Physics

Syllabus

Teaching hours: 150T + 50P
Nature of course: Theory + Practical

Full marks: 100 (75T + 25 P)
Pass Marks: 27T + 8P

Course Contents

Unit 1: Mechanics — 70 teaching hours

1. **Physical Quantities–** Need for measurements; System of units; S.I. unit; Precision and significant figures; Dimensions; Main uses of dimensional equations. [3 hrs]
2. **Vectors–** Graphical presentation of vectors; Addition and subtraction of vectors: Parallelogram, Triangle and polygon laws of vectors; Resolution of vectors; Unit vectors; Scalar and vector products [6 hrs]
3. **Kinematics–** Uniform and non-uniform motion; Average velocity and acceleration, Instantaneous velocity and acceleration; Equation of motion (graphical treatment); Motion of a freely falling body; Relative velocity; Projectile motion [3 hrs]
4. **Laws of Motion–** Newton's laws of motion; Inertia, Force, Linear momentum, Impulse, Conservation of linear momentum; Free-body diagrams; Solid frictions: Laws of solid friction and their verifications; Application of Newton's laws: Particles in equilibrium, Dynamics of particles. [8 hrs]
5. **Work and Energy–** Work; work done by a constant force and a variable force; Power; Energy: Kinetic energy; Work - energy theorem, Potential energy; Conservation of energy; Conservative and non-conservative forces; Elastic and inelastic collision. [4 hrs]
6. **Circular Motion–** Angular displacement, Velocity and acceleration, Relation between angular and linear velocity and acceleration; Centripetal acceleration; Centripetal force; Conical pendulum; Motion in a vertical circle; Motion of cars and cyclist round a banked track. [5 hrs]
7. **Gravitation–** Newton's laws of gravitation; acceleration due to gravity; g; Mass and weight; Gravitational field strength, Variation in value of 'g' due to altitude, Depth and rotation of earth; Weightlessness; Motion of a satellites: Orbital velocity, height and time period of a satellite, Geostationary satellite, Potential and kinetic energy of a satellite; Gravitational potential: Gravitational potential energy; Escape velocity; Black holes. [9 hrs]
8. **Equilibrium–** Moment of forces; Torque; Torque due to a couple; Center of mass; Center of gravity; Conditions of equilibrium. [2 hrs]
9. **Rotational Dynamics–** Rotation of rigid bodies; Equation of angular motion; Relation between linear and angular kinematics; Kinetic energy of rotation of rigid bodies; Moment of inertia: Radius of gyration, Moment of inertia of a uniform rod; Torque and angular acceleration for a rigid body; Work and power in rotational motion; Angular momentum; Conservation of angular momentum. [8 hrs]
10. **Elasticity–** Hooke's law: Force constant, Verification of Hooke's law; Stress; Strain; Elasticity and plasticity; Elastic modulus: Young modulus and its determination, Bulk modulus, Shear modulus, Poisson's ratio, Elastic potential energy. [6 hrs]
11. **Periodic Motion–** Oscillatory motion; Circle of reference; Equation of Simple Harmonic Motion (SHM); Energy in SHM; Application of SHM; Simple pendulum; Damped oscillation; Forced oscillation and resonance. [6 hrs]
12. **Fluid Mechanics–** Fluid statics: Density; Pressure in a fluid; Archimedes Principle; Buoyancy surface tension: Molecular theory of surface tension; Surface energy; Angle of contact and capillarity; Measurement of coefficient of surface tension by capillary tube method.
    Fluid dynamics: Newton's formula for viscosity in a liquid; Coefficient of viscosity; Laminar and turbulent flow; Poiseuille's formula (method of dimensions); Stokes law and its applications; Measurement of viscosity of viscous liquid; Equation of continuity; Bernoulli's equation and its applications. [10 hrs]

Unit 2: Heat and Thermodynamics — 40 teaching hours

1. **Heat and Temperature–** Concept of temperature; Thermal equilibrium, Thermal expansion: linear expansion, cubical expansions and their relation: Measurement of linear expansivity, Liquid Expansion: Absolute and apparent expansion of liquid, Measurement of absolute expansivity by Dulong and Petit method. [5 hrs]
2. **Quantity of Heat –** Heat capacity and specific heat capacity; Newton's law of cooling; Measurement of specific heat capacity of solids by the method of mixture and of liquids by the method cooling.
   Change of phases: Latent heat; Specific latent heat of fusion, and vaporization and their measurements by the method of mixture. [5 hrs]
3. **Thermal Properties of Matter –** Equation of state: Ideal gas equation; P-V diagram; Molecular properties of matter; Kinetic - molecular model of an ideal gas: Derivation of pressure exerted by gas, Average translational kinetic energy of a gas molecule: Boltzman constant, Root mean square speed; Heat capacities; Heat capacities of gases and solids. [8 hrs]
4. **Hygrometry –** Saturated and unsaturated vapor pressure; Behavior of saturated vapor; Boiling point; Triple point and critical point; Dew point, Absolute humidity; Relative humidity and its determination. [3 hrs]
5. **Transfer of heat –** Conduction, Thermal conductivity and its determination by Searle's method; Convection: convective coefficient Radiation: Ideal radiator; Black body radiation; Stefan-Boltzmann law [4 hrs]
6. **First law of thermodynamics –** Thermodynamic systems; Work done during volume change, Heat and work; Internal energy and First law of thermodynamics; Thermodynamic processes: Adiabatic, Isochoric, Isothermal, Isobaric processes; Heat capacities of ideal gas at constant pressure and volume and relation between them; Isothermal and Adiabatic processes for ideal gas. [9 hrs]

7. **Second law of thermodynamics-** Direction of Thermodynamic processes; Second law of thermodynamics; Heat engines; Internal combustion engines: Otto Cycle, Diesel cycle; Carnot cycle; Kelvin temperature scale; Refrigerators; Entropy and disorder (introduction only) [6 hrs]

Unit 3: Geometric Optics — 20 teaching hours

1. **Photometry, Reflection at curved mirrors-** Convex and concave mirrors; Image in Spherical mirrors, Mirrors formula; Real and Virtual images. [2 hrs]
2. **Refraction at plane surfaces-** Laws of refraction: Refractive index; Relation between refractive indices; Lateral shift; Total internal reflection and its applications; critical angle; optical fiber. [3 hrs]
3. **Refraction through prisms-** Minimum deviation; Relation between Angle of prism, minimum deviation and refractive index; Deviation in small angle prism. [3 hrs]
4. **Lenses-** Spherical lenses; thin lens formula; Lens maker's formula; Power of a lens; Combination of thin lenses in contact. [4 hrs]
5. **Dispersion-** Spectrum; Spectrometer; Pure spectrum; Dispersive power; Achromatic lenses; Condition for achromatic lenses in contact, Chromatic aberration Spherical aberration; Scattering of light-blue color of the sky. [3 hrs]
6. **Optical instruments-** The human eye; Defects of vision and their correction; Visual angle; Angular magnification; Magnifier; Camera; Compound microscope, Astronomical Telescope (reflection and refractive type) [5 hrs]

Unit 4: Electrostatics — 20 teaching hours

1. **Electrostatics-** Electric charge: Electric charges; Conductors and insulators; Charging by induction, Coulomb's law- Force between two point charges, Force between multiple electric charges. [3 hrs]
2. **Electric field-** Electric fields; Calculation of electric field due to point charges; Field lines. Gauss Law: Electric Flux; Gauss Law and its application: Field of a charged sphere, line charge, plane sheet of charge. [7 hrs]
3. **Potential-** Potential and potential difference, Potential due to a point charge; Equipotential lines and surfaces; Potential gradient; Potential energy, Electron volt. [3 hrs]
4. **Capacitance and dielectrics-** Capacitance and capacitor; Charging and discharging of capacitor through a resistor; Parallel plate capacitor; Combination of capacitors; Energy of charged capacitor; Effect of a dielectric; Molecular theory of induced charges; Polarization and displacement. [7 hrs]

A student will perform 20 experiments and 4 activities from the given list: General instruction: Students are expected to learn general ideas of errors, order of accuracy and graphical analysis.

List of Experiments

A. Mechanics

1. Use of Vernier calipers:
   a. Determination of the length, the internal and external diameter of a given tube and calculation of its volume and density.
   b. Determination of the volume and density of a given rectangular block and verification of the results using a graduated cylinder.
   c. Determination of the internal diameter, depth and volume of a beaker or calorimeter.
2. Use of Spherometer:
   a. Determination of the thickness of a given rectangular thin glass plate and calculation of its area using a graduated cylinder.
   b. Determination of the radii of curvatures of a watch glass.
   c. Determination of the focal length of a spherical mirror
3. Use of Screw gauge:
   a. Determination of the diameter of a tube (or of a rod) and a small spherical bob and calculation of their densities.
   b. Determination of the length, volume and density of a tangle of wire.
4. Determination of the coefficient of friction for the two surfaces by (i) the horizontal plane method and (ii) an inclined plane method.
5. Verification of the principle of moments and the determination of a mass of a given body
6. Use of Simple pendulum:
   a. Determination of the length of a seconds pendulum and the value of 'g' in the laboratory.
   b. Verification of law of length and determination of the value of 'g' in the laboratory by log- log plot of lime period versus length of the pendulum
7. Verification of Archimedes' Principle and determination of the specific gravity of a solid heavier than and insoluble in water
8. Determination of the specific gravity of
   a. A liquid
   b. A solid lighter than and insoluble in water
   c. A solid heavier than and soluble in water
9. Use of Boyle's law apparatus:
   a. Verification of Boyle's Law
   b. Determination of the atmospheric pressure in the laboratory without reading a barometer and verification of the result by reading a barometer.

10. Use of Young's modulus apparatus
    a. Verification of Hooke's Law
    b. Determination of Young's modulus of elasticity of the material of a given wire
11. Determination of the surface tension of water by capillary tube method
12. Determination of the coefficient of viscosity of liquid by Stoke's method

B. Heat

13. Calibration of a given thermometer and determination of the correct temperature of tap water.
14. Use of Pullinger's apparatus
    Determination of the linear and cubical expansivity of a rod
15. Use of Regnault's apparatus:
    a. Determination of the specific heat capacity of a solid by the method of mixture.
    b. Determination of the specific heat capacity of a liquid by the method of mixture.
16. Determination of the specific heat capacity of a liquid by the method of cooling.
17. Determination of latent heat of fusion of ice.
18. Determination of latent heat of vaporization of water.
19. Determination of the melting point of a solid by
    a. Cooling curve method
    b. Capillary tube method
20. Determination of the thermal conductivity of a good conductor by Searle's method.

C. Geometrical Optics

21. Reflection of light:
    a. Verification of the laws of reflection of light.
    b. Verification of the law of rotation of light.
22. Use of rectangular glass slab:
    a. Verification of the laws of refraction of light.
    b. Study of the variation of lateral shift with angle of incidence and determination of the thickness of the slab.
23. Use of Travelling Microscope:
    Determination of the refractive index of glass slab
24. Determination of the refractive index of a prism by (i) symmetry method.(ii) I-D curve method.
25. Determination of the focal length of
    a. A concave mirror.
    b. A convex mirror
26. Determination of the focal length of
    a. A convex lens by double pin method
    b. A convex lens by displacement method
27. Determination of the focal length of a concave lens by using convex lens
28. Determination of the refractive index of the material of a plano- convex lens

List of Activities

1. To study the variation in the range of a jet of water with angle of projection
2. To study the effect of detergent on surface tension by observing the capillary rise
3. To study the factors affecting the rate of loss of heat of a liquid
4. To study the nature and size of the image formed by a convex lens using a candle and a screen.
5. To study the conservation of energy of a ball rolling on inclined plane.

Note: The above are only the specimens of activities. In order to arouse creativity, the students must be encouraged to take up new activities (other than mentioned above) in consultation with the teacher concerned.

Evaluation Scheme (Theory)

Unit	Teaching Hours	LAQ	SAQ	Numerical Problem	Mark Distribution			Total
					LAQ	SAQ	Numerical Problems	
Mechanics	70	3/4	5/7	3/4	5+5+4	2×5=10	5+3+3	35
Heat and Thermodynamics	40	2/3	3/4	2/2	4+4	2×3=6	3+3	20
Geometrical Optics	20	1/2	1/2	1/1	4	2	4	10
Electrostatistics	20	1/2	1/2	1/1	4	2	4	10
Total	150	7/11	10/15	7/8	30	20	25	75

Note: LAQ: Long answer Questions **SAQ:** Short answer Questions

a. Q. No. 1, 5, 8 and 10, the first questions of group A, B, C and D respectively should contain 7, 4, 2 and 2 conceptual questions each carrying 2 marks, out of which students should give answers as indicated in the table.
b. In the table numerator denotes the number of questions to be attempted and denominator denotes the number of questions asked. For example, 3/4 means 3 questions are to be answered out of 4 questions.
c. Short answer questions should cover the entire course as far as possible. These questions should be of conceptual type.

d. Each of the questions numbering 2, 3, 6, 7, 9, 10 and 11 contains a long answer theory question and a numerical problem carrying marks as specified in the table.
e. There will be only one specific 'or' choice in one of the questions of LAQ type in each group.
f. There will be only one specific 'or' choice for numerical problems in mechanics.

Practical

Every student will perform at least 20 experiments and 4 activities during the academic year.

Evaluation Scheme for Practical Examination:

One experiment	12 Marks
One activity	3 Marks
Practical record of experiments and activities	5 marks
Viva on experiment and activity	5 Marks
Total	**25 Marks**

Textbook:

University Physics, Sears F.W, M.W. Zemansky, H.D. Young and R.A. Freedman, 11th edition, Pearson Education Singapore, 2004

Reference Books:

Advanced Level Physics, Nelkon and Parker, Heimesmann Education book Ltd., 2000.
Advanced Physics, Tom Duncan, John Murray Ltd, 2000.

NEB New MODEL QUESTION- 2065

Time: 3 Hours **Full Marks: 75**

General Instructions

i. This paper contains three groups of questions: Group A, Group B and Group C
ii. Group A contains short answers questions, carrying 2 marks each.
iii. Group B contains long answer questions, carrying 4 marks each.
iv. Group C contains numerical problems, carrying 4 marks each except question 12 (last question) which carry 3 marks.
v. You may use the following values of physical constants wherever necessary:
$c = 3 \times 10^8 m/s$
$g = 10\ m/s^2$
$k = 1.38 \times 10^{-23} J/K$
Density of steel = $7800\ kg/m^3$
Sp. Heat capacity of water = $4200\ Jkg^{-1}\ K^{-1}$

Group A

1. Answer, in brief, any SIX questions [6×2=12]

a. What is the difference between accurate and precise measurement?
b. A ball having a momentum p hits a bat and its momentum becomes – p. What is the change in momentum of the ball?
c. State the conditions of equilibrium of a system of coplanar force.
d. Does the acceleration of a body moving in a circular path remain constant?
e. Sand is thrown on the roads covered with snow. Why?
f. Since the moon is constantly attracted towards the earth by the gravitational interaction, why doesn't it crash into the earth?
g. Explain in terms of breaking stress why elephant has thicker legs as compared to human beings?

2. Answer, in brief, any TWO questions: [2×2 = 4]

a. Why are two thin blankets warmer than a single blanket of double the thickness?
b. Distinguish between saturated and unsaturated vapor pressure.
c. Does the coefficient of linear expansion depend on length? Explain.

3. Answer, in brief, any ONE question: [1×2=2]

a. Can a convex mirror ever form a real image? If so, explain with diagram.
b. What are grazing incidence and grazing emergence?

4. Answer, in brief, any ONE question: [1×2=2]

a. A man inside an insulated metallic cage does not receive shock when the cage is highly charged. Explain.
b. Is it possible to charge a capacitor to any potential?

Group B

5. Answer any THREE questions: [3×4=12]

a. State the principle of conservation of linear momentum. How does Newton's third law of motion lead to the principle of conservation of linear momentum?
b. Prove that the total mechanical energy in gravitational field is always conserved. Also explain conservative and non-conservative forces.
c. What is SHM? Show that the motion of a bob of simple pendulum is simple harmonic. Find its time period.
d. What is capillarity? Deduce an expression for the rise of a liquid in a capillary tube.

6. Answer any TWO questions: [2×4=8]

a. Define specific latent heat of fusion of a solid. Develop an expression for determination of the latent heat of fusion of ice.
b. Define the coefficient of thermal conductivity of a substance. Describe Searle's method for determination of the thermal conductivity of a good conductor.
c. What is a Carnot engine? Derive an expression for its efficiency.

7. Answer any ONE question: [1×4=4]

a. Define power of a lens. Derive the formula for the effective power of two thin lenses in contact.
b. Describe the construction and working of a compound microscope and hence derive an expression for its magnifying power.

8. Answer any ONE question: [1×4=4]

a. State Gauss law. Apply it to obtain an expression for electric field outside the charged spherical conductor.

b. Find the equivalent capacitance of two capacitors when they are in (i) series and (ii) parallel.

Group C

9. Solve any THREE numerical questions: [3×4=12]

a. A ballet dancer spins with 2.4 rev/s with her arms outstretched, when the moment of inertia about the axis of rotation is I. With her arms folded, the moment of inertia about the same axis becomes 0.61. Calculate the new rate of spin.

Ans: 4 rev/ sec

b. A canoe has a velocity of 0.40 m/s southeast relative to the earth. The canoe is on the river that is flowing at 0.50 m/s east relative to the Earth. Find the velocity (magnitude and direction) of the canoe relative to the river.

Ans: 0.353 m/sec in 53.18° South east

c. The sun has mass 330,000 times that of the earth. For a person on the earth, the average distance to the center of the sun is 23,500 times the distance to the center of earth. In magnitude, what is the ratio of the sun's gravitational force on you to the earth's gravitational force on you?

Ans: 1/1673.5

d. Castor oil at 20°C has a coefficient of viscosity 2.42 N.s/m^2 and a density 940 kg/m^3. Calculate the terminal velocity of a steel ball of radius 2.0 mm falling under gravity in the oil taking the density of steel as 7800 kg/m^3.

Ans: 0.025 m/sec

10. Solve any TWO numerical questions: [2×4=8]

a. A ball of copper of specific heat capacity 400 J kg^{-1} K^{-1} weighing 400 g is transferred from a furnace to 1 kg of water at 20°C. The temperature of water rises to 50°C. What is the original temperature of the ball?

Ans: 837.5°C

b. An ideal gas initially at 4.00 atm and 350 K is permitted to expand adiabatically to 1.50 times its initial volume. Find the final pressure and temperature if the gas is (a) monatomic (b) diatomic with $C_v = \frac{5}{2}R$.

Ans: (a) 2 atm, 266.74 k (b) 2.27 atm, 297.6 k

c. At what temperature will the average speed of oxygen molecule be sufficient so as to escape from the earth? Escape velocity from the earth is 11.2 km/s and mass of one oxygen molecule is 5.34×10^{-26} kg.

Ans: 1.6×10^5 K

11. A microscope is focused on the upper surface of a glass plate. A second plate is then placed over the first. In order to focus on the bottom surface of the second plate, the microscope must be raised another 1mm. In order to focus on the upper surface, it must be raised another 2 mm. Find the index of refraction of the second plate. [4]

Ans: 1.5

12. Two point charges + 1 μC and + 4 μC are placed at a distance of 0.12 m apart. Determining the point joining the line between two charges where net force acting on the unit positive charge is zero? [3]

Ans: 0.04 m

Chapter Based Questions

Unit 1: Mechanics

1. Physical Quantities

FORMULAE

1. To find the numerical value of a system using another system of units, we use,

$$N_2 = N_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

Short Answer Questions

1. 2076 Set B Q.No. 1a The energy of a photon is given by E = hf. Find the dimension and unit of Planck's constant h, where f is the frequency of radiation. [2]

Ans: [ML^2 T^{-1}], Js

2. 2076 Set C Q.No. 1a Distinguish between precise and accurate measurements. [2]

3. 2075 Set A Q.No. 1a Differentiate between accuracy and precession of measurement. [2]

4. 2075 Set B Q.No. 1g In one of the printed documents the unit of universal gravitational constant is given as NmKg^{-2}. Check its correctness from dimensional analysis. [2]

Ans: Incorrect

5. 2074 Supp. Q.No. 1a 2063 Q.No. 1a Is dimensionally correct equation necessarily be a correct physical relation? What about dimensionally wrong equation? [2]

6. 2074 Set B Q.No. 1f 2067 Q.No. 1a What is the difference between accurate and precise measurements? [2]

7. 2073 Supp Q.No. 1g A student writes an expression for the momentum (p) of a body of mass (m) with total energy (E) and considering the duration of time (t) as $p = \sqrt{2mE}/t$. Check its correctness on dimensional analysis. [2]

Ans: Incorrect

8. 2073 Set C Q.No. 1a Check dimensionally the correctness of the Stoke's formula, F = 6 πηrv, where symbols have their usual meanings. [2]

Ans: Correct

9. 2072 Supp Q.No. 1a Check the correctness of the formula, PV = RT. [2]

Ans: Correct

10. 2072 Set C Q.No. 1a The diameter of a steel rod is given as 56.47 ± 0.02 mm. What does it mean? [2]

11. 2072 Set D Q.No. 1a The length of rod is exactly 1 cm. An observer records the readings as 1.0 cm, 1.00 cm, and 1.000 cm, which is the most accurate measurement? [2]

Ans: 1.000 cm

12. 2071 Supp Q.No. 1a What do you mean by significant figure? [2]

13. 2071 Set D Q.No. 1 d A student writes an expression of the force causing a body of mass (m) to move in a circular motion with a velocity (v) as F = mv^2. Use the dimensional method to check its correctness. [2]

Ans: Incorrect

14. 2070 Supp (Set B) Q.No. 1 g Check the correctness of the relation $h=\frac{2T\cos\theta}{r\rho g}$, where symbols have usual meaning. [2]
Ans: Correct

15. 2070 Set C Q.No. 1 a Name any two physical quantities which have the same dimensions. Can a quantity have unit but no dimension? Explain. [2]

16. 2070 Set D Q.No. 1 b If $y = a + bt + ct^2$, where y is the distance and t is the time. What is the dimension and unit of c? [2]
Ans: $[M^0LT^{-2}]$

17. 2069 Supp Q.No. 1a Find the dimensions of Planck's constant 'h' from the given equation: $\lambda = \frac{h}{p}$; where λ is wavelength and p is the momentum of photon. [2]
Ans: $[ML^2T^{-1}]$

18. 2069 (Set A) Old Q. No. 1a What are the limitations of dimensional analysis? [2]

19. 2069 (Set B) Q. No. 1a Check the correctness of the formula $t = 2\pi\sqrt{\frac{l}{g}}$ using dimensional analysis, t is the time period of simple pendulum, l is the length of simple pendulum and g is the acceleration due to gravity. [2]
Ans: Correct

20. 2069 Old (Set B) Q. No. 1a The force F is given in terms of time 't' and displacement 'x' by the equation F = AsinBx + C sin Dt. What is the dimension of D/B? [2]
Ans: $[M^0LT^{-1}]$

21. 2068 Old Q.No. 1 a Determine the dimensional formula for gravitational constant (G). [2]
Ans: $[M^{-1}L^3T^{-2}]$

22. 2067 Supp Q.No. 1 a Write dimensional formula of gravitational constant and latent heat. [2]
Ans: $[M^{-1}L^3T^{-2}]$ $[M^0L^2T^{-2}]$

23. 2066 Old Q. No. 1 a Is a dimensionally correct equation necessarily be a correct physical relation? Justify your answer. [2]

24. 2064 Q.No. 1 b Check the correctness of formula $t = 2\pi\sqrt{m/k}$ where t be the time period, m is the mass and k is the force per unit displacement. [2]
Ans: Correct

25. 2062 Q.No. 1 b A student writes $\sqrt{\frac{R}{2GM}}$ for escape velocity. Check the correctness of the formula by using dimensional analysis. [2]
Ans: Incorrect

26. 2061 Q.No. 1 a Convert 10 ergs in joules. [2]
Ans: 10^{-6} J

27. 2059 Q.No. 1 a Check the correctness of the formula $v^2 = u^2 + 2as$ using dimensional analysis. [2]
Ans: Correct

28. 2057 Q.No. 1 a Taking force, length and time to be fundamental quantities, find the dimensional formula for the density. [2]
Ans: $[FL^{-4}T^2]$

29. 2056 Q.No. 1 e Calculate the dimensional formula for Universal Gravitational Constant 'G'. [2]
Ans: $[M^{-1}L^3T^{-2}]$

30. 2055 Q.No. 1 e The escape velocity of a body is $V_g = \sqrt{\frac{2GM}{R}}$ Check the correctness of the formula using dimension. [2]
Ans: Correct

31. 2055 Q.No. 1 i The density of gold is 19.3 gm/cc. Express its value in SI unit. [2]
Ans: 19300 kg/m^3

32. 2054 Q.No. 1 a Obtain dimensions of specific heat capacity and gravitational constant. [2]
Ans: $[M^0L^2T^{-2}K^{-1}]$ $[M^{-1}L^3T^{-2}]$

2. Vectors

FORMULAE

1. The magnitude of resultant of two vectors $\vec{A}$ and $\vec{B}$,
$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

2. The direction (β) of resultant vector $\vec{R}$ with respect to vector $\vec{A}$,
$\beta = \tan^{-1}\left(\frac{B\sin\theta}{A + B\cos\theta}\right)$.

3. The scalar product of two vectors $\vec{A}$ and $\vec{B}$,
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$.

4. Vector product of two vectors $\vec{A}$ and $\vec{B}$,
$\vec{A}\times\vec{B} = |\vec{A}||\vec{B}|\sin\theta\,\hat{n}$

5. The components of two vectors $\vec{A}$ and $\vec{B}$,
$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$
and, $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$
Then $\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$.
and angle, $\cos\theta = \frac{\vec{A}\cdot\vec{B}}{|\vec{A}||\vec{B}|} = \frac{A_xB_x + A_yB_y + A_zB_z}{|\vec{A}||\vec{B}|}$
$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$
$|\vec{B}| = \sqrt{B_x^2 + B_y^2 + B_z^2}$

6. In vector resolution,
X-component of $\vec{A} = |A_x| = A\cos\theta$
Y- Component of $\vec{A} = |A_y| = A\sin\theta$

7. The dot product of mutually perpendicular vectors,
$\hat{i}\cdot\hat{j} = 0, \hat{j}\cdot\hat{k} = 0, \hat{k}\cdot\hat{i} = 0$
$\hat{i}\cdot\hat{i} = 1, \hat{j}\cdot\hat{j} = 1, \hat{k}\cdot\hat{k} = 1$

8. The cross product of mutually perpendicular vectors,
$\hat{i}\times\hat{j} = \hat{k}, \hat{j}\times\hat{k} = \hat{i}, \hat{k}\times\hat{i} = \hat{j}$, reverses are negative in sign
$\hat{i}\times\hat{i} = 0, \hat{j}\times\hat{j} = 0, \hat{k}\times\hat{k} = 0$

Short Answer Questions

1. **2076 Set C Q.No. 1b** If $\vec{A} = 4\hat{i} - \hat{j} + 3\hat{k}$ and $\vec{B} = 7\hat{i} + 5\hat{j} + \hat{k}$, find the angle between the vectors $\vec{A}$ and $\vec{B}$. [2]
Ans: 54°

2. **2075 Set B Q.No. 1a** $\vec{A}$ and $\vec{B}$ are two non-zero vectors. If $|\vec{A} \times \vec{B}| = \vec{A}.\vec{B}$, what is the angle between $\vec{A}$ and $\vec{B}$? [2]
Ans: 45°

3. **2074 Supp. Q.No. 1b** If $\vec{A}.\vec{B} = 0$, what is the value of angle between $\vec{A}$ and $\vec{B}$? [2]
Ans: 90°

4. **2074 Set A Q.No. 1c** Resultant of two equal forces may have the magnitude equal to one of the forces. At what angle between the two equal forces this is possible? Justify your answer. [2]
Ans: 120°

5. **2074 Set B Q.No. 1e** Two vectors are given as $\vec{V_1} = 2\hat{i}+3\hat{j}+4\hat{k}$ and $\vec{V_2} = 3\hat{i} + 2\hat{j} - 4\hat{k}$. Which one of two is larger in magnitude? Justify your answer. [2]
Ans: Equal Magnitude = $\sqrt{29}$ units

6. **2073 Supp Q.No. 1e** A vector is defined as $\vec{E} = 2\hat{i} + 3\hat{j} - 4\hat{k}$. What is the magnitude of the Y-component of $\vec{E}$? [2]
Ans: 3

7. **2073 Set D Q.No. 1a** Two vectors have equal magnitudes and their resultant also has the same magnitude. What is the angle between the two vectors? [2]
Ans: 120°

8. **2072 Supp Q.No. 1e** **2061 Q.No. 1 c** Can the sum of two equal vectors be equal to either vector? [2]
Ans: Yes at θ = 120°

9. **2072 Set D Q.No. 1b** Given two vectors $\vec{A} = 4.00\,\hat{i} + 3.00\,\hat{j}$ and $\vec{B} = 5.00\,\hat{i} - 2.00\,\hat{j}$. Find the magnitude of each vector. [2]
Ans: 5, $\sqrt{29}$

10. **2072 Set E Q.No. 1a** A vector $\vec{F} = \hat{i} + 2\hat{j} - 3\hat{k}$ is given. What is the magnitude of the y-component of the vector? [2]
Ans: 2

11. **2071 Supp Q.No. 1b** Is a physical quantity having magnitude and direction necessarily a vector quantity? Explain. [2]

12. **2071 Set C Q.No. 1 b** A force (in Newton) expressed in vector notation as $\vec{F} = 2\hat{i} + \hat{j} - 3\hat{k}$ is applied on a body so that the displacement produced in meter is given by $\vec{D} = \hat{i} - 2\hat{j} - 3\hat{k}$. Express the result and nature of the work done. [2]
Ans: 9 J

13. **2071 Set D Q.No. 1 c** A force (in Newton) expressed in vector notation as $\vec{F} = 4\hat{i} + 7\hat{j} - 3\hat{k}$ is applied on a body and produces a displacement (in meter), $\vec{D} = 3\hat{i} - 2\hat{j} - 5\hat{k}$ in 4 seconds. Estimate the power. [2]
Ans: 3.25 W

14. **2070 Supp (Set A) Q.No. 1 a** What does $\vec{A}.\vec{A}$, the scalar product of a vector with itself gives? What about $\vec{A} \times \vec{A}$, the vector product of a vector with itself? [2]

15. **2070 Supp (Set B) Q.No. 1 a** Can you find a vector quantity that has a magnitude of zero but components that are different from zero? Explain. [2]

16. **2070 Set C Q.No. 1 b** If $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x, y and z-axis respectively, find $\hat{i}.(\hat{j} \times \hat{k})$. [2]
Ans: 1

17. **2070 Set D Q.No. 1 a** The angle between two vectors $\vec{A}$ and $\vec{B}$ is θ. Find the magnitude and direction of $\vec{A} \times \vec{B}$ and $\vec{A}.\vec{B}$. [2]

18. **2069 (Set A) Q. No. 1d** If $\vec{A}$ and $\vec{B}$ are non zero vectors, is it possible for $\vec{A} \times \vec{B}$ and $\vec{A}.\vec{B}$ both to be zero? Explain. [2]

19. **2069 Old (Set B) Q. No. 1b** If a vector has zero magnitude, is it meaning full to call it vector? [2]

20. **2068 Q.No. 1a** **2060 Q.No. 1a** If the scalar product of two vectors in equal to the magnitude of their vector product, find the angle between them. [2]
Ans: 45°

21. **2067 Q.No. 1 b** $\vec{C}$ is the vector sum of $\vec{A}$ and $\vec{B}$ i.e. $\vec{C} = \vec{A} + \vec{B}$ for C = A + B to be true, What is the angle between $\vec{A}$ and $\vec{B}$? [2]
Ans: 0°

22. **2067 Supp Q.No. 1 b** What should be the angle between the two vectors of same magnitude, so that their resultant is equal to either of them? [2]
Ans: 120°

23. **2066 Old Q. No. 1 b** **2063 Q.No. 1 b** The magnitude of two vectors are 3 and 4, and their dot product is 6, what is the angle between them? [2]
Ans: 60°

24. **2065 Q. No. 1 a** If $\vec{A}.\vec{B} = 0$, what is angle between $\vec{A}$ and $\vec{B}$? [2]
Ans: 90°

25. **2064 Q.No. 1a** Two vectors $\vec{A}$ and $\vec{B}$ are such that $\vec{A} - \vec{B} = \vec{C}$ and A — B = C. Find the angle between them. [2]
Ans: 0°

26. **2062 Q.No. 1 e** What is the difference between scalar and vector products of two vectors? Explain. [2]

27. **2054 Q.No. 1 b** If B is added to A, under what condition does the resultant vector have a magnitude equal to A + B? Under what conditions is the resultant vector equal to zero? [2]
Ans: zero degree, if A = B and θ = 180°.

Long Answer Questions

28. 2075 GIE Q.No. 5a 2069 (Set A) Q. No. 5a State the parallelogram law of vector addition. Derive expressions for the magnitude and direction of the resultant of two vectors inclined at an angle θ from each other. [4]
29. 2070 Supp (Set A) Q.No. 5 a State and explain the parallelogram law of vector addition. [4]
30. 2066 Q. No. 5 a State triangle law of vector addition. Obtain an expression for the resultant of two vectors P and Q inclined at angle θ. [4]
31. 2055 Q.No. 2 OR State the parallelogram law of vector addition. Derive the magnitude and direction of the resultant vector. [4]

Numerical Problems

32. 2076 Set B Q.No. 9a A disoriented physics professor drives 3.25 km north, then 4.75 km west and then 1.50km south. Find the magnitude and direction of the resultant displacement. [4]

Ans: 5.06 km, 20.2° in second quardant

33. 2075 Set A Q.No. 9a A rocket fires two engines simultaneously. One produces a thrust of 725N directly forward, while the other gives a 513 N thrust at 32.4° above the forward direction. Find the magnitude and direction of the resultant force that these engines exert on the rocket. [4]

Ans: 1190N and 13.4° above F

3. Kinematics

Values of Physical Constants

Acceleration due to gravity (g) = 10 m/s²

FORMULAE

1. Equation of Motions,

Equations of motion in straight line	Equations of motion under gravity	
	For downward motion	For upward motion
$v = u + at$	$v = u + gt$	$v = u - gt$
$s = ut + \frac{1}{2}at^2$	$h = ut + \frac{1}{2}gt^2$	$h = ut - \frac{1}{2}gt^2$
$v^2 = u^2 + 2as$	$v^2 = u^2 + 2gh$	$v^2 = u^2 - 2gh$

2. Distance travelled in n^{th} second,

$$s_n^{th} = u + \frac{a}{2}(2n - 1)$$

3. Relative velocity of object A with respect to object B,

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

Similarly, relative velocity of B with respect to A,

$$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$$

4. Relative velocity when two objects are inclined,

$$v_{AB} = \sqrt{v_A^2 + v_B^2 - 2v_Av_B\cos\theta}$$

Direction of resultant,

$$\tan\beta = \frac{v_B\sin\theta}{v_A - v_B\cos\theta}$$

5. A projectile when fired horizontally from certain height,

Time of flight, $T = \sqrt{\frac{2H}{g}}$,

Horizontal range, $R = u\sqrt{\frac{2H}{g}}$

Velocity at any instant, $v = \sqrt{u^2 + g^2t^2}$

and direction of velocity with respect to x direction,

$$\theta = \tan^{-1}\left(\frac{gt}{u}\right)$$

6. Projectile fired at an angle with the horizontal,

Time of flight, $T = \frac{2u\sin\theta}{g}$

Horizontal range, $R = \frac{u^2\sin 2\theta}{g}$

Maximum height attained, $H = \frac{u^2\sin^2\theta}{2g}$

Maximum horizontal range, $R_{max} = \frac{u^2}{g}$ at $\theta = 45°$

Short Answer Questions

1. 2076 Set B Q.No. 1b From a flying aeroplane a body should be dropped in advance to hit the target, why? [2]
2. 2075 GIE Q.No. 1b Is it possible to get a body accelerated even if it is moving with a uniform speed? Justify. [2]
3. 2075 GIE Q.No. 1f A ball is dropped gently from the top of a tower and another ball is thrown horizontally at the same time. Which ball will hit the ground first? [2]
4. 2075 Set A Q.No. 1b Can an object with constant acceleration reverse its direction of travel? Explain. [2]
5. 2074 Set A Q.No. 1e Velocities of two bodies A and B are given in vector notation as $\vec{V_A} = \hat{i} + 2\hat{j} - 3\hat{k}$ and $\vec{V_B} = 3\hat{i} + 2\hat{j} - \hat{k}$ respectively. What will be the relative velocity of B with respect to A in this notation? [2]

Ans: $2\hat{i} + 2\hat{k}$

6. 2074 Set B Q.No. 1b Two stones P and Q of different masses m and 2m respectively are dropped simultaneously from the top of a tower and reach the ground with different energies. Which one is faster? [2]
7. 2073 Supp Q.No. 1a A ball is thrown with a velocity v at an angle θ with the horizontal. Can an another angle of projection achieve the same horizontal range? Justify your answer. [2]
8. 2072 Supp Q.No. 1b 2070 Set C Q.No. 1c 2069 Old (Set B) Q. No. 1c Rain drops hitting the side windows of a car in motion often leave diagonal streaks. Why? [2]
9. 2072 Set C Q.No. 1b If the displacement of a body is proportional to square of time, state whether the body is moving with uniform velocity or uniform acceleration. [2]
10. 2071 Set D Q.No. 1 b A bomb is to be dropped from a moving helicopter on a target on the ground. Explain how it can hit the target. [2]
11. 2070 Supp (Set A) Q.No. 1 b Can you have a zero acceleration but non-zero velocity? Explain with help of a graph. [2]
12. 2070 Set D Q.No. 1 c A projectile moves in a parabolic path without air resistance. Is there any point at which its acceleration is perpendicular to the velocity? Explain. [2]
13. 2069 (Set A) Q. No. 1c Can the direction of the velocity of a body be changed when its acceleration is constant? [2]
14. 2069 (Set B) Q. No. 1b 2066 Q. No. 1 a Can an object with constant acceleration reverse its direction? Explain. [2]
15. 2069 Old (Set B) Q. No. 1d If the displacement of a body is proportional to the square of time, state the nature of motion of the body. [2]

16. 2068 Q.No. 1 b From a high tower, one ball is dropped from rest and the second ball is simultaneously projected horizontally. Neglecting air resistance, which ball will reach the ground earlier? [2]
17. 2068 Old Q.No. 1 b Can a body have a constant speed but changing velocity? Explain with example. [2]
18. 2066 Old Q. No. 1 c If the displacement of a body is proportional to square of time, state the nature of motion of the body. [2]
19. 2065 Q. No. 1 b A swimmer wants to reach to a point just opposite on the other bank of the river. How should he swim and why? [2]
20. 2062 Q.No. 1 c A ball is dropped gently from the top of a tower and another ball is thrown horizontally from the same point at the same time. Which ball will hit the ground earlier? [2]
Ans: At the same time
21. 2061 Q.No. 1 b Find the angle of projection at which the horizontal range and maximum height of a projectile are equal. [2]
Ans:75.96°
22. 2059 Q.No. 1 b Two stones are projected simultaneously from a height. One falls freely while the other is projected horizontally. Which one reaches the ground first? Explain. [2]
Ans: Same time
23. 2058 Q.No. 1 a What would be the effect on maximum range in doubling the initial velocity of a projectile? [2]
Ans: $R_{max} = u^2/g$ i.e $R_{max} \propto u^2$ $\therefore$ R' = 4R
24. 2057 Q.No. 1 b A ball is dropped gently from the top of a tower and another ball is thrown horizontally at the same time. Which ball hit the ground earlier? Explain. [2]
Ans: Same time
25. 2056 Q.No. 1 f Can an object have an eastward velocity experiencing a westward acceleration? Give reason. [2]
Ans: In case of retardation
26. 2053 Q.No. 1 b A car is moving on the road when the rain is falling vertically downwards. Why does the front wind screen get wet? [2]
Ans: due to V_{RC}
27. 2052 Q.No. 1 e A projectile fired at an angle of 18° has certain horizontal range. State another angle of projection for the same horizontal range. **Ans= 72°** [2]
28. 2051 Q.No. 1 i Give with an example a case where the velocity of an object is zero but its acceleration is not zero. [2]
Ans: In vertical motion, at highest point, V = 0 but a = g.
29. 2050 Q.No. 1 i Because of air resistance, two objects of unequal mass do not fall at precisely the same rate. If two bodies of identical shape but unequal mass be dropped simultaneously from the same height, which one reaches the ground first? [2]
Ans: Heavier ball

Long Answer Questions

30. 2076 Set C Q.No. 5a 2073 Set D Q.No. 5a A projectile is fired at an angle of θ with the horizontal. Show that its trajectory is a parabola. Also, derive expressions for the maximum height attained and the time of flight. [4]
31. 2074 Set A Q.No. 5a A projectile is projected with a velocity v making an angle θ with the horizontal. Derive relation for its trajectory. Also show the components of velocity at any point on the trajectory in a diagram. [4]
32. 2071 Supp Q.No. 5a Show that path followed by a projectile fired at an angle with horizontal is a parabola. Assuming that the point of projection and the landing point are at the same horizontal level, find the expression for horizontal range. [4]
33. 2069 Supp Q.No. 5a Show that the path followed by a projectile fired at an angle 'θ' with the horizontal is a parabola and derive general expression for the time of light and horizontal range. [4]
34. 2067 Q.No. 5 a Derive expressions for maximum height, range of projectile fired at angle 'θ' with horizontal. [3]
35. 2067 Supp Q.No. 5 a A projectile is fired with a velocity v and making an angle θ with the horizontal. Derive expressions for the maximum height obtained, the time of flight and the horizontal range. [4]
36. 2064 Q.No. 3 a OR A stone is projected with a velocity in a direction making an angle θ with horizontal. Derive expression for: (i) maximum height (ii) time of flight (iii) horizontal range.
Also find the condition for maximum horizontal range. [3+1]

