Ramsaday College

Class: B.Sc. Part-I **Full Marks: 100** **Subject: Physics (Hons.)**

Paper-First

Model Question Paper: 2018

Answer Question ***No. 1*** and any four questions each from ***Unit-1*** and ***Unit-2***

1. Answer any ten questions:

(a) Show that the infinite series $\sum \frac{1}{n^p}$ is convergent if P>1.

(b) Show that a Hermition matrix remain Hermition under unitary transformation.

(c) What is the Fourier transform of $\delta(x)$?

(d) A progressive harmonic wave is represented as $y(x,t) = a\sin(0.5x - 10t)$ where x is in meters and t is in seconds. Obtain the wave velocity.

(e) Establish the relation $I_c = \beta E_B + (1+\beta)I_{CBO}$ for the transistor in active CE mode.

(f) Evaluate $\iint_R xyddy$ where R is the quadrant of the circle with $x \geq 0,\ y \geq 0$.

(g) Define bandwidth and quality factor with respect to resonance.

(h) Determine the condition under which the differential equation

$C_1 \frac{\partial \psi}{\partial t} + C_2 \frac{\partial^2 \psi}{\partial t^2} + V(x,t)\psi(x,t) = 0,$ can be solved using the method of separation of variables.

(i) The band gap of GaAs is 1,98 eV. Determine the wavelength of e.m. radiation upon recombination of holes and electrons.

(j) A surface in 3-dimensionas is described by u(x,y,z)=C where C is a constant. Show that

(k) Verify the Boolean identity (A+B)(B+C)(C+A)=AB+BC+CA

(l) State the order and degree of the differential equation $\frac{d^2 y}{dx^2} + \left(\frac{dy}{dx}\right)^2 + xy = 0.$

Unit-1

2. (a) Express the divergence operator I spherical polar coordinates starting from the expression of the same in Cartesian coordinates.

   (b) Find the first four terms in the Maclaurin series expansion of *(1+x)ln(1+x)*.

   (c) Six coins are tossed simultaneously. What is the probability of (i) 2 heads (ii) at least 2 heads.

4+2+(2+2)

3. (a) Apply Frobenius method to the equation $\frac{d^2y}{dx^2} + \omega^2 y = 0$ setting $y(x) = \sum a_\lambda x^{k+\lambda}$ with $a_0 \neq 0$.

   (i) Verify that the indicial equation is $k(k-1)=0$.

   (ii) For k=1, show that a_1 is necessarily zero.

   (iii) Find the recurrence relation.

   (iv) Using the recurrence relation, show that k=1 leads to the solution

   $$y(x) = \frac{a_0}{\omega} \sin \omega x.$$

   (b) Legendre polynomials $P_n(x)$ may me expressed as $\left(1 - 2xt + t^2\right)^{-1/2} = \sum_{n=0}^{\infty} P_n(x) t^n$. Using this show that $P_n(-x) = (-1)^n P_n(x)$.

(2+2+2+2)+2

4. (a) Find the eigenvalues of and normalized eigenvectors of the matrix $\begin{bmatrix} 1 & 1 \\ 4 & 1 \end{bmatrix}$.

   (b) If a matrix is both Hermitian and unitary, show that all its eigen values are ± 1.

   (c) Show that the product of two symmetric matrices is symmetric only the commute.

(2+3)+3+2

5. (a) Show that $\frac{1}{3}\oint_S \vec{r}.d\vec{s} = V$ where V is the volume enclosed by the surface S.

(b) By the Stokes theorem proved that $\vec{\nabla} \times \vec{\nabla}\phi = 0$.

(c) A particle moves along the cure $x = 2t^2,\ y = 4t^2 - 1,\ z = 5t - 3,$ where t denotes time. Find the component of acceleration at time t=1 in the direction $\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$.

(d) Show that the line integral of $\vec{F} = -\hat{i}y + \hat{j}x$ around a continuous closed curve in x-y plane is twice the area enclosed by the curve. 2+2+3+3

6. (a) Solve $x^2 \dfrac{d^2y}{dx^2} - 6y = 0$ by method of Frobenius.

   (b)) Solving the question using the method separation of variables,

   $\dfrac{\partial^2 V}{\partial x^2} + \dfrac{\partial^2 V}{\partial y^2} = 0$ With V=0 for Y=0 and Y=π

   V=V_0 for x=1

   V(-x,y)=V(x,y) 4+6

7. (a) Find the Fourier transform F(k) of the function f(x)=N$e^{-\alpha x^2}$ where N and α are constants. Calculate the stared deviation of both f(x) and F(k). Plot F(k) against k and f(k) against **x**.

   (b) Plot the function f(x) defined by f(x)=0 for $-\pi$<x<0, f(x)=1 for 0<x<π, f(x+π)=f(x) and find the Fourier series expansion for it.

   (c) Evaluate the $\int_{-1}^{+1} e^x \delta'(x)dx$, where the prime denotes diffraction with respect to x.

(2+1+1)+4+2

Unit-2

8. (a) Define principal points and nodal points of an optical system.

   (b) Find out the condition for smallest separation between an object and its real image produced by a converging lens.

   (c) State Fermat's principle. Use it establish conjugate foci relations for refraction at a spherical surface.

3+3+(1+3)

9. (a) Solved the equation of motion of a damped forced SHM and derived the condition for velocity resonance.

(b) Contract the differential equation of wave motion starting from the equation of a plane progressive harmonic wave given by $y(x,t) = A\sin\left(\omega t - \frac{\omega}{v}x + \alpha\right)$ where the notations have their as usual meanings.

(c) Distinguish between amplitude resonance and velocity resonance.

(4+2)+2+2

10. (a) Draw a two-input positive logic diode AND circuit and explained its operation.

(b) Design a two-input XOR gate using NOR gates excursively.

(c) Verify the following identities:

(i) $(A+B)(A+C) = A + BC$

(ii) $(A + \overline{A}B) = A + B$ (1+2)+3+(2+2)

11. (a) State and prove the maximum power transfer theorem.

(b) Find out the value of R_L such that maximum is delivered to it. Also, find the value of maximum power. (2+3)+5

12. (a) Explained the behavior of a p-n junction diode under reverse bias and hence explain the characteristics of a p-n junction diode.

(b) Sketch the output characteristics of a CE mode n-p-n transistor and explained it operation.

(c) Sketch the basic structure of an n-channel depletion MOSFET.

(3+1)+(2+2)+2

13. (a) Define linear and angular magnification of a optical system. Derive Helmholtz-Legrange relation between these two types of magnification.

(b) Define paraxial ray. Derive the system matrix of two thin lenses separated by a distance‘t’ in air.

(1+1+4)+1+3