Vivekananda College

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Question Bank

Part I

Physics Hons.

Paper I; Unit I

Mathematical Methods I

- **Preliminary Topics:**

***Infinite Sequence and Series*:**

1. Sketch the two Gaussian probability density functions $f_1(x)$ and $f_2(x)$ with the same mean x=0, but with two different standard deviations σ_1 and σ_2, where $\sigma_2 > \sigma_1$.
2. Define an infinite sequence, a monotonic sequence, a strictly monotonic sequence with examples. 5
3. Define a bounded sequence, an oscillatory sequence with examples. 2
4. Define convergent, divergent and oscillatory series. 3
5. State the difference between conditionally and absolutely convergent series. 3
6. Test the convergence of:

   i) $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\pm---------$ 2

   ii) $\frac{1}{1.2}+\frac{1}{2.3}+\frac{1}{3.4}\pm---------$ 3
7. Comment on the convergence of $1-\frac{1}{2}+\frac{1}{3}-\frac{1}{4}+--------$ 3
8. Test the convergence of :

   i) Σn^{-p} for p<1,p=1,p>1.3

   ii) $\Sigma\left(\frac{1}{2}+\frac{1}{n}\right)^n$ 3

   iii) $x+\frac{x^2}{2}+\frac{x^3}{3}+\frac{x^4}{4}+---------$ 3

   iv) $x+\frac{1}{2}\frac{x^3}{3}+\frac{1.3}{2.4}\frac{x^5}{5}+\frac{1.3.5}{2.4.6}\frac{x^7}{7}+---------$ 4

   v) $x+\frac{2^2x^2}{2!}+\frac{3^3x^3}{3!}+\frac{4^4x^4}{4!}+----------$

- **Multiple Choice Type:**

a.An infinite sequence is

i) an endless succession of numbers arranged in a definite order

ii) a limited succession of numbers arranged in a definite order

iii) an endless expression of terms

iv) a limited expression of terms

b. If the sum of a series of positive and decreasing terms (u_n) be convergent,

then i) $Lt.n \to \infty n u_n = 0$

ii) $Lt.n \to \infty u_n = 0$

iii) $Lt.n \to \infty \frac{u_n}{n} = 0$

iv) None of the above

c . $\{-n^2\}$ is i) bounded above
ii) bounded below
iii)bounded above and below
iv) None of the above

- **<u>True or False type</u>**

i) $\{1/n\}$ is a monotone increasing sequence.
ii) A sequence is said to be divergent if it has a limit.
iii) $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \text{-----}$ is in harmonic progression.
iv) An oscillatory series can have both +ve and –ve sum.
v) Leibnitz criterion is applicable to G.P. series.

- ***Taylor Series of two variables***

8.i)Write down the Taylor series expansion of a function of two variables. 3

ii) Mention an application of the Taylor series expansion of a function of two variables
2

- ***Multiple Integrals***

9.i)Evaluate $\int\int_A xy\,dx\,dy$ where A is the domain bounded by x-axis, ordinate x=2a and the curve $x^2=4ay$. 3

ii) Evaluate $\int_0^a \int_0^{\sqrt{a^2-x^2}} \sqrt{x^2+y^2}\,dy\,dx$ 3

iii) Find the area between the parabolas $y^2=4ax$ and $x^2=4ay$ 3

iv)Evaluate $\int\int_R \left(1-\frac{x^2}{a^2}-\frac{y^2}{b^2}\right)dx\,dy$ where R consists of points in the +ve quadrant of the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$.

- **<u>True or False type</u>**

i) Jacobian is a co-ordinate transformation.

ii) Jacobian $J\left|\frac{x,y}{u,v}\right| = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{vmatrix}$

iii) Multiple integrals have two or more integration variables.

- ***Probability and Statistics***

10.i) Define the terms a)random variable b) sample points c)sample space 3

ii)If $f(x) = cx^2 for 0 < x < 3$

$= 0$otherwise

then find $P(0 \leq x \leq 2)$ 3

iii) Explain what you mean by expectation of a random variable. 2

iv) Explain what you mean by variance of a random variable. 2

v) Explain what you mean by standard deviation of a random variable. 2

vi)Show that the standard deviation $\sigma = E(x^2) - (E(x))^2$where E(x) is the expectation value of x. 2

vii) Why is standard deviation used more frequently than variance. 2

viii) How is dispersion related to variance? 2

ix) Write down the Bernoulli distribution of a random variable. What is it alternatively called? 2

- **<u>Multiple Choice Type</u>:**

a. If an event occurs p times and does not occur q times then its probability of occurrence is i) $\frac{p}{q}$ ii) $\frac{q}{p}$ iii)$\frac{p}{p+q}$ iv)$\frac{q}{p+q}$

b. The probability of a certain event is i) 0 ii) 1/2iii) 1iv) None of the above.

c. From a bag containing 4 white balls and 5 black balls. If now 3 balls are drawn at random the probability that at least one is white is i) 1ii) 3/18 iii) 5/42iv)7/39

d. Binomial distribution is for i) discrete points ii) continuous points iii) both discrete and continuous points iv) None of the above

- **Vector Analysis**

11. Consider an orthogonal transformation of co-ordinate system $OXYZ$ to $OX'Y'Z'$ with unit vectors $\hat{\imath},\ \hat{\jmath}, \hat{k} \rightarrow \widehat{\imath'}, \widehat{\jmath'}, \widehat{k'}$ & position vector in these systems can be expressed as:

$\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$=$x'\widehat{\imath'} + y'\widehat{\jmath'} + z'\widehat{k'}$. Show that $x' = (\widehat{\imath'}.\hat{\imath})x + (\widehat{\imath'}.\hat{\jmath})y + (\widehat{\imath'}.\hat{k})z$&c.

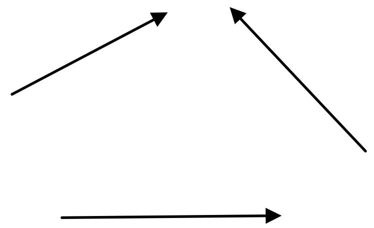
Hence establish,

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

where $a_{11} = \widehat{\imath'}.\hat{\imath}$,$a_{12} = \widehat{\imath'}.\hat{\jmath}$&c. 5

12.

$\vec{A}\vec{B}$



$\vec{C}$

If vectors $\vec{A}, \vec{B}$ &$\vec{C}$are as shown above construct vectors i) $\vec{A} - \vec{B} + 2\vec{C}$

ii) $3\vec{C} - \frac{1}{2}(2\vec{A} - \vec{B})$. 3

13. Differentiate between polar and axial vectors with examples. 2

14. Prove vectorially that the diagonals of a parallelogram bisect each other. 3

15. Define dot and cross product of two vectors. Which one commutes? 3

16. Determine the value of 'a' so that $\vec{A} = 2\hat{\imath} + a\hat{\jmath} + \hat{k}$ and $\vec{B} = 4\hat{\imath} - 2\hat{\jmath} - 2\hat{k}$ are perpendicular. 3

17.Find the unit vector along a line with direction cosines (α, β, γ). 3

18.Provevectorially that the angle in a semi-circle is a right angle. 3

19. Show vectorially that in a triangle the perpendiculars drawn from the vertices to the opposite sides are concurrent. 3

20.Provevectorially that the right bisectors of the sides of a triangle concur at the circumcentre. 3

21. What can you infer if the above identity is equal to zero. 1

22.Prove that $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A}.\vec{C}) - \vec{C}.(\vec{A}.\vec{B})$ 3

23. Under what condition $\frac{\partial^2 A}{\partial x \partial y} = \frac{\partial^2 A}{\partial y \partial x}$? 2

24.Define gradient, divergence and curl vector differential operators. 3

25. What are solenoidal and irrotational vectors? Give examples. 3

26. If $\vec{u}$ is a vector point function, what is the difference between $\vec{\nabla}.\vec{u}$and $\vec{u}.\vec{\nabla}$? 1

27.Find$\vec{\nabla}\varphi$ when i) φ=ln$|r|$ 3

ii)$\varphi = \frac{1}{r}$ 3

iii) $\varphi = r^n$ 2

28.Find$\vec{\nabla}.(\vec{\nabla}\varphi)$ where $\varphi = 2x^3y^2z^3$. 3

29Prove that $\nabla^2\left(\frac{1}{r}\right) = 0$.What is this equation called? 3

30. Find $\vec{\nabla} \times \{\vec{r}f(r)\}$where f(r) is differentiable. 3

31.If$\vec{V}$=$\vec{\omega} \times \vec{r}$, prove that $\vec{\omega} = \frac{1}{2}\vec{\nabla} \times \vec{V}$. 3

32. Show that $\vec{F} = \vec{\nabla}\varphi$ is a necessary and sufficient condition for work to be independent of path. 5

33.Evaluate $\iint_s \vec{A}.\hat{n}ds$ where $\vec{A} = 18z\hat{\imath} - 12\hat{\jmath} + 3y\hat{k}$ and S is that part of the plane 2x+3y+6z=12 which is located in the first octant. 5

34.Evaluate $\iint_s \vec{A}.\hat{n}ds$ where $\vec{A} = z\hat{\imath} + x\hat{\jmath} - 3y^2z\hat{k}$ and S is the surface of the Cylinder $x^2+y^2=16$ included in the first octant between z=0 and z=5. 5

35 Prove Green's theorem in a plane. 3

36. Prove Green's 1st and 2nd identities. 3

37. Prove Gauss' divergence theorem of vector calculus. 5

38.Derive the expression for curl in orthogonal curvilinear coordinates. 4

39. Derive the expression for Laplacian in orthogonal curvilinear coordinates. 4

40.Write their corresponding expressions in cylindrical polar coordinates 5

41.Write their corresponding expressions in spherical polar coordinates 5

- **Multiple Choice Type**:

a.Two vectors $\vec{A}$ *and* $\vec{B}$ which are not null vectors are perpendicularif i) $\vec{A}.\vec{B}$=0 ii) $\vec{A} \times \vec{B} = 0$iii)$\vec{A}\vec{B} = 0$iv)None of the above.

b.Three vectors$\vec{A}, \vec{B}$ and $\vec{C}$ are coplanar if i)$\vec{A}.(\vec{B} \times \vec{C}) = 0$ ii)$\vec{A} \times (\vec{B}.\vec{C})$=0 iii)$\vec{A} \times (\vec{B} \times \vec{C})$=0 iv) None of the above.

c. Gradient operator acts on a i)vector ii)tensor iii)scalar iv)None of the above

d.$\vec{\nabla}.\vec{r} =$ i)0 ii)-1 iii)1 iv)3

e. The line integral of a conservative force over a closed path is i)∞ ii)1 iii)0 iv)None of the above.

f. Which one is not a curvilinear coordinate system i) cylindrical coordinate system ii) spherical coordinate system iii)parabolic coordinate system iv)None of the above.

