This question paper contains 7 printed pages]

Your Roll No. ....

1221

B.Sc. (Hons.)/II **A**

PHYSICS—Paper XI

(Vibrations and Wave Optics)

Time : 3 Hours *Maximum Marks* : 38

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. 1 is compulsory.

Attempt *one* question from each Section.

1. Attempt any *four* of the following : 2×4

(*a*) Explain with the help of a figure, how a hologram is produced.

(*b*) Compare the intensity pattern obtained by Young's double slit Interference experiment and Fraunhofer diffraction due to a double slit.

(*c*) Explain the term normal modes and normal co-ordinates of a coupled system.

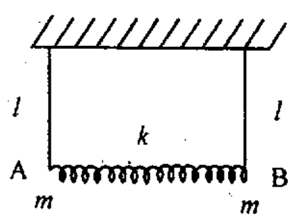
(*d*) Show that if one beam of a two beam interference set up has intensity N times that of the other beam, then fringe visibility V is given by :

$$V = \frac{2\sqrt{N}}{N + 1}$$

(*e*) Write *two* differences between travelling and stationary wave.

Section A

2. (*a*) Consider the system of two identical pendulums coupled by a spring as shown in the figure. 5½



Assuming weak coupling and starting with the initial conditions that at $t = 0$, the displacement of pendulum

A is "a" and is at rest. The pendulum B is at rest at its equilibrium configuration. Obtain the expression for the energy of each pendulum. Also prove that the energy of this system remains constant.

(*b*) Consider a mass m attached with two identical massless springs having spring constant k, relaxed length a_0 and equilibrium length 'a' each. Show that the frequency of transverse oscillation (under slinky approximation) is : 2

$$W = \sqrt{\frac{2k}{m}}$$

3. (*a*) A wave group is formed by superposition of two harmonic waves of equal amplitude but slightly different frequencies, travelling in the same direction in a dispersive medium. Obtain the expressions for the phase and group velocities. 3

(*b*) Show that, for light waves of frequency ν travelling in a dispersive medium of refractive index η, the group velocity V_g is given by :

$$\frac{1}{V_g} = \frac{1}{V} - \frac{\lambda}{c}\frac{d\eta}{d\lambda}.$$

where V is the phase velocity, c is the velocity of light in vacuum and λ is the wavelength. 2

(*c*) The refractive index η of a gas for waves of wave number k is given by :

$$\eta^2 = \frac{c^2}{v^2} = \alpha + \beta k^2 - \frac{\gamma}{k^2},$$

where α, β and γ are constants, v is the phase velocity and c is the velocity of light in vacuum. Show that group velocity is given by :

$$V_g = \frac{v}{\eta^2}\left(\alpha - \frac{2\gamma}{k^2}\right).$$ 2½

Section B

4. (*a*) Define spatial coherence. Show that a finite source of width l can give rise to visible interference fringes in Young's double slit experiment provided the slits S_1 and S_2 are separated by distance d, such that : 4½

$$l << \frac{\lambda a}{d},$$

where a is the distance between source and the two slits S_1 and S_2, and λ is the wavelength of light emitted by the source.

(*b*) Compare the interference pattern produced by Biprism and Lloyd's mirror experiment. 1½

(*c*) Show that when light is reflected from rare-denser surface, a phase change of π is introduced in the reflected rays. 1½

5. (*a*) Derive Airy's formula for the intensity distribution of the transmitted beam in case of Fabry-Perot interferometer. Explain the sharpness of fringes obtained with the interferometer in terms of fringe half width. 5

(*b*) In a Michelson interferometer, a gas is allowed to flow into an evacuated glass pipe of length 10 cm, placed in one arm of the interferometer. How many fringes would be counted; if the gas were carbon dioxide of refractive index 1.00045, using a sodium light of λ = 589 nm. 2½

Section C

6. (*a*) Using the Helmholtz-Kirchhoff integral theorem, derive the Fresnel-Kirchhoff diffraction formula. 5½

(*b*) A transmission grating having 15000 lines per inch is 2.5 inch wide. If red light of wavelength 650 nm falls on it, what is the resolving power in the third order. Calculate the minimum resolvable wavelength difference in the second order. 2

7. (*a*) Derive an expression for intensity distribution due to Fraunhofer diffraction at a single slit.

Calculate the exact positions of secondary maxima by drawing various graphs. 4

(*b*) Calculate the ratio of intensity at the central maxima to the first secondary maxima. 1½

(*c*) Find the missing orders in the double slit diffraction pattern, if width of slit is half of separation of two slits. 2

Section D

8. (*a*) What are Fresnel's integrals ? Derive them. 5½

(*b*) Derive an expression for the intensity due to unobstructed wave front in terms of Fresnel's integrals. 2

9. (*a*) Explain the formation and properties of Cornu's spiral. 4

(*b*) Using Cornu's spiral, explain the Fresnel diffraction due to a straight edge. 3½