Numerical Problems

37. 2075 GIE Q.No. 9a A swimmer's speed along the river is 20 kmph and up stream is 8 kmph. Calculate the velocity of the stream and the swimmer's possible speed in still water. [4]
Ans: 14 km/hr, 6 km/hr
38. 2075 Set B Q.No. 9d A body is projected upwards making an angle θ with the horizontal with a velocity of 300 ms^{-1}. Find the value of θ so that the horizontal range will be maximum. Hence find its range and time of flight. [4]
Ans: 45°, 9000 m, 42.42 sec
39. 2074 Supp. Q.No. 9a A stone on the edge of a vertical cliff is kicked so that its initial velocity is 9 m/s horizontally. If the cliff is 200m high, calculate: [4]
i. time taken by stone to reach the ground.
ii. How far from the cliff the stone will hit the ground?
Ans: (i) 6.32 sec (ii) 56.92 m
40. 2074 Set B Q.No. 9c 2073 Supp Q.No. 9a 2066 Q. No. 9 a A projectile is fired from ground level with a velocity 500 ms^{-1} at 30° to horizontal. Find the horizontal range, the greatest height and the time to reach the greatest height. [4]
Ans: 21651 m, 3125 m, 25 sec.
41. 2073 Set C Q.No. 9a A batter hits a baseball so that it leaves the bat with an initial speed 37m/s at an angle of 53°. Find the position of the ball and the magnitude and direction of its velocity after 2 seconds. Treat the baseball as a projectile. [4]
Ans: 24.23 m/sec, 23.21°
42. 2072 Supp Q.No. 9a 2069 (Set B) Q. No. 9a A base ball is thrown towards a player with an initial velocity 20ms^{-1} and 45° with the horizontal. At the moment, the ball is thrown the player is 50m from the thrower. At what speed and in what direction must he run to catch the ball at the same height at which it is released? [4]
Ans: 3.5 m/sec towards thrower
43. 2072 Set D Q.No. 9a An airplane is flying with a velocity of 90.0 m/s at an angle of 23.0° above the horizontal. When the plane is 114 m directly above a dog that is standing on level ground, a suitcase drops out of luggage compartment. How

far from the dog will the suitcase land? You can ignore air resistance. [4]

Ans: 778.7 m from dog

44. 2071 Set C Q.No. 9 d A bullet is fired with a velocity of 100 m/s from the ground at an angle of 60° with the horizontal. Calculate the horizontal range covered by the bullet. Also calculate the maximum height attained. [4]

Ans: 866m; 375 m

45. 2070 Supp (Set A) Q.No. 9 a A car travelling with a speed of 15m/s is braked and it slows down with uniform retardation. It covers a distance of 88 m as its velocity reduces to 7m/s. If the car continues to slow down with the same rate, after what further distance will it be brought to rest? [4]

Ans: 24.5 m

46. 2070 Supp (Set B) Q.No. 9 a A stone is projected horizontally with 20m/s from top of a tall building. Calculate its position and velocity after 3 sec neglecting the air resistance. [4]

Ans: 36 m/sec; 56.3°

47. 2069 Supp Q.No. 9a A swimmer's speed along the river (down stream) is 20 km/h and can swim up-stream at 8 km/h. Calculate the velocity of the stream and the swimmer's possible speed in still water. [4]

Ans: 14 km/hr, 6 km/hr

48. 2069 (Set A) Q. No. 9a A man wishes to swim across a river 600m wide. If he can swim at the rate of 4km/h in still water and the river flows at 2km/h. Then in what direction must he swim to reach a point exactly opposite to the starting point and when will he reach it? [4]

Ans: 120° with water and 10.4 min

49. 2069 (Set B) Q. No. 9c A body falls freely from the top of a tower and during the last second of its fall, it falls through 25m. Find the height of tower. [4]

Ans: 45 m

50. 2069 Old (Set B) Q. No. 2b A projectile is launched with an initial velocity of 30ms^{-1} at an angle of 60° above the horizontal. Calculate the magnitude and direction of its velocity 5s after launch. [4]

Ans: 28.3 m/s and 58° C from horizontal

51. 2068 Old Q.No. 2 b A projectile is fired from the ground level with velocity 150m/s at 30° to the horizontal. Find its horizontal range. What will be the least speed with which it can be projected to achieve the same horizontal range? [4]

Ans: 1949 m, 140 m/sec

52. 2065 Q. No. 2 b A projectile is fired from the ground level with a velocity of 500ms^{-1} at 30° to horizon. Find the horizontal range, and greatest vertical height to which it rises. What is the least speed with which it could be projected in order to achieve the same horizontal range? [g = 10 N kg^{-1}] [4]

Ans: 21651 m, 3125 m, 464 ms^{-1}

53. 2063 Q.No. 2 b An object is dropped from the top of the tower of height 156.8 m. and at the same time another object is thrown vertically upward with the velocity of 78.1 ms^{-1} from the foot of the tower, when and where the object meet? [4]

Ans: 2 sec. and 20 m below from top

54. 2060 Q.No. 2 b A body is projected horizontally from the top of a tower 100 m high with a velocity of 9.8 ms^{-1}. Find the velocity with which it hits the ground. [4]

Ans: 45.82 m/s at 77.9°

4. Laws of Motion

Values of Physical Constants

Acceleration due to gravity (g) = 10 m/s^2

FORMULAE

1. The linear momentum, p = mv
2. Force, $F = \frac{mv - mu}{t} = \frac{dp}{dt}$

   $\Rightarrow F = \frac{mv - mu}{t} = ma$
3. Impulse = force x time = dp = F t
4. In Newton's third law of motion,

   $F_{AB} = - F_{BA}$
5. Apparent weight of body in a lift,

   i. when a lift moves upwards,

   R = m(g + a)

   ii. when a lift moves downwards,

   R = m (g – a)

   iii. when a lift is at rest or moves with uniform velocity (a=0)

   R = mg.

   iv. when a lift falls freely (a = g), R = 0.
6. Principle of conservation of linear momentum,

   $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$,
7. Recoil of gun, Momentum of gun = – momentum of bullet i.e., (Mv' = – mv).
8. Coefficient of static friction, $\mu_s = \frac{F_c}{R}$
9. Coefficient of kinetic friction, $\mu_k = \frac{F_k}{R}$
10. Motion of connected bodies,

    $a = \frac{M - m}{M + m} g$ and $T = \frac{2Mm}{M+m} g$
11. Motion along an inclined plane,

    i. when a body moves down,

    $F_N = mg \sin\theta - F_k$, where F_k = frictional force.

    ii. when a body moves up,

    $F = mg \sin\theta + F_k = mg (\sin\theta + \mu \cos\theta)$

    iii. when a body moves up net upward force,

    $F_N = ma + mg \sin\theta + F_k$
12. Angle of Repose, $\mu_s = \tan\alpha = \tan\theta$

Short Answer Questions

1. 2075 GIE Q.No. 1a Can a body be said to be at rest and in motion at the same time? [2]
2. 2073 Set C Q.No. 1b A woman in an elevator lets go of her briefcase but it does not fall to the floor. How is the elevator moving? [2]
3. 2073 Set D Q.No. 1b It can hurt our foot more to kick a big rock than a small pebble. Why? [2]
4. 2072 Set C Q.No. 1g Why is it easier to pull a body than to push it? [2]
5. 2072 Set D Q.No. 1g Why does a cricketer lower his hand while catching cricket ball? [2]
6. 2072 Set E Q.No. 1b Explain why a fielder lowers his hand while catching a cricket ball? [2]
7. 2071 Set D Q.No. 1 a Explain the difference between a "push" and a "pull" in the case of a heavy roller on a level road where the force acts on the roller making an angle with the horizontal road. [2]

8. 2070 Supp (Set B) Q.No. 1 e A firecracker at rest explodes, sending fragments off in all directions. Initially the firecracker has zero momentum, but after the explosion the fragments flying off each other have quite a lot of momentum. Hasn't momentum been created? If not, explain why not? [2]
9. 2069 Supp Q.No. 1b It is easier to pull a heavy load than to push it. Why? [2]
10. 2069 (Set A) Q. No. 1f A man drops his briefcase in an elevator but it does not fall to the floor. What can be concluded about the situation? [2]
11. 2069 (Set A) Old Q. No. 1c A cricketer lowers his hands while catching balls. Why? [2]
12. 2069 (Set A) Old Q. No. 1d In rain a scooter may slip on the turning of a road. Why? [2]
13. 2069 (Set B) Q. No. 1c 2066 Q. No. 1b When a large heavy truck collides with a passenger car, the occupants of the car are more likely to be hurt than the truck driver. Why? [2]
14. 2068 Old Q.No. 1 c It is easier to pull a lawn roller than to push it, why? [2]
15. 2067 Supp Q.No. 1 c Why does a heavy rifle not kick as strongly as a light rifle using the same cartidges? [2]
16. 2065 Q. No. 1 d Why a man getting out of a moving bus must run in the same direction for a certain distance? [2]
17. 2063 Q.No. 1 d Explain why a coin placed on a cardboard covering a glass falls into the glass when the cardboard is pulled suddenly to one side? [2]
18. 2061 Q.No. 1 d Explain how Newton's first law of motion follows from the second law. [2]
19. 2061 Q.No. 1 f Why is the kinetic friction less than the limiting fraction? [2]
20. 2060 Q.No. 1 b Can a body be regarded in a state of rest as well as in motion at the same time? Give an example. [2]
21. 2060 Q.No. 1 e Why do we slip on a rainy day? [2]
22. 2059 Q.No. 1 c Is friction a necessary evil? Explain. [2]
23. 2056 Q.No. 1 b The leaves fall when a tree is shaken. Give reason. [2]
24. 2056 Q.No. 1 c Why is it difficult to run fast on sand? [2]
25. 2054 Q.No. 1 c Explain why a cricketer moves his hands backwards while catching a ball? [2]
26. 2053 Q.No. 1 c Give reasons why a man getting out of moving bus must run in the same direction for a certain distance. [2]
27. 2052 Q.No. 1 a If action and reaction are always equal and opposite, why don't they always cancel each and leave no force for acceleration of the body? [2]
28. 2052 Q.No. 2 a 2050 Q.No. 2a State Newton's second law of motion. [2]
29. 2051 Q.No. 1 iv When a balloon filled with air and its mouth downwards is released, it moves upwards, why? [2]
30. 2050 Q.No. 1 v The acceleration of a falling body is measured in elevator travelling at a constant speed of 9.8 m/s. What result is obtained? [2]
31. 2050 Q.No. 1 x Is momentum of a moving body a vector or a scalar? [2]

Long Answer Questions

32. 2076 Set B Q.No. 5b Define angle of friction and angle of repose. Establish a relation between them. [4]
33. 2075 Set A Q.No. 5a State and explain the principle of conservation of linear momentum. Hence derive it from Newton's law of motion. [4]
34. 2075 Set B Q.No. 5a Explain the difference between conservative and non-conservative forces. Also state and prove law of conservation of linear momentum. [4]
35. 2074 Supp. Q.No. 5a 2050 Q.No. 6 State the principle of conservation of linear momentum and show how it follows from Newton's second law of motion. [4]
36. 2074 Set B Q.No. 5c State and explain the principle of conservation of linear momentum. [4]
37. 2073 Set C Q.No. 5a Define angle of repose. Show that the angle of repose and the angle of friction are equal for the given pair of surfaces. [4]
38. 2072 Set D Q.No. 5a State Newton's laws of motion. How does it lead to the principle of conservation of linear momentum? [4]
39. 2072 Set E Q.No. 5c What do you understand by friction and mention its cause. Obtain expression for the relation between angle of friction and angle of repose. [4]
40. 2070 Supp (Set B) Q.No. 5 a What do you mean by cold weldings? Show that angle of repose and angle of friction are equal. [4]
41. 2069 (Set A) Q. No. 5c State the principle of conservation of linear momentum. How does the Newton's third law of motion lead to the principle of conservation of linear momentum? [4]
42. 2069 (Set A) Old Q. No. 3a State and prove the principle of conservation of linear momentum. [4]
43. 2064 Q.No. 2 a State Newton's laws of motion. Show that Newton's first law of motion defines force and second law of motion defines the unit of force. [1+1+3]
44. 2063 Q.No. 2 a What is the angle of repose? Show that when a body just begins to slide down on an inclined plane, the coefficient of friction is equal to the tangent of inclination of the plane. [4]
45. 2062 Q.No. 3 a What do you understand by friction? Explain its cause. Show that the coefficient of static friction is equal to the angle of repose. [4]
46. 2060 Q.No. 2 a State the principle of conservation of linear momentum. Show that in collision between two moving bodies in which no external forces act. [4]
47. 2055 Q.No. 5 State the laws of limiting friction. How would you measure the coefficient of friction between a body and an inclined plane? [4]
48. 2052 Q.No. 2 b Show that the principle of conservation of linear momentum can be verified by using Newton's law. [4]
49. 2051 Q.No. 6 What are the laws of friction? How are they experimentally verified? [4]

Numerical Problems

50. 2076 Set C Q.No. 9a An iron block of mass 10 kg rests on a wooden plane inclined at 30° to the horizontal. It is found that the least force parallel to the plane which causes the block to slide up is 100 N. Calculate the coefficient of friction between the two surfaces. [4]

Ans: 0.577

1. **2074 Set A Q.No. 9a** A box of mass 15 kg placed on horizontal floor is pulled by a horizontal force. What will be the work done by the force if the coefficient of sliding friction between the box and the surface of the floor is 0.3 and body moved at unit distance. [4]

Ans: 45 J

2. **2073 Set C Q.No. 9b** A little red wagon with mass 7 kg moves in a straight line on a frictionless horizontal surface. It has an initial speed of 4 m/s and then is pushed 3 m in the direction of the initial velocity by a force of 10N. Calculate the wagon's final speed and the acceleration produced by the force. [4]

Ans: 4.96 m/sec, 1.43 m/sec^2

3. **2073 Set D Q.No. 9a** In a physics lab experiment, a 6 kg box is pushed across a flat table by a horizontal force F.
   i. If the box is moving at a constant speed of 0.35 m/s and the coefficient of kinetic friction is 0.12, what is the magnitude of F?
   ii. If the box is speeding up with a constant acceleration of 0.18 m/s^2, what will be the magnitude of F? [4]

Ans: (i) 7.2 N (ii) 8.28 N

4. **2072 Supp Q.No. 9c** A ball of mass 0.05Kg strikes a smooth wall normally four times in 2 seconds with a velocity of 10ms^{-1}. Each time the ball rebounds with the same speed of 10ms^{-1}. Calculate the average force on the wall. [4]

Ans: 2 N

5. **2072 Set C Q.No. 9a** A 550N physics student stands on a bathroom scale in an elevator. As the elevator starts moving the scale reads 450N. Draw free body diagram of the problem and find the magnitude and direction of the acceleration of the elevator. [4]

Ans: 1.8 m/sec^2

6. **2071 Supp Q.No. 9a** Suppose you try to move a crate by tying a rope around it and pulling on the rope at angle of 30° above the horizontal. What is the tension required to keep the crate moving with constant velocity? Assume weight of the crate 'w' = 500 N and coefficient of dynamic friction $\mu_k = 0.40$. [4]

Ans: 187.6 N

7. **2070 Set C Q.No. 9 a** A light rope is attached to a block with mass 4 kg that rests on a frictionless, horizontal surface. The horizontal rope passes over a frictionless pulley and a block with mass m is suspended from the other end. When the blocks are released, the tension in the rope is 10 N. Draw free body diagrams and calculate the acceleration of either block and the mass m of the hanging block. [4]

Ans: 2.5 m/sec^2, 1.33 kg

8. **2070 Set D Q.No. 9 a** In a physics lab experiment, a 6kg box is pushed across a flat table by a horizontal force F. If the box is moving at a constant speed of 0.35m/s and the coefficient of kinetic friction is 0.12, find the magnitude of force F. What is the magnitude of force F if the box is moving with a constant acceleration 0.18 m/s^2? [4]

Ans: 7.2 N, 8.28 N

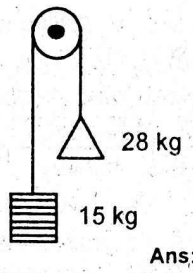
9. **2069 Supp Q.No. 9b** What would be the acceleration of a block sliding down an inclined plane that makes an angle of 45^0 with the horizontal if the coefficient of sliding friction between two surfaces in 0.3? [4]

Ans: 4.95 m/sec^2

10. **2069 (Set A) Q. No. 9c** A cricket ball of mass 145 g is moving with a velocity of 14m/s and is being hit by a bat, so that the ball is turned back with a velocity of 22m/s. The force of blow acts on the ball for 0.015 sec. Find the average force exerted by the bat on the ball. [4]

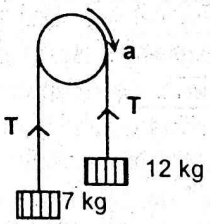
Ans: 348 N

11. **2068 Q.No. 9 a** A 15 kg load of bricks hangs from one end of a rope that passes over a small, frictionless pulley. A 28 kg counterweight is suspended from the other end of the rope as shown in figure. The system is released from rest. Using free body diagram method, find the magnitude of upward acceleration of the load and the tension in the rope while the load is moving. [4]



Ans: 3.02 m/sec^2 and 195.35 N

12. **2067 Supp Q.No. 9 a** Two masses 7 kg and 12 kg are connected at the two ends of a light inextensible string that passes over a frictional pulley. Using free body diagram method, find the acceleration of masses and the tension in the siring, when the masses are released. [4]



Ans: 2.63 m/sec^2; 88.42 N

13. **2066 Old Q. No. 2 b** A vehicle having a mass of 500 kg is moving with a speed of 10 ms^{-1}. Sand is dropped into it at the rate of 10 kg/min. What force is needed to keep the vehicle moving with a uniform peed? [4]

Ans: F = 1.67 N

14. **2059 Q.No. 2 b** A lift moves (i) up and (ii) down with an acceleration of 2ms^{-2}. In each case, calculate the reaction of the floor on a man of mass 50 kg standing in the lift. [4]

Ans: 600 N, 400 m

15. **2057 Q.No. 2 b** The mass of gas emitted from the rear of toy rocket is initially 0.2 kgs^{-1}. If the speed of the gas relative to the rocket is 40 ms^{-1}, and the mass of rocket is 4 kg, what is the initial acceleration of the rocket? [4]

Ans: 2 m/sec^2

5. Work and Energy

Values of Physical Constants

Acceleration due to gravity (g) = 10 m/s^2

FORMULAE

1. Work done, $W = \vec{W} = \vec{F} \cdot \vec{s} = Fs \cos\theta$
2. Kinetic energy, $E_K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$
3. Work energy theorem,
   W = change of kinetic energy $= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

4. Gravitational potential energy, $E_p = mgh$
5. Power,
$$P = \frac{\text{Work done}}{\text{Time taken}} = \frac{W}{t} = \vec{F} \cdot \vec{v} = Fv\cos\theta$$
6. For explosion of a body,
$$\frac{E_1}{E_2} = \frac{m_2}{m_1} \quad \text{i.e.,} \quad E \propto \frac{1}{m}$$
7. Work done by frictional force,
W = Frictional force × displacement

Short Answer Questions

1. 2076 Set B Q.No. 1c A light body and a heavy body have the same momentum. Which one will have greater kinetic energy? Explain. [2]
2. 2076 Set C Q.No. 1c A body is moving with constant velocity v along a circular path of radius r. How much work is done by the centripetal force in revolving the body? [2]
3. 2075 Set A Q.No. 1g 2069 (Set A) Old Q. No. 1f 2066 Old Q. No. 1f 2057 Q.No. 1c Distinguish between conservative and non-conservative forces. [2]
4. 2074 Supp. Q.No. 1c A stationary mass suddenly explodes into two fragments; one heavy and another light. Which one has greater kinetic energy and why? [2]
5. 2073 Set D Q.No. 1c A man carrying a bucket of water is walking on a level road with a uniform velocity. Does he do any work on the bucket while carrying it? [2]
6. 2070 Supp (Set A) Q.No. 1 c The moon is accelerating toward the earth. Why isn't it getting closer to us? [2]
7. 2070 Supp (Set B) Q.No. 1 b Explain why the force of gravity due to the Earth does not pull the Moon in closer and closer on an inward spiral until it hit the Earth surface? [2]
8. 2069 (Set A) Q. No. 1a How does the kinetic energy of a body change if its momentum is halved? [2]
9. 2068 Q.No. 1 d What are elastic and inelastic collisions? Give examples of each. [2]
10. 2066 Old Q. No. 1 d If you are given two objects one is heavier and another is lighter, both have the same kinetic energy. Which one has more linear momentum? [2]
11. 2064 Q.No. 1 e Two bodies of different masses are moving with the same kinetic energy of translation. Which one has more momentum? [2]
12. 2063 Q.No. 1 c "The earth moving round the sun in an orbit is acted upon by a force, hence the work must be done on the earth by this force" .Do you agree with this statement? [2]
13. 2060 Q.No. 1 d How does the K.E. of an object change if its momentum is doubled? [2]
14. 2058 Q.No. 1 b If a moving bullet striking a block of wood on a frictionless table embeds inside it what happens to the KE of the bullet? [2]
15. 2055 Q.No. 1 a Differentiate between conservation of kinetic energy and conservation of linear momentum. [2]
16. 2054 Q.No. 2 a What is meant by elastic and non-elastic collision? [2]
17. 2050 Q.No. 1 ii In a syphon, water is lifted above its original level during its flow from one container to another. Where does it get the needed potential energy from? [2]

Long Answer Questions

18. 2073 Supp Q.No. 5c What is the physical difference between elastic and inelastic collisions? Prove that the colliding objects having same masses exchange their velocities in one dimensional elastic collision. [4]
19. 2072 Supp Q.No. 5a 2069 (Set B) Q.No. 5a 2069 Old (Set B) Q.No. 2a 2057 Q.No. 2a What is the principle of conservation of energy? Show that total mechanical energy of a body is conserved when it moves under the action of gravitational field. [4]
20. 2072 Set C Q.No. 5b Write expressions for work done by a constant and a variable force. Show that the work done by the resultant force on a particle is equal to the change in kinetic energy of the particle. [4]
21. 2071 Supp Q.No. 5b What do you mean by variable force? Derive an expression for work done by a variable force. [4]
22. 2071 Set C Q.No. 5 d What is elastic collision? Prove that the colliding objects exchange their velocities in one dimensional elastic collision. [4]
23. 2070 Set C Q.No. 5 a What is elastic collision? Show that in an elastic collision between two particles, the relative velocity of separation after collision is equal to the relative velocity of approach before collision. [4]
24. 2070 Set D Q.No. 5a 2067 Supp Q.No. 5b Define work. Derive an expression to calculate the work done by a variable force. [4]
25. 2068 Old Q.No. 2 a What do you mean by elastic and inelastic collisions? Write with one example of each. Show that the sum of kinetic energy and potential energy of a freely falling body remains constant at any instant. [2+3]
26. 2067 Q.No. 5 b Define work. Derive an expression to calculate work done by a variable force. [3]
27. 2066 Q. No. 5 d What are conservative and non-conservative forces? Illustrate your answer by reference to the energy changes occurring in a body whilst falling freely under gravity. [4]
28. 2065 Q. No. 2 a State and prove conservation of the mechanical energy. [1+3]
29. 2059 Q.No. 3 a What are elastic and inelastic collision? Give an example of each. Write the energy and momentum equations for an inelastic collision. [2+3]

Numerical Problems

30. 2075 GIE Q.No. 9b A car of mass 1000 kg moves at a constant speed of 20 m/s along a horizontal road. If a constant frictional force of 200 N is acting between the car and the road. Calculate the power developed by the engine. [4]
Ans: 4 KW
31. 2075 Set B Q.No. 9c A water reservoir tank of capacity 250 m^3 is situated at a height of 20 m from the water level. What will be the power of an electric motor to be used to fill the tank in 3 hours? Efficiency of motor is 70%. [4]
Ans: 6614 Watt
32. 2074 Set A Q.No. 9c A stationary mass explodes into two parts of mass 4 units and 40 units respectively. If the larger mass has an initial K.E. 10 J, what is the initial kinetic energy of the smaller mass? [4]
Ans: 100 J

33. **2074 Set B Q.No. 9a** An explosive of mass M placed at a point explodes into one-third and two-third parts. If the initial kinetic energy of the smaller part is 1000 J. What will be the initial K.E. of the bigger part? [4]
Ans: 500 J

34. **2072 Set D Q.No. 9b** You throw a 20 N rock vertically into the air from ground level. You observe that when it is 15 m above the ground, it is travelling at 25 m/s upward. Use the work-energy theorem to find (i) its speed as it left the ground and (ii) its maximum height. [4]
Ans: 30.41 m/sec, 46.25 m

35. **2071 Set C Q.No. 9 a** A 650 KW power engine of a vehicle of mass 1.5×10^5 Kg is rising on an inclined plane of inclination 1 in 100 with a constant speed of 60 km/hr. Find the frictional force between the wheels of the vehicle and the plane. [4]
Ans: 24000 N

36. **2071 Set D Q.No. 9 b** A stationary mass explodes into two parts of mass 4 kg and 40 kg. The initial kinetic energy of larger mass is 10 J. Find the velocity of the smaller mass. [4]
Ans: 7.07 m/sec

37. **2070 Supp (Set A) Q.No. 9 b** A block of weight 150N is pulled 20m along a horizontal surface at constant velocity. Calculate the work done by the pulling force if the coefficient of Kinetic friction is 0.20 and the pulling force makes an angle of 60° with the vertical. [4]
Ans: 537.9 J

38. **2070 Supp (Set B) Q.No. 9 b** The constant force resisting the motion of a car of mass 1500 kg is equal to one fifteenth of its weight if, when travelling at 48 km/h, the car is brought to rest in a distance of 50 m by applying the brakes, find the additional retarding force due to the brakes (assumed constant) and heat developed in the brakes. [4]
Ans: 1666.67 N; 83333.5 J

39. **2069 (Set A) Old Q. No. 3b** **2068 Q.No. 9b** A stationary mass explodes into two parts of mass 4 units and 40 units respectively. If the larger mass has an initial K.E. 100J, what is the initial K.E. of the smaller mass? [3]
Ans: 1000 J

40. **2069 (Set B) Q. No. 9b** A 0.15 kg glider is moving to the right on a frictionaless horizontal air track with a speed of $0.80 ms^{-1}$. It has a head on collision with a 0.300 kg glider that is moving to the left with a speed of $2.2 ms^{-1}$. Find the final velocity (magnitude and direction) of each glider if the collision is elastic. [4]
Ans: $3.2 ms^{-1}$ and $0.2 ms^{-1}$ in opposite direction

41. **2067 Q.No. 9 a** A typical car weighs about 1200 N. If the coefficient of rolling friction is $\mu r = 0.015$. What horizontal force is needed to make the car move with constant speed of 72 km/h on a level road? Also calculate the power developed by the engine to maintain this speed. [4]
Ans. 18 N, 360 W

42. **2066 Q. No. 9 c** A car of mass 1000 kg moves at a constant speed of 25 m/s along a horizontal road where frictional force is 200 N. Calculate the power developed by the engine. [4]
Ans: 5 kw

43. **2061 Q.No. 2 b** A train of mass 2×10^5 kg moves at a constant speed of 72 kmh^{-1} up a straight inclined against a frictional force of 1.28×10^4N. The incline is such that the train rises vertically 1.0 m for every 100 m travelled along the incline. Calculate the necessary power developed by the train. [4]
Ans: 656 KW

44. **2058 Q.No. 2 b** A ball A of mass 0.1 kg moving with a velocity of $6 ms^{-1}$ collides directly with a ball B of mass 0.2 kg at rest. Calculate their common velocity if both balls move off together. If ball A had rebounded with a velocity of $2 ms^{-1}$ in the opposite direction after collission, what would be the new velocity of B? [2+2]
Ans: 2 m/sec, 4 m/sec

45. **2058 Q.No. 3 b** A car of mass 1000 kg. moves at a constant speed of 20 ms^{-1} along a horizontal road where the friction force is 200 N. Calculate the power developed by the engine. [4]
Ans: 4 KW

46. **2056 Q.No. 2 b** A ball of mass 4 kg moving with a velocity 10 ms^{-1} collides with another body of mass 16 kg moving with 4 ms^{-1} from the opposite direction and then coalesces into a single body. Compute the loss of energy on impact. [4]
Ans: 313.6J

47. **2053 Q.No. 3** A bullet of mass 20 g. travelling horizontally at 100 ms^{-1} embeds itself in the centre of a block of wood mass 1 kg. which is suspended by light vertical string 1 m. in length. Calculate the maximum inclination of the string to the vertical. [4]
Ans: 35.9°

48. **2051 Q.No. 5** A bullet of mass 10g is fired from a gun of mass 1 kg. with a velocity of 100 ms^{-1}. Calculate the ratio of the kinetic energy of the bullet and the gun. [4]
Ans: 100 : 1

49. **2050 Q.No. 3 OR** Find the power of an engine in kilowatts which pulls a train of mass 600 tonnes up an incline of 1 in 100 at the rate of 60 km/hr. The weight of the engine is 200 tonnes and the resistance due to friction is 50 Newton's per tonne. [4]
Ans: 2000 KW

6. Circular Motion

FORMULAE

1. The angular displacement, $\theta = \frac{l}{r}$
2. Angular velocity, $\omega = \frac{\text{angular displacement}}{\text{time taken}} = \frac{\theta}{t}$
3. The relation of linear velocity and angular velocity: $v = r\omega$
4. Angular acceleration, $\alpha = \frac{\text{angular velocity}}{\text{time taken}} = \frac{\omega}{t}$.
5. Let T, f and ω are related as , $\omega = 2\pi f$, $f = \frac{1}{T}$ and $\omega = \frac{2\pi}{T}$.
6. Centripetal acceleration, $\alpha = \frac{v^2}{r} = \omega^2 r$.
7. Centripetal force, $F = \frac{mv^2}{r} = m\omega^2 r$.

8. Motion in vertical circle,

i. At the lowest point, the maximum tension,

$T_{max} = \frac{mv^2}{r} + mg$

ii. At the highest point, the minimum tension,

$T_{min} = \frac{mv^2}{r} - mg$

iii. At horizontal diametrical points

$T_{av} = \frac{mv^2}{r}$

9. Motion of Cyclist, $\tan\theta = \frac{v^2}{rg}$

10. Motion at Banked Road,

$R\sin\theta = \frac{mv^2}{r}$, $R\cos\theta = mg$, $\tan\theta = \frac{v^2}{rg}$, $v_{max} = \sqrt{\mu rg}$.

11. Motion of Conical Pendulum, $T\sin\theta = \frac{mv^2}{r}$,

$T\cos\theta = mg$, $\tan\theta = \frac{v^2}{rg}$ and $t = 2\pi\sqrt{\frac{l\cos\theta}{g}}$.

Short Answer Questions

1. 2075 Set B Q.No. 1e A stone tied at one end of a string is whirled in a vertical circle. Where will the tensions in the string be maximum and minimum? Show them in a diagram. [2]
2. 2074 Supp. Q.No. 1d 2060 Q.No. 1c What is the source of centripetal force to a satellite revolving round the earth? [2]
3. 2073 Set C Q.No. 1c If there is a net force acting on a particle in uniform circular motion, why does the particle's speed not change? [2]
4. 2073 Set D Q.No. 1e Why is it more difficult to move a stone tied with a longer string than a stone tied with a shorter string? [2]
5. 2072 Set C Q.No. 1d Why is it more difficult to revolve a stone by tying it to a longer string than by tying it to a shorter string? [2]
6. 2071 Supp Q.No. 1c In a washing machine, there is a spin dryer, which removes the water from clothes easily. What could be its working principle? Justify. [2]
7. 2071 Set C Q.No. 1 f Explain the significance of the banking of a curved road. [2]
8. 2071 Set D Q.No. 1 e Explain the difference between a simple and conical pendulum. [2]
9. 2070 Supp (Set B) Q.No. 1 f Why does a cyclist lean from vertical while turning on curved track? [2]
10. 2067 Supp Q.No. 1 d Roads are banked at the turnings, why? [2]
11. 2067 Q.No. 1 c 2054 Q.No. 1e Explain why a cyclist inclines himself to the vertical while moving round a circular path. [2]
12. 2063 Q.No. 1e 2056 Q.No. 1a The positively charged nucleus of an atom attracts the electrons in the orbit. Why do electrons not collapse into the nucleus? [2]
13. 2062 Q.No. 1 a Why are curved roads banked? Explain. [2]
14. 2059 Q.No. 1 d Why are roads banked on curved path? [2]
15. 2055 Q.No. 1 g Why does a cyclist bend while going along curved road? [2]
16. 2053 Q.No. 2 a What is meant by angular velocity? [2]
17. 2052 Q.No. 1 f When a bus takes a turn, passengers are thrown away from the centre of the curved path. Why? [2]
18. 2052 Q.No. 1 g A solid tied at the end of a string is revolved in vertical. At what point the tension in the string will be the greatest? [2]

Long Answer Questions

19. 2076 Set C Q.No. 5b What is meant by banking of a road? Discuss the motion of a vehicle round a banked circular track and obtain an expression for the banking angle in terms of speed of the vehicle. [4]
20. 2075 GIE Q.No. 5b 2069 Supp Q.No. 5b Define centripetal force. Show that the acceleration of the body moving in a circular path of radius r with uniform speed v is v^2/r and draw a diagram to show the direction of the acceleration. [4]
21. 2075 Set A Q.No. 5b What is a conical pendulum? Obtain an expression for its time period. [4]
22. 2075 Set B Q.No. 5d What is the difference between the conceptual design of a conical pendulum with respect to that of a simple pendulum? Derive relations of time period and frequency of a conical pendulum. [4]
23. 2074 Set A Q.No. 5b What is a conical pendulum? Derive an expression for its time period. [4]
24. 2073 Set D Q.No. 5b Describe the motion of a conical pendulum and derive an expression for its time period. [4]
25. 2072 Set C Q.No. 5a Define centripetal and centrifugal forces. Derive an expression for the force acting on a body moving with uniform speed along a circular path. [4]
26. 2071 Set D Q.No. 5 a What do you mean by the banking of a curved path? Derive an expression for the banking angle. [4]
27. 2070 Supp (Set A) Q.No. 5 b Define centripetal force. Show that the acceleration of a body moving in a circular path of radius 'r' with uniform speed v is v^2/r and is directed towards the centre of circular. [4]
28. 2069 Old (Set B) Q. No. 3a Define centripetal force. Calculate the force acting on a body moving with a uniform speed along circular path. [1+3]
29. 2068 Q.No. 5 c What is conical pendulum? Show that the period of oscillation of this pendulum is given by: $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$ [4]
30. 2068 Old Q.No. 3 a Define centripetal force. Discuss the motion of a car moving round in a circular bonked track. [1+3]
31. 2066 Q. No. 5 c What is conical pendulum? Show that the period of oscillation of this pendulum is given by $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$ where symbols have their usual meanings. [4]
32. 2066 Old Q. No. 3 a Define the centripetal force. Derive an expression for the force acting on a body moving with uniform speed along a circular path. [1+3]
33. 2062 Q.No. 3 OR What is centripetal force? Derive it in the case of motion of a bi-cycle on a curved road. [4]
34. 2061 Q.No. 2 a Explain what is meant by angular velocity. Show that the acceleration of a body moving in a circular path of radius r with uniform speed v is v^2/r. [1+3]
35. 2058 Q.No. 2 OR Define centripetal acceleration. Derive an expression for it. [1+3]

36. 2056 Q.No. 2 OR Define centripetal force. Calculate the force acting on a body moving with a uniform speed along a circular path. [4]

37. 2053 Q.No. 2 b Derive an expression for the force required to make a particle of mass m move in a circle of radius r with uniform angular velocity ω. [4]

38. 2051 Q.No. 2 Why a force is necessary to keep a body moving with uniform speed in a circular motion? Deduce its expression. [4]

Numerical Problems

39. 2076 Set B Q.No. 9b A bob of mass 200 gram is whirled in a horizontal circle of radius 50 cm by a string inclined at 30° to the vertical. Calculate the tension in the string and the speed of the bob in the horizontal circle. [4]
Ans: 2.3 N, 1.7 m/s

40. 2073 Supp Q.No. 9d An object of mass 0.5 kg is rotated in a horizontal circle by a string in 1 m long. The maximum tension in the string before it breaks is 50 N. What is the greatest number of revolutions per second of the object? [4]
Ans: 1.6 rev/sec

41. 2072 Set D Q.No. 9c A stone with mass 0.8 kg is attached to one end of a string 0.9 m long. The string will break if its tension exceeds 600 N. The stone is whirled in a horizontal circle, the other end of the string remains fixed. Find the maximum speed, the stone can attain without breaking the string. [4]
Ans: 0.85 rev/ sec

42. 2072 Set E Q.No. 9a An object of mass 4 kg is whirled round a vertical circle of radius 1 m with a constant speed of 3 ms^{-1}. Calculate the maximum tension in the string. [4]
Ans: 76 N

43. 2071 Set C Q.No. 9 b A mass of 0.2 Kg is rotated by a string at a constant speed in a vertical circle of radius 1 m. If the minimum tension in the string is 3 N, calculate the magnitude of the speed and the maximum tension in the string. [4]
Ans: 5 m/sec; 7 N

44. 2071 Set D Q.No. 9 c At what angle should a circular road be banked so that a car running at 50 Km/hr be safe to go round the circular turn of 200 m radius? [4]
Ans: 5.5°

45. 2070 Set C Q.No. 9 b A mass of 1 kg is attached to the lower end of a string 1 m long whose upper end is fixed. The mass is made to rotate in a horizontal circle of radius 60 cm. If the circular speed of the mass is constant, find the tension in the string and the period of motion. [4]
Ans: 12.5N, 1.77 Sec

46. 2070 Set D Q.No. 9 b A certain string breaks when a weight of 25N acts on it. A mass of 500 gram is attached to one end of the string of 1 m long and is rotated in a horizontal circle. Find the greatest number of revolutions per minute which can be made without breaking the string. [4]
Ans: 67.5 rpm

47. 2059 Q.No. 3 b An object of mass 8.0 kg is whirled round in a vertical circle of radius 2m with a constant speed of 6ms^{-1}. Calculate the maximum and the minimum tensions in the string. [4]
Ans: 224 N, 64 N

48. 2052 Q.No. 3 A coin placed on a disc rotates with speed of $33\frac{1}{3}$ rev. min^{-1} provided that the coin is not more than 10 cm. from the axis. Calculate the coefficient of static friction between the coin and the disc. [4]
Ans: 0.122

7. Gravitation

Values of Physical Constants
Acceleration due to gravity (g) = 10 m/s^2

FORMULAE

1. The gravitational force, $F = G\frac{m_1m_2}{r^2}$
2. The acceleration due to gravity, $g = \frac{GM}{R^2}$
3. The mean density of the earth, $\rho = \frac{3g}{4\pi GR}$
4. Acceleration due to gravity g at height h, $g' = g\left(1 - \frac{2h}{R}\right)$, for h<<R
5. Acceleration due to gravity g at depth x, $g' = g\left(1 - \frac{x}{R}\right)$
6. Acceleration due to gravity g due to the rotation of the earth, $g' = g\left(1 - \frac{R\omega^2\cos^2\phi}{g}\right)$
7. The intensity of gravitational field, $E = \frac{GM}{r^2}$
8. The gravitational potential, $V = \frac{-GM}{r}$
9. Gravitational potential energy is, $U = -\frac{GMm}{r}$
10. Total gravitational energy,
    $T.E. = K.E. + P.E. = \frac{1}{2}mv^2 + \left(-\frac{GMm}{r}\right)$,
    v = orbital velocity.
11. Escape velocity, $v_e = \sqrt{2gR}$
12. Motion of satellite,
    Orbital velocity, $v = R\sqrt{\frac{g}{R+h}}$,
    Time period, $T = \frac{2\pi}{R}\sqrt{\frac{(R+h)^3}{g}}$,
    Height, $h = \left(\frac{T^2R^2g}{4\pi^2}\right)^{1/3} - R$
13. The Schwarzschild radius of black hole is, $R_s = \frac{2GM}{c^2}$.

