Question Set 9

SHORT ANSWER QUESTIONS

Chapter 1. Rotational dynamics

Q. 1. Do we need a banked road for a two-wheeler? Explain. *(2 marks)*

Ans. When a two-wheeler takes a turn along an unbanked road, the force of friction is the centripetal force. The two-wheeler leans inward to counteract a torque that tends to topple it outward. But, friction cannot be relied upon to provide the necessary centripetal force on all road conditions. Secondly, the friction results in wear and tear of the tyres. On a banked road at a turn, any vehicle can negotiate the turn without depending on friction and without straining the tyres.

Q. 2. In a vertical circular motion, is zero speed possible at the top (uppermost point)? Under what condition(s)? *(2 marks)*

Ans. In a nonuniform vertical circular motion, e.g., that of a small body attached to a string or the loop-the-loop manoeuvres of an aircraft or motorcycle, the body must have some minimum speed to reach the top and complete the circle. In this case, the motion is controlled only by gravity and zero speed at the top is not possible.

However, in a controlled vertical circular motion, e.g., that of a small body attached to a rod or of a giant wheel (Ferris wheel) ride, the body or the passenger seat can have zero speed at the top, i.e., the motion can be brought to a stop.

Q. 3. On what factors does the frequency of conical pendulum depend? Is it independent of some factors? *(2 marks)*

Ans. The frequency of a conical pendulum, of string length L and semivertical angle θ, is

$$n = \frac{1}{2\pi}\sqrt{\frac{g}{L\cos\theta}}$$

where g is the acceleration due to gravity at the place.

From the above expression, we can see that

(i) $n \propto \sqrt{g}$

(ii) $n \propto \dfrac{1}{\sqrt{L}}$

(iii) $n \propto \dfrac{1}{\sqrt{\cos\,\theta}}$ (if θ increases, cos θ decreases and n increases)

(iv) The frequency is independent of the mass of the bob.

Q. 4. What can you infer if a uniform ring and a uniform disc have the same radius of gyration? ***(2 marks)***

Ans. The radius of gyration of a thin ring of radius R_r about its transverse symmetry axis is

$$k_r = \sqrt{I_{CM}/M_r} = \sqrt{R_r^2} = R_r$$

The radius of gyration of a thin disc of radius R_d about its transverse symmetry axis is

$$k_d = \sqrt{I_{CM}/M_d} = \sqrt{\frac{M_d R_d^2/2}{M_d}} = \frac{1}{\sqrt{2}} R_d$$

Given $k_r = k_d$,

$$R_r = \frac{1}{\sqrt{2}} R_d \text{ or, equivalently, } R_d = \sqrt{2}\,R_r.$$

Chapter 2. Mechanical properties of fluids

Q. 5. What is the work done in blowing a soap bubble of radius *r*? ***(2 marks)***

Ans. Let T be the surface tension of a soap solution.

The initial surface area of soap bubble = 0

The final surface area of soap bubble = $2 \times 4\pi r^2$

∴ The increase in surface area = $2 \times 4\pi r^{2-}$

The work done in blowing the soap bubble is

W = surface tension × increase in surface area

$= T \times 2 \times 4\pi r^2 = 8\pi r^2 T$

Q. 6. Why two or more mercury drops form a single drop when brought in contact with each other? ***(3 marks)***

Ans. A spherical shape has the minimum surface area-to-volume ratio of all geometric forms. When two drops of a liquid are brought in contact, the cohesive forces between their molecules coalesce the drops into a single larger drop. This is because, the volume of the liquid remaining the same, the surface area of the resulting single drop is less than the combined surface area of the smaller drops. The resulting decrease in surface energy is released into the environment as heat.

