<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1. (a)</td><td>

(i)

1. The reflected ray, the incident ray, and the normal to the mirror at the point of incidence all lie in the same plane.
2. The angle of incidence is equal to the angle of reflection

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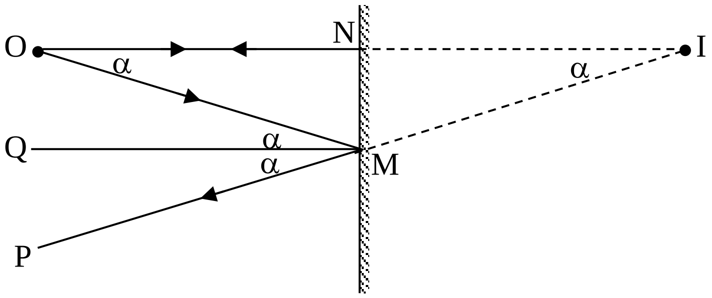
(ii)



A ray ON from O, normal to the mirror, is reflected back along NO.
Another ray OM is reflected at M at the same angle, α, to the normal QM and moves along MP.
The point I where the reflected rays appear to emerge from, is therefore the image of O
According to the geometry of the figure, ΔNOM is similar to ΔNIM and since the two triangles share a common side MN, ON must be equal to IN.
Thus, the image is as far behind the

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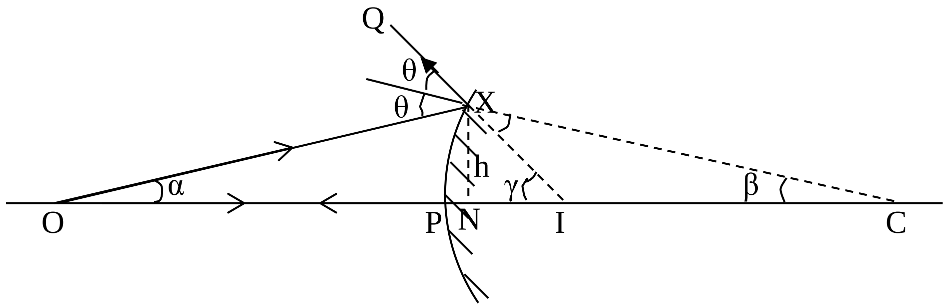
<tr><td>(b)</td><td>

(ii)



Consider a point object O on the principle axis of a convex mirror.
A ray OX from O is reflected along XQ.
A ray OP, incident at the pole P, is reflected back along PO and the point I where the two rays appear to emerge from is the virtual image of O.
The normal at X must be passing through the centre of curvature, C, of the mirror.
From the geometry of the figure

$$\theta = \alpha + \beta \text{ ....(1)}$$

$$\text{Also } \theta = \gamma - \beta \text{ ....(2)}$$

Therefore $\gamma - \beta = \alpha + \beta$

∴ $\gamma - \alpha = 2\beta$ ....(3)

Now α, β and γ are small angles, and if measured in radians,
$\alpha = \tan\alpha$, $\beta = \tan\beta$ and $\gamma = \tan\gamma$

So $\gamma = \dfrac{h}{IN} = \dfrac{h}{-IP}$ as I is virtual.

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</table>

$$\alpha = \frac{h}{ON} = \frac{h}{+OP} \quad \text{as O is real}$$ ½

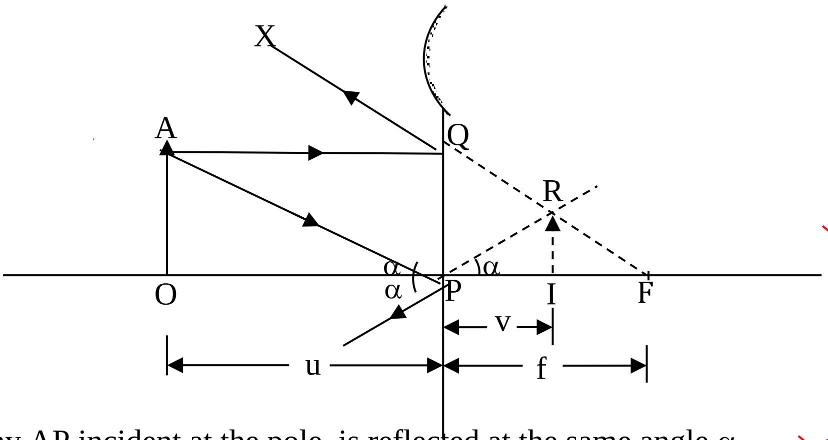
$$\beta = \frac{h}{NC} = \frac{h}{-PC} \quad \text{as C is virtual}$$