Short Answer Questions

1. 2076 Set B Q.No. 1d A person sitting in an artificial satellite of the earth feels weightlessness, but a person standing on moon has weight through the moon is a satellite of the earth. Why? [2]
2. 2076 Set C Q.No. 1d If the earth suddenly stops rotating about its axis, what would be the effect on 'g' ? Would this effect be the same at all places? [2]
3. 2075 GIE Q.No. 1c Suppose the radius of the earth were to shrink by 2%, its mass remaining the same, would the acceleration due to gravity 'g' increase or decrease and by what percent? [2]

4. 2075 GIE Q.No. 1d An astronaut releases a spoon out of a satellite in the space. Will the spoon fall on the earth? [2]
5. 2075 Set A Q.No. 1f How does the weight of a body vary on going from earth to moon? Would its mass change? [2]
6. 2074 Set A Q.No. 1f Distinguish between gravitational potential and gravitational field strength. [2]
7. 2074 Set B Q.No. 1g What is a black hole? Explain its characteristic nature. [2]
8. 2073 Set C Q.No. 1d An astronaut inside a small space ship orbiting around the earth does not experience any gravity. But an astronaut on the moon which is also orbiting around the earth does experience gravity. Why? [2]
9. 2073 Set D Q.No. 1d If the earth suddenly stops rotating about its axis, what would be the effect on acceleration due to gravity at [2]
   i. the equator ii. the poles?
10. 2072 Set C Q.No. 1e An astronaut in a space capsule orbiting the earth experiences weightlessness. Why? [2]
11. 2072 Set D Q.No. 1c At what condition does a body become weightless at the equator? [2]
12. 2072 Set E Q.No. 1c Write the unit and dimension of gravitational field with its definition. [2]
13. 2071 Set C Q.No. 1e 2071 Set D Q.No. 1g What is a black hole? Write down its characteristic features. [2]
14. 2070 Supp (Set A) Q.No. 1 e If heavier bodies are attracted more strongly by the earth why do they not fall faster than lighter ones? (neglect air resistance) [2]
15. 2070 Set C Q.No. 1 g What will happen to the value of acceleration due to gravity if the earth stops rotating about its axis? [2]
16. 2069 Supp Q.No. 1c Suppose the radius of the earth were to shrink by 2%, its mass remaining the same, calculate the percent change in the acceleration due to gravity 'g'. [2]
17. 2069 (Set A) Q. No. 1b 2067 Q.No. 1d 2066 Q. No. 1c If the sun some how collapsed to form a black-hole, what effect would this event have on the orbit of the earth? [2]
18. 2068 Q.No. 1 e If the force of gravity acts on all bodies in proportion to their masses, why does not a heavy body fall faster than a light body? [2]
19. 2064 Q.No. 1 f If earth suddenly stops rotating about its axis, what would be the effect on g? [2]
20. 2062 Q.No. 1 d What do you mean by geo-stationary satellite? Explain. [2]
21. 2058 Q.No. 1 d Explain why the moon has no atmosphere? [2]
22. 2055 Q.No. 1 b How does 'g' at a point vary with the distance from the centre of the earth? Where is the highest value of g? Explain. [2]
23. 2054 Q.No. 1 d Why an astronaut in a space capsule orbiting the earth experiences a feeling of weightlessness? [2]
24. 2053 Q.No. 1 d The weight of a body is less inside the earth than on the surface. Explain. [2]
25. 2052 Q.No. 1 d Obtain an expression for gravitational potential energy and establish its dimension. [2]
26. 2051 Q.No. 1 v What will happen to the value of 'g' if the earth stops rotating? [2]

Long Answer Questions

27. 2076 Set B Q.No. 5a What is escape velocity? Derive an expression for it on the surface of the earth. [4]
28. 2075 GIE Q.No. 5c What is escape velocity? Show that the velocity of escape of a body is $\sqrt{2}$ times the orbital velocity? [4]
29. 2074 Set B Q.No. 5a Explain the meaning of escape velocity based on the concept of gravitational potential. Hence derive expression for escape velocity of a body thrown from the surface of the earth. [4]
30. 2073 Set C Q.No. 5b What is escape velocity? Derive an expression for the escape velocity on the surface of the earth. [4]
31. 2072 Set D Q.No. 5b What is a geostationary satellite? Derive an expression for the time period of the satellite revolving around the earth? [4]
32. 2072 Set E Q.No. 5a Derive expressions for the time period and height of artificial satellite from the surface of the earth. [4]
33. 2071 Supp Q.No. 5c Obtain an expression for variation of 'g' with rotation of earth. [4]
34. 2071 Set C Q.No. 5 c Explain the concept of geostationary satellite. Find an expression for the total energy of the moon revolving around the earth. [4]
35. 2070 Supp (Set A) Q.No. 5 c What is escape velocity? Show that the escape velocity of a body is $\sqrt{2Rg}$. Where symbols have usual meanings? [4]
36. 2070 Supp (Set B) Q.No. 5 b Define gravitational potential energy and derive its expression. [4]
37. 2070 Set C Q.No. 5 b Define escape velocity. Find an expression for the escape velocity from the surface of the earth. [4]
38. 2070 Set D Q.No. 5 b What is a gravitational potential energy? Obtain an expression for the gravitational potential energy of a body at a distance r from the centre of the earth. [4]
39. 2069 (Set A) Q. No. 5b What is geo stationary satellite? Obtain an expression for the total energy of a satellite orbitting round the earth? [4]
40. 2069 (Set B) Q. No. 5c What do you mean by the terms black hole and event horizon? Obtain an expression for the schwarzschild radius. [4]
41. 2069 (Set A) Old Q. No. 2a or What is escape velocity? Derive an expression for it. [1+4]
42. 2069 (Set B) Old Q. No. 3a OR What do you mean by parking orbit? Derive an expression for the orbital velocity and hence find time period of the satellite revolving around the earth. 1+3
43. 2068 Q.No. 5 a What is escape velocity? Derive its expression on the surface of the earth. [4]
44. 2068 Old Q.No. 3 a or Derive an expression for the variation of acceleration due to gravity of the earth with the altitude and explain its meaning. [1+3]
45. 2067 Q.No. 5 c What is a satellite? Obtain an expression of the total energy of a satellite orbiting round the earth. [3]
46. 2066 Old Q. No. 2 a What is escape velocity? Prove that escape velocity of a body from earth's surface is $\sqrt{2gR}$ where g is the acceleration due to gravity on the surface of the earth and R is the radius of the earth. [4]

47. 2065 Q. No. 3 a OR What do you mean by parking orbit? Derive an expression for the orbital velocity and hence find time period of the satellite revolving around the earth. [1+3+1]

48. 2064 Q.No. 3 a How does acceleration due to gravity vary with distance from the centre of earth above and below its centre? [2+2]

49. 2063 Q.No. 3 a Suppose that a strong man can throw a stone so that it will never return to the surface of earth. How much work does he have to do in throwing up the stone of mass 'm' and find an expression for its minimum velocity? [4]

50. 2061 Q.No. 3 a Explain what is meant by the universal gravitational constant. Discuss the variation of acceleration due to gravity with attitude and derive an expression for its value at height h above the surface of the earth. [1+4]

51. 2060 Q.No. 3 a Explain what is meant by the universal gravitational constant. Discuss the variation of acceleration due to gravity with depth and derive an expression for its value at depth d below the surface of the earth. [1+3]

52. 2059 Q.No. 2 a Define escape velocity of a body on a planet. Derive an expression for it. [1+3]

53. 2058 Q.No. 3 a What is acceleration due to gravity? Explain how it veries with the altitude. [1+3]

54. 2057 Q.No. 3 a What is gravitational potential? Derive the relation for gravitational potential at a point due to a point mass. [1+4]

55. 2056 Q.No. 2 a What is a satellite? Calculate the orbital velocity of an artificial satellite. [4]

56. 2053 Q.No. 4 Discuss the variation of acceleration due to gravity below the earth's surface. [3]

57. 2050 Q.No. 6 OR Assuming the earth to be perfectly spherical, give sketch graphs to show how:
   a. The acceleration due to gravity, and
   b. The gravitational potential due to earth's mass vary with distance from the surface of the earth to points external to it. [4]

Numerical Problems

58. 2076 Set C Q.No. 9b A remote sensing satellite of the earth revolves in a circular orbit at a height of 250 km above the earth's surface. What is the orbital speed and period of revolution of the satellite? [4]
Ans: 7835.5 m/sec, 5314 sec

59. 2075 Set A Q.No. 9b A man can jump 1.5 m on earth. Calculate the approximate height he might be able to jump on a planet whose density is one quarter of the earth and where radius is one third that of the earth. [4]
Ans: 18 m

60. 2075 Set B Q.No. 9a An artificial satellite revolves round the earth in 2.5 hours in a circular orbit. Find the height of the satellite above the earth assuming earth as a sphere of radius 6370 km. [4]
Ans: 3040 Km

61. 2074 Supp. Q.No. 9b Obtain the value of g from the motion of moon assuming that its period of rotation round the earth is 27 days 8 hours and the radius of its orbit is 60.1 times the radius of the earth. [4]
Ans: 9.76 m/sec^2

62. 2074 Set A Q.No. 9d The period of moon revolving under the gravitational force of the earth is 27.3 days. Find the distance of the moon from the centre of the earth if the mass of earth is 5.97×10^{24} kg. [4]
Ans: 3.83×10^8 m

63. 2073 Supp Q.No. 9b Mass of earth is nearly 81 times heavier than the moon. Its diameter is about 4 times larger than that of the moon. Estimate the value of acceleration of gravity on the surface of the moon. [4]
Ans: 1.94 m/s^2

64. 2073 Set D Q.No. 9b Taking the earth to be uniform sphere of radius 6400km, calculate the total energy needed to raise a satellite of mass 1000 kg to a height of 600 km above the ground and to set it into circular orbit at that altitude. [4]
Ans: 3.47×10^{10} J

65. 2072 Set C Q.No. 9b Taking the earth to be uniform sphere of radius 6400 km and the value of g at the surface to be 10 ms^{-2}, calculate the total energy needed to raise a satellite of mass 2000 kg to a height of 800 km above the ground and to set it into circular orbit at that altitude. [4]
Ans: 7.12×10^{10} J

66. 2071 Set D Q.No. 9 d An earth satellite moves in a circular orbit with a speed of 6.2 kms^{-1}. Find the time of one revolution and its centripetal acceleration. [4]
Ans: 2.99 hrs, 3.6 m/sec^2

67. 2069 Supp Q.No. 9d Calculate the points along a line joining the centres of earth and moon where there is no gravitational force. [$M_e = 6\times10^{24}$ Kg, $M_m = 7.4\times10^{22}$ Kg, $d = 3.8\times10^8$m] [4]
Ans: 3.42×10^8m from earth centre

68. 2067 Supp Q.No. 9 b Assuming the earth to be uniform sphere of radius 6400 Km, calculate the total energy needed to raise a satellite of mass 2000 kg to a height of 800 km above the surface of the earth and to set it into circular orbit at that altitude. [4]
Ans: 7.12×10^{10}J

69. 2066 Q. No. 9 d What is the period of revolution of a satellite of mass m that orbits the earth in a circular path of radius 7880 km about 1500 km above the surface of the earth? [4]
Ans: 1.907 hr

70. 2054 Q.No. 3 Calculate the period of revolution of a satellite revolving at a distance of 20 km above the surface of the earth, (Radius of the earth = 6400 km. acceleration due to gravity = 10 m/s^2). [4]
Ans: 5048 sec

71. 2051 Q.No. 3 A 200 kg. satellite is lifted to an orbit of 2.2×10^4 km radius. If the radius and mass of the earth are 6.37×10^6 m and 5.98×10^{24} kg respectively, how much additional potential energy is required to lift the satellite? [4]
Ans: 4.47×10^7J

8. Equilibrium

FORMULAE

1. Torque, $\vec{\tau} = \vec{r} \times \vec{F}$
2. The principle of moment, $F_1 \times r_1 = F_2 \times r_2$

Short Answer Questions

1. 2076 Set B Q.No. 1e The passengers in a small boat are not allowed to stand, why? [2]

2. 2076 Set C Q.No. 1e A table lamp has a heavy and large base, why? [2]
3. 2075 Set A Q.No. 1c 2051 Q.No. 1 vi Why is a cow more stable than a man? [2]
4. 2074 Supp. Q.No. 1e Why a wrench of longer arm is preferred more? [2]
5. 2074 Set B Q.No. 1d One end of a solid rod of length L (in m) is fixed at one end. Can the magnitude and direction of torque be estimated if a force $\vec{F}$ (in N) act at a point l (in m) from the fixed end making an angle 150^0 with the horizontal? Explain. [2]
6. 2073 Set C Q.No. 1e 2073 Set D Q.No. 1f 2072 Set C Q.No. 1c 2070 Supp (Set A) Q.No. 1 d 2070 Set C Q.No. 1d Does the centre of gravity of a solid body always lie within the material of the body? Explain with example. [2]
7. 2072 Supp Q.No. 1c Does the centre of mass and centre of gravity lie at the same point? Explain with example. [2]
8. 2072 Set D Q.No. 1d A handle or a knob is fixed at the free end of the door. Explain why? [2]
9. 2071 Supp Q.No. 1d What is the difference between centre of mass and centre of gravity of a system? [2]
10. 2071 Set C Q.No. 1 g Mention the conditions of stable equilibrium. [2]
11. 2070 Set D Q.No. 1 e When four-legged animals walk, they always have three of their legs on the ground at any instant. Explain why? [2]
12. 2069 Supp Q.No. 1g A man carrying a load on his back leans forward. Why should he do so? [2]
13. 2069 (Set A) Old Q. No. 1b A coolie carrying a load on his back leans forward. Why? [2]
14. 2069 (Set B) Q. No. 1d Does the centre of gravity of a solid always lie within the material of the body? If not, give a counter example. [2]
15. 2068 Q.No. 1 c Explain why a man carrying a load on his back leans forward. [2]
16. 2068 Old Q.No. 1 d A man carrying a bucket full of water on his right hand always leans towards his left hand. Why? [2]
17. 2067 Q.No. 1 e During pregnancy, women often develop back pains from leaning backward while walking. Why do they have to walk this way? [2]
18. 2065 Q. No. 1 c Why a wrench of longer arm is preferred in comparison to a wrench of short arm? [2]
19. 2064 Q.No. 1 d Define the terms: Couple and moment of couple. [2]
20. 2058 Q.No. 1 e A man carrying a bucket of water on his hand always leans to the opposite side. Explain why? [2]
21. 2055 Q.No. 1 f Why is a horse more stable than a man? [2]
22. 2054 Q.No. 1 f Can a body be in equilibrium if it is in motion? Explain. [2]
23. 2053 Q.No. 1 g What is meant by the moment of a couple? [2]
24. 2053 Q.No. 1 e Explain why a man carrying a load on his back leans forward. [2]
25. 2052 Q.No. 1 b State principle of moment and give an example. [2]
26. 2051 Q.No. 1 ii What is the difference between centre of gravity and centre of mass of a system? [2]
27. 2050 Q.No. 1 vi Is it possible for a solid body to have matter at it centre of gravity? [2]

Long Answer Questions

28. 2059 Q.No. 3 a OR State principle of moments. Explain how you verify the principle of moment in your laboratory. [1+4]

Numerical Problems

29. 2075 Set B Q.No. 9b Two forces of 1.5 N and 2.0 N act vertically at the two ends of a metre scale. Where and in what direction should a force be applied so that the scale remains horizontally stable? [4]
Ans: 0.43 m from 2N or 0.57 from 1
30. 2072 Supp Q.No. 9b Two people are carrying a uniform wooden board that is 3m long and weights 160N. If one person applies an upward force equal to 60N at one end, at what point does the other person lift? [4]
Ans: 2.4 m from 60
31. 2050 Q.No. 4 A roller whose diameter is 1.0 m weights 360 N. What horizontal force is necessary to pull the roller over a brick 0.1m high when the force is applied at the centre? [4]
Ans: 270 N

9. Rotational Dynamics

FORMULAE

1. The counterpart symbols in translational motion and rotational motion,

Translational Motion	Rotational Motion
1. Linear displacement=s	1. Angular displacement=θ
2. Linear velocity, $v = \frac{ds}{dt}$	2. Angular velocity, $\omega = \frac{d\theta}{dt}$
3. Linear acceleration, $a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$	3. Angular acceleration, $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$
4. Mass, m	4. Moment of inertia, I
5. Linear momentum, $p = mv$	5. Angular momentum, $L = I\omega$
6. Force, $F = \frac{dp}{dt} = ma$	6. Torque, $\tau = \frac{dL}{dt} = I\alpha$
7. Work done by force, $W = Fs$	7. Work done by torque, $W = \tau\theta$
8. Translational kinetic energy, $E_k = \frac{1}{2}mv^2$	8. Rotational Kinetic energy, $E_k = \frac{1}{2}I\omega^2$
9. Equations of translational motion; i. $s = ut$ ii. $v = u + at$ iii. $s = ut + \frac{1}{2}at^2$ iv. $v^2 = u^2 + 2as$	9. Equations of rotational motion: i. $\theta = \omega_0 t$ ii. $\omega = \omega_0 + \alpha t$ iii. $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ iv. $\omega^2 = \omega_0^2 + 2\alpha\theta$

2. The moment of inertia, $I = \sum_{i=1}^{n} m_i r_i^2$
3. Radius of gyration, $K = \sqrt{\frac{r_1^2 + r_2^2 + \ldots + r_n^2}{n}}$
4. The total kinetic energy of a rolling body, $K.E. = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$
5. Conservation of angular momentum, $I_1\omega_1 = I_2\omega_2$

6. The acceleration of a cylinder rolling down an inclined plane,

$$a = \frac{g \sin\theta}{1 + \frac{I}{Mr^2}}$$

Short Answer Questions

1. 2076 Set B Q.No. 1f 2073 Set C Q.No. 1f If the ice on the polar caps of the earth melts, how will it affect the duration of the day? Explain. [2]
2. 2076 Set C Q.No. 1f Can you distinguish a raw egg and a hardboiled egg by spinning each one on the table? Explain.[2]
3. 2075 Set A Q.No. 1e Experienced cooks can tell whether an egg is raw or hard boiled by rolling it down a slope. How is this possible? What are they looking for? [2]
4. 2075 Set B Q.No. 1d Both "the work done by a force" and "the torque produced by a force" are the product of force and the position vector. How can one make the difference between the two? Explain. [2]
5. 2074 Supp. Q.No. 1f If earth shrinks, how will be the duration of a day affected? [2]
6. 2074 Set A Q.No. 1g Does the angular momentum of a body moving in a circular path change? Give explanation to your answer. [2]
7. 2072 Supp Q.No. 1g 2069 (Set B) Q. No. 1e The cap of a bottle can be easily opened with the help of two fingers than with one finger. Why? [2]
8. 2071 Supp Q.No. 1e The work done by a force is the product of force and distance. The torque due to the force is the product of force and distance. Does this mean that torque and work are equivalent? Explain. [2]
9. 2070 Supp (Set A) Q.No. 1 f A ballet dancer stretches her hands when she wants to come to rest. Why? [2]
10. 2070 Supp (Set B) Q.No. 1 d A flywheel rotates with constant angular velocity. Does a point on its rim have a tangential acceleration? A radial acceleration? Are these accelerations constant in magnitude? In direction? In each case give the reasoning behind your answer. [2]
11. 2070 Set D Q.No. 1 g 2067 Supp Q.No. 1 e 2051 Q.No. 1 iii A fan with blades takes longer time to come to rest than without blades. Why? [2]
12. 2069 Old (Set B) Q. No. 1e A solid sphere and a hollow cylinder of same mass and same size is rolling down on an inclined plane from rest. Which one reaches the bottom first? Why?[2]
13. 2068 Old Q.No. 1 e A ballet dancer can increase or decrease her spining rate by using the principle of conservation of angular momentum, how ? [2]
14. 2058 Q.No. 1 c A ballet dancer stretches her arms to reduce her motion. Explain. [2]
15. 2057 Q.No. 1 e A dancer girl is rotating over a turnatable with her arms outstretched. If she lowers her arms how does this effect her motion? [2]
16. 2056 Q.No. 1 d Explain why spokes are fitted in the cycle wheel. [2]
17. 2055 Q.No. 1 c What is the counterpart of the mass and force in rotational motion? [2]
18. 2054 Q.No. 1 h Suppose that only two external forces act on a rigid body and the two forces are equal in magnitude but opposite in direction. Under what conditions will the body rotate? [2]
19. 2053 Q.No. 1 f If the earth is struck by meteorites, the earth will slow down slightly. Why? [2]
20. 2050 Q.No. 1 iii Why is it easier to hold down a 10 kg. body in your hand at your side than to hold it with your arm extended horizontally? [2]

Long Answer Questions

21. 2076 Set B Q.No. 5c Define moment of inertia. Derive an expression for the moment of inertia of thin uniform rod about an axis through its centre and perpendicular to its length. [4]
22. 2075 Set A Q.No. 5c Show that in rotational motion, power is the product of torque and angular velocity. [4]
23. 2075 Set B Q.No. 5c What is the physical meaning of moment of inertia of a rigid body? Also derive its expression in the case of a thin and uniform rod about an axis passing through one end and perpendicular to its length. [4]
24. 2074 Supp. Q.No. 5b What is meant by moment of inertia? How is it related with the rotational kinetic energy of a body? [4]
25. 2074 Set A Q.No. 5c Explain the concept of torque and angular acceleration in the case of a rigid body. Derive a relation between them. [4]
26. 2074 Set B Q.No. 5d Define moment of inertia. How is it related with angular momentum of a body rotating about an axis of rotation? [4]
27. 2073 Supp Q.No. 5b Define torque and couple in rotational motion. Also derive an expression for the work done by a couple. [4]
28. 2073 Set C Q.No. 5c Define moment of inertia. Obtain an expression for the moment of inertia of a thin and uniform rod about an axis passing through the centre and perpendicular to its length. [4]
29. 2072 Supp Q.No. 5d What is radius of gyration? Show that the acceleration of a body rolling down an inclined plane is $a = \frac{MgSin\theta}{(M+\frac{I}{R^2})}$, where θ is the angle of inclination of the plane through which a body rolls down. M is the mass of the body, I is the moment of inertia and R is the radius. [4]
30. 2072 Set D Q.No. 5c Define moment of inertia and radius of gyration. Derive an expression for the kinetic energy of rotation of a rigid body. [4]
31. 2072 Set E Q.No. 5d State and explain the principle of conservation of angular momentum with example. [4]
32. 2071 Set C Q.No. 5 a Define torque and couple in rotational motion. Derive an expression for the work done by the couple. [4]
33. 2071 Set D Q.No. 5 d What do you mean by a rigid body? Obtain an expression for the moment of inertia of a thin and uniform rod about an axis passing through the centre and perpendicular to its length. [4]
34. 2070 Set C Q.No. 5 c Derive a relation between torque applied and angular acceleration produced in a rigid body and hence define moment of inertia. [4]

35. 2070 Set D Q.No. 5 d Derive a relation between angular momentum and moment of inertia of a rigid body and hence define moment of inertia. [4]

36. 2069 Supp Q.No. 5d Define moment of inertia. Obtain an expression for the moment of inertia of a thin rod about an axis passing through one end and perpendicular to its length. [4]

37. 2068 Q.No. 5 b Define moment of inertia and angular momentum. Establish a relation between them. [4]

38. 2066 Old Q. No. 3 a OR What is meant by a couple? Derive an expression for the work done by a couple. [1+3]

39. 2062 Q.No. 2 a Define the terms: couple and moment of a couple. Derive an expression for the work down by a couple. [1+1+3]

40. 2060 Q.No. 3 OR Explain the meaning of the term 'moment of inertia'. Show that the quantity 1/2 IW^2 is the Kinetic energy of rotation of a rigid body rotating about an axis with angular velocity w. [1+3]

41. 2057 Q.No. 3 OR Define moment of inertia. How is it related with rotational kinetic energy of a body? [1+4]

42. 2051 Q.No. 4 OR What is meant by moment of inertia? How is it related with the rotational kinetic energy of a body? [4]

Numerical Problems

43. 2076 Set C Q.No. 9c A wheel starts from rest and accelerates with constant angular acceleration to an angular velocity of 15 revolutions per second in 10 seconds. Calculate the angular acceleration and angle which the wheel has rotated at the end of 2 second. [4]

Ans: 9.42 rad/sec², 188.4 radian

44. 2075 GIE Q.No. 9c A ballet dancer spins with 2.4 rev/s with her arms outstretched when the moment of inertia about the axis of rotation is I. With her arms folded, the moment of inertia about same axis becomes 0.6I. Calculate the new rate of spin. [4]

Ans: 4 rev/sec

45. 2073 Set D Q.No. 9c An electric fan is turned off, and its angular velocity decreases uniformly from 500 rev/min to 200 rev/min in 4 seconds. Find the angular acceleration and the number of revolutions made by the motor in the 4 sec interval. [4]

Ans: –7.85 rad/sec², 23.3

46. 2072 Set C Q.No. 9d 2070 Supp (Set A) Q.No. 9d 2061 Q.No. 3b 2054 Q.No. 5 A constant torque of 500 Nm turns a wheel which has a moment of inertia 20 kgm² about its center. Find the angular velocity gained in 2 second and the kinetic energy gained. [4]

Ans: 50 rad/sec, 25,000J

47. 2072 Set E Q.No. 9b A disc of radius 1 m and mass 5 kg is rolling along a horizontal plane. Its moment of inertia about its centre is 2.5 kg m². If its velocity along the plane is 2 ms^{-1}, find its angular velocity and the total energy. [4]

Ans: 2 rad/sec, 15 J

48. 2071 Supp Q.No. 9b A constant torque of 500Nm turns a wheel about its center. The moment of inertia about this axis is 100 kgm². Find the angular velocity gained in 4 seconds and kinetic energy gained after 20 revolutions. [4]

Ans: 20 rad/sec, 62800

49. 2070 Supp (Set B) Q.No. 9 c A computer disk drive is turned on starting from the rest and has constant angular acceleration. (a) how long did it take to make the first complete rotation and (b) what is its angular acceleration? Given that the disk took 0.750 sec for the drive to make its second complete revolution. [4]

Ans: 1.81 sec, 3.83 rad/sec²

50. 2069 Supp Q.No. 9c A constant torque of 200 Nm turns a wheel about its centre. The moment of Inertia about the axis is in 100 kg m². Find the angular velocity gained in 4 seconds and the kinetic energy gained after 10 revolutions. [4]

Ans: 8 rad/sec, 12566.4J

51. 2069 (Set A) Q. No. 9b A ballet dancer spins with 2.4 rev/sec with her arms outstretched when the moment of inertia about the axis of rotation is I. With her arms folded, the moment of inertia about the same axis becomes 0.6I. Calculate the new rate of spin. [4]

Ans: 4

52. 2069 (Set A) Old Q. No. 2b 2055 Q.No. 3 A constant torque of 200N turns a wheel about its center. The moment of inertia of it about the axis is 100 kg m². Find the K.E. gained after 20 revolutions when it starts from rest. [4]

Ans: 25132.7 J

53. 2067 Supp Q.No. 9 c A ballet dancer spins about a vertical axis at 1 revolution per second with her arms stretched. With her arms folded, her moment of inertia about the axis decreases by 40%, calculate the new rate of revolution. [4]

Ans: 1.67 rps

54. 2067 Q.No. 9 b An electric fan is turned off, and its angular velocity decreases uniformly from 500 rev/min to 200 rev/min in 4.00s (a) Find the angular acceleration and the number of revolutions made by the motor in 4.00s interval. (b) How many more seconds are required for the fan to come to rest if the angular acceleration remains constant? [4]

Ans. -7.85 rad s^{-2}, 23.3, 2.68 sec

55. 2066 Q. No. 9 b A disc of moment of inertia 5×10^{-4} kg m² is rotating freely about the axis through its centre at 40 rpm. Calculate the new revolution per minute if some wax of mass 0.02 kg is dropped gently on to the disc 0.08 m from the axis. [4]

Ans: n = 32 rpm

56. 2063 Q.No. 3 b A constant torque of 200 Nm turns a wheel about its centre. The moment of inertia about this axis is 100 kg m². Find the kinetic energy gained after 20 revolutions. [4]

Ans: 25132.82 J

57. 2052 Q.No. 3 OR Speed of a body spinning about an axis increase from rest to 100 rev. min^{-1} in 5 sec., if a constant torque of 20 Nm is applied. The external torque is then removed at the body comes to rest in 100 sec. due to friction. Calculate the frictional torque. [4]

Ans: 1 Nm

10. Elasticity

Values of Physical Constants
Young's modulus of steel = 2×10^{11} Nm^{-2}

FORMULAE

1. Stress = $\frac{\text{Force}}{\text{Area}} = \frac{F}{A}$
2. Strain = $\frac{\text{Change in confugiration}}{\text{original configuration}}$

i. Longitudinal strain = $\frac{\text{Change in length}}{\text{Original length}} = \frac{\Delta L}{L} = \frac{e}{L}$

ii. Volumetric strain = $\frac{\text{Change in volume}}{\text{Original volume}} = \frac{\Delta V}{V}$

iii. Shear strain = angle of deviation from the original position = θ

3. Hooke's law, Stress $\propto$ strain
4. Moduli of elasticity,

i. Young's modulus of elasticity,
$Y = \frac{\text{Normal stress}}{\text{Longitudional strain}} = \frac{FL}{Ae}$.

ii. Bulk modulus of elasticity, $K = \frac{\text{Normal stress}}{\text{volume strain}} = \frac{-dP\,V}{\Delta V}$.

iii. Modulus of rigidity, $\eta = \frac{\text{tangential stress}}{\text{shear strain}} = \frac{F}{A\theta}$.

5. Total potential energy stored in the stretched wire,
$W = \frac{1}{2} F.e = \frac{1}{2}$ stress $\times$ strain $\times$ volume of wire

Energy density, $U = \frac{1}{2}$ stress $\times$ strain. For a missile, we use, $\frac{1}{2} F.e = \frac{1}{2} mv^2$

6. The Poisson's ratio, $\sigma = \frac{\text{lateral strain}}{\text{longitudional strain}} = \frac{-\Delta D/D}{\Delta L/L}$

Short Answer Questions

1. 2075 GIE Q.No. 1g Why do spring balances show wrong readings after long use? [2]
2. 2074 Set A Q.No. 1d 2073 Supp Q.No. 1c Will the Young's modulus of elasticity change if the load hanging on it is doubled? Why? [2]
3. 2072 Set D Q.No. 1e What is elastic limit and breaking stress? [2]
4. 2072 Set E Q.No. 1s Explain the physical meaning of Poisson's ratio. [2]
5. 2071 Supp Q.No. 1f 2057 Q.No. 1a Why are bridges declared unsafe after a long use? [2]
6. 2070 Supp (Set A) Q.No. 1g What happens in the Young's modulus of elasticity of a material when the load hanging on it is doubled? [2]
7. 2069 Supp Q.No. 1f Steel bridges are declared unsafe after a few decades of use. Why? [2]
8. 2069 (Set B) Q. No. 1f Compare the mechanical properties of a steel cable, made by twisting many thin wires together, with those of solid steel rod of the same diameter. [2]
9. 2069 Old (Set B) Q. No. 1f 2066 Q. No. 1f Explain in terms of breaking stress why elephant has thicker legs as compared to human beings? [2]
10. 2065 Q.No. 1 a How will you justify that stone is more rigid than iron? [2]
11. 2064 Q.No. 2 a Two wires A and B have equal lengths and are made of same material. If the diameter of wire A is twice that of wire B, which wire has the greater extension for a given load? [2]
12. 2063 Q.No. 1d 2059 Q.No. 1a Why are rubbers used as vibration absorbers? [2]
13. 2062 Q.No. 1a Differentiate between elasticity and plasticity. [2]
14. 2061 Q.No. 1a Explain why steel is said to be more elastic than rubber. [2]
15. 2058 Q.No. 1a Explain which one is more elastic-rubber or steel. [2]

Long Answer Questions

16. 2076 Set C Q.No. 5c Define elastic limit and Young's modulus of elasticity. How can you determine the Young's modulus for a material in the laboratory? Explain. [4]
17. 2075 GIE Q.No. 5d 2071 Supp Q.No. 5d 2069 (Set A) Q. No. 5d 2067 Q.No. 5d Derive an expression for the energy stored in a stretched string. Define the term energy density of a body under strain. [4]
18. 2075 Set B Q.No. 5b Explain Hooke's law with necessary figure and derive and expression for the energy density in a stretched wire. [4]
19. 2074 Supp. Q.No. 5c What does the term Strain refer to? Find an expression for energy stored in a stretched wire. [4]
20. 2073 Supp Q.No. 5a Derive an expression for the energy stored in a stretched wire. Also define Poisson's ratio. [4]
21. 2073 Set D Q.No. 5d Define Young's modulus of elasticity. Deduce an expression for the energy stored in a stretched wire. [4]
22. 2071 Set C Q.No. 5 b What do you understand by Poisson's ratio? Derive an expression for energy stored in a stretched wire. [4]
23. 2071 Set D Q.No. 5 b Define Young's modulus, bulk modulus, modulus of rigidity and Poisson's ratio. [4]
24. 2069 (Set A) Old Q.No. 3a What do you mean by elastic limit? Derive an expression for the energy stored in stretched wire. [3+1]
25. 2069 (Set B) Q. No. 5b What are the proportional limit and the elastic limit? Derive an expression for the energy stored in a stretched wire? [4]
26. 2068 Q.No. 5 d Define stress and strain. Derive an expression for energy stored in a stretched wire. [4]
27. 2066 Q.No. 3 a State Hooke's Law and describe different types of modulus of elasticity. [1+3]
28. 2062 Q.No. 3 a OR What does the term strain refers to? What are different types of strain? Find an expression for the energy stored in a wire. [1+1+1]
29. 2061 Q.No. 3 a Why is energy stored in a wire? Prove that the elastic energy stored per unit volume of a stretched wire is equal to ½ × stress × strain. [1+3]
30. 2060 Q.No. 3 a Define elastic limit and Young's modulus of elasticity. Explain how would you determine Young's modulus for a material in the form of a wire. [1+3]

31. 2058 Q.No. 3 a State Hooke's law. How would you verify it experimentally? [1+3]

32. 2057 Q.No. 3 a OR What is Poisson's ratio? Derive an expression for the energy stored in a stretched wire? [1+3]

Numerical Problems

33. 2076 Set B Q.No. 9c A copper wire and a steel wire of the same cross sectional area and of length 1 m and 2 m respectively are connected end to end. A force is applied, which stretches their combined length by 1 cm. Find how much each wire is elongated. [4]

Ans: 4.5×10^{-3} m and 5.5×10^{-3} m

34. 2075 Set A Q.No. 9c The rubber cord of a catapult has a cross-sectional area 1.0mm^2 and total unstretched length 10 cm. It is stretched to12 cm and then released to project a missile of mass 5.0g. Calculate the velocity of projection. [4]

Ans: 20 m/sec

35. 2074 Set B Q.No. 9b A wire of length 2.5 m and area of cross-section 1×10^{-6} m^2 has a mass of 15 kg hanging on it. What is the extension produced? How much is the energy stored in the extended wire if Young's modulus of wire is 2×10^{11} Nm^{-2}. [4]

Ans: 0.14 J

36. 2073 Set C Q.No. 9d A uniform steel wire of density 8000 kg m^{-3} weight 20 g and is 2.5 m long. It lengthens by 1 mm when stretched by a force of 80 N. Calculate the value of the Young's modulus of steel and the energy stored in the wire. [4]

Ans: 2×10^{11} N/m^2, 40×10^{-3} J

37. 2072 Supp Q.No. 9d What force is required to stretch a steel wire of cross-sectional area 1cm^2 to double its length? [4]

Ans: 2×10^7 N

38. 2072 Set C Q.No. 9c Calculate the work done in stretching a steel wire 100 cm in length and of cross-sectional area 0.030 cm^2 when a load of 100N is slowly applied before the elastic limit is reached. [4]

Ans: 8.33×10^{-3} J

39. 2070 Supp (Set A) Q.No. 9 c A uniform steel wire of density 7800 kgm^{-3} weights 16gm and is 250 cm long. It lengthens by 1.2 mm when stretched by a force of 80 N. Calculate the Young's modulus and the energy stored in the wire. [4]

Ans: 2.0×10^{11}N/m^2; 4.8×10^{-2} J

40. 2070 Supp (Set B) Q.No. 9 d A steel cable with cross-sectional area 3 cm^2 has an elastic limit of 2.40×10^8pa. Find the maximum upward acceleration that can be given a 1200 kg elevator supported by the cable if the stress is not exceed one third of the elastic limit. [4]

Ans: 20 m/sec^2

41. 2070 Set C Q.No. 9 c A vertical brass rod of circular section is loaded by placing a 5 kg weight on top of it. If its length is 50 cm and radius of cross section is 1 cm, find the contraction of rod and the energy stored in it. [4]

Ans: 2.3×10^{-6}m, 5.68×10^{-6}J

42. 2070 Set D Q.No. 9 c Calculate the work done is stretching a steel wire 100 cm in length end of cross sectional area 0.03cm^2 when a load of 100N is slowly applied without the elastic limit being reached. [4]

Ans: 8.3×10^{-3}J

43. 2069 (Set B) Q. No. 9d How much force is required to punch a hole 1 cm in diameter in a steel sheet 5mm thick whose shearing strength is 2.76×10^8 Nm^{-2}. [4]

Ans: 43354 N

44. 2068 Old Q.No. 3 b Find the work done in stretching a wire of cross sectional area 10^{-2} cm^2 and 2m long through 0.1 mm. If Y for the material of wire is 2×10^{11}Nm^{-2}. [3]

Ans: 5×10^{-3}J

45. 2067 Supp Q.No. 9 d A uniform steel wire of density 7800 kgm^2 weights 16 gram and is 250 cm. It lengthens by 1.2 mm when a load of 8 kg is applied. Calculate the value Young's modulus for the steel and the energy stored in the wire. [4]

Ans: 2.0×10^{11}N/m^2; 4.8×10^{-2}J

46. 2064 Q.No. 3 b A steel wire of density 8000 kg m^{-3} weighs 24 g and is 250 cm. long. It lengthens by 1.2 mm when stretched by a force of 80N. Calculate the Young's modulus for the steel and the energy stored in the wire. [4]

Ans: 1.4×10^{11} Nm^{-2}, 0.048J

11. Periodic Motion [Harmonic]

FORMULAE

1. Restoring force, $F = -ky$, where, k is the restoring force constant
2. The wave equation for S.H.M., $y = A\sin(\omega t + \phi_0)$
3. The displacement, velocity, acceleration, time period and frequency of SHM:

S. N.	Physical Quantity	Formula
i.	Displacement	$y = A\sin(\omega t + \phi)$
ii.	Velocity	$v = \omega\sqrt{A^2 - y^2}$, At mean position, $y = 0$, $v = A\omega = v_{max}$ At extreme position, $y = A$, $v = 0 = v_{min}$
iii.	Acceleration	$a = -\omega^2 y$ At mean position, $y = 0$, $a = 0 = a_{min}$ At extreme position, $y = A$, $a = -\omega^2 A = a_{max}$
iv.	Time period	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\text{Displacement}}{\text{Acceleration}}}$ In oscillation of spring, $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\text{Inertia factor}}{\text{Spring factor}}}$
v.	Frequency	$f = \frac{1}{T} = \frac{\omega}{2\pi}$

4. Energy in SHM: Kinetic energy, $E_k = \frac{1}{2}k(A^2 - x^2) = \frac{1}{2}m\omega^2(A^2 - x^2)$ and potential energy, $E_p = \frac{1}{2}kx^2 = \frac{1}{2}m\omega^2x^2$ Total energy, $E = \frac{1}{2}m\omega^2A^2$
5. Oscillation of simple pendulum: (i) Time period, $T = 2\pi\sqrt{\frac{l}{g}}$ (ii) frequency, $f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$
6. Oscillation of loaded spring: $T = 2\pi\sqrt{\frac{m}{k}}$

Short Answer Questions

1. 2075 Set B Q.No. 1f The position of a certain object in S.H.M. is given as x = 0.05 cos (290t + 2.5); where x is in meter and t is in sec. What are the amplitude, period and initial phase angle for this motion? [2]
   Ans: 0.05 m, 0.022 sec, 2.5 rad.
2. 2074 Set B Q.No. 1c If the length of second's pendulum is increased further by 200 percent, will it lose or gain time? [2]
3. 2073 Supp Q.No. 1b 2072 Set E Q.No. 1d What do you understand by a second's pendulum? If it is taken to moon, will it gain or lose time? Why? [2]
4. 2072 Supp Q.No. 1f A simple harmonic motion is represented, in usual notation, by y =a sin (wt + ϕ). Find its acceleration.[2]
5. 2071 Set C Q.No. 1 a How does the frequency of vibration of a simple pendulum related with its length? Hence estimate the frequency of a second's pendulum. [2]
   Ans: 1/2 Hz
6. 2071 Set C Q.No. 1 d In usual notation, a simple harmonic motion is given as y = a sin (ωt – ϕ). Find its acceleration: [2]
   Ans: a = – ω^2y
7. 2071 Set D Q.No. 1 f A SHM is represented as y = a cos (ωt + ϕ) in usual notation. Find its acceleration. [2]
   Ans: a = – ω^2y
8. 2069 Supp Q.No. 1e A pendulum clock is taken to moon, will it gain or lose the time? Why? [2]
9. 2068 Q.No. 1 g Explain why soldiers are ordered to break steps while crossing a bridge. [2]
10. 2067 Supp Q.No. 1 f Why are bells made of metal and not of wood? Explain. [2]
11. 2066 Old Q. No. 1 e A pendulum clock is in an elevator that descends at constant velocity. Does it keep correct time? If the some clock is in an elevator in free fall, does it keep correct time? [2]
12. 2066 Q. No. 1 d A body is moving in a circular path with constant speed. Is this motion a simple harmonic? Why? [2]
13. 2065 Q. No. 1 e A pendulum clock is taken to moon. Will it gain or lose time? [2]
14. 2059 Q.No. 1 e What are the drawbacks of simple pendulum?[2]
15. 2057 Q.No. 1 d On what factors does the period of a simple pendulum depend? [2]
16. 2052 Q.No. 1 c If length of a simple pendulum increased by 4 times its original length, will its time period change? If yes, by how much? [2]
    Ans: 2 times increase
17. 2050 Q.No. 1 iv If a pendulum clock is taken to a mountain top, does it gain or lose time? [2]

