O Level Pure Physics Structured

Light Test 1.0

Q1

A collector views a postage stamp of height 1.5 cm through a lens. The lens is 2.0 cm from the stamp and the ratio of height of image to height of object is 3.0.

(a) In Fig. 6.1, complete the full scale ray diagram to determine the image of the stamp. [3]

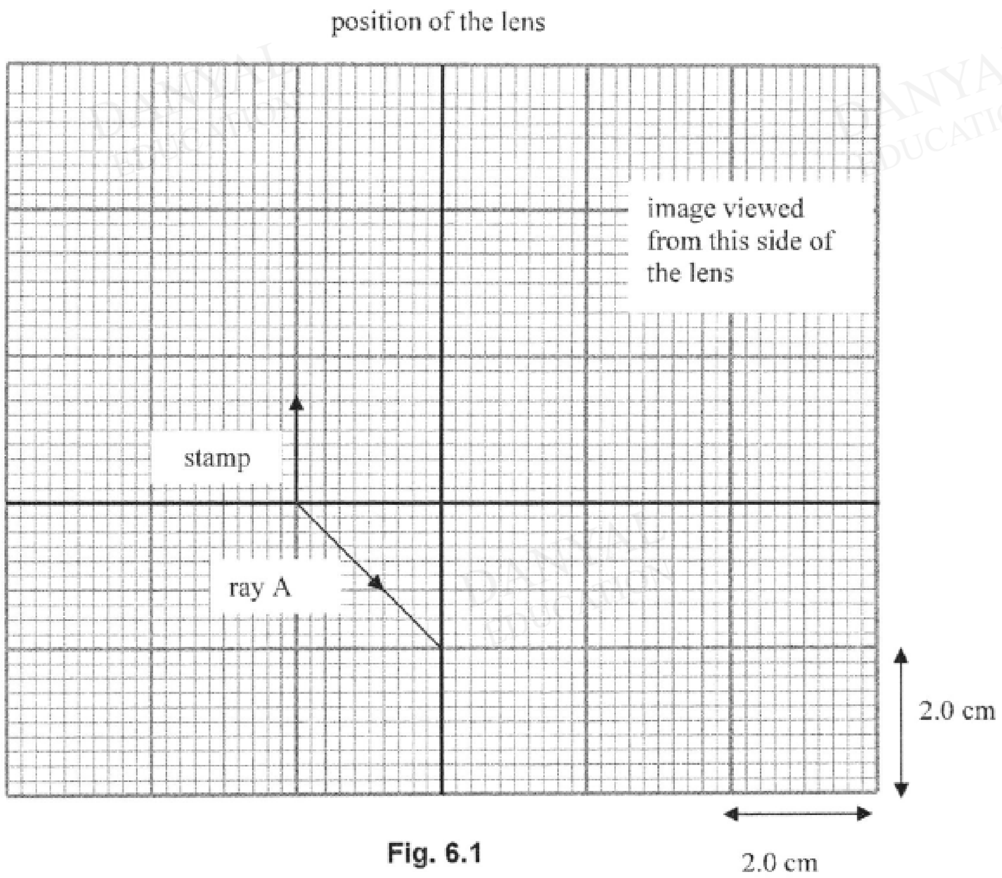


Fig. 6.1

(b) State what is meant by a virtual image.

....

.... [1]

(c) Use your drawing to determine the focal length of the lens.

focal length = ... [1]

(d) On Fig. 6.1, complete the path of ray A after passing through the lens. [1]

Q2

An object is placed in front of a thin converging lens and a real image is formed on the opposite side of the lens. The object distance is varied and the image distance is measured. A graph of the image distance against object distance is shown in Fig. 4.1.

