Physicsaholics

DPP – 4 (Wave Optics)

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Q 1. Unpolarized light is incident on a plane glass surface. What should be the angle of incidence so that the reflected and refracted rays are perpendicular to each other? (Given refractive index of glass, n=1.5)

(a) $\sin^{-1} 1.5$ (b) $\tan^{-1} 1.5$

(c) $\cos^{-1} 1.5$ (d) $\sin^{-1} \frac{2}{3}$

Q 2. Light waves can be polarized as they are

(a) Transverse (b) Of high frequency

(c) Longitudinal (d) Reflected

Q 3. In the case of linearly polarized light, the magnitude of the electric field vector

(a) Is parallel to the direction of propagation

(b) Does not change with time

(c) Increases linearly with time

(d) Varies periodically with time

Q 4. The angle of polarization for any medium is 60°, what will be critical angle for this

(a) $\sin^{-1} \sqrt{3}$ (b) $\tan^{-1} \sqrt{3}$

(c) $\cos^{-1} \sqrt{3}$ (d) $\sin^{-1} \frac{1}{\sqrt{3}}$

Q 5. A polaroid is placed at 45° to an incoming light of intensity I_0. Now the intensity of light passing through polaroid after polarization would be

(a) I_0 (b) $\frac{I_0}{2}$

(c) $\frac{I_0}{4}$ (d) zero

Q 6. Unpolarized light falls on two polarizing sheets placed one on top of the other. What must be the angle between the characteristic directions of the sheets if the intensity of the transmitted light is one third of intensity of the incident beam ?

(a) $\tan^{-1}\left(\sqrt{\frac{3}{2}}\right)$ (b) $\sin^{-1}\left(\sqrt{\frac{3}{2}}\right)$

(c) $\cos^{-1}\left(\sqrt{\frac{2}{3}}\right)$ (d) $\sin^{-1}\left(\sqrt{\frac{1}{3}}\right)$

Q 7. Unpolarized light of intensity I_0 is incident on a polarizer and the emerging light strikes a second polarizing filter with its axis at 45° to that of the first. The intensity of the emerging beam

(a) $\frac{I_0}{2}$ (b) $\frac{I_0}{4}$

(c) I_0 (d) $\frac{I_0}{3}$

Q 8. A beam of the plane polarized light having flux 10^{-3} watt falls normally on a polarizer of a cross sectional area $3\times 10^{-4}\ m^2$. The polarizer rotates with an angular frequency of 31.4 rad/s. The energy of the light passes through the polarizer per revolution will be

(a) 10^{-4} J (b) 10^{-3} J

(c) 2×10^{-4} J (d) 3×10^{-4} J

Q 9. The angle between pass axis of polarizer and analyzer is 45°. The percentage of polarized light passing through analyzer is

(a) 100 % (b) 50 %

(c) 25 % (d) 75 %

Q 10. A ray of light is incident on the surface of a glass plate at an angle of incidence equal to Brewster's angle θ. If μ represents the refractive index of glass with respect to air, then the angle between reflected and refracted rays is

(a) 90°+θ (b) $\sin^{-1}(\mu\cos\theta)$

(c) 90° (d) $90°-\sin^{-1}\left(\sin\frac{\theta}{\mu}\right)$

Q 11. Polarized glass is used in sun glasses because

(a) It reduces the light intensity to half an account of polarization

(b) It is fashionable

(c) It has good colour

(d) It is cheaper

Q 12. A light has amplitude A (after polarizer) and angle between analyzer and polarizer is 60°. Light is reflected by analyzer has amplitude

(a) $A\sqrt{2}$ (b) $\frac{A}{\sqrt{2}}$

(c) $\frac{\sqrt{3}A}{2}$ (d) $\frac{A}{2}$

Q 13. When a plane polarized light is passed through an analyzer and analyzer is rotated through 90°, the intensity of the emerging light

