2019

PHYSICS

[Honours]

PAPER – I

Full Marks : 90

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

Illustrate the answers wherever necessary

GROUP – A

Answer any **two** questions : 15×2

1. (a) State Stoke's theorem. Verify it for

$$\vec{A} = (2x - y)\,\hat{i} - yz^2\,\hat{j} - y^2z\,\hat{k}$$

considering the upper half surface of sphere
$x^2 + y^2 + z^2 = 1$. $1 + 3$

(b) Express $f(x) = x$ as a half-range sine series in the interval $0 < x < 2$.   3

(c) Find the integral

$$\int_{-1}^{+1} x^2 P_n(x) P_m(x)\, dx, \quad \text{where } P_n(x)$$

represent Legendre polynomial of degree n.   4

(d) Solve

$$x^2 \frac{d^2 y}{dx^2} - 6y = 0$$

by the method of Frobenius.   4

2. (a) Obtain an expression for intensity of Fraunhofer diffraction pattern of a double slit. How does the pattern differ from that one produced by a single slit ?   4 + 2

(b) Hence deduce the condition for maxima and minima. What is missing order in a double slit pattern ?   2 + 2

(c) Fraunhofer diffraction pattern is observed by a double slit having slit width $a = 0 \cdot 16$ mm

and separation between the slits $b = 0.8$ mm. Find the missing orders. 3

(d) What are the differences between a zone plate and a convex lens ? 2

3. (a) A particle is simultaneously under two simple harmonic motion at right angles to each other, represented by

$x = a \sin wt$ and
$y = b \sin (wt + \delta)$

(i) Show that the resultant motion is represented by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} \cos \delta = \sin^2 \delta$$

(ii) What will be the locus of the particle when

$$\delta = \frac{\pi}{2} \text{ and } a = b. \qquad 3 + 2$$

(b) Prove (i) $Y = 3k(1 - 2\sigma)$
(ii) $Y = 2\eta(1 + \sigma)$ 2 + 2

(c) Define flexural rigidity. What do you mean by internal bending moment ? Consider a uniform horizontal light (weightless) beam clamped at one end and loaded at free end, find the expression for the internal bending moment and depression at any point.

$$2 + (2 + 2)$$

4. (a) Explain why a transistor needs biasing ? 2

(b) Find the stability factor of a voltage divider type transistor biasing circuit using emitter resistance. Find the condition for its optimum operation. 3 + 1

(c) What do you mean by load line and Q-point of a transistor amplifier ? 1 + 1

(d) A *n-p-n* transistor is connected in CB mode and gives a reverse saturation current $I_{CBO} = 12$ μA. If $\alpha = 0.98$, determine the base current and collector current for an emitter current of 2 mA. 5

(e) Show that 2

$$(A \oplus B) \oplus C = A \oplus (B \oplus C).$$

GROUP – B

Answer any **five** questions : 8×5

5. (a) Show that

$$nP_n = (2n-1)\, x\, P_{n-1} - (n-1)\, P_{n-1}.$$ 5

(b) Solve the differential equation

$$y'' + 4y = \tan 2x.$$ 3

6. (a) State clearly the assumptions made to derive Poiseuille's formula formula for flow of liquid through a narrow tube. 2

(b) A liquid of coefficient of viscosity η flows steadily through a cylindrical tube of radius 'a' and length 'l' under a pressure difference 'ρ'. Show that its velocity at a point inside the tube at a distance 'r' from the axis is 3

$$v = \frac{P}{4\eta l}\,(a^2 - r^2).$$

(c) Distinguish between amplitude and velocity resonance. 3

7. (a) Explain the term surface energy. Show that the excess pressure acting on the curved surface of a curved membrane is given by

$$P = 2S\left(\frac{1}{r_1} + \frac{1}{r_2}\right),$$

where r_1, r_2 are the radii of curvature and S is the surface tension.   1 + 4

(b) If a number droplets of water, all of the same radius 'r' cm, Coalesce to form a single drop of radius R cm, show that the rise in temperature of water will be given by   3

$$\frac{3S}{J}\left(\frac{1}{r} - \frac{1}{R}\right).$$

8. (a) In a transverse arrangement of Melde's experiment the string vibrates in 3 loops when the tension is 200 gm-wt. Calculate the tension required to make the string vibrate in 2 loops in the longitudinal arrangement.   2

(b) What do you mean by progressive wave ? Find an expression for propagation of a longitudinal wave through elastic medium. 1 + 3

(c) What is Bel and Phon ? 2

9. (a) Solve

$$x^2 \frac{d^2y}{dx^2} - x \frac{dy}{dx} + 2y = x \log x$$ 4

(b) How is the depletion region formed in p-n junction ? Explain the variation of its width with biasing. 2 + 2

10. (a) What do you understand by double refraction ? What are ordinary and extra-ordinary rays ? 1 + 2

(b) Give the construction of a quarter wave plate. 3

(c) Calculate the thickness of $\frac{\lambda}{4}$ plate for light of wavelength $\lambda = 5893\text{Å}$, given $\mu_0 = 1\cdot544$. $\mu_e = 1\cdot553$. 2

11. (a) Obtain formal Taylor's series for $\cos x$ about $x = 0$.   4

   (b) A field vector is given by

$$\vec{A} = \sin y\,\hat{i} + (1 + \cos y)\,j$$

Evaluate $\oint \vec{A}\,dr$ over a circular path given by $x^2 + y^2 = a^2,\ z = 0$.   4

12. (a) Convert (i) the decimal number 23·8125 to its binary equivalent.

      (ii) the binary number 11·1101 to its decimal equivalent.   2 + 2

   (b) Draw a logic circuit using NOR gates to implement the Boolean expression   4

$$AB + \overline{B}\,\overline{C}.$$

GROUP – C

Answer any **five** questions :   4 × 5

13. Show that

$$\int\limits_{-1}^{+1} [P_n(x)]^2\,dx = \frac{2}{2n+1}. \qquad 4$$

14. What is reverberation ? On which factors does the reverberation time depend ? What do you mean by reverberation time ? $1+1+2$

15. An achromatic converging combination of focal length 60 cm is formed with a convex lens of crown glass and concave lens of flint glass placed in contact with each other. Calculate their focal lengths, if the dispersive power of crown glass is 0·03 and that flint glass is 0·05. 4

16. (*a*) A ray of light is incident on a glass plate (r.i. = 1·5) at the polarising angle. Find the corresponding angle of refraction. 2

(*b*) Find the state of polarisation when the x and y components of the electric fields are 2

$$E_x = E_0 \sin (wt + kz) \text{ and}$$
$$E_y = E_0 \cos (wt + kz)$$

17. Two cylindrical shafts have same length and mass and are made of the same material, one is solid, while the other, which is hollow, has an external radius twice the internal radius. *Compare their torsional rigidities.* 4

18. Distinguish between avalanche breakdown and Zener breakdown. 4

19. Find the differential equation for the transverse vibration of a stretched string. Define eigen frequencies. $2\frac{1}{2}+1\frac{1}{2}$

20. (*a*) Why is it necessary to use narrow source for Fresnel's biprism and extended source for Newton's ring experiment ?

(*b*) Write down the conditions for sustained interference of light. 2 + 2

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