VECTOR ALGEBRA

1. State the triangle rule of addition of two vectors.
2. Prove using vector algebra that the diagonals of a rhombus are perpendicular to each other.
3. Using vectors, show that the medians of a triangle are concurrent.
4. Prove using vector algebra that the perpendiculars drawn on the sides of a triangle from the opposite vertices are concurrent.
5. If $|\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$, then prove that $\vec{A}$ and $\vec{B}$ are perpendicular to each other.
6. Why orthogonal components of a vector are very useful?
7. Why a vector in space may be called ordered triplet of numbers.
8. What are right-handed and left-handed co-ordinate systems?
9. Why unit vector does not have unit?
10. Define scalar product of two vectors. Give one example. How scalar product of two vectors can indicate whether these two are (i) parallel, (ii) perpendicular and (iii) antiparallel?
11. Show that scalar product is distributive over addition.
12. Define vector product of two vectors. Give one example. Why vector product is not commutative? Show that magnitude of the vector product is equal to the area of the parallelogram formed by the two vectors. What is the condition for two vectors to be perpendicular?
13. What are the magnitude and direction of an infinitesimal vector area?
14. (a) What are axial and polar vectors?
    (b) Give an example of axial vector
    (c) Is angular velocity an axial vector or polar vector?
15. What is the condition of parallelism of two vectors?
16. Define scalar triple product and explain an useful meaning of its value.
17. What is the condition for three vectors to be coplanar?
18. Define vector triple product.
19. In which plane $\vec{A} \times (\vec{B} \times \vec{C})$ lie? Justify?
20. State whether the quantities $\vec{A}.\vec{B}.\vec{C}$ and $\vec{A} \times \vec{B} \times \vec{C}$ are meaningful and defined quantities
21. Show that the scalar triple product vanishes when any two vectors are equal or parallel.
22. Prove that if the sum of three vectors is zero, then their scalar triple product is zero and the vectors are coplanar.
23. Prove the following:
    I. $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$.
    II. $\vec{A} \times (\vec{B} \times \vec{C}) + \vec{B} \times (\vec{C} \times \vec{A}) + \vec{C} \times (\vec{A} \times \vec{B}) = 0$
    III. $(\vec{A} \times \vec{B}) \cdot (\vec{C} \times \vec{D}) = (\vec{A} \cdot \vec{C})(\vec{B} \cdot \vec{D}) - (\vec{A} \cdot \vec{D})(\vec{B} \cdot C)$
    IV. $\vec{A} \cdot (\vec{A} \times \vec{C}) = 0$
24. For what value of C (scalar), the length of the vector $\vec{A} = C(3\hat{\imath} - 6\hat{\jmath} + \hat{k})$ is of 3 units.

25. For what value of m, the following three vectors are coplanar?

$\vec{A} = \left(3\hat{i} + m\hat{j} + \hat{k}\right), \vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$ and $\vec{C} = \hat{i} + \hat{j} + \hat{k}$

26. Find the unit vector in the direction of the following vector $\vec{A} = 2\hat{i} + 3\hat{j} + 4\hat{k}$.

27. Find the unit vector which is perpendicular to both the vectors: $\vec{A} = \hat{\imath} + \hat{\jmath} + \hat{k}, \vec{B} = 2\hat{\imath} - \hat{\jmath}$

VECTOR ANALYSIS

1. What are scalar fields and vector fields? Give two examples of each.
2. How from a scalar field ϕ *(x, y, z)* you may derive a vector field $\vec{A}$? What information about the scalar field we may get from $\vec{A}$?
3. What is called vector differential operator? Which fields we may get when it operates on a scalar field and a vector field?
4. Are all vector fields may be derived from a scalar field?
5. A vector field is derived from a scalar field. What is its essential property?
6. What are level surfaces of a scalar field? Why two such surfaces cannot intersect?
7. Draw a level surface in a scalar field φ (x, y, z) and then draw the vector $\vec{\Delta}\varphi$.
8. What is line integral of a vector field? What are the values of a line integral of a conservative field (i) over an arbitrary line and (ii) over a closed line?
9. What is surface integral of a vector over a surface? Why it is called the flux of the vector? Explain your answer taking an example of flowing liquid.
10. State divergence theorem and Stokes' theorem. Give their mathematical expression.
11. Explain (i) gradient of a scalar (ii) divergence of a vector (iii) curl of a vector. State Gauss' theorem.
12. Explain the term (i) line integral and (ii) surface integral of a field vector.
13. What does it mean if div $\vec{A}$ integrated over a volume is zero?
14. Show that div $\frac{\vec{r}}{r^3}$ = 0.
15. Obtain an expression for the gradient of a scalar field in rectangular co-ordinates.
16. Show that when a vector field can be derived as the gradient of a scalar field, the line integral of the vector taken round any closed path in the vector field is zero.
17. Write down the expression for the del operator in Cartesian co-ordinates. What is the physical significance of $-\vec{\nabla} V$, where V is electric potential?
18. Explain the physical meaning of divergence of a vector field $\vec{A}$.
19. A rigid body is rotating with angular velocity ω about a fixed axis. Prove that $\omega = \frac{1}{2}\, curl\vec{v}$, where v is the linear velocity of a point on the body.
20. Define curl of a vector field and give its physical significance. Derive the expression for the curl of a vector field.
21. Which vector field is called solenoidal?
22. Which vector field is called irrotational?
23. Express div grad φ in Cartesian co-ordinates, where φ is a scalar field. What is Laplacian operator?
24. Prove (i) curl grad φ = 0 and (ii) div grad $\vec{A}$ = 0.

ORDINARY DIFFERENTIAL EQUATIONS

1. What is a differential equation? Why do differential equations arise so often in physics?
2. What is meant by solution of a differential equation?
3. Why do constants appear in the solutions of differential equations? How values of these constants are found?
4. Why the general solution of a second order differential equation should contain two arbitrary constants?
5. What are meant by general solution and particular solution of a differential equation?
6. Which are ordinary differential equation and partial differential equation?
7. When a differential equation is called homogeneous and when it is inhomogeneous?
8. When is a differential equation called linear? Give one example of a linear and a non-linear equation.
9. When are two solutions of a differential equation called linearly independent?
10. What is the principle of superposition in the context of differential equation?
11. Explain what are meant by the order and degree of a differential equation.
12. Consider the different possibilities of second order homogeneous differential equations with constant coefficients and find the solutions in each case. Discuss the characteristics of the solution in each case.

CLASSICAL MECHANICS

1. What is frame of reference in mechanics? In which frame of reference Newton's laws of motion is obeyed? State the characteristics of inertial frame of reference.
2. Write down Newton's second law of motion as differential equations in terms of (i) momentum of a particle and (ii) acceleration of a particle. What is the assumption we make when we write the equation in the second form? State the SI unit in which this equation is valid.
3. Write down the equations of motion in the following cases:

   (a) A body of mass m is pulled by a constant horizontal force $\vec{p}$ and there is a force of friction $\overrightarrow{F}$ from the ground.

   (b) A body of mass m is situated in the gravitational field of the earth near the earth's surface. Mass and radius of the earth are M and R respectively.

   (c) A particle of mass m and charge q is situated in constant electric field $\bar{E}$.

   (d) A body of mass m, resting on a frictionless ground, is attached to a rigid wall by a massless spring of spring constant k. It is given a small displacement x and released.

   (e) If in the above case *(d)*, there is a damping force present, which is proportional to velocity of the particle.
4. A particle of mass m and charge q moving with a velocity v enters into a constant magnetic field $\vec{B}$ in a direction at right angle to the field. Which kind of motion is predicted by Newton's law?
5. Explain how principle of conservation of momentum may be derived from Newton's second law of motion.
6. What is time integral of a force? What is its alternative name? Express the time integral of a force in terms of momentum of a particle.
7. What are impulsive forces?
8. What is path or line integral of a force? Which physical quantity does it represent? Explain the principle of conservation of mechanical energy with its help, stating the condition, if any, on the nature of the force.
9. What is the work-energy principle in mechanics? Prove the principle for variable force acting on a body.
10. What are conservative and dissipative forces? Give examples of these forces. Is gravitational force a conservative force? From these definitions show that (i) line integral of a conservative force over a closed path is zero and (ii) line integral of a non-conservative force over a closed path is non-zero.
11. Show that for a particle moving under a conservative force, its total energy can be written as the sum of kinetic energy and potential energy.
12. Show that conservative force can be written as the gradient of a scalar function. What is the name of that function?

13. Prove that total energy of a body remains constant when it is moving under a conservative force. What happens when dissipative forces are also present?
14. Prove that the curl of a conservative force is zero.
15. What is central force? Prove that central force is a conservative force.
16. Sand is falling vertically at a uniform rate on a conveyor belt moving with uniform velocity. Find the external force necessary to maintain the motion and the power supplied by the source. Show that half of the power supplied is equal to the rate of increase of energy. Explain this result.
17. Explain the basic principle by which a rocket moves. Establish the equation of motion for a system of variable mass, according to Newton's law.
18. In free space a rocket is moving without any external force. Show that the speed of the rocket at any time t is independent of time or how fast the mass is released and it depends on the exhaust velocity and the fraction of mass exhausted during that time.
19. Define moment of a force or torque acting on a particle about a point. Define angular momentum of a moving particle about a point. Derive the relation between the two from Newton's second law.
20. Find the relation between the torque acting on particle and its angular acceleration momentum.
21. State the principle of conservation of angular.
22. Define angular momentum of a particle. Show that the time rate of change of momentum of a particle is equal to the torque acting on it.
23. Is angular momentum an axial or polar vector? Justify your answer.
24. What do you mean by time integral and path or line integral of a force? When is a force said to be conservative?
25. Find the radial and transverse components of acceleration of a particle moving in a plane.
26. Show that the angular momentum of any particle moving under a central force is conserved.
27. Show that the path of the particle moving under the action of a central force must lie in a single plane containing the centre of force.
28. A torque acts on a particle for some time. Find the power supplied by the torque at any instant and the total work done by it.
29. Write down the equations of Galilean co-ordinates transformation, explaining the meaning of each symbol. What are its immediate consequences? Why we cannot do any experiment in an inertial frame by which we can distinguish one inertial frame from another?
30. Why absolute rest is neither verifiable not is necessary in dynamics?
31. State the three basic assumptions in Galilean relativity? In which conditions are these acceptable?
32. State the classical principle of relativity.
33. Which are non-inertial frames of reference? Show how pseudo-forces arise in these frames. In which direction it acts? Why it is called inertial force?
34. Show that Newton's law is invalid in a non-inertial frame.

35. Define centre of mass of a system of particles. From this definition calculate the momentum of the centre of mass of a moving system of particles and show how this momentum is related to the net force acting on the system. Which conclusion is obvious from the above results?
36. A time bomb moving in a straight line with uniform speed in free space explodes into pieces. Explain what happens to the centre of mass of the system.
37. What is a rigid body? Define centre of mass of a rigid body.
38. Explain what should happen to the centre of mass of a rigid body when a couple acts on it.
39. Explain what happens when force acting on rigid body does not pass through its centre of mass.
40. Calculate kinetic energy and angular momentum of body rotating with a constant angular velocity about a vertical axis and explain the importance of moment of inertia of the body.
41. Explain how moment of inertia of a body is related with the inertial property of a body.
42. Define radius of gyration of a body rotating about a vertical axis and explain its significance. Is it a constant quantity for a rigid body?
43. Suppose the radius of gyration and the distance of the centre of mass of a body from the axis of rotation are k and R respectively. Explain which of them is bigger.
44. Define a rigid body and its moment of inertia.
45. Starting from the definition of angular momentum and using Newton's law obtain the relation between angular momentum and torque. Explain how the principle of conservation of angular momentum follows from it.
46. From basic principles explain why velocity of a planet varies all along its path round the sun.
47. How the constant duration of day and night can be explained and how it may change?
48. State and prove perpendicular axis theorem on moment of inertia of a laminar body.
49. State and prove parallel axis theorem on moment of inertia.
50. Calculate the moment of inertia of a solid cylinder about an axis passing through its centre of mass and perpendicular to its length.
51. Calculate the moment of inertia of a uniform thin rod about an axis passing through its centre of mass and perpendicular to the rod.
52. Find the moment of inertia of a solid sphere about its diameter.
53. Find the moment of inertia of a solid cone about its axis.
54. Calculate moment of inertia of a flywheel.
55. Find the total energy of a sphere or a cylinder rolling over a horizontal surface without slipping.
56. Find the acceleration of a sphere or a cylinder rolling down an inclined plane without slipping. What would happen if the surface of the incline is perfectly smooth? Explain how from the observations of their fall we can distinguish a solid sphere or cylinder from a hollow one.

GRAVITATION

SHORT ANSWER TYPE

1. Find out the value of gravitational potential at a point (a) inside (d) outside a hollow sphere.
2. Find the gravitational potential and intensity at a point inside a thin spherical shell.
3. Calculate gravitational intensity at an external point due to a thin spherical shell.
4. (a) Derive expressions for gravitational potential and gravitational field due to a solid sphere for points both inside and outside the sphere.

   (b) Derive an expression for the gravitational potential at a point inside a solid sphere. Hence show that gravitational attraction is proportional to the distance from the centre of the sphere for a point inside it.
5. So far as the intensity at an external point is concerned, show that a solid sphere behaves as if the whole mass is concentrated at its centre.
6. (a) Prove that the velocity of escape of a body out of the field of earth's gravitational attraction into space is given by $v_e = \sqrt{\frac{2GM}{R}}$, where *G, M* and *R* are the constant of gravitation, mass and radius of the earth respectively.

   (b) Prove that the velocity of an artificial satellite in a circular orbit is given by $v = \sqrt{\frac{GM}{R+h}}$ where the symbols have their usual meaning.
7. A straight, frictionless tunnel is bored through the centre of the earth. Show that a body dropped into it will execute simple harmonic motion, if the earth were a homogeneous sphere.
8. What do you mean by gravitational self-energy of a system? Obtain an expression for the self-energy of a homogeneous sphere.
9. Show that the conservation of angular momentum applied to a planetary motion led to Kepler's law of constant areal velocity.
10. Show that gravitational force is a central attraction force. Hence prove that a particle moves under a gravitational force in a single plane with a constant angular momentum and its areal velocity is constant.
11. Explain the motion of a planet in a circular path round the sun on the basis of Newton's law of gravitation. Find the relation between the time period of the planet and the radius of the circular orbit.
12. Calculate the velocity of escape of a small body from the surface of a planet.
13. Calculate the value of the gravitational potential at the centre of the earth. $\left[Ans. -\frac{3}{2}\frac{GM}{a}\right]$
14. Prove that the gravitational intensity and potential at any point on the surface of the earth are 'g' and 'gR' respectively, assuming the earth to be a uniform sphere of radius R.
15. Derive expressions for gravitational potential and intensity inside and outside of a thin spherical shell. Draw graphs to show the nature of variations.
16. Compare the escape velocity of a body from earth with the velocity of a satellite circling round the earth at low altitude.

17. Find out the distance from the centre of the earth at which an artificial satellite moving in a circular orbit always appears to be above same point of the earth. Give your answer in terms of gravitational constant *G*, the mass of the earth *M* and the distance from of the centre of the earth *R*.
18. The gravitational force exerted by the sun on the moon is larger than that exerted by the earth on the moon. Why does not the moon fly towards the sun then? Why are lighter gaseous elements like hydrogen, helium etc., rare in the earth's atmosphere?
19. What are geosynchronous orbits and geostationary orbits?
20. State some of the uses of geosynchronous and geostationary satellites.
21. What is Global Positioning System? Explain its uses.
22. Why astronauts feel weightlessness in an artificial satellite?
23. What are the Physiological effects on astronauts when they make space travels?

<u>ESSAY TYPE</u>

1. State and explain Newton's Law of gravitation. What celestical evidence led to the formulation of the law?
2. State Kepler's law of planetary motion. Show how the law of gravitation can be deduced from Kepler's laws.
3. What do you mean by the following terms: - (i) Gravitational potential (ii) Gravitational constant (iii) Gravitational intensity (iv) Escape velocity.
4. What are the differences between gravitational potential, electric potential and magnetic potential.
5. Why is gravitational potential negative? Why is the work done in bringing a unit mass from infinity to a point close to the earth's surface negative?
6. What is the relation between the intensity and potential at a point in a gravitational field?
7. (a) Why are lighter gaseous elements, like hydrogen, helium etc., rare in the earth's atmosphere?

   (b) Two artificial satellites of different masses are revolving round the earth at the same altitude. Which one will be moving faster? Justify your answer.
8. What is geostationary satellite? What is the distance of the orbit of a geostationary satellite from earth's surface? What is its utility?
9. Consider a hollow spherical shell. How does the gravitational potential inside compare with that on the surface? What is the gravitational field strength inside?
10. State whether the statements made below are correct or incorrect:

    (i) Gravitational attraction between two masses is proportional inversely to the distance between them.