(a) Varies between maximum and zero

(b) Becomes zero

(c) Does not vary

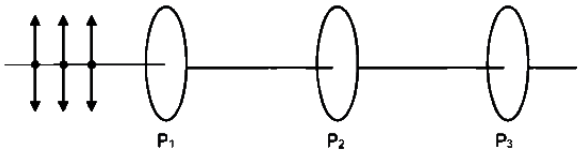
(d) cant say anything

Q 14. When the angle of incidence on a material is 60°, the reflected light is completely polarized. The velocity of the refracted ray inside the material is (in m/s)

(a) 3×10^8 (b) $\frac{3}{\sqrt{2}}\times 10^8$

(c) $\sqrt{3}\times 10^8$ (d) 0.5×10^8

Q 15. Unpolarized light beam of intensity I_0 is incident on polaroid P_1. The three polaroids are arranged in such a way that transmission axis of P_1 and P_3 are perpendicular to each other. Angle between the transmission axis of P_2 and P_3 is 60°. The intensity of the beam coming out from P_3 will be

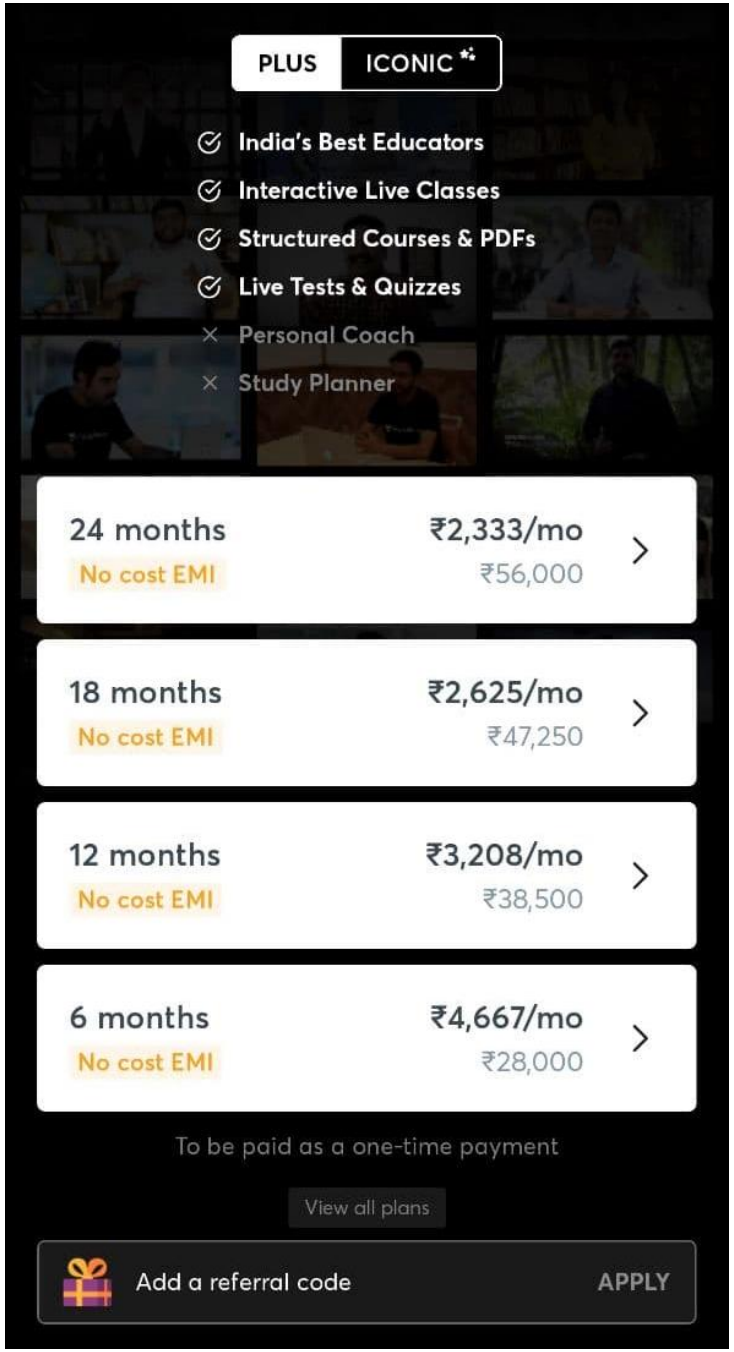


(a) $\frac{I_0}{2}$ (b) $\frac{3I_0}{8}$

(c) $\frac{3I_0}{32}$ (d) $\frac{3I_0}{64}$

Answer Key

Q.1 b	**Q.2 a**	**Q.3 d**	**Q.4 d**	**Q.5 b**
Q.6 c	**Q.7 c**	**Q.8 a**	**Q.9 b**	**Q.10 c**
Q.11 a	**Q.12 d**	**Q.13 a**	**Q.14 c**	**Q.15 c**



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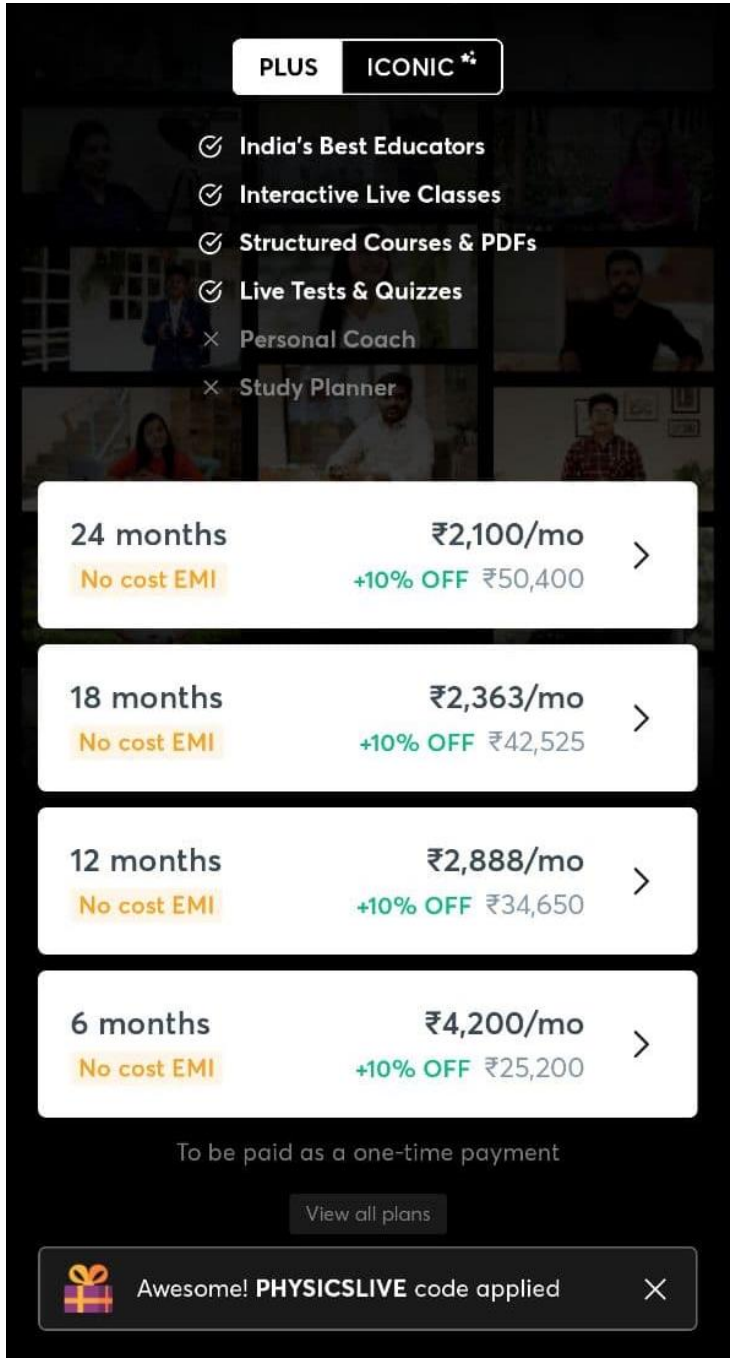


