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)

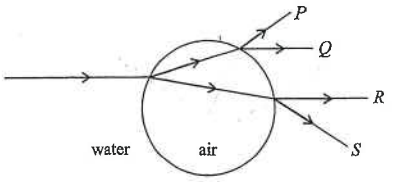
DSE Physics - Section C : M.C. PC - WA3 - M / 01
WA3 : Reflection and Refraction of Light

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 >**

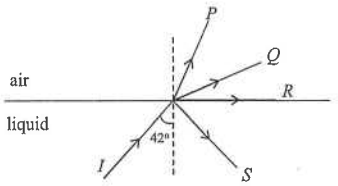
A point light source is placed in a liquid. Rays from the source leave the liquid surface through a circular area of diameter 24 cm. The refractive index of the liquid is 1.25. The depth of the source below the liquid surface is

A. 9 cm
B. 15 cm
C. 16 cm
D. 18 cm

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



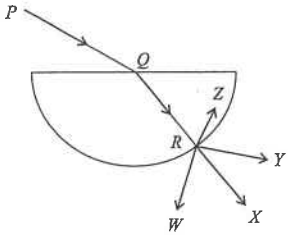
6. **< HKCE 1983 Paper II - 18 >**

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

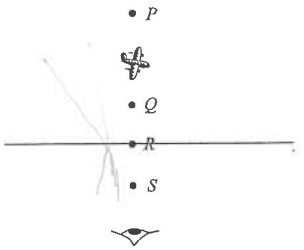
7. **< HKCE 1983 Paper II - 16 >**



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 >**



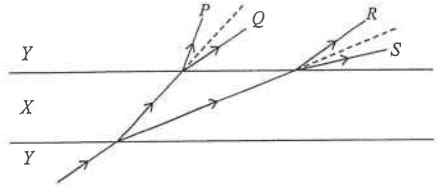
As shown in the diagram, the apparent position of the aeroplane seen by the diver at the bottom of the small pond is at

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 ?

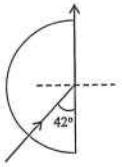
A. P
B. Q
C. R
D. S



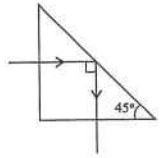
10. **< HKCE 1987 Paper II - 18 >**

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°.)

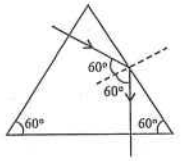
(1)



(2)



(3)

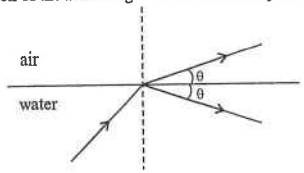


A. (2) only
B. (3) only
C. (2) & (3) only
D. (1), (2) & (3)

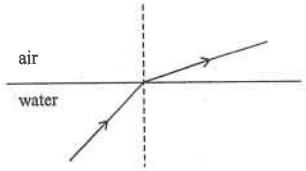
11. **< HKCE 1988 Paper II - 19 >**

Which of the following best describes a ray of light travelling from water to air ?

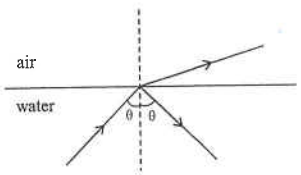
A.



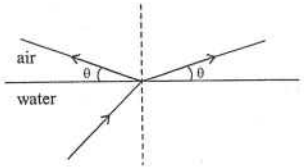
B.



C.



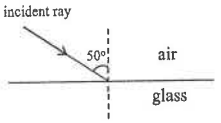
D.



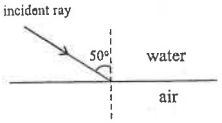
12. **< HKCE 1992 Paper II - 16 >**

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 ?

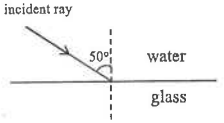
(1)



(2)



(3)



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

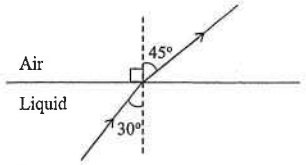
13. **< HKCE 1993 Paper II - 11 >**

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

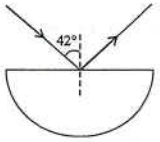
15. **< HKCE 1994 Paper II - 13 >**

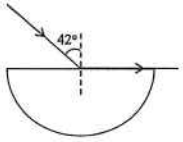
Which of the following devices involve(s) total internal reflection of light as they work ?
(1) Optical fibres
(2) A prismatic periscope
(3) A plane mirror

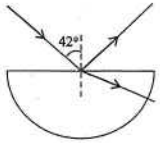
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

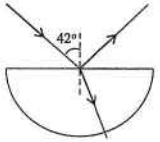
16. **< HKCE 1994 Paper II - 14 >**

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.


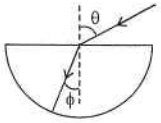
B.


C.


D.


17. **< HKCE 1996 Paper II - 17 >**

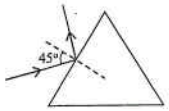
A ray of light travelling in air enters a semi-circular glass block as shown. Different values of the angle of incidence θ and the corresponding values of the angle of refraction ϕ are measured. Which of the below expressions represents the refractive index of the glass ?

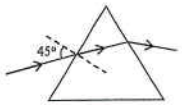


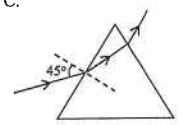
A. the slope of the graph of sin θ against sin ϕ
B. the slope of the graph of sin ϕ against sin θ
C. the slope of the graph of θ against ϕ
D. the slope of the graph of ϕ against θ

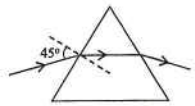
18. **< HKCE 1996 Paper II - 14 >**

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.

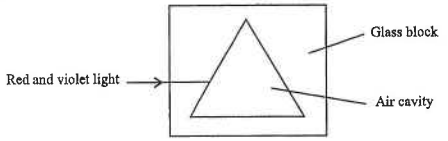
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

20. **< HKCE 1998 Paper II - 18 >**

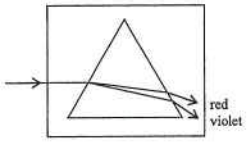
Which of the following phenomena is/are caused by the refraction of light ?
(1) If a man who is spear-fishing aims his spear at where the fish appears to be, he will miss it.
(2) A spectrum is formed when white light passes through a prism.
(3) A light ray is transmitted through a curved glass fibre.

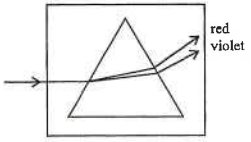
A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

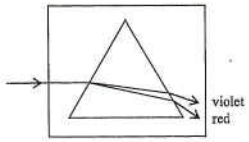
21. **< HKCE 1998 Paper II - 16 >**

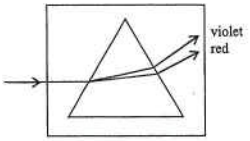


A beam consisting of red and violet light travels in a glass block with an air cavity. The cavity is in the shape of a prism as shown above. Which of the following diagrams best shows the subsequent path of the beam ?

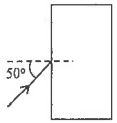
A.


B.


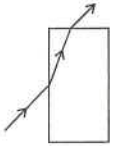
C.


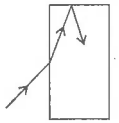
D.


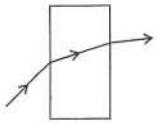
22. < HKCE 1999 Paper II - 13 >

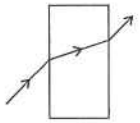


A ray of light travels in air and strikes a rectangular glass block at an angle of incidence 50°. The critical angle of the glass is 42°. Which of the following diagrams best shows the path of the ray ?

