O Level Combined Physics Structured

Light Test 1.0

Q1

A lens has a focal length of 3.0 cm. The image of an object is found to be at the location as shown in Fig. 6.1. The focal points of the lens are marked "*F*".

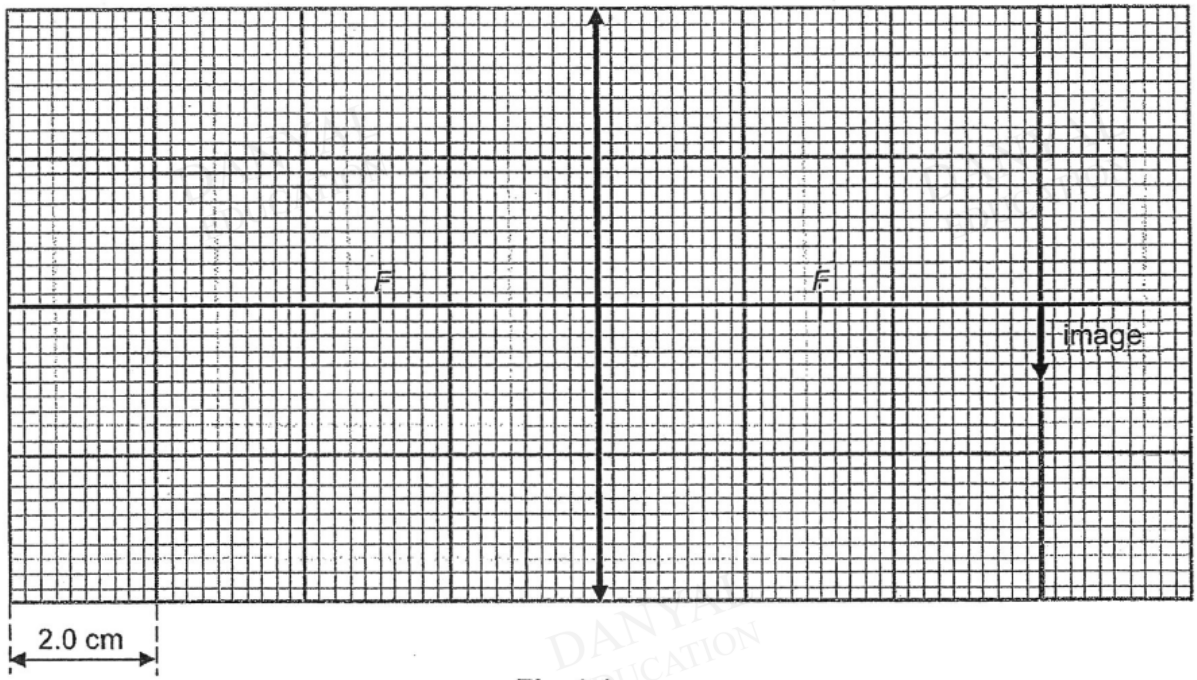


Fig. 6.1

(a) On Fig. 6.1, draw two rays to locate the object. Label the object "*O*". [3]

(b) State the characteristics of the new image formed when the object is shifted to a distance of 2.8 cm from the lens.

.....[1]

Q2

A student performs an experiment with a semi-circular glass block and a ray of white light. Fig. 12.2 shows the path taken by this ray of light as it enters the glass at R till it hits point S.

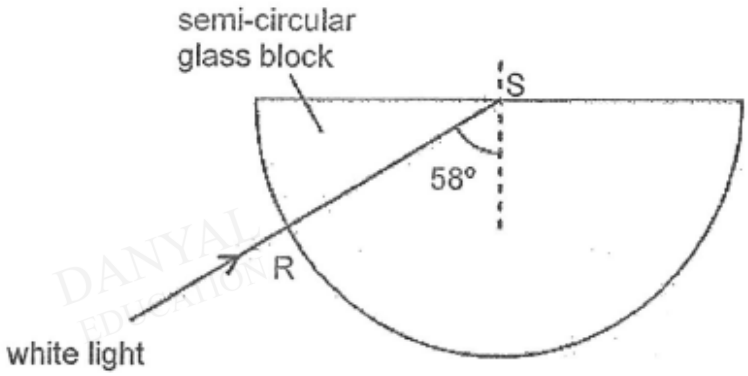


Fig. 12.2

(i) Explain why the ray does not change direction when it enters the glass block at R.

