B.Tech.

First Semester Examination

Physics-I (PHY-101F)

Note : Attempt five, questions In all, taking at least two questions from each part.

Part-A

Q. 1. (a) Discuss the formation of Newton's ring by (i) reflected light (ii) transmitted light. Derive an expression for diameter of nth dark ring in reflected light ?

Ans. Newton's Rings by Reflected Light:

The condition of maximum intensity or for a bright ring,

$$2\mu t - \frac{\lambda}{2} = 2m \cdot \frac{\lambda}{2}$$

$$2\mu t = (2m+1)\frac{\lambda}{2}, \quad m = 0, 1, 2, 3, \ldots\ldots\ldots$$

$$2\mu t = (2n-1)\frac{\lambda}{2}$$

$$2\mu t - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}$$

$$r^2 = 2Rt$$

$$t = \frac{r^2}{2R}$$

$$2\mu \frac{r^2}{2R} = (2n-1)\frac{\lambda}{2}$$

$$r^2 = (2n-1)\frac{\lambda R}{2\mu}$$

$$r_n^2 = \frac{(2n-1)\lambda R}{2\mu}$$

$$\left(\frac{Dn}{2}\right)^2 = \frac{(2n-1)\lambda R}{2\mu}$$

$$Dn^2 = \frac{2(2n-1)\lambda R}{\mu}$$

$$Dn^2 = 2(2n-1)\lambda R$$

$$Dn = \sqrt{[2\lambda R(2n-1)]}$$

$$= \sqrt{2\lambda R}\sqrt{(2n-1)}$$

$$Dn = k\sqrt{(2n-1)} \text{ where } k = \sqrt{2\lambda R}$$

T hus, the diameters of the bright rings are proportional to the square roots of the odd natural numbers.

Newton's Rings by **Transmitted Light**:

$$\Delta = 2\mu t - \frac{\lambda}{2} + \frac{\lambda}{2} = 2\mu t$$

$$t = P\varphi = \frac{r^2}{2R}$$

$$\Delta = 2\mu t$$

$$= \frac{2\mu r^2}{2R} = \frac{\mu r^2}{R}$$

$$r = D/2$$

$$\Delta = \frac{\mu D^2}{2.2R}$$

$$Dn^2 = \frac{2\lambda R(2n-1)}{\mu}$$

$$Dn^2 = 2\lambda R(2n-1)$$

$$Dn = \sqrt{(2n-1).2\lambda R} = \sqrt{(2\lambda R)(2n-1)}$$

If $\mu = 1$ $$Dn = \sqrt{(4n\lambda R)} = \sqrt{(4\lambda R)}\sqrt{n}$$

Q. 1. (b) In an experiment with Fresnel's **biprism fringes for light of wavelength 5** x **10^{-7} m are** observed 0.2 x 10^{-3} **m apart at a distance of 1.75 m from the prism. The prism is made of glass of** refractive index 1.50 and it is **at a distance of 0.25 m from the illuminated slit. Calculate the angle at the** vertex of the biprism.

Ans.

$$\omega = 0.196 \text{ mm}$$

$$= 0.0196 \text{ cm}$$

$$D = 100 \text{ cm}$$

$$\mu = 30 \text{ cm}$$

$$v = 100 - 30 = 70 \text{ cm}$$

$$d_1 = 0.70 \text{ cm}$$

$$\frac{d_1}{2d} = \frac{v}{\mu}$$

$$\frac{0.70}{2d} = \frac{70}{30}$$

$$2d = \frac{30 \times 0.70}{70} = 0.30 \text{ cm}$$

$$\lambda = \frac{2d}{D} \cdot \omega$$

$$= \frac{0.30 \times 0.0196}{100}$$

$$\lambda = 5880 \times 10^{-8} \text{ cm}$$

$$\boxed{\lambda = 5880^{\circ}\text{ A}}$$

Q. 2. (a) Discuss two methods in detail for finding the wavelength of a given monochromatic light one using interference of tight and another based upon diffraction of light phenomenon.

Ans. Determination of (a + *b)*

$$N(a+b) = N = 2.54 \text{ cm}$$

$$(a+b) = \frac{2.54}{N} \text{ cm}$$

Determination of θ

Adjustments

(i) The eye-piece **of telescope** are adjusted for parallel rays by Schuster's method,

(ii) The collimator & the telescope are adjusted for parallel rays by cross-wires.

$$(a+b)\sin\theta = n\lambda$$

$$(a+b)\cos\theta \frac{d\theta}{d\lambda} = n$$

Dispersive power, $$\frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

Q. 2. (b) A diffraction grating which has 4000 lines to a cm is used at normal incidence. Calculate the dispersive power of the grating in the third order spectrum in the wavelength region 5000 A.