    (ii) An artificial satellite will move around the earth in an elliptic path

    $$\text{if } v^2 > \frac{GM}{R}\ but < \frac{2GM}{R}.$$

    (iii) Archimedes' principle is not applicable inside a revolving artificial satellite because everything inside it loses weight.

    (iv) Law of gravitation cannot be applied universally to all matter.

(v) The magnitudes of gravitational field at distances r_1 and r_2 from the centre of a uniform sphere of radius R and mass M are F_1 and F_2 respectively. Then,

(A) $\frac{F_1}{F_2} = \frac{\eta_1}{r_2}$ if $r_1 < R$ and $r_2 < R$

(B) $\frac{F_2}{F_1} = \frac{r_2^2}{r_1^2}$ if $r_1 > R$ and

(C) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 > R$ and $r_2 > R$

(D) $\frac{F_1}{F_2} = \frac{r_1^2}{r^2}$ if $r_1 < R$. Which is correct?

OSCILLATIONS

SHORT ANSWER TYPE

1. When is a system capable of vibration?
2. A system capable of vibration is displaced slightly from its mean position and left to itself. If there is no friction of any kind what happens to its potential energy?
3. Equation of a particle vibrating simple harmonically is $x = 10 \sin(\omega t + \pi/3)$ m. What is the significance of $\pi/3$ occurring in the argument of sine?
4. Why amplitude and epoch should not be regarded as intrinsic property of a vibration system?
5. What is the intrinsic property of a vibrating body?
6. At what displacement of an ideal harmonic oscillator, is its total energy equally divided between kinetic and potential energy?
7. From consideration of conservation of energy, derive the equation of motion of a simple harmonic motion.
8. Explain why if momentum of a harmonic oscillator is plotted against its displacement, we get an ellipse. Draw the ellipse for a particular oscillator.
9. Explain why if potential energy of a harmonic oscillator is plotted against its displacement, we get a parabola. Why the two wings of the parabola terminate at definite points? What is the name of this position?
10. Explain clearly the terms free vibration, damped vibration.
11. Write down the equation of motion of a linearly damped harmonic oscillator and explain the different symbols in the equation.
12. What are the effects of the damping forces on the nature of vibration?
13. What are the differences in the observation if a vibrating system is set into vibration, if it is (i) underdamped, (ii) critically damped and (iii) overdamped?
14. Draw displacement-time curves for a (i) underdamped, (ii) critically damped and (iii) overdamped oscillator.
15. In which conditions is an oscillator (i) underdamped, (ii) critically damped and (iii) overdamped?
16. A harmonic oscillator is underdamped. How can it can be made (i) critically damped and (ii) overdamped?
17. Why critical damping is useful in many applications? Give examples.
18. When quality factor of an oscillator should be higher?
19. How quality factor of an oscillator may be increased?
20. What is logarithmic decrement of an oscillator?
21. How logarithmic decrement of an oscillator may be determined by observing its oscillation for some time?

ESSAY TYPE

1. Establish the differential equation of S.H.M. Solve the equation and hence show that the mode of motion is repeated at a regular interval of time.
2. Motion of a simple pendulum for small oscillation is simple harmonic'. Prove the statement. Hence find an expression for the time-period of the simple pendulum.
3. (a) Prove that the vertical oscillations of a loaded spring are simple harmonic; hence find out an expression for the time-period of its oscillations.

   (b) A wooden cylinder of mass M and cross- sectional area a is floating in equilibrium vertically in a liquid of density p. If the cylinder is depressed slightly and is then released, show that the cylinder undergoes S.H.M. with time period $T= 2л \sqrt{m/\rho a g}$.

   (c) Some liquid is taken in a U-tube of uniform cross-section. If liquid in one arm of the tube be pressed and released, show that it executes S.H.M. Find the time period of oscillation.
4. A light elastic spring of spring constant k is held vertically with upper end fixed and a mass m suspended at its lower end. The mass is depressed a little and released. Establish the equation of motion of the suspended mass and find its period of oscillation.
5. If the displacement of a particle moving with S.H.M. about a fixed point is given by $x = a \sin(\omega t + \varphi)$, show that the total energy of the particle at any instant is given by $m\omega^2 a^2$. The symbols have their usual meaning.
6. From the basic equation of a free simple harmonic motion derive the relations showing the dependences of velocity, momentum. acceleration, kinetic energy and potential energy on time and displacement. Draw corresponding curves.
7. Prove that the total energy of a simple harmonic motion is constant.
8. Starting from the fact the total energy of a simple harmonic motion is constant, derive the equation of motion of a simple harmonic motion.
9. Establish the equation of motion of a linearly damped harmonic oscillator. Now solve it to find the displacement as a function of time for three distinct conditions: (i) underdamped, (ii) critically damped and (iii) overdamped. Draw displacement -time graphs for each case.
10. Show that the rate of energy loss in a damped vibration is equal to the rate of work done against the retarding force due to damping.
11. A body is in damped harmonic vibration. What observations are necessary to determine the restoring force per unit displacement and (ii) retarding force per unit velocity?
12. Define logarithmic decrement and derive a relation for it. Explain how it can be determined experimentally.
13. Show that time-constant for the decay of energy is one half the time-constant for the decay of amplitude for linearly damped vibrating system.

ELASTICITY

SHORT ANSWER TYPE

1. Define shearing strain.
2. What are normal stress and shearing stress?
3. Define Poisson's ratio and Young modulus of a material.
4. Can longitudinal strain be produced in a piece of material without any volume strain?
5. Why the elastic moduli of a material are interrelated?
6. Write down the relations between the elastic moduli of a material and find the limiting values of Poisson's ratio.
7. What are elastic limit and breaking stress?
8. Why a material is said to be elastic below its elastic limit?
9. In which condition the elastic reaction force developed within the material may be regarded as *conservative*. How we can use this character in different applications?
10. Suppose the stress in a material is increased beyond the elastic limit but not beyond yield point. Then the stress is gradually reduced to zero. What is the expected behaviour?
11. Which materials are called ductile? Give examples.
12. Which materials are called brittle? Give examples.
13. What is torsional rigidity of a material?
14. How torsional rigidity of piece of wire depends on its physical dimensions?
15. How is perfectly elastic behaviour defined?
16. Define the terms: (i) Perfectly rigid (ii) Breaking weight. State Hook's law.
17. Two wires of same length and material but different radii are suspended from a rigid support.Both carry the same load at the lower end. Will, in the two wires (i) stress (ii) strain and (iii) extension be same or different?
18. Relate the angle of twist at the end of a wire of length l with radius R when a torque T is applied at one end, the other end being fixed. If this method is used to obtain the modulus of rigidity of the wire, why must R be measured as accurately as possible?
19. What is the difference between angle of twist and angle of shear?
20. What is torsional rigidity? Give its unit in cgs system.
21. Explain the terms: - (i) bending moment(ii) flexural rigidity (iii) neutral axis.
22. What is a cantilever? What is its difference with ordinary lever?
23. Explain whether a large torque is required to twist a wire of large circular cross-section?
24. A wire suddenly breaks due to a weight being suspended. Will the temperature of wire change as a result?
25. Show that in practice s = 0.5 is not an acceptable value.

26. What are the advantages and disadvantages of using a long wire of small cross-section rather than a short thick bar when measuring Young's modulus by direct stretching?

ESSAY TYPE

1. Define Young's modulus, bulk modulus, modulus of rigidity and Poisson's ratio of a homogenous isotropic solid and establish the relations between them.
2. Describe a suitable method of determining the Young's modulus of a material in the form of uniform wire. State the necessary formula.
3. Show that the Poisson's ratio lies between – 1 and ½.
4. Show that a pure shear strain is equivalent to two equal and opposite strains at right angles to each other.
5. If Y, K, n and σ represent respectively Young's modulus, bulk modulus, modulus of rigidity and Poisson's ratio of the material of a substance, then derive the relationship connecting (i) Y, k and σ (ii) Y, n and σ (iii) k, n and σ.
6. Explain stress, strain and elastic limit. Show that $\sigma = 3k - 2n / 6k + 2n$ and $Y = 9nk / 3k + n$.
7. (a) Find an expression for the work done in stretching a wire and hence find the energy per unit volume of the wire.

   (b) Deduce an expression for the amount of energy stored in an elastic body due to longitudinal strain.
8. Describe the dynamical method of finding the coefficient of rigidity of a wire and deduce the formula to be used.
9. Show that when a cylinder is twisted, the torsional couple per unit angular twist is $\frac{\pi n r 4}{2 l}$ where the symbols have their usual significance.
10. Prove that for a homogeneous and isotropic medium, Y = 3k (1 - 2σ) where Y denotes Young's modulus, *k* bulk modulus, and σ Poisson's ratio. Describe a laboratory method for the determination of Young's modulus of the material in the form of uniform wire. Write down the necessary formula.
11. Briefly describe a method of comparing the modulus of rigidity and Young's modulus of material in the from of short wire and give the underlying theory.
12. Calculate the strain energy per unit volume in a material,

   (i) when it is subjected to a volume strain,

   (ii) when it is subjected to a longitudinal strain,

   (iii)when it is subjected to a shearing strain.

   What happens to this energy when the stress is withdrawn?
13. Calculate the energy stored in a twisted wire.
14. Develop the theory and explain how the moment of inertia of a body of irregular shape may be determined.

15. Explain what happens when a short piece of elastic rod is uniformly bent. Which is called the neutral surface? Prove that internal bending moment developed in a bent beam is $\frac{\mathrm{YAK2}}{R}$, where the symbols have the usual meanings. What is flexural rigidity?
16. Describe Searle's apparatus to compare Young's modulus and modulus of rigidity and to determine the Poisson's ratio.
17. Describe the static method of the determination of modulus of rigidity.
18. Develop the theory and explain how modulus of rigidity may be determined by the dynamical method.
19. Draw the stress-strain curve for an elastic solid. In the curve show the proportional limit,elastic limit and yield point and explain the significances of those point.

SPECIAL THEORY OF RELATIVITY

1. What is an inertial frame?
2. State the two postulates of special theory of relativity.
3. Explain how the first postulate of relativity extends the validity of Galilean relativity.
4. Explain how the second postulate goes against the ordinary common sense.
5. Explain what are meant by (i) relativity of simultaneity, (ii) Time dilation, (iii) Length contraction.
6. With the help of simple thought experiments show that above three are consequences of the postulates of special relativity.
7. Show that the above three effects confirm with the non-relativistic notions, when the velocity of the moving frames are very small compared to the speed of light in vacuum.
8. What is the law of relativistic addition of velocities? From this law show that speed of light in any frame of reference is equal to universal constant speed of light in vacuum.
9. Show that the law of relativistic addition of velocities reduces to the law we learn in classical relativity, when the velocities involved are very small compared to the speed of light in vacuum.
10. Show that sum of any two velocities can never exceed the speed of light in vacuum.
11. Write down the equations of Lorentz transformation for two inertial frames moving with a constant velocity with respect to each other. Show that it reduces to the equations of Galilean transformation in the non-relativistic limit.
12. What is rest frame? What are proper time interval and proper length?
13. Explain why proper time interval is the shortest time interval of a process and a proper length is the maximum of an object.
14. Explain that order of two events does not change in spite of the relative nature of time interval of any two events.
15. What is proper mass or invariant mass or rest mass of a particle?
16. How momentum of a particle is defined in relativistic mechanics? Show that it reduces to the definition of Newtonian mechanics in the non-relativistic limit.
17. Write down the relation between total energy and momentum of a particle in relativistic mechanics.
18. What is massless particle or particle with rest mass zero? Show that a massless particle must move with a speed equal to that of light in vacuum.
19. What is meant by 'rest energy"? Which particle has a larger rest energy: an electron or a proton?
20. Starting from the definition of momentum in relativistic dynamics show that force acting on a particle is in general not parallel to the acceleration. In which conditions it is parallel to the acceleration?
21. Write down the expression for relativistic kinetic energy of a particle of invariant mass m and velocity v. Show that this expression reduces to the expression for kinetic energy of Newtonian mechanics in the non-relativistic limit. Also show why it is not possible for the particle to attain the speed c, however large a force acts on it for however long time.

SURFACE TENSION AND VISCOSITY

SHORT ANSWER TYPE

1. How does surface tension of a liquid vary with temperature?
2. What are meant by (i) surface tension (ii) surface energy and (iii) angle of contact of a liquid? What is the unit of surface tension?
3. Two drops of water coalesce to form one drop. Will the surface energy change?
4. Explain why very small drops of liquid are spherical.
5. Why are the globules of mercury on glass spherical?
6. (a) Why are droplets of water on a lotus leaf spherical in shape?
   (b) A steel sewing needle can be made to float on the surface of undisturbed water. Explain briefly how this occurs. If a few drops of soap water be added to water, the needle sinks. Why?
7. Why it is so difficult to separate two glass plates when there is a water film quizzed between them?
8. Define the unit in which co-efficient of viscosity is expressed.
9. Define co-efficient of viscosity of a liquid. Distinguish between streamline flow and turbulent flow of a liquid.
10. What is critical velocity? Upon what factors does it depend?
11. What is Reynold's number? State its utility.
12. A liquid of high density and low viscosity flowing through a tube of wide bore helps motion to be turbulent. Explain.
13. What is the relation between the co-efficient of viscosity of a liquid and temperature?
14. Two streamlines cannot intersect - Explain.
15. How does the co-efficient of viscosity of a liquid depend upon the temperature and pressure?
16. What do you understand by Newtonian and Non-Newtonian liquids?
17. State Newton's law of viscous flow and hence define the co-efficient of viscosity of a liquid. What is its unit? How does viscosity of a liquid change with temperature?
18. 'For a non-viscous liquid, the flow is always turbulent'. Explain the statement.
19. In determining the co-efficient of viscosity of a liquid by Poiseuille's method the radius of capillary tube should be measured very accurately. What is the reason of it?
20. What do you understand by one 'Poise'?
21. What is critical velocity of liquid and what is its importance?
22. Define the co-efficient of viscosity of a liquid and find out its dimension.
23. Why pressure difference is necessary to maintain flow of liquid in a horizontal tube?

ESSAY TYPE

1. How is the surface tension of a liquid explained on the basis of intermolecular force? Obtain a relationship between surface tension and surface energy of a liquid.
2. Find an expression for the excess pressure within a spherical soap bubble. Give a rough estimate of the energy of the bubble.
3. Deduce a relation between surface tension and surface energy.
4. Explain the origin of surface tension.
5. Calculate the excess of pressures inside a synclastic and an anticlastic surface. From this result find the excess pressure inside a (i) spherical drop, (ii) spherical bubble and (iii) cylindrical bubble.
6. Find the Force between two plates separated by a thin layer of liquid due to surface tension.
7. Explain how surface tension varies with temperature. At which temperature surface tension is zero?
8. (a) Describe the way in which different parts of a viscous liquid move when flowing through a fine tube. What change takes place if the motion is increased?

   (b) What is meant by streamline motion and turbulent motion of a fluid?
9. Deduce Poiseuille's equation for the rate of steady flow of a liquid through a narrow tube. What are the conditions to be satisfied for the deduction of the equation?
10. Give Poiseuille's method of measuring the viscosity of liquids. Derive the theoretical expression on which the method based.
11. Derive Poiuseulli's equation for the flow of liquid through capillary tube. Mention the correction needed for the equation.
12. Explain how we arrive at the idea of viscous resistance of a tube carrying liquid. What is its value?
13. Find the value of equivalent viscous resistance of three water carrying tubes of different radii and lengths when these are joined (i) in series and (ii) in parallel.

ELECTROSTATICS

1. What is quantization of electric charge?
2. What is principle of conservation of electric Charge?
3. State Coulomb's law. Why Coulomb force is called central force?
4. Show that Coulomb's law obeys Newton's third law.
5. Show that I coulomb is a very large unit of charge.
6. Find the dimension of absolute permittivity.
7. Define intensity at a point or field at a point in an electric field.
8. Why electric charges are regarded as scalar quantities?
9. What is principle of superposition in electrostatics?
10. Define electric flux.
11. Why electric field at a point is called electric flux density?
12. State Gauss' law. Derive it from Coulomb's law. Which characteristics of Coulomb's law are crucial for Gauss' law to follow from it? Do you require any other principle?
13. Why charges situated outside a closed surface do not contribute to the flux through that closed surface? Do these charges contribute to the field within or on the closed surface?
14. Why Gauss' law should be regarded as more fundamental law of electricity than Coulomb's law?
15. Derive Coulomb's law from Gauss' law stressing the assumption you make in the derivation.
16. Applying Gauss' law find electric fields for the following charge distributions: (i) a point charge, (ii) uniformly charged infinitely long line charge, (iii) uniformly charged infinitely long cylinder both at a point inside and outside it, (iv) uniformly charged sphere both at a point inside and outside it, (v) uniformly charged hollow spherical surface and also find the discontinuity in the field at the surface, (vi) uniformly charged hollow spherical shell at points outside it, inside the material and in inner cavity and (vii) uniformly charged infinite plane sheet and also find the discontinuity in electric field as the sheet is crossed.
17. Draw graphs showing the variation of the electric field with distance in each case.
18. Considering the electric field of a point charge prove that the work done to take a charge from one point to another in an electric field is independent of the path chose between the two points
19. Prove that electric field is conservative in nature. Which property of the electric field is crucial for this nature?
20. An electric charge in an electric field is taken from one point to another. Why this cannot be done without doing any work? How much total work is done if it comes back? Explain your answer.
21. Prove that curl of an electrostatic field is zero.
22. Prove that electrostatic field is irrotational.
23. Why electrostatic field can be expressed as the gradient of a scalar field? What is the name of this scalar field? Why negative sign occurs in this relation between electric field and potential.