- **True or False type**

i)Cross product of two vectors is commutative.

ii)$\hat{\imath}$and$\hat{\jmath}$ are not linearly independent vectors.

iii) Divergence is a directional derivative

iv)Magnetic field is solenoidal in nature.

v)$\oint \vec{F}.d\vec{r} = 0$implies $\vec{F} = \vec{\nabla}\varphi$.

vi)Scale factors do not depend on coordinate system.

- **Matrices**

1. Define a Hermitian matrix. Give an example. 2

2. Define a unitary matrix. Give an example. 2
3. Show that the Pauli spin matrices are both Hermitian and Unitary. 5
4. Define an orthogonal matrix. Give an example. 2
5. What are symmetric and skew symmetric matrices? 2
6. 47. Show that every square matrix can be expressed as a sum of a symmetric and a skew symmetric matrix. 3
7. When are two matrices conformable for multiplication? 2
8. What is inverse of a matrix? 3
9. Find the inverse of the matrix $\begin{pmatrix} 1 & -1 & 3 \\ -1 & 1 & 2 \\ 3 & 2 & -1 \end{pmatrix}$. 5
10. What is the trace of a matrix? 1
11. Define rank of a matrix. Find the rank of the matrices $\begin{bmatrix} 2 & 1 & -1 \\ 0 & 3 & -2 \\ 2 & 4 & -3 \end{bmatrix}$ 3
12. Define a similarity transformation of a matrix. 2

- **<u>Multiple Choice Type</u>:**

a. $\begin{bmatrix} 0 & -i & -3i \\ i & 5 & 0 \\ 3i & 0 & 2 \end{bmatrix}$ is a i)unitary matrix ii)orthogonal matrix iii)hermitian matrix iv)None of the above.

b. For the inverse of a matrix A to exist det A= i)0 ii)$\neq 0$ iii)<0 iv)>0

c. Cofactor of any element $a_{ij}$of a matrix A is i)a_{ij}ii)$(-1)^{i-j}a_{ij}$ iii) $(-1)^{i+j}a_{ij}$ iv) None of the above.

d.The determinant of an orthogonal matrix is = i) 1 ii) -1 iii) both ± 1 iv) 0.

e.$(AB)^{-1}$ = i)$A^{-1}B^{-1}$ii)$B^{-1}A^{-1}$ iii) $(BA)^{-1}$iv) None of the above

- **<u>True or False type</u>**

i)For a symmetric matrix A element $a_{ij} = a_{ji}$.

ii)A 2$\times 3$ matrix can be multiplied with a 3$\times 2$ matrix.

iii)The trace of a matrix is the sum of the square of the diagonal elements.

iv)For the inverse of a matrix A to exist det A$\neq 0$

<u>Mathematical Methods II</u>

Ordinary Differential Equations

1. Comment on the power series solution of a linear, second order and homogeneous differential equation. 3

2. For the equation $2x^2y'' - xy' + (1 - x^2)y = 0$ show that the recursion relation is given by $a_n = \frac{1}{(m+n-1)(2m+2n-1)} a_{n-2}$ for $n \geq 2.$ 5
3. Hence find the general solution for y. 5
4. Show that the recursion relation for the series solution of the differential equation $\frac{d^2y}{dx^2} + \omega^2 y = 0$ is given by $a_{r+2} = \frac{\omega^2}{(k+r+2)(k+r+1)} a_r$ 5
5. Hence find the general solution of y. 5
6. Check whether the solutions are linearly independent. 5
7. Check whether the Frobenius method is applicable in solving the Legendre differential equation $(1 - x^2)\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + l(l+1)y = 0$ at x=0 3
8. Derive the Rodrigues formula forLegendre polynomials. 5
9. Hence find the values of $P_0(x)$,$P_1(x)$ and $P_2(x)$. 3
10. Show that i) $P_l(1) = 1$ 2

    ii)$P_l(-x) = (-1)^l P_l(x)$ 2
11. Show that i) $nP_n(x) = (2n-1)xP_{n-1}(x) - (n-1)P_{n-2}(x)$ 4

    ii)n$P_n(x) = \frac{dP_n(x)}{dx} - \frac{dP_{n-1}(x)}{dx}$ 4

    iii)$P_n'(x) - P_{n-1}'(x) = (2n+1)P_{n-1}'(x)$ 3

    iv)$P_{n+1}'(x) - xP_n'(x) = (n+1)P_n(x)$ 3
12. Using Legendre polynomials show that $\int_{-1}^{1} x^m P_n(x) = 0$ where m,n are +ve integers and m<n. 4
13. From the generalized expression for Hermite's polynomials for even as well as odd n viz. $H_n(x) = \sum_{r=0}^{p} \frac{n!}{r!(n-r)!}(2x)^{n-2r}$ where p=n/2 if n is even and p=(n-1)/2 if n is odd, find the values of H_0(x),$H_1(x)$,$H_2(x)$ etc. 3
14. Show that e^{2xz-z^2} is, in fact, the generating function of the Hermite's polynomials. 5
15. Establish the Rodrigues' formula for the Hermite's polynomials viz. $H_n(x) = e^{x^2}(-1)^n \frac{\partial^n}{\partial x^n} e^{-x^2}$.What is its speciality? 5
16. CalculateH_0(x),$H_1(x)$,$H_2(x)$ etc. from the Rodrigues' formula for the Hermite's polynomials. 3
17. Prove the orthogonality property of Hermite's polynomials:

    $\int_{-\infty}^{\infty} e^{-x^2} H_m(x)H_n(x)dx = 0$if m≠n

    $= 2^n$n!$\sqrt{\pi}$if m=n.

    where $H_n(x)$is the Hermite's polynomials of degree of n 5

- Partial Differential Equations

1. Mention the three important types of differential equations encountered in physics. What are they called alternatively? 3
2. Find the general solution of the diffusion equation $\nabla^2 u = \frac{1}{c^2}\frac{\partial u}{\partial t}$ 3
3. Solve the Laplace's equation in two dimensional cylindrical(or plane polar) coordinates. What are the solutions called? 5
4. Solve the Laplace's equation in three dimensional cylindrical polar coordinates.What is cylindrical symmetry? 5
5. The potential of the side and bottom surfaces of a cylinder of radius 'a' and height 'h' is zero. The potential is V_0 on the top. Find an expression for the potential V(r, θ, z). 5.
6. Find the potential in the interior of a sphere of unit radius when the potential on the surface is f(θ)=$\cos^2\theta$. 4

- **<u>True or False type</u>**

  i) Legendre polynomials are not linearly independent.
  ii)Time dependent Schrodinger equation is a diffusion type equation.
  iii)An ellipse has azimuthal symmetry.

Fourier Series

1. Under what conditions can a function be expanded in a Fourier series? 2
2. Given $f(x) = a_0 + \sum_{n=1}^{\infty} a_n \cos nx + \sum_{n=1}^{\infty} b_n \sin nx$ find the values of a_0, a_n, b_n. 5
3. Can y=tan x be expanded in a Fourier series. Justify your answer. 2
4. Expand f(x) in a Fourier series when f(x) is an even function of x and an odd function of x. 3

   i) Expand f(x) =x2 in a Fourier series in the interval $-\pi \le x \le \pi$. Hence evaluate the Riemannian zeta function $\zeta(2)$. 5

   ii)Expand f(x) in a Fourier series in the interval $-\pi < x < \pi$ where

   f(x) =0 when $-\pi < x < 0$

   $= \frac{\pi x}{4}$ when 0<x< π and hence deduce that

   $\frac{\pi^2}{8} = 1 + \frac{1}{3^2} + \frac{1}{5^2} + ---------$ 5

   iii) Expand f(x) in a Fourier series where

   f(x)=k for 0<x< π

   f(x)=-k for $-\pi$<x<0

   and hence show that $\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + -----$ 5
5. Prove the Parseval's identity

$\langle [f(x)]^2 \rangle = a_0^2 + \frac{1}{2}\sum_{n=1}^{\infty}(a_n^2 + b_n^2)$ 3

6. Find an expression for the Fourier transform of a function f(x) in the domain $-\infty$ and ∞. 4
7. Prove the Paseval's relation $\int_{-\infty}^{\infty} |f(x)|^2\, dx = \int_{-\infty}^{\infty} |F(k)|^2\, dk$ 4
8. Find the Fourier transform of the delta function. 3
9. Find the Fourier transform of f(x) defined by

   f(x)=1, $-a < x < a$

   $= 0, |x| > a$. 3
10. Show that the Fourier transform of a Gaussian is another Gaussian. 3
11. Find the Fourier sine transform of f(x)=$\frac{1}{x}$ 4
12. Evaluate the integral by the Fourier transform technique.

    $\int_0^{\infty} \frac{coskxdx}{a^2+k^2}$ 4

- **<u>True or False type</u>**

  i)Any periodic function can be expanded in a Fourier series.

  ii)The Fourier expansion of an odd function of x results in sine series.

  iii)The Fourier transform of a plane wave is a plane wave.

  iv)Convolution integral is applicable to Fourier transform.

Unit 2

<u>Waves & Optics I</u>

Linear harmonic oscillator

1. Define simple harmonic motion and state its characteristics. 3
2. Set up the differential equation of SHM and solve it. 5
3. Is y=a sin kt +b sin kt an equation of an SHM. If so find its amplitude, time period and phase. 4
4. What are Lissajous' figures? 2
5. Discuss the formation of Lissajous' figures by the superposition of two perpendicular SHMs when

   i)the periods are the same but the amplitudes and phases are different 4

   ii)the periods are in the ratio 1:2 but the amplitudes and phases are different
6. 96.What is damped harmonic vibration? 1
7. 97.Set up the differential equation of damped harmonic vibration when it is under the action of a resisting force proportional to its velocity and restoring force proportional to its displacement from mean position. 2
8. Find the general solution of the above equation. 4
9. Discuss the case of overdamped motion. 5
10. Discuss the case of underdamped motion. 5
11. Discuss the case of critically damped motion. 5

12. What is forced vibration? 1
13. Arrive at the general solution of the differential equation for forced damped harmonic vibration. 5
14. Can beats be heard during forced vibration? 3
15. What is resonance? 3
16. Obtain an expression for energy of response of such a system. 3
17. Hence obtain the energy at resonance.
18. What is sharpness of resonance? 2

- **True or False type**

i)SHM occurs when displacement is in the direction of the force.
ii) The velocity of a particle undergoing SHM is maximum at the farthest point.
iii) The amplitude of oscillation in SHM is small.
iv)For a SHM average potential energy is equal to average kinetic energy.
v)Frequency at amplitude resonance is greater than that at velocity resonance.
vi)Quality factor of resonance is directly proportional to the damping factor.