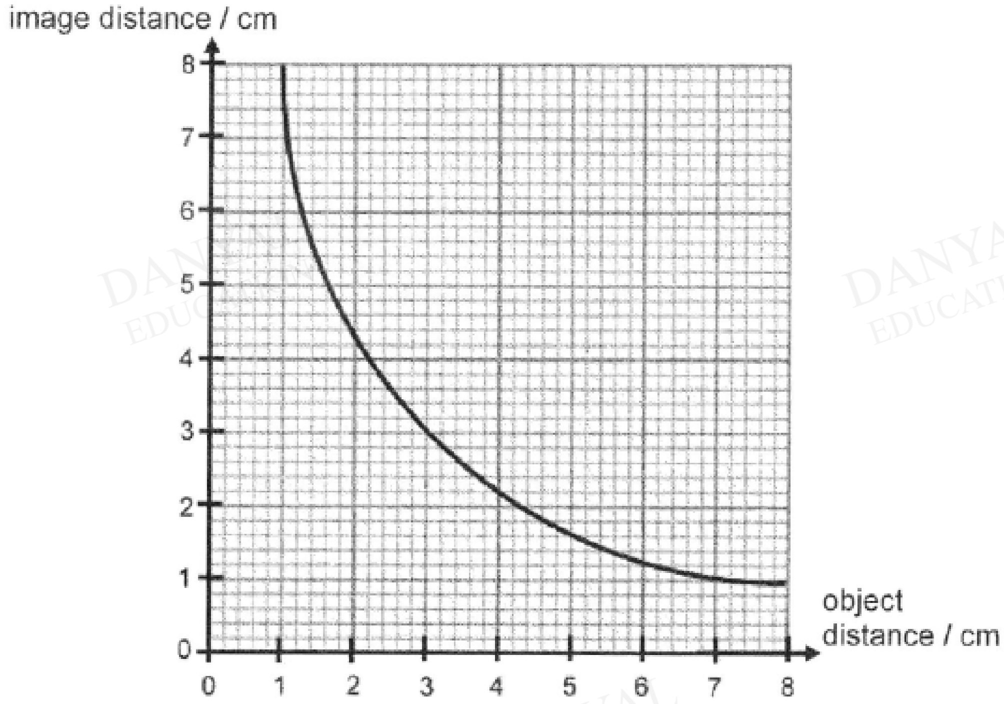


Fig. 4.1

(a) Determine the focal length from Fig. 4.1.

focal length = ________________ [1]

(b) Fig. 4.2 shows an incomplete full-scale ray diagram. Using data from Fig. 4.1, complete Fig.4.2 for the object when it is placed at a certain distance in front of the thin converging lens. Show the position the image (I) formed. [4]

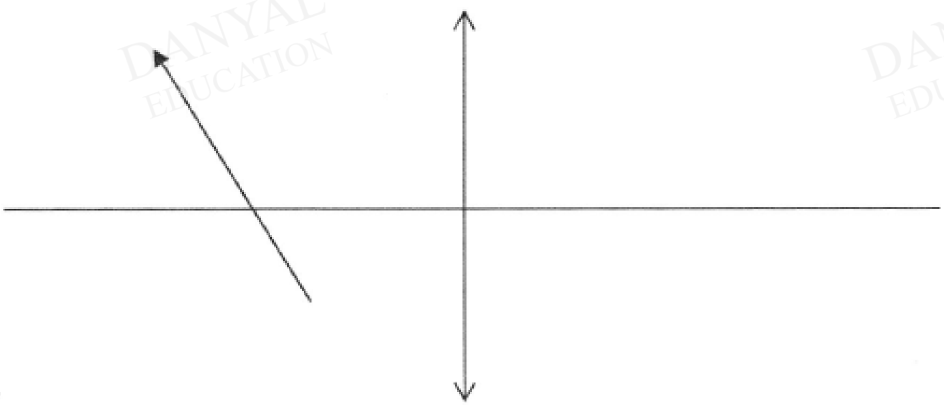


Fig. 4.2

Q3

Read the passage carefully and then answer the questions that follow.

Gemstones used in jewellery are known for several of their physical properties – primarily lustre and optical brilliance. Lustre is a measure of the amount of light that strikes a gemstone's surface and is reflected. Flat and smooth surfaces increase a gemstone's lustre. Light that is not reflected by a gem's lustrous surface passes into the stone. The brilliance of a gemstone is a measure of the amount of light entering the gem that is reflected back to the viewer. Precise techniques are used to cut gemstones into shapes that produce maximum brilliance. The combination of a specialised shape and the gemstone's inherent high refractive index gives gems their brilliance.