Written Solution

DPP-4 Wave Optics: Polarization

By Physicsaholics Team

Solution: 1

if reflected & refracted rays are perpendicular then;

$\tan\theta = \mu$ ⟶ (Brewster's Law)

$\tan\theta = 1.5$

$\theta = \tan^{-1}(1.5)$

Ans. b

Solution: 2

Polarization of light waves is possible only because they can oscillate in more than one orientation i.e., they are transverse in nature. It has no dependence on its wavelength and frequencies.

Ans. a

Solution: 3

In any type of light whether polarized or unpolarized, the magnitude of electric field vector always varies periodically with time.

Ans. d

Solution: 4

From Brewston's Law

$\theta_p = 60^\circ$

then $\tan\theta_p = \mu$

$\mu = \tan 60^\circ$

$\boxed{\mu = \sqrt{3}}$

Now for critical angle

$\sin\theta_c = \frac{1}{\mu}$

$\sin\theta_c = \frac{1}{\sqrt{3}}$

$\boxed{\theta_c = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)}$ Ans.

Ans. d

Solution: 5

$I_p = I_0 \cos^2\theta$

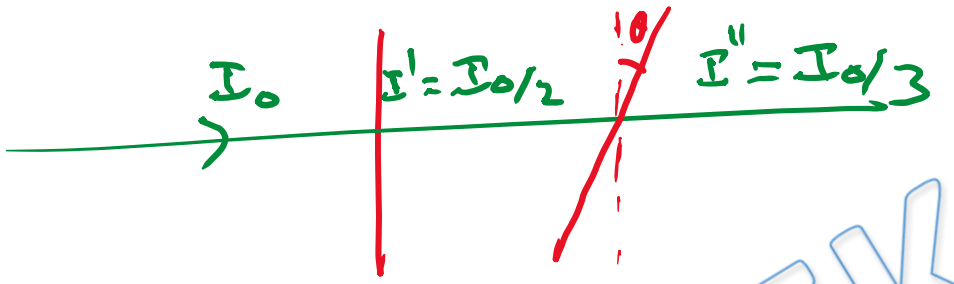
$I_p = I_0 \cos^2 45^\circ$

$= I_0 \left(\frac{1}{\sqrt{2}}\right)^2$

$\boxed{I_p = \frac{I_0}{2}}$ Ans.

Ans. b

Solution: 6



$$I'' = I' \cos^2\theta$$

$$\frac{I_0}{3} = \frac{I_0}{2}\cos^2\theta$$

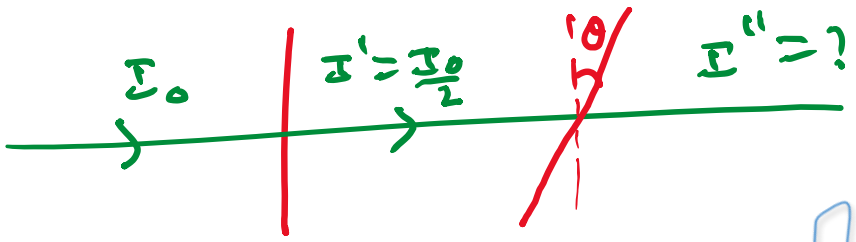
$$\frac{2}{3} = \cos^2\theta$$

$$\cos\theta = \sqrt{\frac{2}{3}}$$

$$\boxed{\theta = \cos^{-1}\left(\sqrt{\frac{2}{3}}\right)} \quad \text{Ans.}$$

Ans. c

Solution: 7



$\theta = 45^\circ$

$I'' = I' \cos^2\theta$

$I'' = \left(\frac{I_0}{2}\right) \cos^2(45^\circ)$

$I'' = \frac{I_0}{2} \times \left(\frac{1}{\sqrt{2}}\right)^2$

$\boxed{I'' = \frac{I_0}{4}}$ Ans.