- **Waves**

1. Set up the equation of a plane progressive wave. 2
2. The equation of a plane progressive wave is given by y= 6.0$\times 10^{-6} \cos(1900t + 5.72x)$. Find the frequency, wavelength, particle velocity and velocity of the wave. 4
3. Set up the differential equation followed by longitudinal plane progressive waves in an elastic medium in one dimension. 5
4. Define intensity of a plane progressive wave. 2
5. Derive an expression for intensity in terms of energy density of such a Wave. 3
6. Define phase velocity and group velocity of a plane progressive wave. 4

- **Multiple Choice Type:**

a.Longitudinal waves propagate in i) elastic medium ii) inelastic medium iii) in bothelastic medium and inelastic medium iii) None of the above

b.If a is the amplitude of the wave λ its wavelength and k is the modulus of elasticity then r.m.s acoustic pressure is given by i) $\frac{\pi a k}{\lambda}$ ii) 2 $\frac{\pi a k}{\lambda}$ iii) $\sqrt{2}\frac{\pi a k}{\lambda}$ iv)None of the above.

- **True or False type**

i)The equation of a plane progressive wave along +ve x direction may be written as y=a sin ($\omega t - kx$).
ii) In a longitudinal wave every particle undergoes SHM in a direction perpendicular to the direction of wave propagation.

iii) There is no excess pressure during longitudinal wave propagation.

iv) A plane wave can be represented by $\frac{e^{ikx}}{x}$.

v)For a non – dispersive medium group velocity and phase velocity are the same.

Geometrical optics

1. The limit $\lambda \to 0$ is called ray optics – explain. 2
2. What is principle of independence in geometrical optics? 1
3. What is optical path? 1
4. State Fermat's principle. 1
5. Prove the laws of reflection in a plane from Fermat's principle. 3
6. Prove the laws of refraction in a plane from Fermat's principle. 3
7. Prove Fermat's principle from laws of reflection in a plane. 3
8. Prove Fermat's principle from laws of refraction in a plane. 3
9. Establish Fermat's principle for reflection at a spherical boundary. 3
10. Establish Fermat's principle for refraction at a spherical boundary. 3
11. Prove the laws of reflection at a spherical surface from Fermat's principle. 3
12. Hence derive the equation obeyed for reflection at a spherical surface. 3
13. .Prove the laws of refraction at a spherical surface from Fermat's principle. 3
14. Hence derive the equation obeyed for refraction at a spherical surface. 3
15. Establish the thin lens formula applying Fermat's principle. 4
16. Define the lateral magnification at a spherical surface. 2
17. Define the longitudinal magnification at a spherical surface. 2
18. Define the angular magnification at a spherical surface. 2
19. Derive a relation between the three magnifications defined above. 2
20. Derive Lagrange's relation regarding magnification at a spherical surface. 4
21. How did Helmholtz modify it? 2
22. Derive the formula for the equivalent focal length of two thin lenses separated by a distance. 4
23. Derive the expression for a translation matrix of an optical system. 3
24. Derive the expression for a refraction matrix of an optical system. 3
25. How can you obtain a reflection matrix from a refraction matrix.2
26. What is a system matrix? 2
27. Derive the system matrix for refraction at a convex spherical surface. 4
28. Hence derive the Gaussian formula for this single refracting surface. 4
29. Derive the lens-maker's formula by the matrix method. 4

- **<u>Multiple Choice Type</u>:**
  a. When light travels between two points the path taken is i)maximumii) minimum iii) extremumiv) None of these
  b. The path is an extremum for i) plane surface ii) spherical surface iii) both plane and spherical surface iv) None of these
  c. Magnification produced by a refracting surface is i) lateral ii) longitudinal iii) angular iv) all the three aforesaid.
- **<u>True or False type</u>**

i) Light travels in straight line.
ii) Fermat's principle can be called the principle of least time.
Iv) Paraxial rays are rays parallel to the axis.

- **<u>Physical Optics</u>**

1. What is anwavefront? 1
2. Explain what you mean by Huygen's theory of wavefront propagation. 2
3. Why does Huygen's wavefront not move in the backward direction? 2
4. Establish reflection of light for a plane wavefront from Huygen's theory. 4
5. Establish refraction of light for a plane wavefront from Huygen's theory.5

- **<u>True or False type</u>**

i) A wavefront is the locus of points on the wave in the same phase and perpendicular to the direction of wave propagation.
ii) $\frac{e^{ikr}}{r}$ signifies a plane wavefront
iii) A spherical wavefront is emanated from a line source.
iv) Huygen's theory can explain the phenomenon of interference.

<u>Electronics I</u>
Networks

1. State Thevenin's theorem. 2
2. State Norton's theorem. 2
3. State maximum power transfer theorem. 2

- **<u>Multiple Choice Type</u>:**

a.Thevenin resistance is obtained by i)connecting the load resistance ii) disconnecting the load iii)taking the equivalent resistance of the network iv) None of these.
b.Norton current is obtained by i)shorting the load ii) opening the load iii) keeping the load intact iv) None of these
c.Thevenin voltage is obtained by taking the voltage i) across the load ii) across the load terminals but opening the load iii) across the battery iv) None of these
d. Maximum power is obtained when load resistance is equal to i) Thevenin resistance ii) Norton resistance ii) any one of the above two iv) None of these

- **<u>Semiconductor Diodes</u>**

1. Distinguish between conductors, insulators and semiconductors from band theory. 3
2. Distinguish between intrinsic and extrinsic semiconductors. 3
3. Explain the origin of intrinsic potential barrier across a junction.2
4. An intrinsic sample of Ge crystal has 1013 holes per cm3 .When doped with Sb, The hole concentration decreases to 1011 cm-3. What is the electron concentration of the doped sample? 2

5. What is a depletion region? 3
6. Explain the terms i) peak inverse voltage ii) ripple factor
7. Explain the working principle of a full-wave rectifier with π -section filter. 3
8. Explain the terms i)avalanche breakdown 2
   ii) Zener breakdown 2

- **Multiple Choice Type:**
  a. The electron and hole ion concentration is the same in i) extrinsic semiconductors ii) intrinsic semiconductors iii) in both of the above iv) None of these
  b. The band gap is zero for i) a semiconductor ii) a conductor iii) an insulator iv) None of these
  c.Avalanche Breakdown occurs in i)a p-n junction diode ii) a zener diode iii) in both diodes iv) None of these
  d. Ripples are i) small ac's ii) small dc's iii) a combination of the two stated above iv) None of these
  e. A capacitor filter blocks i) ac ii) dc iii) both ac and dc iv) None of these

- **True or False type**
  i) The electrical conductivity of a semiconductor is between those of the insulator and the conductor
  ii) P-N junction diode is a bipolar device.
  iii) A hole has a free +ve charge equal in magnitude to that of the electron.
  Iv) The band gap of semiconductors is about 6 eV.
  v) Semiconductors are electrovalent.
  vi) Effective mass is due to internal field dependence of the electron or hole masses.
  vii) The donor level is near the valence band.
  viii) A zener diode may act as a rectifier.
  ix) Reverse saturation current depends on temperature.
  x) Photodiodes are sensitive to illumination with light.
- **Bipolar Junction Transistors**

1. What are the differences between the emitter, base and collector of a BJT in terms of doping and size? 2
2. For a bipolar transistor $\alpha = 0.99$ and $I_{CBO} = 0.02\mu A$. Calculate the values of β and I_{CEO}. 2
3. Briefly describe an experiment to draw the characteristic curves of a CE amplifier. 4
4. What is a load line? 3
5. What is stability factor? 4
6. What is thermal runway? 2
7. What is a self-bias circuit? 5
8. How do you determine the Q point of such a circuit? 5
9. Discuss the phenomenon of stabilization of such a circuit. 3
10. Define the h parameters. 2
11. For a transistor amplifier find employing h parameters
    i)Current gain ii)Input resistance iii)Voltage gain

iv) Output Resistance v) Power Gain

12. Compare the properties of CE, CB, CC amplifiers. 3

- **Multiple Choice Type:**

  a. α is the i) common emitter voltage gain ii) common base voltage gain iii)common collector voltage gain iv) None of these

  b.When $V_{CE} = 0$ transistor is in i) active region ii) cut-off region iii) saturation region iv) None of these

  c. The best Q point is obtained in the i) end of the load line ii) start of the load line iii) middle of the load line iv) None of these

  d. The hybrid parameter model is applicable for i) large signal analysis ii) medium signal analysis iii) small signal analysis iv) None of these

  e. Emitter follower connection is the i) CE connection ii) CC connection iii) CB connection iv) None of these

- **True or False type**

  i) I_{CEO} is the common emitter leakage current

  ii) $\beta = \frac{\alpha}{1-\alpha}$

  iii) A transistor can be used as a switch.

  iv)There are three stability factors of a transistor.

  v)There is a phase shift in the CE amplifier

Field Effect Transistor

1. Describe the construction of a FET. 3
2. Why is a FET so called? 2
3. Definei) Pinch off voltage
   ii)Channel Ohmic region 2
   iii)Drain resistance 2
   iv) Transconductance 2
4. Compare a FET with a transistor. 3
5. Describe an experiment to draw the output and transfer characteristics of an n-channel FET. 5
6. Derive the relation between the FET parameters 3
7. i) Draw the circuit diagram of a common source small signal FET amplifier. 2
8. What effect will an increased +ve voltage on the gate of an p-channel FET have on the drain current? 2
9. What is the normal polarity of the gate with respect to the source in a p-channel JFET?
10. Describe the construction of a MOSFET. 3
11. What is the basic difference between the enhancement and depletion type MOSFET? What are their symbols? 5

- **Multiple Choice Type:**

  i) Depletion region in an unbiased JFET resemblesi)that of a p – n junction ii) that of a zener diode iii) that of a transistor iv) None of these

  ii) The drain characteristics has a i) cut – off region ii) an active region iii) a saturation region iv) None of these

iii) At pinch – off voltage I_D is i) increasing ii) decreasing iii) saturated iv) None of these.
iv) MOSFET is same as i) JFET ii) IGFET iii) CMOS iv) None of these

