SECTION – I

Q.1. **Select and write the most appropriate answer from the given alternatives for each sub-question:**

i. The moment of inertia of a thin uniform rod of mass M and length L, about an axis passing through a point, midway between the centre and one end, perpendicular to its length is _____.

(A) $\dfrac{48}{7}ML^2$ (B) $\dfrac{7}{48}ML^2$ (C) $\dfrac{1}{48}ML^2$ (D) $\dfrac{1}{16}ML^2$

ii. 'n' droplets of equal size of radius r coalesce to form a bigger drop of radius R. The energy liberated is equal to _____. (T = Surface tension of water)

(A) $4\pi R^2 T[n^{\frac{1}{3}} - 1]$ (B) $4\pi r^2 T[n^{\frac{1}{3}} - 1]$

(C) $4\pi R^2 T[n^{\frac{2}{3}} - 1]$ (D) $4\pi r^2 T[n^{\frac{2}{3}} - 1]$

iii. The buckling of a beam is found to be more if _____.
(A) the breadth of the beam is large.
(B) the beam material has large value of Young's modulus.
(C) the length of the beam is small.
(D) the depth of the beam is small.

iv. When a transverse wave on a string is reflected from the free end, the phase change produced is _____.
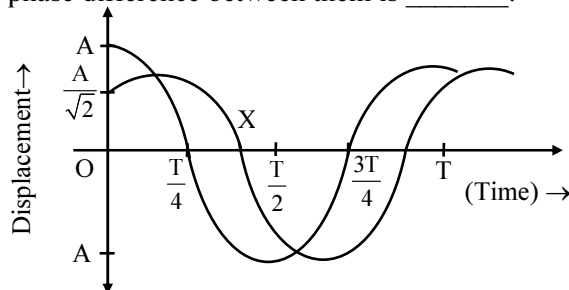
(A) zero rad   (B) $\dfrac{\pi}{2}$ rad   (C) $\dfrac{3\pi}{4}$ rad   (D) π rad

v. The number of degrees of freedom for a rigid diatomic molecule is _____.
(A) 3   (B) 5   (C) 6   (D) 7

vi. Two particles perform linear simple harmonic motion along the same path of length 2A and period T as shown in the graph below. The phase difference between them is _____.
(A) zero rad

(B) $\dfrac{\pi}{4}$ rad

(C) $\dfrac{\pi}{2}$ rad

(D) $\dfrac{3\pi}{4}$ rad

vii. The light from the Sun is found to have a maximum intensity near the wavelength of 470 nm. Assuming the surface of the Sun as a black body, the temperature of the Sun is _____.
(Wien's constant b = 2.898×10^{-3} mK)
(A) 5800 K   (B) 6050 K   (C) 6166 K   (D) 6500 K

Q.2. Attempt any SIX:

i. State Kepler's law of orbit and law of equal areas.

ii. A car of mass 1500 kg rounds a curve of radius 250m at 90 km/hour. Calculate the centripetal force acting on it.

iii. Draw a neat labelled diagram for Ferry's perfectly black body.

iv. A mass M attached to a spring oscillates with a period of 2 seconds. If the mass is increased by 2 kg, the period increases by 1 second. Find the initial mass, assuming that Hooke's law is obeyed.

v. Differentiate between free and forced vibrations.

vi. The surface tension of water at 0 °C is 75.5 dyne/cm. Find surface tension of water at 25 °C. (α for water = 0.0021/°C)

vii. Derive the relation between surface tension and surface energy per unit area.

viii. A wheel of moment of inertia 1 kgm^2 is rotating at a speed of 40 rad/s. Due to friction on the axis, the wheel comes to rest in 10 minutes. Calculate the angular momentum of the wheel, two minutes before it comes to rest.

Q.3. Attempt any THREE:

i. A particle of mass m, just completes the vertical circular motion. Derive the expression for the difference in tensions at the highest and the lowest points.

ii. The Earth is rotating with angular velocity ω about its own axis. R is the radius of the Earth. If $R\omega^2 = 0.03386 m/s^2$, calculate the weight of a body of mass 100 gram at latitude 25°. (g = 9.8 m/s^2)

iii. Derive an expression for kinetic energy, when a rigid body is rolling on a horizontal surface without slipping. Hence find kinetic energy for a solid sphere.

iv. A steel wire of diameter 1×10^{-3} m is stretched by a force of 20 N. Calculate the strain energy per unit volume. (Y steel = 2×10^{11} N/m^2)

Q.4. Define an ideal simple pendulum. Show that, under certain conditions, simple pendulum performs linear simple harmonic motion.

A train blows a whistle of frequency 640 Hz in air. Find the difference in apparent frequencies of the whistle for a stationary observer, when the train moves towards and away from the observer with the speed of 72 km/hour. (Speed of sound in air = 340 m/s)

OR

Q.4. With a neat labelled diagram, show that all harmonics are present in an air column contained in a pipe open at both the ends. Define end correction.

Calculate the kinetic energy of 10 gram of Argon molecules at 127 °C.
(Universal gas constant R = 8320 J/k mole K, Atomic weight of Argon = 40)

SECTION – II

Q.5. Select and write the most appropriate answer from the given alternatives for each sub-question:

i.   In the diffraction pattern due to a single slit of width 'd' with incident light of wavelength 'λ', at an angle of diffraction 'θ', the condition for first minimum is _____.
(A) $\lambda \sin \theta = d$ (B) $d \cos \theta = \lambda$
(C) $d \sin \theta = \lambda$ (D) $\lambda \cos \theta = d$

ii. Kirchhoff's junction law is equivalent to _____.
(A) conservation of energy
(B) conservation of charge
(C) conservation of electric potential
(D) conservation of electric flux

iii. let 'p' and 'E' denote the linear momentum and energy of emitted photon respectively. If the wavelength of incident radiation is increased _____.
(A) both p and E increase
(B) p increases and E decreases
(C) p decreases and E increases
(D) both p and E decrease

iv. The nuclei having same number of protons but different number of neutrons are called _____.
(A) isobars   (B) α - particles
(C) isotopes   (D) γ - particles

v.   In case of transistor oscillator, to obtain sustained oscillations, the product of voltage gain without feedback and feedback factor should be _____.
(A) zero   (B) less than 1
(C) one   (D) infinity

vi. The process of regaining of information from carrier wave at the receiver is called _____.
(A) modulation   (B) transmission
(C) propagation   (D) demodulation

vii. Reactance of a coil is 157 Ω. On connecting the coil across a source of frequency 100 Hz, the current lags behind e.m.f. by 45°. The inductance of the coil is _____.
(A) 0.25 H   (B) 0.5 H
(C) 4 H   (D) 314 H

Q.6. Attempt any SIX:

i.   Draw a neat labelled diagram of a parallel plate capacitor completely filled with dielectric.

ii. A point is situated at 7 cm and 7.2 cm from two coherent sources. Find the nature of illumination at the point if wavelength of light is 4000 Å.

iii. Obtain the expression for current sensitivity of moving coil galvanometer.

iv. In a cyclotron, magnetic field of 3.5 Wb/m^2 is used to accelerate protons. What should be the time interval in which the electric field between the dees be reversed?
(Mass of proton = 1.67×10^{-27} kg, Charge on proton = 1.6×10^{-19} C).

v.   Define magnetization. State its formula and S.I. unit.

vi.   Electrostatic energy of 3.5×10^{-4} J is stored in a capacitor at 700 V. What is the charge on the capacitor?

vii. What is space wave propagation? State its three components.

viii. Find the value of energy of electron in eV in the third Bohr orbit of hydrogen atom.
(Rydberg's constant (R) = 1.097×10^7 m^{-1},
Planck's constant (h) = 6.63×10^{-34} J – s,
Velocity of light in air (c) = 3×10^8 m/s.)

Q.7. **Attempt any THREE:**

i.   With the help of neat labelled circuit diagram explain the working of half wave rectifier using semiconductor diode. Draw the input and output waveforms.

ii.   A cell balances against a length of 200 cm on a potentiometer wire, when it is shunted by a resistance of 8 Ω. The balancing length reduces by 40 cm, when it is shunted by a resistance of 4 Ω. Calculate the balancing length when the cell is in open circuit. Also calculate the internal resistance of the cell.

iii. State the law of radioactive decay. Hence derive the expression $N = N_o e^{-\lambda t}$ where symbols have their usual meanings.

iv.   The photoelectric work function for a metal is 4.2 eV. If the stopping potential is 3 V, find the threshold wavelength and maximum kinetic energy of emitted electrons.
(Velocity of light in air = 3×10^8 m/s,
Planck's constant = 6.63×10^{-34} J - s,
Charge on electron = 1.6×10^{-19} C)

Q.8. State Faraday's laws of electromagnetic induction and Lenz's law.
Prove theoretically, the relation between e.m.f. induced and rate of change of magnetic flux in a coil moving in a uniform magnetic field.

A circular coil of 250 turns and diameter 18 cm carries a current of 12 A. What is the magnitude of magnetic moment moment associated with the coil?

OR

Q.8. On the basis of Huygens' wave theory of light prove that velocity of light in a rarer medium is greater than velocity of light in a denser medium.

In Young's experiment the ratio of intensity at the maxima and minima in the interference pattern is 36:16. What is the ratio of the widths of the two slits?