Substituting for α, β and γ in (3) $\frac{h}{-IP} - \frac{h}{+OP} = \frac{2h}{-PC}$ ½

So $\frac{1}{-IP} - \frac{1}{+OP} = \frac{2}{-PC}$

$$\therefore \quad \frac{1}{v} + \frac{1}{u} = \frac{2}{r} \quad \Rightarrow \quad \mathbf{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}} \quad \text{(since r =2f)}$$ ½

ALTERNATIVELY:
Take a point A on an object OA which is perpendicular to the principal axis.



A ray AP incident at the pole, is reflected at the same angle α.
Another ray AQ, parallel to the principal axis, is reflected along QX and appears to come from the principal focus F.
The reflected rays appear to come from R, which therefore is the image of A. So IR is the image of OA
Now ΔAOP is similar to ΔRIP.

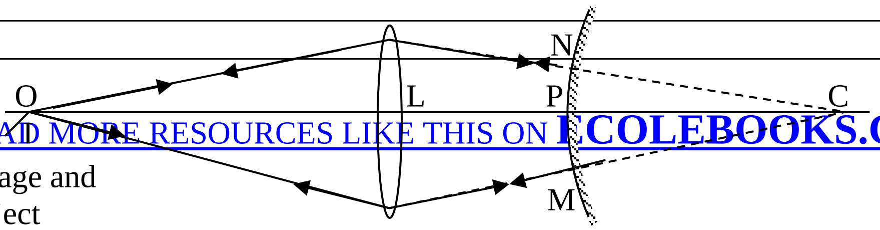
$$\therefore \quad \frac{IR}{OA} = \frac{IP}{OP} = \frac{-v}{u} \quad \ldots\ldots\ldots (1)$$

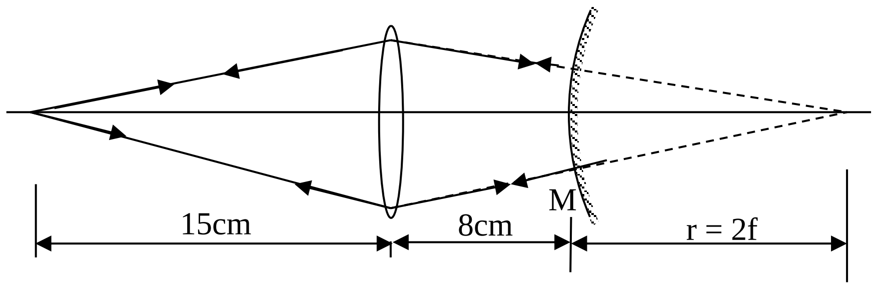
Also ΔQPF is similar to ΔRIF, and PQ = OA

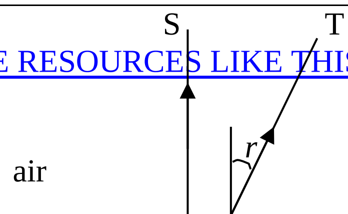
$$\therefore \quad \frac{IR}{OA} = \frac{IF}{PF} = \frac{-f-(-v)}{-f} = \frac{f-v}{f} \quad \ldots\ldots\ldots (2)$$