.....

.....[1]

(ii) Given that the refractive index of the glass block is 1.5, determine the critical angle for light in this glass.

critical angle = ...[2]

(iii) On Fig. 12.2, draw the path of the light ray after it hits point S and indicate the value of the angle that it makes with the normal at S. [1]

Q3

A student investigates the refraction of light when it travels from medium A to air. **Fig. 12.1** shows the arrangement of the apparatus.

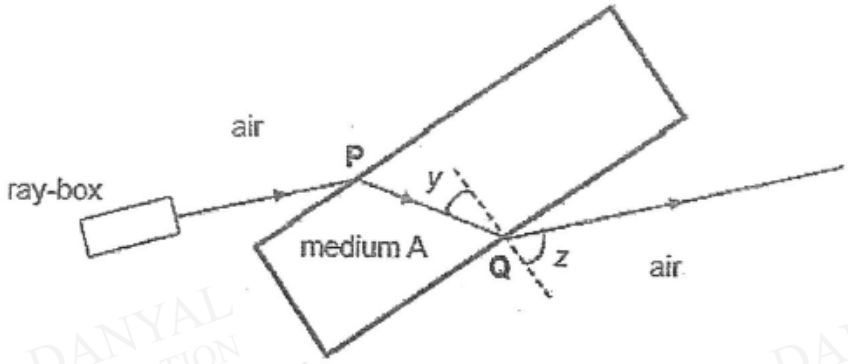


Fig. 12.1

The student uses a ray-box to direct a ray of light towards the boundary between the air and medium **A** at **P** so that it emerges through the other side at **Q**. After tracing the light rays, the student measures the angle *y* in medium A and the angle *z* in the air. He then changes the direction of the light ray at the boundary and measures the new angle y in medium A.

The table below shows his results.

Angle *y* in medium A	Angle *z* in the air
35 °	54 °
22 °	

Table 12.2

(a) Explain why the direction of light changes as it passes from glass into air. [2]

.....

.....

.....

.....

.....

(b) Using the data in **Table 12.2**, calculate the missing value for the angle *z* in the air.

angle *z* == _____ [2]

(c) Calculate the minimum angle *y* at which total internal reflection would occur.
Give the value of the minimum angle *y* to the nearest degree.

minimum angle *y* = _____ [2]

(d) Hence, describe how the direction of the light at the boundary **Q** changes as angle y increases from 20 ° to 60 °. [4]

Q4

Fig. 7.1 below shows a long block of glass over an object O. Light from O reaches the top surface of the glass at **X**, **Y** and **Z**. The refractive index of the glass is 1.5.

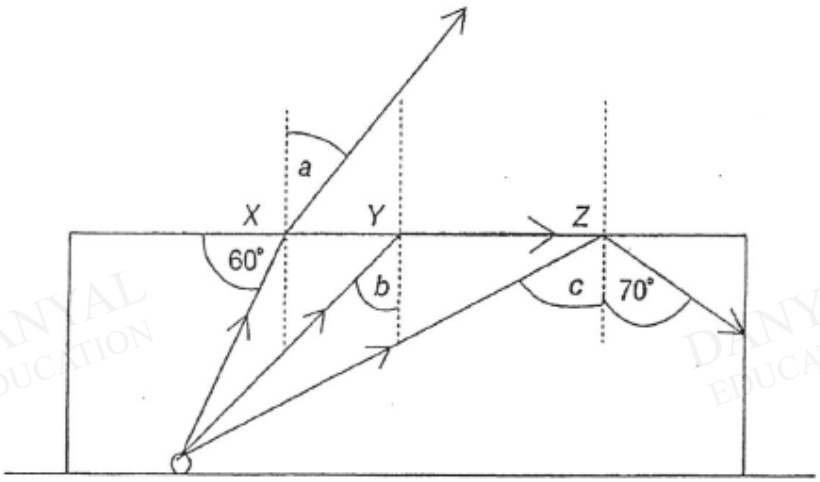


Fig. 7.1

(a) Calculate the value of angle a.

angle a = ... ° [1]

(b) Calculate the value of angle b.

angle b = ... ° [1]

(c) State the value of angle c. and explain why the ray at point **Z** travels in the path as shown in Fig. 7.1.

angle c = ... °

explanation: .....