SECTION – I

Q.1. Derive an expression for the period of motion of a simple pendulum.
On which factors does it depend?

A ballet dancer spins about a vertical axis at 2.5π rad/s with his both arms outstretched. With the arms folded, the moment of inertia about the same axis of rotation changes by 25%. Calculate the new speed of rotation in r.p.m.

OR

Q.1. Draw neat labelled diagrams for modes of vibration of an air column in a pipe when it is
a. open at both ends,
b. closed at one end.
Hence derive an expression for fundamental frequency in each case.

A soap bubble of radius 12 cm is blown. Surface tension of soap solution is 30 dyne/cm. Calculate the work done in blowing the soap bubble.

Q.2. Attempt any THREE:
i. In a conical pendulum, a string of length 120 cm is fixed at rigid support and carries a mass of 150 g at its free end. If the mass is revolved in a horizontal circle of radius 0.2 m around a vertical axis, calculate tension in the string ($g = 9.8$ m/s^2)

ii. Explain the behaviour of metal wire under increasing load.

iii. Derive an expression for one dimensional simple harmonic progressive wave travelling in the direction of positive X-axis. Express it in 'two' different forms.

iv. The kinetic energy of nitrogen per unit mass at 300 K is 2.5×10^6 J/kg. Find the kinetic energy of 4 kg oxygen at 600 K. (Molecular weight of nitrogen = 28, Molecular weight of oxygen = 32)

Q.3. Attempt any SIX:
i. A racing car completes 5 rounds of a circular track in 2 minutes. Find the radius of the track if the car has uniform centripetal acceleration of π^2 m/s^2.

ii. A body weighs 4.0 kg-wt on the surface of the Earth. What will be its weight on the surface of a plant whose mass is $\frac{1}{8}$th of the mass of the Earth and radius half $\left(\frac{1}{2}\right)$ of that of the Earth?

iii. Define radius of gyration. Explain its physical significance.

iv. A body of mass 1 kg is made to oscillate on a spring of force constant 16 N/m. Calculate:
   a. Angular frequency,   b. frequency of vibration.

v. Show that the surface tension of a liquid is numerically equal to the surface energy per unit area.

vi. Explain black body radiation spectrum in terms of wavelength.

vii. 'g' is the acceleration due to gravity on the surface of the Earth and 'R' is the radius of the Earth.
   Show that acceleration due to gravity at height 'h' above the surface of the Earth is
   $$g_h = g\left(\frac{R}{R+h}\right)^2$$

viii. In Melde's experiment, the number of loops on a string changes from 7 to 5 by the addition of 0.015 kgwt. Find the initial tension applied to the string.

Q.4. **Select and write the most appropriate answer from the given alternatives for each sub-questions:**

i. A planet is revolving around a star in a circular orbit of radius R with a period T. If the gravitational force between the planet and the star is proportional to $R^{\frac{-3}{2}}$, then

   (A) $T^2 \propto R^{\frac{5}{2}}$ (B) $T^2 \propto R^{\frac{-7}{2}}$

   (C) $T^2 \propto R^{\frac{3}{2}}$ (D) $T^2 \propto R^4$

ii. If 'L' is the angular momentum and 'I' is the moment of inertia of a rotating body, then $\frac{L^2}{2I}$ represents its _____.
   (A) rotational P.E.   (B) total energy
   (C) rotational K.E.   (D) translational K.E.

iii. A particle executing linear S.H.M. has velocities v_1 and v_2 at distances x_1 and x_2 respectively from the mean position. The angular velocity of the particle is _____.

   (A) $\sqrt{\dfrac{x_1^2 - x_2^2}{v_2^2 - v_1^2}}$ (B) $\sqrt{\dfrac{v_2^2 - v_1^2}{x_1^2 - x_2^2}}$

   (C) $\sqrt{\dfrac{x_1^2 + x_2^2}{v_2^2 + v_1^2}}$ (D) $\sqrt{\dfrac{v_2^2 + v_1^2}{x_2^2 + x_1^2}}$

iv. A metal rod having coefficient of linear expansion (α) and Young's modulus (Y) is heated to raise the temperature by $\Delta\theta$. The stress exerted by the rod is _____.

   (A) $\dfrac{Y\alpha}{\Delta\theta}$ (B) $\dfrac{Y\Delta\theta}{\alpha}$

   (C) $Y\alpha\Delta\theta$ (D) $\dfrac{\alpha\Delta\theta}{Y}$

v. A big drop of radius R is formed from 1000 droplets of water. The radius of a droplet will be _____.

   (A) 10 R   (B) $\dfrac{R}{10}$

   (C) $\dfrac{R}{100}$ (D) $\dfrac{R}{1000}$

vi. Apparent frequency of the sound heard by a listener is less than the actual frequency of sound emitted by source. In this case _____.
   (A) listener moves towards source.
   (B) source moves towards listener.
   (C) listener moves away from the source.
   (D) source and listener move towards each other.

vii. The substance which allows heat radiations to pass through is _____.
   (A) iron   (B) water vapour
   (C) wood   (D) dry air

SECTION – II

Q.5. Obtain an expression for the induced e.m.f. in a coil rotating with uniform angular velocity in uniform magnetic field. Plot a graph of variation of induced e.m.f. against phase ($\theta = \omega t$) over one cycle.

The energy density at a point in a medium of dielectric constant 6 is 26.55×10^6 J/m^3. Calculate electric field intensity at that point. ($\varepsilon_0 = 8.85 \times 10^{-12}$ SI units).

OR

Q.5. Write notes on –
   a.   Nuclear fission   b.   Nuclear fusion

A galvanometer has a resistance of 16 Ω. It shows full scale deflection, when a current of 20 mA is passed through it. The only shunt resistance available is 0.06 Ω which is not appropriate to convert a galvanometer into an ammeter. How much resistance should be connected in series with the coil of galvanometer, so that the range of ammeter is 8 A?

Q.6. Attempt any THREE:
   i.   Draw a well labelled diagram of photoelectric cell.
         Explain the observations made by Hertz and Lenard about the phenomenon of photoelectric emission.

   ii.   Explain the working of transistor as a switch.

   iii. The refractive indices of water for red and violet colours are 1.325 and 1.334 respectively. Find the difference between the velocities of rays for these two colours in water. ($c = 3 \times 10^8$ m/s)

   iv.   In Young's experiment, the ratio of intensity at the maxima and minima in an interference pattern is 36 : 9. What will be the ratio of the intensities of two interfering waves?

Q.7. Attempt any SIX:
   i.   Explain the principle of potentiometer.

   ii.   What is –
         a.   magnetization   and   b.   magnetic intensity?

   iii. What do you mean by polar molecules and non-polar molecules? Give 'one' example each.

   iv.   The minimum angular separation between two stars is 4×10^{-6} rad, if telescope is used to observe them with an objective of aperture 16 cm. Find the wavelength of light used.

   v.   Explain the need for modulation related to the size of antenna (aerial).

   vi.   Four resistances 4 Ω, 8 Ω, X Ω and 6 Ω are connected in a series so as to form Wheatstone's network. If the network is balanced, find the value of 'X'.

   vii. The magnetic susceptibility of annealed iron at saturation is 4224. Find the permeability of annealed iron at saturation. ($\mu_0 = 4\pi \times 10^{-7}$ SI unit)

Q.8. **Select and write the most appropriate answer from the given alternatives for each sub-questions:**

i. A ray of light passes from a vacuum to a medium of refractive index (μ). The angle of incidence is found to be twice the angle of refraction. The angle of incidence is _____.

(A) $\cos^{-1}\left(\dfrac{\mu}{2}\right)$

(B) $\cos^{-1}(\mu)$

(C) $2\cos^{-1}\left(\dfrac{\mu}{2}\right)$

(D) $2\sin^{-1}\left(\dfrac{\mu}{2}\right)$

ii. The fringes produced in diffraction pattern are of _____.
(A) equal width with same intensity
(B) unequal width with varying intensity
(C) equal intensity
(D) equal width with varying intensity

iii. If 'R' is the radius of dees and 'B' be the magnetic field of induction in which positive charges (q) of mass (m) escape from the cyclotron, then its maximum speed (v_{max}) is _____.

(A) $\dfrac{qR}{Bm}$

(B) $\dfrac{qm}{BR}$

(C) $\dfrac{qBR}{m}$

(D) $\dfrac{m}{qBR}$

iv. The number of photoelectrons emitted _____.
(A) varies inversely with frequency
(B) varies directly with frequency
(C) varies inversely with intensity
(D) varies directly with intensity

v. The width of depletion region of p-n junction diode is _____.
(A) 0.5 nm to 1 nm   (B) 5 nm to 10 nm
(C) 50 nm to 500 nm   (D) 500 nm to 1000 nm

vi. A device that converts one form of energy into another form is termed as _____.
(A) transducer   (B) transmitter
(C) amplifier   (D) receiver

vii. A transformer converts 240 V AC to 60 V AC. The secondary has 75 turns. The number of turns in primary are _____.
(A) 600   (B) 500
(C) 400   (D) 300

SECTION – I

Q.1. Attempt any SIX :

i. Explain the rise of liquid in the capillary on the basis of pressure difference.

ii. Show graphical representation of energy distribution spectrum of perfectly black body.

iii. The escape velocity of a body from the surface of the earth is 11.2 km/s. If a satellite were to orbit close to the surface, what would be its critical velocity?

iv. A pipe which is open at both ends is 47 cm long and has an inner diameter 5 cm. If the speed of sound in air is 348 m/s, calculate the fundamental frequency of air column in that pipe.

v. Show that R.M.S. velocity of gas molecules is directly proportional to square root of its absolute temperature.

vi. For a particle performing uniform circular motion $\vec{v} = \vec{\omega} \times \vec{r}$ obtain an expression for linear acceleration of the particle performing non-uniform circular motion.

vii. A stone of mass 1 kg is whirled in horizontal circle attached at the end of a 1 m long string. If the string makes an angle of 30° with vertical, calculate the centripetal force acting on the stone. (g = 9.8 m/s^2).

viii. A solid cylinder of uniform density of radius 2 cm has mass of 50 g. If its length is 12 cm, calculate its moment of inertia about an axis passing through its centre and perpendicular to its length.