Long Answer Questions

18. 2076 Set B Q.No. 5d What is simple harmonic motion? Calculate the total energy of a particle executing simple harmonic motion. [4]
19. 2075 Set A Q.No. 5d What is simple harmonic oscillator? Obtain an expression for its total energy, and time period. [4]
20. 2073 Supp Q.No. 5d Show that the small oscillations of a mass loaded spring suspended vertically are simple harmonic. Deduce expression for its time period. [4]
21. 2073 Set D Q.No. 5c Define simple harmonic motion. Deduce a relation for total energy of a simple harmonic oscillator. [4]
22. 2072 Supp Q.No. 5c 2069 (Set B) Q. No. 5d What is a simple pendulum? Show that motion of the bob of a simple pendulum is simple harmonic. Obtain an expression for its frequency. [4]
23. 2072 Set C Q.No. 5c What are characteristics of simple harmonic motion? Show that motion of vertical mass-spring system is simple harmonic and hence derive formula for its time period. [4]
24. 2070 Supp (Set B) Q.No. 5 c Find an expression for the energy of particle in S.H.M. and show that the particle obeys the law of conservation of energy. [4]
25. 2069 (Set A) Old Q. No. 2a Define Simple harmonic motion and obtain an expression of time period of a simple pendulum.[1+4]
26. 2067 Supp Q.No. 5 c Define SHM. Derive a relation for total energy of a simple harmonic oscillator. [4]
27. 2065 Q. No. 3 a What is meant by simple harmonic motion? Show that the bob of a simple pendulum may move with simple harmonic motion and finds its time period. [1+3+1]
28. 2063 Q.No. 3 a OR Obtain an expression for the time period of a mass 'm' attached with a spring placed horizontally on a smooth table. [4]
29. 2061 Q.No. 3 a OR Define simple harmonic motion. Show that the oscillation of mass suspended from helical spring is simple harmonic. [1+4]
30. 2058 Q.No. 2 a Show that the motion of a simple pendulum is a simple harmonic motion. Derive its time period. [3+1]
31. 2056 Q.No. 3 a Define simple harmonic motion. Show that the vertical oscillations of a mass suspended by a light helical spring are simple harmonic. [1+4]
32. 2055 Q.No. 4 What is simple harmonic motion starts? Derive the relation between the acceleration and displacement of the practical executing S.H.M. [1+3]
33. 2054 Q.No. 4 What is a simple pendulum? Show that motion of the bob of a simple pendulum is simple harmonic. Obtain an expression for its time period. [4]
34. 2052 Q.No. 4 Define simple harmonic motion. Show that system of a spring hung from a support with a mass hanging at free end move simple harmonically. [4]

Numerical Problems

35. 2076 Set C Q.No. 9d The velocity of a particle executing simple harmonic motion is 16 cms^{-1} at a distance of 8 cm from the mean position and 8 cms^{-1} at a distance of 12 cm from the mean position. Calculate the amplitude of the motion. [4]
    Ans: 13.06 cm
36. 2074 Supp. Q.No. 9c 2062 Q.No. 2 b A simple pendulum 4m long swings with an amplitude of 0.2m. Compute the velocity of the pendulum at its lowest point and its acceleration at extreme ends. [4]
    Ans: 0.31 m/sec, 0.49 m/sec^2
37. 2074 Set A Q.No. 9b A body of mass 0.1 kg is undergoing simple harmonic motion of amplitude 1 m and period 0.2 second. If the oscillation is produced by a spring what will be the maximum value of the force and the force constant of the spring? [4]
    Ans: 98.6 N, 98.6 N/m

38. 2073 Set C Q.No. 9c A body of mass 200 g is executing simple harmonic motion with amplitude of 20 mm. The maximum force which acts upon it is 0.8N. Calculate its maximum velocity and its period of oscillation. [4]
Ans: 0.28 m/sec², 0.45 sec

39. 2072 Set E Q.No. 9c A body of mass 2 kg is suspended from a spring of negligible mass and is found to stretch the spring 0.1 m. What is its force constant and the time period? [4]
Ans: 0.628 sec

40. 2071 Supp Q.No. 9c A glider with mass m = 2.00 kg sits on a frictionless horizontal air track, connected to a spring with force constant k = 5.00 N/m. You pull the glider, stretching the spring 0.100 m and then releases it with no initial velocity. The glider begins to move back toward its equilibrium position (x = 0). What is its velocity when x = 0.080m? [4]
Ans: 0.1 m/sec

41. 2070 Set C Q.No. 9 d A simple pendulum 5 m long swings with an amplitude 25 cm. Find the velocity of the pendulum at its lowest point and the acceleration at the end of its path. [4]
Ans: 0.35 m/sec, 0.5 m /sec²

42. 2070 Set D Q.No. 9 d A body is vibrating with simple harmonic motion of amplitude 15 cm and frequency 4 Hz. Calculate the maximum value of acceleration and velocity. [4]
Ans: 3.77 m/sec, 94.8 m/sec²

43. 2069 Old (Set B) Q. No. 3b A small mass of 0.2 kg is attached to one end of helical spring and produces an extension of 15mm. The mass is now set into vertical oscillation of amplitude 10 mm. What is:
i. the period of oscillation?
ii. the maximum kinetic energy of the mass?
iii. the potential energy of the spring when the mass is 5mm below the centre of oscillation? ($g = 9.8 ms^{-2}$) [4]
Ans: (i) 0.246 sec (ii) 6.5×10^{-3}J (iii) 1.67×10^{-3}J

44. 2068 Q.No. 9 c A simple pendulum has a period of 4.2 second, when the pendulum is shortened by 1m the period is 3.7 second. From these measurements, calculate the acceleration of free fall and the original length of the pendulum. [4]
Ans: 10 m/s², 4.5m

45. 2068 Old Q.No. 3 b A second pendulum is taken to the moon. If the time period on the surface of the moon is 4.90 seconds, what will be the acceleration due to gravity of the moon? Take acceleration due to gravity of the moon to be $\frac{1}{6}^{th}$ that of the earth. [3]
Ans: 1.63m/sec²

46. 2067 Q.No. 9 c Calculate the period of oscillation of a simple pendulum of length 1.8m with a bob of mass 2.2 kg. If the bob of this pendulum is pulled aside a horizontal distance of 20 cm and released. What will be the values of (i) the K.E. and (ii) the velocity of the bob at the lowest point of the swing? [4]
Ans. 0.243J, 0.47 ms⁻¹

47. 2064 Q.No. 2 b The displacement y of a mass vibrating with simple harmonic motion is given by $y = 20 \sin 10 \pi t$. Where y is in millimeter and t is in second. What is:
(i) amplitude (ii) the period (iii) the velocity at t = 0 [4]
Ans: (i) 2×10^{-3} m (ii) 0.2 s (iii) 0.628 m/s

48. 2060 Q.No. 3 b A particle of mass 0.3 kg. vibrates with period of 2 seconds. If its amplitude is 0.5m what is its maximum kinetic energy? [4]
Ans: 37×10^{-3}J

49. 2053 Q.No. 5 A small mass rests on a horizontal platform which vibrates in simple harmonic motion with a period of 0.25s. Find the maximum amplitude of the motion which will allow the mass to remain in contact with the platform throughout the motion. [4]
Ans: 0.015m

50. 2050 Q.No. 5 A simple pendulum 4m. long swings with an amplitude of 0.2 m.
a. Compute the velocity of the pendulum at its lowest point.
b. Compute its acceleration at the end of its path. [4]
Ans: 0.316m/sec, 0.499m/sec²

12. Fluid Mechanics [Surface, Tension and Viscosity]

A. Fluid Static

Values of Physical Constants
Specific gravity of steel = 7.8
Density of water = 1000 Kg/m³

FORMULAE

1. Pascal's law, $P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$
2. According to Archimedes' principle,
Loss in weight of a body in a liquid
= weight of liquid displaced
= volume × density × acceleration due to gravity
3. Apparent weight of solid in a liquid
= True weight – weight of liquid displaced
= mg – V' ρ'g
4. When a body just floats,
Weight of the body = weight of liquid displaced
$V\rho g = V'\rho' g$
or, $\frac{V'}{V} = \frac{\rho}{\rho'}$
i.e., $\frac{\text{Volume of immersed portion}}{\text{Total volume of the solid}} = \frac{\text{Density of solid}}{\text{Density of liquid}}$
5. Specific gravity = $\frac{\text{Density of substance at t°C}}{\text{Density of water at 4°C}}$

Short Answer Questions

1. 2075 GIE Q.No. 1e Why do clouds seem to be floating in the sky? [2]
2. 2075 Set B Q.No. 1c Which one gives the feeling of heaviness in the case of a kilogram of cotton or a kilogram of lead? Why? [2]
3. 2074 Supp. Q.No. 1g 2063 Q.No. 1 f A body floats in a liquid contained in a beaker. The whole system falls under gravity. What is the value of upthrust on the body due to liquid? [2]
4. 2074 Set A Q.No. 1b Why is the bottom of a ship made heavy? Explain. [2]
5. 2070 Supp (Set B) Q.No. 1 c The purity of the gold can be tested by weighting it in air and water. How? [2]
6. 2070 Set C Q.No. 1 f In still air, a helium filled balloon rises up to a certain height and then stops rising. Why? [2]

7. 2069 (Set A) Q. No. 1e In hot air ballooning, a large balloon is filled with air heated by a gas burner at the bottom. Why must the air be heated? [2]
8. 2069 (Set A) Q. No. 1g An ice cube floats in a glass of water. When the ice melts, will the water level in the glass rise, fall or remain unchanged? Explain. [2]
9. 2069 (Set A) Old Q. No. 1e 2051 Q.No. 1 vii Why is the bottom of a ship made heavy? [2]
10. 2068 Old Q.No. 1 f What will happen to the level of water in a container when a submerged piece of ice melts completely? [2]
11. 2065 Q. No. 1 f Distinguish between density and specific gravity. [2]
12. 2064 Q.No. 1 c If a cork is released from the bottom of a jar filled with water, what will happen and why? [2]
13. 2062 Q.No. 1 f How will you make difference between density and specific gravity of a body? [2]
14. 2061 Q.No. 1 e A cork is floating in water. What is the apparent weight of the cork? [2]
15. 2060 Q.No. 1 f A helium filled balloon rises to a certain height and then halts. Why? [2]
16. 2059 Q.No. 1 f Why is it easier to lift a body in a liquid than in air? [2]
17. 2058 Q.No. 1 f A piece of ice is floating in water. Will the water level rise if the ice melts completely? Explain. [2]
18. 2057 Q.No. 1 f What are centre of buoyancy and metacentre? [2]
19. 2055 Q.No. 1 d State the laws of floatation. [2]
20. 2054 Q.No. 1 i Lead has a greater density than iron, and both are denser than water. Is the buoyant force on a lead object greater than, less than, or equal to the buoyant force on an iron object of the same volume? [2]
21. 2053 Q.No. 1 h Does a ship sink more in river water or in sea water? Explain. [2]
22. 2052 Q.No. 1 i Steel balls sink in water but they don't sink in mercury. Why? [2]
23. 2050 Q.No. 1 vii Why does ice float in water? [2]
24. 2050 Q.No. 1 ix A rigid, lighter than air balloon filled with Helium can not continue to rise indefinitely. Why? [2]

Numerical Problems

25. 2074 Set B Q.No. 9d An iceberg having volume 2.06 litre floats in sea water of density 1.03 gm/ cm^{-3} with a portion of 224 CC above the surface. Calculate the density of ice. [4]
Ans: 918 kg/m^3
26. 2073 Supp Q.No. 1f 2066 Q. No. 1 e A boy can lift a maximum load of 250 N of water. How many litres of mercury of density 13600 kgm^{-3} he can lift in an identical vessel? [2]
Ans: 1.838 l
27. 2066 Old Q. No. 3 b A geologist finds that a moon rock whose mass is 7.2 kg has an apparent mass 5.88 kg when submerged in water. What is the density of the rock? [1+3]
Ans: 5454.54 kg m^{-3}
28. 2065 Q. No. 3 b A string supports a solid iron object of mass 200gm totally immersed in a liquid of specific gravity 0.9. Calculate the tension in the string it the density of iron is 8000 kg m^{-3}. [3]
Ans: 1.775N
29. 2064 Q.No. 3 b An alloy of mass 588 g and volume 1000 c.c. is made of iron of density 8.0 gm/cc and aluminum of density 2.7 gm/cc. Calculate the proportion by (i) volume (ii) by mass of the constituents of the alloy. [3]
Ans: (I) 6×10^{-6} m^3, 4×10^{-6} m^3 (II) 0.48 kg, 0.108 kg.
30. 2062 Q.No. 3 b A string supports a solid iron object of mass 200gm totally immersed in a liquid of density 800km^{-3}. The density of iron is 8000 kgm^{-3}. Calculate the tension in the string. [3]
Ans: 1.8 N
31. 2057 Q.No. 3 b A string supports a solid iron of mass 200 gm. totally immersed in a liquid of density 900 kg m^{-3}. Calculate the tension in the string if the density of iron is 8000 kg m^{-3}. [3]
Ans: 1.775 N
32. 2056 Q.No. 3 b An iceberg having a volume of 2060 cc floats in sea-water of density 1030 kg m^{-3} with a portion of 224 cc above the surface. Calculate the density of ice. [3]
Ans: 918 Kg/ m^3
33. 2055 Q.No. 6 OR A piece of gold-aluminium alloy weights 100 cc in air and 80 g in water. What is the weight of the gold in the alloy if the relative density of gold is 19.3 and that of aluminium is 2.5 [3]
Ans: 0.057 kg
34. 2054 Q.No. 5 OR A string supports a solid iron object of mass 180g totally immersed in a liquid of density 800 kg/m^3. The density of iron is 8000 kg/m^3. Calculate the tension in the string. [3]
Ans: 1.62 N
35. 2052 Q.No. 5 A 25 cm. thick block of ice floating on fresh water can support an 80 kg man standing on it, what is the smallest area of the ice block? (sp gr. of ice = 0.917). [3]
Ans: 4 m^2
36. 2051 Q.No. 3 OR The density of ice is 971 km m^{-3}, and the approximate density of seawater in which an iceberg floats is 1025 kg m^{-3}. What fraction of the iceberg, is beneath the water surface? [3]
Ans: 0.95

B. Surface Tension

Values of Physical Constants

Surface tension of water = 7.0×10^{-2} Nm^{-1}

FORMULAE

1. Surface tension, $T = \frac{\text{Force}}{\text{Length}} = \frac{F}{L}$
2. Work done, W = surface tension × increase in area of the liquid surface i.e. $W = T \times A$
3. Height of liquid in capillary tube, $h = \frac{2T\cos\theta}{r\rho g}$, where θ is angle of contact

Short Answer Questions

1. 2076 Set B Q.No. 1g Why does hot soup taste better than cold soup? [2]
2. 2076 Set C Q.No. 1g A tiny liquid drop is spherical but a larger drop has oval shape. Why? [2]
3. 2075 Set A Q.No. 1d 2070 Set D Q.No. 1 f 2066 Q.No. 1 a Why is soap solution a better cleaning agent than ordinary water? [2]

4. 2075 Set B Q.No. 1b How does the shape of the surface of mercury look like in a capillary tube dipped in it? Explain in a figure with proper justification. [2]
5. 2074 Set A Q.No. 1a Explain why liquid drops are spherical in shape? [2]
6. 2074 Set B Q.No. 1a Why are liquid drops spherical in shape? Explain. [2]
7. 2073 Supp Q.No. 1d 2072 Set E Q.No. 1f It is observed that the surface of a liquid in a capillary tube dipped in it is either convex or concave. What may be the reason? Explain. [2]
8. 2073 Set D Q.No. 1g Hot soup gives better taste than cold one, why? [2]
9. 2072 Supp Q.No. 1d On what factors does the surface tension of a liquid depend? Explain. [2]
10. 2072 Set C Q.No. 1f Why the small liquid drops are spherical while large drops are flat? [2
11. 2070 Set C Q.No. 1 e Soap bubbles are almost perfect spheres. Why? [2]
12. 2069 Supp Q.No. 1d Antiseptics used in cuts and wounds of human flesh have low surface tension, Why? [2]
13. 2069 (Set A) Old Q.No. 1a How do the leaves of tree get water from ground? [2]
14. 2069 (Set A) Old Q.No. 2a What are cohessive and adhessive forces? [2]
15. 2069 (Set B) Q. No. 1g Why the antiseptics used for cuts and wounds in human flesh have low surface tension? [2]
16. 2068 Q.No. 1 f What will happen if a capallary tube of insufficient height is dipped in water? [2]
17. 2068 Old Q.No. 1 a Why are small liquid drops always spherical in shape? [2]
18. 2067 Q.No. 1 f The tip of the nib of a pen is split. Why? [2]
19. 2063 Q.No. 1 a Small particles of camphor dance on the surface of water, why? [2]
20. 2063 Q.No. 2 a Hot soup is more tasty than a cold one, why? [2]
21. 2062 Q.No. 2 a We use towels to dry our body after taking a shower, why? [2]
22. 2061 Q.No. 2 a Hairs of a brush spread out when it is dipped in water and cling together as soon as it is taken out of water. Explain. [2]
23. 2060 Q.No. 1 a Why are small drops of mercury spherical and bigger drops oval in shape? [2]
24. 2059 Q.No. 2 a Why does mercury inside the capillary tube made of glass depress when dipped in a reservoir of mercury? [2]
25. 2058 Q.No. 2 a Why mercury does not wet the glass tube? [2]

Long Answer Questions

26. 2073 Set C Q.No. 5d What is capillarity? Deduce a relation for the height of liquid column rise in a capillary tube when one end is dipped in the liquid. [4]
27. 2072 Set D Q.No. 5d Define surface tension and angle of contact. Deduce an expression for rise of a liquid in a capillary tube. [4]
28. 2068 Old Q.No. 3 a Or Explain, with necessary theory, the capillary tube method for the measurement of surface tension of a liquid. [4]
29. 2067 Supp Q.No. 5 d What is capillarity? Deduce an expression for the rise of a liquid in a capillary tube. [4]
30. 2065 Q.No. 3 a OR Prove that the surface energy and surface tension are numerically same. Explain the concept of the angle of contact, with necessary figure, when the surface of the liquid is convex if viewed from the above. [1+3]
31. 2064 Q.No. 3 a Define surface tension and surface energy of a liquid and derive a relation between them. [2+2]
32. 2062 Q.No. 3 a What causes liquid fall or rise in a capillary tube? Derive an expression for the rise or fall of a liquid in a capillary tube. [4]
33. 2061 Q.No. 3 a OR 2059 Q.No. 3 a OR What causes the surface of a liquid as if it is under tension? Show that $T = \frac{hpgr}{2\cos\theta}$ where the symbols have their usual meaning. [4]
34. 2057 Q.No. 3 a Deduce an expression for the rise of a liquid in a capillary tube. [4]

Numerical Problems

35. 2074 Supp. Q.No. 9d Angle of contact of mercury with glass is 135°. A narrow tube of glass having diameter 2mm is dipped in a beaker containing mercury. By what height does the mercury go down in the tube relative to the level of mercury outside? [4]
Ans: –5.7 mm
36. 2072 Set E Q.No. 9d 2058 Q.No. 3 b A capillary tube of 0.4 mm diameter is placed vertically inside a liquid of density 800 kgm^{-3}, surface tension $5 \times 10^{-2} Nm^{-1}$ and angle of contact 30°. Calculate the height to which liquid rises in the capillary tube. [4]
Ans: 0.055 m
37. 2071 Supp Q.No. 9d A rectangular plate of dimensions 6cm by 4 cm and thickness 2 mm is placed with its largest face flat on the surface of water. Calculate the downward force on the plate due to surface tension assuming zero angle of contact. What is the downward force if the plate is placed vertical so that it's longest side just touches the water? [4]
Ans: 1.4×10^{-2} N, 8.92×10^{-3} N
38. 2071 Set C Q.No. 9 c Find the work done required to break up a drop of water of radius 5×10^{-3} m into eight drops of water, assuming isothermal condition. [Surface tension of water = 7.2×10^{-3} N/m] [4]
Ans: 2.26×10^{-3} J
39. 2071 Set D Q.No. 9 a A capillary tube of 0.3 m diameter is placed vertically inside a liquid of density 800 Kgm^{-3}, surface tension $5 \times 10^{-4} Nm^{-1}$ and angle of contact 30°. Calculate the height to which the liquid rises in the capillary tube. [4]
Ans: 7.2×10^{-7} m
40. 2069 (Set A) Old Q.No. 3b A rectangular plate of dimensions 6cm by 4 cm and thickness 2mm is placed with its largest face flat on the surface of water. Calculate the downward force on the plate due to the surface tension assuming zero angle of contact. (Surface tension of water = $7 \times 10^{-2} Nm^{-1}$) [3]
Ans: 1.4×10^{-2}N
41. 2066 Q.No. 3 b Calculate the work done in breaking a drop of water of 2mm diameter into million droplets of same size. The surface tension of water is $72 \times 10^{-3} Nm^{-1}$. [3]
Ans: 8.9×10^{-5} J

42. 2060 Q.No. 3 b A rectangular plate of dimensions 6cm. by 4 cm. and thickness 2mm. is placed vertical so that its largest side just touches the surface of the water. Calculate the downward force on the plate due to surface tension. (Surface tension of water = 7.0×10^{-2} Nm^{-1}) [3]
Ans: 8.92×10^{-3} N

C. Viscosity

FORMULAE

1. The viscous force, $F = -\eta A\frac{dv}{dx}$, where η is called the coefficient of viscosity
2. The equation of continuity is Av = constant i.e., $A_1v_1 = A_2v_2$
3. The Bernoulli's formula, $P + \rho gh + \frac{1}{2}\rho v^2$ = constant, for horizontal flow of liquid, $h = 0$
4. Poiseuille's formula, $Q = \frac{\pi Pr^4}{8\eta l}$
5. Stoke's formula, $F = 6\pi\eta r v_t$
6. Terminal velocity, $v_t = \frac{2}{9}\frac{r^2}{\eta}(\rho - \sigma)g$.

Short Answer Questions

1. 2073 Set C Q.No. 1g Small air bubbles rise slowly while big bubbles rise rapidly through the liquid. Why? [2]
2. 2072 Set D Q.No. 1f Why is a suction effect experienced by a person standing close to the platform at a station when a fast train passes? [2]
3. 2072 Set E Q.No. 1g Explain with a diagram, the meaning of velocity gradient in the case of liquid flowing in a tube. [2]
4. 2071 Supp Q.No. 1g Airports at high elevations have longer runways for take offs and landings than do airports at sea level, why? [2]
5. 2071 Set C Q.No. 1 c Express the dimension of the velocity gradient from the definition of the coefficient of viscosity. [2]
Ans: $[T^{-1}]$
6. 2070 Set D Q.No. 1 d When a smooth-flowing stream of water comes out of a faucet, it narrows as it falls. Explain. [2]
7. 2069 (Set A) Old Q.No. 1b Define coefficient of viscosity and poise. [2]
8. 2069 (Set A) Old Q.No. 2b State Bernoulli's theorem. [2]
9. 2068 Old Q.No. 2 a Why does a flag flutter on strong wind? [2]
10. 2067 Supp Q.No. 1 g Why do bigger air bubbles rise faster than the smaller ones in boiling water? [2]
11. 2067 Q.No. 1 g Explain why a suction effect is experienced by a person standing close to the platform at a station when a fast train passes. [2]
12. 2066 Q. No. 1 g When a smooth-flowing stream of water comes out of a faucet, it narrows as it falls. Explain why this happens. [2]
13. 2066 Q.No. 2 a Why are light roofs blown off during cyclones or strong wind storms? [2]
14. 2064 Q.No. 1 a Define viscosity. Does it depend on temperature? [2]
15. 2060 Q.No. 2 a During certain windstorm, light roofs are blown off. Why? [2]
16. 2057 Q.No. 2 a Machine parts are jamed in cold day. Why? [2]

Long Answer Questions

17. 2076 Set C Q.No. 5d What is terminal velocity? Derive an expression for the terminal velocity of a small spherical body falling through a viscous fluid. [4]
18. 2074 Supp. Q.No. 5d 2058 Q.No. 3a OR Using dimensional consideration, deduce Poiseulle's formula for the rate of flow of a liquid through a tube. [4]
19. 2074 Set A Q.No. 5d Describe Stoke's method to find the coefficient of viscosity of liquid in the laboratory with necessary theory. [4]
20. 2074 Set B Q.No. 5b 2064 Q.No. 3a OR State and prove Bernoulli's principle. [4]
21. 2072 Supp Q.No. 5b What is terminal velocity? Describe Stoke's method to determine the coefficient of viscosity of a liquid. [4]
22. 2072 Set C Q.No. 5d State and prove Bernoulli's theorem for the steady flow of an incompressible and non-viscous flow. [4]
23. 2072 Set E Q.No. 5b State and prove Bernoulli's theorem in flowing liquid. [4]
24. 2071 Set D Q.No. 5 c Describe the experimental method to find the coefficient of viscosity of a liquid by Stoke's method. [4]
25. 2070 Supp (Set A) Q.No. 5 d State Stoke's law and deduce it from dimensional analysis. Define coefficient of viscosity of a liquid. [4]
26. 2070 Supp (Set B) Q.No. 5 d State and prove Bernoulli's principle for a liquid flow. [4]
27. 2070 Set C Q.No. 5 d State and prove Bernoulli's theorem for the flow of non-viscous fluids. [4]
28. 2070 Set D Q.No. 5 c Define terminal velocity and hence describe the method of determining the coefficient of viscosity of a liquid using Stoke's law. [4]
29. 2069 Supp Q.No. 5c 2066 Q. No. 5 b Derive an expression for terminal velocity of small spherical ball of radius 'a' dropped gently in a viscous liquid of density 'ρ' and the coefficient of viscosity 'η'. [4]
30. 2069 (Set A) Old Q.No. 3aOR What is terminal velocity? Using Stoke's formula, find the expression for the terminal velocity. What is the acceleration of the body inside the liquid before it attains terminal velocity? [4]
31. 2068 Old Q.No. 3 a Derive Newton's formula for viscous force Define coefficient of viscosity. Calculate its dimensions. [2+1+1]
32. 2066 Q.No. 3 a OR What is viscosity? Obtain an expression of viscous force from Newton's laws for viscosity. [4]
33. 2065 Q.No. 3 a How is the coefficient of viscosity related with the velocity gradient of the following liquid? Use dimensional method to obtain Poiseuille's formula for the flow of fluid. [1+3]
34. 2063 Q.No. 3 a 2059 Q.No. 3a Derive Bernoulli's equation from the work energy theorem. Explain why the equation is valid only for steady non-viscous and incompressible fluid? [1+3]
35. 2063 Q.No. 3 a OR Derive an expression for terminal velocity of a small spherical ball dropped gently in a viscous liquid. [1+3]
36. 2060 Q.No. 3 a OR Explain why a sphere falling through a viscous medium acquires a terminal velocity. Derive an expression for it. [1+3]

Numerical Problems

37. 2076 Set B Q.No. 9d Eight spherical rain drops of the same mass and radius are falling down with a terminal speed 5 cms^{-1}. If they coalesce to form one big drop, what will be its terminal speed? [4]
Ans: 0.2 m/s

38. 2075 GIE Q.No. 9d 2069 (Set A) Q. No. 9d Castor oil at 20°C has a coefficient of viscosity 2.42 Ns/m^2 and density 940kg/m^3. Calculate the terminal velocity of a steel ball of radius 2.00 mm falling under gravity in the oil. [Density of steel = 7800 kg/m^3] [4]
Ans: 0.025 m/sec

39. 2075 Set A Q.No. 9d Calculate mass of an aeroplane with the wings of area 55m^2 flying horizontally. The velocity of air above and below the wings is 155 m/s and 140 m/s respectively. [4]
Ans: 1.57×10^4 Kg

40. 2073 Supp Q.No. 9c 2062 Q.No. 3 b- XII Calculate the magnitude and direction of the terminal velocity of an air bubble of radius 1 mm passing through an oil of viscosity 0.2 Nsm^{-2} and specific gravity 0.9 if the density of air is 1.29 Kgm^{-3}. [4]
Ans: –0.0099 m/sec

41. 2073 Set D Q.No. 9d Eight spherical raindrops of equal size are falling vertically through air with a terminal velocity of 0.15 m/s. What would be the terminal velocity, if they coalesce to form a big drop? [4]
Ans: 0.6 m/sec

42. 2072 Set D Q.No. 9d 2057 Q.No. 3 b XII Castor oil at 20°C has a coefficient of viscosity 2.42 Ns/m^2 and density 940 kg/m^3. Calculate the terminal velocity of steel ball of radius 2.00 mm falling under gravity in the oil, taking density of steel as 7800 kg/m^3. [4]
Ans: 0.025 m/sec

43. 2068 Q.No. 9 d Water flows steadily through a horizontal pipe of non-uniform cross section. If the pressure of water is $4\times10^4 Nm^{-2}$ at a point where the velocity of flow is $2ms^{-1}$ and cross section is 0.02m^2, what is the pressure at a point where cross section reduces to 0.01m^2? [4]
Ans: $3.4\times10^4 Nm^{-2}$

44. 2067 Q.No. 9 d Three spherical raindrops of equal size are falling vertically through air with a terminal velocity of 0.150 m/s. What would be the terminal velocity if these three drops were to coalesce to form a larger spherical drop? [4]
Ans. 0.31 ms^{-1}

45. 2065 Q.No. 3 b Two drops of same liquid of same radius are falling through air with steady velocity of 2.0 ms^{-1}. If the two drops coalesce what would be the terminal velocity? [3]
Ans: 3.17ms^{-1}

46. 2061 Q.No. 3 b What is the terminal velocity of a glass ball falling through a tall jar containing glycerene? The densities of the glass ball and glycerene are 2.6 g/cc and 1.32 g/cc respectively and the viscosity of the glycerene is 0.85 poise and radius of the glass ball is 2mm. [4]
Ans: 0.132 m/sec

47. 2059 Q.No. 3 b What is the terminal velocity of a steel ball falling through a tall jar containing glycerin? The densities of the steel ball and glycerine are 8.5 g/cc and 1.32 g/cc respectively and the viscosity of the glycerine is 0.85 poise and radius of the steel ball is 2 mm. [4]
Ans: 0.75m/sec

Unit 2: Heat and Thermodynamics

1. Heat and Temperature

Values of Physical Constants

Coefficient linear expansion of aluminium	$= 2.4 \times 10^{-5} K^{-1}$
Coefficient linear expansion of brass	$= 2.0 \times 10^{-5} K^{-1}$
Cubical expansivity of benzene	$= 1.2 \times 10^{-3} K^{-1}$
Cubical expansivity of wood	$= 1.5 \times 10^{-4} K^{-1}$
Density of mercury (ρ)	$= 13600 kg/m^3$
Linear expansivity of brass (α)	$= 2 \times 10^{-5} K^{-1}$
Linear expansivity of glass	$= 1.8 \times 10^{-6} K^{-1}$
Linear expansivity of steel	$= 1.2 \times 10^{-5} K^{-1}$
Cubical expansivity of mercury	$= 1.8 \times 10^{-4} K^{-1}$
Young's modulus of steel	$= 2 \times 10^{11} N/m^2$

FORMULAE

1. Relationship between C, F and K,
$$\frac{C}{100} = \frac{F-32}{180} = \frac{K-273}{100}$$
2. The coefficient of linear, superficial and cubical expansions, $\alpha = \frac{\Delta l}{l_1 \Delta\theta}$, $\beta = \frac{\Delta A}{A_1 \Delta\theta}$ and $\gamma = \frac{\Delta V}{V_1 \Delta\theta}$
3. Relation between α, β and γ be, $\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$
4. Tension on a wall due to the expansion of rod, $F = YA\alpha(\theta_2 - \theta_1)$
5. The relation of real expansivity, apparent expansivity and expansivity of vessel, $\gamma_r = \gamma_a + \gamma_v$, since $\gamma = 3\alpha$
6. Variation of density with temperature,
$$\rho_\theta = \frac{\rho_0}{1 + \gamma\Delta\theta} = \rho_0 (1 - \gamma\Delta\theta)$$

Short Answer Questions

1. 2074 Supp. Q.No. 2a A student claimed that thermometers are useless because a thermometer always registers its own temperature. How would you respond? [2]
2. 2074 Set B Q.No. 2a Express 98°F into Kelvin scale. [2]
Ans: 310 k
3. 2073 Supp Q.No. 2a Two metallic rod of the same material but of different length are heated. Smaller rod has circular area of cross-section but larger rod has rectangular cross-section. Will their linear expansivity be the same or different? Give justification of your answer. [2]
4. 2073 Set D Q.No. 2a Why is it sometimes possible to loosen caps on screw top bottles by dipping the cap briefly in hot water? [2]
5. 2072 Set E Q.No. 2a Explain why the possibility of "water taps burst" rises in severe winter. [2]
6. 2071 Supp Q.No. 2a A square brass plate has a large circular hole cut in its centre. If the plate is heated, it will expand. Will the diameter of the hole expand or contract? Explain your answer. [2]

7. 2071 Set C Q.No. 2 b Explain the significance of anomalous expansion of water with an example observed in nature. [2]
8. 2071 Set D Q.No. 2 a Define the coefficient of cubical expansion of a solid and hence write an expression for the variation of its density with temperature. [2]
9. 2070 Supp (Set A) Q.No. 2 b Forzen water pipes often burst. Will a alcohol thermometer break if the temperature drops below the freezing point of alcohol? [2]
10. 2070 Set C Q.No. 2 a A hole is drilled in a flat metal sheet. What happens to the diameter of the hole as the metal sheet is heated to higher temperature? [2]
11. 2070 Set D Q.No. 2 a Does the cubical expansivity of a liquid depend on its original volume? Explain. [2]
12. 2069 (Set A) Q. No. 2a Frozen water pipes often burst, will a mercury thermometer break if the temperature of the thermometer is brought below the freezing point of mercury?[2]
13. 2069 Old (Set B) Q. No. 4a At what temperature will the Celsius scale reading double the Fahrenheit reading? [2]
14. 2068 Q.No. 2 a Define obsolute temperature. [2]
15. 2068 Old Q.No. 4 a At what temperature, do the Fahrenheit-thermometer and Celsius-thermometer show the same reading? [2]
16. 2067 Supp Q.No. 2 a Does the coefficient of linear expansion depend on length? Justify your answer. [2]
17. 2066 Q. No. 2 b When a metallic block with hole in it is heated, why does not the material around the hole expand into the hole and make it smaller? [2]
18. 2065 Q. No. 4 a Why are glass windows possible to be cracked in very cold region? [2]
19. 2064 Q.No. 4 a 2050 Q.No. 7 i Two bodies made of the same material have the same external dimension and appearance, but one is solid and the other is hollow. When they are heated, is the overall volume expansion the same or different? [2]
20. 2063 Q.No. 4 a Why does a thick glass tumbler crack when boiling water is poured on it? [2]
21. 2062 Q.No. 4 a Why a column of mercury in a thermometer first descends slightly and then rises when placed in hot water? Explain. [2]
22. 2061 Q.No. 4 b At what point of thermometric scale does kelvin scale reading coincide with Fahrenheit scale reading?[2]
23. 2059 Q.No. 4 a What are the differences between heat and temperature? [2]
24. 2058 Q.No. 4 a Fishes stay alive in frozen pond in winter. Explain. [2]
25. 2058 Q.No. 4 c Why mercury is used in thermometer? [2]
26. 2055 Q.No. 7 d Does the coefficient of linear expansion depend on length? Explain. [2]
27. 2055 Q.No. 7 e Why is mercury used commonly as a thermometric substance? Give two reasons. [2]
28. 2054 Q.No. 7 b Explain why a column of mercury in thermometer first descends slightly and then rises when placed in hot water? [2]
29. 2052 Q.No. 7 c Water level initially falls in a vessel when it is heated. Why? [2]
30. 2052 Q.No. 7 d Why is it sometimes possible to loosen caps on screw top bottles by dipping the cap briefly in hot water? [2]
31. 2052 Q.No. 7 e Why do frozen water pipe burst? [2]

Long Answer Questions

32. 2076 Set C Q.No. 6a Define the coefficients of real expansion and apparent expansion and hence derive the relation between them. [4]
33. 2075 GIE Q.No. 6a Define linear and cubical expansivity of solids. Establish a relationship between the coefficients of linear and cubical expansions. [4]
34. 2075 Set B Q.No. 6b Define real and apparent expansivities of a liquid? Derive the relation between them. [4]
35. 2074 Supp. Q.No. 6a Describe how the cubical expansivity of a liquid can be determined by the use of balanced columns. [4]
36. 2073 Set C Q.No. 6a Define coefficients of real and apparent expansion of a liquid, and establish a relation between them. [4]
37. 2072 Supp Q.No. 6a Define the coefficients of linear and cubical expansion of solid and establish their relation. [4]
38. 2072 Set C Q.No. 6a Distinguish between real and apparent expansion of liquid. Describe with mathematical detail, a method to determine real expansivity of a liquid. [4]
39. 2071 Set C Q.No. 6 c Does cubical expansivity depend upon the initial volume of a solid? Write the unit of this expansivity. Also derive its relation with superficial expansivity. [4]
40. 2070 Supp (Set B) Q.No. 6 a What are meant by real and apparent expansions of a liquid? Show that sum of coefficient of real expansion of a liquid is sum of coefficient of apparent expansion of the liquid and coefficient of cubical expansion of the vessel. [4]
41. 2070 Set C Q.No. 6 a Describe a method to determine the linear expansivity of a solid. Can the cubical expansivity be derived from this value? [4]
42. 2070 Set D Q.No. 6 a Define the coefficient of real and apparent expansions of a liquid and derive a relation between them. [4]
43. 2069 (Set A) Q. No. 6a Define linear and cubical expansivities of solids. Derive an expression for the variation in density of a solid when its temperature is raised from θ_1°C to θ_2°C. [4]
44. 2069 (Set A) Old Q. No. 5a Define coefficient of linear expansion. Obtain the relation between α and γ. [4]
45. 2066 Q. No. 6 a Define linear and cubical expansions of solid, and establish a relation between their coefficients. [4]
46. 2060 Q.No. 5 a Define linear, superficial, and cubical expansivities. Show that $\beta = 2\alpha$ where α and β are linear and superficial expansivities. [2+3]
47. 2059 Q.No. 5 a Why do substances expand on heating? Show that $\alpha = \frac{\gamma}{3}$ where α and γ are the coefficient of linear, and cubical expansion of a substance. [1+4]
48. 2056 Q.No. 5 a Define linear and cubical expansivities. Derive a relation between them. [1+1+3]
49. 2051 Q.No. 8 Obtain an expression for the change in density of a gas due to the thermal expansion. [4]

Numerical Problems

50. 2076 Set B Q.No. 10a 2054 Q.No. 10 b A glass flask of volume 400 cm^3 is just filled with mercury at 0°C. How much mercury will overflow when the temperature of the system rises to 80° C. [4]
Ans: 0.192 cm^3

51. 2075 GIE Q.No. 10c A Steel wire having length 8 m and diameter 4 mm is fixed between two rigid support. Calculate increase in tension on a wire when temperature falls by 10°C. Where Young's modulus of wire = 2×10^{11} N/m^2, linear expansivity of steel = $1.2\times10^{-5}K^{-1}$. [4]
Ans: 301.6 N

52. 2075 Set A Q.No. 10a An iron rod of length 100 m at 10°C is used to measure a distance of 2 km on a day when the temperature is 40°C. Calculate the error in measuring the distance. [4]
Ans: 0.72 m

53. 2074 Set A Q.No. 10a A seconds pendulum made of brass keeps correct time at 10°C. How many seconds it will lose or gain per day when the temperature of its surrounding rises to 35°C? [4]
Ans: 21.6 sec

54. 2074 Set B Q.No. 10b Two ends of a steel wire of length 8 m and 2 mm radius are fixed to two rigid supports. Calculate the increase in tension in the wrie when temperature falls by 10°C. [4]
Ans: 75.36 N

55. 2073 Set D Q.No. 10a A glass flask with volume 200 cm^3 is filled to the brim with mercury at 20°C. How much mercury overflows when the temperature of the system is raised to 100°C? [4]
Ans: 2.688 cm^3

56. 2072 Set D Q.No. 10a The marking on an aluminium ruler and a brass ruler are perfectly aligned at 0°C. How far apart will the 20.0 cm marks be on the two rulers at 100°C, if precise alignment of the left hand ends of the rulers is maintained? [4]
Ans: 0.008 cm

57. 2072 Set E Q.No. 10a A brass pendulum clock keeps correct time at 15°C. How many seconds per day it will lose or gain at 0°C? [4]
Ans: 12.96 sec

58. 2071 Supp Q.No. 10a Using the following data, determine the temperature at which wood will just sink in benzene. Density of benzene at 0°c = 9.0×10^2 kgm^{-3}. Density of wood at 0°c = 8.8×10^2 kg/m^3. [4]
Ans: 21.7°C

59. 2070 Supp (Set A) Q.No. 10b 2069 (Set A) Q. No. 10c A glass vessel of volume 50cm^3 is filled with mercury and is heated from 20°C to 60°C. What volume of mercury will overflow? [4]
Ans: 0.35 cm^3

60. 2069 (Set B) Q. No. 10a The pendulum of a clock is made of brass. If the clock keeps correct time at 15°C, how many seconds per day will it lose at 20°C? [4]
Ans: 4 sec

61. 2069 Old (Set B) Q. No. 5b The length of an iron rod is measures by a brass scale. When both of them are at 10°C, the measured length is 50cm. What is the length of the rod at 40°C when measured by the brass scale at 40°C.? (α for brass = $24\times10^{-6}°C^{-1}$, α for iron = $16\times10^{-6}°C^{-1}$) [4]
Ans: 49.98 cm

62. 2068 Q.No. 10 a A steel wire 8m. long and 4mm. in diameter is fixed to two rigid supports. Calculate the increase in tension when the temperature falls by 10 °C. [4]
Ans: 301.6 N

63. 2068 Old Q.No. 5 b A brass rod of length 0.40 m and steel rod of length 0.60 m, both are initially at 0°C are heated to 75°C. If the increase in lengths is the same for both the rods, calculate the linear expansivity of brass. The linear expansivity of steel is 12×10^{-6} °C^{-1}. [4]
Ans: $18\times10^{-6}°C^{-1}$

64. 2067 Q.No. 10 a A copper vessel with a volume of exactly 100m^3 at a temperature of 15°C is filled with glycerin. If the temperature rises to 25°C, how much glycerin will spill out? [4]
Ans. 0.48 m^3

65. 2067 Supp Q.No. 10 a A glass flask of volume 500 cm^3 is just filled with mercury at 0°c. How much mercury overflows when the temperature of the system is raised to 80°c. [4]
Ans: 0.24 cm^3

66. 2066 Old Q. No. 5 b A clock which has a brass pendulum beats seconds correctly when the temperature of the room is 30°C. How many seconds will it gain or lose per day when the temperature of the room falls to 10°C? (α for brass = 0.000018°C^{-1}). [4]
Ans: 16.92 sec gain

67. 2063 Q.No. 3 b A copper wire of diameter 0.5 mm. is stretched between two points at 25°C. Calculate the increase in tension in the wire if the temperature falls to 0°C. (Young's modulus for copper = 1.2×10^{11} Nm^{-2}, linear expansivity for copper = $18\times10^{-6}K^{-1}$) [4]
Ans: 10.6N