Proof : Let n droplets each of radius r coalesce to form a single drop of radius R. As the volume of the liquid remains constant,

volume of the drop = volume of n droplets

$$\therefore \frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$$

$$\therefore R^3 = nr^3 \qquad \therefore R = \sqrt[3]{n}\, r$$

Surface area of n droplets $= n \times 4\pi r^2$

Surface area of the drop $= 4\pi R^2 = n^{2/3} \times 4\pi r^2$

$\therefore$ The change in the surface area

= surface area of drop — surface area of n droplets

$= 4\pi r^2 (n^{2/3} - n)$

Since the bracketed term is negative, there is a *decrease* in surface area and a *decrease* in surface energy.

Q. 7. State the conditions for concavity and convexity of a liquid surface where it is in contact with a solid. ***(2 marks)***

Ans. For a molecule in the liquid surface which is in contact with a solid, the forces on it are largely (i) the solid-liquid adhesive force $\vec{F}_A$, normal and into the solid surface and (ii) the liquid-liquid cohesive force $\vec{F}_C$ at nearly 45° with the horizontal.

If $\vec{F}_C \ll \vec{F}_A$ or if $F_C < \sqrt{2}\, F_A$, the contact angle is correspondingly zero or acute and the liquid surface is concave with the solid.

If $F_C > \sqrt{2} F_A$, the contact angle is obtuse and the liquid surface curves down, i.e., convex, with the solid.

Q. 8. Explain the effect of impurity on the angle of contact (or surface tension of a liquid). ***(2 marks)***

Ans. Effect of impurity :

(i) The angle of contact or the surface tension of a liquid increases with dissolved impurities like common salt. For dissolved impurities, the angle of contact (or surface tension) increases linearly with the concentration of the dissolved materials.

(ii) It decreases with sparingly soluble substances like phenol or alcohol. A detergent is a surfactant whose molecules have hydrophobic and hydrophilic ends; the hydrophobic ends decrease the surface tension of water. With reduced surface tension, the water can penetrate deep into the fibres of a cloth and remove stubborn stains.

(iii) It decreases with insoluble surface impurities like oil, grease or dust. For example, mercury surface contaminated with dust does not form perfect spherical droplets till the dust is removed.

Q. 9. What do you mean by viscous drag ? What causes viscous drag in fluids ? ***(3 marks)***

Ans. When a fluid flows past a solid surface, or when a solid body moves through a fluid, there is always a force of fluid friction opposing the motion. This force of fluid friction is called the drag force or **viscous drag**.

In liquids, the viscous drag is due to short range molecular cohesive forces while in gases it is due to collisions between fast moving molecules. For laminar flow in both liquids and gases, the viscous drag is proportional to the relative velocity between the layers, provided the relative velocity is small. For turbulent flow, the viscous drag increases rapidly and is proportional to some higher power of the relative velocity.

Q. 10. State the applications of Bernoulli's principle. ***(2 marks)***

Ans. Applications of Bernoulli's principle :

(1) Venturi meter : It is a horizontal constricted tube that is used to measure flow speed in a gas.

(2) Atomizer : It is a hydraulic device used for spraying insecticide, paint, air perfume, etc.

(3) Aerofoil : The aerofoil shape of the wings of an aircraft produces aerodynamic lift.

(4) Bunsen's burner : Bernoulli effect is used to admit air into the burner to produce an oxidising flame.

Chapter 4. Thermodynamics

Q. 11. A solar cooker and a pressure cooker both are used to cook food. Treating them as thermodynamic systems, discuss the similarities and differences between them. ***(2 marks)***

Ans. Solar cooker and pressure cooker treated as thermodynamic systems :

Similarities :

(1) Heat must be added to both the systems.

(2) Internal energy (temperature) of the systems increases.

Differences :

(1) A solar cooker is an open thermodynamic system while a pressure cooker is a closed system.

(2) The contents of a solar cooker are at normal or surrounding pressure and the food is cooked at the normal boiling point of water. In the case of a pressure cooker, the increase in pressure increases the boiling point of water thereby cooking the food faster.

Q. 12. A mixture of fuel and oxygen is burned in a constant-volume chamber surrounded by a water bath. It was noticed that the temperature of water is increased during the process. Treating the mixture of fuel and oxygen as the system, (a) has heat been transferred ? (b) has work been done ? (c) What is the sign of ΔU ? ***(2 marks)***

Ans. (a) Heat has been transferred from the chamber to the water bath.