Q.2. Attempt any THREE:

i. Derive an expression for acceleration due to gravity at depth 'd' below the earth's surface.

ii. A copper metal cube has each side of length 1 m. The bottom edge of the cube is fixed and tangential force 4.2×10^8 N is applied to a top surface. Calculate the lateral displacement of the top surface if modulus of rigidity of copper is 14×10^{10} N/m^2.

iii. State an expression for K.E. (kinetic energy) and P.E. (potential energy) at displacement 'x' for a particle performing linear S.H.M. Represent them graphically. Find the displacement at which K.E. is equal to P.E.

iv. The equation of simple harmonic progressive wave is given by $y = 0.05 \sin \pi \left[20t - \dfrac{x}{6} \right]$, where all quantities are in S. I. units. Calculate the displacement of a particle at 5 m from origin and at the instant 0.1 second.

Q.3. State and prove the theorem of 'parallel axes'.

Calculate the density of paraffin oil, if glass capillary of diameter 0.25 mm dipped in paraffin oil of surface tension 0.0245 N/m rises to a height of 4 cm.
(Angle of contact of paraffin with glass = 28° and acceleration due to gravity = 9.8 m/s^2.)

OR

Q.3. A wire of density 'ρ' and Young's modulus 'Y' is stretched between two rigid supports separated by a distance 'L' under tension 'T'. Derive an expression for its frequency in fundamental mode.

Hence show that n = $\dfrac{1}{2L}\sqrt{\dfrac{Yl}{\rho L}}$, where symbols have their usual meanings.

When the length of a simple pendulum is decreased by 20 cm, the period changes by 10%. Find the original length of the pendulum.

Q.4. **Select and write the most appropriate answer from the given alternatives for each sub-question:**

i.   The bulging of earth at the equator and flattening at the poles is due to _____.
   (A)   centripetal force   (B)   centrifugal force
   (C)   gravitational force   (D)   electrostatic force

ii.   Young's modulus of material of wire is 'Y' and strain energy per unit volume is 'E', then the strain is

   (A) $\sqrt{\dfrac{Y}{2E}}$ (B) $\sqrt{\dfrac{E}{Y}}$ (C) $\sqrt{\dfrac{2E}{Y}}$ (D) $\sqrt{2EY}$

iii. The wavelength range of thermal radiation is
   (A)   from 4000 Å to 7000 Å   (B)   from 7700 Å to 4 × 10^6 Å
   (C)   from 10^6 Å to 10^8 Å   (D)   from 4 × 10^{-12} Å to 4 × 10^8 Å

iv.   A pipe open at both ends resonates to a frequency 'n$_1$' and a pipe closed at one end resonates to a frequency 'n$_2$'. If they are joined to form a pipe closed at one end, then the fundamental frequency will be _____.

   (A) $\dfrac{n_1 n_2}{2n_2 + n_1}$ (B) $\dfrac{2n_2 n_1}{2n_2 + n_1}$

   (C) $\dfrac{2n_2 n_1}{n_1 + n_2}$ (D) $\dfrac{n_2 + 2n_1}{n_1 n_2}$

v.   The phase difference between displacement and acceleration of a particle performing S.H.M. is _____.

   (A) $\dfrac{\pi}{2}$ rad   (B)   π rad   (C)   2π rad   (D) $\dfrac{3\pi}{2}$ rad

vi.   Let n$_1$ and n$_2$ be the two slightly different frequencies of two sound waves. The time interval between waxing and immediate next waning is _____.

   (A) $\dfrac{1}{n_1 - n_2}$ (B) $\dfrac{2}{n_1 - n_2}$ (C) $\dfrac{n_1 - n_2}{2}$ (D) $\dfrac{1}{2(n_1 - n_2)}$

vii. A metal ball cools from 64 °C to 50 °C in 10 minutes and to 42 °C in next 10 minutes. The ratio of rates of fall of temperature during the two intervals is _____.

   (A) $\dfrac{4}{7}$ (B) $\dfrac{7}{4}$
   (C)   2   (D)   2.5

SECTION – II

Q.5. Attempt any SIX :

i. Show that the orbital magnetic dipole moment of a revolving electron is $\dfrac{evr}{2}$.

ii. Describe the construction of photoelectric cell.

iii. For a glass plate as a polariser with refractive index l.633, calculate the angle of incidence at which light is polarised.

iv. The susceptibility of magnesium at 300 K is 2.4×10^{-5}. At what temperature will the susceptibility increase to 3.6×10^{-5}?

v. Draw a neat labelled diagram for Davisson and Germer experiment, for diffraction of electron wave.

vi. Explain the terms : (a) Transmitter and (b) receiver in communication system.

vii. A metal rod $\dfrac{1}{\sqrt{\pi}}$ m long rotates about one of its ends perpendicular to a plane whose magnetic induction is 4×10^{-3} T. Calculate the number of revolutions made by the rod per second if the e.m.f. induced between the ends of the rod is 16 mV.

viii. Find the wave number of a photon having energy of 2.072 eV.
Given : Charge on electron = 1.6×10^{-19} C,
Velocity of light in air = 3×10^{8} m/s,
Planck's constant = 6.63×10^{-34} J-s.

Q.6. Attempt any THREE :
i. State Ampere's circuital law. Obtain an expression for magnetic induction along the axis of toroid.

ii. Calculate the radius of second Bohr orbit in hydrogen atom from the given data.
Mass of electron = 9.1×10^{-31} kg
Charge on the electron = 1.6×10^{-19} C
Planck's constant = 6.63×10^{-34} J-s.
Permittivity of free space = 8.85×10^{-12} C^2/Nm^2

iii. Explain the working of P-N junction diode in forward and reverse biased mode.

iv. A network of four capacitors of 6 μF each is connected to a 240 V supply. Determine the charge on each capacitor.
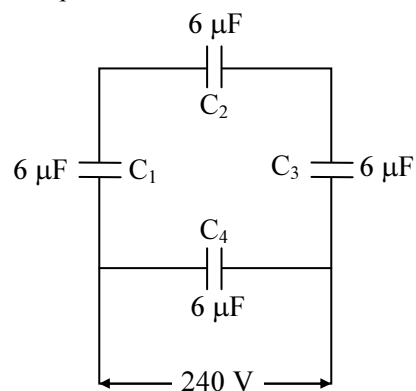
Q.7. Describe biprism experiment to find the wavelength of monochromatic light. Draw the necessary ray diagram for magnified and diminished images of virtual sources.

If the difference in velocities of light in glass and water is 2.7×10^7 m/s, find the velocity of light in air.
(Refractive index of glass = 1.5, Refractive index of water = 1.333)

OR

Q.7. State the principle of a transformer. Explain its construction and working. Derive an expression for the ratio of e.m.f.s in terms of number of turns in primary and secondary coil.

Two diametrically opposite points of a metal ring are connected to two terminals of the left gap of metre bridge. The resistance of 11 Ω is connected in right gap. If null point is obtained at a distance of 45 cm from the left end, find the resistance of metal ring. [7]

Q.8. Select and write the most appropriate answer from the given alternatives for each sub-question: [7]

i. Intensity of electric field at a point close to and outside a charged conducting cylinder is proportional to _____.
(r is the distance of a point from the axis of cylinder)

(A) $\dfrac{1}{r}$ (B) $\dfrac{1}{r^2}$

(C) $\dfrac{1}{r^3}$ (D) r^3

ii. When a hole is produced in P-type semiconductor, there is _____.
(A) extra electron in valence band
(B) extra electron in conduction band
(C) missing electron in valence band
(D) missing electron in conduction band

iii. The outermost layer of the earth's atmosphere is _____.
(A) stratosphere   (B) mesosphere
(C) troposphere   (D) ionosphere

iv. Accuracy of potentiometer can be easily increased by _____.
(A) increasing resistance of wire   (B) decreasing resistance of wire
(C) increasing the length of wire   (D) decreasing the length of wire

v. When electron in hydrogen atom jumps from second orbit to first orbit, the wavelength of radiation emitted is λ. When electron jumps from third orbit to first orbit, the wavelength of emitted radiation would be _____.

