2020

PHYSICS

[HONOURS]

Paper : II

Full Marks : 75 Time : 4 Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

1. Answer any **five** questions from the following: 1×5=5

a) The stationary waves on a string is represented by $y(x, t) = 0.15 \sin 5x \cos 300tm$. Find the

i) Distance between two consecutive nodes

ii) Wave length of the wave.

b) Define principal plane and nodal plane.

c) What is ellipsoidal mirror and where is it used in our daily life?

d) Write down the condition of achromatism of two lenses separated by a distance and also state the condition if the lenses are the same material.

e) In Lissajous figure how can the clockwise and anticlockwise direction of motion in the elliptic path be ascertained from the equations defining the component motion?

f) Define absorptive and dispersive amplitude for the steady state motion in forced vibration.

g) 'The transverse waves are also known as shear waves.' Why? Where such waves are generally occurred?

2. Answer any **six** questions from the following: 2×6=12

a) Prove that under certain condition, superimposition of two waves propagating in opposite direction along any axis, the resultant wave consist of a stationary wave and a progressive wave.

b) Explain what is 'optimum reverberation time'.

c) What is the distinction between the dispersive power and the refracting power of a material?

d) Show that if the sizes of the images in the two position of the lens are y_1 and y_2, then the size of the object will be $y = \sqrt{y_1 y_2}$.

e) What are conditions for application of the matrix method in geometrical optics?

f) What do you mean by 'principle of independence' and 'principle of reversibility'?

Which of the principle gives the idea of conjugate foci?

g) Define stiffness-controlled, mass controlled and resistance controlled motion of a harmonic oscillator executing forced vibration.

h) Distinguish between the energy density and the intensity of the sound wave.

i) With proper justification mention the physical dimension of a low-pitched tuning fork.

j) Define 'bel' and distinguish it from 'phon'.

3. Answer any **three** questions from the following: 6×3=18

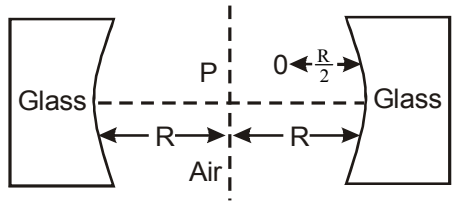
a) i) Define three basic laws for ray optics.

ii) Establish Smith-Helmholtz equation and hence Lagrange's law.

iii) Show that the deviation produced by a thin lens is independent of the position of the object. 1+3+2

b) i) Establish laws of refraction at a spherical surface using Fermat's Principle.

ii) Two concave refracting surfaces of equal radii of curvature and refractive index 1.5 face each other in air as show in figure.



A point object is placed mid-way between the centre and one of the vertices. What is the separation between the images of O formed by each refracting surface? 3+3

c) i) Show that the amplitude 'A' of the displacement resulting from the superposition of 'N'SHMs, all of the same amplitude 'a' and frequency 'ω' but having different phase angles of $\delta_1 = \varepsilon,\ \delta_2 = 2\varepsilon, \ldots, \delta_N = N\varepsilon$ is given by

$$A = \frac{a \sin(N\varepsilon/2)}{\sin(\varepsilon/2)}.$$

ii) The phase velocity of deep water waves is given by $c^2 = \frac{g\lambda}{2\pi} + \frac{2\pi S}{\rho\lambda}$, where g is the gravitational acceleration, ρ is the density of water, S is the surface tension of water. Find the wave length λ_0 at

which the waves do not disperse in water and show that for $\lambda \ll \lambda_0$, group velocity $= 3c/2$. 3+3

d) i) Obtain an expression for the displacement in a damped oscillatory motion.

ii) Consider the following equation which represents the equation of motion of a weakly damped harmonic oscillator driven by a constant external force

$$F_0 : m\ddot{x} + R_m\dot{x} + Sx = F_0 .$$

Solve the equation for small damping and sketch graphically the nature of variation of x with t. 3+3

e) i) In an experiment with Kund's tube it is found that the distance between two consecutive antinodes are 3.46 cm and 3.16 cm for the tube filled with air and argon respectively. Density of air and argon are $1.29\,kg/m^3$ and $1.78\,kg/m^3$. From these datas, show that argon is a monatomic gas.

ii) Show that the acoustic pressure and dilation satisfy the differential wave equation. 3+3

4. Answer any **four** questions from the following: 10×4=40

a) i) Establish the relation between the object distance and image distance for refraction at a single spherical surface separating two media. Hence derive the lens maker's formula.

ii) An object P is placed at a distance of 40 cm in front of a convex lens (O_1) of focal length 20cm. Behind the convex lens, a concave lens (O_2) of focal length 10cm is placed at a distance of 15cm from the convex lens. Find the cardinal points of the lens system and the position of the final image from the centre of the second image. 5+5

b) i) Consider a plano-convex lens of a material of refractive index 1.5. The convex surface has a radius of curvature of 2.5cm and is facing the incident light. The centre thickness of the lens is 0.6cm. Construct the system matrix.

ii) Discuss how the spherical aberration of a lens can be made minimum in the case of a thin lens by adjusting the radii of curvature of its surface.

iii) Find the radii of curvature of a double convex lens of focal length 20cm which shows minimum spherical aberration. Take the refractive index n=1.5.

4+4+2

c) i) Describe different parts of a modern microscope. On what factors does its magnifying power depends?

ii) The refractive indices of crown glass for red and violet lights are 1.517 and 1.523, respectively and the corresponding values for dense flint glass are 1.650 and 1.664 respectively. A plano-convex achromatic doublet of focal length 50cm is designed. Find the focal lengths of lenses of different materials with mentioning their type. Also determine the radii of different surfaces. 5+5

d) i) A particles executes S.H.M. with a time-period T_1 under one constraining force and with time period T_2 under another. Show that the time-period when both the constraining force act together is given by $T = T_1 T_2 \sqrt{\frac{1}{T_1^2 + T_2^2}}$.

ii) Compare between amplitude resonance and velocity resonance.

iii) The angular frequency of vibration of a Co-molecule is 6×10^{15} s^{-1}. Calculate the work required for streching it by $0.5\,\overset{0}{A}$ from its equilibrium position.

3+4+3

e) i) Prove that the acoustic intensity for a plane wave is the product of the rms acoustic pressure and the rms particle velocity.

ii) The intensity level in a conversation is 70 dB above the threshold of 10^{-12} W/m^2. Calculate the amplitude of vibration of the air particles in the sound wave. Given: Velocity of sound=350 m/s, density of air=1.25g/litre, mean frequency=500 Hz.

iii) What is a piezoelectric crystal? Explain briefly how such a crystal can be used for the generation of ultrasonic waves?

3+3+4

f) i) Write down the particle displacement for an open pipe of a vibrating air column.

ii) Prove that the energy of the vibrating air column is distributed among the modes of vibration.

iii) A uniform string of length l is streched between its fixed ends x=0 and x=l. Obtain an expression for the transverse displacement y(x,t) of the string when it is struck at the centre so that the velocity varies linearly from zero at the ends to v_0 at the centre [use the necessary displacement equation without deduction].

iv) Why in a struck stringed musical instrument, the string is usually strucked at about 1/7th of the length?

1+4+4+1