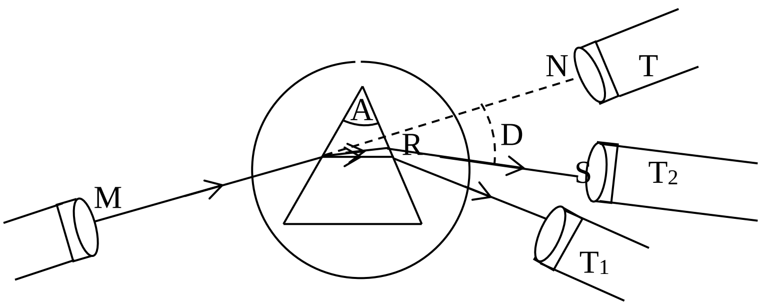
From (1) and (2) $\frac{-v}{u} = \frac{f-v}{f}$

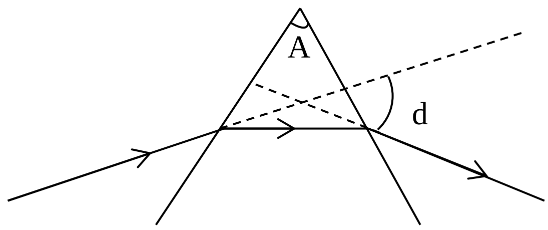
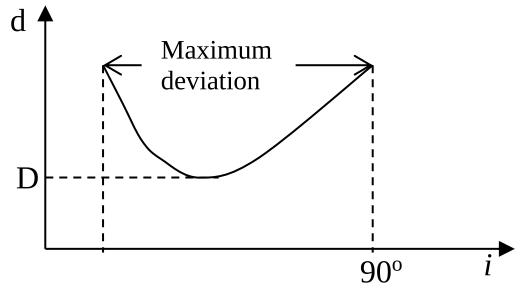
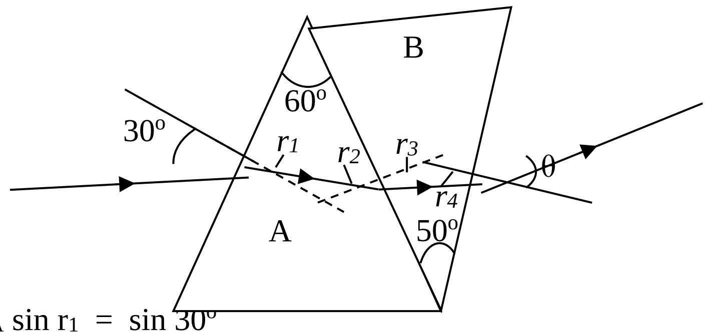
$$\therefore \quad \frac{-v}{u} = 1 - \frac{v}{f} \quad \text{from which} \quad \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$



(c)	(ii) - Using a convex lens L, a real image of an illuminated object O is formed at point C. Distance LC is noted. - The convex mirror is then placed between L and C with its reflecting surface facing the lens and is moved along the axis OC until a real image of O is formed at O. Distance LP is noted. Under these conditions the rays from O must be striking the mirror normally e.g. at M and N. Thus PC = r, the radius of curvature Now PC = LC – LP $\therefore$ r = LC – LP $\therefore$ focal length, f = $\frac{1}{2}$r = $\frac{1}{2}$(LC – LP)	1 1 ½ 1 ½ ½ ½
(d)	 For the convex lens $\frac{1}{8+2f} + \frac{1}{15} = \frac{1}{10}$ $\therefore \quad \frac{1}{8+2f} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$ $\therefore \quad 8 + 2f = 30$ $\therefore \quad f = 11$ $\therefore$ f = **-11 cm**	1 1 1 1
Total = 20		
2. (a)	(i) …the ratio of the velocity of light in vacuum to the velocity of light in the medium	1
	(ii) Consider an object O below the surface of the liquid of refractive index n.	



