2016

# PHYSICS

( Major )

Paper : 4.2

*Full Marks* : 60

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

## GROUP—A

## ( Wave Optics )

**1.** Answer the following questions : 1×4=4

*(a)* The phase difference between two waves reaching a point is $\pi/2$. What is the resultant amplitude if the individual amplitudes are 3 mm and 4 mm?

*(b)* What is the grating constant of a plane transmission grating?

(c) A single-slit diffraction pattern is completely immersed in water without changing any other parameter. How is the width of central maximum affected?

(d) Write one dissimilarity of a zone plate and a convex lens.

2. (a) Why does an excessively thin film appear black in reflected light? 2

(b) Calculate the possible order of spectra with a plane transmission grating having 18000 lines per inch when light of wavelength 4500 Å is used. 2

(c) Calculate the thickness of double refracting plate capable of producing a path difference $\lambda/4$ between extra-ordinary and ordinary waves.

(Given : $\lambda = 5890$ Å, $\mu_o = 1 \cdot 53$, $\mu_e = 1 \cdot 54$) 2

**3.** Answer any *two* questions of the following : 5×2=10

*(a)* Draw a neat diagram of Michelson's interferometer. Explain the use of a compensating glass plate. State the conditions for—

*(i)* circular fringes;

*(ii)* straight line fringes;

*(iii)* white light fringes. 1+1+3=5

*(b)* Show that the intensity distribution pattern in Fraunhofer diffraction due to double slit is

$$I = 4I_0\left(\frac{\sin^2\alpha}{\alpha^2}\right)\cdot\cos^2\beta$$

where the symbols have their usual meanings. 5

*(c)* Distinguish between plane, circular and elliptical polarizations. How would you produce and detect circularly polarized light? 2+3=5

4. Answer any *two* questions of the following : 10×2=20

(a) (i) Discuss the condition necessary for observing interferences of light. How are these satisfied in a biprism? Explain the interference pattern produced by a biprism with white light. 1+2+2=5

(ii) Write a short note on half-shade polarimeter. 5

(b) (i) In Newton's rings set-up, the plano-convex lens of radius of curvature $R$ is separated from the glass plate by a distance $x$. Show that the wavelength $\lambda$ of the monochromatic light used is independent of $x$ and is given by

$$\lambda = \frac{(D_{m+p}^2 - D_m^2)\mu}{4pR}$$

where $D_m$ and $D_{m+p}$ are the diameters of the $m$th and $(m+p)$th bright rings and $\mu$ the refractive index of the material of the film enclosed between the lens and the plate. 5

(ii) Discuss the phase change due to reflection of light from the surface of a denser medium. 5

(c) (i) What do you mean by Fresnel half-period zone? Show that the radii of half-period zones are proportional to the square roots of natural number. 2+3=5

(ii) Explain how the wavelength of light can be determined with a plane transmission grating. Compare the grating spectra with prism spectra. 3+2=5

## GROUP—B

## ( Special Theory of Relativity )

**5.** Answer the following questions : 1×3=3

(a) What do you mean by an inertial frame?

(b) Write the relativistic mass variation formula.

(c) What is twin paradox of special theory of relativity?

**6.** *(a)* A constant force $F$ is acted upon a particle of mass $m$ and moving with velocity $v$. Show that the acceleration of the particle is

$$a = \frac{F}{m}\left(1 - \frac{v^2}{c^2}\right)^{3/2}$$ 2

*(b)* Write the inverse Lorentz transformation equation for space and time. Derive the formula for time dilation using the inverse Lorentz transformation. 2+3=5

**7.** Answer any *two* questions of the following :

*(a)* Derive the relativistic formula for composition of velocity. 5

*(b)* *(i)* From the relativistic concept of mass and energy, show that the kinetic energy of the moving mass $m$ with velocity $v$ is $m_0 v^2/2$, when $v \ll c$ ($c$ being the velocity of light). 3

*(ii)* Show that $E^2 = c^2P^2 + m_0^2 c^4$ is Lorentz invariant. 2

(c) What is relativistic Doppler effect? If the angle between the direction of motion of a light source of frequency $\gamma_0$ and the direction from it to an observer is $\theta$, show that the frequency $\gamma$, the observer finds is given by

$$\gamma = \gamma_0 \frac{\sqrt{1 - v^2/c^2}}{1 - \frac{v}{c}\cos\theta}$$

where $v$ is the relative speed of source.

2+3=5

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