- **Digital Electronics**

1. Convert (15)10 to binary. 2
2. Convert (10110)2 to decimal. 2
3. i) Add 10001 to 111. Ii) Subtract 1001 from 1011 2
4. Prove the following Boolean identities i) A.(A+B) = A 2
   ii) A+BC=(A+B)(A+C) iii) A+ $\bar{A}B = A + B$
5. Explain the action of OR,AND gate with discrete components. 5
6. Explain the action of NOT gate with discrete components. 3
7. Write the truth table of NAND and NOR gates. 3
8. Show how a NAND gate can be used as a universal gate. 3
9. Show how a NOR gate can be used as a universal gate. 3
10. State de – Morgan's theorems. 3
11. What is 2's complement? 2
12. Subtract 1011 from 1001 by the 2's complement method. 2
13. What is an X – OR gate? Draw its circuit and write its truth table. 4
14. What is a Karnaugh map? 3

4

- **Multiple Choice Type**:

i) A hexadecimal system has i) 10 numbers ii) 2 numbers iii) 16 numbers iv) None of these
ii)The binary equivalent of 23 is i)11001 ii) 10111 iii) 11101 iv) 11110
iii) In Boolean algebra A+1= i) A ii) 1 iii) 0 iv) None of these
iv) The 1's complement of 110 is i) 010 ii) 001 iii) 011 iv) None of these

Paper II A
Unit 03

- **Classical Mechanics I**

Mechanics of a single particle

1. 197.Find expressions for velocity and acceleration in i) Plane polar coordinates 3
   ii) Cylindrical polar coordinates 5
   iii) Spherical polar coordinates 5
2. 198.Define time integral and path integral of a force. 4
3. Find $\int \vec{F}.\overrightarrow{dr}$ along the curve $x=t^2+1, y=2t^2$ and $z=t^3$ from t=1 to t=2 for the force
   $\vec{F} = 3xy\hat{\imath} - 5z\hat{\jmath} + 10x\hat{k}$. 4
4. 200.If$\vec{F} = (5xy - 6x^2)\hat{\imath} + (2y - 4x)\hat{\jmath}$, evaluate $\int \vec{F}.\overrightarrow{dr} along$ the curve $y=x^3$ in the xy plane from the point (1,1) to (2,8). 3
5. 201.State the principle of conservation of linear and angular momentum. 3
6. Define a conservative force? 1
7. Show that for a conservative force $\vec{F}$,

i) $\vec{F} = \vec{\nabla}\varphi$ where scalar potential $\varphi = \varphi(x, y, z)$ 2

ii) $\vec{\nabla} \times \vec{F}$ =0 2

8. Is $\vec{F} = 2xz\hat{\imath} + (x^2 - y)\hat{\jmath} + (2z - x^2)\hat{k}$ a conservative force? 3
9. Prove that the sum of the potential and kinetic energies of a particle is a constant at every point in a conservative field. 3

- **<u>True or False type</u>**

  i) $\oint \vec{F} \cdot \vec{dr}$ =0 means $\vec{F}$ is conservative.

  ii) Linear momentum is not always conserved.

  iii) Angular momentum of a particle $= \vec{r} \times \vec{p}$

  Impulse has the dimension of momentum.

- **<u>Mechanics of a system of particles</u>**

1. Define centre of mass (C.M.) for a system of particles. 2
2. Show that for a system of N particles the torque about any point due to mutually interacting forces assumed to be central vanishes. 3
3. Show that for the any system of particles $\frac{d\vec{L}}{dt} = \vec{N}$. 4
4. State the law of conservation of angular momentum from above. 1
5. Show that for a system of particles angular momentum about a point is equal to the angular momentum of the total mass concentrated at the C.M together with the angular momentum of the system about the C.M. 5

- **<u>True or False type</u>**

  i) The C.M. of a body may lie outside the body.

  ii) The C.M. of a body is unique.

  iii) For a system of particles $\vec{N} = \sum \vec{r}_i \times \vec{F}_i$

- **<u>Rotational Motion</u>**

1. Define moment of inertia (M.I) of a rigid body. What is its physical significance?
2. Prove the parallel axes theorem. 4
3. Prove the perpendicular axes theorem. 3
4. Calculate the M.I. of

   a) Thin uniform rod

   i) about an axis passing through one end of the rod and perpendicular to its length

   ii) about an axis passing through its centreand perpendicular to its length. 2

   b) Rectangular Lamina

   i) about an axis parallel to its length and passing through its C.M. – the axis lying in the plane of the lamina. 3

   ii) about an axis parallel to its breadthth and passing through its C.M. – the axis lying in the plane of the lamina. 3

   iii) about an axis passing through its C.M. and perpendicular to the plane of the lamina.

   c)Circular Disc

i)about an axis passing through its centreand perpendicular to its plane. 2
ii) about a diameter 2
iii) about a tangent parallel to one diameter 2
iv) about an axis tangential to the disc and perpendicular to its plane. 2
d) Thin Uniform Circular Ring
i)about an axis passing through its centreand perpendicular to its plane. 3
ii)about an axis passing through its centreand perpendicular to its plane. 2
iii) about a tangent lying in the plane 2

5. How will you distinguish one hollow sphere from a solid sphere when both are of the same mass and size. 4
6. Two particles of masses m and M are distance ‘d’ apart. Calculate the M.I. of the system about an axis passing through the C.M. and perpendicular to the line joining the two masses. If γ is the frequency of revolution, show that the rotational Kinetic energy of the system is :$2\pi^2\gamma^2 d^2 \frac{mM}{m+M}$ 4
7. A rigid body rotates with angular velocity $\vec{\omega}$ about an axis through the origin O and having direction cosines (l,m,n).
   i) Show that the M.I. of the rigid body about the axis is
   $I_{lmn} = l^2 I_{XX} + m^2 I_{YY} + n^2 I_{ZZ} + 2lmI_{XY} + 2mnI_{YZ} + 2nlI_{ZX}$
   ii) Hence find the equation of the ellipsoid of inertia about O. 2
   iii)Define the principal M.I. , products of inertia and principal axes of a rigid body.
8. Explain with physical arguments how you could choose principal axes of a symmetric rigid body. 4
9. For a cylinder of mass M, radius r and height h find the relation r=f(h) so that ellipsoid of inertia becomes a sphere. 3
10. Three particles each of mass m are situated at (a,0,0), (0,a,2a), (0,2a,a). Set up the principal axes of the system and calculate the principal moments of inertia.
11. Set up the Euler dynamical equations of motion 5

- **Multiple Choice Type**

  a. Radius of gyration of a cylinder of radius r about its own axis is
  i) $\frac{1}{2}r^2$ ii) r^2 iii) $\frac{1}{4}r^2$ iv) None of these
  b.By principal axes transformation the value of M.I.of a body is i)increased ii) decreased iii) not changed iv) None of these
- **Thermal Physics I**
- **Kinetic Theory of gases**

1. Show that the pressure of a perfect gas is $P = \frac{1}{3}mn\overline{c^2}$where m=mass of a molecule, n=number density, c=velocity. 5
2. From the above expression prove i) Boyle’s law 2
   ii)Charle’s law ii) Avogadro hypothesis 2
3. Deduce Maxwell’s velocity distribution law. 5
4. Write the energy distribution function for a system of gas molecules. 2
5. Assuming a Maxwellian distribution for the velocities show that the expression for mean free path is $1/\sqrt{2}n\pi\sigma^2$ where symbols have usual meanings.

6. State the law of equipartition of energy. 2
7. Show that the average energy obtained from equipartition of energy is consistent with that obtained from Maxwellian distribution of energy. 4

- **Transport Phenomenon**

1. Indicate what type of physical phenomenon occurs when there is
   i)transport of momentum
   ii) transport of thermal energy
   iii) transport of mass 3
2. On the basis of kinetic theory of gas
   i)derive an expression for coefficient of viscosity of a gas. 5
   ii) derive an expression for coefficient of thermal conductivity of a gas 5
   iii) What is their relation? 1
3. How doesviscosity and thermal conductivity depend on pressure and temperature?
4. What is Brownian motion? 2
5. Describe how Perrin determined the value of Avogadro number. 4
6. Using Einstein's theory find the temperature dependence of the mean squared displacement per unit time of colloidal particles suspended in a liquid. 5

- **Real Gases**

1. What do you mean by ideal gas? In what situation does a real gas behave like an ideal gas? 2
2. With the help of a rough sketch, show the nature of intermolecular attraction for molecules of a real gas. 2
3. Plot the isotherms of a pure substance near the critical point. Comment on the nature of the plot. 4
4. Write down the Kammerling – Onnes' equation of state. Define Boyle temperature from it. 3
5. Derive Van der Waals' equation of state for a real gas.How does it tally with experimental result? 5
6. i) Derive the expressions for critical constants of a Van der Waals gas. 5
   ii) Hence derive the reduced equation of state. 2
   iii) What is the law of corresponding states? 1

Conduction of Heat

7. What is thermal conductivity of a substance? Find its dimensions and state its unit in the c.g.s. and S.I. systems. 2+1+1
8. Explain the difference between thermal conductivity and thermometric conductivity of a material. 2
9. Establish Fourier's heat equation for one dimensional heat flow taking radiation loss into account. 5
10. Obtain Fourier's heat conduction equation in three dimentions in an infinite medium in steady state. What modification will be required in case of a finite boby.
    5
11. Considering the stationary condition of a conducting spherical sheel, integrating Fourier's equation for heat flow to obtain the temperatures at the two surfaces of the shell.
    5

Part II
Physics Hons.
Paper III; Unit- 05

Electronics II

1. Draw the circuit diagram of a two stage R-C coupled amplifier. Analyze its frequency response curve.
2. Indicate the differences between class A amplifier and class B amplifier with reference to the selection of Q-point.
3. A multistage amplifier employs five stages each of power gain 30. What is the gain of the amplifier in dB.
4. What is tuned amplifier?
5. What are their principal uses?
6. Draw the circuit diagram of a single tuned RF transistor amplifier.
7. Draw the nature of its frequency response curve.
8. Show that the maximum efficiency of a class A power amplifier directly coupled to the load resistance is 25%.
9. The mid-band gain of an RC-coupled amplifiers is 120. At frequencies of 100Hz and 100 Hz, the gain falls to 60. Determine the bandwidth.
10. What is an OP AMP? Why is it so-called?
11. Write down the characteristics of an ideal OP AMP.
12. How do the characteristics of a practical OP AMP differ from those of an ideal OP AMP?
13. Describe the use of an OP AMP as an inverting amplifier.
14. What is its voltage gain? What is the phase difference between the input and output voltages?
15. Why is the inverting terminal a virtual earth?
16. What is a non-inverting OP AMP?
17. Derive an expression for the gain of a non-inverting amplifier using OPAMP.
18. What are half adder and full adder? How can it be implemented by logic gates?
19. Draw the logic block diagram for adding two decimal numbers?
20. Draw a truth table for a three-input adder. Hence write the Boolean expression for the sum and the carry.
21. What is a multiplexer? Draw a logic block diagram of a 4:1 multiplexer.
22. Design a 4-to- multiplexer using basic gates.
23. Define a sequential logic system. How does it differ from combinational logic system?
24. What is an S-R flippflop? Give its logic symbol, truth table and circuit realization using NOR/NAND gates.
25. Show how an S-R flip-flop can be converted into a J-K flip-flop.
26. What is meant by race-around condition in a flip-flop? How can it beavoided?
27. What do you mean by edge triggering in a flip-flop?
28. What is a counter? Construct a four-bit ripple counter. What do you mean by up and down counters?
29. What is amplitude modulation? Define the term modulation index.
30. Show that an AM wave consists of an carrier and two sideband components for each modulation frequency.