68. 2055 Q.No. 9 OR The density of silver at 0°C is 10310 kgm^{-3} and the coefficient of linear expansion is 0.000019/°C. Calculate its density at 100°C. [4]
Ans: 10251.57 kg/m^3

69. 2053 Q.No. 8 An aluminum rod when measured with a steel scale, both being at 25°C appears to be 1 m long. If the scale is correct at 0°C, what will be the length of the rod at 0°C? (linear expansivity of aluminum 26×10^{-6} k^{-1} and of steel = 12×10^{-6} k^{-1}). [4]
Ans: 0.99 m

2. Quantity of Heat

Values of Physical Constants	
Latent heat of fusion (Li) of ice	= 80 cal/gm
Latent heat of ice L	= 3.36×10^5 J Kg^{-1}
Latent heat of steam	= 540 cal/gm
Specific heat capacity of copper	= 390 $Jkg^{-1}k^{-1}$
Specific heat capacity of ice	= 2100 $Jkg^{-1}K^{-1}$
Specific heat capacity of iron	= 470 $Jkg^{-1}k^{-1}$
Specific heat capacity of water	= 4190 $Jkg^{-1}k^{-1}$
Specific heat of iron	= 0.1 cal $g^{-1}C^{0-1}$

FORMULAE

1. Heat gained or heat lost by a body,
   i. $Q = mS\Delta\theta$, (For same phase)
   ii. $Q = mL$, (for same temperature)
2. Principle of calorimetry, Heat gained = Heat lost

Short Answer Questions

1. 2076 Set B Q.No. 2a The latent heat of vaporization is much larger than the latent heat of fusion of a substance. Why? [2]
2. 2075 Set A Q.No. 2c Why does steam at 100°C give more severe burn than water at the same temperature? [2]
3. 2073 Set C Q.No. 2a Groundnuts are fried along with sand, why? [2]
4. 2072 Supp Q.No. 2a Why is the groundnut fried along with sand? [2]
5. 2072 Set E Q.No. 2c Water remains cool in earthen pots than in metal pots in summer. Explain why? [2]
6. 2069 Supp Q.No. 2a A medical officer prescribes to put wet cloths on the forehead of a person suffering from high fever, why? [2]
7. 2069 Supp Q.No. 2c Why does the temperature of ice fall when some salt is added to it? [2]
8. 2069 (Set A) Q. No. 2b If you add heat to an object, do you necessarily increases its temperature? Justify your answer.[2]
9. 2069 (Set A) Old Q. No. 4a Water in earthen pot remains cold in summer. Explain, why? [2]
10. 2069 (Set B) Q. No. 2a Why do you feel cool in the mouth when you eat halls? [2]
11. 2069 Old (Set B) Q. No. 4b Why does a food cook faster in pressure cooker than open vessel with boiling water? [2]
12. 2069 Old (Set B) Q. No. 4c Explain why a person feels cooling when he pours a little spirit on his hand. [2]
13. 2067 Q.No. 2 a During a high fever, a wet cloth is kept on the forehead of a person. Why? [2]
14. 2066 Old Q. No. 4 a How is it that ice cream appears cooler to the mouth than ice at 0°C? [2]
15. 2066 Old Q. No. 4 c If you wet your hand and pickup an ice tray that is below 0°C, your hand may stick to it. This does not happen to wood. Why? [2]
16. 2061 Q.No. 4c 2053 Q.No. 7c Explain why water remains cool in earthen pot in summer. [2]
17. 2060 Q.No. 4 c Why do we feel cold when we spray perfume on our body? [2]
18. 2056 Q.No. 4 a When you come out of swimming pool, you feel cold. Why? [2]
19. 2056 Q.No. 4 b Why does steam at 100°C causes severe burns than hot water at 100°C? [2]
20. 2054 Q.No. 7 c Why can you get a more severe burn from steam at 100°C than from water at 100°C? [2]
21. 2053 Q.No. 7 b Why is spark produced when two stones are stricken against one another? [2]
22. 2051 Q.No. 7 d During high fever, a wet cloth is kept on the forehead of a person. Why? [2]
23. 2050 Q.No. 7 b Why does food cook faster in a pressure cooker than in an open pot? [2]

Long Answer Questions

24. 2076 Set B Q.No. 6a State Newton's law of cooling. Use it to find the specific heat capacity of a unknown liquid. [4]
25. 2075 GIE Q.No. 6c 2066 Old Q. No. 5a OR Describe the method to determine latent heat of vaporization of water in laboratory. [4]
26. 2075 Set A Q.No. 6a What is meant by heat capacity? Describe the method of mixture to determine specific heat capacity of a solid. [4]
27. 2074 Supp. Q.No. 6b State Newton's law of cooling. Use this law to determine the specific heat capacity of a liquid. [4]
28. 2074 Set A Q.No. 6a State Newton's Law of cooling. Describe how is this law applied to determine the specific heat capacity of a liquid. [4]
29. 2074 Set B Q.No. 6c Describe experimental method, with necessary theory, to determine the latent heat of vaporization of water. [4]
30. 2073 Supp Q.No. 6a Describe, in brief, the laboratory method of mixture to determine the specific heat capacity of a solid. [4]
31. 2073 Set D Q.No. 6c State and explain Newton's law of cooling. Describe with mathematical detail a method for the determination of specific heat capacity of a liquid. [4]
32. 2072 Supp Q.No. 6b What is specific heat capacity of a substance? Describe the method of mixture to measure the specific heat capacity of solid. [4]
33. 2072 Set D Q.No. 6a State and explain Newton's law of cooling. Describe with mathematical detail a method for the measurement of specific heat capacity of a liquid. [4]
34. 2072 Set E Q.No. 6b What is the difference between the "specific heat capacity" and "latent heat"? Describe in brief, the laboratory experiment for the determination of latent heat of fusion of ice. [4]
35. 2071 Supp Q.No. 6a Define specific latent heat of fusion of ice. Develop an expression for the determination of specific latent heat of fusion of ice. [4]
36. 2071 Set D Q.No. 6 a Describe in brief the method of mixture to determine the specific heat of a solid in the laboratory? [4]
37. 2069 Supp Q.No. 6b Describe the experiment that is applied to determine the specific heat capacity of a solid by the method of mixture. [4]
38. 2069 (Set B) Q. No. 6a 2062 Q.No. 5a State and explain Newton's law of cooling and derive the expression for the specific heat of the liquid. [4]
39. 2069 Old (Set B) Q. No. 5a Why the temperature is constant during change of state of the substance? Develop an expression for the determination of the latent heat of vaporization. [1+4]
40. 2068 Q.No. 6 a Define latent heat of fusion of ice. Describe the method for the measurement of it in the laboratory. [4]
41. 2068 Old Q.No. 5 a Define latent heat of fusion of ice. Explain the method of determining the latent heat of fussion of ice by the method of mixture in laboratory. [1+4]
42. 2067 Supp Q.No. 6 a Explain with necessary theory how to determine the specific heat capacity of a liquid by the method of cooling. [4]
43. 2067 Q.No. 6a 2060 Q.No. 5a OR Define specific heat of substance. Describe the method of mixture to determine the specific heat of a solid. [4]
44. 2065 Q. No. 5 a State and explain Newton's law of cooling. Determine the specific heat capacity of liquid by method of cooling. [1+4]

45. 2064 Q.No. 5 a Define specific heat capacity and heat capacity. Describe the method of mixture to determine the specific heat capacity of a liquid. [1+4]

46. 2063 Q.No. 5 a State and explain Newton's Law of cooling. [1+4]

47. 2058 Q.No. 5 a Explain how you determine the specific heat of a solid by the method of mixture. [4]

48. 2055 Q.No. 8 What is specific latent heat of vapourisation of a liquid? Develop an expression for the determination of the latent heat of vapourisation. [4]

Numerical Problems

49. 2076 Set B Q.No. 10b A copper calorimeter of mass 300 g contains 500 g of water at temperature 15°C. A 560 g block of aluminium at temperature 100°C is dropped in the calorimeter and the temperature is observed to increase to 22.5°C. Find the specific heat capacity of aluminium. [4]
Ans: 383.64 J kg^{-1} $°C^{-1}$

50. 2076 Set C Q.No. 10a A substance takes 3 minutes in cooling from 50°C to 45°C and takes 5 minutes in cooling 45° C to 40°C. What is the temperature of the surroundings? [4]
Ans: 35°C

51. 2075 GIE Q.No. 10a How much heat is required to convert 10kg of ice at -10°C into steam at 100°C ? (SP. heat of ice = 2100Jkg^{-1} K^{-1}, latent heat of fusion of ice = 3.36×10^{5}Jkg^{-1}, latent heat of vaporization = 2.268 × 10^{6}Jkg^{-1})
Ans: 3.037×10^7 J

52. 2075 Set B Q.No. 10a A mixture of 500g water and 100 g ice at 0°C is kept in a copper calorimeter of mass 200 g. How much steam from the boiler be passed to the mixture so that the temperature of the mixture reaches 40°C? [4]
Ans: 54.78 g

53. 2073 Supp Q.No. 10c 2072 Supp Q.No. 10b 2069 (Set B) Q. No. 10b What is the result of mixing 100 g of ice at 0°C into 100 g of water at 20°C in an iron vessel of mass 100 g? [4]
Ans: 27.5 g of ice and 127.5 g of water at 0°C

54. 2073 Set C Q.No. 10a In an experiment on the specific heat of a metal, a 200 g block of metal at 150°c is dropped in a copper calorimeter of mass 270 g containing 150 cm^3 of water at 27°c. The final temperature is 40°c. Calculate the specific heat of the metal. [S_c = 390 J/Kg°C, S_w = 4200 J/kg °C] [4]
Ans: 434.5 J/Kg °C

55. 2072 Set C Q.No. 10a A copper pot with mass 0.5 kg contains 0.170 kg of water at a temperature of 20°C. A 0.250 kg block of iron at 85°C is dropped into the pot. Find the final temperature assuming no heat loss to the surroundings. [4]
Ans: 27.45°

56. 2071 Set C Q.No. 10 a Find the result of mixing 0.8 kg of ice at –10°C with 0.8 kg of water at 80°C. [4]
Ans: 0°C with 1.55 kg water and 0.047 kg of ice

57. 2071 Set D Q.No. 10 c From what height should a block of ice be dropped in order that it may melt completely? [4]
Ans: 33600 m

58. 2070 Supp (Set A) Q.No. 10 a How much heat is required to convert 5 kg of ice at –10°C into steam at 100°C? [4]
Ans: 1.52 × 10^7 J

59. 2070 Supp (Set B) Q.No. 10 a A copper calorimeter of mass 300 g contains 500 g of water at a temperature of 15°C. A 560g block of aluminium at temperature of 100°C is dropped in the water of the calorimeter and the temperature is observed to increase 22.5°C. Find the specific heat capacity of aluminium, neglecting the heat lost to the surroundings. [4]
Ans: 528.57 J $kg^{-1}°C^{-1}$

60. 2070 Set C Q.No. 10 a A ball of copper weighing 400 gram is transferred from a furnace to a copper calorimeter of mass 300 gram and containing 1 kg of water at 20°C. The temperature of water rises to 50°C. What is the original temperature of the ball? [4]
Ans: 860°C

61. 2070 Set D Q.No. 10 a A copper calorimeter of mass 300 gram contains 500 gram of water at 15°C. A 560 gram of aluminium ball at temperature of 100°C is dropped in the calorimeter and the temperature is increased to 25°C. Find the specific heat capacity of aluminium. [4]
Ans: 528.57 J $kg^{-1}°C^{-1}$

62. 2069 (Set A) Q. No. 10b 10 g of steam at 100°C is passed into a mixture of 100 g of water and 10 g of ice at 0°C. Find the resulting temperature of the mixture. [4]
Ans: 46.67°

63. 2066 Q. No. 10 b What is the result of mixing 10gm of ice at 0°C into 15gm of water at 20°C in a vessel of mass 100 g and specific heat 0.09? [4]
Ans: 21gm of water and 4 g of ice at 0°C

64. 2061 Q.No. 5 b What is the result of mixing 100g of ice at 0°C and 100g of water at 100°C. Latent heat of fusion of ice = 336 × 10^3 jk^{-1}, specific heat of water = 4200 Jkg^{-1} k^{-1}. [4]
Ans: 10°C

65. 2059 Q.No. 5 b 2051 Q.No. 11 How much heat is needed to change 10 g of ice at - 10°C to steam at 100°C. (Specific heat capacity of ice = 0.5 cal g^{-1} C^{-1}, Latent heat of fusion of ice = 80 cal g^{-1}, Latent heat of vaporization = 540 cal g^{-1}). [4]
Ans: 30450J

66. 2057 Q.No. 5 b From what height a block of ice be dropped in order that it may completely melt. It is assumed that 20% of energy of fall is retained by ice. [L = 80 cal./g]. [4]
Ans: 168000m

67. 2052 Q.No. 10 b 50 gm. of ice at - 6°C is dropped into water at 0°C. How many grams of water freeze? (Given: SP heat capacity of ice = 2000 J. Kg^{-2} $°C^{-1}$). [4]
Ans: 1.786 g

68. 2050 Q.No. 8 Evaporation or perspiration is an important mechanism for temperature control of warm-blooded animals. What mass of water must evaporate from the surface of an 80 kg human body to cool it by 1°C? The specific heat capacity of the human body is approximately 0.1 cal gm^{-1} °C and the latent heat of vaporization of water at the body temperature is 577 cal. gm^{-1}? [4]
Ans: 0.0139 kg.

3. Thermal Properties of Matter

Values of Physical Constants

Universal gas constant = 8.314 Jmol^{-1} K^{-1}

Ratio of Specific heat capacity of gases $\gamma = 1.42$

Ratio of Specific heat capacities of a monoatomic ideal gas = $\frac{5}{3}$

Relative molecular mass of oxygen = 32

FORMULAE

1. Boyle's law, $PV = \text{constant}$, or, $P_1V_1 = P_2V_2$
2. Charles' law, $\frac{V}{T} = \text{constant}$, or, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
3. Equation of state, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
4. Ideal gas equation, $PV = nRT$, where R is the universal gas constant
5. The Boltzmann's constant, $k_B = \frac{R}{N_A} = 1.38 \times 10^{-23}\ JK^{-1}$
6. Rms speed of gas molecules,
$$c_{rms} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + \ldots\ldots + c_N^2}{N}}$$
7. Pressure exerted by a gas, $P = \frac{1}{3}\frac{m}{V}\bar{c}^2$
8. The rms speed of gas molecules, $c_{rms} = \sqrt{\frac{3P}{\rho}}$
9. The mean kinetic energy per molecule of a gas,
$E_k = \frac{1}{2}m\bar{c}^2 = \frac{3}{2}k_BT$
10. Avogadro's number,
$N_A = \frac{\text{Molar mass}}{\text{Mass of 1 molecule}} = 6.023 \times 10^{23}$
11. Number of mole of substance, $n = \frac{\text{total mass of gas}}{\text{molar mass}} = \frac{m}{M}$
12. Variation of rms speeds,
$\frac{c_1}{c_2} = \sqrt{\frac{T_1}{T_2}}, \frac{c_1}{c_2} = \sqrt{\frac{\rho_2}{\rho_1}}$ and $\frac{c_1}{c_2} = \sqrt{\frac{M_2}{M_1}}$

Short Answer Questions

1. 2075 Set B Q.No. 2a How can Kelvin scale, in principle, be designed by the experiment based on ideal gas law? Explain. [2]
2. 2074 Set A Q.No. 2c When a car is driven some distance, the air pressure in the tyre increases. Why? [2]
3. 2073 Supp Q.No. 2c What physical concept is provided by universal gas constant? Write its unit. [2]
4. 2072 Set C Q.No. 2c Explain on the basis of kinetic theory that the pressure of a gas increases with increase of temperature. [2]
5. 2072 Set D Q.No. 2c On reducing the volume of a gas at constant temperature, the pressure of a gas increase. Why? [2]
6. 2072 Set E Q.No. 2b What does "the kinetic interpretation of temperature" signify? Explain. [2]
7. 2071 Set C Q.No. 2 a What is the difference between a real and an ideal gas? Explain on the basis of the hypothesis of the kinetic theory. [2]
8. 2070 Supp (Set B) Q.No. 2 a At a fixed temperature the volume of a vessel is compressed to half. How will the rms speed of the gas in it change? [2]
9. 2069 (Set A) Old Q. No. 4b Do you expect the gas in cooking gas cylinder to obey the ideal gas equation? [2]
10. 2068 Old Q.No. 4 b What are the characteristics of a gas to be an ideal? [2]
11. 2065 Q. No. 4 c Which has more molecules: A kilogram of hydrogen or a kilogram of oxygen? [2]
12. 2064 Q.No. 4 c Absolute zero temperature is not zero energy temperature. Explain. [2]
13. 2063 Q.No. 4 c In the kinetic theory of gases, why do we not take into account the changes in gravitational potential energy of the molecule? [2]
14. 2062 Q.No. 4 c Write the unit of the universal gas constant and give its physical meaning. [2]
15. 2060 Q.No. 4 b Under what conditions do the real gases obey more strictly the gas equation PV = RT? [2]
16. 2057 Q.No. 4 a Why does the cycle tube burst sometimes in summer? [2]
17. 2057 Q.No. 4 b At absolute zero temperature, why the kinetic energy is zero? [2]
18. 2055 Q.No. 7 a Why do you consider an ideal gas while formulating the pressure in the light of kinetic theory of gases? [2]
19. 2053 Q.No. 7 d Molecules of different gases have equal average kinetic energines, provided their temperature is the same. Do these molecules have equal velocities also? [2]
20. 2053 Q.No. 10 a Outline the essential features of the kinetic theory of gases. [2]
21. 2050 Q.No. 7 e Which has more atoms: a kilogram of hydrogen or a kilogram of iron? [2]

Long Answer Questions

22. 2076 Set B Q.No. 6b 2076 Set C Q.No. 6b 2074 Set A Q.No. 6b Derive an expression for the pressure exerted by an ideal gas on the basis of Kinetic theory. [4]
23. 2075 Set A Q.No. 6b Starting from basic postulate for kinetic theory of gas, derive an expression for the pressure exerted by the gas contained in a box. [4]
24. 2074 Set B Q.No. 6b Deduce an expression for pressure exerted by a ideal gas from kinetic theory? [4]
25. 2073 Supp Q.No. 6b State Boyle's and Charle's laws. Describe how these laws are combined to derive ideal gas law. [4]
26. 2073 Set C Q.No. 6b Using the postulates of kinetic theory of gases, deduce an expression for the pressure exerted by an ideal gas on the walls of a container. [4]
27. 2073 Set D Q.No. 6a State and explain Boyle's law and Charle's law. Use these laws to derive the ideal gas equation for n-moles of a gas. [4]
28. 2072 Set C Q.No. 6c Use the concepts of the kinetic theory of gases to derive an expression for pressure exerted by the gas on the walls of a container. Extend your result to establish a relation between pressure and average kinetic energy of the gas. [4]
29. 2071 Set C Q.No. 6 a Obtain combined equation of state of an ideal gas on the basis of statements and explanations of Boyle's and Charles laws. [4]
30. 2071 Set D Q.No. 6 b Derive ideal gas equation on the basis of kinetic theory of a gas. [4]
31. 2070 Supp (Set B) Q.No. 6 b What do you mean by ideal gas? Derive pv = mrT, where symbols have usual meanings. [4]
32. 2070 Set C Q.No. 6 b What do you mean by an ideal gas? Derive ideal gas equation for n mole of gas. [4]
33. 2070 Set D Q.No. 6 b What is perfect gas? Prove that the average kinetic energy of a gas molecule is directly proportional to the absolute temperature of the gas. [4]

34. 2069 Supp Q.No. 6a Using the postulates of kinetic theory of gases, derive an expression for the pressure exerted by an ideal gas. [2]

35. 2069 (Set A) Old Q. No. 5a OR State Charle's law of gases. Derive the ideal gas equation PV = nRT. Where symbols have usual meaning. [1+4]

36. 2069 (Set B) Q. No. 6b Use the kinetic theory of gases to derive an expression for the pressure exerted by a gas on the walls of its container. [2]

37. 2068 Q.No. 6 b On the basis of kinetic theory of gases, deduce the relation, $P = \frac{1}{3} \rho C^2$.

Where the symbols have their usual meanings. [2]

38. 2067 Supp Q.No. 6 b State Boyle's law and Charle's law. Use them to derive the ideal gas equation Pv = nRT.

39. 2066 Q. No. 6 b Prove that the pressure exerted by a gas on the wall of a container is 2/3 times the kinetic energy per unit volume of the gas. [2]

40. 2066 Old Q. No. 5 a Outline essential features of the kinetic theory of gases. Obtain an equation of state on the basis of kinetic theory. [3+2=5]

41. 2064 Q.No. 5 a OR Define volume coefficient and pressure coefficient. How pressure coefficient and volume coefficient are related? [1+4]

42. 2062 Q.No. 5 a Or State Boyle's and Charle's law and hence obtain the relationship for the combined gas law. [5]

43. 2061 Q.No. 5 a OR State Boyle's law and derive ideal gas equation. [1+4]

44. 2059 Q.No. 5 a Or Using postulates of kinetic theory of a gas, derive an expression for the pressure exerted by the gas on the wall of a box. [1+4]

45. 2057 Q.No. 5 a State Charle's law and derive ideal gas equation. [1+4]

46. 2054 Q.No. 9 Use the kinetic theory of gases to derive an expression for the pressure exerted by a gas on the walls of its container. [4]

47. 2052 Q.No. 9 State Boyle's and Charle's law. Show how can be combined to given equation of state of an ideal gas. [4]

48. 2051 Q.No. 10 Starting from the pressure relation $P = \frac{mn\ \bar{c}^2}{3V}$ in kinetic theory of gases, derive Boyle's law and Charle's law. [4]

49. 2050 Q.No. 10 OR Show that, on the basis of the simple kinetic theory of gases, the pressure P of an ideal gas of density ρ is given by $P = 1/3\ \rho\bar{c}^2$, where $\bar{c}^2$ is the mean square speed of the molecules. Explain the assumptions you have made in deriving this formula. [4]

Numerical Problems

50. 2075 Set B Q.No. 10b 2072 Supp Q.No. 10a 2067 Q.No. 10b 2065 Q. No. 5b Air at 273 K and 1.01×10^5 N/m² pressure contains 2.70×10^{25} molecules per cubic meter. How many molecules per cubic meter will there be at a place where the temperature is 223 K and the pressure is 1.33×10^4 N/m²? [4]
Ans: 4.35×10^{24} mol m³

51. 2074 Supp. Q.No. 10a The correct inflation of a tyre at 20°C is 2 kg/cm². After driving several hours, the driver checks the tyres. If the tyre's temperature is 50°C, what should be the pressure reading? [4]
Ans: 2.2×10^5 Nm⁻²

52. 2073 Supp Q.No. 10a The root mean square (rms) speed of a gas molecule is 600 ms⁻¹ at 500°C. Calculate the rms speed of the gas at 100°C. [4]
Ans: 416.97 m/s

53. 2072 Set D Q.No. 10b A cylindrical tank has a tight fitting piston that allows the volume of the tank to be changed. The tank originally contains 0.110 m³ of air at a pressure of 3.4 atm. The piston is slowly pulled out until the volume of the gas is increased to 0.390 m³. If the temperature remains constant what is the final value of the pressure? [4]
Ans: 0.95 atm

54. 2072 Set E Q.No. 10c At a pressure of 700 mm of Hg the root mean square speed of the molecules of a gas is 400 ms⁻¹. What is its density? [4]
Ans: 1.785 kg m⁻³

55. 2071 Supp Q.No. 10b What is average translational K.E. of a molecule of an ideal gas at a temperature of 27°c? What is the total random translational kinetic energy of the molecules in 1 mole of this gas? What is the root-mean-square speed of oxygen molecules at this temperature? [4]
Ans: 484.4 m/sec

56. 2070 Supp (Set A) Q.No. 10 c At what temperature will the average speed of oxygen molecule be sufficient so as to escape from the earth? [Escape velocity from the earth is 11.2 km/s and mass of one oxygen molecule is 53.4×10^{-24} g] [4]
Ans: 1.62×10^5 k

57. 2069 (Set A) Q. No. 10a Air at a temperature of 273 K and a pressure of 1.01×10^5 N/m² pressure contains 2.7×10^{25} molecules per cubic meter. How many molecules per cubic meter will be there at a place where the temperature is 223K and the pressure is 1.33×10^4 N/m². [4]
Ans: 4.35×10^{24}/m³

58. 2067 Supp Q.No. 10 b Taking the density of Nitrogen at STP to 1.251 kgm⁻³, find the root mean square velocity of Nitrogen molecules at 127°c. [4]
Ans: 596.6m/s

59. 2063 Q.No. 5 b A cylinder of gas has a mass of 10 kg. and pressure of 8 atmosphere at 27°C. When some gas is used in a cold room at -3°C, the gas remaining in the cylinder at this temperature has a pressure of 6.4 atmospheres. Calculate the mass of gas used. [4]
Ans: 1.1 kg.

60. 2060 Q.No. 5 b Helium gas occupies a volume of 0.04m³ at a pressure of 2×10^5 Nm⁻² and temperature 300 k. Calculate the mass of the helium and root mean square speed of its molecules.(Relative molecular mass of helium = 4, molar gas constant = 8.3 J mol⁻¹ k⁻¹) [4]
Ans: 0.0129 kg, 1364 m/sec.

61. 2058 Q.No. 5 b Find the rms speed of nitrogen at NTP. Density of N_2 = 1.29kg/m³ at NTP. [4]
Ans: 484.65 m/sec.

62. 2056 Q.No. 5 b Two glass bulbs of equal volume are joined by a narrow tube and are filled with a gas at s.t.p. When one bulb is kept in melting ice and the other is placed in a hot bath, the new pressure is 877.6 mm of Hg. Calculate the temperature of the bath. [4]
Ans: 373 K

63. 2052 Q.No. 8 Two bulbs of equal volume are joined by a narrow tube and are filled with gas at STP. When one bulb is kept in melting ice and the other in boiling water, calculate the new pressure of the gas. [4]
Ans: 877.65 mm of Hg

4. Hygrometry

FORMULAE

1. Pressure, $P = h\rho g$
2. Absolute Humidity
$$= \frac{\text{Amount of water vapour actually present in a certain volume}}{\text{Amount of water vapour required to saturate the same volume at same temperature}}$$
3. Relative Humidity (RH) = $\frac{\text{Saturated vapour pressure (SVP) at dew point}}{\text{Saturated vapour pressure (SVP) at room temperature}} \times 100\%$

Also, $RH = \frac{p}{P} \times 100\%$

Short Answer Questions

1. 2076 Set B Q.No. 2b 2071 Supp Q.No. 2b Why does it take longer time to dry wet clothes in rainy summer than in sunny winter? [2]
2. 2076 Set C Q.No. 2a 2073 Set C Q.No. 2b Dews are formed in the clear night but not in the cloudy night. Why? [2]
3. 2075 Set A Q.No. 2a Explain why we can see our breath in winter but not in summer? [2]
4. 2075 Set B Q.No. 2c Point out the differences between saturated and unsaturated vapour pressures with examples. [2]
5. 2074 Supp. Q.No. 2b Why do we feel uncomfortable during very high relative humidity of air? [2]
6. 2074 Set A Q.No. 2b 2068 Q.No. 2b Explain why dews are formed in clear night but not in cloudy night. [2]
7. 2074 Set B Q.No. 2b Point out the differences between saturated and unsaturated vapour pressures. [2]
8. 2073 Set D Q.No. 2b Dews are formed in the early morning hours, why? [2]
9. 2072 Set C Q.No. 2a What is triple point? Show that there exist a single value of triple point. [2]
10. 2072 Set D Q.No. 2a What is the difference between saturated and unsaturated vapour? [2]
11. 2071 Set D Q.No. 2 b Why are dews formed in the clear nights but not in the cloudy ones? Explain. [2]
12. 2070 Supp (Set B) Q.No. 2 b A weather report said relative humidity of 80%. Explain its meaning [2]
13. 2070 Set D Q.No. 2c 2067 Supp Q.No. 2b Define triple point and write its significance. [2]
14. 2069 (Set A) Old Q. No. 4c What is meant by triple point? [2]
15. 2068 Old Q.No. 4 c What do you mean by triple point of water? [2]
16. 2067 Q.No. 2 b Why is the triple point, instead of the melting point or boiling point of water, taken as a standard fixed point in modern thermometry? [2]
17. 2066 Old Q. No. 4 b What is relative humidity? Why is its value more near the sea shore? [2]
18. 2064, Q.No. 4(b) Why are you more uncomfortable on a hot day when the humidity is high than when it is cooled? [2]
19. 2063 Q.No. 4 b What is relative humidity? Why is its value more near sea water? [2]
20. 2062 Q.No. 4 b Explain the difference between saturated and unsaturated vapour pressure. [2]
21. 2061 Q.No. 4 a Distinguish between a gas and vapour. [2]
22. 2059 Q.No. 4 b How are dews formed? [2]
23. 2058 Q.No. 4 b What are saturated and unsaturated vapours? [2]
24. 2057 Q.No. 4c 2051 Q.No. 7e Why are dews formed in the early morning hours? [2]
25. 2056 Q.No. 4 c What do you mean by Triple Point? [2]
26. 2055 Q.No. 7b Distinguish between saturated and unsaturated vapour pressure. [2]
27. 2054 Q.No. 7a Why is the triple point of water chosen as a standard fixed point in modern thermometry? [2]
28. 2054 Q.No. 10a Compare the properties of saturated and unsaturated vapours. [2]
29. 2053 Q.No. 7 f Define Triple point. [2]
30. 2052 Q.No. 7 f Define due point. [2]

Numerical Problems

31. 2052 Q.No. 8 OR At certain day the air temperature in a room is 17.7°C and the dew point 5.3°C. Find the relative humidity (SVP at 5°, 6°, 17° and 18°C are 0.654 cm, 0.705 cm, 1.442 cm, 1.546 cm respectively). [4]
Ans: 44.18%

5. Transfer of Heat

Values of Physical Constants

Stefan's constant (σ) $= 5.67 \times 10^{-8}$ w/m^{2}k^4
Thermal conductivity of Aluminium $= 205.0$ Wm^{-1} k^{-1}
Thermal conductivity of Brass $= 109.0$ Wm^{-1} k^{-1}

FORMULAE

1. Rate of heat conduction, $\frac{dQ}{dt} = \frac{kA(\theta_1 - \theta_2)}{x}$
2. Stefan's law, $E = \sigma T^4$ here,
$E = \frac{Q/t}{A} = \frac{\text{Power radiated}}{\text{Surface areea}} = \frac{P}{A}$
Then, $P = \sigma AT^4$,
In general form, $P = e\sigma AT^4$, where e is called emissivity of a black body
3. Stefan-Boltzmann law, $E = \sigma(T^4 - T_0^4)$.
For any black body, $P = e\sigma A(T^4 - T_0^4)$.
4. Surface temperature of the sun, $T = \left[\frac{r^2 S}{R^2 \sigma}\right]^{1/4}$

Short Answer Questions

1. 2076 Set C Q.No. 2b Cooking utensils are blackened at the bottom and polished on the upper surface. Explain, why? [2]

2. 2075 GIE Q.No. 2b How can water be boiled in a thin paper cup? [2]
3. 2075 GIE Q.No. 2c 2069 (Set A) Q. No. 2c Why are the polar regions much cooler than the equatorial regions despite the fact that the polar regions are periodically tilted towards the sun? [2]
4. 2075 Set B Q.No. 2b What is the physical meaning of emissivity? Write its unit. [2]
5. 2072 Supp Q.No. 2b Air is a bad conductor of heat. Why do you feel cool without cloth in your body? [2]
6. 2072 Supp Q.No. 2c 2069 (Set B) Q. No. 2c 2052 Q.No. 7 a Although aluminium is good conductor of heat, how can aluminium foil with shining surface can be used to keep food hot for a long time? [2]
7. 2070 Set C Q.No. 2 b Birds often swell their feathers in winter. Why? [2]
8. 2070 Set D Q.No. 2 b Animals curl into a ball, when they feel very cold. Why? [2]
9. 2066 Q. No. 2a 2060 Q.No. 4a Why are two thin blankets warmer than a single blanket of double the thickness? [2]
10. 2059 Q.No. 4 c During the winter, the animals curl into a ball. Explain why? [2]
11. 2055 Q.No. 7 c Why are good absorbers always good emitters? [2]
12. 2054 Q.No. 7 f What is a black body? How is it realized in practice? [2]
13. 2053 Q.No. 7 a Hot water pipes used in the room are painted black. Why? [2]
14. 2052 Q.No. 7 b Metal knob of door is colder than wooden parts at the same temperature. Why? [2]
15. 2051 Q.No. 7 a How can water be boiled in a paper cup? [2]

Long Answer Questions

16. 2075 Set B Q.No. 6a On what factors the thermal conductivity of a solid depends? Describe, Searle's experimental method to determine the thermal conductivity of a solid. [4]
17. 2072 Set D Q.No. 6c 2057 Q.No. 5 a OR State and explain Stefan's law of black body radiation. Can a perfect black body be realized in practice? [4]
18. 2072 Set E Q.No. 6c State and explain Stefan's law of black body radiation. [4]
19. 2071 Supp Q.No. 6b State and explain Stefan's black body radiation. Explain how a black body can be realized in practice. [4]
20. 2071 Set C Q.No. 6 b Define the coefficient of thermal conductivity. Describe, with necessary theory, an experiment for its determination in the laboratory. [4]
21. 2070 Supp (Set A) Q.No. 6 b Define coefficient of thermal conductivity. Describe Searl's method of determining thermal conductivity. [4]
22. 2069 Old (Set B) Q. No. 5a OR Define thermal conductivity. Describe Searle's method of determination of thermal conductivity of good conductor. [1+4]
23. 2068 Old Q.No. 5 a or Discuss the methods of heat transmission. Define reflection, transmission and absorption coefficients of heat radiation and relate them. [3+2]
24. 2067 Q.No. 6 b What do you mean by thermal conductivity of a substance? Deduce an expression for the thermal conductivity of a good conductor in steady state. [4]
25. 2065 Q. No. 5 a Or Define thermal conductivity. Write its units and dimensions. Describe Searle's method of determination of thermal conductivity of good conductor. [1+1+3]
26. 2063 Q.No. 5 a OR Describe Searle's method of determination of thermal conductivity of a good conductor. [5]
27. 2061 Q.No. 5 a Define thermal conductivity. Describe with the necessary theory on experiment to determine the thermal conductivity of a metal bar. [1+4]
28. 2058 Q.No. 5 a OR What is a black body? Derive Stefan's law of black body radiation. [5]
29. 2056 Q.No. 5 OR What do you mean by perfectly black body. State and explain Stefan's law of black body radiation. [5]
30. 2051 Q.No. 9 Define thermal conductivity. Derive an expression for thermal conductivity of a good conductor in steady state. [5]
31. 2050 Q.No. 9 What is radiation and how does this mode of heat transfer differ from conduction and convection? [5]

Numerical Problems

32. 2076 Set C Q.No. 10b A bar 0.2m in length and 2.5 cm^2 in cross section is ideally lagged. One end is maintained at 100° C and the other end is maintained at 0° C by immersing in melting ice. Calculate the mass of ice melt in one hour. Thermal conductivity of the material of the bar is 4×10^{-2} Wm^{-1} K^{-1}. [4]
Ans: 5.36×10^{-5} kg
33. 2075 Set A Q.No. 10c The Sun is a black body of surface temperature about 6000K. If Sun's radius is 7×10^8m, calculate the energy per second radiated from its surface. The earth is about 1.5×10^{11} m from the Sun. Assuming all the radiation from the Sun falls on the surface of sphere of this radius, estimate the energy per second per $meter^2$ received by the earth. [4]
Ans: 4.55×10^{26} W, 1609 Wm^{-2}
34. 2074 Supp. Q.No. 10b A sphere of radius 2.00 cm with a black surface is cooled and then suspended in a large evacuated enclosure with black walls maintained at 27°C. If the rate of change of thermal energy of sphere is 1.85JS^{-1} when its temperature is –73°C, calculate the value of Stefan's Constant. [4]
Ans: 5.66×10^{-8} Wm^{-2} K^{-4}
35. 2074 Set A Q.No. 10b Estimate the power loss through unit area from a perfectly black body at 327°C to the surrounding environment at 27°C. [4]
Ans: 6889.05 W
36. 2074 Set B Q.No. 10c A spherical blackbody of radius 5 cm has its temperature 127°C and its emissivity is 0.6. Calculate its radiant power. [4]
Ans: 27.34 W
37. 2073 Supp Q.No. 10b Estimate the radiant power loss from a human body at a temperature 38.5°C to the environment at 0°C if the surface area of the body is 1.5 m^2 and its emissivity is 0.6. [4]
Ans: 197 W

38. **2073 Set C Q.No. 10b** A pot with a steel bottom 8.5 mm thick rest on a hot stove. The area of the bottom of the pot is $0.15m^2$. The water inside the pot is at 100°c and 390 g of water is evaporated every 3 minute. Find the temperature of lower surface of the pot which is in contact with the stove. [k = 50.2 W/mk, $L_v = 2256 \times 10^3$ J/Kg] [4]
Ans: 105°C

39. **2073 Set D Q.No. 10b** A rod 1.3 m long consists of a 0.8 m length of aluminium joined end to end to a 0.5 m length of brass. The free end of the aluminium section is maintained at 150°C and the free end of the brass piece is maintained at 20°C. No heat is lost through the sides of the rod. At a steady state, what is the temperature at the point where the two metals are joined? [K_{al} = 205 W/mK, K_b = 110 w/mk] [4]
Ans: 90°C

40. **2072 Set C Q.No. 10c** A rod 1.300 m long consists of a 0.800 m length of aluminium joined end to end to a 0.500 m length of brass. The free end of the aluminium section is maintained at 150°C and the free end of the brass piece is maintained at 20°C. No heat is lost through the side of the rod. At steady state what is the temperature of the point when two metals are joined.
Ans: 90° C

41. **2071 Set D Q.No. 10 b** The element of an electric fire with an output of 1.5 Kw is a cylinder of 0.3 m long and 0.04 m in radius. Calculate its temperature if it behaves as a black body. [4]
Ans: 770 k

42. **2070 Supp (Set B) Q.No. 10 b** A bar 0.2 m in length and of cross-sectional area $2.5 \times 10^{-4}m^2$ is ideally lagged. One end is maintained at 373 K while the other is maintained at 273 K by immersing in melting ice Calculate the rate at which the ice melts owing to the flow of heat along the bar. [4]
Ans: 1.5×10^{-4} kg/sec

43. **2070 Set C Q.No. 10 b** A slab of stone of area 0.36 m^2 and thickness 10 cm is exposed on the lower surface to steam at 100°C . A block of ice at 0°C rests on the upper surface of the slab. In one hour, 4.8 kg of ice is melted. Calculate the thermal conductivity of stone. [4]
1.244 watt $m^{-1}k^{-1}$

44. **2070 Set D Q.No. 10 b** A metal rod of length 20cm and cross sectional area 3.14 cm^2 is covered with non-conducting substance. One of its end is maintained at 100°C, while the other end is put in ice at 0°C. It is found that 25 gram of ice melts in 5 minutes. Calculate the thermal conductivity of the metal. [4]
Ans: 178.3 watt/mk

45. **2069 Supp Q.No. 10c** **2062 Q.No. 5 b** Estimate the rate of heat loss through a glass window of area $2m^2$ and thickness 4mm when the temperature of the room is 300K and temperature outside is 5°C. [4]
Ans: Given, K = 1.2 $Wm^{-1}K^{-1}$, 13200 Watt

46. **2069 (Set A) Old Q. No. 5b** The sun is a black body of surface temperature about 6000 K. If the sun's radius is 7×10^8m, calculate the energy per second radiated from its surface. (Stefan's constant = 5.7×10^{-8} $Wm^{-2}K^{-4}$) [4]
Ans: 4.55×10^{26}W

47. **2068 Q.No. 10 b** An Ice box is made of wood 1.75 cm. thick lined inside with cork 2 cm. thick. If the temperature of inner surface of the cork is steady at 0°C and that of the outer surface of the wood is steady at 12°C; what is the temperature of the interface? The thermal conductivity of wood is five times that of cork. [4]
Ans: 10.23°C

48. **2066 Q. No. 10 c** A man, the surface area of whose skin is $2m^2$ is sitting in a room where the air temperature is 20°C. If his skin temperature is 37°C, find the rate at which his body loses heat. The emissivity of his skin is 0.97. [4]
Ans: 206 W

49. **2064 Q.No. 5 b** Assuming that the thermal insulation provided by a woolen glove is equivalent to a layer of quiescent air 3 mm thick, determine the heat loss per minute from a man's hand, surface area 200 cm^2 on a winter day when the atmospheric air temperature is –3°C. The skin temperature is to be taken as 35°C and thermal conductivity of air as 24×10^3 Wm^{-1} k^{-1}. [4]
Ans: 364.8 J, 0.101 J/min

50. **2055 Q.No. 9** Estimate the rate of heat loss through a glass window of area $2m^2$ and thickness 3mm when the temperature of the room is 20°C and that of air outside is 5°C. Given K = 1.2 $Wm^{-1}k^{-1}$ [4]
Ans: 12 kw

51. **2054 Q.No. 8 OR** What is the ratio of the energy per second radiated by the filament of a lamp at 2500 k to that radiated at 2000 k, assuming the filament is a black body radiator? [4]
Ans: 2.44:1

52. **2053 Q.No. 10 b** Estimate the rate at which ice would melt in a wooden box 2.5 cm. thick of inside measurement 100 cm. × 60 cm. × 40 cm. assuming that the external temperature is 35°C and thermal conductivity of wood is 0.168 wm^{-1} k^{-1}. [4]
Ans: 1. 6 × 10^{-3} kg./sec.

