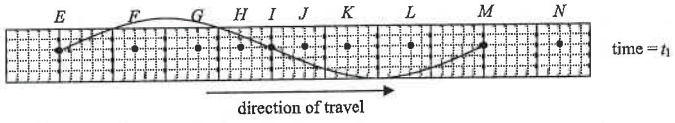


The wave would travel towards the left after $t = 1$ s as shown by the dotted line.

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.

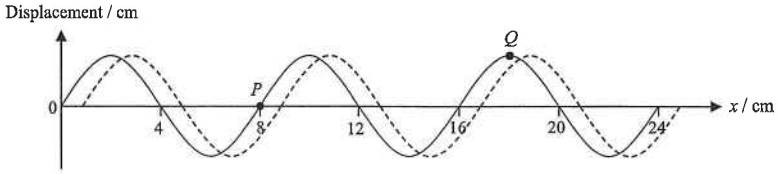
26. B

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

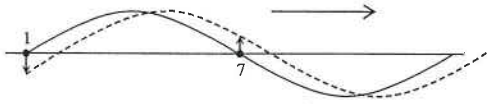
28. C

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

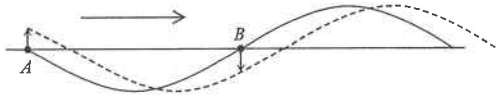
$\therefore$ $T = 2 \times 10^{-3}$ s

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

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

32. A

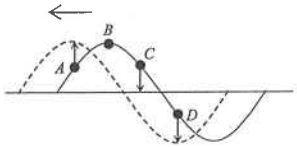
Take the rightward direction as (+) :



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

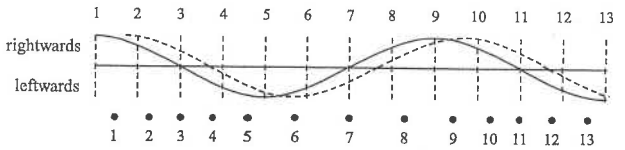
× A. As P is at the crest, it must be momentarily at rest.

× 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

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.

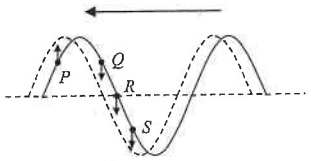
Particle d should then be at the extreme position.

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

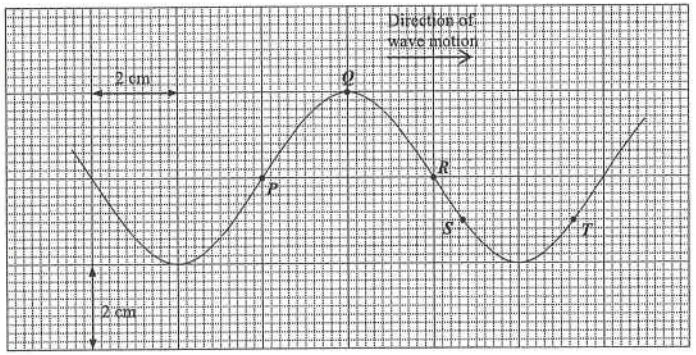
✓ (1) At $t = 2$ s, P is at the position of trough, thus it must be momentarily at rest.

✓ (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.

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)

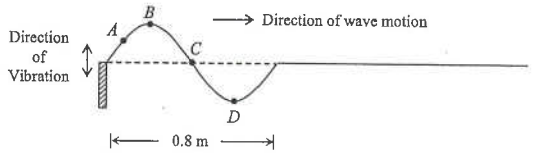
2. **< HKCE 1990 Paper I - 5 >**

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.



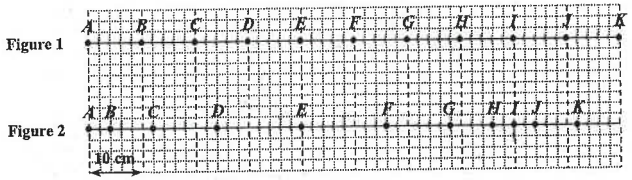
(i) At the instant shown, which of the particles A, B, C, D is/are

(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)

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,

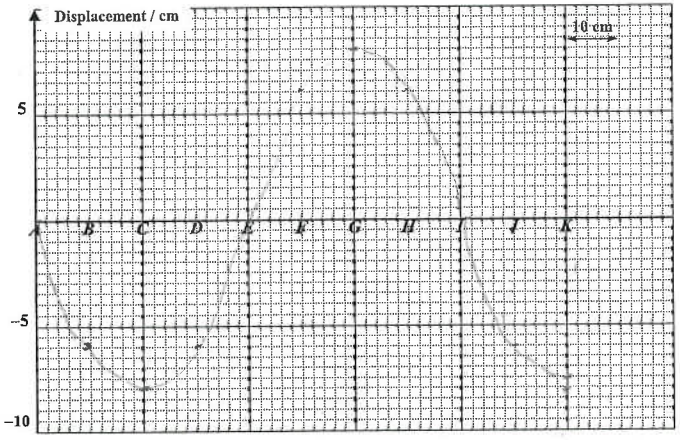
(ii) at the centre of a rarefaction. (2 marks)

(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									

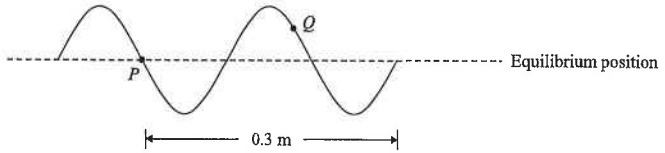
(ii) In the figure below, draw a graph showing the displacements of the particles along the wave at time t. (2 marks)



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)

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]

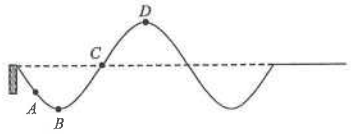
(b) By $d = vt$ [1]

$\therefore (2) = (3.2)t \quad \therefore t = 0.625$ 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

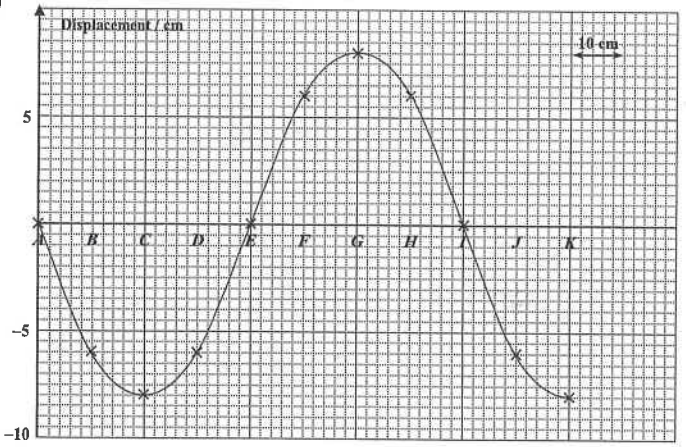
(b) (i) Particle A (**OR** I) is at a centre of compression. [1]

(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]