31. Discuss the frequency spectrum of an FM wave.
32. What is the advantage of FM over AM?

Electricity and Magnetism

- ***Magnetic effect of steady current***

1. A current I is uniformly distributed over a wire of circular cross section, with radius ‘a’. Find the volume current density **J**.
   2
2. A phonograph record carries a uniform density of "static electricity" a. If it rotates at angular velocity w, what is the surface current density **K** at a distance r from the center?
   2
3. Find the magnetic field a distance s from a long straight wire, carrying a steady current **I**.2
4. Find the vector potential of an infinite solenoid with n turns per unit length, radius R, and current **I**.
   2
5. Explain the physical significance of $\vec{\nabla}.\vec{B} = 0$. 2
6. Find the trajectory of a charge particle in a uniform electromagnetic field (Electric field is perpendicular to magnetic one) if it starts at the origin with velocity
   (a) v(0) = (E/B)$\hat{y}$,
   (b) v(0) = (E/2B) $\hat{y}$,
   (c) v(0) = (E/B)($\hat{y} + \hat{z}$)
   4
7. A rectangular loop of wire, supporting a mass m, hangs vertically with one end in a uniform magnetic field B, which points into the page in the shaded region of Fig. 1. For what current I, in the loop, would the magnetic force upward exactly balance the gravitational force downward?

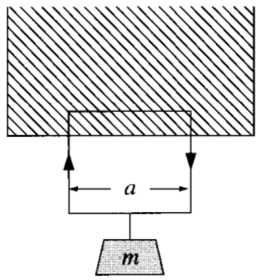


Fig 1 4

8. Suppose that the magnetic field in some region has the form B=kz$\hat{x}$ (where k is a constant). Find the force on a square loop (side a), lying in the yz plane and centered at the origin, if it carries a current I, flowing counterclockwise, when you look down the x axis. 4
9. Find the force on a triangular loop placed as shown in Fig. 2, near an infinite straight wire. Both the loop and the wire carry a steady current I.

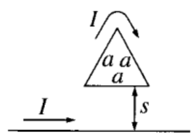


Fig 2 4

10. Suppose you have two infinite straight line charges ‘λ’, a distance ‘d’ apart, moving along at a constant speed ‘v’. How great would v have to be in order for the magnetic attraction to balance the electrical repulsion? Work out the actual number... Is this a reasonable sort of speed? 4
11. A steady current I flows down a long cylindrical wire of radius a. Find the magnetic field, both inside and outside the wire, if
    (a) The current is uniformly distributed over the outside surface of the wire.
    (b) The current is distributed in such a way that J is proportional to s, the distance from the axis. 4
12. Two long coaxial solenoids each carry current I, but in opposite directions, The inner solenoid (radius a) has n_1 tums per unit length, and the outer one (radius b) has n_2. Find B in each of the three regions: (i) inside the inner solenoid, (ii) between them, and (iii) outside both. 4
13. A spherical shell, of radius R, carrying a uniform surface charge σ, is set spinning at angular velocity ω. Find the vector potential it produces at point r.
    4
14. If B is uniform, show that $\mathbf{A}(\mathrm{r}) = -{}^{1}\!/_{2}\ (\mathbf{r} \times \mathbf{B})$ works. That is, check that $\nabla . \boldsymbol{A} = 0$ and $\nabla \times \boldsymbol{A} = \boldsymbol{B}$. Is this result unique, or are there other functions with the same divergence and curl?
    4
15. Show that the magnetic field of a dipole can be written in coordinate free form:
    $\mathbf{B}_{\text{dip}}(\mathbf{r}) = \frac{\mu_0}{4\pi}\frac{1}{r^3}[3(\mathbf{m}\cdot\hat{\mathbf{r}})\hat{\mathbf{r}} - \mathbf{m}].$
    4
16. The magnetic field on the axis of a circular current loop is far from uniform (it falls off sharply with increasing z). We can produce a more nearly uniform field by using two such loops a distance d apart (Fig.3).

    (a) Find the field (B) as a function of z, and show that $\frac{\partial \mathbf{B}}{\partial z}$ is zero at the point midway between them (z = 0). Now, if we pick d just right the second derivative of B will also vanish at the midpoint.
    (b) Determine d such that $\frac{\partial^2 \mathbf{B}}{\partial z^2} = 0$ at the midpoint, and find the resulting magnetic field at the center. 4

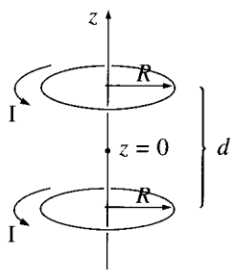


Fig 3

- **Field and magnetic materials**

17. Of the following materials, which would you expect to be paramagnefic and which diamagnetic? Aluminum, copper, copper chloride ($CuCl_2$), carbon, lead, nitrogen (N_2), salt (NaCl), sodium, sulfur, water. 2
18. Find the magnetic field of a uniformly magnetized sphere. 2
19. An infinite solenoid (n tums per unit length, current I) is filled with linear material of suscep- tibility χ_m. Find the magnetic field inside the solenoid. 2
20. Calculate the torque exerted on the square loop shown in Fig. 4, due to the circular loop (assume r is much larger than a or b). If the square loop is free to rotate, what will its equilibrium orientation be? 2

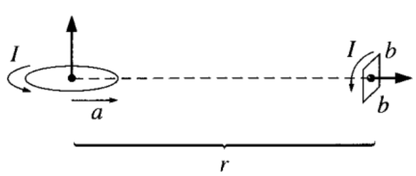


Fig 4

21. A long circular cylinder of radius R carries a magnetization $M = ks^2\hat{\varphi}$, where k is a constant, s is the distance from the axis, and $\hat{\varphi}$ is the usual azimuthal unit vector. Find the magnetic field due to M, for points inside and outside the cylinder. 4
22. An infinitely long cylinder, of radius R, carries a "frozen-in" magnetization. parallel to the axis, $M = ks\hat{z}$, where k is a constant and s is the distance from the axis; there is no free current anywhere. Find the magnetic field inside and outside the cylinder. 4
23. Show that the energy of a magnetic dipole in a magnetic field **B** is given by U=**-m.B,** and hence show that the interaction energy of two magnetic dipoles separated by a displacement r is given by

$$U = \frac{\mu_0}{4\pi}\frac{1}{r^3}[\mathbf{m}_1 \cdot \mathbf{m}_2 - 3(\mathbf{m}_1 \cdot \hat{\mathbf{r}})(\mathbf{m}_2 \cdot \hat{\mathbf{r}})].$$

4

- **Electromagnetic induction**

24. Two long cylinders (radii a and b) are separated by material of conductivity σ. If they are maintained at a potential difference V, what current flows from one to the other, in a length L? 2
25. A long cylindrical magnet of length L and radius a carries a uniform magnetization M parallel to its axis. It passes at constant velocity v through a circular wire ring of slightly larger diameter Graph the emf induced in the ring, as a function of time.
    2
26. A uniform magnetic field B(t), pointing straight up, fills the shaded circular region. If B is changing with time, what is the induced electric field?
    2
27. A capacitor C has been charged up to potential V_0; at time t = 0 it is connected to a resistor R, and begins to discharge.
    (a) Determine the charge on the capacitor as a function of time, Q(t). What is the current through the resistor, I(t) ?
    4
28. A metal disk of radius a rotates with angular velocity w about a vertical axis, through a uniform field B, pointing up. A circuit is made by connecting one end of a resistor to the axle and the other end to a sliding contact, which touches the outer edge of the disk (Fig. 5). Find the current in the resistor.
    4

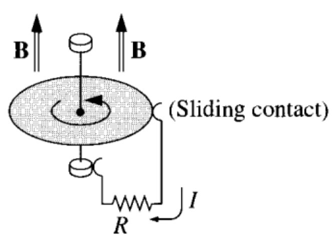


Fig 5.

29. A metal bar of mass rn slides frictionlessly on two parallel conducting rails a distance l apart. A resistor R is connected across the rails and a uniform magnetic field B, pointing into the page, fills the entire region.
    (a) If the bar moves to the right at speed v, what is the current in the resistor? In what direction
    does it flow?
    (b) What is the magnetic force on the bar? In what direction?
    (c) If the bar starts out with speed v_0 at time t = 0, and is left to slide, what is its speed at a later time t ?
    (d) The initial kinetic energy of the bar was, of course, $.5mv_o^2$. Check that the energy delivered

to the resistor is exactly $.5mv_o^2$.

4

30. A square loop of wire (side a) lies on a table, a distance s from a very long straight wire, which carries a current I.

(a) Find the flux of B through the loop.

(b) If someone now pulls the loop directly away from the wire, at speed v, what emf is generated? In what direction (clockwise or counterclockwise) does the current flow?

(c) What if the loop is pulled to the right at speed v, instead of away?

4

31. A short solenoid (length l and radius a, with n_1 turns per unit length) lies on the axis of a very long solenoid (radius b, n_2 turns per unit length). Current I flows in the short solenoid. What is the flux through the long solenoid?

4

32. Find the self-inductance of a toroidal coil with rectangular cross section (inner radius a, outer radius b, height h), which carries a total of N turns.

4

33. A long coaxial cable carries current I (the current flows down the surface of the inner cylinder,radius a, and back along the outer cylinder, radius b) as shown in Fig.6. Find the magnetic energy stored in a section of length I.