Refractive index is a measure of how much light is slowed/bent as it passes through a material. A higher value, or more 'bending power' means greater ability for the gem, with proper cutting, to re-route light back out to the observer rather than passing through the gem to the backside, and thus creating more total brilliance. A lower value means more light will 'pass through' or create a 'window' or see- through zone, as you tilt the stone or view it less than straight on. Thus, less brilliance because more light is simply escaping out the back of the gem rather than being captured and returned back out the front for you to see as light play and sparkle.

Thus, a gem's refractive index is very much a measure of its expected brilliance (assuming optimal cutting which must use matching angles and symmetry to maximise it).

Note that when a value is listed as with two values with a hyphen, it means the material is doubly refractive. In other words, the value from light entering the side is different than light entering the top.

material	**refractive index**
Diamond	2.42
Moissanite	2.65 ~ 2.69
Ruby	1.76 ~ 1.77
Sapphire	1.76 ~ 1.77
Emerald	1.57 ~ 1.60

Reference: https://betterthandiamond.com/pages/Listing-of-Gem-Refractive-Index-or-brilliance-potential.html

(a) State the two phenomena that occur to give a gem its brilliance. [2]

(b) Suggest a gem that can produce the maximum brilliance. Explain your choice. [3]

(c) Calculate the critical angle of diamond. [2]

(d) The speed of light through an unknown gemstone is 1.9×10^8 m/s. Identify the gemstone. Show all necessary working. [3]

Q4

A diamond, refractive index of 2.4, has an excellent cut where it has the shape shown at the sectional view in Fig. 7.1 with a certain percentage of the build to be the crown and pavilion. This cut allows light rays falling on the diamond to be reflected multiple times inside the diamond. A light ray is also shown emitting from the diamond at an angle 50° about the surface of the diamond.

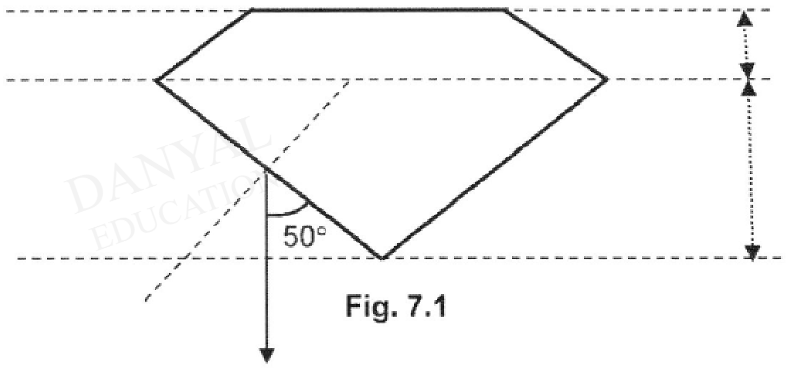


Fig. 7.1

(a) Suggest how does the cut of diamond allow light rays to be reflected multiple times. **[2]**

____

____

____

____

(b) (i) Calculate the critical angle of the diamond. **[2]**

(ii) Calculate the angle of incidence for the light ray that emits from the diamond shown in Fig. 7.1. **[2]**

Q5

Light enters a parallel-sided glass block at A. The angles between the side of the block and the ray of light in air is 35°.

The light then strikes the edge of the block at B. **Fig. 4.1** shows the ray of light and the glass block.

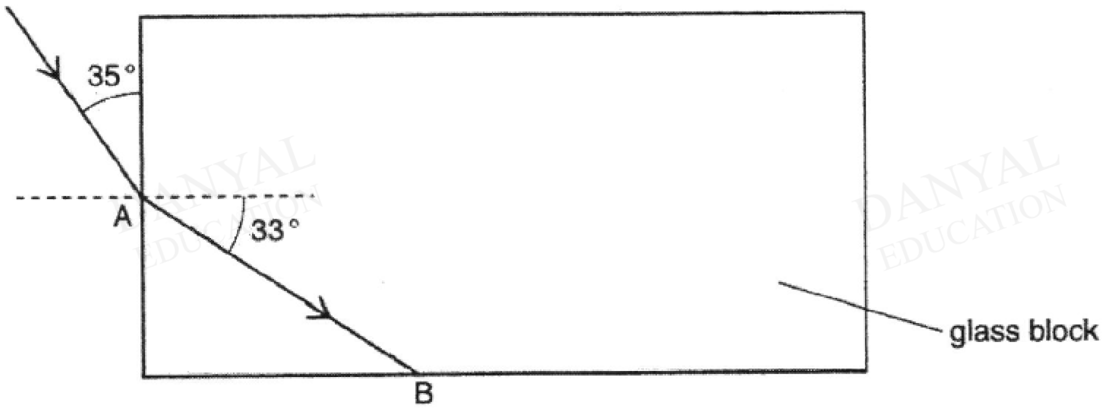


Fig. 4.1

The angle of refraction in the glass at A is 33°.