Ans. b

Solution: 8

$P = 10^{-3}$ watt

$T = \frac{2\pi}{\omega} = \frac{2\pi}{31.4} = \frac{2 \times 3.14}{31.4} = \frac{2}{10} = 0.2$ sec

Let incident on polarizer $= E_i$

then; $P = \frac{E_i'}{t}$

$E_i = Pt = 10^{-3} \times 0.2 = 2 \times 10^{-4}$ J

as if incident intensity $= I_i$

then average intensity passed through polarizer in one cycle $= \langle I \rangle = \langle I_i \cos^2\theta \rangle$

$= I_i \langle \cos^2\theta \rangle$

$= \frac{I_i'}{2}$

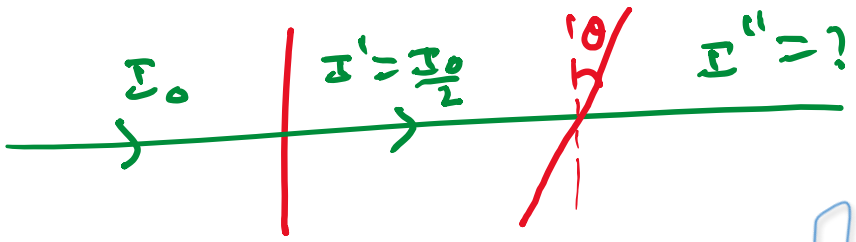
so; Energy passed through polarizer $= E_0 = \frac{E_i'}{2}$

$E_0 = \frac{2 \times 10^{-4}}{2} = 10^{-4}$ J

$\boxed{E_0 = 10^{-4} \text{ J}}$ Ans

Ans. a

Solution: 9



$$I'' = \left(\frac{I_0}{2}\right)\cos^2 45^\circ$$

$$= \frac{I_0}{2} \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$\boxed{I'' = \frac{I_0}{4}}$$

% of Polarized light passing through analyzer $= \frac{I''}{I} \times 100 = \frac{I_0/4}{I_0/2} \times 100$

$$= \frac{1}{2} \times 100$$

$$= 50\% \quad \text{Ans.}$$

Ans. b

Solution: 10

At polarizing/Brewster's angle, the reflected and refracted rays are mutually perpendicular to each other.

