2015

OLD

Part I 3-Tier

ELECTRONICS

PAPER—I

(General)

Full Marks : 100

Time : 3 Hours

The figures in the right-hand margin indicate full 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 : 2×15

1. (a) If θ be the angle between the lines with direction cosines $(\alpha_1, \beta_1, \gamma_1)$ and $(\alpha_2, \beta_2, \gamma_2)$ then show that $\cos\theta = \cos\alpha_1\cos\alpha_2 + \cos\beta_1\cos\beta_2 + \cos\gamma_1\cos\gamma_2$. 3

(b) For a particle rotating with angular velocity $\vec{\omega}$ show that $\text{curl}\,\vec{v} = 2\vec{\omega}$. 3

(c) Prove $\oiint \vec{r} \times \vec{ds} = 0$ for any closed surface. 4

(d) Solve $\frac{d^2y}{dx^2} + y = \sec x$. 5

2. (a) Use Maxwell's velocity distribution law to find (i) average speed $\bar{c}$, (ii) r.m.s. speed $c_{r.m.s.}$ and (iii) most probable speed c_m for a two-dimensional ideal gas. 3×3

(b) Prove that in a gas of ordinary pressure the number of molecules (n) striking unit area of the wall per second is $\frac{1}{4}n\bar{c}$. 6

3. (a) For a damped oscillator with damping force proportional to velocity :

(i) Set up the equation of motion ;

(ii) Discuss the conditions for weekly damped, critically damped and over damped oscillations and find the displacements in each case.

1+3+3+3

(b) Prove that $\hat{L}[f(t-a).\theta(t-a)] = \bar{e}^{as} F(s)$

If $\hat{L}f(t) = F(s)$

where $\theta(t = a)$ represents unit step function and $\hat{L}$ stands for Laplace transform. 5

Group—B

Answer any *five* questions. 5×8

4. (a) Write down the essential differences between adiabatic expansion and Joule-Thomson expansion.

(b) Prove that Joule-Thomson co-efficient is given by :

$$\mu = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right].$$ 3+5

5. (a) If $f(x) = x^2$, for $-\pi \leq x \leq \pi$ find the Fourier series expansion of $f(x)$.

(b) Find the sum of the series :

$$\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \cdots$$ 5+3

6. Derive an expression for the wavelength of monochromatic light source used in Newton' ring experiment in terms of diameters of ring and radius of curvature of the lens used. 8

7. Use Euler's method to solve $\frac{dy}{dx} = x + y$, $y(0) = 0$ in six steps, choosing $h = 0.2$. 8

8. If n_0 is the refractive index for O-rays, n_e the principal refractive index for E-rays, then show that the refractive index n_θ for E-rays in a direction θ with optic axis is given by :

$$\frac{1}{n_\theta^2} = \frac{\cos^2\theta}{n_0^2} + \frac{\sin^2\theta}{n_e^2}.$$ 8

9. Find the energy of vibration of a stretched string and show that for a particular mode, energy of vibration varies as square of the eigen frequency and the square of amplitude of the mode. 8

10. Expand $f(x) = 1 \quad \text{for } 0 < x < 1$
$= 0 \quad \text{for } -1 < x < 0$

in a series of the form $\sum A_n P_n(x)$ upto five terms. 8

11. Prove that in a plane transmission grating

$$I = I_0 \frac{\sin^2\alpha}{\alpha^2} \frac{\sin^2(N\gamma)}{\sin^2\gamma}$$

where $\alpha = \frac{\pi a \sin\theta}{\lambda}$ and $\gamma = \frac{\pi (a+b)\sin\theta}{\lambda}$.

Other symbols have equal meanings. 8

Group—C

Answer any *five* questions : 5×4

12. Define the terms : Thermodynamic intensive and extensive variables, reversible process and quasistatic process. 4

13. State the law of equipartition of energy and discuss its limitations. 4

14. Prove that $P_{2n}(0) = (-1)^n \frac{(2n)!}{2^{2n}(n!)^2}$ for Legendre polynomial. 4

15. If $F(S) = \frac{1}{S^2\left(S^2 + w^2\right)}$, find f(t). 4

16. Explain rectilinear propagation of light with zone-plate theory. 4

17. Write down Sabine's formula for reverberation time. What is a 'dead room'? 4

18. Prove that :

$$TdS = C_V\left(\frac{\partial T}{\partial P}\right)_V dP + C_P\left(\frac{\partial T}{\partial V}\right)_P dV.$$ 4

19. Discuss the stage of polarization if

$$E_x = E_0 \cos (\omega t + kz)$$

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

Plot the rotation of the tip of the electric vector on the plane $z = 0$.

[Internal Assessment — 10]

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