4

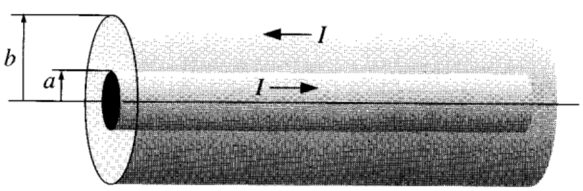


Fig 6.

34. Suppose the circuit in Fig. 7 has been connected for a long time when suddenly, at time t = 0, switch S is thrown, bypassing the battery.

(a) What is the current at any subsequent time t?

(b) What is the total energy delivered to the resistor?

(c) Show that this is equal to the energy originally stored in the inductor.

4

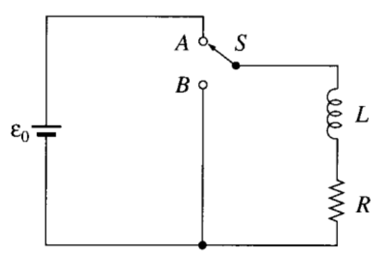


Fig 7

Unit- VI

Wave & Optics II

1. What d0 you mean by interference of light ?
2. State the conditions for the production of sustained interference fringes.
3. What do you mean by coherent sources ?
4. Explain wheather light energy is destroyed in the region of destructive interference.
5. What will happen if the amplitudes of two interfering waves are not equal ?
6. What do you mean by time coherence and length coherence ?
7. If the Biprism experiment is done by using white light , what will happen ?
8. If the whole arrangement of Young's double slit experiment is totally immersedin water then what will happen?
9. What will be the change in interference fringes if the fringe width is increased ?
10. Why the angle of the Biprism in Fresnel's interference experiment is made very acute?
11. What will be the nature of the rings in Newton's ring experiment if white light is used insteadofmonochromatic light?
12. What will happen if the width of the slit in Fresnel's biprism experiment will increase continuously?
13. What do you mean by fringes of equal width and fringes of equal inclination?
14. Will the destructive interference violates the law of conservation of energy?
15. What do you mean by localised and non – localized fringes ?
16. Mention the differences between interference and diffraction.
17. Distinguish between Fresnel and Fronhofer classes of diffractions.
18. What is Fresnel's half-period zone? Why is it so called ?
19. What do you understand by Frsnel classes of diffraction ?
20. What do you mean by zone plate ?
21. What do you mean by plane transmission grating ?
22. Compare between zone plate and convex lens.
23. Find out the no of lines per cm of a grating where the angle of diffraction for 1st order spectrum
    is 90°.
24. What do you mean by grating element ? What is its relation with the no of lines per cm of the grating?
25. What will be the nature of diffraction fringes produced by a grating if white light is used instead of Monochromatic light ?
26. How does a grating spectrum differ froma prismatic spectrum ?
27. What do you mean by ' Ghost line ' ?
28. What happens when the ruled surface of the grating is directed towards the collimator ?
29. How is the replica grating constructed ?
30. How do Newton's rings differ from biprism fringes ?

Parer IVA

Unit- VII

Quantum Mechanics I

1. State the Plank’s law of blackbody radiation.
2. State the basic characteristics of Einstein’s Photoelectric effect.
3. What is de-Broglie hypothesis.
4. What is the de-Broglie wavelength of an automobile of mass 1000 Kg moving with a velocity of 80 Km/hr? Can you detect it? Explain.
5. Making use of the uncertainty principle, evaluate the minimum permitted energy of an electron in a hydrogen atom and its corresponding mean distance from the nucleus.
6. In what way does the diffraction of an electron beam differ from that of the beam of light?
7. An electron with kinetic energy of 2 KeV is confined to a region of atomic dimension 10^{-10}m. Find the uncertainty in linear momentum.
8. A photon of energy 1.02 MeV undergo Compton Scattering through an angle of 180^0. Calculate the energy of the scattered photon.
9. Obtain a relation between phase velocity and group velocity. Which velocity has de Broglie associated with the matter waves?
10. The de Broglie wavelength of an electron is 0.15 A^0. Calculate the phase and group velocity of a de Broglie wave.
11. Starting from the uncertainty principle $\Delta x \Delta_{px} \geq \hbar/2$, obtain the energy uncertainty relation.
12. What do you mean by the wavefunction of a moving particle? Give its physical significance.
13. What is a Hermitian operator?
14. Prove that the eigen values of the Hermitian operators are real.
15. Prove that if the operators A and B commute, they have the same set of eigenfunctions.
16. Test whether x and d/dx are linear operators.
17. State the fundamental postulates of quantum mechanics.
18. State the principle of superposition in the case of quantum mechanics.
19. Derive an expression for the kinetic energy of recoil electron in Compton effect.
20. What is the effect on Compton shift?
21. Why Compton effect cannot be observed with visible light?
22. Describe the necessary theory of Davission Germer experiment for establishing wave nature of electron.
23. Explain the need for a wave equation to describe the behavior of a quantum system. Discuss the required characteristics of such a wave equation.
24. Show that $d\langle x\rangle/dt = \langle p_x\rangle/m$ and $d\langle p_x\rangle/dt=\langle F_x\rangle$, where the symbols have their usual meanings.

25. Derive the equation of continuity for probability.
26. Define the probability current density.
27. What are the boundary conditions imposed on a well behaved wavefunction.
28. What is the implication of the result [H, L] = 0.
29. Using the basic relation $[x, p_x]=i\hbar$, show that $[p, x^n]=-i\hbar n x^{n-1}$ and for any function $[p, f(x)]=-i\hbar df/dx$.
30. Show that the Schrodinger equation is linear.

<u>Thermal Physics II</u>

Thermodynamics

1. Explain clearly the meaning of a 'quasistatic' process. Define the following terms: cyclic process, isothermal process, isobaric process, isochoric process and adiabatic process. How would you represent, on a p-V diagram, an isobaric and an isochoric process?
2. Show that for van der waal's gas
$$C_p - C_v = R\left\{1 + \frac{2a}{RTV^3}(V-b)^2\right\}$$
3. What is enthalpy? Show that the enthalpy of a system is given by H=U+pV. Is H a state function? Explain.
4. Deduce an expression for the work done in a quasistatic isothermal expansion or compression of an ideal gas. Comment on: 'The work done depend on the path'.
5. It is given, with usual symbol, that
$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p$$
Where U=internal energy of the system. Show that one mole of a van der waal's gas
$$\bar{d}Q = C_V dT + \frac{RT}{V-b}dV$$
6. State the essential difference between the first and second law of thermodynamics. Show that all reversible engine working between two constant temperatures will have the same efficiency being independent of the nature of the working substances and the manner in which it performs the mechanical work.
7. Define entropy and state briefly its physical significance. Show that the entropy increases in natural processes.
8. Show that the entropy is a measure of the so-called unavailable energy. When two gases at same temperature and pressure diffuse into each other, show that there is an increase in entropy in the process. Discuss Gibb's paradox in this connection.
9. Explain how one arrives at the idea of entropy as a state function. Prove also that for an ideal isolated system, the entropy cannot decrease.
Calculate the increase in entropy when n_1 moles of a gas mix up with n_2 moles of another gas, both being same temperature and pressure.
10. Assuming the temperature to be a thermodynamic coordinate of a system, show how Kelvin derived a scale of temperature independent of the properties of the measuring system. What is ideal gas scale temperature? Explain the relation between ideal gas scale and Kelvin scale of temperature.
11. Derived Maxwell's thermodynamics relation and hence prove the relation
$$C_p - C_V = T\left(\frac{\partial p}{\partial T}\right)_V\left(\frac{\partial V}{\partial T}\right)_p$$

Show that for a van der Waal's gas $C_p - C_V$ is given by

$$C_p - C_V = \frac{R\left(p + \frac{a}{V^2}\right)}{p - \frac{a}{V^2} + \frac{2ab}{V^3}}$$

12. Prove thermodynamically the following relation:
$(i)\,\frac{E_S}{E_T} = \frac{C_p}{C_V} = \gamma\;(ii)\,\frac{\partial C_V}{\partial V} = T\frac{\partial^2 p}{\partial T^2}\,(iii)\,\frac{\partial C_p}{\partial V} = -T\frac{\partial^2 V}{\partial T^2}$
where the symbols have their usual meanings.
13. From the first and second law of thermodynamics prove that for any system
$(a)\,C_p - C_V = \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right]\left(\frac{\partial V}{\partial T}\right)_p;\ (c)\,TdS = C_V dT + \frac{\alpha T}{K}dV$
$(b)\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p;\ (d)\,C_p - C_V = \frac{TV\alpha^2}{K_T}$
Where α is the volume coefficient of expansion and K_T the isothermal compressibility=$-\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$ and other symbols have their usual significance.
14. Prove the thermodynamic relation$TdS = C_p - T(\partial V/\partial T)_p dp$. Find an expression for the heat absorbed, when one mole of a liquid is compressed isothermally, in terms bulk modulus and the coefficient of expansion of liquid. What will happen if the liquid is water having a temperature between 0^0C and 4^0C?
15. If the state function x, y, z are related by an equation of state z=f(x,y), show that
$\frac{\partial^2 z}{\partial x \partial y} = \frac{\partial^2 z}{\partial y \partial x}\ and\ \left(\frac{\partial z}{\partial x}\right)_y\left(\frac{\partial x}{\partial y}\right)_z\left(\frac{\partial y}{\partial z}\right)_x = -1$
Prove the first TdS equation: $TdS = +T\left(\frac{\partial p}{\partial T}\right)_V dV$.
16. Explain clearly why F defined by F=U-TS and G defined by G= U+pV-TS are called energies- Helmholtz and Gibbs free energies respectively. Show that internal energies is made up of two parts- the free energy and latent energy – or available energy and unavailable energy for useful work.
17. Prove that
$(i)\ S = -\left(\frac{\partial G}{\partial T}\right)_p\ and\ (ii)\ V = \left(\frac{\partial G}{\partial p}\right)_T$ where symbols have their usual meanings.
18. What is meant by the first order phase transition? Establish the Clapeyron equation for a system which can have a first phase transition.
19. From thermodynamic considerations deduce the relation
$\frac{dL}{dT} = \frac{L}{T} + c_2 - c_1$
Where c_2 is the specific heat of saturated vapour and c_1 the specific heat of liquid, L=latent heat of liquid. Explain why specific heat of saturated stream is negative.
20. What is Gibbs potential? How is related with the first order phase transition? Hence deduce the relation
$\frac{dp}{dT} = \frac{L}{T(v_2 - v_1)}$