..... [1]

Q5

8 Fig 8.1 shows the full scaled diagram of a converging lens with a focal length of 4.0 cm.

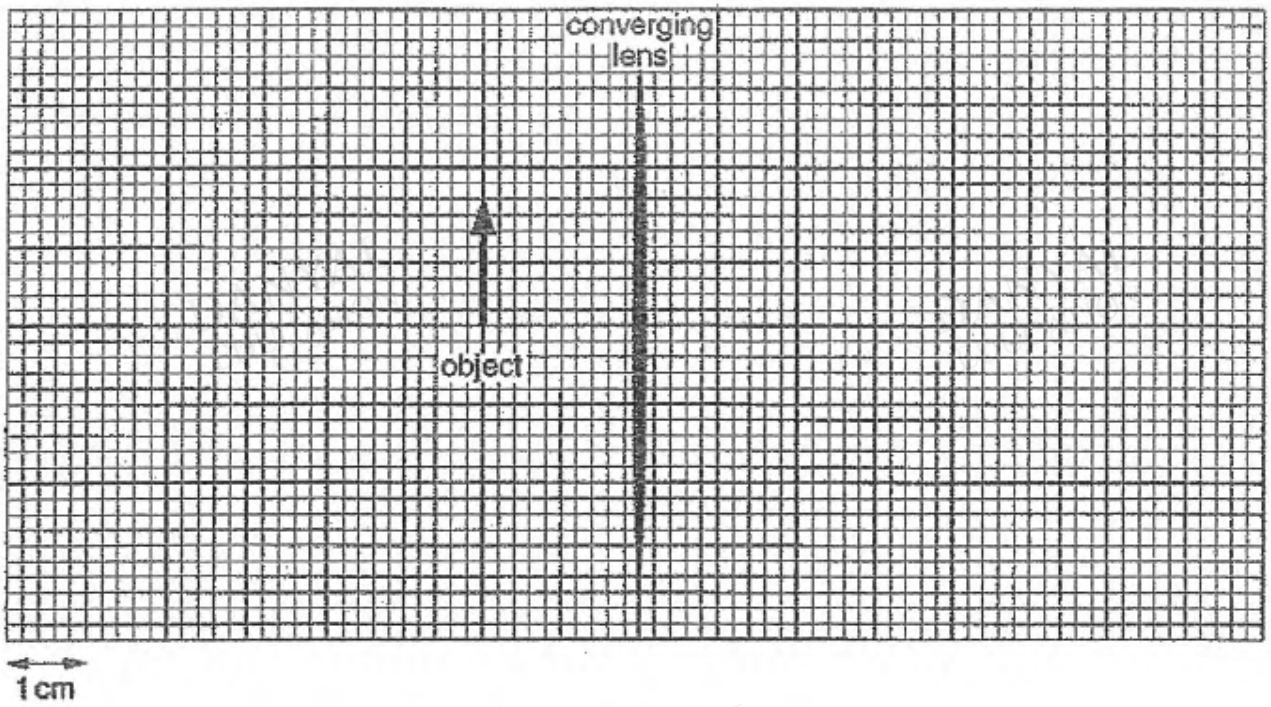


Fig 8.1

(a) Draw two rays from the top of the object to locate the top of the image formed. Complete the diagram by drawing the whole image formed. [2]

(b) State two changes to the image if the object is now placed 5.0 cm from the lens.

.....

.....

.....