24. Find the relation between potential difference between two points and electric field.
25. Show that electric potential at a point in an electric field has an ambiguity? How this ambiguity is removed.
26. Define electric potential at point in an electric field. From this definition find the value of the electric potential due to a point charge.
27. Obtain the differential form of Gauss' theorem from its integral form.
28. Obtain Poisson's and Laplace's equations from integral form Gauss' theorem.
29. Explain why potential due to a positive charge is positive and that due to a negative charge is negative.
30. Explain the relation between electric potential and electric potential energy.
31. Explain how potential can be known from an electric field and electric field from electric potential.
32. If electric intensity is zero at a given point, must the electric potential be zero at that point? Give an example to prove your answer.
33. If electric Potential is zero at a given point, must the electric field be zero at that point? Give an example to prove your answer.
34. What are equipotential surfaces in an electric field? Explain and justify how electric field lines intersect equipotential surfaces.
35. Find the outward pressure acting on the surface of a charged conductor. Express it in terms of electric field.
36. Find electric potential for the following configuration of charges:
    I. Due a uniformly charged spherical shell at points both outside and inside the shell.
    II. Due a uniformly charged sphere at points both outside and inside the sphere.
    III. Due to a uniformly charged disc at distance r from its centre. Find the intensity and see what should be the value of intensity at a very large distance. Comment on the result. Draw graphs showing the variation of the potentials with the distance from the centre for the (i) and (ii).
37. Explain why the electric field inside a conductor placed in an electric field is zero.
38. From Gauss' law prove that all excess charges in a conductor reside on the outermost surface of the conductor.
39. Surface of charged conductor is equipotential. State True or False.
40. Electric potential at all points within a charged conductor is constant. Justify.
41. By Gauss' law find electric field near a charged conductor. Is there is any discontinuity in the field?
42. Find the electric pressure on a charged conductor and from this calculate energy density of electric field.
43. Explain clearly how charge is distributed over the surface of a charged conductor:
44. Calculate electric energy of four-point charges placed near to each other in terms of electric potential. What happens if the charges are released from rest?
45. What is an electric dipole? Where do we find dipoles in nature?

46. Find the electric potential and electric field due to an electric dipole at an arbitrary point. What is electric dipole moment? Why it is definitely a vector quantity?
47. Explain what happens when a dipole is placed in an electric field and the field (i) uniform, (ii) non-uniform.
48. What are the torque and force that act on a dipole when it is situated in a non-uniform field?
49. Find the frequency of oscillation of a dipole placed in a uniform electric field.
50. Find the potential energy of a dipole placed in a uniform electric field. Identify the positions in which it is in stable equilibrium, unstable equilibrium and has zero potential energy.
51. Find the mutual potential energy of two point dipoles placed at certain distance from each other.
52. Find the forces and torque acting on a dipole when it is placed at a distance from each other. Now find the force (i) when the two dipoles moments are parallel to each other along the same line, (ii) when one dipole moment is perpendicular to the axis of another.
53. Define capacitance of a conductor. Does its value remain the same in all conditions? Explain.
54. What is farad? Give an example to show that it is a very large unit.
55. Find the dimensions of capacitance.
56. What is a capacitor? Define capacitance of a capacitor.
57. Calculate the energy of a charged capacitor. From this expression of energy calculate the energy density of an electric field.
58. Prove that there is always some loss in energy when two charged capacitors share charges among them.
59. Calculate the capacitances of the following capacitors: (i) Parallel-plate capacitor, (ii) Spherical capacitor outer sphere is earthed, (iii) Spherical capacitor inner sphere is earthed, (iv) cylindrical capacitor.
60. What is dielectric? Explain why capacitance of a parallel plate capacitor increases when that air space between the two plates is filled up by a dielectric.
61. Explain why electric field always decreases when a dielectric material is introduced between the two plates of a capacitor.
62. What are polar and non-polar dielectric materials?
63. What happens when a dielectric is polarized? Define polarization. What is its unit?
64. What are electric susceptibility and dielectric constant of a linear and isotropic dielectric material? Write down the relation between them.
65. What is absolute permittivity of a dielectric material? Why is it greater that the permittivity of vacuum?
66. Considering the situation within a dielectric material, explain how we come across the D-field. What is its property? what is its value in vacuum?
67. Write down the relation between electric displacement, electric field and polarization of a linear and isotropic dielectric material. Explain which are the sources of three fields.

68. In a capacitor filled with linear and isotropic dielectric material, the surface density of charges given to the two plates are $\pm\sigma_f$. Calculate the surface density of bound charges in the material and the field produced by the bound in terms of σ_f.
69. Calculate capacitance of a capacitor when a dielectric material fills the whole space between the two plates. Why does capacitance increase?
70. Calculate the energy density of the electric field within a linear isotropic dielectric. Express it in terms of electric displacement.
71. Field due to a polarized material can be regarded as equivalent to two charge densities. Which are these two? How are these two related to polarization produced in the dielectric?
72. Suppose that in a polarized dielectric material volume density of free charge and bound charges are p_f and p_b respectively. Show that we can define a field $\vec{D}$ in that space which depends only on p_f and $\vec{\nabla}.\vec{D} = p_f$.
73. Calculate the force between two-point charges within a dielectric material extended over a large region of space and show that it is a simple modification of Coulomb's law in a dielectric medium. Why the force is reduced somewhat in the dielectric media?
74. From the equation $\vec{\nabla}.\vec{D} = p_f$ arrive at the integral form of Gauss' law in a dielectric medium.

STEADY ELECTRIC CURRENT

1. What is electric current? What is the conventional direction of current?
2. What is filamentary current? Is it a vector? Explain.
3. Define volume current density and surface current density, explaining the situations where they are useful.
4. Find the relations between the filamentary current and volume current density and surface current density.
5. What is current element? Express the current element in terms of filamentary current, volume current density and surface current density.
6. Explain how the idea of resistance of a conductor comes from Ohm's law. Find the dimensions of resistance.
7. Suppose resistance of a circuit is increased five times, how the current at different portions of a circuit will be affected. Explain your answer
8. Considering the example of a simple cell, explains why non-electrostatic field is necessary for continuous supply of electric current.
9. Why electromotive force of a cell is constant for a particular type of a cell?
10. Considering a real cell explain how the chemical energy converted by the cell is used up.
11. What is drift velocity of charge carriers in a conductor? Find the relation between drift velocity and current. Obtain Ohm's law.
12. What is differential or microscopic form of Ohm's law? Explain why the latter form should be regarded as more general law.
13. Define conductivity and mobility of charge carriers in a conductor. Find the relation between them.
14. Explain how principle of conservation of charge during flow of current leads to equation of continuity. What is the equation of continuity when steady current flows?
15. What are the cause and effect of resistance in an electric circuit?

MAGNESTISM

SHORT ANSWER TYPE

1. Which are the sources of magnetic field?
2. Write down the Biot-Savart law in vector form.
3. What is the value of the permeability of free space?
4. Compare the magnetic field due to a current element and electric field due to a point charge.
5. What is force that acts on current carrying conductor placed in a magnetic field? Which common electric device use this rule?
6. A current carrying straight conductor placed in a magnetic field does not feel any force. Explain how it is possible.
7. A conductor of length L bent in the form of a semicircle carrying current l is placed in a uniform magnetic field B. Write the force acting on it in vector form.
8. What is the force acting on a particle having charge q moving with a velocity through a magnetic field?
9. Why magnetic force acting on a charged particle is a no-work force?
10. A charged particle is moving with a small uniform velocity. Find the magnetic field produced by it. Draw magnetic field lines around the trajectory of the particle.
11. Write down the expression for Lorentz force. State the obvious differences between the electric and magnetic force.
12. Two charged particles are moving with uniform small velocities in different directions. Write down the magnetic force between them.
13. Write down the magnetic field due to steady current in very long wire. Draw the magnetic field lines.
14. Write down the magnetic field due to a circular wire carrying steady current at a point on its axis. Find the field at a large distance and show that a current loop acts like magnetic dipole. Find the magnetic moment of the equivalent dipole.
15. Explain qualitatively by drawing graphs how uniform magnetic field may be produced with the help of two parallel coils.
16. Show qualitatively that two parallel current attract each other and two antiparallel current repel each other.
17. Write down the force between two current elements. Compare this force with that between two point charges.
18. State two alternative definitions of Tesla.
19. Find the dimensions of magnetic field.
20. Find the units and dimensions of permeability of free space.
21. State Ampere's circuital law.
22. Explain what happens when a moving charged particle enters a magnetic field (i) at right angle to a uniform magnetic field and (ii) making angle with the magnetic field.

23. From Biot-Savart law prove that $\vec{\nabla} . \vec{B}$ =0. What is the significance of that equation? Compart this equation with the corresponding relation fi electrostatic field.
24. From Ampere's law prove that $\vec{\nabla}$ x $\vec{B} = \mu_0 \vec{J}$. What is the significance of that equation? Compare this equation with the corresponding relation for electrostatic field.
25. What is the essential difference between electric field lines and magnetic field lines?
26. Define magnetic flux. Find its units and dimensions.
27. Derive Gauss' law of magnetism from the divergence of magnetic field.
28. What is the magnetic flux over a closed surface.
29. Compare Gauss' law of electrostatic an magnetostatics.
30. Explain why magnetic field in general does have a scalar potential, but has a vector potential. Explain the ambiguity of the magnetic v potential?
31. Prove that magnetic field is non-conservative.
32. Suppose $\vec{A}$ and $\vec{A}$' are the vector potentials representing the same magnetic field B. Explain how it can be possible.
33. Explain in which condition magnetic vector potential may be related to current density as $\nabla^2 \vec{A} = - \mu_0 \vec{J}$.
34. In which condition can a magnetic field be described by a scalar potential? Show that magnetic potential satisfies Laplace's equation.
35. Can magnetic potential be interpreted as work done as we do for electrostatic potential?
36. What are the units of magnetic scalar and vectorpotential?
37. Find the magnetic scalar potential due to a circular loop carrying current at a point on its axis.
38. A material is placed in a very strong non-uniform magnetic field. What different behaviors you may expect to observe? Which are the names for these materials?
39. Why all materials should show some kind of response to an applied magnetic field?
40. A material is placed in a magnetic field. Explain what is meant by magnetization of the material? What is Amperian current?
41. Express magnetic moment of V volume of a material placed in a magnetic field in terms of magnetization. What is the unit of magnetization?
42. Which are the two current densities by which a magnetized material may be replaced, so far as the field produced by it is concerned? What is the difference, if any, of these current densities with familiar current densities?
43. Which currents are the three vectors $\vec{B}.\overrightarrow{H}$. and $\overrightarrow{M}$ associated with? State the relation between these vectors.
44. Express the Ampere's law in differential form for a magnetized material. Now show that a new field $\vec{H}$ can be defined. Which interesting and useful property this new field has?
45. Find the Ampere's law in integral form in terms of B field and also in terms of H field.

46. Prove the relation $\vec{\nabla} \cdot \vec{H} = -\vec{\nabla} \cdot \vec{M}$
47. Define magnetic susceptibility, absolute permeability and relative permeability of a material. What is meant by the statement: absolute permeability of a material can take into account the effect of the magnetisation?
48. Why μ_0 is appropriately called permeability of vacuum?
49. Within a material there are two contributions to the magnetic field. Which are these two? Write down the appropriate relation.
50. What is diamagnetism? Why it is a general property of all substances?
51. Explain why susceptibilities of diamagnetic substances are independent of temperature.
52. What is Para magnetism?
53. What should be the expected values of susceptibilities, permeabilities and relative permeabilities of diamagnetic, paramagnetic and ferromagnetic materials?
54. Draw *M-H* curve and *B-H* curve for diamagnetic and paramagnetic substances and discuss about the slopes of these curves.
55. Why diamagnetism is said to be weaker than para magnetism?
56. How susceptibilities of diamagnetic and paramagnetic substances change with temperature?
57. Why permeability and susceptibility of a ferromagnetic substance cannot be defined easily.
58. What are spontaneously magnetized domains? What are approximate size of the domains in absence of any external magnetic field?
59. Draw the full hysteresis loop for a ferro magnetic material and explain which information we may get about the property of ferromagnetic substance from this curve.
60. What are magnetic saturation, retentivity, coercivity of a ferromagnetic material?
61. What is the work done to drive a ferro magnetic material once through a hysteresis loop? What happens to this energy?
62. What is Curie temperature of a ferromagnetic material?
63. What happens when a ferromagnetic material crosses its Curie point? Why it is called a phase transition?
64. Explain how hysteresis loops of a ferromagnetic materials are useful to choose the right material for different practical uses.

ESSAY TYPE

1. State Laplace's law for intensity of magnetic field at a point due to a current element. Apply the law to prove that the intensity of magnetic field at a point distant *r* from a long straight conductor is $\mu_0{}^{i}/ 2\pi r$, where is the current in ampere in the conductor.
2. State Laplace's law for the magnetic field at a point due to a current element. Obtain an expression for the magnetic field at the centre of a circular wire carrying current.
3. Derive an expression for the magnetic field intensity at a point on the axis of a circular coil of wire carrying electric current.

4. A straight solenoid of length l and radius r is wound uniformly with n turns of wire carrying a current i. Derive an expression for the intensity of the magnetic field at a point on the axis of the solenoid midway between its ends.
5. Show that a current element $i\,\overrightarrow{dl}$ placed in a magnetic field $\vec{B}$ experiences a force d given by $\overrightarrow{dF} = i\,(\overrightarrow{dl} \times \vec{B})$. How will you get the direction of the force?
6. Show that the magnetic field inside a long solenoid is $\mu_0 ni$ where n is the number of truns per unit length and the current in ampere.
7. In the case of a long solenoid, prove that the intensity of the magnetic field at a point well inside the solenoid is double that at any end.
8. State Ampere's law in magnetostatics and show that it leads to mathematical form $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$.
9. What is Ampere's circuital theorem? Explain it. Use the theorem to find the magnetic induction (i) inside (ii) on the surface and (iii) at any point outside a long straight current carrying conductor.
10. Find the force per unit length of a current carrying conductor placed in a uniform magnetic field. Express result in vector form.
11. Show that the force on a conductor of length l, when perpendicular to a magnetic field of induction B is Bil where i is the current in the conductor in ampere.
12. Find the force per unit length of a current carrying conductor placed in a uniform magnetic field. Hence, find the force between two long straight conductors carrying current. State the laws of parallel and angular currents.
13. A particle with charge e is moving in a uniform magnetic field of induction $\vec{B}$. Show that the magnetic force F_m on the particle is $\overrightarrow{Fm} = e\,(\vec{v} \times \vec{B})$ where v is the velocity of the particle. What is Lorentz force?
14. Describe the principle of action of a suspended coil galvanometer.
15. From the experimental law of force on a current carrying conductor deduce the force that acts on a charge moving in a magnetic field.
16. Starting from Biot-Savart law deduce the force that acts between two moving charged particles.
17. Starting from Biot-Savart law deduce the magnetic field produced by a moving charged particle. Draw magnetic field lines.
18. Starting from Biot-Savart law deduce the magnetic field at point due to a straight conductor carrying steady current. What would be the field if the conductor be infinitely long?
19. Starting from Biot-Savart law deduce the magnetic field at a point on the axis of small coil carrying steady current. Find the field at a point at the centre of the coil. Draw graphs showing the variation of the magnetic field with distance.
20. From Biot-Savart law show that a small circular coil carrying current is equivalent to a magnetic dipole. Find the moment of the dipole. Explain why the result is true for any shape of the coil.