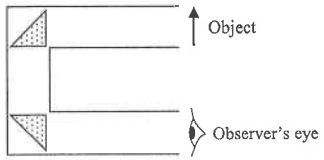
A.


B.


C.


D.


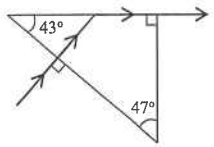
23. < HKCE 2000 Paper II - 18 >



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.

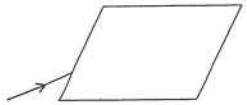
24. < HKCE 2000 Paper II - 16 >



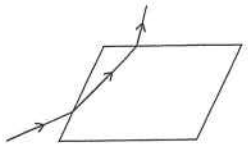
A ray of light enters a glass prism and travels along the path as shown above. Find the refractive index of the glass.

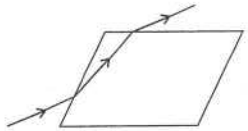
A. 1.07
B. 1.37
C. 1.47
D. 1.50

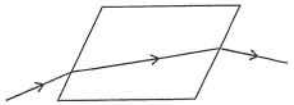
25. < HKCE 2002 Paper II - 14 >

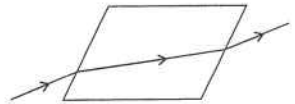


A ray of light travels in air and strikes a glass block as shown above. Which of the following diagrams best shows the path of the ray ?

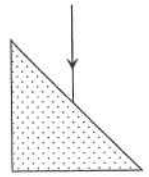
A.


B.


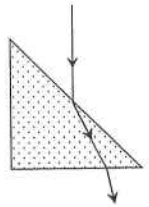
C.


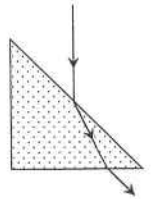
D.


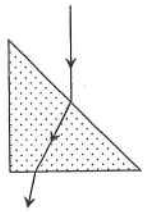
26. < HKCE 2003 Paper II - 13 >

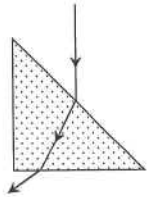


A ray of light travels in air and strikes a glass prism as shown above. Which of the following diagrams best shows the path of the ray ?

A.


B.


C.


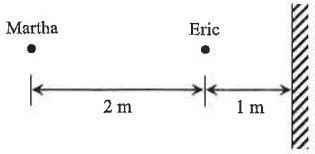
D.


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

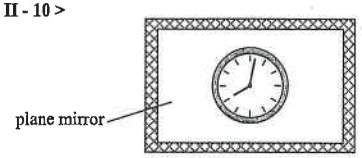
28. **< HKCE 2004 Paper II - 13 >**



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 >**

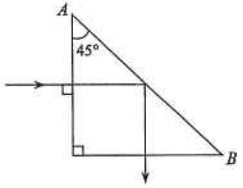
Which of the following surfaces produce diffuse reflection when parallel light rays fall on them ?

(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 >**

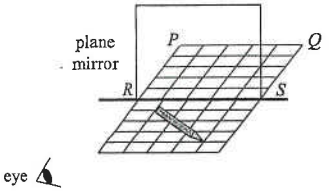
A light ray enters normally from the air into a right-angled prism and is totally internally reflected at face *AB* as shown below. Based on this optical phenomenon, which of the following is/are the possible value(s) for the refractive index of the material of the prism ?



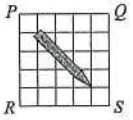
(1) 1.35
(2) 1.45
(3) 1.55

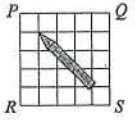
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

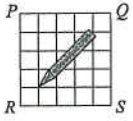
32. **< HKCE 2007 Paper II - 11 >**

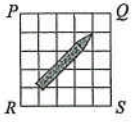


A pencil is placed in front of a vertical plane mirror as shown in the figure above. Which of the following shows the correct position of the image ?

A.


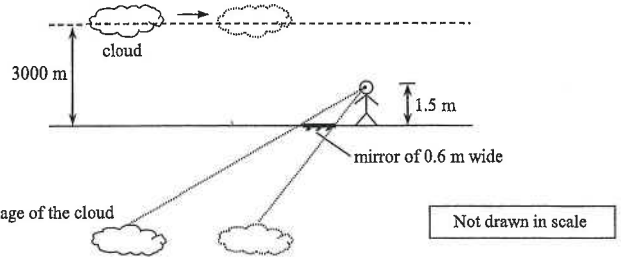
B.


C.


D.


33. **< HKCE 2007 Paper II - 35 >**

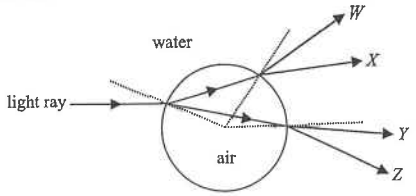
John wants to estimate the speed of a cloud in the following experiment. The cloud is moving horizontally at a height of 3000 m above the ground. He looks at the image of the cloud in a mirror of 0.6 m wide placed on the horizontal ground 1.5 m below his eye level. He finds that the image of the cloud 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}

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 ?

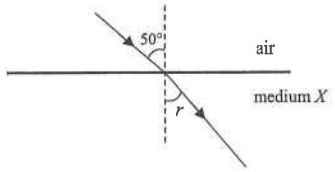


Figure (a)

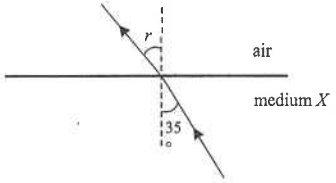
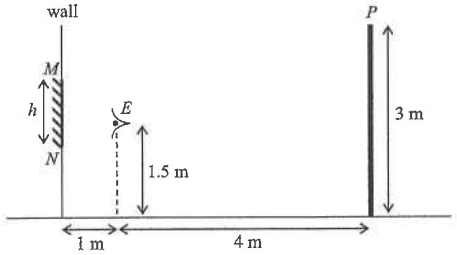


Figure (b)

A. 26.1°
B. 41.5°
C. 42.5°
D. 48.5°

36. < HKCE 2008 Paper II - 13 >

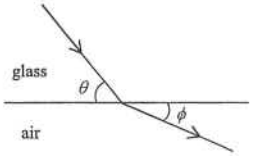


In the figure, a plane mirror MN of height h is mounted in an adjustable vertical position on a vertical wall. E is an observer's eye which is 1 m from the wall and 1.5 m above the ground. PQ is a vertical post of height 3 m and is 4 m behind the observer. Looking into the mirror the observer can see 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 >

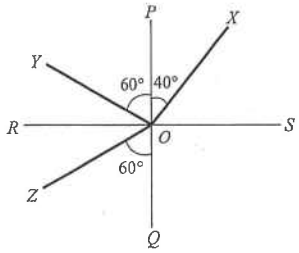
Which of following statements about total internal reflection is/are correct ?

(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 >

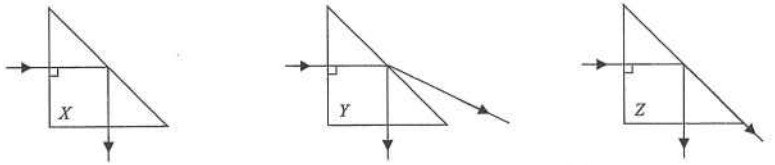
A light ray undergoes reflection and refraction at an air-glass boundary as shown. PQ is perpendicular to RS. OX, OY and OZ are the paths of the light rays. Which of the following deductions is/are correct ?



(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

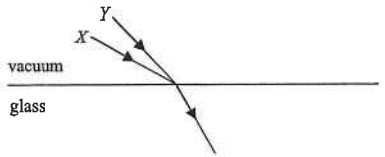
40. < HKCE 2009 Paper II - 34 >



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. $Z > Y > X$

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 >**

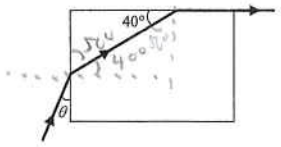
A student performs an experiment to find the refractive index of a material and the result is shown below. Which of the following set of data is likely to be wrong ?