(A) $\dfrac{27}{32}\lambda$ (B) $\dfrac{32}{27}\lambda$

(C) $\dfrac{2}{3}\lambda$ (D) $\dfrac{3}{2}\lambda$

vi. An ideal voltmeter has _____.
(A) low resistance   (B) high resistance
(C) infinite resistance   (D) zero resistance

vii. The resolving power of telescope of aperture 100 cm for light of wavelength 5.5×10^{-7} m is _____.
(A) $0.149 \times 10^{+7}$ (B) $1.49 \times 10^{+7}$
(C) $14.9 \times 10^{+7}$ (D) $149 \times 10^{+7}$

SECTION – I

Q.1. Attempt any THREE:

i. Draw a diagram showing all components of forces acting on a vehicle moving on a curved banked road. Write the necessary equation for maximum safety speed and state the significance of each term involved in it.

ii. Explain Maxwell distribution of molecular speed with necessary graph.

iii. Find the total energy and binding energy of an artificial satellite of mass 800 kg orbiting at a height of 1800 km above the surface of the earth.

   $(G = 6.67 \times 10^{-11}$ S.I. units, Radius of earth : R = 6400 km, Mass of earth : M = 6×10^{24} kg)

iv. Wavelengths of two notes in the air are $\left(\dfrac{70}{153}\right)$ m and $\left(\dfrac{70}{157}\right)$ m . Each of these notes produces 8 beats per second with a tuning fork of fixed frequency. Find the velocity of sound in the air and frequency of the tuning fork.

Q.2. Attempt any SIX:

i. Draw a diagram showing different stages (cases) of projection for artificial satellite.

ii. State the law of conservation of angular momentun and explain with a suitable example.

iii. Define the angle of contact and state its any 'two' characteristics.

iv. With a neat and labelled diagram, explain Ferry's perfectly black body.

v. A stone of mass 5 kg, tied to one end of a rope of length 0.8 m, is whirled in a vertical circle. Find the minimum velocity at the highest point and at the midway point. (g = 9.8 m/s^2)

vi. The maximum velocity of a particle performing linear S.H.M. is 0.16 m/s. If its maximum acceleration is 0.64 m/s^2, calculate its period.

vii. Water rises to a height 3.2 cm in a glass capillary tube. Find the height to which the same water will rise in another glass capillary having half area of cross section.

viii. A 36 cm long sonometer wire vibrates with frequency of 280 Hz in fundamental mode, when it is under tension of 24.5 N. Calculate linear density of the material of wire.

Q.3. Select and write the most appropriate answer from the given alternatives for each sub-questions:

i. A thin wire of length L and uniform linear mass density ρ is bent into a circular coil. Moment of inertia of the coil about tangential axis in its plane is _____.

(A) $\dfrac{3\rho L^2}{8\pi^2}$

(B) $\dfrac{8\pi^2}{3\rho L^3}$

(C) $\dfrac{3\rho L^3}{8\pi^2}$

(D) $\dfrac{8\pi}{3\rho L^2}$

ii. The average displacement over a period of S.H.M. is _____.
(A = amplitude of S.H.M.)
(A) 0

(B) A

(C) 2A

(D) 4A

iii. In which of the following substances, surface tension increases with increase in temperature?
(A) Copper

(B) Molten copper

(C) Iron

(D) Molten iron

iv. The ratio of diameters of two wires of the same material and length is n : 1. If the same load is applied to both the wires then increase in the length of the thin wire is (n > 1) _____.
(A) $n^{1/4}$ times

(B) $n^{1/2}$ times

(C) n times

(D) n^2 times

v. The co-efficient of reflection of an opaque body is 0.16. Its co-efficient of emission is _____.

(A) 0.94

(B) 0.84

(C) 0.74

(D) 0.64

vi. Let velocity of a sound wave be 'v' and 'ω' be angular velocity. The propagation constant of the wave is _____.

(A) $\sqrt{\dfrac{\omega}{v}}$

(B) $\sqrt{\dfrac{v}{\omega}}$

(C) $\dfrac{\omega}{v}$

(D) $\dfrac{v}{\omega}$

vii. The value of end correction for an open organ pipe of radius 'r' is _____.
(A) 0.3 r

(B) 0.6 r

(C) 0.9 r

(D) 1.2 r

Q.4. Distinguish between forced vibrations and resonance. Draw neat, labelled diagrams for the modes of vibration of a stretched string in second harmonic and third harmonic.

The area of the upper face of a rectangular block is 0.5 m × 0.5 m and the lower face is fixed. The height of the block is 1 cm. A shearing force applied at the top face produces a displacement of 0.015 mm. Find the strain and shearing force.
(Modulus of rigidity : $\eta = 4.5 \times 10^{10}$ N/m^2)

OR

Q.4. Define phase of S.H.M. Show variation of displacement, velocity and acceleration with phase for a particle performing linear S.H.M. graphically, when it starts from extreme position.

A body starts rotating from rest. Due to a couple of 20 Nm it completes 60 revolutions in one minute. Find the moment of inertia of the body.

SECTION – II

Q.5. Attempt any THREE:

i. In a biprism experiment, a slit is illuminated by a light of wavelength 4800 Å. The distance between the slit and biprism is 15 cm and the distance between the biprism and eyepiece is 85 cm. If the distance between virtual sources is 3 mm, determine the distance between 4th bright band on one side and 4th dark band on the other side of the central bright band.

ii. Six capacitors of capacities 5, 5, 5, 5, 10 and X μF are connected as shown in the network given below.
Find:
a. The value of X if the network is balanced, and
b. the resultant capacitance between A and C.
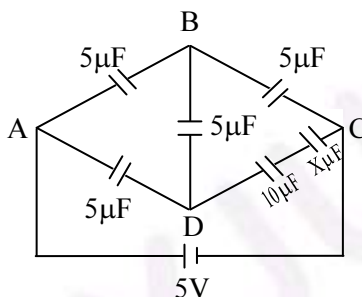
iii. Show that the current flowing through a moving coil galvanometer is directly proportional to the angle of deflection of coil.

iv. Explain the formation of energy band diagram in case of conductor and semiconductor.

Q.6. Attempt any SIX:

i. Draw a neat labelled diagram showing the plane of vibration and plane of polarisation for polarised light.

ii. State the conditions to get steady interference pattern.

iii. In a hydrogen atom, an electron carrying charge 'e' revolves in an orbit of radius 'r' with speed 'v'. Obtain an expression for the magnitude of magnetic moment of a revolving electron.

iv. Draw a neat, labelled block diagram for a generalised communication system.

v. A red light of wavelength 6400 Å in air has wavelength 4000 Å in glass. If the wavelength of violet light in air is 4400 Å, find its wavelength in glass.
(Assume that $\mu_r \approx \mu_v$)

vi. The magnetic moment of a magnet of dimensions 5 cm × 2.5 cm × 1.25 cm is 3 Am^2. Calculate the intensity of magnetization.

vii. An A.C. circuit consists of inductor of inductance 125 mH connected in parallel with a capacitor of capacity 50 μF. Determine the resonant frequency.

viii. Calculate the de Broglie wavelength of an electron moving with 1/3rd of the speed of light in vacuum.
(Neglect relativistic effect)
(Planck's constant : h = 6.63 × 10^{-34} Js,
Mass of electron : m = 9 .11 × 10^{-28} g)

Q.7. Select and write the most appropriate answer from the given alternatives for each sub-questions

i. If numerical aperture of a microscope is increased, then its _____.
(A) resolving power decreases   (B) limit of resolution decreases
(C) resolving power remains constant (D) limit of resolution increases

ii. A solenoid of length 1.5 m and 4 cm in diameter possesses 10 turns per metre. A current of 5 A is flowing through it. The magnetic induction at a point inside the solenoid along the axis is _____. ($\mu_0 = 4\pi \times 10^{-7}$ Wb/Am)

(A) $\pi \times 10^{-5}$ T 　　　　　　　　　　　(B) $2\pi \times 10^{-5}$ T

(C) $3\pi \times 10^{-5}$ T 　　　　　　　　　　　(D) $4\pi \times 10^{-5}$ T

iii. Kirchhoff's voltage law and current law are respectively in accordance with the conservation of _____.

(A) charge and momentum 　　　　　　　(B) charge and energy

(C) energy and charge 　　　　　　　　　(D) energy and momentum

iv. When radiations of wavelength λ_1 and λ_2 are incident on certain photosensitive material, the energies of electron ejected are E_1 and E_2 respectively, such that $E_1 > E_2$. Then Planck's constant 'h' is _____. (c = velocity of light)

(A) $\dfrac{(E_1 - E_2)(\lambda_1 - \lambda_2)}{c(\lambda_1 \cdot \lambda_2)}$ 　　　　　　(B) $\dfrac{(E_1 - E_2)\lambda_1 c}{(\lambda_1 - \lambda_2)\lambda_2}$

(C) $\dfrac{(E_1 - E_2)\lambda_1 \lambda_2}{c(\lambda_2 - \lambda_1)}$ 　　　　　　(D) $\dfrac{(\lambda_2 - \lambda_1)c}{(E_1 - E_2)\lambda_1 \cdot \lambda_2}$

v. Colour of light emitted by LED depends upon _____.

(A) its forward bias

(B) its reverse bias

(C) the band gap of the material of semiconductor

(D) its size

vi. Line of sight propagation is also called as _____ propagation.

(A) sky wave 　　　　　　　　　　　　　(B) ground wave

(C) sound wave 　　　　　　　　　　　　(D) space wave

vii. Two parallel plates separated by distance d are kept at potential difference V volt. A charge q of mass m enters in parallel plates with some velocity. The acceleration of the charged particle will be _____.