6. First Law of Thermodynamics

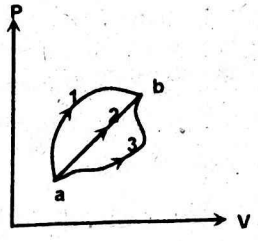
Values of Physical Constants
Universal gas constant = 8.314 $Jmol^{-1}$ K^{-1}
Ratio of Specific heat capacity of gases γ = 1.42
Ratio of Specific heat capacities of a monoatomic ideal gas = 5/3

FORMULAE

1. First law of thermodynamics, $dQ = dU + dW$
2. The relationship of molar heat capacities is, $C_p - C_v = R$
3. The specific heat capacity ratio, $\gamma = \frac{C_p}{C_v} = \frac{c_p}{c_v}$, The value of γ depends on atomicity of gas
4. The equation for isothermal process, PV = constant or $P_1V_1 = P_2V_2$
5. The equations of adiabatic process are,
   i. $P_1V_1^{\gamma} = P_2V_2^{\gamma}$. ii. $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$
   iii. $\frac{P_1^{\gamma-1}}{T_1^{\gamma}} = \frac{P_2^{\gamma-1}}{T_2^{\gamma}}$
6. Work done in isothermal expansion,
   i. $W = nRT \log_e \frac{V_2}{V_1}$ ii. $W = nRT \log_e \frac{P_1}{P_2}$
7. Work done in adiabatic expansion,
   i. $W = \frac{nR}{\gamma - 1}(T_1 - T_2)$ ii. $W = \frac{1}{\gamma - 1}(P_1V_1 - P_2V_2)$

Short Answer Questions

1. 2076 Set B Q.No. 2c The internal energy of a compressed gas is less than that of a rarefied gas at the same temperature. Why? [2]
2. 2076 Set C Q.No. 2c Why does the temperature of a gas drop during an adiabatic expansion? [2]
3. 2075 GIE Q.No. 2a Why does the temperature of a gas undergoing adiabatic expansion decrease? [2]
4. 2075 Set A Q.No. 2b Why does a gas have two specific heat capacities? [2]
5. 2074 Set B Q.No. 2c Explain the significance of the first law of thermodynamics. Hence write its expression in terms of the change in entropy of the system. [2]
6. 2073 Set D Q.No. 2c Compare the internal energy of a compressed gas with that of the rarefied gas at the same temperature. [2]
7. 2072 Set C Q.No. 2b Why specific heat capacity of gas at constant pressure is greater than its specific heat capacity at constant volume? [2]
8. 2072 Set D Q.No. 2b When a gas expands adiabatically, it does work on its surroundings. But, if there is no heat input to the gas where does the energy come from? [2]
9. 2071 Supp Q.No. 2c Is C_p always greater than C_v? [2]
10. 2070 Supp (Set A) Q.No. 2 a Explain, why the temperature of gas drops in an adiabatic process. [2]
11. 2070 Supp (Set B) Q.No. 2 c What are the limitations of first law of thermodynamics? [2]
12. 2070 Set C Q.No. 2 c A gas has two specific heats. Which one is greater and why? [2]
13. 2069 (Set A) Old Q.No. 1c Can heat be considered as a form of potential energy? [2]
14. 2069 (Set B) Q. No. 2b When we blow on the block of our hand with our mouth wide open, we feel warm. But if we partially close out mouth to form an 'O' and then blow on our hand, our breath feels cool. Why? [2]
15. 2069 Supp Q.No. 2b Air escaping from a tiny hole of a tube is felt cool, why? [2]
16. 2068 Q.No. 2 c 2065 Q. No. 4 b 2050 Q.No. 7 iv Air escaping from an air hose at a gas station always feels cold. Why? [2]
17. 2068 Old Q.No. 1 b Explain why temperature of gas drops in adiabatic expansion. [2]
18. 2068 Old Q.No. 2 b Milk is poured into a cup of tea and is mixed with spoon. Is this an example of reversible process? Explain. [2]
19. 2067 Supp Q.No. 2 c Why is the molar heat capacity of a gas at constant pressure always greater than at constant volume? [2]
20. 2067 Q.No. 2 c A system is taken from state 'a' to state 'b' along the three paths shown in adjacent figure. Along which path is the work done by the system greatest and the least? Give reason. [2]



21. 2066 Q.No. 1 b What happens to the internal energy of a gas during (1) isothermal expansion (ii) adiabatic expansion? [2]
22. 2066 Q. No. 2 c Explain why the temperature of a gas drops in an adiabatic process? [2]
23. 2065 Q.No. 1 b What is the difference between isobaric and isochoric processes? Explain. [2]
24. 2064 Q.No. 1 b Explain why C_p is greater than C_v. [2]
25. 2064 Q.No. 2 b Is it possible to increase temperature of a body without giving heat to it? Explain. [2]
26. 2062 Q.No. 1 b Is internal energy of an ideal gas, the sum of kinetic energy and potential energy at a temperature greater than absolute zero? Explain. [2]
27. 2061 Q.No. 1 b A cylinder filled with a gas is being carried inside a fast moving train, what change will be there in the internal energy of the gas? [2]
28. 2060 Q.No. 1 b What do you mean by internal energy of a gas? [2]
29. 2059 Q.No. 1 b Why is C_p greater than C_v? [2]
30. 2059 Q.No. 2 b Why does internal energy remain constant in an isothermal system? [2]
31. 2058 Q.No. 1 b What is meant by adiabatic expansion? Explain. [2]
32. 2057 Q.No. 2 b 2053 Q.No. 7 e Why has a gas two values of molar heat capacities? [2]
33. 2054 Q.No. 7 d Distinguish between an isothermal change and an adiabatic change. [2]
34. 2052 Q.No. 10 a Differentiate between isothermal and adiabatic change. [2]

Long Answer Questions

35. 2076 Set C Q.No. 6c State. and explain first law of thermodynamics. Derive the relation, $C_p - C_v = R$, where the symbols have their usual meanings. [4]
36. 2075 Set A Q.No. 6c What do you mean by adiabatic process? Deduce the equation PV^γ = const. where the symbols have their usual meaning. [4]
37. 2074 Supp. Q.No. 6c Why does a gas have two molar heat capacities? Show that for an ideal gas; $C_p - C_v = R$, where symbols have their usual meanings. [4]
38. 2074 Set A Q.No. 6c Why does a gas have two molar heat capacities? Derive relation between them for an ideal gas. [4]
39. 2074 Set B Q.No. 6a What is the difference between isothermal and adiabatic process. Prove that PV^r is constant in an adiabatic process r is the ratio of C_p and C_v. [4]
40. 2073 Supp Q.No. 6c What is adiabatic process? Derive an expression for the work done in this process. [4]
41. 2073 Set C Q.No. 6c What is an isothermal process? Derive the relation, PV^γ = constant, where symbols have their usual meanings. [4]
42. 2072 Set D Q.No. 6b Explain the term, Thermodynamic process. Obtain an expression for the work done by a gas during adiabatic expansion. [4]
43. 2072 Set E Q.No. 6a What do you understand by isothermal and adiabatic processes? Derive PV^r = constant, where symbols have their usual meaning. [4]

44. 2071 Supp Q.No. 6c For an adiabatic process show that PV^{γ} = constant. [4]

45. 2071 Set D Q.No. 6 c What is an adiabatic process? Prove the relation PV^{γ} = constant, where notations carry usual meanings. [4]

46. 2070 Supp (Set A) Q.No. 6 a Explain, why do the gases have two specific heat capacities. Also, show that $C_p - C_v = R$. where the symbols carry usual meaning. [4]

47. 2070 Set C Q.No. 6 c What is thermodynamic process? Describe different thermodynamic processes. [4]

48. 2070 Set D Q.No. 6 c Derive an expression for the work done during the adiabatic expansion of an ideal gas. Does the internal energy of the system change during adiabatic expansion? [4]

49. 2069 (Set A) Old Q.No. 4a What do you mean by isothermal process? Obtain an expression for the work done by an ideal gas in the isothermal process. [1+3]

50. 2069 (Set A) Old Q.No. 4a Or Define two specific heat capacity of the gas. Show that for an ideal gas $C_p - C_v = R$. [1+3]

51. 2069 (Set A) Q. No. 6b Define adiabatic process in thermodynamics. Show that: PV^{γ} = constant. Where symbols have their usual meanings. [4]

52. 2068 Q.No. 6 c Why does a gas have two molar heat capacities? Show that for an ideal gas: [4]
$C_p - C_v = R$. Where R is the molar gas constant.

53. 2068 Old Q.No. 4 a Show that for an ideal gas $C_p - C_v = R$. [4]

54. 2066 Q.No. 4 a What is adiabatic process? Derive the relation PV^{γ} = K, where symbols have their usual meaning. [1+3]

55. 2065 Q.No. 4 a OR Discuss the limitations of the first law of thermodynamics. Also derive an expression for equation of ideal gas during adiabatic process relating its temperature with pressure. [1+3]

56. 2064 Q.No. 4 a State and explain first law of thermodynamics and use it to derive the relation, PV^{γ} = constant, where the symbols have their usual meanings. [1+3]

57. 2063 Q.No. 4 a OR What is adiabatic process? Derive an expression for work done in adiabatic system. [1+3]

58. 2062 Q.No. 4 a OR Explain why C_P is greater than C_V? Derive an expression relating C_P, C_V and R. [1+3]

59. 2061 Q.No. 4 a One mole of ideal gas undergoes an isothermal expansion from pressure V_1 to V_2 at constant temperature T. Find the expression for work done in this process. [1+3]

60. 2060 Q.No. 4 a What are reversible and irreversible processes? Derive an expression for the work done by an ideal gas during isothermal expansion. [1+3]

61. 2057 Q.No. 4 a Derive the relation $C_p - C_v = R$, where the symbols have their usual meaning. [4]

62. 2053 Q.No. 9 Derive a relation between the two molar capacities of a gas. [4]

Numerical Problems

63. 2076 Set B Q.No. 10c A certain volume of dry air at NTP is allowed to expand five times of its original volume under adiabatic condition. Calculate the final pressure and temperature. [4]
Ans: 1.06×10^4 N/m², 196 K

64. 2075 GIE Q.No. 10b A certain volume of dry air at NTP is allowed to expand four times of its original volume under (i) isothermal conditions (ii) adiabatic conditions. Calculate the final pressure and temperature in each case. (γ=1.4).
Ans: 25250 Nm^{-2}, 1092 K, 14502.3 N/m^{-2}, 157 K

65. 2075 Set B Q.No. 10c A gas in a cylinder initially at a temperature of 10°C and one atmospheric pressure is to be compressed adiabatically to 1/8 of its volume. Find the final temperature. (Take γ = 1.4) [4]
Ans: 650 K

66. 2073 Set D Q.No. 10c A gas in a cylinder is initially at a temperature of 17°C and pressure 1.01×10^5 Nm^{-2}. If it is compressed adiabatically to one-eighth of its original volume, what would be the final temperature and pressure of the gas? [4]
Ans: 18.56×10^5 N/m², 666.24K

67. 2072 Supp Q.No. 10c For hydrogen the molar heat capacities at constant volume and constant pressure are 20.5Jmol^{-1}K^{-1} and 28.8Jmol^{-1}K^{-1} calculate (i) the heat needed to raise the temperature of 8g of hydrogen from 10°C to 15°C at constant pressure, (ii) the increase in internal energy of the gas. [molar mass of H_2 = 2gm] [4]
Ans: 576 Joule, 410 Joule

68. 2072 Set C Q.No. 10b Five moles of an ideal gas are kept at constant temperature of 53°C while the pressure of the gas is increased from 1.00 atm to 3.00 atm. Calculate work done by the gas. [4]
$W = nRT\log_e\left(\frac{P_1}{P_2}\right)$
Ans: –14881 J

69. 2071 Set C Q.No. 10 b Air is compressed adiabatically to half its volume. Calculate the change in its temperature. [4]
Ans: 32%

70. 2070 Supp (Set B) Q.No. 10 c A monoatomic ideal gas that is initially at a pressure of 1.50×10^5 pa and has a volume of 0.08m³ compressed adiabatically to a volume of 0.04 m³. (a) What is the final pressure? (b) How much work is done by the gas? (c) What is the ratio of the final temperature of the gas to its initial temperature? [4]
Ans: 476220 pa; 10573 J, 1.58

71. 2069 Supp Q.No. 10a If the ratio of specific heat capacities of a gas is 1.4 and its density at S.T.P. is 0.09 kg/m³. Calculate the values of specific heat capacities at constant pressure and at constant volume. [4]
Ans: 1.03×10^4Jkg^{-1}, 1.44×10^4Jkg^{-1}k^{-1}

72. 2067 Supp Q.No. 10 c Gas in a cylinder initially at a temperature of 17°c and pressure of 1.01×0^5 Nm^{-2} is to be compressed adiabatically to one-eight of its volume. Find the temperature and pressure of the gas. [4]
Ans: 1.85×10^6N/m²; 666.24K

73. 2067 Q.No. 10 c A liter of air, initially at 20°C and at 760 mm of Hg pressure, is heated at constant pressure until its volume is doubled. Find (i) the temperature, (ii) external work done by the air in expanding, and (iii) the quantity of heat supplied. Specific heat capacity at constant volume = 714 J/kg K. [4]
Ans. 586K, 101.3J, 352.8J

74. 2066 Q.No. 4 b A litre of air initially at 20°C and at 760mm of Hg pressure is heated at constant pressure until its volume is doubled. Find the final temperature and the external work done by the gas in expanding. [3]
Ans: 586 K, 101.3J

75. 2066 Q. No. 10 a An ideal gas initially at 4 atmosphere and 300 k is permitted to expand adiabatically twice its initial volume. Find the final pressure and temperature if the as is (i) monatomic and (ii) diatomic with $C_V = 5/2\ R$ [4]
Ans: (a) 1.257atm; 189k (b) 1.52 atm; 227.35 k

76. 2065 Q.No. 4 b The density of an ideal gas is 1.6 kgm^{-3} at 27°C and $10^5 Nm^{-2}$ pressure. Its specific heat capacity at constant volume is 312 $JKg^{-1}K^{-1}$. Find the ratio of the specific heat at constant pressure to that at constant volume. [3]
Ans: 1.67

77. 2064 Q.No. 4 b 2061 Q.No. 4 b The density of a gas is 1.775 Kg m^{-3} at 27°C and 10^5 Nm^{-2} pressure. If the specific heat capacity at constant pressure is 846 $Jkg^{-1}\ k^{-1}$. Find the ratio of specific heat capacity at constant pressure to that at constant volume. [4]
Ans: 1.29

78. 2062 Q.No. 4 b An ideal gas in slowly compressed at constant temperature of 50°C to one half of its original volume. In this process, 80 cal of heat was given. How much work was done and what was the change in the internal energy of the gas? Assume one mole of an ideal gas. [4]
Ans: 807.03 J; 1143.03 J

79. 2060 Q.No. 4 b 16g. of oxygen having volume 0.02m^3 at a temperature of 27°C and pressure of 2×10^5 Nm^{-2} is heated at constant pressure until its volume increases to 0.03m^3. Calculate the external work done and increase in internal energy of the gas if its Molar heat capacity at constant volume is 0.8 J $mol^{-1}\ k^{-1}$ and Molar mass of oxygen is 32. [4]
Ans: 2×10^3 J, 60 J

80. 2059 Q.No. 4 b A gasoline engine takes in air at 25°C and one atmospheric pressure and compresses adiabatically to one-tenth of its original volume. Find the final temperature and pressure. ($\gamma = 1.4$). [4]
Ans: 748.5 K, 25.11 atmosphere

81. 2058 Q.No. 4 b A mass of air occupying initially a volume 2×10^{-3} m^{-3} at a pressure of 760 mm of mercury and a temperature of 20°C is expanded adiabatically and reversibly to twice its volume, and then compressed isothermally and reversibly to a volume of $3\times10^{-3}m^3$. Find the final pressure assuming the ratio of the specific heat capacities of air to be 1.4. [4]
Ans: 384 mm of Hg

82. 2057 Q.No. 4 b Gas in a cylinder, initially at a temperature of 10°C and pressure of 1.01×10^5 Nm^{-2} is to be compressed adiabatically to one eight of its volume. Find final pressure and temperature. (Ratio of molar heat capacities = 1.40) [4]
Ans: 18.5×10^5 Nm^{-2}, 560.16K

7. Second Law of Thermodynamics

FORMULAE

1. Efficiency of heat engine,
$$\eta = \frac{\text{Work done}}{\text{Heat input}} = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$
2. Efficiency of Carnot's engine,
$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$
3. The efficiency of Petrol engine and Diesel engine,
$$\eta = \frac{\text{Work done}}{\text{Heat input}} = \frac{W}{Q_1} = 1 - \left(\frac{1}{\rho}\right)^{\gamma-1}$$
where
$\rho = \frac{V_2}{V_1}$ is called compression ratio and
$\gamma = \frac{c_p}{c_v}$ = specific heat ratio.
4. The coefficient of performance of a refrigerator,
$$\beta = \frac{Q_2}{W} = \frac{Q_1}{Q_2 - Q_1} = \frac{T_2}{T_1 - T_2}$$

Short Answer Questions

1. 2074 Supp. Q.No. 2c Why does a refrigerator consume more power in summer than in winter to cool the same quantity of food by same degree? [2]
2. 2074 Set A Q.No. 2a Why not an ideal heat engine is cent percent efficient? [2]
3. 2073 Supp Q.No. 2b An engine cannot have 100% efficiency. Why and which basic expression of thermodynamic law suggest this? [2]
4. 2073 Set C Q.No. 2c Explain the significance of second law of thermodynamics. [2]
5. 2071 Set C Q.No. 2 c Entropy is defined in the second law of thermodynamics. Can the first law be expressed in terms of entropy? How? [2]
6. 2071 Set D Q.No. 2 c Explain the significant difference between the first and the second laws of thermodynamics. [2]
7. 2070 Supp (Set A) Q.No. 2 c Spark plug is not necessary in a diesel engine, why? [2]
8. 2066 Q.No. 2 b Is it possible to construct a heat engine that creates no thermal pollution? [2]
9. 2065 Q.No. 2 b Write down the statements of second law of thermodynamics. [2]
10. 2063 Q.No. 2 h Why do diesel engines need no spark plugs? [2]
11. 2062 Q.No. 2 b Petrol engine is less efficient than diesel engine. Explain why? [2]
12. 2061 Q.No. 2 b 2054 Q.No. 7 e State second law of thermodynamics. [2]
13. 2060 Q.No. 2 b Can the thermal efficiency of an engyine ever be 100%? Give reason. [2]
14. 2058 Q.No. 2 b Can a room be cooled by leaving the doors of an electric refrigerator open in a closed room? [2]
15. 2057 Q.No. 1 b Distinguish between petrol and diesel engine. [4]

Long Answer Questions

16. 2076 Set B Q.No. 6c Describe the working principle of diesel engine with the help of PV diagram. [4]

17. 2075 GIE Q.No. 6b State and explain second law of thermodynamics. Define the efficiency of a heat engine and explain qualitatively why the efficiency of such an engine is always less than 100%? [4]

18. 2075 Set B Q.No. 6c Describe the working principle of petrol engine with the help of its PV diagram. [4]

19. 2073 Set D Q.No. 6b What is efficiency of a heat engine? Describe the working of a petrol engine with the help of its P–V diagram. [4]

20. 2072 Supp Q.No. 6c 2070 Supp (Set B) Q.No. 6c 2069 Set A Q.No. 6c 2067 Q.No. 6 c 2066 Q. No. 6 c Describe the working of a petrol engine with the help of its P-V diagram. [4]

21. 2072 Set C Q.No. 6b Describe the working of diesel engine with a P-V diagram. What are its merits and demerits? [4]

22. 2070 Supp (Set A) Q.No. 6 c Discuss the working principle of a diesel engine with the help of p-v diagram. [4]

23. 2069 Supp Q.No. 6c 2067 Supp Q.No. 6 c Describe the working of a diesel engine with the help of P.V. diagram. [4]

24. 2069 (Set B) Q. No. 6c Describe the working of carnot's engine with the help of its p-v diagram. [4]

25. 2068 Old Q.No. 4 a Or What is a heat engine? Calculate the thermal efficiency of a heat engine. [1+3]

26. 2066 Q.No. 4 a OR Draw and explain the P–V diagram of petrol engine. [1+3]

27. 2065 Q.No. 4 a Explain the working of a diesel engine on P-V diagram and write down its merits and demerits. [3+1]

28. 2064 Q.No. 4 a OR 2060 Q.No. 4 a OR 2059 Q.No. 4 a OR Explain the working mechanism of a Petrol engine with the help of a PV diagram. [4]

29. 2063 Q.No. 4 a State and explain the second law of thermodynamics. [4]

30. 2062 Q.No. 4 a Explain the working mechanism of a diesel engine with the help of a PV diagram. [4]

31. 2061 Q.No. 4 a OR Explain the working of a Carnot engine with the help of a P-V diagram. [4]

32. 2059 Q.No. 4 a What is the basis difference between the first law and the second law of thermodynamics? Explain on the basis of Carnot's engine that no heat engine have efficiency of unity? (Derivation not required). [2+2]

33. 2058 Q.No. 4 a What do you mean by a heat engine? How do you define its efficiency? [4]

34. 2058 Q.No. 4 a OR Explain the working of a diesel engine with the help of P-V diagram. [4]

35. 2057 Q.No. 4 a OR Draw the P-V diagram for petrol engine and explain its working on the basis of the diagram. [4]

Numerical Problems

36. 2076 Set C Q.No. 10c The efficiency of a Carnot cycle is 15%. If on reducing the temperature of sink by 65°C, the efficiency becomes double, find the temperature of source and sink. [4]
Ans: 433.33k, 368.33k

37. 2075 Set A Q.No. 10b A Carnot engine has 40% efficiency with a sink at 10°C. By how many degrees should the temperature of the source be increased in order to raise the efficiency to 65%? [4]
Ans: 63.57°C

38. 2074 Supp. Q.No. 10c 2071 Supp Q.No. 10c 2068 Q.No. 10 c A Carnot engine has 50% efficiency with a sink at 9°C. By how many degrees should temperature of source be increased in order to raise the efficiency to 70%? [4]
Ans: 376 K

39. 2074 Set A Q.No. 10c An ideal heat engine operates between two reservoirs at two temperatures. In order to achieve 30% efficiency when the temperature of the sink is 50°C, what should be the temperature of the source? [4]
Ans: 461.43 K

40. 2074 Set B Q.No. 10a The source reservoir of a carnot engine is at a temperature of 400 K and takes 400 J of heat and rejects 20 J of heat to the sink reservoir in each cycle. What is the efficiency of engine and the temperature of the sink? [4]
Ans: 20 K

41. 2073 Set C Q.No. 10c A Carnot's engine has 25% efficiency with a sink at 9°c. By how many degrees should the temperature of the source be increased in order to raise the efficiency to 70%? [4]
Ans: 564 K

42. 2072 Set D Q.No. 10c A diesel engine performs 2200 J of mechanical work and discards 4300 J of heat each cycle. (i) How much heat must be supplied to the engine in each cycle? (ii) What is the thermal efficiency of the engine? [4]
Ans: 6500 J, 33.85%

43. 2072 Set E Q.No. 10b What will be the thermal efficiency of an engine if it takes 8 kJ heat from the source and rejects 6 kJ to the sink in one cycle? [4]
Ans: 25%

44. 2071 Set C Q.No. 10 c A Carnot engine works between the source and the sink with efficiency 40%. How much temperature of the sink be lowered keeping the source temperature constant so that its efficiency increases by 10%? [4]
Ans: 30 K

45. 2071 Set D Q.No. 10 a A Carnot engine works between the source and the sink with 25% efficiency. How much temperature of the sink be raised keeping the sink at the same constant temperature at 27°C so that the efficiency is increased by 15°C? [4]
Ans: 100 K

46. 2070 Set C Q.No. 10 c The efficiency of a Carnot cycle is 15%. If on reducing the temperature of the sink by 65°C, the efficiency becomes 30%, find the initial and final temperatures between which the cycle is working. [4]
Ans: 433.33 k, 368.33 k

47. 2070 Set D Q.No. 10 c A petrol engine consumes 25kg of petrol per hour. The calorific value of petrol is 11.4×10^6 cal/kg. The power of the engine is 99.75kw. Calculate the efficiency of the engine. [4]
Ans: 30%

48. 2069 Supp Q.No. 10b A Carnot Engine works between 800^0 and 400^0 C. If it is possible either to increase the source temperature by 50°C or to decrease the sink temperature by 50°C, which of these actions will be causing more increase in the efficiency? Justify your answer. [4]
Ans: To decrease the sink by 50°C because efficience is more, η on increasing temperature of source is 40% while decreasing is 42%.

49. 2069 (Set A) Old Q.No. 4b A carnot engine absorbs heat from a reservoir at the temperature 127°c. If the engine absorbs 1000 calories of heat from the high temperature reservoir, find the work done and the efficiency. [3]
Ans: 1333.5J

50. 2069 (Set B) Q. No. 10c A petrol engine consumes 10 kg of petrol in one hour. The calorific value of petrol is 11.4×10^3 cal/gm. The power of the engine is 20 kwatts. Calculate the efficiency of the engine. [4]
Ans: 15%

51. 2068 Old Q.No. 4 b A carnot engine whose low temperature reservoir is at 27°C has an efficiency of 25%. In order to increase the efficiency to 50%, how much the temperature of the high temperature reservoir be increased, if the temperature of the low temperature reservoir remains constant. [3]
Ans: 200 K

52. 2063 Q.No. 4 b A petrol engine consumes 5 kg of petrol per hour. If the power of engine is 20 KW and the calorific value of petrol is 11×10^3 K cal per kg Calculate the efficiency of the engine. [4]
Ans: 31.15%

Unit 3: Geometric Optics

1. Reflection at Curved Mirrors

FORMULAE

1. Relationship between focal length and radius of curvature, $f = \frac{R}{2}$.
2. Mirror formula, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
3. Magnification, $m = \frac{h_i}{h_o} = \frac{v}{u}$.

Short Answer Questions

1. 2074 Set B Q.No. 3a Use graphical method to locate image of an erect object placed before a concave mirror between its pole and the focus. Hence write down the nature of image so formed. [2]
2. 2073 Set C Q.No. 3a A concave mirror is often used as an aid for applying cosmetics to the face, why? [2]
3. 2073 Set D Q.No. 3a Convex mirrors are used as rear view mirrors in cars, why? [2]
4. 2072 Supp Q.No. 3b Does focal length change when the curve mirror is dipped in liquid? Why? [2]
5. 2071 Set C Q.No. 3 b Spherical mirror may behave as a plane mirror as a special case. Explain. [2]
6. 2070 Supp (Set B) Q.No. 3 a A spherical mirror is cut in half horizontally. Will an image be formed by the bottom half of the mirror? How? [2]
7. 2070 Set D Q.No. 3 b Distinguish between real and virtual images. [2]
8. 2069 (Set A) Q. No. 3a Can a convex mirror ever form real image? Justify your answer. [2]
9. 2069 (Set A) Old Q. No. 6a Can a convex mirror ever produce a real image? [2]
10. 2068 Old Q.No. 6 b What types of mirror will you suggest for shaving or make-up purpose and why? [2]
11. 2065 Q. No. 6 a A spherical mirror be immersed in water. Will its focal length change? [2]
12. 2059 Q.No. 6 b Trace the position of an image formed by a concave mirror when real object is placed at a distance less than its focal length. [2]
13. 2056 Q.No. 6 a Why are convex mirrors used in cars for rear view? [2]

Long Answer Questions

14. 2076 Set C Q.No. 7a Derive mirror formula for a concave mirror and state the sign convention used. [4]
15. 2074 Set A Q.No. 7b Derive mirror formula in the case of concave mirror. Also discuss the nature of the image formed due to object placed at different positions. [4]
16. 2073 Supp Q.No. 7a Derive mirror formula in the case of concave mirror. Also discuss the nature of images. [4]
17. 2071 Set C Q.No. 7 b How will you make difference between real and virtual images? Obtain an expression for the relation between object distance, image distance and the focal length in the case of a convex mirror. [4]
18. 2069 (Set B) Q. No. 7a 2061 Q.No. 7 a Point out the difference between real image and virtual image. Obtain a relation connecting the object distance, image distance and focal length of concave mirror. [4]
19. 2064 Q.No. 7 a What do you mean by principal focus of a convex mirror? Prove mirror formula for a convex mirror and also show that m = v/u for the same mirror. [1+3+1]

Numerical Problems

20. 2071 Set D Q.No. 11 At what position an object be placed in front of a concave mirror of radius of curvature 0.4 m so that an erect image of magnification 3 be produced? [4]
Ans: 0.133 m
21. 2066 Old Q. No. 7 b A pole 4 m long is laid along the principal axis of a convex mirror of focal length 1m. The end of the pole nearer the mirror is 2 m from it. Find the length of the image of the pole. [4]
Ans: 0.190 m
22. 2060 Q.No. 7 b An erect image, three times the size of the object is obtained with a concave mirror of radius of curvature 36 cm. What is the position of the object? [4]
Ans: 12 cm
23. 2057 Q.No. 7 b An object 10 cm high is placed in front of a convex mirror of focal length 20 cm and the object is 30 cm from the mirror. Find the height of the image. [4]
Ans: 0.04 m
24. 2055 Q.No. 15 b Calculate the focal length of a concave mirror when an object placed at a distance of 40 cm makes image equal to the size of the object. [4]
Ans: 20 cm
25. 2053 Q.No. 13 A metre scale is placed along the axis of a convex mirror of focal length 25 cm, its nearer end being at a distance of 50 cm. Calculate the size of the image formed. [4]
Ans: 4.67 cm
26. 2050 Q.No. 15 A convex mirror with a radius of curvature 30 cm. forms a real image 20 cm. from its pole. Explain how it is possible and find whether the image is erect or inverted. [4]
Ans: 8.57, Erect

2. Refraction at Plane Surfaces

Values of Physical Constants

$c = 3 \times 10^8$ ms^{-1}

FORMULAE

1. $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} = {}_1\mu^2$
2. Lateral displacement, $d = \frac{t \sin (i - r)}{\cos r}$
3. Apparent shift, $d = t\left(1 - \frac{1}{\mu}\right)$
4. Refractive index = $\frac{\text{Real depth}}{\text{Apparent depth}}$
5. $\mu = \frac{1}{\sin c}$, c is the critical angle

Short Answer Questions

1. 2076 Set C Q.No. 3a Why does the bottom of a swimming pool always appear shallower than it actually is? [2]
2. 2070 Supp (Set A) Q.No. 3 a Why does the sun look slightly oval when it is near the horizon? [2]
3. 2069 (Set A) Old Q. No. 6b A stick partially dipped in water seems to be bent. Why? [2]
4. 2062 Q.No. 6 b Can told internal reflection be achieved if object originates in rarer medium? Explain with a diagram to justify your answer. [2]
5. 2061 Q.No. 6 b A ray of light in air strikes a glass surface. Is there a range of angles for which total internal reflection takes place? [2]
6. 2058 Q.No. 6 c Why does diamond sparkle? [2]
7. 2057 Q.No. 6 b Why does the sun look a little oval when it is at the horizon? [2]
8. 2054 Q.No. 11 b Why does a clear pool of water always appear to be shallower than it actually is? [2]
9. 2053 Q.No. 11 c Why do in summer, roads often appear to be covered with water when seen from a distance? Explain. [2]

Long Answer Questions

10. 2076 Set B Q.No. 7a Define lateral shift and derive an expression for it due to a parallel edged glass slab. [4]
11. 2074 Supp. Q.No. 7a What causes the bending of light when it passes from one medium to another medium? Deduce the relation, $\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$. [4]
12. 2073 Set D Q.No. 7a Define lateral shift. Derive an expression for it. Show in a graph the variation of lateral shift with the angle of incidence. [4]
13. 2072 Set C Q.No. 7b What is lateral Shift? Deduce lateral shift in terms of thickness of a slab and the angle of incidence of light. [4]
14. 2070 Supp (Set A) Q.No. 7 a What is lateral shift? Derive an expression for it due to a rectangular glass slab. [4]
15. 2070 Set D Q.No. 7a 2065 Q. No. 7a What is lateral shift? Derive an expression for its value. How does the lateral shift change with the increase in the angle of incidence? [4]
16. 2067 Supp Q.No. 7 a Derive an expression for lateral shift. Show in a graph how does the lateral shift vary with the increase in angle of incidence ? [4]
17. 2067 Q.No. 7 a What is lateral shift? Derive an expression for it due to a parallel edged glass slab. [4]
18. 2056 Q.No. 7 a What do you mean by critical angles and total internal reflection? Derive a relation between critical angle and refractive index. [1+1+3]
19. 2052 Q.No. 15 a Define critical angle and total internal reflection. [3]

Numerical Problems

20. 2075 Set A Q.No. 11 A transparent cube of 12 cm edge contains a small air bubble. Its apparent depth when viewed through one face of the cube is 6 cm and when viewed through the opposite face is 2 cm. What is the actual distance of the bubble from the first face? [4]
    Ans: 9 cm
21. 2075 Set B Q.No. 11 Calculate the critical angles of (i) glass-water and (ii) water-air interfaces if object lies in the denser medium. [4]
    Ans: (i) 62.46°, (ii) 48.76°
22. 2072 Set D Q.No. 11 An optical fiber with refractive index 1.72 is surrounded by a glass coating having refractive index 1.50. Find the critical angle for total internal reflection at the fiber glass interface. [4]
    Ans: 61°
23. 2071 Set C Q.No. 11 What is the apparent position of an object below a rectangular glass slab of refractive index 1.45 and the thickness 0.06 m if a layer of water 0.04 m thick is on the top of the glass slab? [4]
    Ans. 0.0789 m below from the top
24. 2068 Old Q.No. 7 b What is the apparent position of an object below a rectangular block of glass 8 cm thick if a layer of water 6 cm thick is on the top of the glass. (Take: $_a\mu_g = 1.50$ and $_a\mu_w = 1.33$) [4]
    Ans: 10 cm below from top
25. 2067 Q.No. 11 What is the apparent position of an object below a rectangular glass slab 6 cm thick if a layer of water 4 cm thick is on the top of the glass slab? [4]
    Ans. 0.07 m below from the top
26. 2063 Q.No. 7 b Light from a luminous point on the lower face of a rectangular glass slab, 2 cm. thick, strikes the upper face and the totally reflected rays outline a circle of 3.2 cm. radius on the lower face. What is refractive index of the glass? [4]
    Ans: 1.6
27. 2059 Q.No. 7 b A microscope is focused on a scratch on the bottom of a beaker. Turpentine is poured into the beaker to a depth of 4 cm, and it is found necessary to raise the microscope through a vertical distance of 1.25 cm to bring the scratch again into focus. Find the refractive index of turpentine. [4]
    Ans: 1.45
28. 2058 Q.No. 7 b What is the apparent position of an object below a rectangular block of glass 6 cm thick if a layer of water 4 cm thick is on the top of the glass? (Refractive index of glass =3/2 and that of water =4/3). [4]
    Ans: 0.07m below from the top

29. 2054 Q.No. 13 OR How long will the light take in travelling a distance of 500 m in water? Refractive index for water is 1.33 and velocity of light in vacuum is 3×10^8 m/s. [4]
Ans: 2.2×10^{-6} sec.

3. Refraction through Prisms

FORMULAE

1. R.I. of a prism, $\mu = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\dfrac{A}{2}}$
2. For a small angled prism, angle of deviation, $\delta = (\mu - 1)A$

Short Answer Questions

1. 2076 Set C Q.No. 3b Under what conditions does a prism produce the angle of minimum deviation? Explain. [2]
2. 2075 Set A Q.No. 3a What are the conditions for minimum deviation of a ray of light passing through a prism? [2]
3. 2075 Set B Q.No. 3a A ray of light originated in air falls perpendicularly on the shorter face of a right angled isosceles (90° – 45° – 45°) triangular glass prism of refractive index 1.5. Find the angle of deviation in this case in a diagram. [2]
4. 2074 Supp. Q.No. 3b A glass prism is immersed in water. What happens to the value of angle of minimum deviation? [2]
5. 2074 Set A Q.No. 3b What do you understand by minimum deviation in the case of refraction through a prism? Plot a graph between angles of incidence and the deviation produced. [2]
6. 2066 Old Q. No. 6 c State the factors on which the deviation produced by a prism depend. [2]
7. 2060 Q.No. 6 c What are the advantages of total reflecting prism over plane mirror? [2]
8. 2051 Q.No. 12 e Under what condition does a prism produce the angle of minimum deviation? [2]

Long Answer Questions

9. 2074 Set B Q.No. 7a Explain with necessary theory of measuring the refractive index of a prism by minimum deviation method. [4]
10. 2072 Set D Q.No. 7a Discuss the phenomenon of refraction through a prism. Derive an expression for the refractive index of the material of the prism in terms of the angle of minimum deviation. [4]
11. 2072 Set E Q.No. 7a Derive a relation between the refractive index, angle of minimum deviation and the angle of prism. Also discuss the nature of the change in deviation with respect to the angle of incidence on one of the refracting surface of the prism. [4]
12. 2071 Set C Q.No. 7 a Explain why a ray of light in air deviates while entering into a medium. Derive an expression for the refractive index of a glass prism if the ray suffers a condition of minimum deviation. [4]
13. 2070 Supp (Set B) Q.No. 7 a What do you mean by minimum deviation of light when passing through a prism? Show that the deviation produced by a small angle prism is independence of angle of incidence. [4]
14. 2070 Set C Q.No. 7 a What is prism? Show that the deviation produced by a small angle prism is independent of the angle of incidence, provided the angle of incidence is small. [4]
15. 2069 Set A Old Q. No. 7a What is the deviation of light? Show that deviation produced by a small angled prism is independent of the angle of incidence. [1+4]
16. 2069 Set B Q. No. 7b Show that $\mu = \dfrac{\sin\left(\dfrac{A+\delta m}{n}\right)}{\sin A/2}$ for a prism where the notations carry their usual meanings. [4]
17. 2069 Old Set B Q. No. 7a What is prism? Show that $\mu = \dfrac{\sin\left(\dfrac{A+\delta m}{n}\right)}{\sin A/2}$ for a prism where the notations carry their usual meanings. [1+4]
18. 2068 Q.No. 7 a Define angle of prism. Prove that the deviation produced by a small angle prism for small angle of incidence is independent of angle of incidence. [4]
19. 2068 Old Q.No. 7 a or What is the cause of dispersion of light? Prove that the deviation produced by a small angle prism for small angle of incidence is independent of angle of incidence. [2+3]
20. 2066 Q. No. 7 b What is minimum deviation for prism? Prove that the refractive index of the prism is $\mu = \dfrac{\sin\left(\dfrac{A+\delta m}{n}\right)}{\sin A/2}$. Each symbol has its usual meaning. [4]
21. 2063 Q.No. 7 a Derive an expression connecting refractive index of the material prism with minimum deviation. [4]
22. 2060 Q.No. 7 a Discuss the phenomenon of refraction through prism and show that the deviation of incident ray produced by a small angled prism for small angle of incidence is independent of the angle of prism. [2+3]
23. 2059 Q.No. 7 a Show that $\dfrac{\sin\left(\dfrac{A+\delta m}{n}\right)}{\sin A/2}$ for a prism where the notations carry usual meaning. [5]
24. 2057 Q.No. 7 a Or Derive an expression connecting the refractive index of the material of the prism with the angle of minimum deviation. [5]
25. 2054 Q.No. 12 Derive an expression for the refractive index of the material of the prism in terms of the refracting angle and the angle of minimum deviation. [5]
26. 2050 Q.No. 12 Derive the formula connecting the refractive index of a prism and the angle of minimum deviation, if the angle of the prism is A. [5]

Numerical Problems

27. 2073 Set C Q.No. 11 A ray of light is refracted through a prism of angle 60°. Find the angle of incidence so that the emergent ray just grazes in the second face. Refractive index of the material of the prism is 1.45. [4]
Ans: 24.2°

18. 2072 Supp Q.No. 11 A narrow beam of light is incident normally on one face of an equilateral prism and finally emerges from the prism. The prism is now surrounded by water. What is the angle between the directions of the emergent beam in the two cases? [$\mu_g = 1.45$, $\mu_w = 1.33$] [4]
Ans: 49.29°

19. 2071 Supp Q.No. 11 A certain prism is found to produce a minimum deviation of 51°, while it produces a deviation of 62°48' for two values of angle of incidence, namely 40°6' and 82°42' respectively. Determine the refractive angle of prism, the angle of incidence at minimum deviation and the refractive index of the material of the prism. [4]
Ans: 60°, 55.5°, 51° and 1.65

30. 2064 Q.No. 7 b A narrow beam of light incident normally on one face of an equilateral prism (refractive index 1.45) being surrounded by water (refractive index 1.44). At what angle the ray of light emerges out? [4]
Ans: 71°

31. 2062 Q.No. 7 b 2055 Q.No. 13 A glass prism of angle 72° and index of refraction 1.66 is immersed in a liquid of refractive index 1.33. Find the angle of minimum deviation for parallel beam of light passing through the prism. [4]
Ans: 22.4°

32. 2051 Q.No. 16 OR A glass prism of angle A and refractive index 1.5 produces the angle of minimum derivation equal to 40°. Calculate the value of angle of prism. [4]
Ans: 62.8°

4. Lenses

FORMULAE

1. Lens formula, $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$.
2. Lens maker's formula, $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$
3. Linear magnification, $m=\frac{h_i}{h_o}=\frac{v}{u}$
4. Power of a lens, $P=\frac{1}{f\text{ (in metre)}}$.