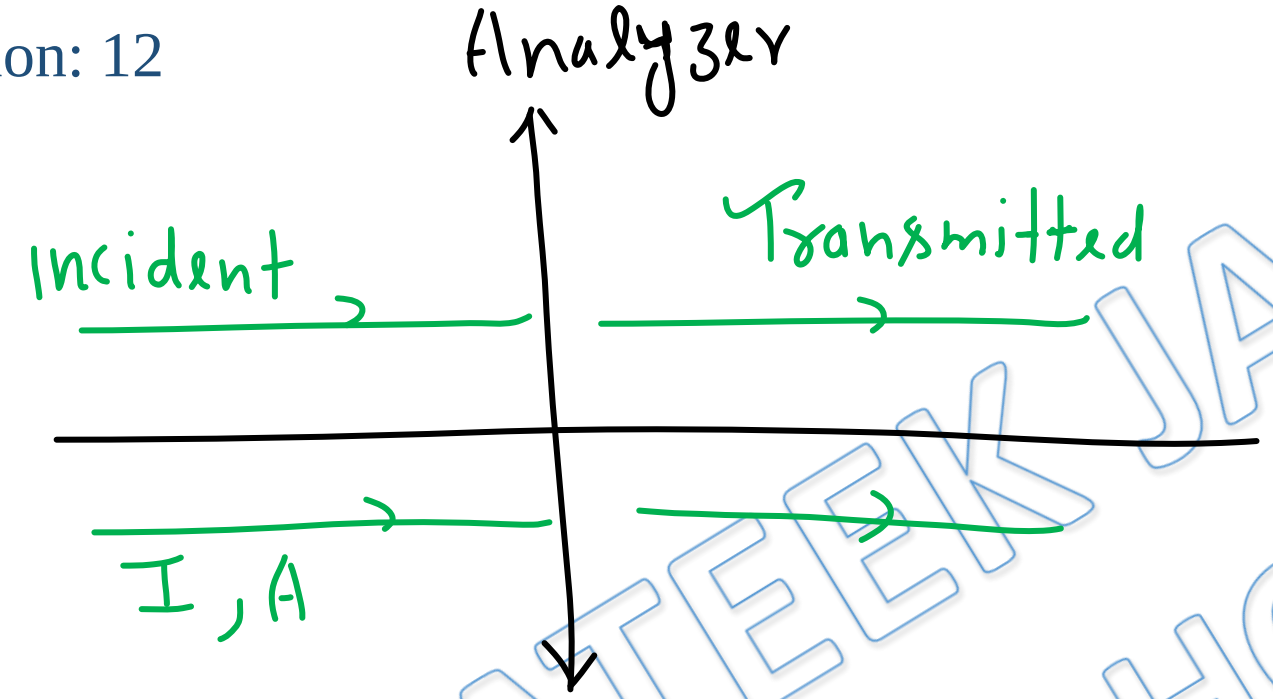
Ans. c

Solution: 11

It reduces the light intensity to half an account of polarization.