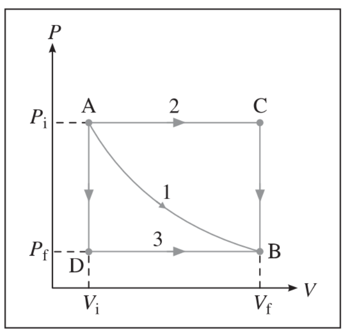
(b) No work is done by the system (the mixture of fuel and oxygen) as there is no change in its volume.

(c) There is an increase in the temperature of water. Therefore, ΔU is positive for water.

For the system (the mixture of fuel and oxygen), ΔU is negative.

Q. 13. Draw $P-V$ diagrams to illustrate that the work done by a system depends on the process even when the initial and final states are the same. ***(2 marks)***

Ans. In the given diagram, the initial state of a gas is $A \equiv (V_i, P_i)$ and the final state of the gas is $B \equiv (V_f, P_f)$. Path 1 corresponds to an isothermal process. Path 2 corresponds to the combination of an isobaric process AC and isochoric process CB. Path 3 corresponds to the combination of an isochoric process AD and isobaric process DB. The work done by the gas (W) in each case is the area under the respective curve, different in each case.



Different ways to change a system

Q. 14. Define a reversible process. What is an irreversible process ? ***(2 marks)***

Ans. A reversible process is one which is performed in such a way that, at the end of the process, both the system and its local surroundings can be restored to their initial states, without producing any change in the rest of the universe. A process may be reversible if it takes place quasistatically *and* without dissipative effects.

A process which does not fulfill the requirements of reversibility is said to be an irreversible process. In this case, the system and the local surroundings cannot be restored to their initial states without affecting the rest of the universe. All natural processes are irreversible.

Q. 15. What are the limitations of the first law of thermodynamics ? ***(July '22) (2 marks)***

Ans. Limitations of the first law of thermodynamics : There can be thermodynamic processes which are consistent with the first law but not observed in nature.

(1) According to first law of thermodynamics, heat and work are interconvertible. But, the law does not tell us whether a particular process can or cannot occur. For example, we see a *net* transfer of energy (heat) from a hot body to a cold body but never the other way.

(2) The law does not rule out total (i.e., 100%) conversion of heat into work or work into heat. However, this is impossible in practice. For example, it is impossible to design a heat engine that can completely convert heat into work, i.e., no heat engine is 100% efficient. Similarly, it is impossible to remove heat from a system without doing some work on the system, i.e., the coefficient of performance of a refrigerator can never be infinite.

(3) Diffusion of two dissimilar inert gases is an irreversible process. For example, we never see the reverse process of a gaseous mixture separating into separate chambers, although such a process would not violate the first law.

Chapter 5. Oscillations

Q. 16. For a particle performing linear SHM, show that its average speed over one oscillation is $\frac{2\omega A}{\pi}$, where *A* is the amplitude of SHM. *OR*

Show that the average speed of a particle performing SHM in one oscillation is $\frac{2}{\pi} \times$ maximum speed. ***(2 marks)***

Ans. During one oscillation, a particle performing SHM covers a total distance equal to $4A$, where A is the amplitude of SHM. The time taken to cover this distance is the period (T) of SHM.

$$\text{Average speed} = \frac{\text{distance covered in one oscillation}}{\text{time taken for one oscillation}}$$

$$\therefore \ v_{av} = \frac{4A}{T}$$

But $T = \frac{2\pi}{\omega}$

where ω is a constant related to the system.

$$\therefore \ v_{av} = 4A \times \frac{\omega}{2\pi} = \frac{2\omega A}{\pi}$$

But ωA = maximum speed

$$\therefore \ \text{Average speed} = \frac{2}{\pi} \times \text{maximum speed}$$