21. Distinguish between cooling produced by J-T process and adiabatic expansion. Derive an expression for J-T cooling. What is temperature of inversion? Show how you can calculate it from van der Waal’s critical constant.
22. Show that the expression for the J-T coefficient in an isenthalpic change is given by
$$\mu_H = \frac{1}{C_p}\left(\frac{\partial H}{\partial p}\right)_T$$
and hence discuss the factors influencing the J-T throttling process.
23. Show how J-T expansion becomes of much importance in the liquefaction of gases. Give an account of KemerlingOnnes’ work in connection with liquefaction of helium.
24. Obtain an expression for J-T cooling in a gas assuming the gas obeys van der Waals’ equation and also for temperature of inversion for such a gas. Why do hydrogen and helium show a heating effect at ordinary temperature?
25. Explain the principle of regenerative cooling and describe a method for liquefying air, based on this principle.
26. Distinguish between the Carnot cycle and the Rankine cycle for a reciprocating stream engine working between the same two fixed temperatures. Draw T-S diagram of the two cycles and explain why the former is impracticable and thelatter less efficient.
27. Obtain an expression for the efficiency of an internal combustion engine of constant volume ignition type.
28. Explain the principle of working of an Otto or a Diesel engine with the help of an indicator diagram and obtain expression for its efficiency.
29. Explain the working principle of a Diesel engine. Derive an expression for its efficiency. Discuss the relative merits and demerits of such an engine.
30. (a) Describe an Otto cycle and calculate its efficiency.
(b) Describe with a net diagram a simple type of refrigerating machine and evaluate its coefficient of performance.

Part-III

Paper V

Unit-09

- **Classical Mechanics II**

1. State the integral version of Gauss' divergence theorem.
2. A circular loop of radius 'R' carrying a uniform line charge density is lying on the XY-plane with the centre
at the origin. The total charge on the loop is 'Q'. A thread carrying a uniform line charge density is lying along the Z-axis from the origin to the point (0,0,R) with total charge q. Find out the total force acting on the loop.
3. A sphere with a uniform charge density is centered at the origin.
The total charge is Q. What is the total flux of the electric field through an infinite plane which is tangential to the sphere and is parallel to the XY plane.
4. Using the Lorentz force law show that magnetic forces can not work.

5. Find out the torque acting on a rectangular current loop placed parallel to a uniform magnetic field such that the normal to the plane of the loop is perpendicular to the direction of the magnetic field.
6. What is the number physical variables having independent dimensions in the rationalized MKSA system of units. State the corresponding physical variables.
7. A ring of radius 'R' lying on the XY-plane with the center at the origin has a constant line charge density 'l'. Find the electric field at the point (0,0,z).

- **Special Theory of relativity**

1. Let us consider a rod of length 'L' lying on the 'X'-axis of 'S'. The rod is moving with a constant acceleration a along the 'Y'-axis. What is the shape of the rod in the 'S' frame at any instant of time in 'S'. 'S'$is moving with velocity 'v' along the 'S' frame 'X'-axis.
2. 'S' and 'S" are in standard configuration. In 'S' a straight rod in the 'X'-'Y' plane is rotating with constant angular velocity about its centre which is the origin of 'S'. Find the shape of the rod in the 'S'-frame at t = 0. Also show that when the rod is orthogonal to the 'X'- axis in 'S' it appears straight in 'S'.
3. Solve problems 21 - 30 of Ch.2, R. Resnick using the invariance of the interval under the Lorentz transformations.
4. Show that the sum and difference of any two orthogonal space-like vectors is also orthogonal.
5. Define the Minkwosky space. Write down the expression for invariant interval. Derive an expression for time-dilation from the invariance of the interval under the Lorentz transformation.
6. Explain what you mean by a principle of relativity in Physics.
7. State the assumptions of the Galilean Relativity.
8. What do we mean by Clock synchronization. What do you mean by "Absolute time"'.
9. State the purpose of the Michelson-Morley experiment.
10. Give a schematic diagram of the Michelson-Morley interferometer explaining the purpose of the different components.
11. Show that even with finite speed signals, time remains absolute under the transformations between the inertial frames provided we assume the Galilean law of velocity addition.
12. Explain that clock synchronization is relative in the special theory of relativity.
13. Obtain the relativistic expression for length-contraction using the invariance of the interval.
14. Explain how causality is protected in the Special Theory of Relativity.

Unit-10

- **Quantum Mechanics II**

1. Write down the Hamiltonian for a free particle.
2. Determine the eigenfunction of this operator.
3. Is this eigenfunction is also the eigenfunction of the momentum operator?
4. What do you mean by degenerate wave functions?

5. If $H=p^2/2m+V(x)$, show that $[x, [x, H]]=-\hbar^2/2m$.
6. Find the eigenvalues and eigenfunctions of the angular momentum operator $L_z=-i\hbar\partial/\partial\varphi$.
7. Show that for a potential $V(-\mathbf{r})=-V(\mathbf{r})$, the wavefunction is of either even or odd parity.
8. If $u_1(x)$ and $u_2(x)$ are two degenerate, orhogonal eigenfunctions of the Hamiltonian $H=p^2/2M+V(x)$,then show that $\int u_1(x)(xp_x - p_x x)u_2(x)dx=0$.
9. Set up Schrodinger equation for a particle in an infinite square well where, V= 0 for $-a<x<a$; $V=\infty$ elsewhere. Solve the equation to find energy eigenvalues and eigenfunction.
10. Derive an expression for transmission coefficient of a particle through a rectangular potential barrier of height V_0, when the total energy E of the particle is less than the barrier height.
11. Calculate the transmission probability of a beam of electrons of energy 1eV through a 1 – D rectangular barrier of height 5eV and width $1A^0$.
12. A aparticle with a definite wavelength λ having function $\Psi(x, t)$ in a frame S. Determine the wavelength of the same particle in the frame $S^/$, when the two frames are related by Galilean transformation.
13. Show that $\sin\alpha x$ and $\cos\alpha x$ are degenerate eigenstates of the operator d^2/dx^2.
14. A particle in a 1 – D box with infinite walls has a ground state wavefunction given by $\Psi(x)=A\cos(\pi x/2a)$. What is the width of the box? Find the value of A.
15. Find the expectation value $<x>$ for the wavefunction $\Psi(x)=(1/\sigma\sqrt{\pi})^{1/2}\exp(-x^2/2\sigma^2)\exp(ikx)$.
16. For the first excited state of the harmonic oscillator, the wavefunction is given by $\Psi_1(x)=(\alpha/4\pi)^{1/4}xe^{-\alpha x2/2}$, $\alpha=m\omega/\hbar$. Show that the value of uncertainty product $\Delta x\Delta p=3/2\hbar$.
17. Particle in the ground state is located in a 1-D square well potential of length L with absolutely impenetrable walls ($0<x<L$). Find the probability of the particle staying within the region $L/3\leq x\leq 2L/3$.
18. A 1- D wavefunction is given by $\Psi(x)=\sqrt{a}e^{-ax}$, find the probability of particle between $x=1/a$ and $x= 2/a$.
19. Denoting the two spin ½ states by $\chi^{\pm}$write down the normalized singlet and triplet spin states formed by the combination of these two states.
20. Write down the three angular momentum operators in the coordinate representation in terms of spherical polar co-ordinates.
21. Write down the schrodinger equation for the hydrogen atom assuming the nucleus to be heavy. Obtain the radial part of the equation.
22. The ground state wavefunction for hydrogen like atom is $\Psi_{100}(r)=Ne^{-Zr/a}$. Determine the normalization factor N. Sketch the radial probability distribution function indicating the value at which it attains its maximum. Calculate the expectation value $<1/r>$ in this state.
23. Show that spherical harmonics are function of definite parity.
24. Prove that parity operator P commutes with L_z and L^2.
25. Prove that eigenvalue of L^2 is (2l+1) fold degenerate.
26. Determine the degeneracy belonging to energy of the hydrogen problem.
27. Find the expectation values of the kinetic and potential energies of harmonic oscillator in its ground state.

- **Atomic Physics**

1. Explain magnetic moment of atom and derive an expression for it.

2. Show that the ratio of the orbital magnetic moment to the angular momentum of the atom is e/2m.
3. What is spin orbit coupling.
4. Define total angular momentum j and show that its Z –component is quantized.
5. Find the value of the total angular momentum j for one electron atom and the value of j for l=1.
6. Describe Stern-Gerlach experiment with necessary theory. What was aim of the experiment? Discuss its significance.
7. Give the standard spectroscopic term notation for the ground state of the sodium atom.
8. How many spectral lines appear in the Zeeman splitting of the $^2D_{3/2}\rightarrow{}^2P_{1/2}$ transition of sodium?
9. What is the origin of the doublet structure of sodium D-line?
10. Distinguish between normal and anomalous Zeeman effect.
11. Explain why normal Zeeman effect occurs only in atoms with even number of electrons.
12. What is meant by space quantization? Which experiment directly demonstrate space quantization.
13. What is Raman effect? What are Stoke's and anti – Stoke's lines?
14. The ground state of aChlorine atom is $^2P_{3/2}$. Find out the magnetic dipole moment of a Chlorine atom in its ground state.
15. Why alkali spectra differ from Hydrogen spectrum? Explain.
16. What is the principal difference between Compton effect and Raman effect?
17. Why is it difficult to observe Raman effect in the Lab?
18. Which of the following substance can give rise to pure rotation- vibration spectra? H_2, HF, O_2, CO.
19. Pure rotation spectra are almost always seen as absorption lines and not as emission lines. Explain the reason.
20. What is a selection rule?
21. What selection rule is observed during transition between different levels of an atom?
22. Obtain an expression for Lande g factor.
23. What is Larmor precessional frequency?
24. Calculate the Larmor precessional frequency for an electron in the field of 1 Tesla.
25. What is the major difference between spontaneous and stimulated emission?
26. Obtain a relation between the transition probabilities of spontaneous and stimulated emissions.
27. What is population inversion?
28. Obtain a relation between Einstein's A and B coefficients.
29. Show that for normal optical source($T = 10^3K, \lambda= 6000A^0$) emission is incoherent.
30. For 2P→1S transition in hydrogen atom,the mean spontaneous life tiem is 1.66 ms and the frequency of the emitted radiation is $2.4x10^{15}$Hz. Calculate the probability of stimulated emission.