21. From Biot-Savart law calculate the magnetic field at a point on the axis of a long solenoid. Find the field at the middle and at the ends of the solenoid. Draw graph showing the variation of the field with distance.
22. Explain by elaborate calculation how a uniform magnetic field may be produced with the help of two coils. Draw graphs to explain your result.
23. Find the force of interaction between two straight wires carrying parallel and anti-parallel currents. Define the unit of current from this result.
24. Find the general formula for the force acting between two current elements. Compare it with Coulomb's law.
25. State Ampere's law. Deduce it in a simple way.
26. Apply Ampere's law to calculate (i) magnetic field it a point on the axis of a solenoid carrying current, (ii) magnetic field within a toroid. Compare the field produced in the two cases.
27. A rectangular turn of wire is placed hanging in a magnetic field, which is in the plane of the coil and perpendicular to the length of the coil. Calculate the couple acting on it.
28. Which purpose a galvanometer is used for? 2What modifications are necessary to convert a galvanometer to (i) an ammeter and (i) voltmeter? When an ammeter and a voltmeter should be regarded as ideal?
29. A particle with charge q having mass m enters a uniform magnetic field B at right angle to the field. Explain its future motion in detail.
30. A particle with charge q having mass m enters a uniform magnetic field B making an angle θ with the field. Explain its future motion in detail.
31. A particle with charge moving with a velocity v enters a region where there are electric and magnetic fields at right angle to each other. The particle moves without any deviation. Explain in detail how this is possible.
32. Derive a relation connecting permeability of a magnetic substance.
33. Define magnetic permeability and susceptibility and show how these are related to each other.
34. Show that for a magnetic material $\vec{B} = \mu_0 (\vec{H} + \vec{M})$.
35. Describe an experimental method for determining the magnetic permeability and susceptibility of a specimen in the form of a thin rod.
36. (a) Show the general nature of a *B-H* loop and explain the term retentivity, coercivity and hysteresis with reference to it. Compare the *B-H* loops for iron and steel. Prove that the energy dissipated per unit volume of a material during a complete hysteresis cycle is $\frac{1}{4\pi}$ times the area enclosed by *B-H* curve.

    (b) What is hysteresis? Calculate the work done when a magnetic substance is brought round a hysteresis cycle.
37. Briefly state how can distinguish between a ferromagnetic, para magnetic and dia-magnetic material.
38. Illustrate the nature of hysteresis loop of a sample of steel and that of a soft iron piece. Indicate from these how the two materials differ in their magnetic behaviour

39. Draw curves showing the manner in which the magnetisation varies in a sample of soft iron and in a sample of steel as each is taken through a complete cycle of magnetising force. With reference to the above curve, compare the properties of the two samples in respect of residual magnetism, coercive force and bysteresis loss. Discuss fully, why soft iron is suitable for use as the core of a transformer while steel is preferred for making permanent magnets.
40. What is the meaning of hysteresis in ferro magnetics? State the mathematical relation between *B, M* and *H* in a magnetic material.
41. Prove that when a sample of magnetic material is subjected to a periodic magnetising field, an amount of energy proportional to the area of the hysteresis loop is lost per cycle.
42. Show that the area of the *B-1* loop is 4π times the area of *M-H* loop.
43. (a) Prove that in SI system, the energy dissipated per unit volume of a magnetic material during a complete hysteresis cycle is equal to the area enclosed by the *B-H* loop of the material.

    (b) Explain the terms: retentivity, coercivity and hysteresis.
44. Define intensity of magnetization, magnetic induction and magnetic susceptibility. Obtain a relation among them.
45. Explain the terms *M, B* and *H*. State the units. Establish the relation $\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M}$.
46. If μ_r and *K* be the permeability and susceptibility of a magnetic specimen shows that $\mu_r = 1+K$.
47. What are the characteristics of dia magnet para magnetism and ferro magnetism? Illustrate by simple experiments.

ELECTROMAGNETIC INDUCTION

1. State Faraday's and Lenz's law of electromagnetic induction and express it quantitatively.
2. Faraday-Lenz's law is $\epsilon = -\frac{d\phi m}{dt}$. Explain the different symbols and the negative sign in the above equation.
3. What are the laws of electromagnetic induction? What decides (i) the duration (ii) the direction and the magnitude of induced emf in a circuit?
4. From Faraday-Lenz's law in its basic form, derive the integral form and the differential form of the law. Explain what new phenomenon is revealed from these formulations?
5. In Faraday's law $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$, the electric field $\vec{E}$ is called non-electrostatic electric field. Explain.
6. Is there is any difference between induced electric field and the electric field produced by a static charge?
7. When magnetic field $\vec{B}$ varies with time an electric field $\vec{E}$ is produced. What is the relation between these two field?
8. What is motional emf? Derive its value from Lorentz force.
9. Show clearly that when electric energy is derived from motional emf some external agent must do work to supply that energy.
10. Show that motional emf $\vec{E} = -\frac{d\phi_m}{dt}$.
11. Find the emf developed (i) across the ends of a conductor and (ii) between the rim and center of a disc, moving with angular velocity in the plane perpendicular to a uniform magnetic field. Once the rotation is started can it move forever? Explain your answer.
12. Show that some charge flows through a closed circuit when the magnetic flux linked with it suddenly changes. Show by proper calculation which factors the charge flown does depend upon and on which factor it does not.
13. Explain what should be the essential requirements for a ballistic galvanometer to enable it to measure charge? How the effect of damping of the coil may affect the observation and how is corrected?
14. What is self-induction? Explain how it follows from Faraday's law of induction.
15. State the two alternative definitions of self- inductance of a coil.
16. Define henry. Find the unit of μ_0 in terms of henry.
17. Find energy stored in the magnetic field around a coil of self-inductance L when current flowing through it is I.
18. Define self-inductance of a coil in terms of energy contained in the magnetic field of the coil carrying a steady current.
19. The self-inductance of a circuit is analogous to the inertia of an inert body. Explain.

20. Calculate the self-inductance of (i) solenoid, (ii) toroid, (iii) straight wire, (iv) two parallel wires and (v) two coaxial coils.
21. Calculate the inductance of a solenoid with an iron core.
22. How are non-inductive coils prepared? Discuss the principle underlining it.
23. Define mutual induction. Explain why it happens.
24. State the two equivalent definitions of mutual inductance of two coils. Which factors it depends upon?
25. Calculate the energy of the system of two coils, having self-inductances L_1 and L_2 and mutual inductance M, carrying steady currents I_1 and I_2 respectively.
26. Find the mutual inductance of two (i) coaxial and (ii) parallel coils.
27. For two magnetically coupled coils having self- inductances L_{1-} and L_2 carrying currents, find the relation between self-inductances and mutual inductance and find the maximum value of the mutual inductance.
28. What is coefficient of coupling k of two magnetically coupled coils? Explain in which conditions two coils have $k = 0$, $k < 1$ land $k = 1$.
29. Find the equivalent inductance of two magnetically coupled coils when these are joined in (i) series and (ii) parallel.
30. What is mutual induction? Explain how this phenomenon is used to construct a transformer.
31. What are step-up and step-down transformers?
32. Starting from the energy stored in the magnetic field of a coil carrying current, derive the energy per unit volume in a magnetic field.

MAXWELL'S EQUATIONS AND
ELECTROMAGNETIC WAVE PROPAGATION

1. Write down the four basic equations of electromagnetism and the equation of continuity those we had learned before Maxwell made his contribution. Explain the symbols present in the equations.
2. Which inconsistency did Maxwell discover in the basic four relations of electromagnetism and the equation of continuity?
3. How Maxwell removed the inconsistency in the basic equations of electromagnetism?
4. What is displacement current? Which physical facts does it stand for?
5. Describe a simple situation where the idea of displacement current can remove an obvious in consistency.
6. Mention one experimental observation which can justify that displacement current is a physical fact of nature.
7. Explain how the idea of displacement current could show a symmetry in the properties of electric and magnetic field.
8. Is displacement current important when there is conduction current in a conductor under the action of an alternating electric field? Give an idea of their relative magnitudes when both are present in a conductor under the action of a time varying electric field.
9. In which conditions there is displacement current between the plates of a capacitor and when there is none ?
10. Write down the four Maxwell's equations of electromagnetism in differential and integral forms. Explain the symbols present in the equations.
11. Write down the four Maxwell's equations of electromagnetic theory and compare the similarity and difference between electric and magnetic fields as expressed in the equations.
12. Why Maxwell's equations are said to be linear coupled differential equations? What are the implications of this fact?
13. Explain how Maxwell's equations represent the basic facts of electrostatic, magnetostatics and electromagnetism.
14. Write down Maxwell's equations in free space where there is neither any charge nor any current. From these equations obtain the two differential equations which involve one field each. Which fact these two equations point to?
15. Which single observation led Maxwell to the conclusion that light is electromagnetic wave?
16. An electromagnetic plane wave is propagating in the direction of z-axis through free s Explain the following with proper diagrams, if necessary.
    i. What are directions of the electric field, magnetic field and the wave vector?
    ii. What is the relation between the phases of the electric field and magnetic field?
    iii. What is the relation between the magnitudes of electric and magnetic fields?

17. Show that the energy is equally shared between electric and magnetic fields, when an electromagnetic wave is passing through free space.
18. What is Poynting vector? Find its relation with the electric and magnetic field vectors.
19. Find the intensity or irradiance of a sinusoidal plane electromagnetic wave in terms of the electric field.
20. What should be the speed of light waves in at transparent isotropic dielectric medium? Find the relation between the absolute refractive index medium with permittivity and permeability of the medium.
21. Write down the Maxwell's equations in a transparent dielectric medium and explain the different symbols in the equations.
22. Explain how it follows from Maxwell's equations that speed of light in any transparent medium is less than that in vacuum.
23. Explain how from Maxwell's theory we may get the relation $n = \sqrt{k_e}$, when n is the absolute refractive index and k_e is the dielectric constant of a transparent material. Why this relation does not hold for many materials?
24. Why vacuum may be called non-dispersive medium for light?
25. A plane sinusoidal electromagnetic wave propagating along the Y-axis is polarized along Z-axis. Write down the three components c electric and magnetic fields.
26. State how the electric field vector of a plane e.m. wave behaves when it is (i) linearly polarized (ii) circularly polarized and (iii) elliptically polarized.
27. How circularly and elliptically polarized wave may be produced?
28. Suppose $\Psi(z, t)$ represents one component o electric or magnetic field, obeying Maxwell's equations. Write down the differential equation it satisfies. Then write down its sinusoidal solution. Now justify that it represents a plane wave proceeding along the z-axis.
29. Suppose that electric and magnetic fields of a plane electromagnetic wave are represented by either real or complex part of the following two equations:

    $$\vec{E}(\vec{r}, t) = \vec{E}_0 e^{i(\vec{k}.\vec{r} - \omega t)}$$

    and $$\vec{B}(\vec{r}, t) = \vec{B}_0 e^{i(\vec{k}.\vec{r} - \omega t)}$$

    In order that these equations satisfy all the Maxwell's equations, there should be definite relations between the direction of the fields $\vec{E}$ and $\vec{B}$ and the propagation vector $\overrightarrow{k}$. Also, there should be a definite relation between the magnitudes of the two fields. Find these relations.
30. Write down the relation between pressure of electromagnetic radiation and energy density. From this relation derive the relation between momentum density and intensity of electromagnetic wave.
31. Explain Joule's heating in resistance in a circuit from electromagnetic theory.
32. What are the different spectral regions of electromagnetic wave and their wavelength ranges?

ALTERNATING CURRENT

1. Obtain expressions for the mean value and r.m.s. value of a sinusoidal alternating current.
2. Distinguish between mean value and root mean square value of an alternating potential. Obtain expressions for the same in the case of a simple harmonically varying potential.
3. Show how the average, virtual and peak values of alternating current are related to one another.
4. Define the form factor of an alternating wave. Calculate the value of the same for a pure sinusoidal current.
5. An alternating emf $E = E_0 \sin \omega t$ is applied to the ends of a circuit consisting of a resistor R and a coil of self-inductance L in series. Deduce an expression for the current in the circuit.
6. Derive an expression for the instantaneous current of an a.c. circuit consisting of a capacitor and a resistor.
7. Deduce an expression for the power consumed in a circuit carrying alternating current.
8. Show that in the case of an inductive or capacitative circuit, the power absorbed per cycle is zero.
9. An alternating emf $E = E_0 \sin \omega t$ is applied to the ends of series circuit consisting of a resistor R, an inductance L and a capacitance C. Find the current through the circuit at any instant. Explain what is meant by the impedance of the circuit and establish the condition for which the resonance occurs.
10. An alternating source of emf $E = E_0 \sin \omega t$ is connected across an inductance L in parallel with a capacitance C. If the circuit resistance is negligible, find the condition when no current will flow through the circuit.
11. What is impedance triangle? How can you get the impedance and phase angle from the impedance triangle?
12. What is a choke? For what purpose is it used in an a.c. circuit? 'A choke is more economical than a resistor' -explain the statements.
13. (a) The equation of current in an a.c. circuits is $i = 50 \sin 400 \pi t$. What is the r.m.s. current and frequency?

    (b) An inductor L in series with a capacitor C and a resistor R is connected across an a.c. voltage source $E_M \sin \omega t$. Obtain an expression for the instantaneous current in the circuit and hence explain the series resonance.
14. What due understand by the terms "impedance", "reactance" and "power factor" of an AC circuit?
15. Give the physical reason behind that the impedance of an inductor increases with frequency while that of a capacitor decreases with frequency.
16. A sinusoidal voltage is applied to a series LCR circuit. What is the impedance of the circuit? when such a circuit is called inductive, capacitive and resistive? draw the phasor diagram for the three cases.
17. Draw the circuit diagram of an Anderson bridge. Derive the balance condition. Explain how inductance of a coil may be determined by this bridge.
18. Define (i) linear, (ii) non-linear, (iii) unilateral and(iv) bilateral network.
19. What are ideal voltage and current sources and explain the necessary conditions.

20. What are phasors? Why alternating voltage and current are phasors.
21. Explain how alternating voltage and currents may be represented as a complex number. Why these are useful?
22. A sinusoidal voltage is applied to a circuit having (i) L and R in series, (ii) $C$and R in series, (iii) L, C R in series. Find the currents in the circuits using complex representation of the voltage, current and impedances. Draw the phasor diagram for each.
23. State the following theorems for DC and AC circuits: (i) Superposition theorem, (i) Thevenin's theorem, (iii) Norton's theorem, (iv) Maximum power transfer theorem. In which kind of network these hold?
24. Several impedances are joined in (i) series and (ii) parallel in an AC circuit. Find the equivalent impedances applying Kirchhoff's law.

THERMODYNAMICS

1. What are an isolated and a closed system in thermodynamics?
2. What are extensive and intensive variables in thermodynamics? Give examples of each.
3. In thermodynamics we get macroscopic description of a system. What is meant by this statement?
4. How and when two systems attain thermal equilibrium?
5. State zeroth law of thermodynamics. Explain how this law is used in all measurements of temperature.
6. Which thermodynamic property of a system we get from zeroth law of thermodynamics?
7. Explain clearly why the same temperature measured by thermometer using two different methods do not agree with each other?
8. Which is the only one reference temperature in perfect gas scale? Why it is very convenient to use for this purpose?
9. When is a system said to be in thermodynamic equilibrium?
10. What are indicator diagram used in thermodynamics? Explain why an indicator diagram shows the succession of equilibrium states of a system?
11. What are similarity and difference between the two thermodynamic quantities: Heat and work?
12. Suppose a physical quantity z depends on two independent quantities x and y. In which condition dz may be regarded as a perfect differential?
13. Suppose we are given the relation: $dz = M(x, y)\, dx + N(x, y)\, dy$. What is the necessary condition for dz to be a perfect differential?
14. Explain why integral of an exact differential over a closed path is zero.
15. State and express first law of thermodynamics in differential form. Which other principle it is directly related to? Which new property of a system this law leads to?
16. Which experimental observations lead to the idea that internal energy U is a property of a thermodynamic system.
17. Explain why we cannot know the absolute value of internal energy of a system?
18. Explain what internal energy of a thermodynamic system consists of?
19. What are the essential characteristics of isothermal and adiabatic processes?
20. Can a thermodynamic process be isothermal, if there is no exchange of heat between the system and the surroundings?
21. Can the temperature remain constant in an adiabatic process?
22. Show that the work done by a gas when it expands from volume V_1 to V_2 is given by

$$W = \int_{V1}^{V2} p\,dV$$

23. A gas expands in vacuum. Show that it performs no work.
24. Explain how the work done by a compressible system may be determined from p-V indicator diagrams.
25. Draw p-V indicator diagrams for (i) isochoric, (ii) isobaric, (iii) isothermal, (iv) adiabatic and (v) cyclic processes and show how work done by the system in each such process may be known from the graphs.

26. Calculate the works done by a gas when it undergoes through a (1) isobaric, (11) adiabatic, (iii) isothermal, (iv) polytropic and (v) cyclic processes.

27. Identify the following thermodynamic processes:

a) A gas in a thermally insulated chamber expands from initial state (P_1, v_1, T_1) to the final state (P_2, v_2, T_2).
b) A gas expands from initial state (P_1, v_1, T_1) to the final state (P_2, v_2, T_2).
c) A gas is compressed from initial state (P_2, v_2, T_2) to the final state (P_2, v_1, T_1).
d) A gas expands from initial state (p_1, V_1, T_1) to the final state (P_2, v_2, T_2).
e) A gas undergoes the process (c) followed by the process (d).