Ans. a

Solution: 12



Intensity of transmitted light $= I\cos^2 60^\circ = \frac{I}{4}$

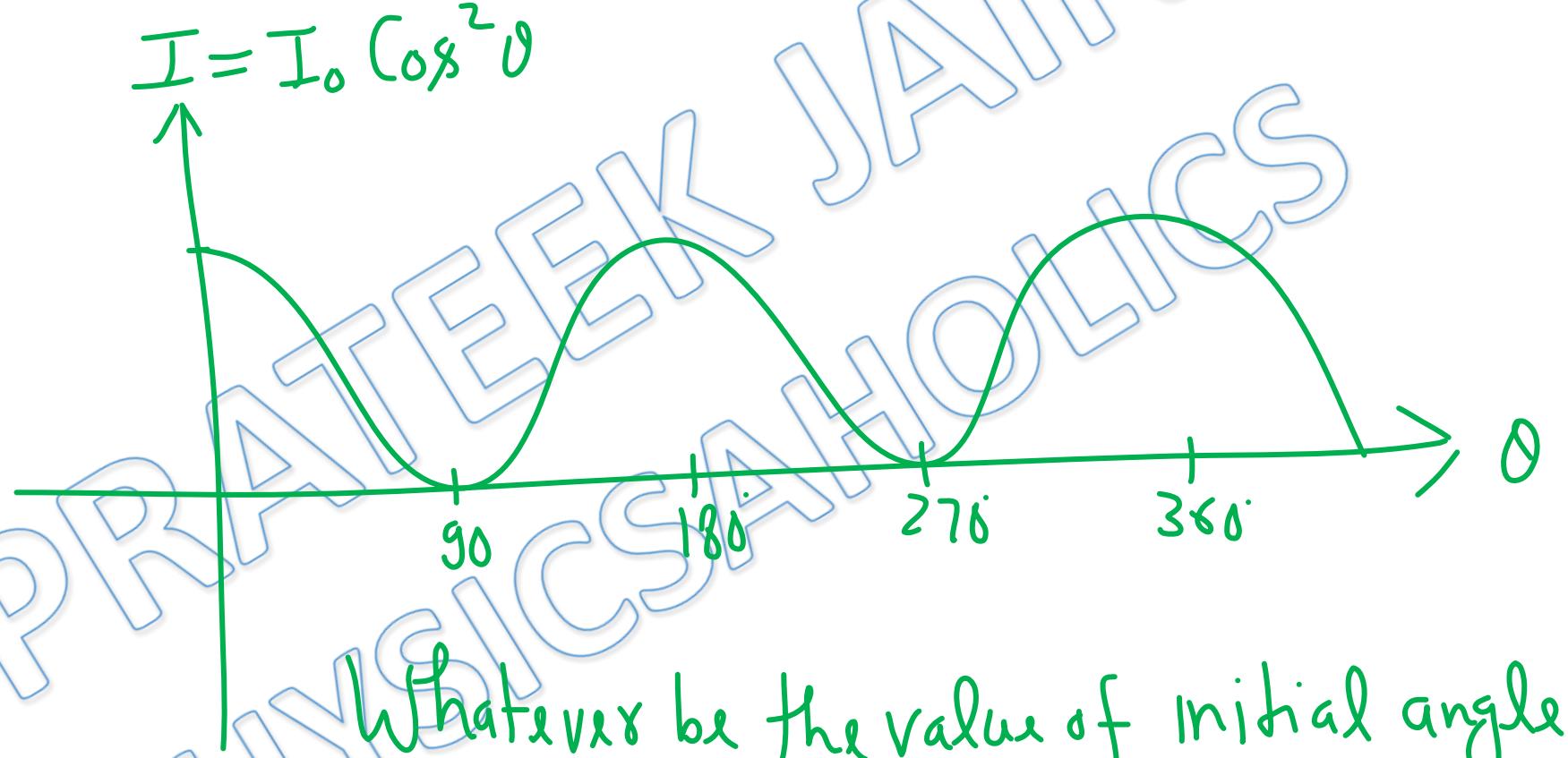
" " reflected " $= \frac{3I}{4}$

Amplitude of reflected light $= \frac{\sqrt{3}A}{2}$ $\left(\text{As } I \propto A^2\right)$

ANS(C)

Solution: 13

the intensity of the emerging light varies between maximum and zero.



Whatever be the value of initial angle, There will be a maxima & zero intensity in a angle variation of 90°.

Ans. a

Solution: 14

if reflected ray is completely polarized

$\theta = \theta_p$

$\rightarrow \tan\theta_p = \mu$

$\tan 60^\circ = \mu$

$\boxed{\mu = \sqrt{3}}$

so, speed of refracted light

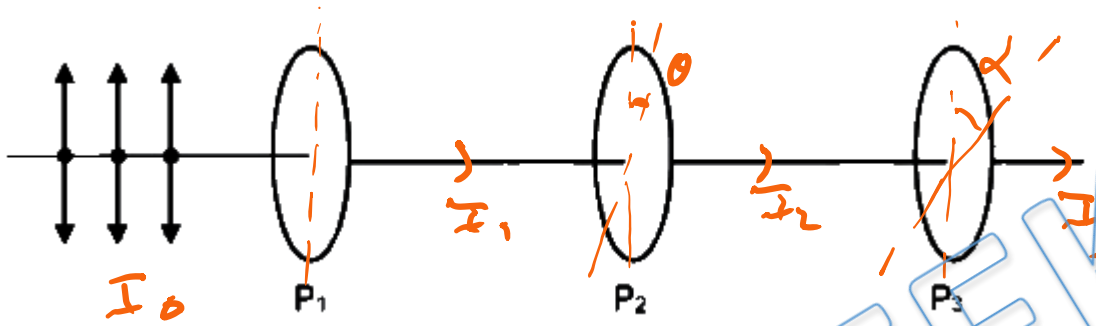
$v = \frac{c}{\mu}$

$v = \frac{3\times10^8}{\sqrt{3}}$

$\boxed{v = \sqrt{3}\times10^8 \text{ m/s}}$ Ans.

Ans. c

Solution: 15



$\alpha = 90°$

$\alpha - \theta = 60°$

$\Rightarrow \theta = 30°$

$$I_1 = \frac{I_0}{2}$$

$I_2 = I_1 \cos^2 30°$

$$I_2 = \frac{I_0}{2}\left(\frac{\sqrt{3}}{2}\right)^2$$

$$I_2 = \frac{3I_0}{8}$$

$\Rightarrow I_3 = I_2 \cos^2 60°$

$$I_3 = \frac{3I_0}{8}\left(\frac{1}{2}\right)^2$$

$$I_3 = \frac{3I_0}{32}$$ Ans

Ans. c

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