(A) $\dfrac{qV}{dm}$ 　　　　　　　　　　　　(B) $\dfrac{dm}{qV}$

(C) $\dfrac{qm}{dV}$ 　　　　　　　　　　　　(D) $\dfrac{dV}{qm}$

Q.8. Explain the phenomenon of self induction and mutual induction. Define coefficient of self induction and mutual induction. Write the SI unit and dimensions of coefficient of self induction.

A potentiometer wire has a length of 4 m and a resistance of 5 Ω. What resistance should be connected in series with a potentiometer wire and a cell of e.m.f. 2 V having internal resistance 1 Ω to get a potential gradient of 10^{-3} V/cm?

OR

Q.8. Derive an expression for the total energy of electron in 'n' th Bohr orbit. Hence show that energy of the electron is inversely proportional to the square of principal quantum number. Also define binding energy.

The photoelectric threshold wavelength of a metal is 230 nm. Determine the maximum kinetic energy in joule and in eV of the ejected electron for the metal surface when it is exposed to a radiation of wavelength 180 nm.

(Planck's constant : h = 6.63×10^{-34} Js,

Velocity of light : c = 3×10^8 m/s.)

SECTION – I

Q.1. **Select and write the most appropriate answer from the given alternatives for each sub-question:**

i.   The period of a conical pendulum in terms of its length (l), semivertical angle (θ) and acceleration due to gravity (g) is:

(A) $\dfrac{1}{2\pi}\sqrt{\dfrac{l\cos\theta}{g}}$

(B) $\dfrac{1}{2\pi}\sqrt{\dfrac{l\sin\theta}{g}}$

(C) $4\pi\sqrt{\dfrac{l\cos\theta}{4g}}$

(D) $4\pi\sqrt{\dfrac{l\tan\theta}{g}}$

ii. The kinetic energy of a rotating body depends upon
   (A)   distribution of mass only.
   (B)   angular speed only.
   (C)   distribution of mass and angular speed.
   (D)   angular acceleration only.

iii. If the metal bob of a simple pendulum is replaced by a wooden bob of the same size, then its time period will
   (A)   increase.   (B)   remain same.
   (C)   decrease.   (D)   first increase and then decrease.

iv. The graph between applied force and change in the length of wire within elastic limit is a
   (A)   straight line with positive slope.   (B)   straight line with negative slope.
   (C)   curve with positive slope.   (D)   curve with negative slope.

v.   When longitudinal wave is incident at the boundary of denser medium, then
   (A)   compression reflects as a compression.
   (B)   compression reflects as a rarefaction
   (C)   rarefaction reflects as a compression.
   (D)   longitudinal wave reflects as transverse wave.

vi. The dimensions of universal gravitational constant are
   (A) $[L^1M^0T^0]$ (B) $[L^2M^1T^0]$
   (C) $[L^{-1}M^1T^{-2}]$ (D) $[L^3M^{-1}T^{-2}]$

vii. Two copper spheres of radii 6 cm and 12 cm respectively are suspended in an evacuated enclosure. Each of them are at a temperature 15 °C above the surroundings. The ratio of their rate of loss of heat is
   (A)   2 : 1   (B)   1 : 4
   (C)   1 : 8   (D)   8 : 1

Q.2.   Attempt any SIX :

i.   In circular motion, assuming $\vec{v} = \vec{\omega} \times \vec{r}$, obtain an expression for the resultant acceleration of a particle in terms of tangential and radial component.

ii.   Explain why an astronaut in an orbiting satellite has a feeling of weightlessness.

iii. State theorem of parallel axes and theorem of perpendicular axes about moment of inertia.

iv.   State:
    a.   Wien's displacement law and
    b.   first law of thermodynamics.

v.   A particle in S.H.M. has a period of 2 seconds and amplitude of 10 cm. Calculate the acceleration when it is at 4 cm from its positive extreme position.

vi.   The surface tension of water at 0 °C is 75.5 dyne/cm. Calculate surface tension of water at 25 °C. (α for water $= 2.7 \times 10^{-3}$/ °C)

vii. The spin dryer of a washing machine rotating at 15 r.p.s. slows down to 5 r.p.s. after making 50 revolutions. Find its angular acceleration.

viii. Calculate the period of revolution of Jupiter around the Sun. The ratio of the radius of Jupiter's orbit to that of the Earth's orbit is 5.
(Period of revolution of the Earth is 1 year)

Q.3. Attempt any THREE

i.   Derive an expression for excess pressure inside a drop of liquid.

ii.   Explain what is Doppler effect in sound and state its any 'four' applications.

iii. Calculate the average molecular kinetic energy:
    a.   per kilomole,
    b.   per kilogram, of oxygen at 27 °C.
(R = 8320 J/k mole K, Avogadro's number $= 6.03 \times 10^{26}$ molecules/K mole)

iv.   A uniform steel rod of 5 mm^2 cross section is heated from 0 °C to 25 °C. Calculate the force which must be exerted to prevent it from expanding. Also calculate strain.
(α for steel $= 12 \times 10^{-6}$/ °C and γ for steel $= 20 \times 10^{10}$ N/m^2)

Q.4. A.   What are forced vibrations and resonance? Show that only odd harmonics are present in an air column vibrating in a pipe closed at one end.

B.   A stretched wire emits a fundamental note of frequency 256 Hz. Keeping the stretching force constant and reducing the length of wire by 10 cm, the frequency becomes 320 Hz. Calculate the original length of wire.

OR

Q.4. A.   Obtain an expression for potential energy of a particle performing simple harmonic motion. Hence evaluate the potential energy
    i.   at mean position and
    ii.   at extreme position.

B.   A horizontal disc is freely rotating about a transverse axis passing through its centre at the rate of 100 revolutions per minute. A 20 gram blob of wax falls on the disc and sticks to the disc at a distance of 5 cm from its axis. Moment of intertia of the disc about its axis passing through its centre of mass is 2 × 10^{-4} kg m^2. Calculate the new frequency of rotation of the disc.

SECTION – II

Q.5. Select and write the most appropriate answer from the given alternatives for each sub-question:

i. Electric field intensity in free space at a distance 'r' outside the charged conducting sphere of radius 'R' in terms of surface charge density 'σ' is

(A) $\dfrac{\sigma}{\varepsilon_0}\left[\dfrac{R}{r}\right]^2$

(B) $\dfrac{\varepsilon_0}{\sigma}\left[\dfrac{R}{r}\right]^2$

(C) $\dfrac{R}{r}\left[\dfrac{\sigma}{\varepsilon_0}\right]^2$

(D) $\dfrac{R}{\sigma}\left[\dfrac{r}{\varepsilon_0}\right]^2$

ii. Instrument which can measure terminal potential difference as well as electro motive force (e.m.f.) is

(A) Wheatstone's meter bridge (B) Voltmeter

(C) Potentiometer (D) Galvanometer

iii. If the frequency of incident light falling on a photosensitive material is doubled, then the kinetic energy of the emitted photoelectron will be

(A) same as its initial value. (B) two times its initial value.

(C) more than two times its initial value. (D) less than two times its initial value.

iv. Linear momentum of an electron in Bohr orbit of H-atom (principal quantum number n) is proportional to

(A) $\dfrac{1}{n^2}$

(B) $\dfrac{1}{n}$

(C) n

(D) n^2

v. In a semiconductor, acceptor impurity is

(A) antimony (B) indium

(C) phosphorous (D) arsenic

vi. The power radiated by linear antenna of length 'l' is proportional to (λ = wavelength)

(A) $\dfrac{\lambda}{l}$

(B) $\left(\dfrac{\lambda}{l}\right)^2$

(C) $\dfrac{l}{\lambda}$

(D) $\left(\dfrac{l}{\lambda}\right)^2$

vii. The numerical aperture of objective of a microscope is 0.12. The limit of resolution, when light of wavelength 6000 Å is used to view an object is

(A) 0.25×10^{-7} m (B) 2.5×10^{-7} m

(C) 25×10^{-7} m (D) 250×10^{-7} m

Q.6. Attempt any SIX :

i. What is a polaroid? State its 'two' uses.

ii. Draw a neat and labelled diagram of suspended coil type moving coil galvanometer.

iii. Define:
   a. Magnetization and
   b. magnetic intensity.

iv. Draw a block diagram of generalized communication system.

v. A solenoid 3.142 m long and 5.0 cm in diameter has two layers of windings of 500 turns each and carries a current of 5 A. Calculate the magnetic induction at its centre along the axis.

vi. A circular coil of 300 turns and average area 5×10^{-3} m² carries a current of 15 A. Calculate the magnitude of magnetic moment associated with the coil.

vii. The magnetic flux through a loop varies according to the relation $\phi = 8t^2 + 6t + C$, where 'C' is constant, 'ϕ' is in milliweber and 't' is in second. What is the magnitude of induced e.m.f. in the loop at t = 2 second?

viii. An electron is orbiting in 5ᵗʰ Bohr orbit. Calculate ionisation energy for this atom, if the ground state energy is −13.6 eV.