28. What is Mayer's hypothesis?

29. Why a gas has two specific heats? Define the two specific heats of a gas and find the relation between them for ideal gas. Which specific heats do we measure for solids and liquids?

30. If δQ_p and δQ_y are heats given to one mole of ideal gas at constant pressure and at constant volume respectively prove that (i) $\delta Q_y = dU = C_v dT$ and (ii) $\delta Q_p = C_v dT - Vdp$, where the symbols have their usual significances.

31. For an ideal gas for an adiabatic process prove that pl-YTY= constant, where the symbols have usual significances.

32. Why adiabatics are steeper than isothermals?

33. Can two adiabatics intersect? Explain.

34. Explain why in an adiabatic process temperature change.

35. From first law of thermodynamics find the changes in internal energy of a system for the following processes: (i) isochoric, (ii) isobaric, (iii) isothermal, (iv) adiabatic and (v) cyclic processes.

36. Define the efficiency of a heat engine and coefficient of performance of a refrigerator.

37. A system is receiving energy from a source but its temperature remains constant. Explains what is happening to the energy transferred as heat?

38. Is first law simply a statement of conservation of energy? Explain.

39. What are the scope and limitation of first law of thermodynamics?

40. State the two equivalent statements of second law of thermodynamics.

41. Show that Kelvin-Planck statement and Clausius statement equivalent of second law of thermodynamics are equivalent.

42. What are reversible and irreversible processes?

43. What are essential conditions for reversibility of a process?

44. Explain why all natural processes are bound to be irreversible?

45. If all natural processes are irreversible, what is the use of imagining reversible process?

46. Mention the essential requirements for the Carnot engine to be a reversible heat engine. Also explain why a definite sequence of steps is necessary in the Carnot cycle to make it reversible?

47. Draw the p-V diagram describing a Carnot cycle. What is the definition of efficiency of such an engine? Write down the expression for the efficiency of a Carnot engine.

48. Write down the efficiency of a Carnot engine working between two temperatures T_1, and T_2. Explain why the engine cannot have efficiency 1.

49. Write down the efficiency of a Carnot engine working between two temperatures T_1 and T_2. Explain how this result confirms second law of thermodynamics.

50. Write down the efficiency of a Carnot refrigerator working between two temperatures T_1, T_2 Explain which fact of a refrigerator confirms second law of thermodynamics.

51. State Carnot's theorem.

52. Why the efficiency of a Carnot engine does not depend on the nature of the working substance.

53. Prove Carnot's theorem.

54. Explain how Kelvin could define an absolute scale of temperature from Carnot's theorem.

55. Why absolute or thermodynamic scale of temperature is called absolute scale?

56. What is Clausius inequality? Explain how from this inequality we can arrive at the idea of entropy?

57. How can we infer that $\frac{\delta Q}{T}$ represents a property of system?

58. Define change in entropy of a system. Why absolute value of entropy cannot be known?

59. A system changes from one equilibrium state to another by an arbitrary process. How we can find the change of entropy of the system.

60. What should be the change in entropy in a thermodynamic cyclic process?

61. From thermodynamic laws we come to know thermodynamic properties of a system. Give three examples.

62. Show that the change in entropy in a reversible path between two equilibrium states has the minimum value.

63. If there is some irreversibility somewhere in at process, show that change in entropy is greater than we expect from a reversible path.

64. Considering one reversible and one irreversible process between two states of a system, show that change in entropy in an irreversible process,

$$dS = \frac{\delta Q}{T} + \delta S_{gen}$$

where δS_{gen} is the entropy generated due to irreversibility. Hence show that

a. in a reversible process, $ds = \frac{\delta Q}{T}$
b. in an irreversible adiabatic process, $dS = \delta S_{gen}$

65. Show that entropy can be increased in two ways: by transferring heat and by irreversibilities.

66. Show that entropy can be *decreased only by transferring heat from the system*.

67. Show that the entropy change of the universe is zero for reversible process, but positive for an irreversible process.

68. Explain why entropy change of an isolated system cannot decrease.

69. State the second law of thermodynamics in terms of entropy.

70. Explain in which condition an adiabatic process may be called isentropic process.

71. Find the change in entropy in the following processes:

I. A body when it is heated or cooled.
II. A piece of material suffers a change of phase.
III. An ideal gas suffers an isothermal expansion or compression.
IV. An isolated ideal gas expands in vacuum.
V. Heat flows from a hot body to a cold one.

72. An amount of heat δQ is absorbed from a body which is at temperature T. What is the available energy from that heat δQ?

73. Heat Q flows from a higher temperature T, to a lower temperature T,. Show that there is a degradation of energy. Find the loss of available energy in terms of change of energy.

74. What is degradation of energy?

75. In all natural processes energy degrades. What is meant by this statement?

76. The available energy of the universe is tending towards zero. Explain the statement.

77. How entropy of a system is related to disorder in the system?

78. What is temperature-entropy diagram? Prove that work done in a reversible cycle is equal to the area of the cycle in the T - S diagram.

79. Draw temperature-entropy diagram of Carnot cycle and derive the efficiency of Carnot cycle from it.

80. Write down the expressions for the first law and second law in differential form. Get the combined law.

81. What are the three thermodynamic potentials H, F and G? Why are these called thermodynamic potentials? Why these are properties of a system and these are extensive properties?

82. Show that specific heat at constant pressure, $C_p = \left(\frac{\partial H}{\partial T}\right)_P$. Now explain in which condition can H be compared to U.

83. Show that enthalpy of an ideal gas is independent of pressure and volume of the gas.

84. Show that free energy F is the available energy from a system at constant temperature.

85. Show that in isothermal condition external work done by a system is the loss of its free energy.

86. Show that in an isothermal process the free energy plays the same part as internal energy in adiabatic process.

87. Show that entropy is the rate at which free energy changes with temperature, when volume is kept constant.

88. Derive Gibbs-Helmholtz relation:

$$U = F - T\left(\frac{\partial F}{\partial T}\right)_S$$

89. Show that entropy is the rate at which Gibbs function changes with temperature, when pressure is kept constant.

90. Derive Gibbs-Helmholtz relation:

$$H = G - T\left(\frac{\partial G}{\partial T}\right)_P$$

91. Show that for a reversible isothermal and isobaric process G constant. In which physical processes are these conditions satisfied?

92. From combined first and second law derive the Maxwell's first relation

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

93. From free energy derive the Maxwell's second relation $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

94. From enthalpy derive the Maxwell's third relation: $\left(\frac{\partial T}{\partial P}\right)_S = -\left(\frac{\partial V}{\partial S}\right)_P$

95. From Gibbs function derive the Maxwell's fourth relation: $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial p}\right)_T$.

96. From combined first and second law and basic definitions deduce the following relation between specific heats at constant of volume and pressure valid for any substance:

$$C_p - C_v = \left[\left(\frac{\partial U}{\partial V}\right)_T + P\right]\left(\frac{\partial V}{\partial T}\right)_P$$

From this relation deduce the relation valid for ideal gas.

97. Derive the relation:

$$C_p - C_v = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)^2_P .$$

Now find the relation valid for ideal gas.

98. Derive the relation: $C_p - C_v = T\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)^2_P$. From this relation show that

(i) For any substance $C_p > C_v$,

(ii) What happens as $T \rightarrow 0$?

(iii) In which condition $C_p = C_v$. Mention one important well-known example where this happens.

99. Derive the relation: $C_p - C_v = \frac{V\gamma 2T}{\beta}$, where γ is coefficient of volume expansion of a substance at constant pressure and β is compressibility.

100. Find the following relations of change of entropy in terms of measurable quantities:

(a) $ds = \frac{1}{T} + C_v dT + \frac{\gamma}{\beta}\, dV$

(b) $ds = \frac{Cp}{T} dT - \gamma V dp$

(c) $dS = \frac{Cv}{T}\frac{\beta}{\gamma} dp + \frac{Cp}{T}\frac{1}{\gamma V} dV$

101. Find change in entropy of n moles of ideal gas when it change from the initial state $A(p_a, V_a, T_a)$ to the final state $B(p_b, V_b, T_b)$ in terms of

(i) initial and final temperatures and pressures,

(i) initial and final temperatures and volumes.

What would be the values of entropy in state B if A is chosen as the standard one?

102. Obtain the first TdS relation and show how to calculate the heat required when a gas undergoes a reversible isothermal expansion in volume.

103. Obtain the second *TdS* relation and show how to calculate the heat required when a gas undergoes a reversible isothermal change in pressure. Now show that for most substances heat is liberated when pressure is increased, but the opposite happens for water between 0°C and4°C.

104. Using combined first and second law and the first and second TdS relations obtain the first and second energy relations

$$\left(\frac{\partial U}{\partial V}\right) = \mathrm{T}\left(\frac{\partial P}{\partial T}\right)v \; - P \;\; and$$

$$\left(\frac{\partial U}{\partial V}\right) = \mathrm{T}\left(\frac{\partial P}{\partial T}\right)v \; - P\left(\frac{\partial V}{\partial p}\right)_{\mathrm{T}}$$

From these relations show that internal energy of ideal gas does not depends on volume and pressure, it depends only on temperature. Now express the above two equations in terms of measurable quantities: p, V, T, γ and β.

105. Derive the following two relations giving the variations of specific heats:

$$\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 p}{\partial T^2}\right)_V \text{ and } \left(\frac{\partial C_p}{\partial p}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_p$$

106. "An isolated system attains stable equilibrium when the entropy becomes maximum value'. Justify the statement.

107. For a thermally and mechanically isolated system, stable equilibrium state is attained when internal energy has the lowest possible value'. Justify the statement.

108. For a mechanically isolated system at constant temperature the equilibrium condition corresponds to minimum free energy'. Justify the statement.

109. At constant temperature and pressure equilibrium is attained when Gibbs' function has the minimum value'. Justify the statement.

110. What is meant by phase transition? Write down the Clausius-Clapeyron's equation and explain the symbols. From these equations justify the following facts:

a) Saturation vapour pressure increases with temperature.
b) Boiling point increases with pressure.
c) Melting point increases with increase of pressure. Mention important and well-known exceptions to the general rule.

111. What are internal and external latent heats?

112. Derive Clausius-Clapeyron's equation from Maxwell's first relation.

113. Write down the second latent heat equation and explain the symbols.

114. Explain briefly what is done in Joule-Thomson throttling experiment. Why it is called adiabatic throttling process? What are the conclusions drawn from this experiment?

115. What is Joule-Thomson effect?

116. Show that throttling process is an isenthalpic process.

117. Define Joule-Thomson coefficient. Explain why the sign of this coefficient decides whether there is cooling or heating in the throttling process.

118. Assuming that in Joule-Thomson throttling process enthalpy remains unchanged, show that the Joule-Thomson coefficient is given by

$$\mu = -\frac{1}{Cp}\left(\frac{\partial U}{\partial p}\right)_T - \frac{1}{Cp}\left(\frac{\partial (pV)}{\partial p}\right)_T$$

Explain that each term represents violation of some well-known law and ideal gas should not show any heating or cooling effect.

119. Assuming that in Joule-Thomson throttling process enthalpy remains unchanged, show that the Joule-Thomson coefficient is given by

$$\mu = -\frac{1}{Cp}\left(\frac{\partial U}{\partial p}\right)_T - \frac{1}{Cp}\left(\frac{\partial (pV)}{\partial p}\right)_T$$

Now explain what we should expect for real gases.

120. Assuming that in Joule-Thomson throttling process enthalpy remains unchanged, show that change in temperature in this process is given by

$$dT = \frac{T\left(\frac{\partial V}{\partial T}\right)_p - V}{Cp}\, dp$$

Now explain when we should expect heating or cooling. Define inversion temperature. Why is it so called?

121. Joule-Thomson coefficient is given by

$$\mu = \left(\frac{\partial T}{\partial p}\right)_H = \frac{1}{C}\left[T\left(\frac{\partial V}{\partial T}\right)_p - V\right]$$

Now find its value for a van der Waals gas. Then find the temperature of inversion.

122. State Planck's statement of third law.

123. Is there any reason for entropy to have non-zero value at absolute zero ? State the more acceptable statement of third law.

124. State the principle of unattainability of absolute zero. Why it can be regarded as an alternate statement of third law of thermodynamics

125. State the most important contribution of third law of thermodynamics.

126. Compare first, second and third law of thermodynamics and indicate the basic difference of third law from the other two.

127. Why we can be sure that reaching absolute zero is not possible. What is the latest record of lowest temperature attained in laboratory condition?

KINETIC THEORY OF GASES

1. Write down the basic assumptions of Kinetic theory of gases.

2. What are the interpretations of pressure and temperature of a gas in kinetic theory of gases?

3. What is root mean square speed of gas molecules? Justify that this speed is more significant for the gas molecules in a gas than ordinary average speed.

4. Derive an expression for the pressure of a gas from the standpoint of kinetic theory.

5. Show that the pressure exerted by a perfect gas is two-thirds of the kinetic energy of the gas molecules per unit volume.

6. (a) State and explain the Maxwell's law of distribution of molecular velocities.

   (b) Mention the characteristics of the motions of the gas molecules in equilibrium at a particular temperature that follow from the law of distribution.

7. N, represents the number of molecules having speeds between v and v+1. Explain how from N_V - V graph we may get the total number of gas molecules in a gas.

8. What are mean, rms and most probable velocities of gas molecules? Find their values from Maxwell's law of distribution of molecular velocities. Hence show that

   $$C_{mp}: C_m: C=\sqrt{2}: \sqrt{\frac{8}{\pi}} : \sqrt{3} = 1: 1.128: 1.225$$

9. Draw the appropriate curve showing Maxwell's distribution of molecular speeds and locate the approximately the positions of mean, rms and most probable speeds in the curve.

10. What is mean free path of gas molecules in a gas? Write down it's expression.

11. What are degrees of freedom of mechanical system? Explain what should be the degrees of freedom of monatomic, diatomic and triatomic molecules?

12. (a) State the principle of equipartition of energy.

    (b) If the number of degrees of freedom per molecule of a perfect gas is x, show that, $\gamma = 1 + \frac{2}{x}$ where y is the ratio of the specific heats of gas at constant pressure and at constant volume.

    (c) Calculate the values of y for monatomic, diatomic and triatomic molecules.

13. What are perfect gas and real gases? Draw the Amagat's isothermal curves (pV against p) for CO_2, N_2, and H_2, gases compare their behaviour with ideal gas at high pressure.

14. Why real gases do not obey Boyle's law?

15. Draw three isothermal curves (p against V) of CO, gas, as was obtained from Andrew's experiment, for three temperatures at, below and above the critical temperatures to show their general nature. Now compare the differences in behaviours of ideal and real gases.

16. Explain the difference between (i) a perfect gas and a real gas.

17. (a) What is critical temperature of a gas?

    (b) Explain why an ideal gas cannot have critical temperature?

    (c) Why O_2, N_2, and H_2, gases are called permanent gases?

    (d) When a gas is called a vapour?

18. Write down the equation of state of van der Waals' equation of state for real gases and explain the significances of the correction terms. Obtain the expressions for T_c, P_c and V_c in terms of a, b and R.

19. (a) Discuss briefly the considerations which led van der Waals to modify the gas equation.

    (b) Deduce van der Waals' equation for real gases.

    (c)What do you understand by the corresponding states? Deduce the law of corresponding states.

20. State van der Waals' equation of state for a real gas. How do you build up from it a reduced equation of state applicable to any gas?

21. Write down the van der Waals' equation for moles of a real gas.

22. If T_c and T_b are the critical and Boyle temperature of a gas obeying van der Waals' equation, show that $T_8 = \frac{27}{8}\, T_{C}$.

23. Find the relation between Boyle temperature and van der Waal's constants.

24. What is an equation of state of a gas? Express the equation of state of real gases in terms of the virial coefficients. Define Boyle temperature from this equation.

25. Show that at Boyle temperature the second virial coefficient is zero.

26. Prove that $\frac{RT_C}{P_C V_C} = \frac{8}{3}$ for van der Waals' gas.

27. Define Boyle's temperature. What would be the nature of the pV - p plot of a real gas at its Boyle's temperature?

28. What is Brownian motion? State the characteristics of Brownian motion. How this motion was explained by Einstein?

29. Show that the kinetic energy of a mole of an ideal gas is given by $\frac{3}{2}$ RT where R is the universal gas constant and T is the temperature of the gas. Hence show that, if two ideal gases are at the same temperature, their molecules have the same kinetic energy.

30. In which of the conditions a real most like an ideal gas.

    a. high pressure and small volume
    b. high pressure and low temperature
    c. low pressure and high temperature
    d. low pressure and large volume

31. Consider a given molecule in an ideal gas a constant temperature. Can this molecule double its speed under this condition? Explain your answer.