		1
	A ray OM from O perpendicular to the surface passes straight into the air along MS.	½
	A ray ON, very close to OM, is refracted at N away from the normal along NT so that to an observer directly overhead the object O appears to be at I.	½
	Now, nsin i = 1 x sin r	1
	i.e. $n = \frac{\sin r}{\sin i} = \frac{MN/IN}{MN/ON} = \frac{ON}{IN}$	½
	Since the observer is directly above O, the rays ON and IN are very close to the normal OM.	½
	Hence ON is approximately equal to OM and IN = IM. Thus $n = \frac{OM}{IM}$ **Therefore** $\mathbf{n = \frac{real\ depth}{apparent\ depth}}$	
	(iii) 	½
	- The spectrometer is first adjusted for use.	½
	- With no prism on the table, the telescope is turned to face the collimator in position T to view the image of the slit. The angular position of T is noted, say θ.	½
	- The prism under investigation is placed on the spectrometer table, with its refracting angle A pointing away from the collimator- see figure.	½
	- The telescope is then turned until an image of the slit is observed on the cross-wires when the telescope is in position T_1.	½

	- The table is then slowly rotated to decrease the angle of incidence, while keeping the image of the slit on the cross-wires by moving the telescope at the same time. Now both the image of the slit and the telescope are approaching the fixed line MN. At a certain position corresponding to T_2 the image of the slit begins to reverse. The angular position T_2 is noted, say θ_2. This is when the emergent ray RS makes an angle D with MN. D is the angle of minimum deviation and it is equal to $(\theta_2 - \theta)$	1 ½ 1
(b)	(i)  d = deviation	1
	(ii) 	1
	(iii) The minimum deviation, D, is read off from the grph Then the refractive index, n $= \dfrac{\sin i}{\sin r} = \dfrac{\sin \frac{1}{2}(\theta + D)}{\sin \frac{1}{2}\theta}$	1 1
(c)	 $n_A \sin r_1 = \sin 30^o$ $\therefore \sin r_1 = \dfrac{\sin 30^o}{1.51} = 0.331$ $\therefore r_1 = 19.3^o$ Now $r_2 = 60^o - r_1 = 40.7^o$ And $n_B \sin r_3 = n_A \sin r_2$ $\therefore \sin r_3 = \dfrac{n_A \sin r_2}{n_B} = \dfrac{1.51 \sin 40.7^o}{1.62} = 0.608$ $\therefore r_3 = 37.4^o$	1 1 1 1 1

<table>
<tr><td></td><td>$\therefore\ r_4 = 50^o - r_3 = 50^o - 37.4^o = 12.6^o$
Now, $\sin\theta = n_B \sin r_4 = 1.62 \sin 12.6^o = 0.353$
$\therefore\quad \theta = \underline{\mathbf{20.7^o}}$</td><td>1</td></tr>
<tr><td>3. (a)</td><td>(i) Frequency is the number of vibrations per second.
Amplitude is the maximum displacement of a vibrating particle from the equilibrium position.</td><td>1

1</td></tr>
<tr><td></td><td>(ii)
Any two @1
<table>
<tr><th>PROGRESSIVE</th><th>STATIONARY</th></tr>
<tr><td>Profile of the wave moves</td><td>Profile of the wave is stationary</td></tr>
<tr><td>Neighbouring particles along the direction of the wave vibrate out of phase</td><td>There are segments in which all the particles vibrate in phase</td></tr>
<tr><td>Particles vibrate with the same amplitude</td><td>The amplitude of the particles varies along the direction of the wave</td></tr>
<tr><td>Energy is transmitted</td><td>No energy is transmitted.</td></tr>
</table></td><td>2</td></tr>
<tr><td>(b)</td><td>(i)
The equation is of the form $y = a \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$
So $\lambda = 1.5$ m and $T = 0.2$ s
$\therefore$ speed, $v = \frac{\lambda}{T} = \frac{1.5}{0.2}$
$= \mathbf{7.5\ m\ s^{-1}}$</td><td>1