	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.

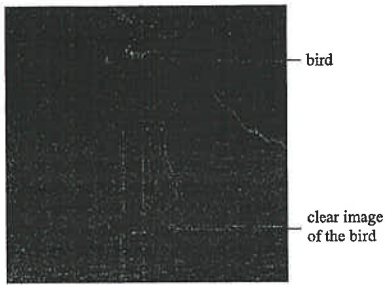
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

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 ?

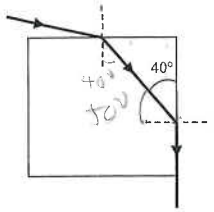
(1) The image is real.
(2) A clear image is formed as regular reflection occurs.
(3) If the bird is closer to the water surface, the size of the image increases.

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

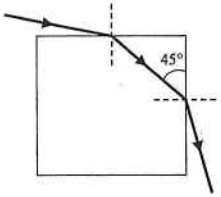
47. **< HKCE 2011 Paper II - 39 >**

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.

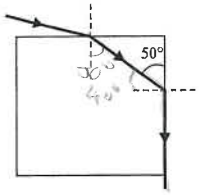
(1)



(2)



(3)



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

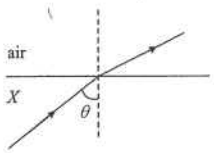
Part B : HKAL examination questions

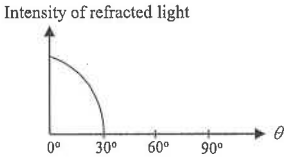
48. < HKAL 1994 Paper IIA - 15 >

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

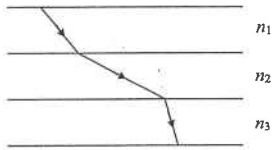
50. < HKAL 1996 Paper IIA - 12 >

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

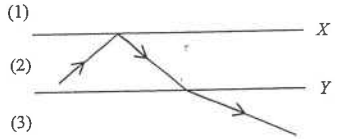
51. < HKAL 1997 Paper IIA - 13 >



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 >

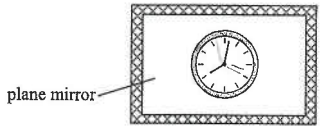
A point source of light is situated at the bottom of a swimming pool. It is found that a circular patch of radius 1.7 m is illuminated on the water surface. Find the depth of water in the pool.

Given : refractive index of water = 1.33

A. 1.2 m
B. 1.3 m
C. 1.4 m
D. 1.5 m

Part C : HKDSE examination questions

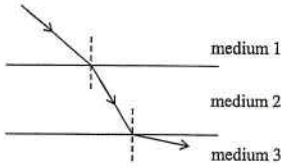
56. < HKDSE Sample Paper IA - 15 >



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

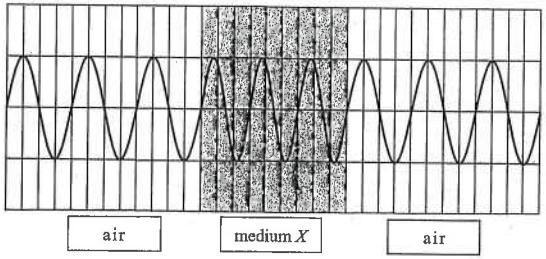
57. < HKDSE Practice Paper IA - 20 >



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 >

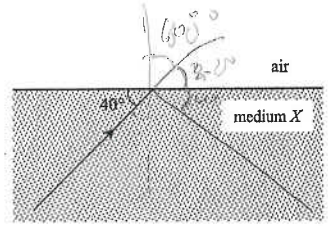


A certain monochromatic light passes through medium X as shown above. What is the refractive index of medium X ?

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. $\frac{\sin 50°}{\sin 60°}$

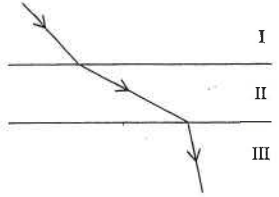
60. < HKDSE 2013 Paper IA - 21 >

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

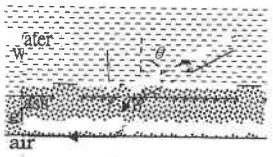
62. < HKDSE 2016 Paper IA - 20 >

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.

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.

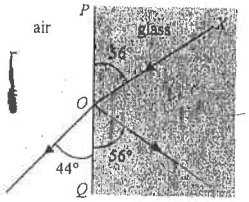


Given : refractive index of water is 1.33.

A. 41.2°
B. 48.8°
C. 53.1°
D. It depends on the refractive index of glass.

64. **< HKDSE 2018 Paper IA - 17 >**

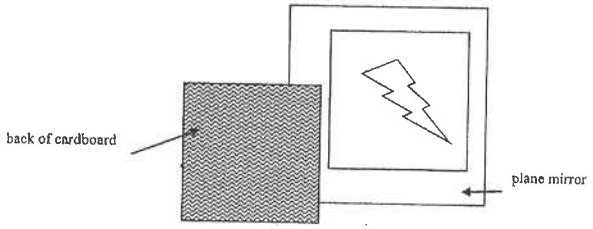
In the figure above, XO is a light ray incident on the glass-air boundary plane PQ. Which of the following gives the refractive index of glass ?



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 >**

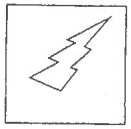
The figure shows the image seen when a plane mirror is placed in front of a cardboard with a design on its front surface.



Which diagram below shows the design on the cardboard ?

A.


B.


C.


D.


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

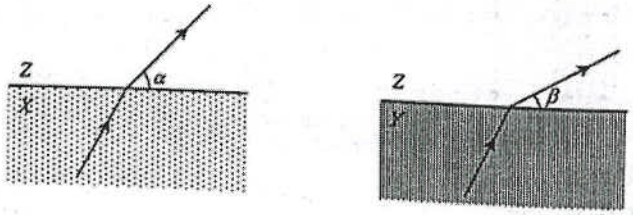
2. C

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)

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.



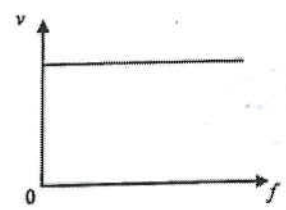
The corresponding refracted rays in Z make angles α and β respectively with the boundary plane (with $\alpha > \beta$). Which medium, X or Y, has a greater refractive index ? In which medium, X or Y, does light travel faster ?

	medium with a greater refractive index	medium in which light travels faster
A.	X	X
B.	X	Y
C.	Y	X
D.	Y	Y

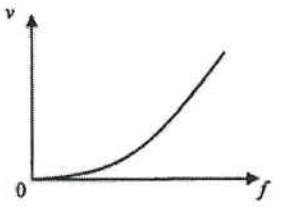
68. <HKDSE 2020 Paper IA-16>

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 ?

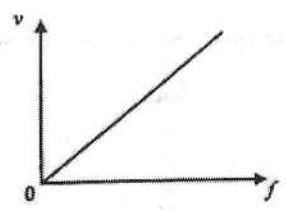
A.



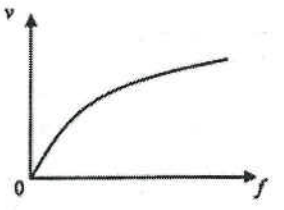
B.



C.



D.



3. D

× (1) Frequency remains unchanged during the refraction of light from one medium into another.

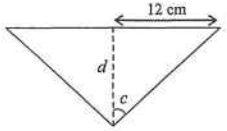
✓ (2) Wavelength must change during the refraction.

