2017

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 stokes theorem 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*) Solve the differential equation

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

(*c*) If

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L} \right)$$

Prove that

$$\int_{-L}^{+L} |f(x)|^2 \, dx = L\left[\frac{a_0^2}{2} + \sum_{n=1}^{\infty}\left(a_n^2 + b_n^2 \right) \right] \qquad 4$$

(*d*) The normal distribution is given by the probability density function

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(x-\mu)^2}{2\sigma^2}} \quad for \quad -\infty < x < +\infty$$

prove that it has two points of inflection at a distance σ on either side of μ. 4

2. (*a*) Find an expression for intensity of Fraunhofer diffraction pattern of a double slit. Hence deduce the conditions for maxima and minima. What is missing order in a double slit pattern ? How does the double slit pattern differ from that produced by a single slit. 4 + 2 + 2 + 1

(*b*) Fraunhofer double slit diffraction pattern is observed in the focal plane of a lens of focal length 0·5 m. The wavelength of incident light is 500 nm. The distance between two maxima adjacent to the maximum of zero order is 5 mm. The fourth order maximum is missing. Find the width of each slit and the distance between their centers. 4

(*c*) What do you mean by spatial and temporal coherence ? 2

3. (*a*) What do you mean by internal bending moment ? Consider a uniform horizontal light (weight negligible)beam clamped at one

end and loaded at free end, find the expression for internal bending moment and depression at any point. 1 + (2 + 2)

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

(*c*) The displacement at a point in a vibrating string to be

$$y = \sum_{S=1}^{\infty} \sin\frac{S\pi x}{L}\left[C_s \cos\frac{S\pi ct}{L} + D_s \sin\frac{S\pi ct}{L}\right]$$

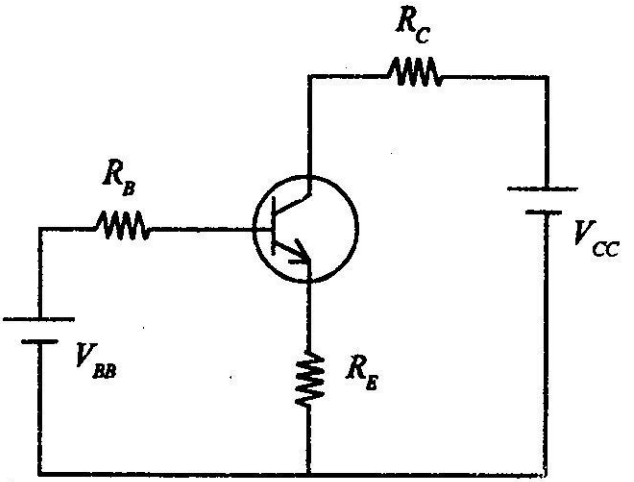
(*i*) Find the total energy of the string

(*ii*) Find average kinetic energy of the string in a full cycle. 3 + 1

(*d*) What is Bel and Phon. 2

4. (*a*) What do you mean by load line and Q point of a transistor amplifier ? 1 + 1

(*b*) Consider the given circuit of a transistor biasing.



Given that $\beta = 100$, $I_{CBO} = 20$ nA, $R_C = 3$ kΩ, $R_B = 50$ kΩ, $R_E = 2$kΩ, $V_{CC} = 10$ V, $V_{BB} = 5$V, V_{BE} (active) = 0·7 V, V_{BE} (sat) = 0·8 V, V_{CE}(sat) = 0·2 V

calculate I_B, I_C, I_{CE} and hence decide in which region the transistor operates ?

2 + 1 + 2 + 1

(*c*) Convert the hexadecimal number $(2A3{\cdot}A)_{16}$ into its decimal equivalent. 2

(*d*) Design a two input XOR gate exclusively with the help of NAND gates. 2

(*e*) Draw the circuit diagram of a positive diode logic AND gate. Explain its operation. 1 + 2

GROUP – B

Answer any **five** questions : 8 × 5

5. (*a*) Prove that

$$\int_{-1}^{+1} P_n(x)P_m(x)dx = 0 \text{ if } m \neq n.$$

and also show that $P_n(-1) = (-1)^n$ by using generating function of Legendre polynomial. 3 + 2

(*b*) Expand by Taylor's theorem $\tan^{-1}\left(\frac{y}{x}\right)$ about (1, 1) upto second degree term. 3

6. (*a*) The length of a simple pendulum is increased by 2%. By what percentage will the frequency increase or decrease. 3