Q. 17. Represents graphically the displacement, velocity and acceleration against time for a particle performing linear SHM when it starts from the mean position. ***(3 marks)***

Ans. Consider a particle performing SHM, with amplitude A and period $T = 2\pi/\omega$ starting from the **mean position** towards the positive extreme position where ω is the angular frequency. Its displacement from the mean position (x), velocity (v) and acceleration (a) at any instant are

$$x = A \sin \omega t = A \sin\left(\frac{2\pi}{T} t\right) \qquad \left(\because \ \omega = \frac{2\pi}{T}\right)$$

$$v = \frac{dx}{dt} = \omega A \cos \omega t = \omega A \cos\left(\frac{2\pi}{T} t\right)$$

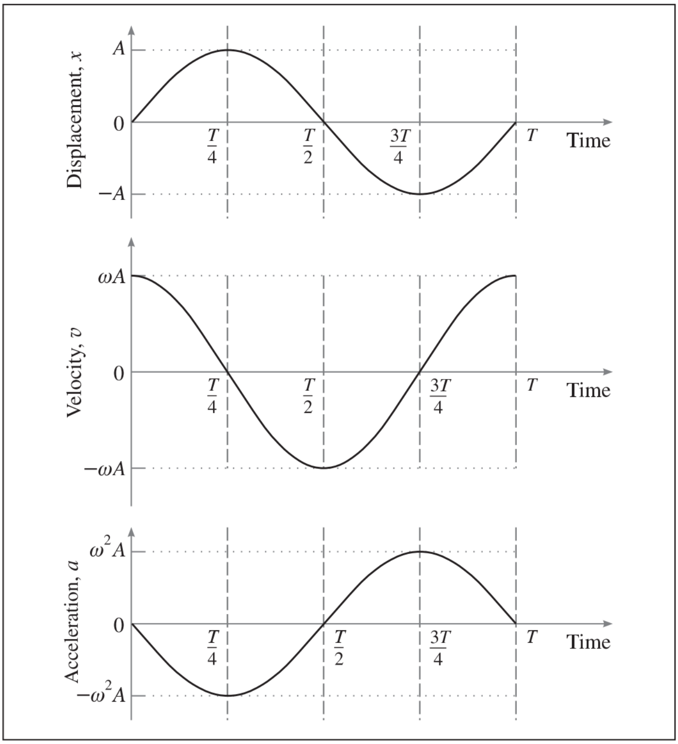
$$a = \frac{dv}{dt} = -\omega^2 A \sin \omega t = -\omega^2 A \sin\left(\frac{2\pi}{T} t\right)$$

as the initial phase $\alpha = 0$.

Using these expressions, the values of x, v and a at the end of every quarter of a period, starting from $t = 0$, are tabulated as follows.

t	0	$T/4$	$T/2$	$3T/4$	T
ωt	0	$\pi/2$	π	$3\pi/2$	2π
x	0	A	0	$-A$	0
v	ωA	0	$-\omega A$	0	ωA
a	0	$-\omega^2 A$	0	$\omega^2 A$	0

Using the values in the table we can plot graphs of displacement, velocity and acceleration with time.



Graphs of displacement, velocity and acceleration with time for a particle in SHM starting from the mean position

Q. 18. What is end correction? State the cause of end correction. How is it estimated? ***(3 marks)***

Ans. When sound waves are sent down the air column in a narrow closed or open pipe, they are reflected at the ends — without phase reversal at an open end and with a phase reversal at a closed end. Interference between the incident and reflected waves under appropriate conditions sets up stationary waves in the air column. Thus, the stationary waves have an antinode at an open end.

However, because air molecules in the plane of an open end are not free to move in all directions, reflection of the longitudinal waves takes place slightly beyond the rim of the pipe at an open end. The distance of the antinode from the open end of the pipe is called end correction. According to Reynolds, the distance of the antinode from the rim is approximately 30% of the inner diameter of a cylindrical pipe. This distance must be taken into account in accurate determination of the wavelength of sound. Hence, this distance is called the end correction.