32. Express van der Waals equation in virial form.

THEORY OF RADIATION

1. What are perfect reflector, perfect transmitter and perfect absorber of radiation?
2. Good reflectors are bad absorbers and vice versa. Justify,
3. Define emissive power and absorptive power of a body. State their units.
4. What is a perfectly black body?
5. State Kirchhoff's law.
6. If a body is capable of emitting a particular radiation, the body will absorb it when it falls upon the body'. Explain how this statement follows from Kirchhoff's law.
7. Good absorbers are good emitters, while poor absorbers are poor emitters. Justify it from Kirchhoff's law.
8. State Stefan-Boltzmann law.
9. What is the relation which gives the energy emitted per second per unit area by any arbitrary body?
10. Define emissivity of the surface of the body. Which factors it depends upon?
11. What is the energy lost by a perfectly black body at a particular temperature placed in an enclosure maintained at another temperature?
12. What is Newton's law of cooling?
13. Show that Newton's law of cooling follows from Stefan-Boltzmann law.
14. How the character of the radiation from a body is decided? Which factors it depends upon ?
15. Draw the relevant curve to show the characteristic blackbody radiation spectra. Why this curve is said to have a universal character?
16. With the help of suitable curves explain the characteristics of black body radiation.
17. State Wien's displacement law and explain it with suitable curves.
18. How temperature of a body emitting radiation may be obtained by Wien's displacement law?
19. Explain how colour of the radiation from a body change as its temperature increases slowly from room temperature.
20. Why and how the distribution curves for black bodies at different temperatures can be made to fit with each other?
21. How from the experimental characteristics curve of a black body we may verify Stefan's law?

22. What is Ferry's black body? Explain why radiation within it may be regarded as black body radiation.
23. What is the main principle utilised to produce perfectly black body in the laboratory?
24. What is cavity radiation? What is its use?
25. Define spectral radiancy and energy density. What is the relation between them?
26. Which were the basic two ideas behind the derivation of Rayleigh-Jeans formula for the radiation emitted from a perfectly black body?
27. Assuming the number of possible modes of vibration per unit volume in the wavelength λ and $\lambda + d\lambda$, apply the principle of equipartition of energy to get Rayleigh-Jeans law.
28. Clearly explain the failures of Rayleigh-Jeans formula in explaining the characteristics curve of blackbody radiation. Why this failure was regarded as a crisis?
29. What new idea was introduced by Max Planck to get the correct radiation formula? Why it was indeed a bold assumption and it goes against classical physics?
30. Can an oscillator vibrating with amplitude a and frequency v lose or gain any amount of energy?
31. Derive Planck's radiation formula starting from his basic assumptions.
32. Draw the experimental characteristic curve for blackbody and show the curves for Rayleigh- Jeans law and Wien's law and the predictions of Planck's law in the same curve.
33. From the Planck's radiation formula deduce the following laws:
    1. Wien's radiation formula.
    2. Rayleigh and Jeans radiation formula.
    3. Wien' displacement law.
    4. Stefan's law.
34. Find the expression for Stefan's constant from Planck's radiation law.

STATISTICAL MECHANICS

1. Explain macrostate and microstate of a system with examples.
2. What is thermodynamic Probability or statistical weight of a macrostate? Can it be probability in mathematical sense?
3. What is the postulate of equal a priori probabilities? Justify this postulate. Can it be derived from some other principle?
4. Find the relation between the probability of a system occurring in a macrostate with the thermodynamic probability or statistical weight of that macrostate.
5. Explain why the macrostate which has the maximum value of the statistical weight is the most probable macrostate for the system.
6. Explain which is the equilibrium macrostate.
7. 'Entropy is a measure of number of microstates corresponding to a macrostate'. Justify.
8. Explain the physical reasons by which Boltzmann related entropy of a system with its statistical weight? Which is the relation he arrived at ?
9. Explain how Boltzmann relation for entropy can justify the third law of thermodynamics.
10. Justify how Boltzmann arrived at the logarithmic relation between entropy of a system and its statistical weight.
11. What is ensemble of a system in statistical mechanics?
12. What is phase space of a single particle? Which purpose it serves?
13. Draw the trajectory in the phase space of
    (i) a particle moving simple harmonically in a straightline,
    (ii) a particle falling freely from rest.
14. What is the phase space of a gas consisting of N molecules? What its uses?
15. Explain what should be the dimensions of phase space of a gas in a container having 1000 molecules maintained at a constant temperature. What does a point in that phase space represent? What should we expect to see if we look at the point for a sufficiently long time?
16. Explain why the trajectory of a representative point in phase space never intersect?
17. How a microstate and macrostate of a system are represented in its phase space?
18. What is ergodic hypothesis in statistical mechanics? What is its usefulness?
19. What are the characteristics of a system which Sobeys Maxwell-Boltzmann law of distribution? Write down the distribution function for a system of this kind. Explain the meaning of each symbol and the important assumption made in the derivation of this formula.
20. Draw suitable graphs showing the nature of the M-B distribution of energy at different temperatures and energies.
21. Applying M-B distribution law derive the Maxwell's law of distribution of velocities.

22. What are the characteristics of a system which obeys Bose-Einstein law of distribution? Write down the distribution function for a system of this kind. Explain the meaning of each symbol and the important assumption made in the derivation of this formula.
23. Write down the distribution function for a system obeying B-E statistics and show the important properties of such a system, which are implied in the distribution function.
24. What is a photon gas? Apply B-E distribution law to a photon gas and obtain the Planck's law of blackbody radiation.
25. What are the characteristics of a system which obeys Fermi-Dirac law of distribution? Write down the distribution function for a system of this kind. Explain the meaning of each symbol and the important assumption made in the derivation of this formula.
26. Which kind of particles obey (i) M-B statistics, (ii)B-E statistics and (iii) F-D statistics?
27. For which kind of particles any number of particles can be accommodated in any energy level?
28. Which should be the spin angular momentum of a system of particles in order that they would obey (1) B-E statistics and (iii) F-D statistics?
29. In how many ways two particles obeying M-B statistics can be distributed in three energy levels?
30. In how many ways two particles obeying B-E statistics can be distributed in three energy levels?
31. In how many ways two particles obeying F-D statistics can be distributed in three energy levels?
32. Write down the distribution function for a system obeying F-D statistics and show the important properties of such a system, which are implied m the distribution function.
33. Write down the distribution function for a system obeying F-D statistics and derive the important properties of such a system of particles at very low temperature.
34. Write down the distribution function for a system obeying F-D statistics and explain the significance of Fermi energy at absoline zero and at any temperature.
35. Explain from distribution function why fermions do not condense into lowest energy level even at lowest temperature. Which principle is responsible for this behaviour?
36. Write down the distribution functions for gasses obeying M-B, B-E and F-D statistics. From these relations answer the following:
    i. The three distributions behave similarly in some condition. Find the condition.
    ii. For small energies probability of occupying the same energy states is higher for bosons that those for classical particles. Which property is responsible for this?
    iii. For small energies the probability of occupying the same energy states is lower for fermions than for classical particles and bosons.
    iv. Pauli exclusion principle is inbuilt into the distribution function for fermions.
    v. Behaviours of fermions are quite different from classical particles and bosons at very low temperature.
37. What are the essential differences for the particles obeying B-E statistics and F-D statistics?
38. In which condition identical and indistinguishable particles behave like classical particles?

39. What is the probability of finding an electron with its energy equal to its Fermi energy at any temperature?
40. Draw curves showing the distributions of energies for particles obeying M-B, B-E and F-D statistics to show their differences and similarities.
41. Draw energy distribution curves for fermions at T-0K and at T>0K and explain the significance of Fermi energy. Does Fermi energy depend on temperature?
42. What are the characteristics of classical particles, bosons and fermions?
43. What is electron gas? Explain why conductors may be assumed to have electron gas within it?
44. Number of free electrons within the energy range E to E+ dE in the electron gas in a metal is given by

$$n(E)dE = \frac{g(E)dE}{e^{(E-E_F)/kT}+1},$$

where $g(E)dE = 4\pi V\left(\frac{2m}{h^2}\right)^{\frac{3}{2}} E^{\frac{1}{2}}dE.$

The different symbols have usual significance. From this relation calculate (i) Fermi energy for the electron gas in a metal at absolute zero, (ii) average energy per electron at absolute zero, (iii) Fermi temperature and (iv) pressure of the electron gas at absolute zero, if they are assumed to be neural.
45. How Fermi energy depends on temperature and why it may be taken to have the same value at all temperature?
46. What are Fermi energy, Fermi temperature, Fermi pressure and Fermi speed?
47. How does Fermi energy change with temperature?

SUPERPOSITION OF SIMPLE HARMONIC OSCILLATIONS

1. What is meant by superposition of two or more simple harmonic motions?
2. What is principle of superposition?
3. Why principle of superposition holds for simple harmonic motions?
4. Why the basic equation of simple harmonic motion is called linear differential equation?
5. Show that principle of superposition is a consequence of linearity of the equation of motion
6. Find the resultant motion of a particle when it has two simultaneous simple harmonic motions having the following characteristics:

   (1) The motions are along the same line having the same frequency, same phase and different amplitudes.

   (11) The motions are along the same line having the same frequency, opposite phase and different amplitudes.

   (iii) The motions are along the same line having the same frequency, arbitrary phase difference and different amplitudes.

   (iv)The motions are along the same line having slightly different frequencies, zero initial phase difference and same amplitude.
7. A particle has two simultaneous simple harmonic motions at right angle to each other, having the same frequency, different amplitudes and phase difference op. Find the resultant motion of the particle. Then discuss the situation in detail in the following cases:

   (i) phase difference is zero, (ii) phase difference is $\pi/4$. (iii) phase difference is $\pi/2$. (iv) phase difference is $\pi / 2$ and amplitudes are equal, (v) phase difference is $3\pi/4$, (vi) phase difference is π, (vii) phase difference is $5\pi/4$, (viii) phase difference is $3\pi/2$, (ix) phase difference is $7\pi/4$,
8. In which condition and how amplitude and epoch of the resultant vibration can be found by regarding the amplitudes of the superposing vibration as vectors?
9. In which condition beats occur? What is beat frequency? How beat frequency is determined in a particular situation?
10. Two simple harmonic vibrations along the same line having small difference in their frequencies, but the same amplitude superpose. Find the resultant amplitude and discuss the implication of the results.
11. Considering the superposition of two appropriate simple harmonic vibrations, show that beat frequency is equal to the difference in frequencies of the two vibrations.
12. (a) Show that the resultant of two S. H. Ms of the same period but different amplitudes and phases in perpendicular direction is an elliptic motion. For what conditions will the path of the resultant motion be a circle and a straight line?

    (b) $x = a \sin \omega t$ and $y = b \sin (\omega t + \phi)$ represents two SHM's at right angle to each other. Show that the resultant motion, in general, is an ellipse.

13. Deduce the condition which results in circular motion of a particle when two mutually perpendicular S. H. M.'s having same frequency and different phases and amplitudes act simultaneously on it.
14. Show that a uniform motion in a circle is equivalent to two S. H. M.s at right angles to each other.
15. What are Lissajou's figures? Describe one method for their experimental demonstration.
16. Two S.H.M's $x = a \sin \omega t$ and $y = b \sin (\omega t + \delta)$ acting on a particle in perpendicular directions. Show that the resultant motion is an ellipse. When can we get (i) a circular and (ii) a linear motion? When 890°, is the motion clockwise or anti- clockwise?

    [***Hints***: anti-clockwise]
17. Prove by taking simple examples that (i) uniform circular motion and (ii) periodic motion along an ellipse can be regarded as composed of two simple harmonic motions of suitable frequencies, amplitudes and phases.
18. Consider the superposition of two mutually perpendicular simple harmonic vibrations of the same frequency but different amplitudes and phases. Show in which conditions the resultant motion will be (i) along a line, (ii) along a circle in the anti-clockwise direction, (iii) along a circle in the clockwise direction, (iv) along an ellipse in the anti-clockwise direction, (v) along an ellipse in the clockwise direction.
19. Two mutually perpendicular simple harmonic vibrations of slightly different frequencies and different amplitudes and phases superpose. Explain what the expected motion is if the situation is observed for a certain length of time?
20. Two mutually perpendicular simple harmonic vibrations of slightly different frequencies and different amplitudes and phases superpose. It is found that a whole sequence of pattern of periodic motions is completed in n seconds. Explain what should be the difference in the frequencies of the two vibrations.
21. What are Lissajous' figures? When these are formed?
22. Which information we may obtain from studies of Lissajous' figures?
23. How Lissajous' figures can be demonstrated very easily by Cathode Ray Oscilloscope?
24. Suppose two mutually perpendicular simple harmonic vibration having frequency ratio 1/2. Find the natures of the Lissajous' figures when the phase difference between them is 0, $\pi/2$ and π.

WAVES MOTION – GENERAL

1. What is a harmonic wave?
2. What happens in a medium when a harmonic wave passes through it?
3. Which characteristics of a wave advances from one point to another when a wave passes through a medium?
4. What is the relation between phase velocity, frequency and wavelength of a harmonic wave? Why this velocity is called phase velocity?
5. A harmonic wave passing through a medium enters a second medium. If dissipation of energy is ignored what change, if any, takes place in the wave? Explain your answer.
6. A harmonic wave of wavelength 2 cm is passing through a medium. What is the phase difference between two particles of the medium separated by a distance of x cm?
7. Wave has two-fold periodicity. What is meant by this statement?
8. What is the change of phase of a particle in the medium in time At when a harmonic wave of time period T is passing through the medium?
9. Show that any progressive wave proceeding along positive X-axis can be represented by the general equation $y = f(x - ct)$ What would be the equation if the wave moves in the opposite direction?
10. From the general equation $y = f(x - ct)$ of a progressive wave derive the equation of a harmonic wave of angular frequency m, wavelength λ and amplitude a.
11. Equation a harmonic wave is represented by the equation: $v = a \cos(\omega t \mp kx + \varepsilon)$ Explain the significances the different terms and the signs.
12. From the general equation $y = f(x - ct)$ of a progressive wave obtain the differential equation of a wave.
13. Any wave is represented by a wave function $\psi(x,t)$. Which physical quantities it may represent for the following waves: (i) wave in a stretched string, (ii) sound wave and (iii) electromagnetic wave?
14. Derive the differential equation of a transverse wave through a stretched string and get the expression for the velocity for transverse wave through a string.
15. Derive the differential equation of a longitudinal wave through an elastic solid and get the expression for the velocity for longitudinal wave through an elastic solid.
16. Explain why longitudinal elastic wave through a solid is always greater than transverse wave.
17. Derive the differential equation of a longitudinal wave through an elastic fluid and get the expression for the velocity of the wave.
18. What is a wavefront of a wave? What is a plane wave? Explain why the equation $\psi(x,t)= a \sin(\omega t - kx)$ represents a plane wave.
19. A plane wave is advancing along the direction of the unit vector $\acute{k}$. Derive the equation of the wave from the equation $\psi(x,t)= a \sin(\omega t - kx)$. Draw a figure to represent such a wave.

20. Explain how a harmonic wave may be represented by a complex quantity? What is the advantage of writing the wave equation in this form? How we may get the intensity of the wave from its complex representation?
21. What is energy density of a wave? Calculate the energy density of a harmonic wave in terms of the characteristics of the wave and the medium.
22. Show that for a harmonic wave the average value of the kinetic energy per unit volume over a time period is equal to the same for potential energy.
23. Show that the energy of a progressive wave is equally divided between the kinetic and potential energies.
24. Draw a curve to show how total energy density of a progressive wave is distributed at different points at a particular time. How its value at a particular point varies with time?
25. Show that energy density propagates like a wave, what are its frequency and wavelength?
26. What is intensity of a wave? Derive the expression for the intensity of a harmonic wave in terms of the characteristics of the wave and the medium. Why intensity is proportional to the square of its amplitude?
27. A wave propagating in all direction in three- dimensional space is represented by the wave function $\psi(\vec{r},t)$. Show how the differential equation of one-dimensional wave may be generalized to a three-dimensional wave equation. Write down the solution of the equation.
28. What is a spherical wave? How intensity of a spherical wave changes with distance from the source?
29. Write down the differential equation for a spherical wave and the general solution of the equation. Explain from the solution how amplitude and intensity of such a wave change with distance.
30. Why the differential equation of a wave is called linear? Explain the most important consequence of this fact.
31. State the principle of superposition of waves.
32. In which condition a stationary wave is formed in a medium and why it is called stationary wave?
33. Explain the formation of nodes and antinodes at regular intervals in a stationary wave.
34. Explain that in a stationary wave energy is fully kinetic and fully potential at regular interval.
35. What are the phases of vibration of the particles (1) in between two nodes and (ii) on the two sides of a node?
36. Show that at the instant stationary wave has only kinetic energy, the strain in the medium is zero.
37. At the instant stationary wave has only potential energy, show that the strain in the medium is zero at the antinodes and maximum at the nodes.
38. A stretched string is fixed at its two ends. Show that the string can vibrate only in a large number of distinct discrete modes and in no others. Find the frequencies of these modes. Also discuss the factors which the frequencies depend upon.
39. Find the frequencies of the normal modes of vibration of a stretched string fixed at its two ends. How do the amplitudes of these modes change?