Q.7. Attempt any THREE

i. Obtain an expression for the radius of Bohr orbit for H-atom.

ii. What are α and β parameters for a transistor? Obtain a relation between them.

iii. Two metal spheres having charge densities 5 μC/m² and −2 μC/m² with radii 2 mm and 1 mm respectively are kept in a hypothetical closed surface. Calculate total normal electric induction over the closed surface.

iv. The threshold wavelength of silver is 3800 Å. Calculate the maximum kinetic energy in eV of photoelectrons emitted, when ultraviolet light of wavelength 2600 Å falls on it.
(Planck's constant, $h = 6.63 \times 10^{-34}$ J.s., velocity of light in air, $c = 3 \times 10^8$ m/s)

Q.8. A. Obtain an expression for e.m.f. induced in a coil rotating with uniform angular velocity in a uniform magnetic field. Show graphically the variation of e.m.f. with time (t).

B. Resistance of a potentiometer wire is 0.1 Ω/cm. A cell of e.m.f. 1.5 V is balanced at 300 cm on this potentiometer wire. Calculate the current and balancing length for another cell of e.m.f. 1.4 V on the same potentiometer wire.

OR

A. Describe biprism experiment to calculate the wavelength of a monochromatic light. Draw the necessary ray diagram.

B. If the critical angle of a medium is $\sin^{-1}\left(\dfrac{3}{5}\right)$, find the polarising angle.

SECTION – I

Q.1. **A.** State an expression for the moment of inertia of a solid uniform disc, rotating about an axis passing through its centre, perpendicular to its plane. Hence derive an expression for the moment of inertia and radius of gyration:
   i.   about a tangent in the plane of the disc, and
   ii.   about a tangent perpendicular to the plane of the disc.

B. In a set, 21 turning forks are arranged in a series of decreasing frequencies. Each tuning fork produces 4 beats per second with the preceding fork. If the first fork is an octave of the last fork, find the frequencies of the first and tenth fork.

OR

A. Discuss the composition of two S.H.M.s along the same path having same period. Find the resultant amplitude and intial phase.

B. A sonometer wire is in unison with a tuning fork of frequency 125 Hz when it is stretched by a weight. When the weight is completely immersed in water, 8 beats are heard per second. Find the specific gravity of the material of the weight.

Q.2. **Select and write the most appropriate answer from the given alternatives for each sub-question :**
   i.   Which of the following substances is ductile?
   (A)   Glass   (B)   High carbon steel
   (C)   Steel   (D)   Copper

   ii.   Angle of contact for the pair of pure water with clean glass is _____.
   (A)   acute   (B)   obtuse
   (C)   90°   (D)   0°

   iii. A seconds pendulum is suspended in an elevator moving with constant speed in downward direction. The periodic time (T) of that pendulum is _____.
   (A)   less than two seconds   (B)   equal to two seconds
   (C)   greater than two seconds   (D)   very much greater than two seconds

   iv.   The equation of a progressive wave is $y = 7 \sin (4t - 0.02x)$, where x and y are in cms and time t in seconds. The maximum velocity of a particle is _____.
   (A)   28 cm/s   (B)   32 cm/s
   (C)   49 cm/s   (D)   112 cm/s

   v.   The dimensions of emissive power are
   (A) $[M^1L^{-2}T^{-3}]$ (B) $[M^1L^2T^{-3}]$
   (C) $[M^1L^0T^{-3}]$ (D) $[M^1L^0T^{-2}]$

vi. The pressure (P) of an ideal gas having volume (V) is $\frac{2E}{3V}$, then the energy E is _____.

   (A) translational kinetic (B) rotational kinetic
   (C) vibrational kinetic (D) inversely proportional to pressure

vii. The fundamental frequency of transverse vibration of a stretched string of radius r is proportional to _____.

   (A) r^{-2} (B) r^{-1}

   (C) $r^{-\frac{1}{2}}$ (D) r^2

Q.3. Attempt any SIX:

i.   Draw a neat labelled diagram of conical pendulum. State the expression for its periodic time in terms of length.

ii. A raindrop of diameter 4 mm is about to fall on the ground. Calculate the pressure inside the raindrop. [Surface tension of water T = 0·072 N/m, atmospheric pressure = $1·013 \times 10^5$ N/m^2]

iii. Discuss the weightlessness experienced by an astronaut in an orbiting satellite.

iv. The periodic time of a linear harmonic oscillator is 2π second, with maximum displacement of 1 cm. If the particle starts from extreme position, find the displacement of the particle after $\frac{\pi}{3}$ seconds.

v.   State and prove : Law of conservation of angular momentum.

vi. A pinhole is made in a hollow sphere of radius 5 cm whose inner wall is at temperature 727°C. Find the power radiated per unit area. [Stefan's constant $\sigma = 5·7 \times 10^{-8}$ J/m^{2}s K^4, emissivity (e) = 0·2]

vii. Draw a neat labelled diagram showing forces acting on the meniscus of water in a capillary tube.

viii. Compute the temperature at which the r.m.s. speed of nitrogen molecules is 832 m/s.
   [Universal gas constant, R = 8320 J/k mole K, molecular weight of nitrogen = 28.]

Q.4. Attempt any THREE:

i.   Discuss the behaviour of wire under increasing load.

ii. Determine the binding energy of satellite of mass 1000 kg revolving in a circular orbit around the Earth when it is close to the surface of Earth. Hence find kinetic energy and potential energy of the satellite.
   [Mass of Earth = 6×10^{24} kg, radius of Earth = 6400 km; gravitational constant G = $6·67 \times 10^{-11}$ Nm^2/kg^2]

iii. Show that all harmonics are present on a stretched string between two rigid supports.

iv. A stone of mass 100 g attached to a string of length 50 cm is whirled in a vertical circle by giving velocity at lowest point as 7 m/s. Find the velocity at the highest point.
   [Acceleration due to gravity = 9·8 m/s^2]

SECTION – II

Q.5. A. Obtain an expression for average power dissipated in a purely resistive A.C. circuit. Define power factor of the circuit and state its value for purely resistive A.C. circuit.

B. A rectangular coil of a moving coil galvanometer contains 50 turns each having area 12 cm^2. It is suspended in radial magnetic field 0·025 Wb/m^2 by a fibre of twist constant 15×10^{-10} N-m/degree. Calculate the sensitivity of the moving coil galvanometer.

OR

A.   State Bohr's third postulate for hydrogen (H_2) atom. Derive Bohr's formula for the wave number. Obtain expressions for longest and shortest wavelength of spectral lines in ultraviolet region for hydrogen atom.

B.   The photoelectric current in a photoelectric cell can be reduced to zero by a stopping potential of 1·8 volt. Monochromatic light of wavelength 2200Å is incident on the cathode. Find the maximum kinetic energy of the photoelectrons in joules. [Charge on electron = $1·6 \times 10^{-19}$ C]

Q.6. Select and write the most appropriate answer from the given alternatives for each sub-question :

i.   Which one of the following particles cannot be accelerated by a cyclotron?
(A)   Electrons   (B)   Protons
(C)   Deuterons   (D) α – particles

ii.   In biprism experiment two interfering waves are produced due to division of _____.
(A)   amplitude   (B)   wavefront
(C)   amplitude and wavefront   (D)   neither wavefront nor amplitude

iii.   The output of NOR gate is high, when _____.
(A)   all inputs are high   (B)   all inputs are low
(C)   only one of its inputs is high   (D)   only one of its inputs is low

iv.   Light of a certain wavelength has a wave number $\bar{\upsilon}$ in vacuum. Its wave number in a medium of refractive index n is _____.

(A) $\dfrac{n}{\bar{\upsilon}}$ (B) $\dfrac{1}{n\bar{\upsilon}}$

(C) $\dfrac{\bar{\upsilon}}{n}$ (D) $n\bar{\upsilon}$

v.   If the radius of a sphere is doubled without changing the charge on it, then electric flux originating from the sphere is _____.
(A)   double   (B)   half
(C)   same   (D)   zero

vi.   The momentum of a photon of de Broglie wavelength 5000Å is _____.
[Planck's constant = $6·63 \times 10^{-34}$ J.s.]
(A) $1·326 \times 10^{-28}$ kg-m/s   (B) $7·54 \times 10^{-28}$ kg-m/s
(C) $1·326 \times 10^{-27}$ kg-m/s   (D) $7·54 \times 10^{-27}$ kg-m/s

vii.   Ionosphere mainly consists of _____.
(A)   positive ions and electrons   (B)   water vapour and smoke
(C)   ozone layer   (D)   dust particles

Q.7. Attempt any SIX:

i.   State any 'two' possible sources of errors in meter-bridge experiment. How can they be minimised?

ii.   A potentionmeter wire has resistance of per unit length of 0·1 Ω/m. A cell of e.m.f. 1·5V balances against 300 cm length of the wire. Find the current in the potentiometer wire.

iii.   Give any 'two' points of differences between diamagnetic and ferromagnetic substances.

iv.   An iron rod of area of cross-section $0·1m^2$ is subjected to a magnetising field of 1000 A/m. Calculate the magnetic permeability of the iron rod.
[Magnetic susceptibility of iron = 59·9, magnetic permeability of vacuum = $4\pi \times 10^{-7}$ S. I. unit]

v.   Draw a neat labelled circuit diagram of experimental arrangement for study of photoelectric effect.

vi.   A coil of 100 turns, each of area 0·02 m² is kept in a uniform field of induction $3·5 \times 10^{-5}$ T. If the coil rotates with a speed of 6000 r.p.m. about an axis in the plane of the coil and perpendicular to the magnetic induction, calculate peak value of e.m.f. induced in the coil.

vii.   Define modulation and transducer.

viii.   In a biprism experiment, when a convex lens was placed between the biprism and eyepiece at a distance of 30 cm from the slit, the virtual images of the slits are found to be separated by 7 mm. If the distance between the slit and biprism is 10 cm and between the biprism and eyepiece is 80cm, find the linear magnification of the image.