✓ (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

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

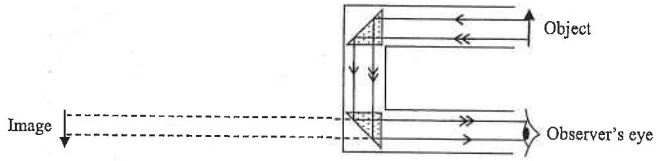
In addition, red light should have the least deviation.

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°

$\therefore$ $i = 90° - 47° = 43°$

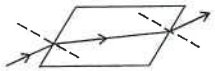
As the emergent angle is 90°, the incident angle 43° is the critical angle of glass

$\therefore$ $n = \frac{1}{\sin 43°} = 1.47$

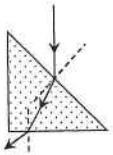
25. D

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.

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 $\qquad c < 45°$

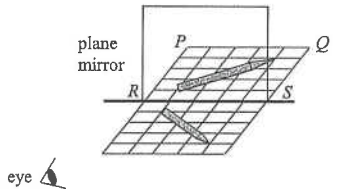
By $\sin c = \frac{1}{n}$, critical angle of different materials can be found.

× (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

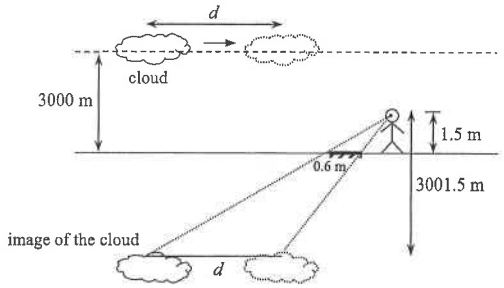
By use of the two similar triangles,

$\frac{d}{0.6} = \frac{3001.5}{1.5}$

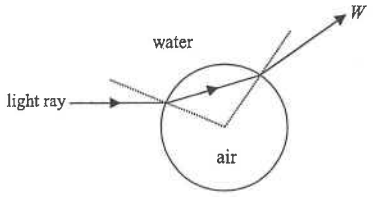
$\therefore\ d = 1200.6 \approx 1200$ m

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.

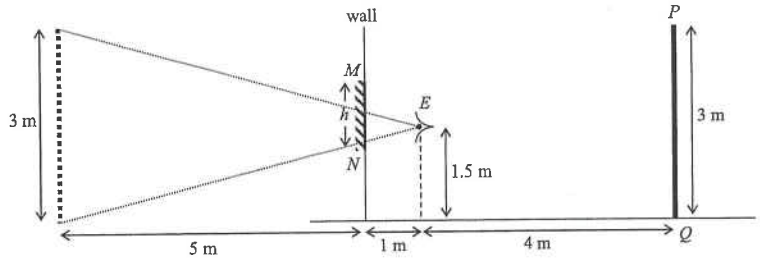
The light then bends towards the normal from air to water.

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.

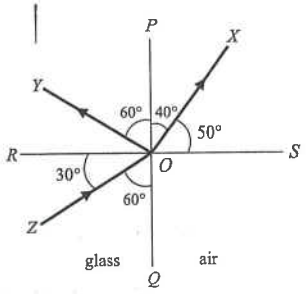
✓ (3) Total internal reflection occurs only if the ray travels from an optically denser medium to an optically less dense medium

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.



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°

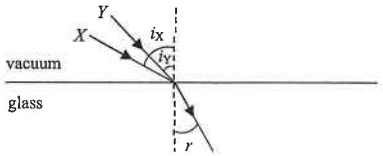
In Z, total internal reflection just occurs at the incident angle of 45°, thus the critical angle is 45°.

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

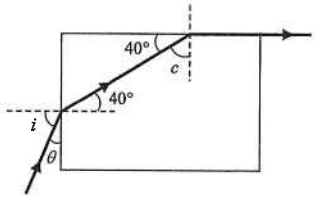
From the figure, critical angle c is 50°.

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 $n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$

$\therefore \ n \propto \dfrac{1}{\sin\theta}$

$\therefore \ \theta_2 > \theta_1 > \theta_3 \Rightarrow n_3 > n_1 > n_2$

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 $v \propto \sin\theta$

$\therefore v_1 > v_3 > v_2$

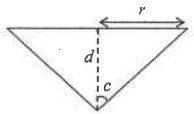
53. A

✓ (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.

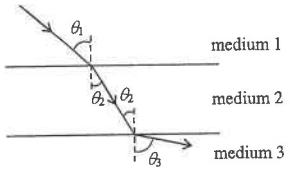
Thus the actual time is 3:58.

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 : $n = \frac{\lambda_{air}}{\lambda_X} = \frac{4}{3} = 1.33$

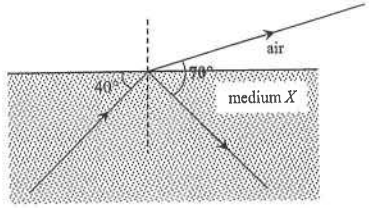
59. C

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.

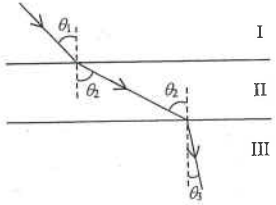
Make down the angles as shown.

From the graph,

$\theta_3 < \theta_1 < \theta_2$

As $\sin\theta \propto v$

$\therefore v_3 < v_1 < v_2$



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

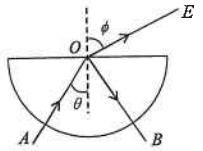
Since the image formed by a plane mirror must be erect and laterally inverted,
the object should be the one shown in option D.

Use the following data wherever necessary :

Speed of light in vacuum $c = 3 \times 10^8\ m\ s^{-1}$

Part A : HKCE examination questions

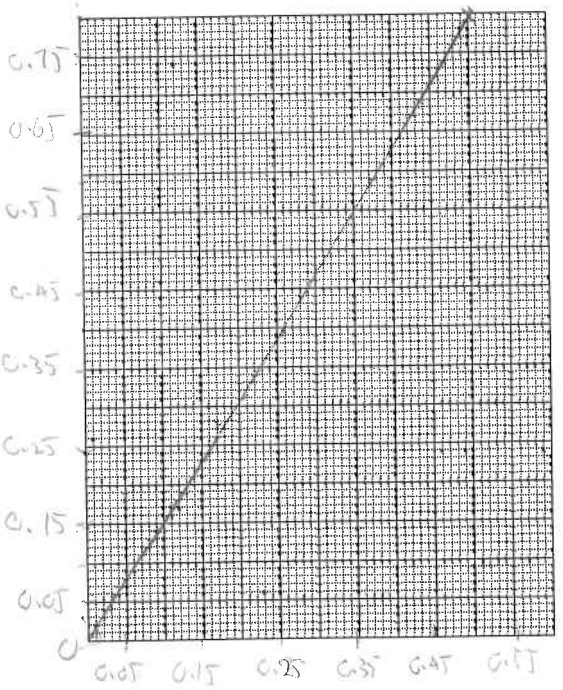
1. **< HKCE 1988 Paper I - 6 >**



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)



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)

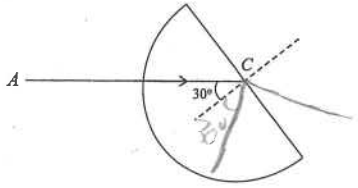
(b) Briefly describe the change in brightness of

(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)