Ans. Dispersive power of **grating**

$$\frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

Condition of maxima in diffraction grating is :

$$(a+b)\sin\theta = n\lambda$$

$$\sin\theta = \frac{n\lambda}{a+b}$$

$$\cos\theta = \sqrt{1-\sin^2\theta}$$

$$= \sqrt{1-\left(\frac{n\lambda}{a+b}\right)^2}$$

Given, $$(a+b) = \frac{1}{4000} \text{ cm}$$

$$\therefore \frac{1}{4\times 10^5} \text{ m}$$

$$n = 2$$

$$\lambda = 5000^\circ\text{A} = 5\times 10^{-7} \text{ m}$$

$$\cos\theta = \sqrt{+1-\left(\frac{2\times 5\times 10^{-7}}{\frac{1}{4}\times 10^5}\right)^2}$$

$$= \sqrt{1-0.16}$$

$$= \sqrt{0.54}$$

$$= 0.916$$

$$\frac{d\theta}{d\lambda} = \frac{2}{\left(\frac{1}{4\times 10^5}\right)\times 0.916}$$

$$= \frac{2\times 4\times 10^5}{0.916}$$

$$= 8.73\times 10^5 \text{ radian/m}$$

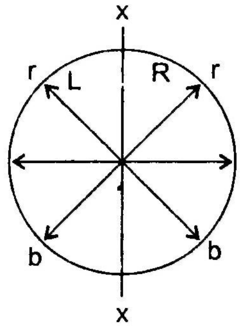
Q. 3. (a) Describe the construction and working of half shade polarimeter. Discuss the relative merits of biquartz and half shade polarimeters.

Ans. The arrangement of bi-quartz polarimeter is same as that of a laurant's half shade polarimeter with the following 2 differences :

(i) It consists of a biquartz plate in place of Laurant's half shade place

(ii) White light is used in place of monochomatic light.

A bi-quartz plate consists of 2 semiconductor plates one of **left handed** quartz and the other of right handed quartz, both cut perpendicular to optic axis and joint together so as to form a complete circular plate.



Circular Plate

When a beam of white light, rendered plane polarised by the polarising Nicol, is incident normally in the bi-quartz plates, it rotates the different wavelengths of white light to different extents, thus, rotatory dispersion occurs in each plane.

Q. 3. (b) What are the specialities of laser light. Give the description of semiconductor laser.

Ans. Light from a laser beam is electromagnetic in nature as light from an ordinary source, but a laser beam has the following specialities :

(i) High directionality

f ii> High intensity

(iii) Highly coherent

(iv) Extra-ordinary monochromacity

$$O = \frac{\beta\lambda}{d}$$

$$I = \frac{p}{4\pi R^2}$$

$$E = \frac{\Delta v}{v_o}$$

Semi Conductor Laser : 2 conditions to be fulfilled :

(i) The semiconductor should be such that the transition probability for a radiation transition across the conduction and valence gap must be high and must exceed the probability for non-radiative transfer of energy to the lattice etc.

(ii) The excess population can be maintained across the laser transition.

The population inversion in semiconductor is achieved by using a P-N junction diode of semiconductor, heavily doped with donors and acceptors.

Q. 4. Write short notes on the following :

(a) Optical fibres and their applications

(b) Nicol prism

(c) He-Ne laser

Ans. (a) Optical Fibres and their Applications : In recent years techniques, have been crossed for transmitting light signals from one point another via transparent dielectric fibres. If the diameter of these fibres is large as compared to the wavelength of radiation, the process of transmission obeys the laws of geometrical optics.

Consider a straight glass cylinder surrounded by air. Let #### be angle of incident ray entering the end face of cylinder. The light striking its walks from within will be totally internally reflected provided that the indicent angle at each reflection is grater than,

$$\theta_c = \sin^{-1}\left(\frac{n_a}{n_f}\right)$$

Where n_a is refractive index of air and n_f is refractive index of fibre material.