Paper VI

Unit- 11

Nuclear and Particle Physics I

1. Exaplain, with examples, the terms ‘isotope’, ‘isobar’, and ‘isotone’. Name the different isotopes of hydrogen.
2. Define unit of atomic mass and calculate its energy equivalence in MeV. What are the masses of a proton and a hydrogen atom with $^{12}C_6$ scale as standard.
3. Define binding energy of nuclei.
4. How does the binding energy per nucleon vary with mass number.
5. What is the size of the nucleus?
6. Mention the different methods of estimating the nuclear size and describe any one in details.
7. Why do the stable medium nuclei contain excess neutrons?
8. On what factors does the stability of a nucleus depend?
9. Show that the energy equivalent of 1u (or 1 amu) is approximately 931 Mev.
10. Why are the values of the magnetic moments of proton and neutron not as expected to be a simple as that of the electron.
11. Polonium-212 emits α- particles, whose kinetic energy is 10.54MeV. Determine the α-disintegration Energy.
12. 1. Write down the semi-empirical nuclear binding energy formula, proposed by Weizsacker.
13. Obtain an equation of mass parabola from it. Hence explain the stability of nuclei against β- decay for odd A .
14. Draw a typical β-ray spectrum. Why was it necessary to postulate the existence of a new type of
    particle to explain this spectrum?
15. Write down the nuclear magic numbers. Why are they so called?
16. Find the parity for the ground state of $^{27}Al_{13}$ nucleus.
17. With a neat diagram, explain the basic working principle of Bainbridge mass spectrograph to measure atomic masses.
18. State the reason that makes I=l +1/2 state deeper-lying or more tightly bound than the I=l -1/2 state in a nucleus.
19. What are the basic assumptions for a liquid drop model of a nucleus? Discuss the limitations of the liquid drop model.
20. State the main assumptions of the nuclear shell model.

Nuclear and Particle Physics II

1. Explain clearly what is ment by Q-value of a nuclear reaction.
2. What are exoergic and endoergic reactions?
3. What are the different types of nuclear reactions?
4. What are the conservation laws applicable to a nuclear reaction?
5. What are artificial radioactivity?
6. Write explanatory notes on:
   A) Radioisotopes and their applications
   B) Compound nucleus and nuclear reactions.
7. Explain the meaning of the following terms: nuclear fission, nuclear fusion, thermal netrons, moderator, critical condition of a reactor, breeder reactor.
8. Give a simple explanation of nuclear fission by the liquid drop model of the nucleus.

9. What is chain reaction in nuclear fission?
10. What is a controlled nuclear chinreaction?
11. What do you mean by an elementary particle?
12. How are the elementary particles classified on the basis of their masses, interaction or statics.
13. What are ‘brayon and lepton number’? Show, with examples, that in any nuclear reaction, they are conserved.
14. What do you mean by ‘quarks’?
15. How many possible quarks are there? Give the charge and quantum number associated with each quark. How do the quarks combine to form baryons and mesons?
16. What are leptons? How many leptons are there? Write their names.
17. What is meant by eight-fold way or octet symmetry?
18. A muon is not a meson. – Discuss.
19. What do you mean by charge conjugation?
20. Is neutron a lepton, a baryon or a meson? Justify your answer.

Unit-12
Solid state Physics I

- **Crystal Structure**

1. Consider an electron traveling at a velocity of 10^8 cm/sec. 2
   (a) Calculate the De Broglie wavelength of the electron. 2
   (b) If an x-ray has the same wavelength, how much energy should be associated with the x-ray?
2. Explain what do you mean by ‘crystalline’ and ‘non-crystalline’ substances . 2
3. Explain what do you mean ‘Crystal Translational Vectors’. 2
4. What do you mean by Lattice and Basis? 2
5. Name a suitable Bravais lattice, its symbol, convenient unit cell characteristics and example of sample. 2
6. What do you mean by Miller Indices . 2
7. What do you mean by reciprocal lattice? 2
8. State and explain Bragg condition for X- ray diffraction in a crystal. 2
9. A beam of X-ray of wavelength 0.25 nm is incident on a crystal of interplanal separation 0.30 nm. Calculate the glancing angle for first order diffraction. 2
10. The lattice parameter of a cubic lattice is 2.4 nm. Find the lattice spacing for plane(122).
11. Show that reciprocal lattice of FCC is BCC and vice versa. 4

- **Structure of solids**

12. How many types of bonding are there? Give one example of each. 2
13. What is effective mass? 2
14. What are Brillouin zones? 2
15. What is the basic physical principle responsible for the origin of energy bands rather the specific energy levels in a solid? 2

16. A metal has a static conductivity of $4*10^7$ mho/m. Assuming that the true charge carriers are free electrons and there are $2*10^{28}$ electrons per m^3, calculate relaxation time. 4
17. Using free electron theory, establish a relation between electrical conductivity of a metal and meam free path. 4
18. Discuss the formation of allowed and forbidden energy bands on the basis of Kronig Penney model. 4

Solid state Physics II

- **Dielectric properties of materials**

1. What is meant by polarization of a solid? Explain polarizability of atoms and molecules.2
2. Derive expressions for electric and ionic polarizability of a dielectric materials. 2
3. If the dielectric constant of NaCl crystal is 5.6 and its optical refractive index is 1.5, find the ratio of its electrical polarizability to its total polarizability. 2
4. Wite down the Calusius Mosotti relation and explain its physical significance. 2
5. Explain the behaviour of a dielectric material in an ac field. 4
6. Derive expression for the energy absorbed per second in a dielectric material when an ac field is applied. 4
7. Derive an expression for the dipolar polarizability for low applied field and high temperature. 4

- **Magnetic properties of materials**

1. Explain how a saturation magnetization depends on temperature. 2
2. Distinguish between classical and quantum theory of Paramagnetism. 2
3. What is meant by magnetic susceptibility? 2
4. What is Curic temperature T_c? Sketch susceptibility of ferromagnetic material as a function of temperature above T_c. 2
5. Discuss the quantum theory of Para magnetism. Obtain curies law for paramagnetic material. 4
6. Explain the Weiss theory of ferromagnetism. Obtain an expression for the susceptibility of ferromagnetic material. 4
7. The Curic temperature of Iron is 1043K. Assume that iron atoms , when in metallic frm, have moment of two Bhor magneton per atom. Iron is BCC with lattic parameter 0.286nm. given $\mu_B = 9.2741*10^{-24}$J/T calculate saturation magnetization Curie constant Weiss field constant. 4
8. What is hysteresis? Explain its origin from domen theory. 4
9. Discuss Langevin theory for a paramagnetic gas and obtain an expression for paramagnetic susceptibility. 4

10. State the basic assumptions of the molecular field theory of ferromagnetism.
4

- **<u>Lattice vibration</u>**

1. Write down basic difference between Einstein's and Debye's theory of specific heat. 2
2. Derive Debye's T^3 law for specific heat of solids. 4
3. Describe the Einstein model of lattice heat capacity. Discuss the successes and failures of this model. 4

- **<u>Superconductivity</u>**

1. Distinguish between type I and type II superconductor with the help of M-H plot. 2
2. What is the implication of isotope effect? 2
3. What do you mean by Meissner effect. 2
4. Sketch the specific heat of a superconductor and a normal metal as a function of temperature in the same graph. 2
5. Show that the magnetic field decays inside the superconductor exponentially with a characteristics length scale. 2

Paper VII A

Unit- 13

Statistical Mechanics

1. (a) Discuss comparatively the basic postulates of MB, BE, and FD-statistics. Name the statistics (MB, BE, FD) obeyed by each of the following particles: neutron, □-meson, muon, photon, phonon, proton, electron, gas molecules, α-particles, H-atom, neutrino, neutral He-atom in ground state.
   (b) Write down the distribution law obeyed by electron gas and apply the same to derive Richardson-Dushman equation.
2. Discuss the limitation of the MB-statistics. Assuming the BE energy distribution law, deduce Planck's law of radiation.
3. A system of identical, non-interacting particles obeys Pauli's principle. Obtain the distribution law. Discuss (i) the classical limit and (ii) the T=0 behaviour of the gas.
4. For a system of non-interacting particles, how does the distribution function differ for particles obeying BE and FD-statistics?

5. Give one example each of the system where you would apply the above two distributions. At T=0, sketch the distribution function in the two cases.
6. Derive Planck's formula for black body radiation using BE-statistics. Using this result, deduce Stefan-Boltzmann law.
7. Explain why dilute gas obeys classical statistics while dense systems follow quantum statistics.
8. What is Fermi energy? Does it depend on temperature?
9. Sketch the FD distribution function at absolute zero and at any finite non-zero temperature.
10. Deduce the internal energy of a Fermi gas system of N free particles at T=0K.
11. What is meant by a priori probability? State the principle of equal a priori probability.
12. Define and explain the following terms: macrostate, microstate and thermodynamic probability.
13. Define ensemble and classify it with explanation.
14. State and establish Liouville's thorem.
15. What do meant by phase space? Draw phase space diagram of i) a simple pendulum, ii) a linear harmonic oscillator.
16. What is partition function? What is it's importance?
17. Starting from the partition function of ideal gas obtain its entropy,Helmholtz free energy.
18. Establish Boltzmann relation connecting entropy and thermodynamic probability.
19. What is density of states? Find an expression of it in momentum space.
20. What is chemical potential? Why it is zero for photons?
21. What do you mean by Fermi velocity, Fermi momentum, Fermi temperature.

- **<u>Electromagnetic Theory</u>**

1. What do you mean by displacement current?
2. Show that Maxwell's equations are consistent with the equation of continuity.
3. Show that Maxwell's equations suggest propagation of electromagnetic wave in a linear homogeneous dielectric medium having no free charge.
4. State and prove Pointing's theorem in electromagnetism.
5. Show that the momentum density stored in an electromagnetic field is given by $\mathbf{g} = \mathbf{S}/c^2$ in vacuum where $\mathbf{S}=\mathbf{E}\times\mathbf{H}$ is the Pointing vector.
6. Why is the rising and setting sun coloured crimson red.
7. Show that in a conductor the electric and magnetic fields are no longer in phase.
8. Starting from Maxwell's equations obtain an expression for the skin depth of a conductor.
9. An electromagnetic wave is propagating from one linear dielectric medium to another with no free charges or currents. Write down the boundary conditions for the electric and magnetic filds.
10. What is dispersion? An electromagnetic wave is incident on a dielectric medium. Assume that the field inside the medium is nearly equal to the incident field. Construct the equation of motion for the bound electrons.

11. Write down the equation of motion of an electron in a radiation field explaining the terms.
12. What is Brewster's angle? Write its expression.
13. Light is incident from air on a glass of refractive index 1.5. Calculate Brewster's angle.