P. R. Thakur Govt. College
Department of Physics
B.Sc. Semester-IV Internal Examination, 2024
Paper - **PHSHGEC04T**
Waves & Optics

Time: 1 Hour **Full Marks: 20**

1. Answer any *five* questions from the following: 2 x 5=10

   (a) Displacement of a particle at an instant t is given by $x(t) = A\cos(\omega t) + B\sin(\omega t)$, where A, B, ω are constants. Show that the particle oscillates simple harmonically.

   (b) What is Lissajous Figure?

   (c) Write down the Dirichlet conditions for expanding a function in Fourier series.

   (d) What is amplitude resonance for a forced oscillation?

   (e) State Huygens' Principle.

   (f) What is critical damping?

   (g) Define wavefront and describe its significance in understanding light propagation according to the Huygens-Fresnel principle.

   (h) Light of wavelength 700 nm passes through a pair of slits separated by 0.7 mm and forms an interference pattern on a screen 1.4 meter away. Calculate the distance between adjacent bright fringes.

2. Answer any *two* questions from the following: 5 x 2=10

   (a) What are beats? Show that the beat frequency is equal to the difference between the frequencies of the component oscillations. 2+3

   (b) State Fourier's theorem. An anti-symmetric square-wave form $f(t)$ is a periodic function with period 2π and is defined as

$$f(t) = \begin{cases} -1, & \text{if } -\pi < t < 0 \\ 1, & \text{if } 0 < t < \pi. \end{cases}$$

   Expand $f(t)$ in a Fourier series. 1+4

   (c) i. Define coherence and explain its role in the interference of waves.

   ii. Two coherent light sources produce an interference pattern. The path difference between the waves at a certain point on the screen is 1.5×10^{-6} meter. If the wavelength of the light is 500 nm, determine whether the interference at this point is constructive or destructive. 2+3

   (d) In a Young's double-slit experiment, monochromatic light of wavelength 500 nm is used. The distance between the slits is 0.80 mm, and the screen is placed 22 meters away from the slits.

   i. Calculate the distance between the central bright fringe and the first-order bright fringe on the screen.

   ii. Determine the position of the second-order dark fringe.

   iii. Explain the conditions for constructive and destructive interference in this experiment.

   iv. Describe how the fringe visibility (contrast between bright and dark fringes) would be affected if the coherence length of the light source is reduced. 2+1+1+1

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1. Answer any *five* questions from the following: 2 x 5=10

   (a) Displacement of a particle at an instant t is given by $x(t) = A\cos(\omega t) + B\sin(\omega t)$. Find the amplitude of the motion.

   (b) What is Lissajous Figure?

   (c) Calculate the dimension of coefficient of viscosity.

   (d) What are beats?

   (e) Define wavefront.

   (f) Two coherent light beams of intensities I and $4I$ produce interference pattern. What is the intensity at a point where the phase difference is $\frac{\pi}{3}$?

   (g) State Huygens' principle.

   (h) State two conditions for two light sources to be coherent.

2. Answer any *two* questions from the following: 5 x 2=10

   (a) Show that the resultant motion of a particle under the influence of two parpendicular SHMs of same frequency is, in general, an ellipse. Under which conditions the resultant motion will be a pair of straight lines? 1+4

   (b) Define coefficient of viscosity of a fluid. Derive Poiseuille's formula regarding volume rate of steady flow of an incompressible viscous liquid through a horizontal capillary of uniform cross-section. 1+4

   (c) Derive a mathematical expression for the width of interference fringes obtained in Young's double slit experiment with the help of a suitable diagram.

   (d) i. The ratio of the intensities at minima to the maxima in the Young's double slit experiment is 9 : 25. Find the ratio of the widths of the two slits.
   ii. Write down the formula for fringe visibility. 4+1

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1 ***Answer any five questions from the following:*** $2 \times 5 = 10$

(a) What are synclastic and anticlastic surfaces?

(b) The amplitude of a particle executing SHM with angular frequency ω is A. Determine the maximum acceleration of the particle.

(c) Compute the excess pressure inside a air bubble of diameter $2mm$ that is entirely inside the air solution. Given the surface tension of the soap solution is 0.025Nm^{-1}.

(d) What are beats?

(e) What are coherent sources ?

(f) What are the condition to have good contrast in the interference pattern?

(g) Why are coherent sources necessary for interference experiment?

(h) Light waves from two coherent sources of same intensity I interfere. Calculate the visibility of fringes.

2 ***Answer any two questions from the following:*** $5 \times 2 = 10$

(a) Define coefficient of viscosity of a fluid. Derive Poiseuille's formula regarding volume rate of steady flow of an incompressible viscous liquid through a horizontal capillary of uniform cross-section.

(b) State Fourier's theorem. An anti-symmetric saw-tooth wave form $f(x)$ is a periodic function with period 2π and is defined as

$$f(x) = x \text{ for } -\pi < x < \pi.$$

Expand $f(x)$ in a Fourier series.

(c) Fringes are produced with monochromatic light of wavelength 689 nm. A thin film of glass of refractive index $n = 1.52$ is placed normally in the path of one of the interfering beams. The central bright fringe is found to be shifted to a position occupied by the fifth bright band from the center. Calculate the thickness of the glass film.

(d) A glass plate 1.2×10^{-3} mm thick is placed in the path of one of the interfering beams in a biprism using $\lambda = 6000$ Å. If the central band shifts a distance equal to the width of the bands, find the refractive index of glass. For what thickness of a plate of index 2.5 introduced in the path of the second beam would the central band be back in its original position?