Here, $$l = \frac{L}{\cos\theta_r}$$

Snell's law, $$\frac{\sin\theta_i}{\sin\theta_r} = \frac{n_f}{n_a}$$

$$\sin\theta_r = \frac{n_a}{n_f}\sin\theta_i = \frac{\sin\theta_i}{n_f}$$

$$\cos\theta_r = \sqrt{1-\sin^2\theta_r}$$

$$= \sqrt{\left(1-\frac{\sin\theta_i}{n_f}\right)^2}$$

$$l = \frac{L}{\sqrt{1-\left(\frac{\sin\theta_i}{n_f}\right)^2}} = \frac{n_f L}{\sqrt{(n_f^2-\sin^2\theta_i)}}$$

$$N = \frac{l}{\theta/\sin\theta_r}+1$$

$$N = \frac{L(n_f\sin\theta_r)}{D\sqrt{n_f^{\,2}-\sin^2\theta_i}}+1$$

$$N = \frac{L\sin\theta_i}{D\sqrt{(n_f^2-\sin^2\theta_i)}}+1$$

$$N = \frac{1\times\sin 30^\circ}{50\times10^{-6}\sqrt{(1.6)^2-\sin^2 30^\circ}}$$

$$= \frac{0.5}{50\times10^{-6}\times1.52}$$

$$= 6580 \text{ reflections/m}$$

(b) Nicol Prism: When an ondnary ray of light is passed through a calcite crystal, it is broken up into 2 rays :

(i) The ordinary ray which is polarised and has its vibrations perpendicular to the principal section of the crystal and

(ii) The extra-ordinary ray which is polarised and has its vibrations parallel to the principal section.

Limitations :

(i) When the angle of incidence of calcite Balsam surface becomes increased, incident ray S_0M, the angle of incidence of calcite Balsam surface decreases. When the angle S_0M_S becomes greater thus 14°, the angle of incidence of calcite Balsam through surface is increased.

(iil When the angle of incidence at the crystal surface is decreased.

(c) **He-Ne** Laser : Ruby laser does not generate a continuous laser beam. To overcome this difficulty Javan, Bennett and Harroit in 1961 reported a gas laser, which exists continuous laser beam rather than in pules.

In consists of:

(i) A working substance in form **of a** mixture of He and Ne gas in the ratio 7:1 at a total pressure of 1 torr.

(n) A resonant cavity of quartz tube of about 0.5 m length and 5 mm diameter. There are 2 windows w_1 and w_2 made optically flat & cemented at Brewster's angle to the tube axis for specific wavelength ####. The ends of the cavity are enclosed by 2 concave minors, M_1 and M_2 one perfectly and the other partially reflecting,

(iii) An exciting source for creating discharge in the tube. It is generally a radio frequency high voltage source such as a. Tesla coil and is applied by means of metal bands around the outer side of the tube.

Part-B

Q. 5. (a) Discuss the theory **of forced oscillators. How does sharpness of resonance dpend on** damping ?

Ans. When a body is set in oscillation under an external force (periodic), frequency of which is not equal to the normal frequency of the body, then in the beginning the body tries to oscillate with its own frequency but very soon these oscillations die out and the body begins to oscillate with the frequency of the external periodic force. Such oscillations of the body are called the forced harmonic oscillations and the particle executing such vibrations is called the forced harmonic oscillator.

The amplitude of forced oscillations is maximum when the frequency of the applied force has a value which satisfies the condition of resonance. As soon as frequency changes from this value, the amplitude facts. The term sharpness of resonance refers to the rate of fall of amplitude with the change in the driving frequency on either side of resonant frequency. If the fall in the amplitude for a small departure of the frequency from the resonant value is considered, the resonance is said to be "sharp." If, on the other hand, the fall is small, the resonance is said to be flat".

$$A = \frac{f_o}{\sqrt{[(w_o^2 - p^2)^2 + 4r^2 p^2]}}$$

Smaller is the damping, sharper is the resonance or larger is the damping, flaten is the resonance.

Q. 5. (b) State Maxwells' **equation for the electromagnetic fields and obtain the** wave **equations in** free space. Discuss the concept of **Poynting** vector.

Ans. Maxwell's Equations :

(i) $\nabla . D = \rho$

(ii) $\nabla . B = 0$

(iii) $\nabla \times E = \frac{-\partial D}{\partial t}$

(iv) $\nabla \times H = J + \frac{\partial D}{\partial t}$

Integral form $\int_s D.ds = \int_v f dV$

$$\int_s B.ds = 0$$

$$\int_c \varepsilon . dl = \frac{-\partial}{\partial t} \int_s B.ds$$

$$\oint_c H.dl = \iint_s \left(I + \frac{\partial D}{\partial t} \right) . ds$$

In some particular cases :

In free space

$$\nabla \cdot D = 0$$

$$\nabla \cdot B = 0$$

$$\nabla \times E = \frac{-\partial B}{\partial t}$$

$$\nabla \times H = \frac{\partial D}{\partial E}$$

$$E = \varepsilon_o E$$

$$B = \mu_o H$$

Poynting Vector :

$$S = E \times H$$

is known as Poyniing vector and is interpreted as power flux i.e., amount of energy crossing unit area placed perpendicular to the vector, per unit time. The conception of energy of the electromagnetic field as residing in the medium is very fundamental one and has great advantage in the development of the theory.