Short Answer Questions

1. 2074 Set B Q.No. 3b 2069 Old (Set B) Q. No. 6c 2067 Q.No. 3 a A convex lens is immersed in water. Will its focal length change? Explain. [2]
2. 2073 Supp Q.No. 3a Two convex lenses of focal length f_1 and f_2 are provided. How will you arrange them as eye piece and object lens to design a compound microscope? Explain with an outline diagram. [2]
3. 2073 Set C Q.No. 3b Sun glasses have curved surfaces but their power is zero, why? [2]
4. 2073 Set D Q.No. 3b A lens is immersed in water. Is there any change in its focal length? Explain. [2]
5. 2072 Set E Q.No. 3b Can a concave and a convex lens be combined so that the combination behaves like a diverging lens? Justify your answer. [2]
6. 2070 Supp (Set B) Q.No. 3 b A converging lens is dipped in a liquid having refractive index greater than the lens. Does its power change? Explain. [2]
7. 2069 Supp Q.No. 3a A convex lens is immersed in water, will its focal length be changed? [2]
8. 2064 Q.No. 6 c If a converging lens and a diverging lens having the same focal length be in contact, how will the combination of lenses behave? [2]
9. 2061 Q.No. 6 c Draw the ray diagram showing the formation of real image by a concave lens. [2]
10. 2060 Q.No. 6 b A lens made of glass is immersed into water. Will its power increase or decrease? [2]
11. 2059 Q.No. 6 c Does the focal length of a lens change when immersed in water? Will it increase or decrease? [2]
12. 2055 Q.No. 11 a Can a concave lens from a real image? Give the condition. [2]
13. 2053 Q.No. 11 a Draw the ray diagram showing the formation of a virtual image by a convex lens. [2]
14. 2052 Q.No. 11 b Does the focal length of a lens change if it is immersed in water? Will it increase or decrease? [2]
15. 2051 Q.No. 12 c Under what conditions does a concave lens form a real image? [2]
16. 2051 Q.No. 12 a At what distance from a convex lens should an object be placed on the axis, so as to form a real image of the same size? Illustrate your answer with a ray diagram. [2]

Long Answer Questions

17. 2076 Set C Q.No. 7b Derive an expression for the combined focal length of two thin lenses in contact. [4]
18. 2075 GIE Q.No. 7a 2070 Set C Q.No. 7b 2058 Q.No. 7 a 2057 Q.No. 7a 2056 Q.No. 7 a OR Derive lens maker's formula. [4]
19. 2075 Set A Q.No. 7a 2071 Supp Q.No. 7a Define power of a lens. Derive the formula for the effective power of two thin lenses in contact. [4]
20. 2075 Set B Q.No. 7b Derive expression for the focal length in Lens maker's formula. [4]
21. 2072 Supp Q.No. 7b 2052 Q.No. 12 Derive lens maker's formula and state the sign convention for radius of curvature. [4]
22. 2072 Set C Q.No. 7a Define principal focus and the power of lens. Derive the formula for the focal length of two thin lenses in contact. [4]
23. 2071 Set D Q.No. 7 b Derive lens Maker's formula and write the unit of the power of a lens. [4]
24. 2069 Supp Q.No. 7a Define an expression for combined focal length when two lenses are combined coaxially [4]
25. 2069 (Set A) Q. No. 7b Derive an expression for lens maker's formula. [4]
26. 2068 Old Q.No. 7 a Define radius of curvature of a lens. Derive lens maker's formula. [1+4]
27. 2066 Old Q. No. 7 a OR Derive the formula relating the object distance, the image distance and the focal length for a concave lens. [5]
28. 2065 Q. No. 7 a OR Define principle focus. Derive the lens formula for the concave lens and show that m = v/u for the same lens. [1+4]
29. 2064 Q.No. 7 a OR What do you mean by conjugate focii? Derive lens maker's formula and state sign convention for the radius of curvature. [1+4]

30. 2063 Q.No. 7 a OR Derive lens maker formula for a convex lens. [1+4]

31. 2062 Q.No. 7 a Draw ray diagram to locate the image of a point object placed between the centre of curvature and the principal focus of a diverging lens. Derive lens formula for the diverging lens. [2+3]

32. 2059 Q.No. 7 a OR Derive the formula relating the object distance, the image distance and the focal length for a convex lens. [5]

33. 2055 Q.No. 12 Derive the combined focal length of two thin lenses in contact. [4]

34. 2051 Q.No. 13 Derive an expression for the equivalent focal length of two thin convex lenses in contact. [4]

35. 2050 Q.No. 14 Describe a method, with a suitable diagram to determine the focal length of a convex lens. [4]

Numerical Problems

36. 2076 Set B Q.No. 11 A convex lens of focal length 24 cm and of refractive index 1.5 is totally immersed in water of refractive index 1.33. Find its focal length in water. [4]
Ans: 94 cm

37. 2074 Supp. Q.No. 11 The image of an object is obtained on a screen with the help of a converging lens. The distance of the object is 40 cm from the screen and size of the image is 9 times the size of the object. Calculate distance of the screen from the lens and focal length of the lens. [4]
Ans: 3.6 cm and 36 cm

38. 2074 Set A Q.No. 11 An object is placed at a distance 30 cm from a thin lens of power 4 Dioptre. Discuss the nature of image formed by the lens. [4]
Ans: 150 cm, 5 real, magnified image

39. 2074 Set B Q.No. 11 An erect object is placed at a distance of 10 cm before a convex lens of focal length 15 cm. When will the image be formed? Discuss the nature of image. [4]
Ans: –30 cm, –3 erect, virtual and manified image

40. 2073 Supp Q.No. 11 A convex lens of focal length 24 cm is totally immersed in water. Find its focal length in water if the refractive indices of glass and water are 1.5 and 1.33 respectively. [4]
Ans: 94 cm

41. 2072 Set E Q.No. 11 An equiconvex lens has a power of 4 dioptre. What will be the radius of curvatures of each surface if the lens is made of glass of refractive index 1.5? [4]
Ans: 0.25 m

42. 2069 (Set A) Q. No. 11 An object to the left of a lens is imaged by the lens on a screen 30cm to the right of the lens. When the lens is moved 4cm to the right, the screen must be moved 4cm to the left to refocus the image. Determine the focal length of the lens. [4]
Ans: 10.55 cm

43. 2068 Q.No. 11 A thin equiconvex lens of glass of refractive index 1.5 whose surfaces have a radius of curvature of 24cm is placed on a horizontal plane mirror. When the space between the lens and mirror is filled with a liquid, a pin held 40 cm vertically above the lens is found to coincide with its own image. Calculate the refractive index of the liquid. [4]
Ans: 1.4

44. 2067 Supp Q.No. 11 A convex lens of focal length 24 cm is totally immersed in water. Find its focal length in water. [4]
Ans: 94cm

45. 2066 Q. No. 11 The real image obtained by a lens of power 5D is three times the length of the object. Calculate the object and image distances. [4]
Ans: u = 26.67 cm; v = 80cm

46. 2061 Q.No. 7 b The radii of curvature of the faces of a thin converging meniscus lens of glass of refractive index 1.5 are 15 cm and 30 cm. What is the focal length of the lens when it is completely immersed in water of refractive index 4/3? [4]
Ans: 2.34 m

47. 2054 Q.No. 13 A convex lens of focal length 24 cm. (refractive index = 1.5) is totally immersed in water (refractive index = 1.33). Find its focal length in water. [4]
Ans: 94 cm

48. 2053 Q.No. 13 OR A luminous object and a screen are placed on an optimal bench and a converging lens is placed between them to throw a sharp image of the object on the screen. The linear magnification of the image is found to be 2.5. The lens is now moved 30 cm. nearer the screen and a sharp image again formed. Calculate the focal length of the lens. [4]
Ans; 14.28 cm

49. 2052 Q.No. 13 A converging meniscus of glass (μ = 1.5) having radius of curvature 4cm. and 8 cm. is put on a horizontal surface facing upward. If it is filed with water, what will be the focal length of the combination? [4]
Ans: 9.6 cm

50. 2051 Q.No. 14 A converging lenses of 5 cm focal length used as a simple magnifier, produces a virtual image 25 cm. from the eye. How far from the lens should the object to placed? What is the magnification? [4]
Ans: –6

5. Dispersion

FORMULAE

1. Cauchy's formula, $\mu = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$
2. Angular dispersion, $\delta_v - \delta_r = (\mu_v - \mu_r) A$
3. Dispersive power, $\omega = \frac{\delta_v - \delta_r}{\delta} = \frac{\mu_v - \mu_r}{\mu - 1}$,
   where $\mu = \frac{\mu_v + \mu_r}{2}$
4. For achromatism, $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$, $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$
5. Rayleigh's scattering law, $I \propto \frac{1}{\lambda^4}$

Short Answer Questions

1. 2076 Set B Q.No. 3b 2072 Set D Q.No. 3b 2064 Q.No. 6 b 2052 Q.No. 11a When white light is dispersed by a prism, red light appears at the top of the spectrum where as violet at the bottom. Why? [2]
2. 2075 GIE Q.No. 3b Why does the sky look blue in a day? [2]
3. 2075 Set A Q.No. 3b Why does the sky appear blue? [2]
4. 2074 Set A Q.No. 3a How do the colours of light related with the refractive index of a lens? Explain. [2]

5. 2073 Supp Q.No. 3b Define dispersive power of a lens and write expression for it in terms of the refractive indices of lens with respect to different colours used. [2]
6. 2072 Supp Q.No. 3a How does the refractive index relate with the wavelength of light? [2]
7. 2072 Set C Q.No. 3b State the necessary conditions for the production of a pure spectrum. [2]
8. 2072 Set E Q.No. 3a Which one of blue and red lights will be deviated more by a prism? Give reason for your answer. [2]
9. 2071 Supp Q.No. 3b 2066 Q. No. 3 a What is the cause of dispersion of light? [2]
10. 2071 Set D Q.No. 3 a Draw an outline sketch to show the chromatic aberration in the case of a lens. How can achromatism be achieved? [2]
11. 2070 Supp (Set A) Q.No. 3 b If a lens made of glass is immersed into water, what will happen to its power? Explain. [2]
12. 2070 Set C Q.No. 3 b A spherical mirror cannot give rise to chromatic aberration. Why? [2]
13. 2069 Supp Q.No. 3b Why does the sun appears red during the sun-rise? [2]
14. 2069 (Set A) Old Q. No. 6c What is the cause of dispersion of a white ray of light? [2]
15. 2069 Old (Set B) Q. No. 6b Does the refractive index depend upon the wavelength of light? [2]
16. 2068 Q.No. 3 b What is chromatic aberration? Explain why a mirror cannot give rise to chromatic aberration. [2]
17. 2068 Old Q.No. 6c 2065 Q. No. 6c What do you mean by chromotic aberration? [2]
18. 2067 Q.No. 3 b The sun looks red at sun-rise and sun-set. Why? [2]
19. 2067 Supp Q.No. 3b Distinguish between chromatic aberration and spherical aberration. [2]
20. 2066 Q. No. 3 b Why is sky blue? Explain. [2]
21. 2066 Old Q. No. 6 b If a plane glass slab is placed on letter of different colours, then violent coloured letters appear more and more raised up. Why? [2]
22. 2063 Q.No. 6c 2057 Q.No. 6c 2054 Q.No. 11c Explained why can a mirror not give rise to chromatic aberration? [2]
23. 2062 Q.No. 6c Explain the meaning of achromatism in a lens. [2]
24. 2056 Q.No. 6 c What do you mean by dispersive power? [2
25. 2055 Q.No. 11 b Why are a number of dark lines seen in the spectrum of light from the sun? [2]
26. 2055 Q.No. 11 d Why there is no dispersion of monochromatic light? [2]
27. 2053 Q.No. 11 b How is dispersive power related to refractive index of the material? [2]

Long Answer Questions

28. 2073 Set C Q.No. 7a What is chromatic aberration in lens? Deduce the condition for achromatism in two thin lenses in contact. [4]
29. 2070 Supp (Set B) Q.No. 7 b What is chromatic aberration in a lens? How will you combine two lenses of different materials so that there is no chromatic aberration. [4]
30. 2070 Set D Q.No. 7 b What is chromatic aberration? Show that for a lens, the chromatic aberration is the product of dispersive power and focal length of mean light. [4]
31. 2069 (Set A) Old Q. No. 7a OR What is chromatic aberration? Show that the chromatic aberration is the product of dispersive power and mean focal length of a lens. [4]
32. 2069 Old (Set B) Q. No. 7a OR 2060 Q.No. 7 a OR What is chromatic aberration? Show that two lenses form an achromatic doublet if the ratio of their focal lengths is numerically equal to the ratio of the corresponding dispersive powers of their materials. [1+4]
33. 2066 Old Q. No. 7 a What do you mean by chromatic aberration? Show for a lens, the chromatic aberration is the product of dispersive power and, its mean focal length. [1+4]
34. 2058 Q.No. 7 a OR Derive the condition for achromatism in two lenses in contact. [5]
35. 2055 Q.No. 14 Derive the condition for achromatic lenses. [4]

Numerical Problems

36. 2073 Set D Q.No. 11 The dispersive powers for crown and flint glass are 0.013 and 0.026 respectively. Calculate the focal lengths of the lenses which form an achromatic doublet of focal length 80 cm, when placed in contact. [4]
Ans: 40 cm, –80 cm
37. 2069 (Set B) Q. No. 11 An achromatic converging lens of mean focal length 40cm is made by combining two lenses of different materials. If the dispersive powers of the two lenses are in the ratio 1:3, find the focal lengths of each lens. [4]
Ans: 80/3cm and – 80cm
38. 2069 (Set A) Old Q.No. 6b An achromatic lens of focal length +30cm is to be constructed by combining a crown glass lens and flint glass lens. What must be the focal lengths of the component lenses if the dispersive powers of crown glass and flint glass are 0.018 and 0.027 respectively? [3]
Ans: 10cm, –15 cm

6. Optical Instruments

FORMULAE

1. Power of lens to remove myopia, $p = -\frac{1}{x}$
2. Power of lens to remove hypermetropia, $p = \frac{x - D}{xD}$
3. Magnifying power of a simple microscope,
   $M = -\left(1 + \frac{D}{f}\right)$
4. The magnifying power of the compound microscope,
   $M = M_e \times M_o = -\frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$
5. Magnifying power of telescope at normal adjustment,
   $M = \frac{f_o}{f_e} = \frac{\text{Diameter of the objective}}{\text{Diameter of the eye ring}} = \frac{D_o}{d_e}$
   Length of the tube, $L = f_o + f_e$
6. Magnifying power of telescope when final image formed at near point, $M = \frac{\beta}{\alpha} = \frac{f_o}{u_e} = \frac{f_o}{f_e}\left[1 + \frac{f_e}{D}\right]$
   Length of the tube, $L = f_o + u_o$.

Short Answer Questions

1. 2075 GIE Q.No. 3a How is it possible to block the huge sun just with a small coin placed right in front of your eye? [2]
2. 2071 Set C Q.No. 3 a What do you mean by accommodation of an eye? [2]
3. 2069 (Set A) Old Q.No. 1f Define power of accommodation and persistance of vision. [2]
4. 2069 (Set A) Q. No. 3b A large object when taken away from you eye appears smaller. Why? [2]
5. 2069 (Set B) Q. No. 3b Why do far objects appear to be smaller than the nearer ones? [2]
6. 2066 Supp Q.No. 1d Define accommodation of eye and its near point. [2]
7. 2055 Q.No. 11 c Why has nature provided us with two eyes? Explain. [2]

Long Answer Questions

8. 2076 Set B Q.No. 7b Explain the construction and working of a compound microscope with final image at near point. Also, derive an expression for its magnifying power. [4]
9. 2075 GIE Q.No. 7b Describe the construction and working of a refraction type astronomical telescope obtain its angular magnification and length of telescope, when the final image is formed at infinity. [4]
10. 2075 Set A Q.No. 7b Describe the construction and working of a compound microscope producing final image at infinity and hence derive an expression for its magnifying power. [4]
11. 2075 Set B Q.No. 7a What are the defects of vision known to you? How are myopic and hypermetropic defects removed? Explain with necessary theory. [4]
12. 2074 Supp. Q.No. 7b What is compound microscope? Outline the ray diagram and find the angular magnification of compound microscope. [4]
13. 2074 Set A Q.No. 7a What do you understand by accommodation and adaptation of an eye? How are the defects related to myopic and hyper-metropic defects corrected? [4]
14. 2074 Set B Q.No. 7b Describe the construction and working of an astronomical telescope. Also obtain its angular magnification when the final image is formed at infinity. [4]
15. 2073 Supp Q.No. 7b Sketch an outline diagram for designing a compound microscope and deduce expression for its magnifying power, when the image is at near point. [4]
16. 2073 Set C Q.No. 7b Describe the structure and working of an astronomical telescope at normal adjustment with a suitable ray diagram. Also, calculate its magnifying power. [4]
17. 2073 Set D Q.No. 7b Draw a labelled diagram and describe the working of a compound microscope with final image at near point. Also, obtain an expression for its magnifying power. [4]
18. 2072 Supp Q.No. 7a Draw a labeled diagram to illustrate the action of a compound microscope with final image at the near point of normal eye. Also, derive an expression for its magnifying power. [4]
19. 2072 Set D Q.No. 7b With a ray diagram, explain the working of a compound microscope. Obtain an expression for its magnifying power, when the image is at near point. [4]
20. 2072 Set E Q.No. 7b Sketch a diagram of an astronomical telescope and derive an expression for its magnifying power, when the final image is formed at near point. [4]
21. 2071 Supp Q.No. 7b 2067 Q.No. 7b Describe the construction and working of a refraction type astronomical telescope. Obtain its angular magnification when final image is formed at infinity. [4]
22. 2071 Set D Q.No. 7 a Sketch an outline diagram of an astronomical telescope and derive expression for its angular magnification when the final image is formed at the least distant of distinct vision. [4]
23. 2070 Supp (Set A) Q.No. 7 b With the help of a ray diagram, derive an expression for angular magnifications of astronomical telescope, when the final image is formed at the least distance of distinct vision. [4]
24. 2069 Supp Q.No. 7b Describe the working of a refracting type astronomical telescope with the help of labelled diagram. Obtain its angular magnification when the final image is formed at infinity. [4]
25. 2069 (Set A) Old Q.No. 6a OR With the help of a labelled diagram, explain the principle and working of a compound microscope. Derive an expression for the magnifying power. [1+3]
26. 2069 (Set A) Q. No. 7a What is long sightedness? Discuss the possible causes of long sightedeness. Explain, how this deflect can be remedied. [4]
27. 2068 Q.No. 7 b Describe with labeled ray diagram, the working of an astronomical telescope when image is formed at near point. Also calculate its magnifying power. [4]
28. 2068 Old Q.No. 6 a Draw a clear ray diagram to illustrate the action of a compound microscope. Also derive an expression for its magnifying power. [2+2]
29. 2067 Supp Q.No. 7 b Describe with a labelled ray diagram, the working of an astronomical telescope Also, derive an expression for its magnifying power. [4]
30. 2066 Q. No. 7 a Describe the construction and working of a compound microscope and hence derive an expression for its magnifying power. [4]
31. 2065 Q.No. 6 a Draw an outline diagram of a compound microscope and derive expression for the magnification. [1+3]
32. 2053 Q.No. 12 What are defects of vision? How are they remedied? [4]

Numerical Problems

33. 2076 Set C Q.No. 11 A compound microscope has lenses of focal length 1 cm and 3 cm. An object is placed 1.2 cm from objective lens. If a virtual image is formed 25 cm from the eye, calculate the separation of the lenses. [4]

Ans: 8.7 cm

34. 2075 GIE Q.No. 11 A person who can see distinctly from a distance of one meter wants to read a book placed at a distance of 0.25m. What kind of lens would be required? Calculate its power. [4]

Ans: Convex lens of power = + 3D

35. 2072 Set C Q.No. 11 The eyepiece of a refracting telescope has a focal length of 90 cm. The distance between objective and eyepiece is 1.8 m and the final image is at infinity. What is the angular magnification of the telescope? [4]

Ans: 1

36. 2070 Supp (Set A) Q.No. 11 In order to correct his near point to 25 cm a man is prescribed with spectacles with conversing lenses of 50 cm focal length and to correct his far point to infinity, he is given diverging lenses of 200 cm focal length. Calculate his far point and near point when not wearing the spectacles. [4]
Ans: Near point = 50 cm, far point = 200 cm

37. 2070 Supp (Set B) Q.No. 11 The focal length of eyepiece and objective lens of a certain microscope is 2.5 cm and 16 mm respectively. The distance between objective and eye piece is 22.1 cm. The final image formed by eyepiece is at infinity. Treat all lenses as thin. (a) What should be the distance of the object from the objective lens? (b) What is the linear magnification produced by the objective? [4]
Ans: 1.74 cm; 140.63

38. 2070 Set C Q.No. 11 A compound microscope has lenses of focal lengths 1 cm and 3 cm. An object is placed 1.2 cm from the object lens. If a virtual image is formed is 25 cm from the eye, calculate the separation of the lenses and the magnification of the instrument. [4]
Ans: 8.7 cm, 46.7

39. 2070 Set D Q.No. 11 A refracting telescope has an objective of focal length 1 m and an eye piece of focal length 2 cm. A real image of the sun, 10 cm in diameter, is formed on a screen 24cm from the eye piece. What angle does the sun subtend at the objective? [4]
Ans: 0.009 rad

40. 2069 Supp Q.No. 11 An optician prescribes converging lenses of focal length 50cm to correct the near point to 25 cm and diverging lenses of focal length 200cm to correct the far point to infinity to a person. Calculate his far point and near point without using the spectacles. [4]
Ans: Near point = 50cm, far point = 200 cm

41. 2068 Old Q.No. 6 b Where is the near point of an eye for which a spectacle lens of power +2D is prescribed? [3]
Ans: 0.51m

42. 2066 Q.No. 6 b A telescope is made of an object glass of focal length 20 cm and an eye-piece of 5cm, both converging lenses. Find the magnifying power (i) When the eye is focused to receive parallel rays, and (ii) when the eye sees the image situated at near point which can be taken as 25 cm. [4]
Ans: 4, 4.8

43. 2050 Q.No. 15 OR An elderly man can not clearly see objects nearer than 200 cm. What spectacles will he need to reduce this distance to 25 cm? If his eyes can focus rays to points not less than 150 cm. behind them, calculate his range of vision while using spectacles. [4]
Ans: Range of vision = 25 cm to 35.3 cm

7. Photometry

FORMULAE

1. Total luminous flux, $\phi = 4\pi L$, for r = 1 m
2. Illuminance, $I = \frac{\phi}{A} = \frac{L}{r^2}$
3. Luminous intensity, $L = \frac{\phi}{\omega}$
4. Inverse square law, $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$, i.e. $I \propto \frac{1}{r^2}$
5. Lambert's cosine law is, $I \propto \cos\theta$
6. For a photometer, $\frac{L_1}{L_2} = \frac{r_1^2}{r_2^2}$

Short Answer Questions

1. 2076 Set B Q.No. 3a 2070 Set C Q.No. 3a 2068 Q.No. 3a The sun is less bright in morning and evening as compared to that at noon although its distance from the observer is almost the same. Why? [2]
2. 2075 Set B Q.No. 3b What do lumen and lux signify? Explain. [2]
3. 2074 Supp. Q.No. 3a 2064 Q.No. 6a 2051 Q.No. 12d Why does the illuminance of a surface decrease as it is moved away from the light source? [2]
4. 2072 Set C Q.No. 3a What is illuminance? Does the direction of incidence of light affect illuminance of surface? Explain. [2]
5. 2072 Set D Q.No. 3a Define Luminous intensity of a source. What is its unit? [2]
6. 2071 Supp Q.No. 3a Explain why illumination of a surface decreases as it is moved away from the light sources. [2]
7. 2071 Set D Q.No. 3 b What do you understand by 1 lumen and 1 phot? What do they signify? [2]
8. 2070 Set D Q.No. 3 a What is illuminance? Name the factors upon which it depends. [2]
9. 2069 (Set B) Q. No. 3a The sun is less bright in the morning and in the evening as compared to the noon although its distance from the observer is almost the same. Explain. [2]
10. 2068 Old Q.No. 6 a Distinguish between illuminance and luminance. [2]
11. 2067 Supp Q.No. 3 a Define illuminance. Name the factors upon which it depends. [2]
12. 2063 Q.No. 6 a Why illumination of a surface decreases as it is moved away from the light sources? [2]
13. 2062 Q.No. 6 a What is the difference between lumen and lux? [2]
14. 2061 Q.No. 6 a Define luminous efficiency of source of light and give its SI unit. [2]
15. 2060 Q.No. 6 a What are the factors on which the illuminance of a surface depends? [2]
16. 2059 Q.No. 6 a What is luminous flux? State its unit. [2]
17. 2058 Q.No. 6 b Define luminous flux. State its unit of measurement. [2]
18. 2054 Q.No. 11 a What is the meaning of Luminous intensity? [2]

Numerical Problems

19. 2069 (Set A) Old Q. No. 7b 2069 Old (Set B) Q. No. 7b A lamp radiating uniformly with a luminous intensity of 200 cd is hung 3 m above the centre of a room of dimensions 8m by 8m. Calculate the illuminance at a point in a corner at floor level. [4]
Ans: 2.3 lux

20. 2065 Q. No. 7 b When a light falls normally on earth, illuminance of 1.57×10^5 lumen/m^2 is produced on earth. The distance between earth and sun is 1.5×10^8 km. Calculate the luminous intensity and luminous flux of the sun. [4]
Ans: 3.5×10^{27} cd and 4.44×10^{28} lumen

21. 2056 Q.No. 7 b If two identical lamps are 1m a part, where should be a screen be placed between them so that the intensity on one side of the screen is four times the intensity on the other side. [4]
Ans: 0.33 m

Unit 4: Electrostatics

1. Electrostatics

Values of Physical Constants

Charge of electron	$= 1.6 \times 10^{-19}$ C
Mass of electron	$= 9.1 \times 10^{-31}$ kg
Permittivity of free space (ϵ_0)	$= 8.854 \times 10^{-12}$ C^2 /Nm^2

FORMULAE

1. Quantization of charge, $q = \pm ne$
2. The electric field intensity, $E = \frac{F}{q_0}$
3. Electric force, $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$
4. Electric field intensity, $E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$
5. Electric flux, $\phi = EA\cos\theta$
6. Gauss's theorem, $\phi = \frac{q}{\epsilon}$
7. Electric field intensity due to a charged hollow conducting sphere of radius R,
   i. $E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$ (outside the sphere)
   ii. $E = \frac{1}{4\pi\epsilon_0}\frac{q}{R^2}$ (on the sphere)
   iii. $E = 0$ (inside sphere)
8. Electric field intensity due to a plane sheet of charges, $E = \frac{\sigma}{2\epsilon_0}$
9. Electric field intensity due to a line charge, $E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}$
10. The electric potential, $V = \frac{W}{q}$
11. Electric potential, $V = \frac{q}{4\pi\epsilon_0}\frac{1}{r}$
12. Electric potential energy, $U = \frac{1}{4\pi\epsilon_0}\frac{qq_0}{r}$
13. Expression for potential difference, $V = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$
14. Relation between electric field intensity and potential difference, $E = -\frac{dV}{dr}$.

Short Answer Questions

1. 2076 Set B Q.No. 4a Bits of paper are attracted to an electrified comb, even though they have no net charge. How is this possible? [2]
2. 2076 Set B Q.No. 4b Can two electric lines of force intersect each other? Explain. [2]
3. 2076 Set C Q.No. 4a What do you mean by quantization of charge? Explain. [2]
4. 2075 GIE Q.No. 4a We often experience the sparks during the winter nights when removing the cloths from our body. Why? [2]
5. 2075 Set A Q.No. 4a Why metallic chain is used in the tanker transporting highly inflammable liquid? [2]
6. 2075 Set A Q.No. 4b Is it possible that electric potential at a point is zero but not electric field? [2]
7. 2075 Set B Q.No. 4b How can a body be charged with positive electricity by the method of induction? Explain. [2]
8. 2074 Supp. Q.No. 4a What is the magnitude of an electric field which will balance the weight of an electron on the surface of earth? [2]
9. 2074 Set A Q.No. 4a Can two electric lines of force ever intersect? Explain. [2]
10. 2074 Set B Q.No. 4a Different charges $q_1, q_2, q_3, \ldots$ are placed at $r_1, r_2, r_3, \ldots$ respectively in an electrostatic field. Write expressions for the total electric potential and intensity at R in proper notations. $r_1, r_2, r_3, \ldots$ and R refer to the distances from origin of the field (or space). [2]
11. 2074 Set B Q.No. 4b Define and write the unit of potential gradient in an electrostatic field. [2]
12. 2073 Supp Q.No. 4a Explain how a pith ball can be electrified with positive or negative charge. [2]
13. 2073 Set C Q.No. 4a What is potential gradient? How is it related with the electric field intensity? [2]
14. 2073 Set D Q.No. 4a Can a charged body attract an uncharged body? Explain. [2]
15. 2072 Supp Q.No. 4a 2072 Set E Q.No. 4a 2065 Q. No. 8 b A man inside an insulated metallic cage does not receive shock when the cage is highly charged, why? [2]
16. 2072 Supp Q.No. 4b How do you charge a body with positive electricity by induction? Explain. [2]
17. 2072 Set C Q.No. 4a Why does bodies get electrified when they are rubbed together for a while? [2]
18. 2072 Set D Q.No. 4a What is electrostatic shielding? [2]
19. 2072 Set D Q.No. 4b Two charged conductors are touched mutually and then separated. What will be the charge on them? [2]
20. 2071 Supp Q.No. 4a If the electric potential is zero at a point, is the electric field intensity also zero at that point? Explain. [2]
21. 2071 Set C Q.No. 4 a Two positive charges separated by a distance create an electrostatic field. Can (i) electric potential, and (ii) electric field intensity be zero at a point between the charges? Justify your answer. [2]
22. 2071 Set D Q.No. 4 b How can a neutral body be changed with negative electricity by induction? Explain. [2]
23. 2070 Supp (Set A) Q.No. 4 a Two electric lines of force never intersect each other, why? [2]
24. 2070 Supp (Set B) Q.No. 4 a The tyres of airplane are made from a special rubber which is resonably good conductor of electricity. What would be the reason behind it? [2]
25. 2070 Set C Q.No. 4 b Can a charged body attract an uncharged body? Explain. [2]
26. 2070 Set D Q.No. 4 a More charge can be stored on a metal if it is highly polished that when its surface is rough. Explain. [2]
27. 2069 Supp Q.No. 4a Why are the four footed animals posed to more threat during close by lightning strike than the two footed humans? [2]
28. 2069 (Set A) Q. No. 4a Why is it dangerous to take shelter under a tall tree during lightening? [2]

29. 2069 (Set A) Q. No. 4b Can two electric lines of force ever intersect each other? Explain. [2]
30. 2069 (Set B) Q. No. 4a The vehicles carrying inflammable fluid drag a chain along the ground. Why? [2]
31. 2069 (Set B) Q. No. 4b Sharp projections are avoided in machines. Why? [2]
32. 2069 Old (Set B) Q. No. 8b Two lines of electric field do not intersect with each other. Why? [2]
33. 2068 Q.No. 4 a What do you mean by quantization of charge?[2]
34. 2068 Old Q.No. 8 b What do you mean by charging by conduction and charging by induction? [2]
35. 2067 Q.No. 4 a Some of the free electrons in a good conductor (such as a piece of copper) move at speeds of 10^6 m/s or faster. Why don't these electrons fly out of the conductor completely? [2]
36. 2067 Supp Q.No. 4 a More charge can be stored on a metal if it is highly polished than when its surface is rough, why? [2]
37. 2067 Supp Q.No. 4 b Define one electron volt. [2]
38. 2066 Q. No. 4 a If the electric field is zero throughout a certain region of space, is the potential also zero in the region or not? Explain. [2]
39. 2066 Q.No. 8 c A man inside an insulated metallic cage does not receive shock when the cage is highly charged. Explain. [2]
40. 2064 Q.No. 8 b Prove $1Vm^{-1} = 1NC^{-1}$. [2]
41. 2064 Q.No. 8 c A comb run through one's dry hair attracts bits of paper. Why? [2]
42. 2063 Q.No. 8 b Why do sharp edges are strictly avoided in an electrical machine? [2]
43. 2063 Q.No. 8 c What is meant by relative ermittivity? What is its minimum value? [2]
44. 2062 Q.No. 8 a Explain the phenomenon of action point in a charged conical sphere. [2]
45. 2061 Q.No. 8 a Why can more charge be placed on a metal if it is highly polished than when its surface is rough? [2]
46. 2060 Q.No. 8 a A charged conical conductor loses its charge earlier than a similarly charged sphere. Why? [2]
47. 2059 Q.No. 8 a Why pointed ends are not kept in the electrostatics machine? [2]
48. 2058 Q.No. 8 a Why are sharp edges or points avoided in electrical machines? [2]
49. 2058 Q.No. 8 b What is an eV? [2]
50. 2057 Q.No. 8 a A man inside an insulated metallic cage does not receive a shock when the cage is highly charged. Explain. [2]
51. 2056 Q.No. 8 b What do you mean by one electron volt? [2]
52. 2056 Q.No. 8 c No two lines of force in an electric field ever intersect each other. Why? [2]

Long Answer Questions

53. 2076 Set B Q.No. 8a State and explain Gauss's law in electrostatics and use it to determine the electric field intensity due to a line charge. [4]
54. 2076 Set C Q.No. 8a State and explain Gauss's theorem and use it to find the electric field intensity due to infinite plane sheet of charge. [4]
55. 2075 GIE Q.No. 8a Define electric potential and derive an expression for it due to a point charge at a distance 'd' from it. [4]
56. 2075 Set A Q.No. 8a Define electric field intensity. Write down its units. Obtain an expression for electric field due to an electric dipole at a point equidistant from each charge. [4]
57. 2075 Set B Q.No. 8b State Gauss law of electrostatics and use it to find the electric field intensity due to a plane charged conductor. [4]
58. 2074 Supp. Q.No. 8a Define electric potential and derive an expression for it due to point charge. [4]
59. 2074 Set A Q.No. 8a 2066 Q. No. 8a State and explain Gauss law of electrostatics. Apply it to obtain an expression for electric field of a linearly charged body. [4]
60. 2074 Set A Q.No. 8b Are electric potential and electric field vector quantities? Justify with their definitions. Also obtain an expression for electric potential at a point due to a point charge. [4]
61. 2074 Set B Q.No. 8a Use Coulomb's law to define potential difference between two points near a static charge. Also derive expression for it. [4]
62. 2074 Set B Q.No. 8b State and explain Gauss law of electrostatics with one of its applications. [4]
63. 2073 Supp Q.No. 8b Define electric field intensity and potential gradient and establish a relation between them. [4]
64. 2073 Set C Q.No. 8a What is electrostatic induction? Explain with necessary diagrams, a method of charging a body positively by induction. [4]
65. 2073 Set C Q.No. 8b State and explain Gauss's theorem and use it to find the electric field due to a charged sphere at a point [4]
    i. outside the sphere and
    ii. inside the sphere.
66. 2073 Set D Q.No. 8a State and explain Gauss's theorem and use it to find the electric field intensity due to a line charge. [4]
67. 2073 Set D Q.No. 8b Define potential gradient and electric field intensity. Establish a relation between them. [4]
68. 2072 Supp Q.No. 8a State Gauss's theorem in electrostatics. Use this theorem to calculate the electric field due to a solid charged sphere at a point outside it. [4]
69. 2072 Set C Q.No. 8b Define potential difference and potential gradient. Obtain an expression for the potential difference between two points in electric field due to a point charge [4]
70. 2072 Set D Q.No. 8a What is electric flux? State and explain Gauss law in electrostatics. Use it to find electric field intensity due to infinite plane sheet of charge. [4]
71. 2072 Set E Q.No. 8a Define electric field intensity and dielectric constant of a medium. Also derive a relation between the electric field with the potential gradient. [4]
72. 2071 Supp Q.No. 8a State Gauss theorem in electrostatics. Use it to calculate electric field near an infinite plane sheet of charge. [4]
73. 2071 Set C Q.No. 8 a State and explain Gauss law. Use it to find the electric field due to a charged conducting sphere (i) outside, and (ii) inside. [4]

74. 2071 Set D Q.No. 8 b State and explain Gauss law of electrostatics and apply it to find an electric field intensity on the surface and inside the surface of a charged sphere. [4]

75. 2071 Set D Q.No. 8 a What is the physical difference between electric potential are electric field intensity? Derive an expression for the potential differences between two points in the electrostatic field. [4]

76. 2070 Supp (Set A) Q.No. 8 a Define electric potential. Derive an expression for the electric potential due to a point charge at a distance 'r' from it. [4]

77. 2070 Supp (Set B) Q.No. 8 a Define potential difference and potential gradient. Derive a relation between the potential gradient and electric field intensity. [4]

78. 2070 Set C Q.No. 8 a Define electric field intensity and potential gradient. Establish a relation between them. [4]

79. 2070 Set C Q.No. 8 b State and explain Gauss's law in electrostatics. Use this law to obtain electric field intensity due to a charged sphere i) outside it ii) inside it. [4]

80. 2070 Set D Q.No. 8 a What is electrostatic induction? How can you charge a body positively by induction? [4]

81. 2070 Set D Q.No. 8 b State and explain Gauss's law in electrostatics. Use it to find the electric field intensity due a line charge. [4]

82. 2069 Supp Q.No. 8a Define electric field intensity and electric potential. Deduce an expression for the potential difference between two points in an electric field. [4]

83. 2069 (Set A) Q. No. 8a State Gauss Theorem. Use this theorem to find the electric field intensity due to a plane charged conductor. [4]

84. 2069 (Set A) Old Q. No. 9b State Gauss law. Use it to find the electric field due to an infinite plane conductor. [4]

85. 2069 (Set B) Q. No. 8a 2069 Old (Set B) Q. No. 9a 2066 Q.No. 9a 2063 Q.No. 9a OR Define electric potential. Derive an expression for the potential due to a point charge at any point in space. [4]

86. 2069 Old (Set B) Q. No. 9a OR 2058 Q.No. 9a State Gauss's theorem in electrostatics. Use this theorem to calculate electric field due to a solid charged sphere at a point inside it. [1+4]

87. 2068 Q.No. 8 a State and explain Gauss's theorem in electrostatics. Use this theorem to find the electric field intensity due to a plane charged conductor. [4]

88. 2068 Q.No. 8 b Define potential gradient. Derive a relation between electric field intensity and potential gradient. [4]

89. 2067 Q.No. 8 a Define electric potential and derive an expression for it due to a point charge. [4]

90. 2067 Supp Q.No. 8 a State and explain Gauss's theorem in electrostatics. Use it to obtain an expression for electric field intensity due to a linearly charged body. [4]

91. 2066 Q. No. 8 b What is electric potential? Write its unit. Obtain an expression for electric potential at a point near an electrostatic charge. [4]

92. 2065 Q. No. 9 a Define electric potential Derive an expression for the potential difference formula and hence obtain the potential at point due to a point charge. [1+3+1]

93. 2062 Q.No. 9 a Define electric potential and intensity at a point due to a charge. Obtain an expression for the potential difference between two points r_1 and r_2 from charge +q. [5]

94. 2061 Q.No. 9 a Define potential and electric field at a point in an electrostatic field. Derive a relation between the electric potential and the electric field strength at a point. [5]

95. 2060 Q.No. 9 a State and explain Gauss's theorem in electrostatics and use it to find the electric field intensity due to a hollow charged spherical conductor. [5]

96. 2057 Q.No. 9 a What is an electric potential? Derive the formula for the potential at a point due to a point charge. [1+4]

Numerical Problems

97. 2076 Set B Q.No. 12 Three equal charges 1.8×10^{-6} C each are located at the corners of an equilateral triangle ABC of side 10 cm. Calculate the electric potential due to these charges at the mid point of AB. [3]

Ans: 8.35×10^5 V/m

98. 2075 GIE Q.No. 12 2069 Supp Q.No. 12 Calculate the value of two equal charges if they repel each other with a force of 0.1N when situated 50 cm apart in vacuum. What would be the distance between them if they are placed in an insulating medium of dielectric constant 10? [3]

Ans: 1.667μC, 0.16 m

99. 2075 Set A Q.No. 12 Two large parallel metal plates carry opposite charges. They are separated by 10 cm and p.d. of 500 volts is applied on them. (a) what is the magnitude of electric field strength between them? Compute the work done by this field on a charge of 2×10^{-9} C as it moves from higher to the lower potential. [3]

Ans: 10^{-4} J

100. 2075 Set B Q.No. 12 Two large parallel metal plates carry opposite charges. They are separated by 0.20 m and the p.d between them is 500 V. What is the magnitude of electric field, if it is uniform, in the region between them? [3]

Ans: 2500 V/m

101. 2072 Set C Q.No. 12 2070 Supp (Set A) Q.No. 12 What distance must an electron move in a uniform potential gradient 200V cm^{-1} in order to gain kinetic energy 3.2×10^{-18} J? [3]

Ans: 0.001 m

102. 2072 Set D Q.No. 12 An electron of mass 9.1×10^{-31} kg and charge 1.6×10^{-19} C is situated in a uniform electric field of intensity 1.2×10^4 Vm^{-1}. Find the time it takes to travel 1 cm from rest. [3]

Ans: 3.1×10^{-9} sec

103. 2072 Set E Q.No. 12 A solid sphere of radius 1 cm is carrying a charge of 2C. Find the electric field intensity at the centre. on its surface and at a point 2 cm from the centre of the charged sphere. [3]

Ans: 1.8×10^{12} N/C, 4.5×10^{13} N/C

104. 2071 Supp Q.No. 12 An alpha particle is a nucleus of doubly ionized helium. It has mass of 6.68×10^{-27} kg and charge of 3.2×10^{-19} C. Compare the force of electrostatic repulsion between the two alpha particles with the force of gravitational attraction between them. [3]

Ans: 3.1×10^{35}

105. 2070 Supp (Set B) Q.No. 12 An electron of charge 1.6×10^{-19}C is situated in a uniform electric field of intensity 120,000 V/m. Find the force on it and its acceleration. [3]
Ans: 1.92×10^{-14} N; 2.1×10^{16} m/sec^2