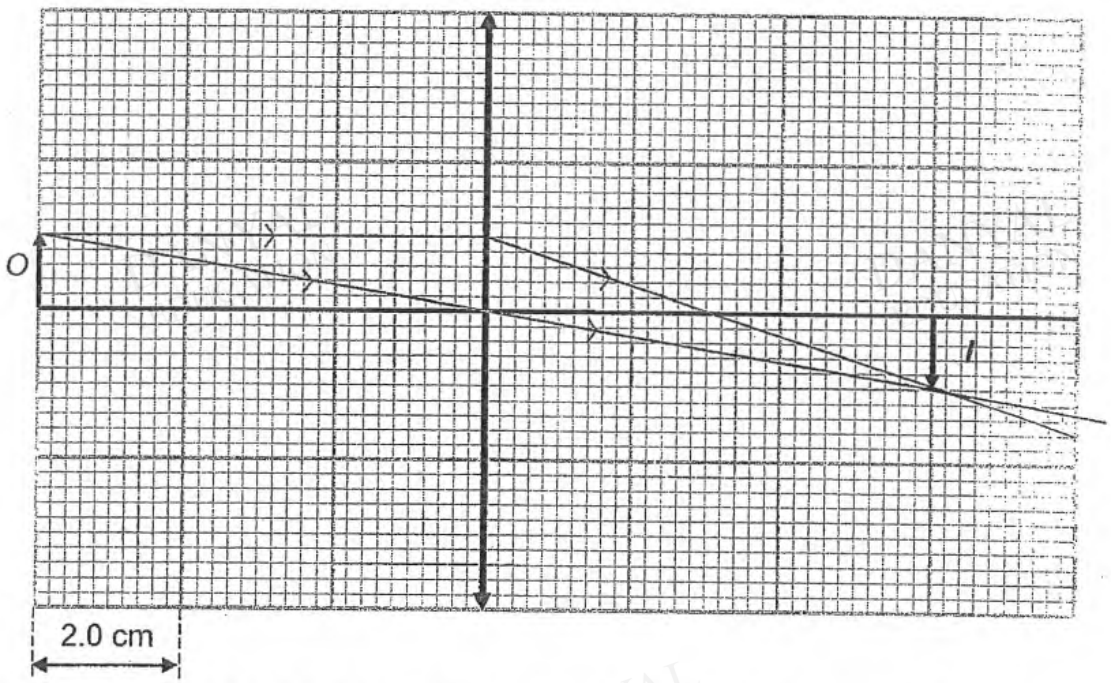
..... [2]

Answers

Light Test 1.0

Q1

(a)



Award 1 m for each ray drawn correctly. Do not penalize if arrows not drawn. B2
However deduct 1 mark for arrows drawn in wrong direction.

Award 1 m for object drawn and labelled correctly. B1
Deduct 1 mark if object is not drawn or not labelled.

(b) Virtual, upright and magnified B1

Q2

)(i) Light ray enters the glass block with angle of incidence of 0° / enters glass block perpendicularly/ Light ray lies along the normal at R

B1

(ii) $\sin c = \frac{1}{n} = \frac{1}{1.5}$ C1

$c = 41.8°$ A1

(iii) Light ray to be reflected back into glass block with angle of reflection of 58°. B1
Award mark as long as angle of reflection is labelled 58° regardless of its accuracy
Allow ECF from (c)(ii)

Q3

A student investigates the refraction of light when it travels from medium A to air. **Fig. 12.1** shows the arrangement of the apparatus.

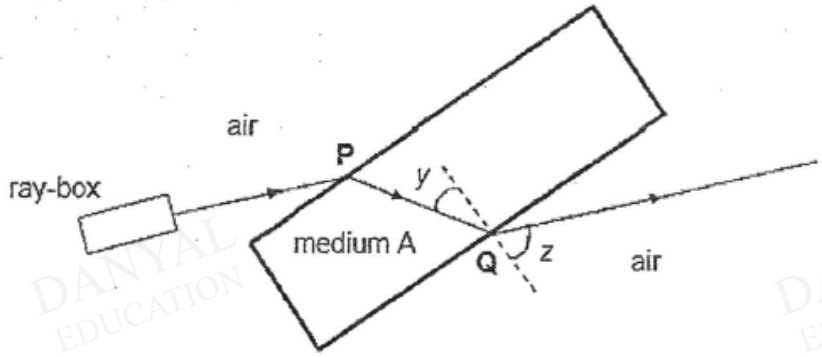


Fig. 12.1

The student uses a ray-box to direct a ray of light towards the boundary between the air and medium **A** at **P** so that it emerges through the other side at **Q**. After tracing the light rays, the student measures the angle *y* in medium A and the angle *z* in the air. He then changes the direction of the light ray at the boundary and measures the new angle y in medium A.