Maxwell thought of the medium as resembling an elastic solid energy as kinetic energy of motion. Though such as mechanical view no longer exists, still the energy is ragarded as being localised in space and as unveiling in the manner indicated by Poynting vector.

Q. 6. (a) **State and prove Gauss law in dielectrics. Deduce an expression for energy stored in dielectric in electrostatic field.**

Ans. The surface integral of displacement vector over a closed surface is euqal to the net free charge enclosed within the surface i.e.,

$$\oint_s D.ds = q$$

If the electric is present, then net charge enclosed by Gaussian surface *is* $q - q'$, q' being induced charge due to polarization.

Hence,

$$\oint E.ds = \frac{1}{\varepsilon_o}(q - q')$$

$$EA = \frac{1}{\varepsilon_o}(q - q')$$

$$E = \frac{q}{E_o A} - \frac{q'}{E_o A}$$

$$\frac{E}{E_o} = \frac{1}{K}$$

$$E = \frac{E_o}{K}$$

$$E = \frac{q}{k\varepsilon_o A}$$

Hence. $$\frac{q}{k\varepsilon_o A} = \frac{q}{\varepsilon_o} - \frac{q'}{\varepsilon_o A}$$

Or induced charge, $$q' = q\left(1 - \frac{1}{K}\right)$$

$$q - q' = \frac{q}{k}$$

$$\oint E d.s = \frac{1}{\varepsilon}\frac{q}{k}$$

$$\oint E.ds = \frac{q}{\varepsilon}$$

$$\oint (\varepsilon E).(ds) = q$$

$$\oint D.ds = q$$

Hence proved

Q. 6. (b) The dielectric constant of helium at 0°C and atmospheric pressure is 1.000074. Find the dipole moment induced in each helium atom. When the gas is in an electric field of intensity 100 Volt/m. (S„ =8.85*10~'²f /m).####################

Ans. $$K = 1 + x_e = 1 + \frac{P}{\varepsilon_o E}$$

$$P = \varepsilon_0 (K-1)E$$

$$P = np$$

$$p = \frac{P}{n} = \varepsilon_o \frac{(K-1)}{n} E$$

$$= \frac{8.854 \times 10^{-12} \times 0.000074 \times 100}{n}$$

$$= \frac{8.854 \times 74 \times 10^{-16}}{n}$$

$$n = \frac{6 \times 10^{23}}{22.4 \times 10^{-3}}$$

$$= \frac{8.854 \times 74 \times 10^{-16} \times 22.4 \times 10^{-3}}{6 \times 10^{23}}$$

$$\boxed{p = 24.46 \times 10^{-40} \text{ cm}}$$

Q. 7. (a) Derive Lorentz transformation equation. Using them prove that "moving clocks appear to go slow."

Ans. $$2r^2 v + c^2 r^2 \left\{\frac{2}{v}\left(-1-\frac{1}{r^2}\right)\right\} = 0$$

$$2r^2 v - \frac{2c^2 r^2}{v}\left(1-\frac{1}{r^2}\right) = 0$$

$$(v^2 - c^2)r^2 + c^2 = 0$$

$$r = \frac{1}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$$

$$x' = r(x - vt)$$

$$t' = r\left[t - \frac{x}{v}\left(1-\frac{1}{r^2}\right)\right]$$

$$= r\left[t - \frac{x}{v}\left(1-\frac{c^2-v^2}{c^2}\right)\right]$$

$$= r\left[t - \frac{v^2 x}{vc^2}\right]$$

$$t' = r\left[t - \frac{vx}{c^2}\right]$$

$$x' = \frac{x - vt}{\sqrt{(1-v^2/c^2)}}$$

$$t' = \frac{(t - vx/c^2)}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$$

$$x' = \frac{x - vt}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$y' = y$$

$$z' = z$$

& $$f' = \frac{t - \frac{vx}{c^2}}{\sqrt{1-v^2/c^2}}$$

These are called Lorentz transformation equations.