(*b*) Consider

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0,$$

which satisfies the conditions

$u(0, y) = u(l, y) = u(x, 0) = 0$ and

$$u(x, a) = \sin \frac{n\pi x}{L}.$$

Solve for

(*i*) $u(x, y)$

(*ii*) Hence use the boundary conditions. 2 + 3

7. (*a*) State the condition to be fulfilled for the production of sustained interference fringes. 2

(*b*) Why is it necessary to use narrow source for Fresnel's biprism and extended source for Newton's ring experiments ? 2

(*c*) Give a ray diagram of the light path in Michelson interferometer ? 1

(*d*) What is the role of the compensator in Michelson interferometer. 1

(*e*) Under what conditions are circular and straight fringes produced by Michelson interferometer. 2

8. (*a*) Show that the excess pressure acting on the curved surface of a curved membrane is

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

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

(*b*) Show that in capillary rise of a liquid one half of the free surface energy is dissipated by viscous forces. 4

9. (*a*) What are half-power frequencies ? How are they related to sharpness of resonance ? 2 + 2

(*b*) Show that the reasonant frequency is the geometric mean between half power frequencies. 2

(*c*) In Melde's experiment, the string vibrates in 5 loops when the tension is T. If T is increased by 0·05 kg. The number of loops becomes 4. Calculate T. 2

10. (*a*) Distinguish between avalanche breakdown and zener breakdown. 2

(*b*) How does the breakdown voltages vary with temperature in both the cases ? 2

(*c*) With the help of circuit diagram explain the operation of Zener diode as a voltage regulator. 4

11. (*a*) Explain the role of Nicol prism as a polariser. 3

(*b*) How can you differentiate between circularly polarised light and unpolarised light ? 3

(*c*) Calculate the thickness of a quarter wave plate for sodium light of wavelength $\lambda = 589.3$ nm. Given $n_0 = 1{\cdot}5442$ and $n_e = 1{\cdot}5533$. Where symbols have their usual meanings. 2

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

(*b*) The *h* parameters of a transistor are $h_{ie} = 1100\ \Omega$, $h_{fe} = 50$, $h_{re} = 5 \times 10^{-4}$ and $h_{oe} = 25 \times 10^{-6}$ A/V. If the transistor is used as a CE amplifier with load resistance 10 kΩ and effective source resistance 600 Ω. Find the current gain, voltage gain, input resistance and output resistance. 4

GROUP – C

Answer any five questions : 4 × 5

13. Solve

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

when $y = 0$, $\frac{dy}{dx} = 1$ for $x = 0$ 4

14. A horizontal tube of dia 2 mm and length 50 cm

is connected to the bottom of a cubical tank of side 100 cm containing water of viscosity 0.01 Poise. The tank is initially full. Water is then allowed to flow out through the tube. Find the time after which the tank will be quarter full ($g = 980$ cm/s^2). 4

15. If

$$\nabla \cdot \vec{E} = 0, \nabla \cdot \vec{H} = 0, \nabla \times \vec{E} = -\frac{\partial \vec{H}}{\partial t}, \nabla \times \vec{H} = \frac{\partial \vec{E}}{\partial t}$$

Show that $\vec{E}$ and $\vec{H}$ satisfy the wave equation as $\nabla^2 u = \frac{\partial^2 u}{\partial t^2}$. 4

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

17. What is Fresnel's half period zone ? Why is it so called ? Show that the amplitude due to a large wave front is just half-that due to first period zone acting alone. 1 + 1 + 2

18. (*a*) Find the state of polarisation when the x and y components of electric field are given by

$$E_x = E_0 \cos(wt + kz)$$

$$E_y = \frac{E_0}{\sqrt{2}} \cos(wt + kz + \pi)$$ 2

(*b*) An unpolarised light of intensity I_0 is incident on two perfect linear polarisers oriented at 45° with each other. What would be intensity of transmitted light. 2

19. (*a*) What is optical activity ? What do you mean by optically active substance ? Define specific rotation. 1 + 1 + 1

(*b*) A ray of light is incident on a glass plate ($r.i = 1.5$) at the polarising angle. Find the corresponding angle of refraction. 1

20. Consider the following truth table. Hence write

down the Boolean expression for output. Simplify it. Implement circuit by basic gates. 1 + 2 + 1

A Input	*B* Input	*C* Input	*Y* Output
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1