40. A stretched string fixed at its two ends is thrown into vibration by plucking or striking at some point. How is the vibration affected by the point chosen for plucking or striking? Is there any effect if the vibrating string is touched momentarily at a point?
41. A stretched string fixed at its two ends is thrown into vibration by plucking at a point and then touched momentarily at the same point. What should happen?
42. A stretched string is fixed at its two ends. Starting from the differential equation of the transverse wave in a stretched string, obtain the equation representing the different modes of vibration for the string.
43. Starting from the equation of a harmonic wave $\psi\ a\ cos\ (\omega t - kx)$, prove that phase velocity of the wave is $v_{p=\frac{\omega}{k}}$.
44. Explain why harmonic wave is an ideal concept. What is a real wave?
45. Why a real wave cannot have a single frequency or wavelength?
46. A wave train or wave packet has many frequencies within a certain range. Justify the statement.
47. What are meant by group velocity and phase velocities of a wave train?
48. Why group velocity is especially important in optics?
49. Write down the relation between phase velocity and group velocity of a wave train.
50. When a medium is called non-dispersive, dispersive and anomalously dispersive? What are the values of phase velocities relative to group velocities in these three kinds of media?
51. Considering the superposition of two harmonic waves of slightly different frequencies, find the relation between group velocity and phase velocity.
52. When is a medium of a wave called non- dispersive? Give examples. What is relation between the phase velocity and group velocity for such a medium?
53. Explain why in some media shape of a wave packet does not change and in some other media it does change?

SOUND

1. In which condition a body is capable of vibrating? In which condition is vibration called free vibration? How the frequency of such a vibration depends on different factors. What is name of this frequency?
2. When a vibration is called linearly damped vibration? Write down its differential equation of such a vibration, explaining the meanings of the different symbols. Write down its solution when damping is small and explain the nature of the motion
3. Draw the displacement-time curve of a particle for a linearly damped vibration when damping is small and compare it with that of a free vibration.
4. Explain how damping force influences the nature of vibration of a body.
5. Describe the behavior of a body when it is displaced from its equilibrium position and then released, if it is (i) critically damped and (ii) overdamped. Draw displacement-time curves for these two types of motion.
6. For a linearly damped body show that the energy of vibration decreases at higher rate than its displacement when damping is small. What is time constant of damped system?
7. (i). What is quality factor of a damped system? Which factors it depends upon?
   (ii) 'Lesser quality factor means greater loss in energy per cycle.' Justify the statement.
8. A simple harmonic force begins to act on a body which is capable of vibrating and having small damping. Describe in detail what is observed over a long time.
9. A simple harmonic force begins to act on a body capable of vibrating and having small damping. Write down the differential equation of vibration of the body explaining the meaning of the different terms. Write down the general solution of the equation. Explain what this solution predicts about the nature of vibration of the body.
10. Which factors amplitude of steady forced vibration of a body depends upon?
11. With the help of a suitable curve explain how the amplitude of vibration of a body changes when the frequency of the forcing system increases from a low value and surpasses the natural frequency of vibration of a body.Also show how damping force present does influence during this process?
12. Suppose frequency of the periodic force is exactly equal to the natural frequency of the body. How does the body respond? What is the phase difference between the vibration of the body and the applied periodic force in this condition?
13. What are energy resonance and amplitude resonance and in which conditions these two occur? Which of them is more significant?
14. Calculate the average power supplied by the forcing system d2uring the forced vibration of a body and its maximum value.
15. When resonance of a forced vibration is called sharp and when it is called flat? How damping force affects the sharpness of resonance?
16. Define: half-power frequency, band width and sharpness of resonance of a forced system.
17. Which factors sharpness of resonance of a body undergoing forced vibration depends upon?

18. Derive the relations: $Q = \frac{1}{2b}\sqrt{\frac{k}{m}}$ and $\omega_1\,\omega_2 = \omega^2$. Where is called sharpness of resonance and co is the natural angular frequency of body undergoing forced vibration and others have usual meaning.
19. Why sharp resonance is often a desirable property of a forced system?
20. What are half-power frequencies, band-width and quality factor of a forced system?
21. Prove that the product of two half-power frequencies is equal to the square of the resonant frequency
22. Explain how different properties of a forced system affect its quality factor?
23. State Fourier's theorem and express it in mathematical terms.
24. What is physical implication of Fourier's theorem?
25. What is Fourier analysis?
26. A square wave is described as function $f(t)$ satisfying the conditions:

    $f(t) = +a$ from $t = 0$ to $t = T/2$

    $f(t) = -a$ from $t = T/2$ to $t = T$

    Analyse the function by Fourier's theorem and express in terms of its Fourier's components.
27. A saw tooth wave is shown in Fig3.10a Expand the function into a Fourier's series.
28. (i) What is the difference between loudness and intensity of sound?

    (ii) Which factors intensity of sound depends upon?

    (iii) What are the two thresholds of intensity for human car?

    (iv) Give an approximate idea of the range of intensity of sound over which our ears can hear. Does this range depend on anything else?
29. What are tone and note?
30. What is pitch of a note? Which physical factors it depends upon?
31. What is quality or timbre of a musical sound? How quality of a sound may change without changing its pitch?
32. How loudness depends on intensity of sound? State the Weber-Fechner law. Is this law applicable to perception of sound only?
33. What is intensity level of sound? Define bel and decibel.
34. If intensity level of a sound is 1 bel, why its intensity is ten times the threshold intensity?
35. Intensity level of a sound is 1 dB. How much higher is its intensity above the threshold intensity?
36. What is the whole range of sound intensity level in dB unit?
37. Define phon. Why it is more appropriate than dB unit for loudness of sound?
38. The decibel scale is an objective measure of a sound; the phon scale is more subjective. Justify the statement.
39. Define sone. Why it is more appropriate than phon as a unit for loudness of sound?
40. What is the relation by which we may convert phon to sone and vice versa?
41. In our perception of variation of pitch of music our ears are sensitive to what?
42. Why numerical differences of frequencies are not important when we hear music?
43. What is musical interval between two notes? Why it is so important? Explain by examples.

44. When interval between the two notes is called octave? When these are said to be in unison?
45. What are consonance and dissonance in perception of musical sound?
46. When do two notes produce pleasant effect?
47. What is the reason behind the dissonance?
48. What is musical scale?
49. What is diatonic scale? Why it represents absolute harmonic perfection? What is its disadvantage?
50. What is tempered scale? What is its advantage over diatonic scale?
51. What are acoustic of building concerned with?
52. What is reverberation? Define reverberation time.
53. Explain why reverberation has both disadvantage and advantage.
54. Define absorption coefficient. Define sabin, which is regarded as perfect absorber of sound? How much a listener a room absorbs sound?
55. State Sabine formula.
56. Give a simple derivation of Sabine formula.
57. Briefly discuss the requirements for good acoustics in a hall and auditorium and how these are achieved?
58. Briefly discuss how reverberation time is measured.

NATURE OF LIGHT WAVE

1. State Huygens' principle. What is a wavefront?
2. Explain how we may get the position of a wavefront at a later time from the knowledge of its position at an earlier time.
3. What is ray of light in Huygens' principle?
4. What are the weaknesses of Huygens' principle?
5. In which condition we get spherical and plane and cylindrical wavefronts of light? How spherical and cylindrical wavefront may be converted to plane wavefront and vice versa.
6. Explain the electromagnetic nature of light wave.
7. Why electromagnetic wave is by its nature transverse wave?
8. When light propagates what really advances from one point to another? Why light is transverse wave? Which range of wavelength of electromagnetic wave is called light?
9. Light wave is represented by the equation $y = a \sin(\omega t - kx + \varepsilon)$. Explain the meaning of each symbol of this equation.
10. What is complex representation of a wave? Explain how from a complex representation we may derive the quantity of interest of the actual wave.
11. Write down the equation of a progressive wave in complex representation and derive the differential equation of the wave.
12. Which nature of wave equation is responsible for the principle of superposition of waves?
13. State the principle of superposition of waves.

INTERFERENCE

1. (a) What is meant by interference of light? What happens as a result of interference?

   (b) Considering the superposition of two light waves show that resultant intensity at a point in the region of overlapping is given by $I = I_1 + I_2, +2\sqrt{I_1 I_2}\, cos\delta$, where the symbols have their usual meaning. Which term is called the interference term? Why is so called?

   (c) Which condition is to be satisfied in order to observe sustained interference effect?

   (d) Find the conditions for maximum and minimum brightness.

2. (i) Light waves from two different sources do interfere. Then why we cannot see the interference pattern?

   (ii) What are the resultant intensities when (a) two incoherent waves superpose and (b) two coherent waves superpose?

3. (a) Which is the necessary condition to observe sustained interference pattern for light waves? How is this condition achieved?

   (b) What are coherent and incoherent waves?

   (c) How Young could obtain two coherent waves in his simple arrangement?

4. Explain how the resultant amplitude of two or more coherent waves may be found by the simple rule of vector addition?

5. (a) If two light waves derived from a single wavefront superpose, resultant amplitude at a point in the region of overlapping is $A^2 = a_1^2 + a_2^2 + 2a_1a_2, cos\delta$,

   where the symbols have their usual meanings. Starting from this relation find the following:

   (i) the positions of maxima and minima, (ii) amplitudes and intensities at these positions and (iii) visibility of the fringes. Explain the initial condition you have taken into account in getting the above results.

   (b) In which condition resultant intensity produced by superposition of two light waves is obtained by (i) adding their individual intensities, (ii) finding the vector sum of the individual amplitudes?

6. What is visibility of interference fringes? Which factors visibility depends upon? Which value of visibility is most desirable and why?

7. Intensity at a point in the region of overlapping of two coherent light waves is $I = I_1 + I_2, +2\sqrt{I_1 I_2}\, cos\delta$ where the symbols have usual meanings. Explain in which condition the fringe system is called $cos^2\theta -$ type fringes. Draw the intensity versus phase difference curve in this condition. Also show in the graph the intensity distribution we should get when the two waves are incoherent. From this curve explain that in interference of light there is only a redistribution of energy and conservation of energy is not violated.

8. In interference of light there is a redistribution of light and conservation of energy is not violated. Justify the statement with a proper energy distribution curve.

9. Give the physical reason why in the region of overlapping, where path difference = $n\lambda$, we get maximum intensity and where path difference = (n + 1/2)λ, we get minimum intensity. In which condition the rule is just reversed?
10. Describe Young's double slit arrangement and explain how coherent waves are obtained in this arrangement. Find the positions of bright and dark fringes in a particular arrangement. What is order number? What is the width of a fringe? Find its value. Why the fringes produced in the arrangement are called non-localized fringes?
11. What is the central fringe? Where is it formed? What is its importance?
12. If it can be assumed that the distance between the slits and the screen is very large compared to other distances, deduce the shape of the fringes produced in a screen in the Young's double slit arrangement. Which shape the fringes should take if the above assumptions are not valid?
13. Suppose we get straight fringes with a monochromatic light in a Young's double slit arrangement. What should we observe if light consists of two colors? What would be our observations if the light is white?
14. Light used in a particular Young's double slit arrangement consists of two colors of wavelengths λ_1, λ_2 $(\lambda_1 > \lambda_2)$ What should be the color of the central fringe? May we see other fringes of the same color as the central fringe? Explain your answer
15. What should be the interference pattern with white light in a Young's double slit arrangement?
16. A thin sheet of transparent material of thickness t and refractive index n is introduced in the path of one of the two interfering waves in Young's double slit arrangement. Find the position of the central fringe on the screen.
17. What are the two methods by which we may get sustained interference pattern? In which condition we get Haidinger fringes and Fizeau fringes?
18. Explain with diagrams why the fringes produced by the method of division of wavefront are non-localized fringes, whereas those by the method of division of amplitude are localized fringes?
19. Describe the arrangement by which we may get interference pattern by using Lloyds' single minor Why the central fringe cannot generally be observed in this arrangement? How we may observe it at a convenient position? What is the nature of the central fringe? Which conclusion we may arrive at looking at the central fringe?
20. Show how by combining the observation of the fringe system produced by Lloyd's mirror and Strokes analysis, we get an important conclusion.
21. What are achromatic fringes? Describe and explain the arrangement by we may get achromatic fringes with the help of Lloyd's mirror.
22. Calculate the maximum number of fringes that can be observed in a particular arrangement of Lloyd's single mirror.
23. Describe the arrangement by which we get interference fringes with the help of Fresnel's biprism. How the wavelength of light may be determined by this arrangement.

24. Find the maximum number of fringes that can be observed in a particular arrangement of Fresnel's biprism.
25. A ray of light is incident at angle of incidence on thin parallel transparent film of thickness / and refractive index *n*. Calculate the geometrical path differences between (i) two consecutive reflected rays and (ii) two consecutive transmitted rays from the film.
26. The geometrical path differences between (i) two consecutive reflected rays and (ii) two consecutive transmitted rays from a thin parallel transparent film of thickness t and refractive index n placed in air is $\Delta = nt \cos r$, where r is angle of refraction in the film. Find the conditions of maximum and minimum intensities for the above two cases and justify the result from by physical reasoning.
27. Explain why an extended source of light is necessary to observe or produce fringes with the help of thin parallel or wedge-shaped film.
28. Explain why visibilities of the fringes produce by thin films are generally low. How can it be improved?
29. What are Haidinger fringes? Describe the arrangements by which Haidinger fringes may be produced by (i) reflected rays and (ii) transmitted rays. Why these fringes are called fringe of equal inclination?
30. A beam of parallel rays of white light from an extended source is incident on a parallel thin film What should we expect to see when we look at the film? What would happen if we slowly change the thickness of the thin film?
31. Explain the actions and uses of (i) Anti-reflection coating and (ii) High-reflection film.
32. A ray of light is incident at angle of incidence i on thin wedge-shaped transparent film of refractive index n placed in air. Calculate the geometrical path differences between two consecutive reflected rays. Find the conditions of maximum and minimum intensities. Why these are called localized fringes? Why these fringes are called fringes of equal thickness?
33. What are Fizeau fringes? Describe a simple arrangement to produce Fizeau fringes. State some of its characteristics.
34. Explain why we may see brilliant colors when white light from a broad source of light is incident on a wedge-shaped thin film. Mention some common examples where we can see such colored fringes.
35. Monochromatic light from a broad source fall on a thin wedge-shaped film. Explain what should we observe if the film is perfectly plane and if it is not so.
36. Describe a simple arrangement to produce Newton's ring.
    (a) Explain why concentric circular bright and dark rings are formed.
    (b) Find the conditions for formation of bright and dark rings.
    (c) Explain why dark spot is produced at the center.
    (d) Explain how order numbers of the fringes changes as go from the central dark spot.
    (e) Explain why we are not sure about the order number of the central spot.
    (f) Find the relation between radii of these rings and wavelength of light.
    (g) Show that in a particular condition the radii of the dark rings are proportional to the square root of natural numbers.

(h) What should we expect to observe if white light is used?

37. In a Newton's ring arrangement, a transparent liquid is kept in the space between the lens and the plate. Find the conditions for the formations of bright and dark rings. Show that in this case the rings become a little shorter.
38. Describe how wavelength of a monochromatic source of light may be determined with the help of Newton's ring arrangement.
39. Describe how refractive index of a liquid may be determined with the help of Newton's ring arrangement.
40. Explain how central spot of Newton's ring may be made bright.
41. Explain: (i) Why only a sinusoidal or harmonic wave can have a definite wavelength?

    (ii) Why strictly monochromatic light wave is an ideal concept?

    (iii) Draw time-displacement curve for a real monochromatic light wave from an ordinary source of light to show its difference with a sinusoidal wave.

    (iv) Why light wave from two different point sources of light can never produce sustained interference pattern?
42. What are coherence length and coherence time?
43. Coherence length of a highly monochromatic light is very long. Justify the statement.
44. Explain what happens to the visibility of the fringe pattern when the path difference between two superposing waves in Young's apparatus is slowly increased from a very small value.
45. What is meant by quasi-monochromatic light? What are its line width and frequency width? What are the relations between frequency width and coherence time and between line width and coherence length?
46. Explain with the help of a suitable figure why finite size of the source in a particular Young's double slit arrangement has important effect on the quality of the interference pattern. Now find the size of the source for which the fringe would disappear. What should be size of the source to get fringes of good visibility?
47. Describe Michelson interferometer and explain how interference fringes are formed. Find the condition for bright and dark fringes.
48. For a Michelson interferometer arrangement, using a monochromatic light, answer the following:

    a) Explain the action of the compensating plate.

    (b) Explain why compensating plate is not necessary for a monochromatic light but it is necessary for polychromatic light.

    (c) In which condition we see fringes of equal inclination?

    (d) In which condition we can soc fringes of equal thickness?

    (e) In which condition we can see the whole field of view as uniformly dark?

    (f) If concentric circular fringes are formed and we move the movable mirror away from and towards the beam splitter, what should we see at the centre?