106. 2069 (Set A) Q. No. 12 Two charges $+1\times10^{-6}$ and -4×10^{-6}C are separated by a distance of 2m. Determine the position of the null point. [3]
Ans: 2 m from small charge

107. 2068 Old Q.No. 9 b Two horizontal parallel plates, 20mm apart, have a potential difference of 1000V between them the upper plate being at a positive potential. A negatively-charged oil drop, mass 4.8×10^{-15} Kg, is situated between the plates. Calculate the number of electrons on the drop if it is stationary in the air, neglecting the density of air. (take g = 10 ms^{-2} and e = 1.6×10^{-19}C) [4]
Ans: 6

108. 2067 Q.No. 12 A hollow spherical conductor of radius 12 cm is charged to 6×10^{-6}C. Find the electric field strength at the surface of sphere, inside the sphere at 8cm and at distance 15 cm from the sphere. [3]
Ans. 3.75×10^6 NC^{-1}, 0, 7.41×10^5 NC^{-1}

109. 2066 Q.No. 9 b Two horizontal parallel plates each of area 500 cm^2 are mounted 2mm apart in vacuum. The lower plate is earthed and the upper one is given a positive charge of 0.05 μC. Find the electric field intensity and the potential difference between the plates. [4]
Ans: 112.9×10^3 Vm^{-1}, 226 V

2. Capacitance and Dielectrics

FORMULAE

1. Capacitance, $C = \frac{q}{V}$
2. Capacitance of sphere, $C = 4\pi\epsilon_0 k R = 4\pi\epsilon R$
3. Capacitance of a parallel plate capacitor, $C = \frac{\epsilon_0 A}{d}$
4. Equivalent capacitance of series combination, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
5. Equivalent capacitance of parallel combination, $C = C_1 + C_2 + C_3$
6. Energy stored in a charged capacitor, $U = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2} CV^2$
7. Common potential, $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$
8. Dielectric constant, $K = \frac{\epsilon}{\epsilon_0}$

Short Answer Questions

1. 2076 Set C Q.No. 4b Two plates of a charged capacitor are brought closer. What happens to its capacitance and energy stored? [2]
2. 2075 GIE Q.No. 4b 2070 Supp (Set A) Q.No. 4b Two identical capacitors are connected in series. Is the resulting capacitance greater or less than that of each individual capacitor? [2]
3. 2075 Set B Q.No. 4a What is the physical significance of relative permitivity of a material placed between two plates of a capacitor? [2]
4. 2074 Supp. Q.No. 4b What are the factors which determine the value of capacitance of a parallel plate capacitor? [2]
5. 2074 Set A Q.No. 4b Two parallel plate capacitors identical in shape and size are filled with air and mica separately. Which one has larger capacitance? Write a proper relation in support of your answer. [2]
6. 2073 Supp Q.No. 4b Explain the difference between dielectric constant and dielectric strength. [2]
7. 2073 Set C Q.No. 4b Can we give any desired charge to a capacitor? Explain. [2]
8. 2073 Set D Q.No. 4b What happens to the capacity and potential difference of a charged capacitor when a dielectric medium is inserted between its plates? [2]
9. 2072 Set C Q.No. 4b Can we give any desired quantity of charge to a capacitor? [2]
10. 2072 Set E Q.No. 4b Two parallel plate capacitors are identical in every aspect except the insulating dielectric media between the plates. If air and mica are kept as dielectric in respective capacitors, which one will have larger capacity? [2]
11. 2071 Supp Q.No. 4b What are the uses of dielectrics in capacitors? [2]
12. 2071 Set C Q.No. 4 b Three capacitors of the same capacitance are joined all in (i) series, and (ii) all in parallel. By how much one of these combinations is larger in magnitude? Explain. [2] **Ans: 9**
13. 2071 Set D Q.No. 4 a Explain the difference between a polar and a non-polar dielectrics with one example of each. [2]
14. 2070 Supp (Set B) Q.No. 4 b What happens to the capacity and potential difference of a charged capacitor when a dielectric medium is inserted between its plates? [2]
15. 2070 Set C Q.No. 4a 2068 Q.No. 4b 2060 Q.No. 8b Distinguish between dielectric constant and dielectric strength. [2]
16. 2070 Set D Q.No. 4 b What are the factors that determine the capacitance of a parallel plate capacitor? [2]
17. 2069 Supp Q.No. 4b Two identical capacitors are connected in series. Is the resultant capacitance greater or less than that of each individual capacitor? What if they are connected in parallel? [2]
18. 2069 Old (Set B) Q. No. 8c Two identical capacitors are connected in series. Is the resulting capacitance greater or less than that of each individual capacitance? What happen if they are connected parallel? [2]
19. 2068 Old Q.No. 8 c Explain how the capacitance of a parallel plate capacitor can be increased. [2]
20. 2067 Q.No. 4 b Differentiate between dielectric strength and dielectric constant. [2]
21. 2066 Q. No. 4 b Is dielectric constant, the same as dielectric strength? Explain with example [2]
22. 2065 Q. No. 8 c How will you arrange 3 capacitors each having the capacity of 2 μF, to get a capacitor of capacity 3 μF? [2]
23. 2062 Q.No. 8 b Define dielectric constant and dielectric strength. [2]
24. 2061 Q.No. 8 c Distinguish between polar and nonpolar dielectrics. [2]

Long Answer Questions

25. 2076 Set B Q.No. 8b What is capacitance of a capacitor? Derive a relation for the energy stored in a capacitor when it is charged to a potential difference of V volts. [4]

26. 2076 Set C Q.No. 8b Define capacitance of a capacitor, Obtain relations for equivalent capacitance for capacitors connected in series and parallel. [4]
27. 2075 GIE Q.No. 8b Define capacitance of a capacitor. Deduce an expression for the capacitance of a parallel plate capacitor. Discuss the action of dielectric between the plates. [4]
28. 2075 Set A Q.No. 8b What is a capacitor? Derive an expression for energy loss, when two charged capacitors are connected with like plates together. [4]
29. 2075 Set B Q.No. 8a Three capacitors are connected in series with a cell. The same three capacitors are connected in parallel with the same cell. Which combination of capacitors is larger in magnitude? Also find an expression for their value in series combination. [4]
30. 2074 Supp. Q.No. 8b Show that the electrical energy is always lost when two capacitors at different potentials are connected together. [4]
31. 2073 Supp Q.No. 8a What do you understand by 'One Picofarad"? Deduce an expression for the energy stored in capacitor. [4]
32. 2072 Supp Q.No. 8b Explain what is meant by the capacitance of a capacitor and define its units. Derive an expression for the energy stored in the capacitor. [4]
33. 2072 Set C Q.No. 8a Define capacitance of a capacitor. Deduce an expression for energy stored in a charged capacitor. [4]
34. 2072 Set D Q.No. 8b Obtain relations for equivalent capacitance for capacitors connected in series and parallel.[4]
35. 2072 Set E Q.No. 8b How big is a microfarad? Discuss the factors on which the capacitance of a parallel plate capacitor depend. What will be the combined capacitance of two such capacitors connected in series with a battery? [4]
36. 2071 Supp Q.No. 8b Three capacitors are arranged in such a way that two capacitors are connected in series combination and across them a third capacitor is connected in parallel combination. Find the net capacitance of the combination of the three. [4]
37. 2071 Set C Q.No. 8b 2067 Supp Q.No. 8b Define capacitance of a capacitor. Deduce an expression for the capacitance of a parallel plate capacitor. [4]
38. 2070 Supp (Set A) Q.No. 8 b Deduce an expression for the effective capacitance when two capacitors C_1 and C_2 are connected in (i) parallel (ii) series. [4]
39. 2070 Supp (Set B) Q.No. 8 b Obtain an expression of energy stored in a charged capacitor and use it to derive the expression of energy density of a dielectric medium in an electric field. [4]
40. 2069 Supp Q.No. 8b Show that there is always loss of energy when two charged capacitors are connected to each other with a conducting wire. [4]
41. 2069 (Set A) Q. No. 8b How can a number of capacitors be connected to increase and decrease the effective capacitance? Find the respective expressions for the effective capacitance in each case. [4]
42. 2069 (Set A) Old Q. No. 9a OR Find the equivalent capacitance of two capacitors when they are connected (i) in series and (ii) in parallel. [4]
43. 2069 (Set B) Q. No. 8b 2063 Q.No. 9a Derive an expression for the energy stored in a capacitor of capacitance "C" when there is potential difference "V" between the plates. [4]
44. 2067 Q.No. 8 b What is a capacitor? Find the energy stored in a charged capacitor. [4]
45. 2064, Q.No. 9 a What do you mean by capacitance? Find the expression for the capacity of (i) parallel plates capacitor and (ii) capacity of an isolated charged sphere. [1+2+2]
46. 2062 Q.No. 9 a OR Three capacitors are arranged in such a way that one of the capacitor is connected in parallel with the series combination of other two. Find the net capacitance of the combination of the three. [5]
47. 2061 Q.No. 9 a OR Explain, what is meant by the capacitance of a capacitor and define its SI units. Derive an expression for the capacitance of a parallel plate capacitor. [5]
48. 2060 Q.No. 9 a OR What do you mean by the term capacitance? Find the equivalent capacitance of two capacitors when they are connected in (i) series (ii) parallel.[5]
49. 2057 Q.No. 9 a OR What is a capacitor? Find an expression for the energy stored in a charged capacitor. [5]

Numerical Problems

50. 2076 Set C Q.No. 12 A 300 V battery is connected across capacitors of 3 μF and 6 μF in parallel. Calculate the energy stored in each capacitors. [3]
Ans: 0.135 J and 0.27 J
51. 2074 Supp. Q.No. 12 A parallel plate air capacitor of capacitance 245 pF has a change of magnitude 0.148 μc on each plate. Find the potential difference and electric field intensity between the plates if the distance between the plates is 5mm? [3]
Ans: 120816 V/m
52. 2074 Set A Q.No. 12 Two capacitors of capacitances 8μF and 15μF respectively are connected in series with a battery of 220V. Find the charge and potential across each capacitor.[3]
Ans: 8.26×10^{-4} C, 165 V, 55 V
53. 2074 Set B Q.No. 12 A parallel plate air capacitor has a capacitance of 10^{-9} F. What potential difference is required for a charge of 5×10^{-5} C? What is the total energy stored in it? [3]
Ans: 5×10^{4} V, 1.25 J
54. 2073 Supp Q.No. 12 2068 Q.No. 12 Two capacitors of capacitance 4 μF and 6 μF respectively are joined in series with a battery of e.m.f. 60 volts. The connections are broken and like terminals of the capacitors are then joined. Find the final charge of each capacitor. [3]
Ans: 28.8 V, 115.2 μC, 173 μC
55. 2073 Set C Q.No. 12 Two capacitors of capacitances 4 μF and 12 μF respectively, are connected in series. The combination is then connected momentarily across a 200 V battery. Find the charge and potential difference across each capacitor. [3]
Ans: 6×10^{-4} C, 150V, 50V

56. 2073 Set D Q.No. 12 A parallel plate capacitor with air as the dielectric has a capacitance of 6×10^{-4} μF and is charged by a 100 V battery. Calculate the charge and the energy stored in the capacitor. [3]
Ans: 6×10^{-2} μC, 3×10^{-6} J

57. 2072 Supp Q.No. 12 Eight drops of water of the same size are equally and similarly charged. They combine together to form a bigger drop. Compare the capacitances of bigger drop with that of the smaller drop. [3]
Ans: 2 : 1

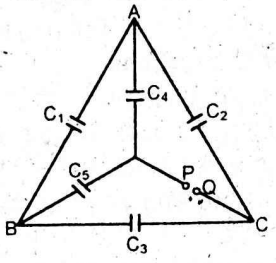
58. 2071 Set C Q.No. 12 Two spheres of radii 5 cm and 10 cm are given charges 100 C and 50 C respectively and then connected by a wire. Calculate the loss of energy after connection. [3]
Ans: 3.38×10^{14}J

59. 2071 Set D Q.No. 12 Three capacitors of 1 μF, 2 μF and 3 μF are connected first in series. The same capacitors are again connect in parallel. Compare their equivalent capacitance. Which one of these combinations gives larger value of capacitance? [3]
Ans: 11 C

60. 2070 Set C Q.No. 12 A parallel plate air capacitor has a plate separation of 5 mm and is charged to a potential difference of 400 V. Calculate the energy density in the region between the plates. [3]
Ans: 2.832×10^{-2}J/m^3

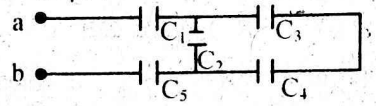
61. 2070 Set D Q.No. 12 A parallel plate air capacitor of capacitance 245 $\times10^{-12}$ F has a charge of magnitude 0.148μC on each plate. Find the potential difference and electric field intensity between the plates if the distance between plates 5mm? [3]
Ans: 604V, 120800 V/m

62. 2069 (Set B) Q. No. 12 Find the equivalength capacitance of the following combination as shown in figure.
In which $C_1 = C_2 = C_3 = C_4 = C_5 = 100$ μF [3]



Ans: 100 μF

63. 2066 Q. No. 12 In the given capacitors circuit applied potential between a b is 220 V. What is the equivalent capacitance of the network between a and b? Given: $C_1 = C_5 = 8.4$ μF and $C_2 = C_3 = C_4 = 4.2$ μF. [3]



Ans: 2.52 μF

64. 2059 Q.No. 9 b 2056 Q.No. 9 b Two capacitors of capacitance 4.0 μF and 12.0 μF respectively are connected in series and the combination connected momentarily across a 200 volt battery. The charged capacitors are now isolated and connected in parallel, similar charged plates being connected together. Calculate the common potential. [3]
Ans: 75 V

65. 2053 Q.No. 9 b A thundercloud and the earth can be regarded as a parallel plate capacitor. Taking the area of the thundercloud to be 50 km^2, its height above the earth as 1 km and its potential 100 kV, calculate the energy stored. (Permittivity of vacuum is 8.85×10^{-12} C^2 N^{-1} m^{-2})
Ans: 2.2×10^3 joules

5 Sets Questions

Set 1

Group A

1. **Answer, in brief, any SIX questions:** [6×2=12]
   a. What is the angle between two vectors $\vec{A}$ and $\vec{B}$, when $|\vec{A} \times \vec{B}| = |\vec{A} \cdot \vec{B}|$?
   b. When a body is thrown upwards, the total momentum decreases. Does this violate the principle of conservation of linear momentum?
   c. What is the effect on the revolution of the earth, if the sun is suddenly converted to black hole?
   d. Explain why air bubble grows in size when it moves upward in water from the bottom.
   e. There are two springs, one delicate and another stiffer one. Which spring will have a greater frequency of oscillation for a load?
   f. How do insects move easily on the surface of water?
   g. Why does an object entering the earth's atmosphere at high velocity catch fire?
2. **Answer, in brief, any TWO questions:** [2×2=4]
   a. Does cubical expansivity depend on the original volume of a substance? Does it depend on temperature of the substance? Explain.
   b. It takes more time to evaporate the same mass of water than to melt the ice by supplying same amount of heat per second, why?
   c. The slop of adiabatic curve is more steeper than isothermal curve, why?
3. **Answer, in brief, any ONE question:** [1×2=2]
   a. Why are mirrors used in search light parabolic but not the concave spherical?
   b. The shape of spectacles is made concavo convex, why?
4. **Answer, in brief, any ONE question:** [1×2=2]
   a. What would be the nature and magnitude of charge when three electrons are ejected from a neutral plastic ball?
   b. Can we apply Gauss law for the irregular closed surface around a charge conductor?

Group B

5. **Answer any THREE questions:** [3×4=12]
   a. Derive the dimensional relation of escape velocity of the earth with acceleration due to gravity and radius of the earth.
   b. State work energy theorem. Derive the expression for the work done by variable forces.

c. Define simple harmonic motion. Show that motion of simple pendulum is simple harmonic. Also find the length of second pendulum.

d. What is coefficient of friction? Derive the relation between coefficient of friction and angle of friction.

6. Answer any TWO questions: **[2×4=8]**

a. Define cubical expansion of a liquid. Derive the expression for the final volume of a liquid when its temperature is increased from 0°C to θ°C.

b. Describe the working principle of Carnot engine with indicator diagram.

c. What is black body? Is it realized in practice? State and prove Stefan's law of black body radiation.

7. Answer any ONE question: **[1×4=4]**

a. Draw a ray diagram of compound microscope. Obtain the magnifying power of it.

b. Derive the relation $\mu = \frac{\sin\frac{A+\delta m}{2}}{\sin\frac{A}{2}}$, Where the symbols have their usual meanings.

8. Answer any ONE question: **[1×4=4]**

a. Define electric potential. Derive the expression for it.

b. What is a capacitor? Derive the expression of energy density for a capacitor.

Group C

9. Solve any THREE numerical questions: **[3×4=12]**

a. A loaded grocery cart is rolling across a parking lot in a strong wind. You apply a constant force $\vec{F} = (30\ N)\hat{i} - (40\ N)\hat{j}$ to the cart as it undergoes a displacement $\vec{s} = (-9.0\ m)\hat{i} - (3.0\ m)\hat{j}$. How much work does the force you apply on the grocery cart?

Ans: –150 J

b. A 15.0 load of brick hangs from one end of a rope that passes over a small, frictionless pulley. A 28.0 kg counterweight is suspended from the other end of the rope, as shown in figure 5.47. The system is released from the rest. (a) Draw two free body diagrams, one for the load of bricks and one for the counterweight. (b) What is the magnitude of the upward acceleration of the load of bricks? (c) What is the tension in the rope while the load is moving? How does the tension compare to the weight of the load of bricks? To the weight of the counterweight?

Ans: 2.96 m s^{-2}, 191 N

c. Two soap bubbles, one of radius 50 mm and the other of radius 80 mm are brought together so that they have a common interface. Calculate the radius of curvature of this interface.

Ans: 0.133 m

d. A specimen of oil having an initial volume of 600 cm^3 is subjected to a pressure increase of 3.6×10^6 Pa, and the volume is found to decrease by 0.45 cm^3. What is the bulk modulus of the material? To compressibility?

Ans: 4.8×10^9 Pa, 2.1×10^{-10} Pa^{-1}

10. Solve any TWO numerical questions: **[2×4 = 8]**

a. Steel trains rails are laid in 12.0 m long segments placed end-to-end. The rails are laid on a winter day when their temperature is –2.0°C. (a) How much space must be left between adjacent rails if they are just to touch on a summer day when their temperature is 33.0°C? (b) If the rails are originally laid in contact, what is the stress in them on a summer day when their temperature is 33.0°C?

Ans: 5.04×10^{-3} m, 8.4×10^{12} Nm^{-2}

b. On a certain day the air temperature is 17.7°C and the dew point is 5.3°C. Find the relative humidity. (SVP at 5°C, 6°C, 17°C, and 18°C are 0.654 cm, 0.705 cm, 1.442 cm and 1.546 cm respectively)

Ans: 44.2%

c. The emissivity of tungsten is 0.35. A tungsten sphere with radius 1.50 cm is suspended within a large evacuated enclosure whose walls are at 290 K. What power input is required to maintain the sphere at atmosphere of 300 K if heat conduction along the supports is neglected?

Ans: 4.54×10^3 W

11. A spherical concave shaving mirror has a radius of curvature of 32.0 cm. (a) What is the magnification of a person's face when it is 12.0 cm to the left of the vertex of the mirror? (b) Where is the image? Is the image real or virtual? (c) Draw a principle ray diagram showing formation of the image. [4]

Ans: - 48 cm, 4, virtual

12. An alpha particle (charge + 2e and mass 6.64×10^{-27} Kg) is traveling to the right at 1.50 km/s. What uniform electric field (magnitude and direction) is needed to cause it to travel to the left at the same speed after 2.65 μs? [3]

Ans: 1.132×10^9 m/s^2, 23.5 N/C

Set 2

Group A

1. Answer, in brief, any SIX questions: **[6×2=12]**

a. Considering force, mass and time be the fundamental physical quantities, find the dimensional formula of displacement.

b. What does the area covered by velocity verses time graph give?

c. Can three coplanar forces bring the body in equilibrium? Explain briefly with necessary sketch.

d. Why artificial satellites do not fall towards the earth surface, although they are kept in the gravitational field?

e. What happens to the modulus of elasticity of most of the materials with increase in temperature?

f. Why does a child in a marry-go-round press the side of his seat radially outwards?

g. Why does a steel ball fall with uniform velocity in a liquid although resultant force along vertical direction is zero?

2. Answer, in brief, any TWO questions: **[2×2=4]**

a. What do you mean by water equivalent of iron is greater than copper?

b. Saturated vapour does not obey the gas laws. Why?

c. Spark plug is not necessary in diesel engine, why?

Answer, in brief, any ONE question: [1×2=2]

a. Optical fibers are used to transmit the cable signals, why?

b. What is luminous intensity? Write its unit.

Answer, in brief, any ONE question: [1×2=2]

a. How will obtain minimum capacitance from three given capacitance?

b. What type of electric field is produced between two parallel metal plates, uniform or non-uniform?

Group B

Answer any THREE questions: [3×4=12]

a. What is centripetal force? Derive its expression

b. Derive the expression for variation of acceleration due to gravity due to the rotation of the earth.

c. State principle of conservation of momentum. Prove this principle considering two bodies collide in a linear path.

d. State and prove Bernoulli's theorem in flowing liquid.

Answer any TWO questions: [2×4=8]

a. Why does gas exert pressure on the wall of a container? Show that the kinetic energy of an ideal gas depends on the absolute temperature of the gas.

b. Define Newton's law of cooling. Describe the experiment for determining the specific heat capacity of a liquid.

c. Describe the working principle of Petrol engine.

Answer any ONE question: [1×4=4]

a. What are the defects of vision? How they are removed?

b. Derive the expression for combined focal length when two lenses are combined coaxially.

Answer any ONE question: [1×4=4]

a. Define electrostatic induction. Describe how a conductor can be charged positively by induction method.

b. State Gauss theorem. Use this theorem to find the electric field intensity due to a plane charged conductor.

Group C

Solve any THREE numerical questions: [3×4=12]

a. A ball is thrown forward from the top of a cliff with a velocity of 10 ms^{-1}. The height of the cliff above the ground is 45 m. Calculate (i) the time to reach the ground (ii) the distance from the cliff of the ball on hitting the ground and (iii) the direction of the ball to the horizontal just before it hits the ground, take g = 10 ms^{-2}.

Ans: 3 s, 30 m, 71.6°

b. A uranium atom traveling with a velocity of 5.00×10^5 ms^{-1} relative to the containing tube breaks up into Krypton and Barium. The Krypton atom is ejected directly backwards at a velocity of 2.35×10^6 m s^{-1} relative to the barium after separation. With what velocity does the barium atom move forward relative to the tube? What is the velocity of the Krypton atom relative to the containing tube? (mass of Kr = 95.0; Ba = 140; U = 235)

Ans: 1.45×10^6 m s^{-1}, 9.0×10^6 m s^{-1}

c. A flywheel requires 4.00 s to rotate through 162 rad. Its angular velocity at the end of this time is 108 rad/s. Find (a) the angular velocity at the beginning of the 4.00 s interval; (b) the constant angular acceleration.

Ans: –27 rad s^{-1}, 33.75 rad s^{-2}

d. A spring is extended by 30 mm when a force of 1.5 N is applied to it. Calculate the energy stored in the spring when hanging vertically supporting a mass of 0.20 kg if the spring was unstretched before applying the mass. Calculate the loss in potential energy of the mass.

Ans: 0.04 J, 0.08 J

10. Solve any TWO numerical questions: [2×4 = 8]

a. A machinist bores a hole of diameter 1.350 cm in a steel plate at a temperature of 25°C. What is the cross-sectional area of the hole (a) at 25°C; (b) when the temperature of the plate is increased to 175°C? Assume the coefficient of linear expansion remains constant over this temperature range.

Ans: 1.437 cm^2

b. A carpenter builds an exterior house wall with a layer of wood 3.0 cm thick in the outside and layer of Styrofoam insulation 2.2 cm thick on the inside wall surface. The wood has K = 0.080 W/m· K and the Styrofoam has K = 0.010 W/m· K. The interior surface temperature is 19.0°C, and the exterior surface temperature is –10.0°C. (a) What is the temperature at the plane where the wood meets Styrofoam? (b) What is the rate of heat flow per square meter through this wall?

Ans: –6°C, 11.36 Wm^{-2}

c. A gas under a constant pressure of 1.50×10^5 Pa and with an initial volume of 0.0900 m^3 is cooled until its volume becomes 0.0600 m^3. (a) Draw a pV-diagram for this process. (b) Calculate the work done by the gas.

Ans: -3×10^3 J

11. The refracting angle of prism is 62° and refractive index of glass for yellow light is 1.65. What is the possible angle of incidence of a ray of this yellow light which is transmitted without total internal reflection? [4]

Ans: 43.6°

12. The dielectric to be used in a parallel plate capacitor has a dielectric constant of 3.60 and a dielectric strength of 1.60×10^7 V/m. The capacitor is to have a capacitance of 1.25×10^{-9} F and must be able to withstand a maximum potential difference of 5500 V. What is the minimum area the plates of the capacitor may have? [3]

Ans: 0.0135 m^2

Set 3

Group A

1. Answer, in brief, any SIX questions: [6×2=12]

a. Each side of a cube is measured to be 7.203 m. What are the total surface area and the volume of the cube to appropriate significant figures?

Ans: 311.3 m^2, 373.7 m^3

b. We get hurt when we kick a brick, however we can displace it easily without pain when it is pushed gently, why?

c. "At the time of MAHABHARAT, when BHIM could not push the cart of jewels and coins given by KUBER, mustard grains were spread over the path. Then, the heavy cart was rolled easily." Do you believe it? If so, what physical quantity is effective to make the movement easier?

d. What would be the time period of simple pendulum when it is taken to space where weight of a body is zero?
e. The angular velocity of revolution of the earth around the sun increases, when it comes to the sun. Why?
f. If two ships happen to be parallel and adjacent to each other, they experience a pull trying to bring them together. Why?
g. Two circular discs of same mass and thickness of different metals. Which disc will have the greater moment of inertia about its center of axis?

2. Answer, in brief, any TWO questions: [2×2=4]

a. The temperature of a gas is increased by 10°C. What is the corresponding change on Fahrenheit scale?
b. If we put on wet clothes, the temperature of the body is lowered considerably. Why?
c. Why do gases have two different specific heat capacities, however liquid and solid have single?

3. Answer, in brief, any ONE question: [1×2=2]

a. For what angle of incidence, the lateral shift produced by a parallel sided plate is maximum?
b. How would you increase the brightness of an image formed by astronomical telescope?

4. Answer, in brief, any ONE question: [1×2=2]

a. We cannot confirm the nature of charge in a body from attraction property. Give reason.
b. Why do equipotential surfaces around a charge do not intersect each other?

Group B

5. Answer any THREE questions: [3×4=12]

a. Show analytically that total energy of a body executing simple harmonic motion is independent of the position of the body during its motion.
b. Define work energy theorem. Derive the expression of work done by variable forces.
c. State triangle law of vector addition. Prove that the sum of two vectors is affected by the angle between them using triangle law of vector addition.
d. How is energy produced in a stretched wire? Derive the expression for the energy density produced in a stretched wire.

6. Answer any TWO questions: [2×4=8]

a. Define linear and cubical expansivities. Derive the relation between them.
b. Describe the experiment to determine the latent heat of fusion of ice.
c. Define isothermal process in thermodynamics. Calculate the external work done when a perfect gas undergoes isothermal process.

7. Answer any ONE question: [1×4=4]

a. Draw a neat ray diagram for the astronomical telescope when eye piece is kept in least distance of distinct vision. Also derive its magnifying power.
b. Derive the expression of lens formula for concave lens.

8. Answer any ONE question: [1×4=4]

a. State Gauss theorem. Use this theorem to find the electric field intensity outside a charged sphere.
b. Define dielectric. Describe its action in the capacitor.

Group C

9. Solve any THREE numerical questions: [3×4=12]

a. A spelunker is surveying a cave. She follows a passage 180 m straight west, then 210 m in a direction 45° east of north, and 280 m at 30° east of north. After the fourth unmeasured displacement, she finds herself back where she started. Find the magnitude and direction of fourth displacement.

Ans: 143.93 m, 40.8°

b. The dinosaur Tyranosaurus rex is thought to have had a mass of about 700 kg.(a) Treat the dinosaur as a particle and estimate its kinetic energy at a walking speed of 4.0 km/h. (b) With what speed would a 70 kg person have to move to have the same kinetic energy as a walking T. rex?

Ans: 4.3×10^3 J, 40 km/hr

c. A uniform ladder rests on a rough horizontal ground, leaning against a smooth vertical wall. Weight of the ladder is 300 N and a man weighing 500 N stands on one quarter of its length from the bottom. Ladder makes 30° to the horizontal. Find the reaction at the wall and the total force on the ground.

Ans: 476.31 N, 931.06 N

d. A shower head has 20 circular openings, each with radius 1.0 mm. The shower head is connected to a pipe with radius 0.80 cm. If the speed of water in the pipe is 3.0 m/s, what is its speed as it exits the shower-head openings?

Ans: 9.6 m/s

10. Solve any TWO numerical questions: [2×4=8]

a. A geologist working in the field drinks her morning coffee out of an aluminum cup. The cup has a mass of 0.120 kg and is initially at 20.0°C when she pours 0.300 kg of coffee initially at 70.0°C. What is the final temperature after the coffee attains thermal equilibrium? (Assume that coffee has the same specific heat as water and that there is no heat exchange with the surroundings).

Ans: 66.0°C

b. A refrigerator has a coefficient of performance of 2.10. Each cycle it absorbs 3.40 × 104 J of heat from the cold reservoir. (a) How much mechanical energy is required each cycle to operate the refrigerator? (b) During each cycle, how much heat is discarded to the high-temperature reservoir?

Ans: 1.62×10^4 J, 5.02×10^4 J

c. One end of an insulated metal rod is maintained at 100°C, and the other end is maintained at 0°C by an ice-water mixture. The rod is 60.0 cm long and has a cross-sectional area of 1.25 cm^2. The heat conducted by the rod melts 8.50 g of ice in 10.0 min. Find the thermal conductivity *k* of the metal.

Ans: 381 $W m^{-1}K^{-1}$

11. A light beam travels at 1.94×10^8 m/s in quartz. The wavelength of light in quartz is 355 nm. (a) What is the index of refraction of quartz at this wavelength? (b) If this same light travels through air, what is its wavelength there? [4]

Ans: 1.55, 549 nm

2. A point charge has a charge of 2.50×10^{-11} C. At what distance from the point charge is the electric potential a) 90.0 V? b) 30.0, V. Take the potential to be zero at an infinite distance from the charge. [3]

Ans: 2.50×10^{-3} m, 7.50×10^{-3} m

Set 4

Group A

1. **Answer, in brief, any SIX questions:** [6×2=12]
   a. What are the dimensions of constants A and B in the given equation $\mu = \frac{A}{\lambda} + \frac{B}{\lambda^2}$, where μ is the refractive index of a medium and λ is the wavelength of radiation.
   b. Two unequal masses are dropped from the same height at a time, which one reaches to the ground first, assuming the air resistance negligible?
   c. The speed of a body moving in a circle is constant for constant centripetal force; however the acceleration is not zero. Explain why?
   d. A bird is sitting on the floor of a wire cage and the cage is in the hand of a boy. The bird starts flying in the cage. Will the boy experience any change in the weight of the cage?
   e. Why does the velocity increase when water flowing in a broader pipe enters a narrow pipe?
   f. What is the average force on a man due to atmospheric pressure? Why one does feel it?
   g. Why should the angular displacement of a simple pendulum not exceed 4 radian?
2. **Answer, in brief, any TWO questions:** [2×2=4]
   a. Which molecules, the molecules of 0°C ice or of 0°C water, have more potential energy and why?
   b. Even an ideal heat engine cannot have the efficiency 100%, why?
   c. Why triple point is appropriate to define absolute temperature?
3. **Answer, in brief, any ONE question:** [1×2=2]
   a. When white light passed through a glass prism, it splits up into seven colours. Why?
   b. What are the advantages of total reflecting mirror over a plane mirror?
4. **Answer, in brief, any ONE question:** [1×2=2]
   a. What would happen the value of capacitance when dielectric material is filled between two plates of a capacitor?
   b. A metallic chain is dragged on the ground from a vehicle that carries inflammable materials, why?

Group B

5. **Answer any THREE questions:** [3×4=12]
   a. State and prove the principle of conservation of energy.
   b. Describe terminal velocity with necessary plot. How do you measure the coefficient of viscosity experimentally?
   c. Derive the expressions for the orbital velocity, time period and height of artificial satellite from the surface of the earth.
   d. Define torque and couple in rotational motion. Derive the expression of work done by couple.
6. **Answer any TWO questions:** [2×4=8]
   a. Define thermal conductivity. Describe the experiment that can measure the thermal conductivity of a metal rod.
   b. Using kinetic theory of gases, derive the expression of pressure exerted by gas molecules inside the wall of a cube.
   c. What is isothermal process? Derive the expression for the work done by a gas in isothermal expansion.
7. **Answer any ONE question:** [1×4=4]
   a. Define lateral shift. Show that lateral shift produced in a glass slab in grazing incidence is equal to the thickness of it.
   b. Derive the expression for the achromatic combination of two lenses.
8. **Answer any ONE question:** [1×4=4]
   a. Deduce the equivalent capacitance of three capacitors when one of them is connected in parallel with other two in series.
   b. Define potential difference in an electric field. Derive the expression for it.

Group C

9. **Solve any THREE numerical questions:** [3×4=12]
   a. A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river; his velocity relative to the water is 4.2 m/s due east. The river is 800 m wide. (a) What is his velocity relative to the earth? (b) How much time is required to cross the river? (c) How far south of his starting point will he reach the opposite bank?

   Ans: 25° south of east, 190 s, 380 m

   b. An object of mass 10 kg is whirled round a horizontal circle of radius 4m by a revolving string inclined to the vertical. If the uniform speed of the object is 5 m s^{-1}, calculate (i) the tension in the string (ii) the angle of inclination of the string to the vertical.

   Ans: (i) 118 N (ii) 32°

   c. The rotating blade of a blender turns with constant angular acceleration 1.50 rad/s^2. (a) How much time does it take to reach an angular velocity of 36.0 rad/s, starting from rest? (b) Through how many revolutions does the blade turn in this time interval?

   Ans: 24 s, 69

   d. A solid weighs 237.5 g in air and 12.5 g when totally immersed in a liquid of density 0.9 g cm^{-3}. Calculate (i) the density of the solid (ii) the density of a liquid in which the solid would float with one fifth of its volume exposed above the liquid surface.

   Ans: 0.95 g cm^{-3}, 1.1875 g cm^{-3}
10. **Solve any TWO numerical questions:** [2×4 = 8]
    a. A steel tank is completely filled with 2.80 m^3 of ethanol when both the tank and the ethanol are at temperature of 32.0°C. When the tank and its contents have cooled to 18.0°C, what additional volume of ethanol can be put into the tank?

    Ans: 0.29 m^3

b. Calculate the root mean square speed at 0°C of (i) hydrogen molecules and (ii) oxygen molecules, assuming 1 mole of a gas occupies a volume of 2×10^{-2} m^3 at 0°C and 10^5 Nm^{-2} pressure. [Relative molecular mass of hydrogen and oxygen = 2 and 32 respectively]

Ans: 1732.05 m/s, 433.01 m/s

c. A Carnot engine takes 2000 J of heat from a reservoir at 500 K, does some work, and discards some heat to a reservoir at 350 K. How much work does it do, how much heat is discarded, and what is the efficiency?

Ans: 600 J, 1400 J, 30%

11. An object is 16.0 cm to the left of a lens. The lens forms an image 36.0 cm to the right of the lens. What is the focal length of the lens? Is the lens converging or diverging? [4]

Ans: 11.1 cm

12. A parallel-plate, air filled capacitor has circular plates separated by 1.80 mm. The charge per unit area on each plate has magnitude 5.60 pC/m^2. What is the potential difference between the plates of the capacitor? [3]

Ans: 1.14×10^{-3} V

Set 5

Group A

1. Answer, in brief, any SIX questions: [6×2=12]

a. What is the difference between the lengths: 11.5 ± 0.1 cm and 7.8 ± 0.1 cm.

Ans: 3.7±0.2 cm

b. Two balls are thrown with the same initial velocity at angles α and $(90° - \alpha)$ with the horizontal. What will be the ratio of the maximum heights attained by them?

c. Where does a body go when it is dropped into a tunnel that penetrates the earth from its center?

d. If the earth were to shrink suddenly, what would happen to the length of the day?

e. The wick of the kerosene lamp burns although kerosene lies at the bottom of the bottle, why?

f. What happens in the young's modulus of elasticity of a material when the load hanging on it is doubled?

g. Glycerin and water are kept in two separate bottles and whirled them at equal angular speed at equal temperature. Which one liquid comes to rest when they are left at a time?

2. Answer, in brief, any TWO questions: [2×2=4]

a. A small space is left between two rails on a railway track. Why?

b. Derive the numerical value of universal gas constant R in SI system.

c. A solid sphere and a hollow sphere of equal radius made of same material are heated to same temperature and allowed to cool in the same environment. Which of them cools in faster rate?

3. Answer, in brief, any ONE question: [1×2=2]

a. How can the magnifying power of compound microscope be increased.

b. What is the relation of angle of prism and critical angle for normal incidence and grazing emergence?

4. Answer, in brief, any ONE question: [1×2=2]

a. Which physical quantity the multiplication of resistance (R) and capacitance (C) gives? Write the answer referring the charging of capacitor.

b. An electron and a proton are situated in a uniform electric field. What is the relation of their acceleration?

Group B

5. Answer any THREE questions: [3×4=12]

a. Write the necessary conditions for projectile motion. Show that a body projected from the ground traces the parabolic path. Find its time of flight.

b. Define Centripetal force. Describe how angle of bending of cyclist depends on the velocity of bicycle and the radius of curvature of the path.

c. What is surface tension? Derive the ascending formula for surface tension.

d. Derive the expression for the acceleration for a cylinder rolling down on inclined plane in terms of angle of inclination 'θ' with horizontal, radius of cylinder 'R' and radius of gyration 'K'.

6. Answer any TWO questions: [2×4=8]

a. Define Boyle's law and Charles's law. Derive the expression for combined gas equation.

b. Describe the experiment that is applied to determine the specific heat capacity of a solid by the method of mixture.

c. Define adiabatic process in thermodynamics. Show that PV^γ = constant, where symbols have their usual meaning.

7. Answer any ONE question: [1×4=4]

a. Derive mirror formula for convex mirror when it forms virtual image.

b. Derive the expression of lens maker's formula.

8. Answer any ONE question: [1×4=4]

a. State and prove Coulomb's law of electrostatics. Write the formula for the electrostatic force when a dielectric medium is enclosed in the space between two charges.

b. Using Gauss theorem, find the electric field intensity (i) on the surface (ii) inside the surface of a charged sphere.

Group C

9. Solve any THREE numerical questions: [3×4=12]

a. A web page designer creates an animation in which a dot on a computer screen has a position of $\vec{r} = [4.0 \text{ cm} + [2.5 \text{ cm/s}^2] t^2] \hat{i} = (5.0 \text{ cm/s}) + \hat{j}$. (a) Find the magnitude and direction of dot's average velocity between t = 0 and t = 2.0 s. (b) Find the magnitude and direction of instantaneous velocity at t = 0, t = 1.0 s and t = 2.0 s

Ans: (a) 7.1 cm s^{-1}, 45°; (b) 5.0 cm s^{-1}, 90°, 7.1 cm s^{-1}, 11.0 cm s^{-1}, 27°

b. The dogs pull horizontally on ropes attached to a post; the angle between the ropes is 60°. If dog A exerts a force of 270 N and dog B exerts a force of 300 N, find the magnitude of the resultant force and the angle it makes with dog A's rope.

Ans: 494 N, 31.7°

c. Astrophysical theory suggests that a burned out star will collapse under its own gravity to form a black hole when its mass is at least three solar masses. If it does, what is the radius of its event horizon?
(Solar mass = 1.99×10^{30} kg)

Ans: 8.9×10^3 m

d. An alloy of mass 588 g and volume 100 cm^3 is made of iron of density 8.0 $gmcm^{-3}$ and aluminum of density 2.7 $gmcm^{-3}$. Calculate the proportion (i) by volume, (ii) by mass of the constituents of the alloy.

Ans: $\frac{3}{2}, \frac{40}{9}$

0. Solve any TWO numerical questions: [2×4 = 8]

a. The density of an ideal gas is 1.60 kg m^{-3} at 27° C and 1.0×10^5 N/m^2 pressure and its specific heat capacity at constant volume is 312 J kg^{-1} K^{-1}. Find the ratio of the specific heat capacity at constant pressure to that at constant volume.

Ans: 1.67

b. A nail is driven into a board increases in temperature. If we assume that 60% of the kinetic energy delivered by a 1.80 kg hammer with a speed of 7.80 m/s is transformed into heat that flows into the nail and does not flow out, what is the temperature increase of an 8.00 g aluminum nail after it is struck ten times?

Ans: 45.1°C

c. A large cylindrical tank consists 0.750 m^3 of nitrogen gas at 27°C and 1.50×10^5 Pa (absolute pressure). The tank has a tight fitting piston that allows the volume to be changed. What will be the pressure if the volume is decreased to 0.480 m^3 and the temperature is increased to 157°C?

Ans: 3.36×10^5 Pa

11. The focal length of the eyepiece of a certain microscope is 18.0 mm. The focal length of the objective is 19.7 cm. The final image formed by the eyepiece is at infinity. Treat all lenses thin. (a) What is the distance from the objective to the object being viewed? (b) What is the magnitude of linear magnification produced by the objective? (c) What is the overall angular magnification of the microscope? [4]

Ans: 8.37 mm, 21.4, 297

12. A very long, straight wire has charge per unit length 1.50×10^{-10} C/m. At what distance from the wire is the electric field magnitude equal to 2.50 N/C? [3]

Ans: 1.08 m