Q.8. Attempt any THREE:

i.   With the help of a neat circuit diagram, explain the working of a photodiode. State its any 'two' uses.

ii.   A parallel beam of monochromatic light is incident on a glass slab at an angle of incidence 60°. Find the ratio of width of the beam in the glass to that in the air if refractive index of glass is 3/2.

iii.   With the help of neat diagram, explain how non-polar dielectric material is polarised in external electric field of increasing intensity. Define polarisation in dielectrics.

iv.   In a single slit diffraction pattern, the distance between first minima on the right and first minima on the left of central maximum is 4 mm. The screen on which the pattern is displaced, is 2m from the slit and wavelength of light used is 6000Å. Calculate width of the slit and width of the central maximum.

SECTION – I

Q.1. Select and write the most appropriate answer from the given alternatives for each sub-question:

i. The difference in tensions in the string at lowest and highest points in the path of the particle of mass 'm' performing vertical circular motion is:
   (A)   2 mg   (B)   4 mg
   (C)   6 mg   (D)   8 mg

ii. The body is rotating with uniform angular velocity (ω) having rotational kinetic energy (E). Its angular momentum (L) is:
   (A) $\dfrac{2E}{\omega}$ (B) $\dfrac{E^2}{\omega}$
   (C) $\dfrac{E}{\omega^2}$ (D) $\dfrac{E}{2\omega}$

iii. The S.I. unit of compressibility is _____.
   (A) $\dfrac{m^2}{N}$ (B) Nm^2
   (C) $\dfrac{N}{m^2}$ (D) $\dfrac{kg}{m^3}$

iv. The working of RADAR is based on _____.
   (A)   resonance   (B)   speed of a star
   (C)   Doppler effect   (D)   speed of rotation of sun

v. If two capillary tubes of different diameters are partially dipped in the same liquid vertically, then the rise of liquid _____.
   (A)   is same in both the tubes.
   (B)   is more in the tube of larger diameter.
   (C)   will not be in smaller diameter tube.
   (D)   is more in the tube of smaller diameter.

vi. A sonometer wire vibrates with three nodes and two antinodes, the corresponding mode of vibration is _____.
   (A)   First overtone   (B)   Second overtone
   (C)   Third overtone   (D)   Fourth overtone

vii. Two gases exert pressure in the ratio 3:2 and their densities are in the ratio 2:3, then the ratio of their R.M.S. velocities is _____.

(A)   2 : 3   (B)   3 : 2

(C)   2 : 1   (D)   1 : 2

Q.2. Attempt any SIX :

i.   Draw a neat labelled diagram showing the various forces and their components acting on a vehicle moving along curved banked road.

ii.   Obtain an expression for critical velocity of a satellite orbiting around the earth.

iii. Draw a neat labelled diagram of rise of liquid in capillary tube showing different components of tension (force).

iv.   State any four assumptions of kinetic theory of gases.

v.   A tube open at both ends has length 47 cm. Calculate the fundamental frequency of air column. (Neglect end correction. Speed of sound in air is 3.3×10^2 m/s).

vi.   A uniform solid sphere has a radius 0.1 m and density 6×10^3 kg/m^3. Find its moment of inertia about a tangent to its surface.

vii. A particle executes S.H.M. with a period of 10 seconds. Find the time in which its potential energy will be half of its total energy.

viii. A stone of mass 2 kg is whirled in a horizontal circle attached at the end of 1.5 m long string. If the string makes an angle of 30° with vertical, compute its period. (g = 9.8 m/s^2)

Q.3. Attempt any THREE

i.   State Kepler's laws of planetary motion.

ii.   Obtain an expression for torque acting on a body rotating with uniform angular acceleration.

iii. A steel wire having cross-sectional area 2 mm^2 is stretched by 10 N. Find the lateral strain produced in the wire.

      (Given : Y for steel = 2×10^{11} N/m^2, Poisson's ratio σ = 0.29)

iv.   A body cools from 62 °C to 54 °C in 10 minutes and to 48 °C in the next 10 minutes. Find the temperature of the surroundings.

Q.4. A. Explain the formation of stationary wave by analytical method. Show that nodes and antinodes are equally spaced in a stationary wave.

B. The speed limit for a vehicle on road is 120 km/hr. A policeman detects a drop of 10% in the pitch of horn of a car as it passes him. Is the policeman justified in punishing the car driver for crossing the speed limit?

(Given : Velocity of sound = 340 m/s)

OR

A. Define practical simple pendulum.

Show that motion of bob of pendulum with small amplitude is linear S.H.M. Hence obtain an expression for its period. What are the factors on which its period depends?

B. The total free surface energy of a liquid drop is $\pi\sqrt{2}$ times the surface tension of the liquid. Calculate the diameter of the drop in S.I. unit.

SECTION – II

Q.5. **Select and write the most appropriate answer from the given alternatives for each sub-question:**

i. A parallel beam of light travelling in water is incident obliquely on a glass surface. After refraction its width _____.
   (A) decreases   (B) increases
   (C) remains the same   (D) becomes zero

ii. If 'a' is the aperture of telescope and 'λ' is the wavelength of light then resolving power of telescope is _____.
   (A) $\dfrac{\lambda}{1\cdot 22a}$ (B) $\dfrac{1\cdot 22a}{\lambda}$
   (C) $\dfrac{1\cdot 22\lambda}{a}$ (D) $\dfrac{a}{1\cdot 22\lambda}$

iii. From earth's surface, ionospheric layer of atmosphere lies between _____.
   (A) 12 km to 50 km   (B) 50 km to 80 km
   (C) 80 km to 400 km   (D) 400 km to 700 km

iv. The kinetic energy of emitted photoelectrons is independent of _____.
   (A) frequency of incident radiation.
   (B) intensity of incident radiation.
   (C) wavelength of incident radiation.
   (D) collector plate potential.

v. In hydrogen atom Balmer series in obtained when the electron jumps from _____.
   (A) higher orbit to first orbit
   (B) first orbit to a higher orbit
   (C) higher orbit to the second orbit
   (D) second orbit to a higher orbit

vi. The fraction of the total current passing through the galvanometer is _____.
   (A) $\dfrac{S}{S+G}$ (B) $\dfrac{G}{S+G}$
   (C) $\dfrac{S+G}{G}$ (D) $\dfrac{S+G}{S}$

vii. A meter gauge train is heading north with speed 54 km/hr in earth's magnetic field 3×10^{-4} T. The e.m.f. induced across the axle joining the wheels is _____.
   (A) 0·45 mV   (B) 4·5 mV
   (C) 45 mV   (D) 450 mv

Q.6. **Attempt any SIX:**

i. Distinguish between intrinsic and extrinsic semiconductor. (Give any two points).

ii. Draw the block diagram of a receiver in communication system.

iii. A point is situated at 6·5 cm and 6·65 cm from two coherent sources. Find the nature of illumination at the point, if wavelength of light is 5000 Å.

iv. Draw the diagrams showing the dipole moments in paramagnetic substance when external magnetic field is (a) absent (b) strong.

v. A voltmeter has a resistance of 100 Ω. What will be its reading when it is connected across a cell of e.m.f. 2 V and internal resistance 20 Ω?

vi. The susceptibility of magnesium at 300 K is $1\cdot2 \times 10^{-5}$. At what temperature will the susceptibility increase to $1\cdot8 \times 10^{-5}$?

vii. What is de Broglie wavelength of an electron accelerated through 25000 volt?

viii. Draw the schematic symbols for AND, OR, NOT and NAND gate.

Q.7. Attempt any THREE:

i. Using analytical method for interference bands, obtain an expression for path difference between two light waves.

ii. State law of radioactive decay. Hence derive the relation $N = N_o e^{-\lambda t}$. Represent it graphically.

iii. Determine the change in wavelength of light during its passage from air to glass, if the refractive index of glass with respect to air is $1\cdot5$ and the frequency of light is 5×10^{14} Hz. Find the wave number of light in glass (velocity of light in air $c = 3 \times 10^8$ m/s).

iv. Light of wavelength 3000 Å falls on a metal surface having work function $2\cdot3$ eV. Calculate the maximum velocity of ejected electrons.
(Planck's constant $h = 6\cdot63 \times 10^{-34}$ Js, Velocity of light $c = 3 \times 10^8$ m/s, mass of an electron = $9\cdot1 \times 10^{-31}$ kg)

Q.8. A. What is electromagnetic induction?

Prove theoretically $e = \dfrac{d\phi}{dt}$

B. A potentiometer wire has length of 2 m and resistance 10 Ω. It is connected in series with resistance 990 Ω and a cell of e.m.f. 2 V. Calculate the potential gradient along the wire.

OR

A. With the help of a neat diagram, describe the construction and working of van de Graff generator.

B. A moving coil galvanometer has a resistance of 25 Ω and gives a full scale deflection for a current of 10 mA. How will you convert it into a voltmeter having range $0 - 100$ V?