The table below shows his results.

Angle *y* in medium A	Angle *z* in the air
35 °	54 °
22 °	

Table 12.2

(a) Explain why the direction of light changes as it passes from glass into air. [2]

Speed of light increases as it passes from glass into air, which is optically denser. [B1: do not award marks if students mention that glass is denser, instead of optically denser] As the light is entering the glass block at an angle [B1], the path of light undergoes refraction and bends

(b) Using the data in **Table 12.2**, calculate the missing value for the angle *z* in the air.

n = sin i / sin r
= sin 54° / sin 35°
= 1.41 [M1]

n = sin z / sin r
1.41 = sin z / sin 22°
z = 31.9 °

[A1: answer to be given to 1 decimal place, minus 1 mark for wrong or missing unit]

angle *z* = _____ [2]

(c) Calculate the minimum angle *y* at which total internal reflection would occur.
Give the value of the minimum angle *y* to the nearest degree.

$c = \sin^{-1}(1 / n)$
$= \sin^{-1}(1 / 1.41)$
$= 45.2°$ [ECF1: student used the n calculated in (b)]
minimum angle $y \approx$ 46 ° [A1: minus 1 mark for wrong or missing unit]

minimum angle *y* = _____ [2]

(d) Hence, describe how the direction of the light at the boundary **Q** changes as angle y is increases from 20 ° to 60 °. [4]

20 ° ≤ y < 46 °: light undergoes **refraction** [B1], with some light undergoing **partial reflection**. As y increases, z increases.

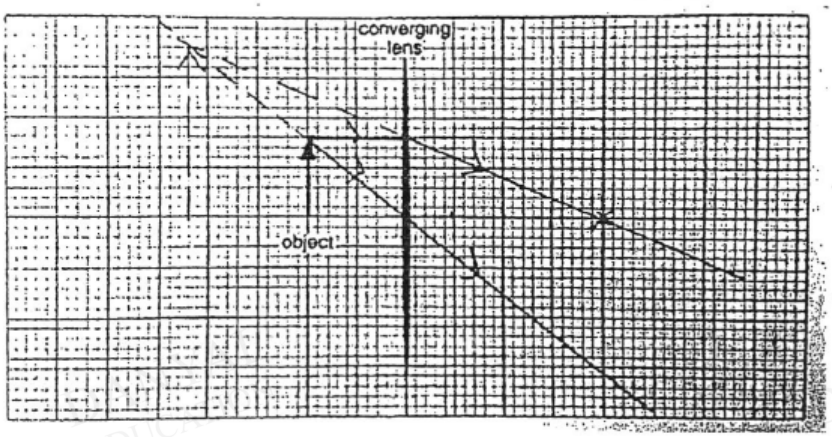
y = 46 ° (critical angle): **light travels along the glass-air boundary, angle of refraction = 90°** [B1]

46 °< y ≤ 60°: light undergoes **total internal reflection**[B1], **light is reflected back into the glass, where angle of incidence is equal to angle of reflection** [B1]

Q4

7a	n = sin i / sinr 1.5 = sin a / sin 30° a = 48.6°	1
b	B = critical angle = $\sin^{-1}(1/1.5)$ = 41.8 °	1
c	70° Total internal reflection occurs as angle i of 70°> c angle of 41.8°	1 1

Q5

5a		2
5b	(Upright, virtual magnified image to inverted real magnified image) From virtual to real image From upright to inverted image From image being on same side of lens as object to opposite side of lens (any 2)	 1 1