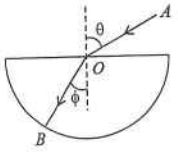
3. **< HKCE 1993 Paper I - 3 >**

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 >**

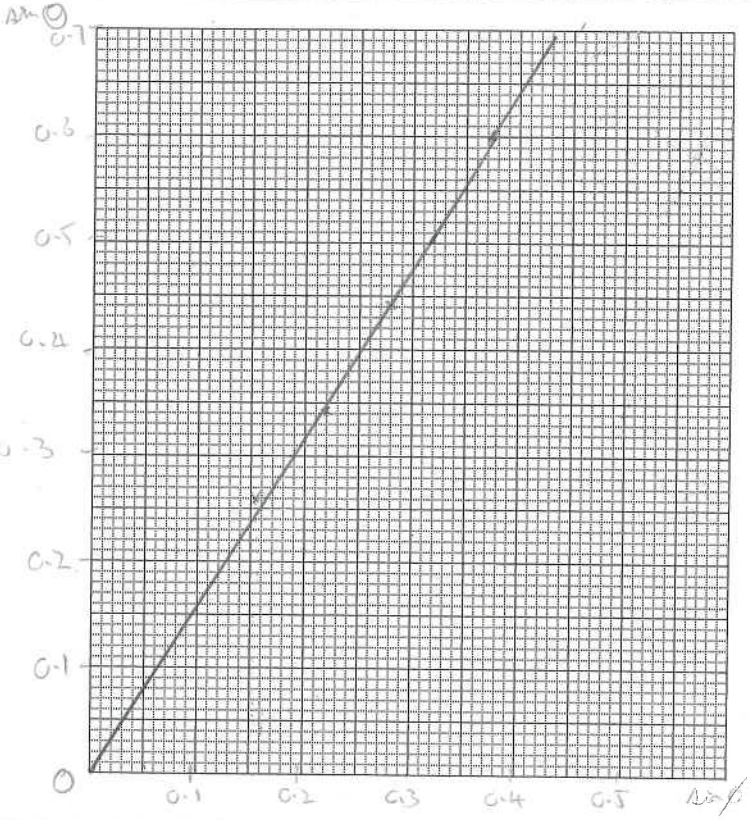


A ray of light travelling in the direction *AO* in air enters a semi-circular glass block as shown in the figure above. The ray is refracted along *OB* in the glass block. Different values of the angle of incidence θ are used and the corresponding values of the angle of refraction ϕ are measured. The following result is obtained :

θ	15°	20°	25°	30°	35°	40°
ϕ	9.0°	12.9°	16.3°	19.0°	22.3°	25.1°

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

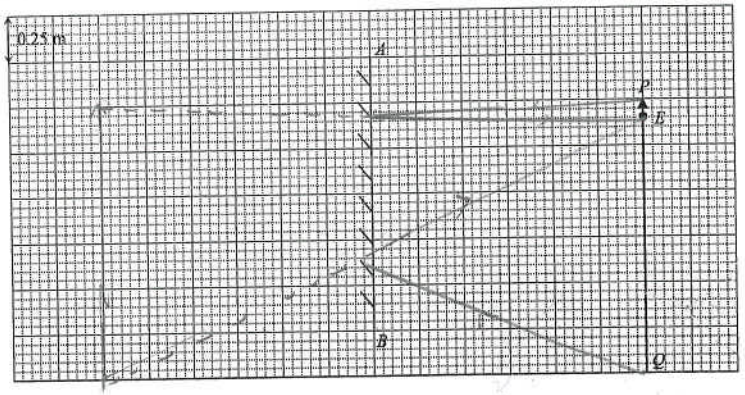
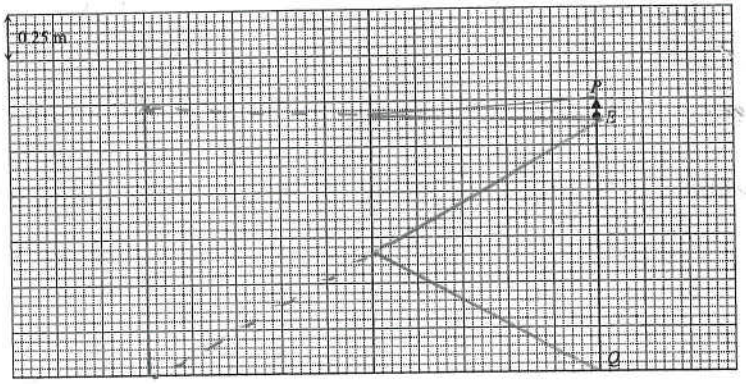


Figure 2



(a) State three properties of the boy's image as formed by the mirror. (2 marks)

(b) In Figure 1, draw

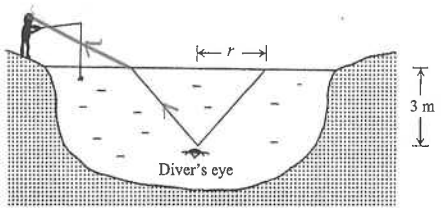
(1) the image of the boy formed by the mirror,

(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)

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)

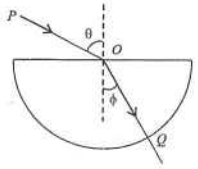


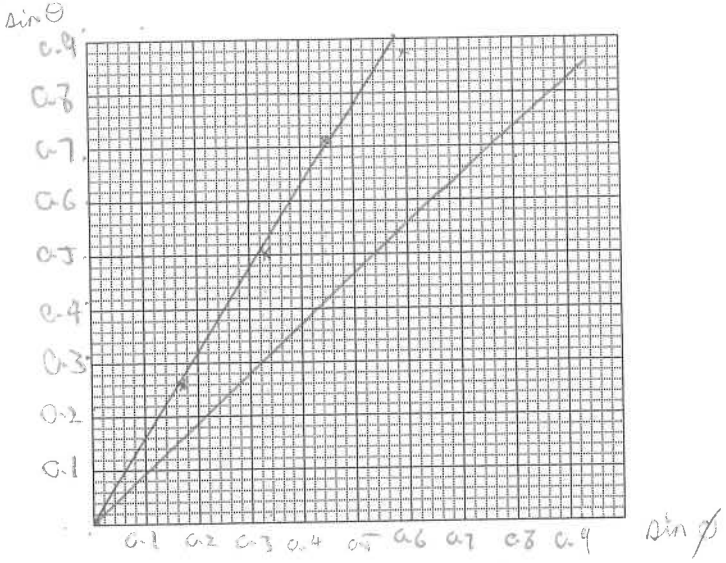
Figure 1

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).]

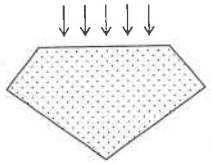


Figure 2

(3 marks)

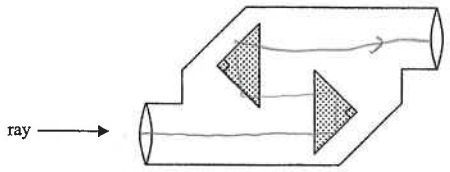
8. **< HKCE 2002 Paper I - 1 >**

(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)

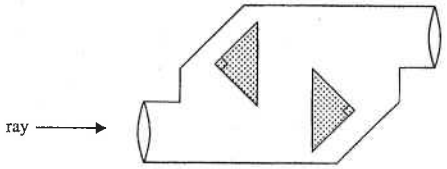
The Figure above shows an ambulance. Explain why the word AMBULANCE is printed in the form as shown in the figure. (2 marks)

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)

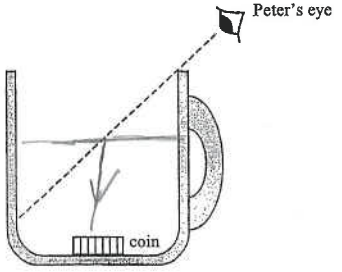
10. **< HKCE 2003 Paper I - 2 >**

(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)

11. < HKCE 2004 Paper I - 1 >

Figure 1

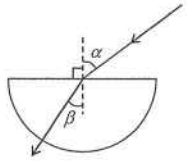
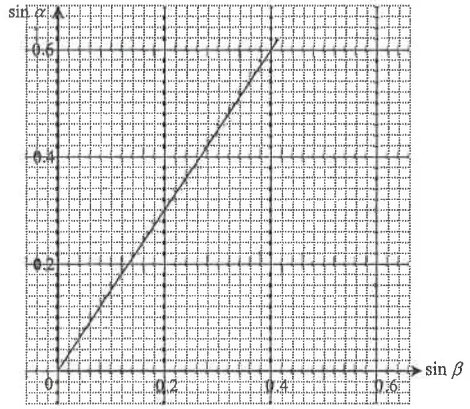


Figure 1 show a set-up used to study the relationship between the angle of incidence α and the angle of refraction β of a ray of light travelling from air into a semi-circular glass block. Figure 2 shows a graph of sin α against sin β.