SECTION – I

Attempt any SIX :

Q.1.

i. In U.C.M. (Uniform Circular Motion), prove the relation $\vec{v} = \vec{\omega} \times \vec{r}$, where symbols have their usual meanings.

ii. Derive an expression for critical velocity of a satellite revolving around the earth in a circular orbit.

iii. Obtain an expression for total kinetic energy of a rolling body in the form $\frac{1}{2} MV^2 \left[1 + \frac{K^2}{R^2} \right]$.

iv. Define 'emissive power' and 'coefficient of emission of a body'.

v. A coin kept at a distance of 5 cm from the centre of a turntable of radius 1.5 m just begins to slip when the turnable rotates at a speed of 90 r.p.m. Calculate the coefficient of static friction between the coin and the turntable. [g = 9.8 m/s^2].

vi. The fundamental frequency of an air column in a pipe closed at one end is in unison with the third overtone of an open pipe. Calculate the ratio of lengths of their air columns.

vii. A particle performing linear S.H.M. has a period of 6.28 seconds and a path length of 20 cm. What is the velocity when its displacement is 6 cm from mean position?

viii. The energy of the free surface of a liquid drop is 5π times the surface tension of the liquid. Find the diameter of the drop in C.G.S. system.

Q.2. Select and write the most appropriate answer from the given alternatives for each sub-question:

i.   A particle rotates in U.C.M. with tangential velocity 'v' along a horizontal circle of diameter 'D'. Total angular displacement of the particle in time 't' is _____.

(A)   vt

(B) $\left[\dfrac{v}{D}\right]\cdot t$

(C) $\dfrac{vt}{2D}$

(D) $\dfrac{2vt}{D}$

ii.   Two springs of force constants K_1 and K_2 ($K_1 > K_2$) are stretched by same force. If W_1 and W_2 be the work done stretching the springs then _____.

(A) W_1 = W_2

(B) $W_1 < W_2$

(C) W_1 > W_2

(D) $W_1 = W_2 = 0$

iii.   A and B are two steel wires and the radius of A is twice that of B. If they are stretched by the same load, then the stress on B is _____.

(A) four   times   that   of   A

(B)   two times that of A

(C)   three   times   that   of   A

(D)   same as that of A

iv.   If sound waves are reflected from surface of denser medium, there is phase change of _____.

(A)   0   rad

(B) $\dfrac{\pi}{4}$ rad

(C) $\dfrac{\pi}{2}$ rad

(D) π rad

v.   A sonometer wire vibrates with frequency n_1 in air under suitable load of specific gravity 'σ'. When the load is immersed in water, the frequency of vibration of wire n_2 will be _____.

(A) $n_1\sqrt{\dfrac{\sigma+1}{\sigma}}$

(B) $n_1\sqrt{\dfrac{\sigma-1}{\sigma}}$

(C) $n_1\sqrt{\dfrac{\sigma}{\sigma+1}}$

(D) $\quad n_1 \sqrt{\dfrac{\sigma}{\sigma - 1}}$

vi. For polyatomic molecules having 'f' vibrational modes, the ratio of two specific heats, $\dfrac{C_P}{C_V}$ is _____.

(A) $\quad \dfrac{1+f}{2+f}$

(B) $\quad \dfrac{2+f}{3+f}$

(C) $\quad \dfrac{4+f}{3+f}$

(D) $\quad \dfrac{5+f}{4+f}$

vii. A body of moment of inertia 5 kgm^2 rotating with an angular velocity 6 rad/s has the same kinetic energy as a mass of 20 kg moving with a velocity of _____.

(A) 5   m/s

(B) 4 m/s

(C) 3   m/s

(D) 2 m/s

Q.3.

A. Define linear S.H.M. Show that S.H.M. is a projection of U.C.M. on any diameter.

B. A metal sphere cools at the rate of 4 °C/min. when its temperature is 50 °C. Find its rate of cooling at 45 °C if the temperature of surroundings is 25 °C

[7]

OR

A. Explain analytically how the stationary waves are formed. Hence show that the distance between node and adjacent antinode is $\dfrac{\lambda}{4}$.

B. A set of 48 tuning forks is arranged in a series of descending frequencies such that each fork gives 4 beats per second with preceding one. The frequency of first fork is 1.5 times the frequency of the last fork, find the frequency of the first and 42nd tuning fork.

[7]

Q.4. **Attempt any THREE:**

i.   What is the decrease in weight of a body of mass 600 kg when it is taken in a mine of depth 5000 m?

[Radius of earth = 6400 km, g = 9.8 m/s^2]

ii.   State and prove theorem of parallel axes about moment of inertia.

iii.   Derive Laplace's law for spherical membrane of bubble due to surface tension.

iv.   A steel wire having cross sectional area 1.5 mm^2 when stretched by a load produces a lateral strain 1.5×10^{-5}. Calculate the mass attached to the wire.

($Y_{steel} = 2 \times 10^{11}$ N/m^2, Poisson's ratio $\sigma = 0.291$, g = 9.8 m/s^2)

SECTION – II

Q.5. Attempt any SIX:

i.   What is 'diffraction of light'? Explain its two types.

ii.   Draw a neat labelled diagram for the construction of 'cyclotron'.

iii.   Distinguish between 'paramagnetic' and 'ferromagnetic' substances.

iv.   Write a short note on surface wave propagation of electromagnetic waves.

v.   The combined resistance of a galvanometer of resistance 500 Ω and its shunt is 21 Ω. Calculate the value of shunt.

vi.   The susceptibility of magnesium at 200 K is 1.8×10^{-5}. At what temperature will the susceptibility decrease by 6×10^{-6} ?

vii.   The co-efficient of mutual induction between primary and secondary coil is 2H. Calculate induced e.m.f. if current of 4A is cut off in 2.5×10^{-4} seconds.

viii. The decay constant of radioactive substance is 4.33×10^{-4} per year. Calculate its half life period.

Q.6. Select and write the most appropriate answer from the given alternatives for each sub-question:

i.   If the polarising angle for a given medium is 60°, then the refractive index of the medium is _____

(A)

$\dfrac{1}{\sqrt{3}}$

(B)

$$\sqrt{\frac{3}{2}}$$

(C)
1

(D)
$\sqrt{3}$

ii.   The resolving power of a telescope depends upon the _____

(A)
length of the telescope

(B)
focal length of an objective

(C)
diameter of an objective

(D)
focal length of an eyepiece

iii.   Electric intensity due to a charged sphere at a point outside the sphere decreases with _____

(A)
increase in charge on sphere.

(B)
increase in dielectric constant.

(C)
decrease in the distance from the centre of sphere.

(D)
Decrease in square of distance from the centre of sphere.

iv.   In potentiometer experiment, if l_1 is the balancing length for e.m.f. of cell of internal resistance r and l_2 is the balancing length for its terminal potential difference when shunted with resistance R then:

(A)

$$l_1 = l_2 \left[\frac{R + r}{R}\right]$$

(B)

$$l_1 = l_2 \left[\frac{R}{R + r}\right]$$

(C)

$$l_1 = l_2 \left[\frac{R}{R - r}\right]$$

(D)

$$l_1 = l_2 \left[\frac{R - r}{R}\right]$$

v.   The energy of photon of wavelength λ is _____.
     [h = Planck's constant, c = speed of light in vacuum]

(A)
$hc\lambda$

(B)
$\dfrac{h\lambda}{c}$

(C)
$\dfrac{\lambda}{hc}$

(D)
$\dfrac{hc}{\lambda}$

vi.   Which logic gate corresponds to the truth table given below?

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(A)
AND

(B)
NOR

(C)
OR

(D)
NAND

vii.   The process of superimposing a low frequency signal on a high frequency wave is _____.

(A)
detection

(B)
mixing

(C)
modulation

(D)
attenuation

Q.7.   **A.**   State the principle on which transformer works. Explain its working with construction. Derive an expression for ratio of e.m.f.s and currents in terms of number of turns in primary and secondary coil.
B.   A conductor of any shape, having area 40 cm^2 placed in air is uniformly charged with a charge 0.2 μC. Determine the electric intensity at a point just outside its surface. Also, find the mechanical force per unit area of the charged conductor.
[ϵ_0 =   8.85 $\times$ 10^{-12} S   .   I.   units]

OR

A.   With the help of a neat labelled diagram, describe the Geiger-Marsden experiment. What is mass defect?
B.   The photoelectric work function for a metal surface is 2.3 eV. If the light of wavelength   6800 Å is incident on the surface of metal, find threshold frequency and incident frequency. Will there be an emission of photoelectrons or not?

[Velocity of light c = 3×10^8 m/s, Planck's constant, h = 6.63×10^{-34} Js]

Q.8. **Attempt any THREE:**

i.   Determine the change in wavelength of light during its passage from air to glass. If the refractive index of glass with respect to air is 1.5 and the frequency of light is 3.5×10^{14} Hz, find the wave number of light in glass. [Velocity of light in air (c = 3×10^8 m/s)]

ii.   In biprism experiment, 10th dark band is observed at 2.09 mm from the central bright point on the screen with red light of wavelength 6400 Å. By how much will fringe width change if blue light of wavelength 4800 Å is used with the same setting?

iii.   Describe Kelvin's method to determine the resistance of galvanometer by using metre bridge.

iv.   Explain the elementary idea of an oscillator with the help of block diagram.