(a) Calculate the refractive index for light in the glass.

refractive index = ... [2]

(b) The light undergoes total internal reflection at B.

(i) State **two** conditions necessary for total internal reflection to occur.

....

....

....

....

....[2]

(ii) On **Fig. 4.1**, continue the ray (need not be drawn to scale) to show the path of the light after total internal reflection at B and until it leaves the block. [1]

Answers

Light Test 1.0

Q1

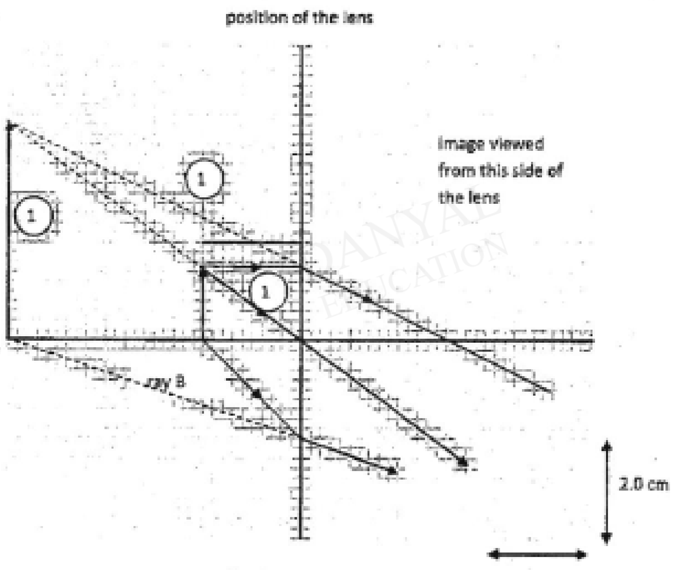
a	correct position (6 cm) or height for image (4.5cm) [A1] drawing of ray passing through centre of lens and extending backwards to meet image. [A1] correct drawing of second ray [A1]	
b	A virtual image is an image that cannot be formed on a screen [B1]	
c	f = 3.0 cm [B1]	
d	correct drawing using concept ray from bottom of object originate from bottom of image [B1]	

Fig. 6.1

Q2

4 (a)	2f = 3.0 cm focal length = 1.5 cm		[1]
(b)	1 ray passing through optical centre without bending 1 ray passing through focal point and parallel to principle axis	2 sets	[2]
	Correct drawing and position of image		[1]
	Correct arrows drawn (from O to I)		[1]

Q3

(a)	Refraction and total internal reflection	[2]
(b)	Moissanite A gem with high refractive index would have small critical angle. This means that there is higher probability for incident angles of light travelling from denser to less dense medium to be greater than critical angle. Hence, more total internal reflection of light could occur and these light rays will be refracted out to give the gems their brilliance.	[1] [1] [1]
(c)	$\sin c = \frac{1}{n} = \frac{1}{2.42}$ $c = 24.4°$	[1] [1]
(d)	n = speed of light in vacuum / speed of light in gemstone $= 3.0 \times 10^8 / 1.9 \times 10^8$ = 1.58 Emerald	 [1] [1] [1]

Q4

(a)	The cut allows **the angle of incidence in the diamond to be greater than the critical angle** thus allowing the light to experience **total internal reflection** multiple times.	B1 B1
(b)(i)	Sin c = 1 / 2.4 C = 24.6 °	
(ii)	sin i / sin r = 1/2.4 sin i / 40 = 1/2.4 Angle of incidence = 15.5 °	M1 A1

Q5

(a)	(n) = sin i/sin r = sin 55°/ sin 33° = 1.5(2 s.f.) or 1.50 (3 s.f)	[1] [1]
b)(i)	angle of incidence greater than critical angle light travels from denser to rarer medium	[1] [1]
b)(ii)	reflected ray in correct direction to edge of block **and** no second TIR	[1]