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.

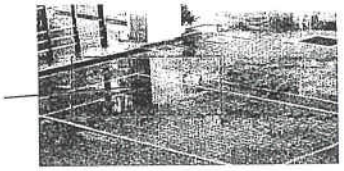
(i) In Figure 1, sketch the subsequent path of the ray. (2 marks)

(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)

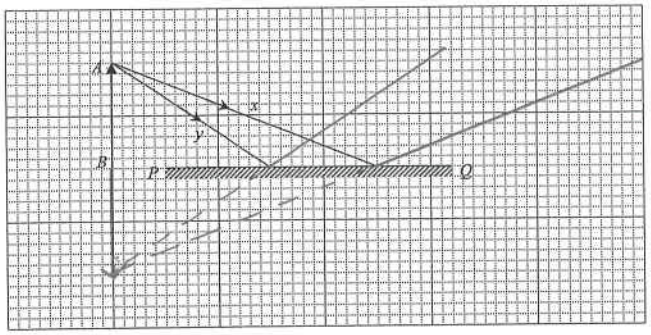
13. < HKCE 2007 Paper I - 5 >

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)

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.

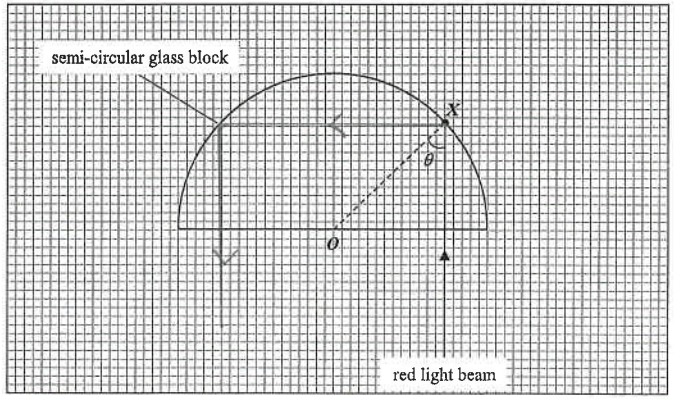


Figure 1

(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)

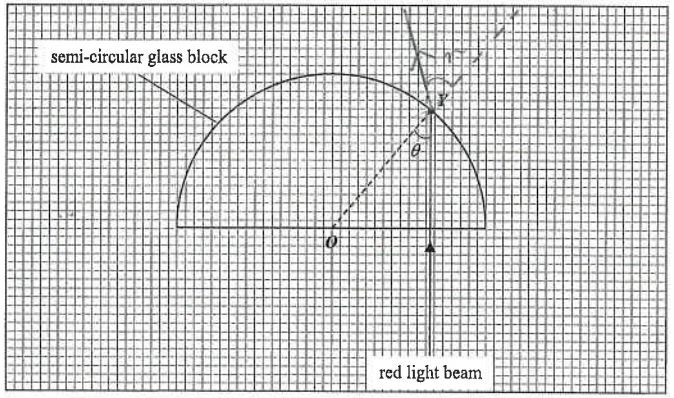


Figure 2

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.

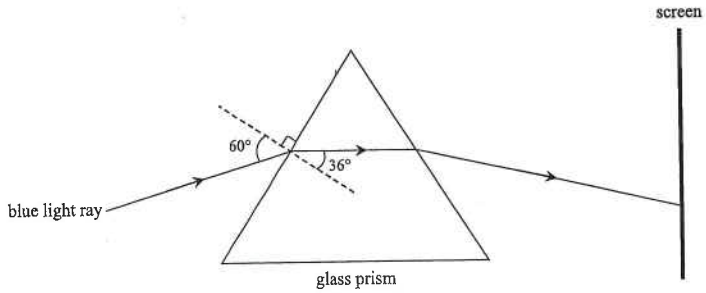


Figure (a)

(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)

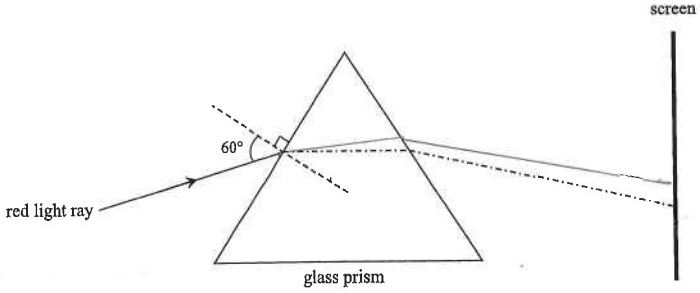


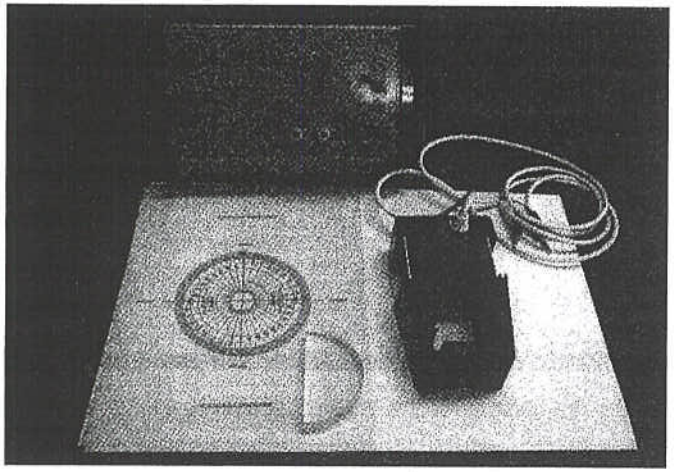
Figure (b)

Part B : HKDSE examination questions

16. < HKDSE Practice Paper IB - 6 >

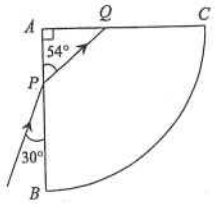
The Figure below shows the following apparatus :

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 >

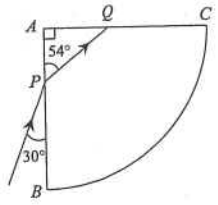


The Figure above shows the cross-section of glass block ABC. ABC is a quarter circle with its centre at A. A ray of red light is incident at P on face AB and the refracted ray strikes the face AC at Q as shown.

(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)

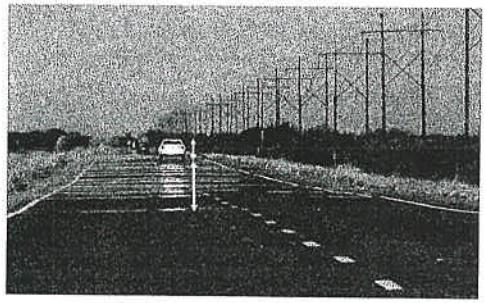


(d) If the incident ray is a ray of white light, what can be observed when it finally emerges from the block ? (1 mark)

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.