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1</td></tr>
<tr><td></td><td>(ii) The maximum velocity of the particles, $v_{max} = \omega a$
$= 2\pi fa$
$= 2\pi \times 5a = 10\pi a$</td><td>1
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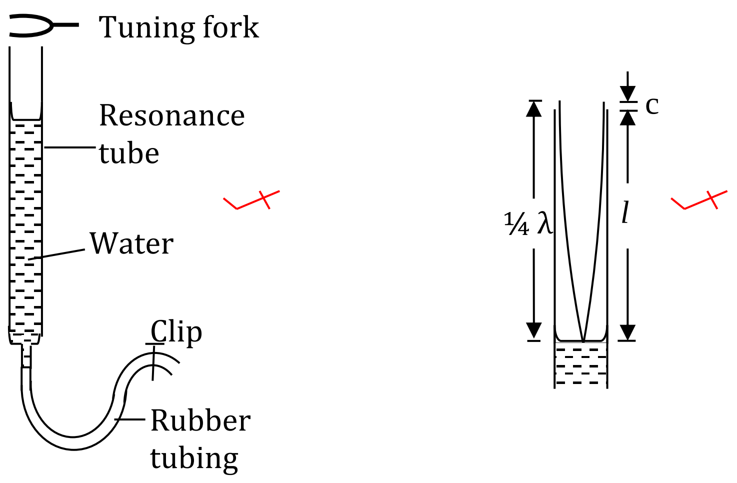
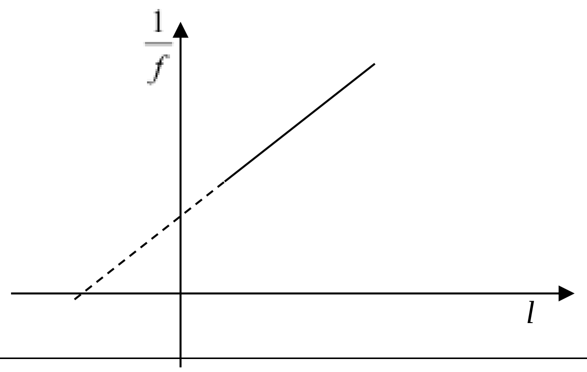
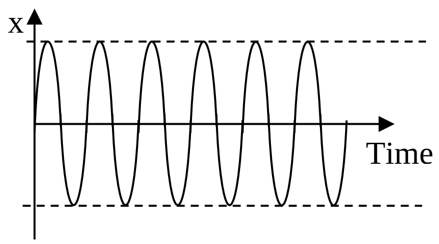
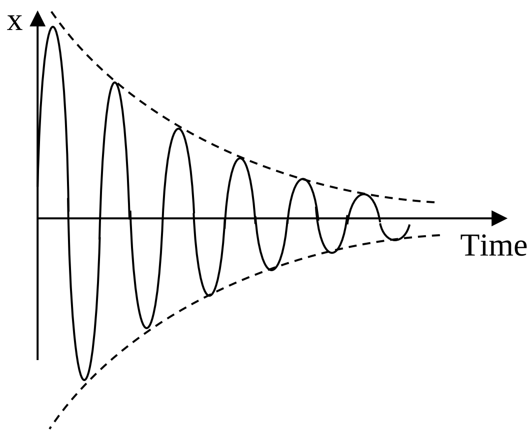
1</td></tr>
<tr><td>(c)</td><td>(ii)


- A resonance tube is almost filled with water
- A tuning fork is sounded near and above the mouth of the tube while the water level is allowed to fall gradually until resonance occurs.
- Then the length, l, of the air column is measured.</td><td>1</td></tr>
</table>

	Then $l + c = \frac{1}{4}\lambda$, where c is the end correction.	½
	But $\lambda = \frac{V}{f}$, where V is the velocity of sound in air and f is the frequency of the tuning fork.	1 ½
	$\therefore \quad l + c = \frac{V}{4f}$	½
	The procedure is repeated with tuning forks of different frequencies and a graph of $\frac{1}{f}$ against l is plotted.	½
	 Gradient $= \frac{4}{V}$ $\therefore V = \frac{4}{gradient}$	1 1
(d)	Free Oscillation – the amplitude is constant	½
		1
	Damped Oscillation – The amplitude decreases with time	½
		1
	1	
4. (a)	(i)	