(g) If we go on moving the movable mirror away from its normal position what gradual change. should we observe in the fringe system and why?

(h) If a thin transparent film is introduced in any one path of the light from beam splitter to the mirror, what happens to the fringe system?

(i) Why the central spot of circular fringes is dark?

49. Explain how we may determine the coherence length of a given light with the help of Michelson interferometer.
50. Explain how we may determine the refractive index of a thin transparent sheet with the help of Michelson interferometer.
51. Explain how we may determine the coherence length of a given light with the help of Michelson interferometer.

DIFFRACTION

1. What is diffraction of light?
2. Diffraction of light is the violation of the principle of rectilinear propagation of light. Justify the statement.
3. Why diffraction of light cannot be seen in ordinary circumstances?
4. How Huygens-Fresnel wave theory can explain the phenomenon of diffraction of light?
5. Explain why there should always be some illumination in the geometrical shadow region.
6. What is the difference between interference and diffraction?
7. Explain why on the basis of Huygens-Fresnel wave theory intensity at any point behind an opaque object is expected to be different from normal intensity?
8. What are Fresnel and Fraunhofer diffraction? Explain how Fraunhofer diffraction is realized in practice.
9. Draw the experimental arrangement required to produce Fraunhofer diffraction of a monochromatic light in a single slit. Explain the mechanism which produces variation of intensity on the screen. Draw suitable diagram to illustrate the variation of intensity in the diffraction pattern
10. Intensity pattern due to Fraunhofer diffraction of monochromatic light in a single slit is given by, $I(\theta) = A^2 a^2 \frac{\sin^2 X}{X^2}, X = \frac{\pi a \sin \theta}{\lambda}, A$ is the amplitude at a point on the screen per unit width of the slit and a is the width of the slit. From this relation answer the following:

    (a) Find the positions and values of principal maximum, minima and secondary maxima. Do the secondary maxima occur at the mid-way between two adjacent minima?

    (b) Find angular spread or breadth of the central band.

    (c) Find the Linear width of the central band on the screen. What happens if white light is used?

    (d) Show that *most of the light energy* is concentrated in the central diffraction band.

    (e) What happens if the width of the slit is slowly increased and decreased?

    (f) Explain why it is claimed that diffraction of light is observable and significant when the size of an obstacle or aperture is comparable to the wavelength.
11. Calculate the intensity of light produced on the screen by Fraunhofer diffraction of light incident normally at a single slit at a particular angle with the forward direction.
12. Explain what happens when light in the form of a plane wavefront strikes two thin slits normally which produces the pattern of intensity on the screen in Fraunhofer diffraction arrangement?
13. Intensity pattern due to Fraunhofer diffraction of monochromatic light in a double slit in a direction making angle θ with the forward direction is given by $I_P = 4A^2 a^2 \frac{\sin^2 X}{X^2} \cos^2 \gamma$, where $X = \frac{\pi a \sin \theta}{\lambda}, \gamma = \frac{kd}{2}, d = a + b, k = \frac{2\pi}{\lambda} \sin \theta$ and A is the amplitude at a point on the screen per unit width of the slit, *a* is width of the slit and *b* is the width of the opaque space between the slits. From this relation answer the following.

(a) Explain why the expression contains the term of diffraction pattern due to a single slit and another additional term?

(b) From this expression obtain the expression for intensity in Young's double slit interference pattern. Compare the essential difference between the two patterns.

(c) Find the intensity and position of the most intense maximum fringe. Find the intensities and the positions of other maxima. Why these positions are approximate?

(d) Why there are two sets of minimum intensities? Find their values.

(e) Explain why several interference maxima may occur within the central diffraction band?

(f) What are missing orders? How their positions can be predicted for a particular double-slit arrangement?

14. Draw suitable graphs to illustrate how the combined effect of the diffraction and interference produce the final intensity pattern in a double-slit arrangement.

15. Deduce the expression describing the intensity pattern produced in a double slit Fraunhofer arrangement.

16. Show that the number of bright fringes seen under the central diffraction band in a Fraunhofer double-slit pattern is given by $2\frac{d}{a}$ - 1, where d and a are the separation and width of slits.

17. Show that in the double-slit Fraunhofer patter the ratio of widths of the central diffraction band to the central interference fringe is independent of wavelength of the light.

18. A plane wave of monochromatic light is incident normally on N identical slits, each of thickness a and separated by opaque space of width b. The intensity pattern produced in a Fraunhofer arrangement in a direction making angle 8 is given by $I(\theta) = A^2a^2\frac{\sin^2 X}{X^2}\frac{\sin^2 N\gamma}{\sin^2 \gamma}$, where $X = \frac{\pi a \sin\theta}{\lambda}, \gamma = \frac{\pi d \sin\theta}{\lambda}, d = a + b$ and A is the amplitude at a point on the screen per unit width of the slit. From this relation answer the following.

(i) Explain what happens when the light is incident on the slits and which term corresponds to which phenomenon.

(ii) Obtain the intensity patterns for a single slit and for double-slit from this.

(iii) Find the conditions for maximum and minimum intensities which follow from this expression.

(iv) Find the intensities of the principal maxima, minima and secondary maxima and their respective directions. Compare the intensities of the two kinds of maxima.

(v) What is the direction of the most intense principal maximum? Why and how do the intensities of other principal maxima change?

(vi) Explain why only the first order spectrum is possible in a grating if the grating element is less than twice the wavelength of the light used.

(vii) Derive the above expression from the Huygens-Fresnel theory of light waves.

19. A plane wave of monochromatic light is incident normally on N identical slits, each of thickness a and separated by an opaque space of width b. Write down the directions of principal maxima and minima.

Now explain how many minima and secondary maxima should be formed between two consecutive principal maxima.

20. Explain in which condition some principal maxima in the intensity pattern produced by a grating in Fraunhofer diffraction arrangement can be missing. Find the order number of such missing lines in terms of width (a) of the slits and separation (d) between the slits.
21. Draw a suitable graph showing the variation of intensity produced in Fraunhofer diffraction arrangement with 6 identical slits, width of each slit is a and separation between two slits is d and $a = \frac{1}{3} d$.
22. Find the angular half width of the nth order principal maxima in the diffraction pattern of a grating and explain in which condition the lines become sharper.
23. Explain (i) why green lines are sharper than red lines in grating spectra, (ii) why all lines become sharper, when a grating of wider width is used.
24. What is a diffraction grating? About how many lines may be there in a grating?
25. You have Fraunhofer diffraction arrangement with a grating using a monochromatic light. Explain how the wavelength of light used may be determined.
26. Polychromatic light is used in Fraunhofer diffraction arrangement with a grating. Explain why dispersion occurs in all directions except one. What are angular dispersion or dispersive power and linear dispersion? Find their magnitudes.
27. Describe the spectra produced by a grating when white light is used. Compare this spectra with that produced by a prism.
28. What is grating spectra? When a spectrum is called normal? For grating spectra justify: (i) For small angle with the forward direction grating spectra is normal, (ii) For large angle with the forward direction it is not normal, (s) Angular dispersion is proportional to order number, (iv) Angular separation between two lines increases if the number of lines per centimeter increases.
29. Explain how overlapping of spectral lines is possible in a grating spectra.
30. Explain the physical meaning of chromatic resolving power of a grating and its exact definition.
31. Why a grating must have a high chromatic resolving power in order to study spectra emitted by different substances?
32. What is Rayleigh's criterion of resolution of two spectral lines? Explain your answer with suitable curves.
33. Derive the expression for resolving power of a grating from Rayleigh's criterion.
34. Which factors resolving power of a grating depends upon?
35. If two lines are not resolved at a particular order, then what are the two choices before you to get the two lines resolved?
36. In an experiment with a polychromatic light the diffraction grating is replaced by another with a broader width. How the observation will change?

37. What is Huygens-Fresnel's wave theory? Explain how the obliquity factor introduced in theory could explain the problem of back wave.
38. (i) Explain how a plane wavefront may be imagined to be divided into a half-period zones with respect to a chosen point of observation. Why these zones are so called?

    (ii) Suppose a plane wavefront of light have been mentally divided into half-period zones with reference to a point of observation. Explain clearly what should be the expected intensity of light produced at that point.

    (iii) Explain how rectilinear propagation of light can be justified as an approximate law by dividing a plane wavefront mentally into half-period zones.

    (iv) Explain how considering a wavefront to be composed of half-period zones, violation of rectangular propagation can be predicted.

    (v) A plane wavefront falls normally on an opaque circular disc. On long exposure we find a bright spot at the center of the geometrical shadow region. Explain this observation with the help of idea of Fresnel's half-period zones.
39. (i) How a zone plate is constructed?

    (ii) Explain how a zone plate can act as a converging lens. What is its primary focal length? How its value depends on the wavelength of light?

    (iii) Explain how a zone plate can act as a lens having multiple foci. Find the values of the focal lengths. How the Intensity of the image changes for the different focal lengths?

    (iv) Can the action of a zone plate be compared to that of diffraction grating?
40. Compare a zone plate with a convex lens.
41. Explain qualitatively the expected diffraction pattern due to (i) straight edge, (ii) single slit and (ii) wire. Draw curves to show the variation of intensity in each case.
42. Explain why diffraction of light affect the formation of image by all optical instruments and this fact puts ultimate limit to the sharpness of the image so formed.
43. (i) What are Airy pattern, Airy disc and Airy rings?

    (ii) When images of two point objects are said to be just resolved according to Rayleigh's criterion?
44. What is meant by resolving power of an optical instrument? Find the expressions for resolution limit or resolving power of a telescope and microscope.
45. Find the necessary magnifying power of a microscope? What is called empty magnification?
46. Explain how resolution limit of a microscope is increased (i) in oil-immersion microscopy and (ii) ultra-microscope?
47. What is the resolution limit of human eye?
48. Describe how we may find three distinct regions of behavior of light when we place a narrow slit before parallel beam on monochromatic light with a screen behind the slit.

POLARIZATION

1. Why light wave or any electromagnetic wave is by its very nature transverse wave?
2. An electromagnetic wave of angular frequency and wave number k is proceeding along z-axis It is linearly polarized in the x-direction. Write down the equations representing the advancing electric and magnetic fields.
3. (i) Why sound wave cannot be polarized?
   (ii) Why natural light is said to be unpolarized?
4. What is the exact difference between unpolarized and linearly polarized lights?
5. Why our eyes cannot distinguish between unpolarized and linearly polarized light?
6. What is the plane of vibration of a linearly polarized light?
7. Explain why and how unpolarized light may be regarded as composed of two plane polarized lights.
8. Explain the situation of the electric field vector of light wave advancing along z-axis for the following cases: (i) unpolarized light, (ii) plane polarized light, (iii) elliptically polarized light, (iv) circularly polarized light.
9. What is partially polarized light? Define degree of polarization of a partially polarized light. What are the extreme values of this?
10. (i) What is a polarizer? You look at an ordinary source of light and then place a polarizer in front of your eye. What would be the immediate change, if any, in your observation? What would you see if the polarizer is rotated about the direction of light? Explain your answer.
    (ii) When a polarizer is called analyzer?
11. (i) Explain how you may determine the plane of vibration of a plane polarized light with the help of a polarizer
    (ii) When two polarizers are said to be crossed?
12. Suppose there is a light which may be unpolarized, plane polarized or partially polarized. Explain how you can confirm its nature with the help of a polarizer.
13. A plane polarized light is incident normally on a polarizer. The polarizer is now rotated about the direction of the light. Derive the relation between the intensity of the transmitted light and the angle of rotation.
14. State Malus' law and express it graphically.
15. (i) State Brewster's law. Explain how the law can be justified from physical reasoning.
16. A ray of unpolarized light is incident on a parallel slab at the polarizing angle. What are the states of polarization of the reflected waves and the transmitted waves?
17. You are given a piece of black glass plate in which the refracted light cannot be seen. How can you measure the refractive index of the glass
18. When light ray passing through a medium enters into medium 2, polarization angle is θ. Explain what should be the polarizing angle when light enters into medium 2 from medium 1?

19. (i) Supposed there is large number of identical parallel plates placed one after another and unpolarized light is incident at the polarizing angle for the material on the first plate. Explain how the state of polarization of the reflected wave and the transmitted wave changes as it traverses through the plates.
(ii) Explain with suitable diagrams how a pile of plates may be used as analyzer and polarizer.
20. What is double refraction or birefringence? Name two materials which have this property. What is the cause of such a property?
21. What are ordinary and extra-ordinary ray in a double refracting uniaxial crystal? What are their relative states of polarization?
22. (i) Define optic axis of calcite crystal with a suitable diagram. Is it true that optic axis may be drawn through any point in a crystal? Explain your answer.
(ii) Define ordinary and extraordinary refractive indices of a double refracting crystal.
23. In which directions in a double refracting uniaxial crystal waves corresponding to O-ray and E-ray move in the same direction with (i) the same speed (ii) different speeds?
24. What are e principal section and the two principal planes in a double refracting uniaxial crystal? When the two principal planes coincide?
25. What are the directions of polarization of the light rays passing through refracting crystal with respect to the optic axis a uniaxial double of crystal?
26. Draw a simple diagram of a Nicol prism and explain how we produce a plane polarized light from an unpolarized light.
27. Explain why the intensity of the polarized light obtained by a Nicol prism cannot be greater than half of the intensity of unpolarized light.
28. What is Dichroism? Where is widely used?
29. Explain in a simple way how light is polarized by scattering. What is the most common example of such phenomena?
30. Circularly polarized and elliptically polarized light waves are advancing along z-axis. Explain with simple diagrams how the electric field vector changes with time at a particular position z, in the two cases. Also indicate when these are called left-handed polarized and right-handed polarized.
31. In which conditions superposition of linearly polarized light waves produce (i) circularly polarized ware and (ii) elliptically polarized wave Explain why the two superposing waves should be coherent.
32. In which conditions superposition of two linearly polarized light waves produce linearly polarized waves.
33. Prove that superposition of two coherent linearly polarized light waves produces, in general, elliptically polarized wave. Now show in which conditions the resultant wave is (i) linearly polarized, (ii) circularly polarized and (iii) elliptically polarized light whose major and minor axes have special directions.
34. Explain how elliptically polarized and circularly polarized wave can be distinguished with the help of a polarizer.

35. Explain why there is similarity of observation when unpolarized wave and circularly polarized wave are passed through a polarizer, but still there is a subtle difference.
36. What are retarding plates? Find the required thicknesses of quarter-wave plate and half-ware plate.
37. Explain the three basic uses of quarter-wave plate.
38. Explain how half-wave plate can be used to change the plane of vibration of a linearly polarized wave by some chosen angle.
39. Explain how you may confirm the exact nature of the polarization state of a light, if it is in any of the following states: (1) Unpolarized light, (2) linearly polarized light, (3) elliptically polarized light (4) circularly polarized light, (5) mixture of unpolarized and linearly polarized light, (6) mixture of unpolarized and elliptically polarized light, (7) mixture of unpolarized and circularly polarized light.
40. Light in unknown state of polarization is analyzed with a polarizer and a quarter wave plate (QWP) and following two observations are found. Deduce the nature of the light in the two cases:

    (a) When the polarizer is rotated about the path of the light there is no intensity variation. With a QWP in front of the rotating polarizer (coming first), one finds a variation in intensity but no angular position of the polarizer gives zero intensity.

    (b) When a polarizer rotated about the path of the light, there is some intensity variation but no position of the polarizer giving zero intensity. The polarizer is set to give maximum intensity. A QWP is allowed to intercept the beam first with its optic axis parallel to the transmission axis of the polarizer Rotation of the polarizer now can produce zero intensity

    [Ans. (a) mixture of unpolarized and circularly polarized light. (b) elliptically polarized light]
41. Plane polarized light is incident normally on a quarter wave plate. Determine the nature of the emergent light in each case, when the vibrations of the incident light make angle 0°, 30°, 45° and 90°. [Ans. plane, elliptically, circularly and plane polarized light]
42. What is optical activity of substance? When a substance is called dextro-rotatory and laevo- rotatory?
43. Give examples where (i) a substance is optically active in their solid states only and not so in liquid states or in their solutions, (ii) a substance can occur in two different varieties one exhibiting dextro-rotatory and other exhibiting laevo- rotatory properties, (iii) a substance is optically active in both solid state and in liquid state or in their solutions, (iv) a substance showing optical activity only in their solutions and (v) pure liquids show optically.

    Mention the causes of the properties in the above different kinds of substances
44. Which factors the angle of rotation due to optical activity depends upon?
45. Define specific rotation for different optically active substances.
46. Explain in a simple way how angle of rotation produced by an optically active substance can be measured with the help of a polarizer and an analyzer. But why this method is found to be not so simple.
47. Describe Laurent's half-shade polarimeter and how it is used.
48. Explain the theory utilized in Laurent's half shade polarimeter.

49. What is polarimeter? What are the wide areas in which it is very useful?
50. Describe a biquartz polarimeter and how it is used.
51. Explain the theory utilized in biquartz polarimeter.