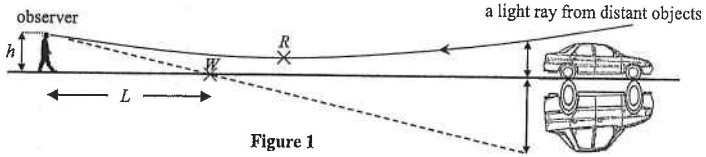


Figure 1

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.

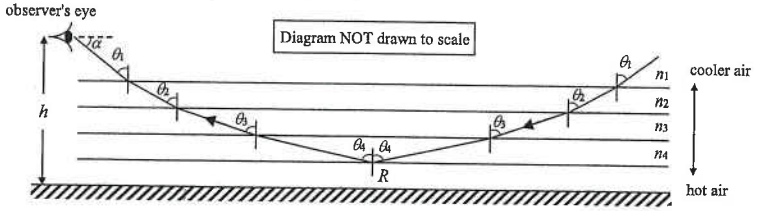


Figure 2

(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.

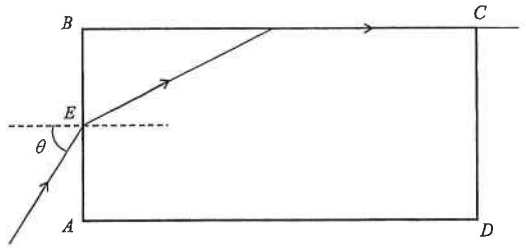


Figure (a)

(i) Find the critical angle of the plastic. (2 marks)

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.

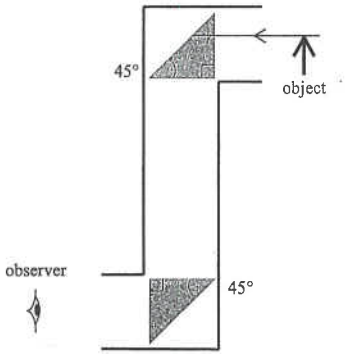


Figure (b)

(i) Complete the path of the light ray from the object in Figure (b), and explain why the periscope fails to work. (3 marks)

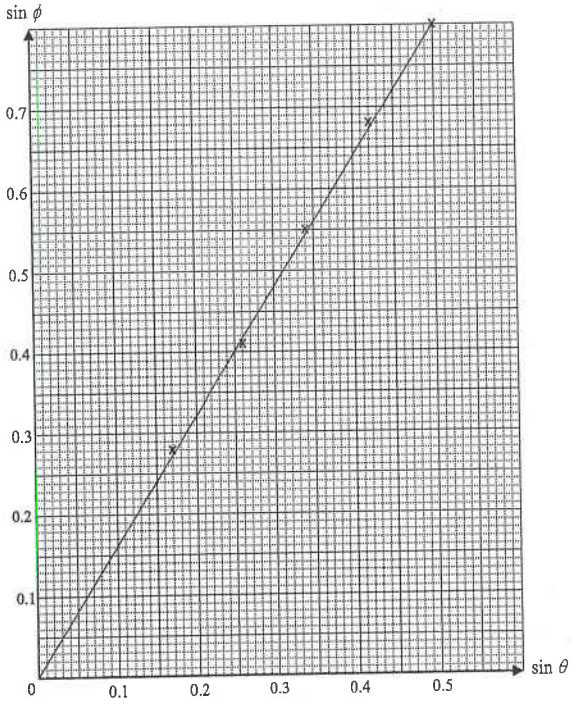
(ii) What can be used to replace the two plastic prisms so that the periscope can work properly ? (1 mark)

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]

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]

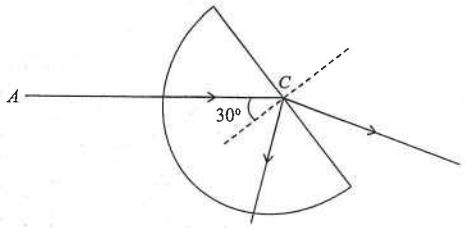
to examine the internal organs of patient [1]

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]

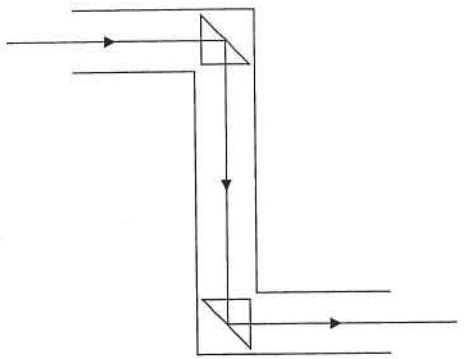
$\therefore \quad n = 1.59$ [1]

(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]

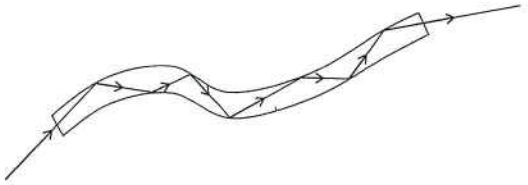
< Correct orientation of prisms > [1]

< 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]

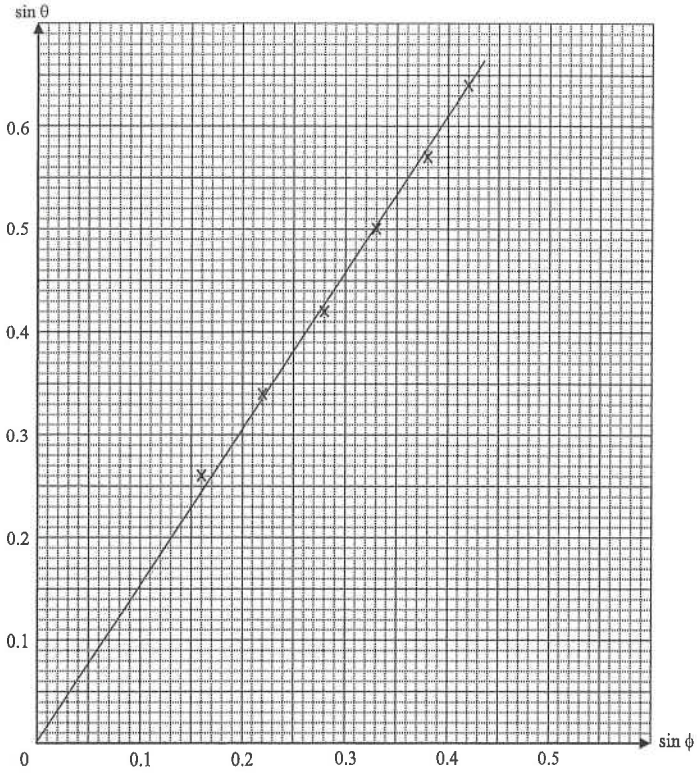
(b) Any **ONE** of the following [1]

* Telecommunications
* Endoscope for internal examination of patients

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)

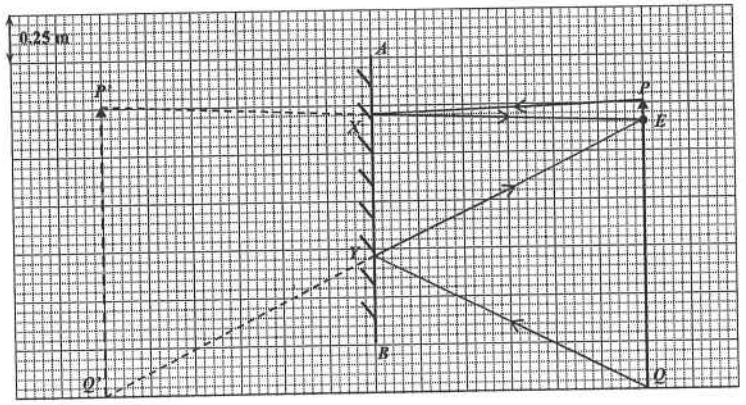


Figure 1

< 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]

5. (d) Yes, the boy can still see all of himself. [1]

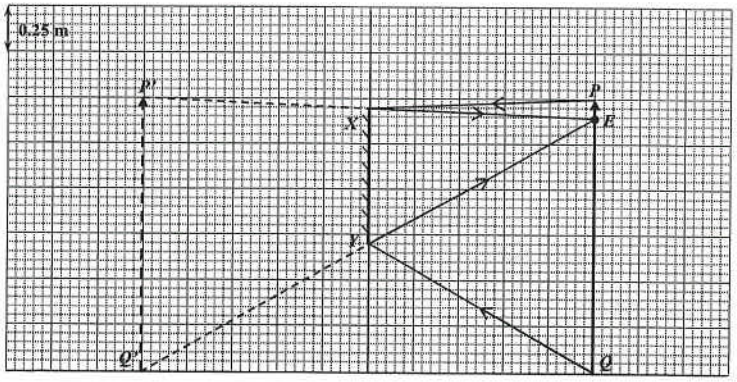


Figure 2

< 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]

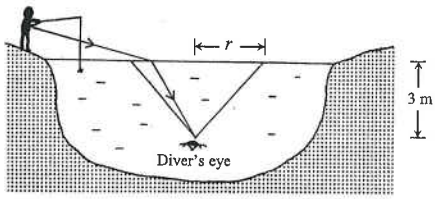
$\therefore\ c = 48.8°$ [1]

(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]

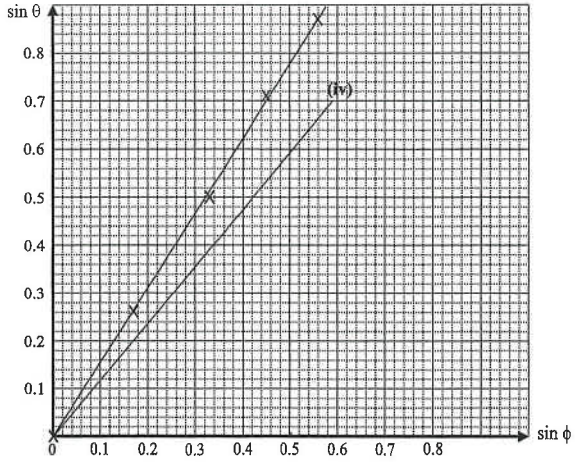
(Note that the light ray should not be along the circular path)

(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]

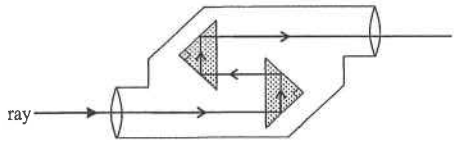
So more light would leave the upper surface and make diamond more sparkling. [1]

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)

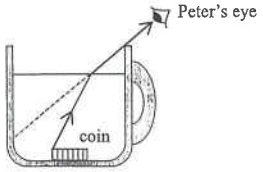
10. (a) (i) By $n = \dfrac{\sin\theta_{air}}{\sin\theta_{water}}$ [1]

$\therefore\ (1.33) = \dfrac{\sin\theta_{air}}{\sin 30^\circ}$ $\therefore\ \theta_{air} = 41.7^\circ$ [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]

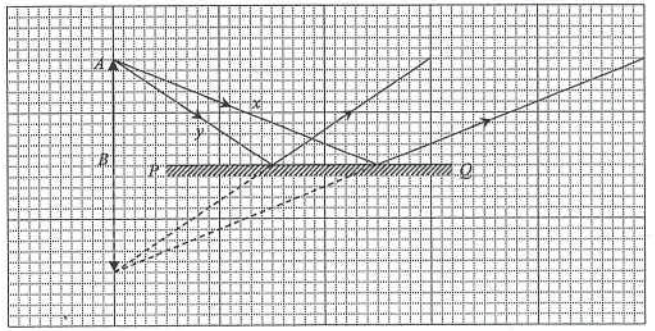
(b) Any **TWO** of the followings : [2]

* 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]

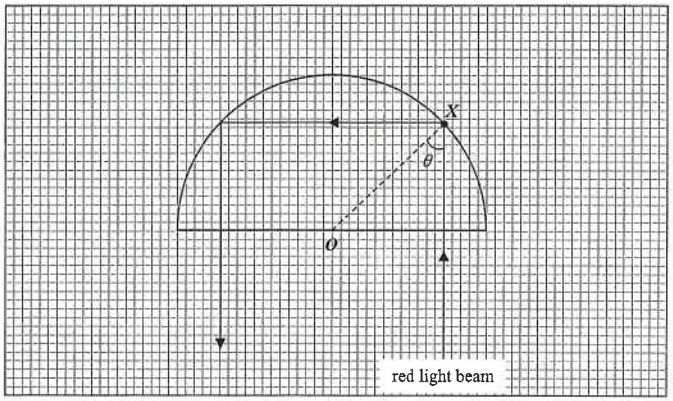
$\therefore\ 1.48 = \dfrac{1}{\sin c}$

$\therefore\ c = 42.5^\circ$ [1]

(b) (i) The angle of incident θ (45°) is greater than the critical angle, [1]

thus, total internal reflection occurs at X. [1]

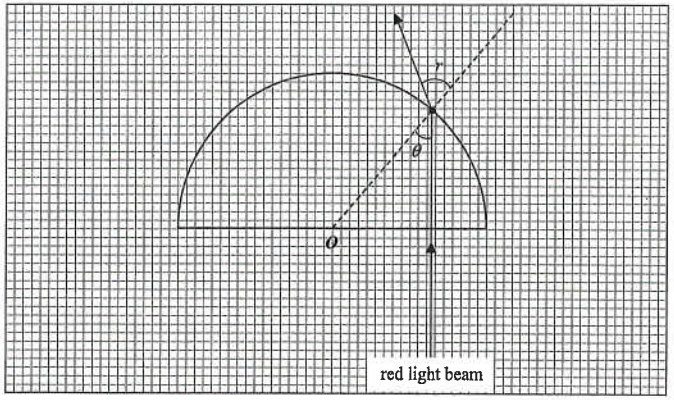
14. (b) (ii)



< total internal reflection drawn at X > [1]

< all rays are correct > [1]

(c)



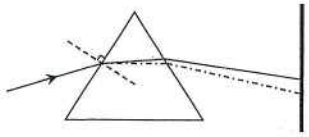
< refracted ray comes out from Y and bends away from the normal > [1]

< 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]

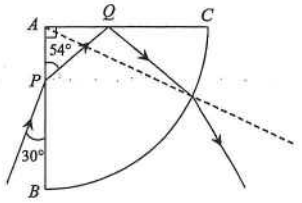
(b) $\sin c = \dfrac{1}{n_g} = \dfrac{1}{1.47}$

$\therefore\ c = 42.9°$ < 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.

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]

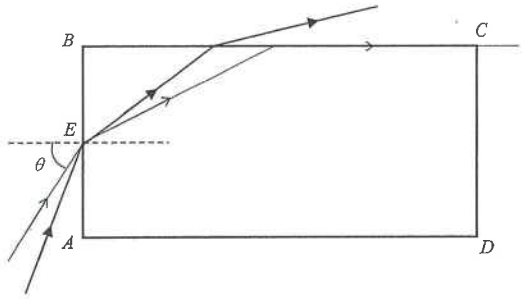
$\therefore c = 47.3°$ [1]

(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]

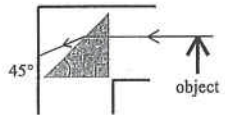
(iii)



<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)