Therefore, if d is the inner diameter of a cylindrical pipe, an end correction $e = 0.3\,d$ for each open end must be added to the measured length of the pipe. If l is the measured length, the effective length of the air column in the case of a pipe closed at one end is $l + 0.3d$, while that for a pipe open at both ends is $l + 0.6d$.

Q. 19. Explain any two applications of beats. ***(2 marks)***

Ans. Applications of beats :

(1) Listening for beats – or rather, their absence – is the usual method of tuning musical instruments and in the determination of the frequency of a musical note.

(2) Ultrasonic calls of bats and dolphins may be detected by superimposing a sound of different frequency to produce audible beats.

(3) In music, beats are used to produce a low frequency sound (a grave tone). Two notes whose difference in frequency is equal to the desired low frequency are used for this purpose. When two notes are nearly in tune, the beats are slow. But as the beat frequency increases to 20 Hz or more, the beats may ultimately merge into a continuous tone known as a difference tone.

(4) (i) Speed of a moving object can be determined using a Doppler RADAR. Radio waves from the RADAR are reflected off a moving object, such as an aeroplane. The superposition of the incident and reflected waves produces beats. The frequency of beats helps to determine the speed of the aeroplane.

The same principle is used in speed guns used by traffic police to determine the speed of cars on a highway.

(ii) In medicine, a Doppler ultrasound test (sonography) uses reflected sound waves to evaluate blood flow through the major arteries and veins of the arms, legs and neck. It can show blocked or reduced blood flow because of narrowing of the major arteries. Duplex (or 2D) Doppler, Colour Doppler and Power Doppler are different techniques of the same test.

Chapter 7. Wave optics

Q. 20. State the conditions for constructive and destructive interference of light. ***(2 marks)***

Ans. (1) Constructive interference (brightness) : There is constructive interference at a point and the brightness or intensity is maximum there, if the two waves of light of the same frequency arrive at the point *in phase*, i.e., with a phase difference of zero or an integral multiple of 2π radians.

A phase difference of 2π radians corresponds to a path difference λ, where λ is the wavelength of light.

$\therefore$ Phase difference $= 0, 2\pi, 4\pi, 6\pi, \ldots$ rad $= n(2\pi)$ rad

or path difference $= 0, \lambda, 2\lambda, 3\lambda, \ldots,$ etc. $= n\lambda$

where $n = 0, 1, 2, 3, \ldots,$ etc.

(2) Destructive interference (darkness) : There is destructive interference at a point and the point is the darkest (the intensity of light is minimum, i.e., zero) if the two waves of light of the same frequency and intensity arrive at the point *in opposite phase,* i.e., with a phase difference of an odd-integral multiple of π radians. A phase difference of π radians corresponds to a path difference $\lambda/2$, where λ is the wavelength of light.

$\therefore$ Phase difference $= \pi, 3\pi, 5\pi, \ldots$ rad $= (2m-1)\pi$ rad

or path difference $= \lambda/2, 3\lambda/2, 5\lambda/2, \ldots,$ etc. $= (2m-1)\dfrac{\lambda}{2}$

where $m = 1, 2, 3, \ldots,$ etc.

Q. 21. State any two conditions for obtaining a steady and distinct interference pattern. ***(Sept. '21) (2 marks)***

Ans. Conditions for a steady and distinct (sharp) interference pattern :

(1) The two light sources must be coherent.

(2) The two light sources should be monochromatic.

(3) The two light sources should be of equal brightness.

(4) The two light sources should be narrow.

(5) The interfering light waves should be in the same state of polarization.

(6) The two light sources should be closely spaced and the distance between the screen and the sources should be large.

Q. 22. State the properties of conductors in electrostatic conditions. ***(2 marks)***

Ans. Properties of a charged conductor in electrostatic conditions :

(1) Net electric field inside the conductor is zero.

(2) Net electric field just outside the conductor is normal to its surface at every point.

(3) Electric potential inside the conductor is constant and equal to that on its surface.

(4) Excess charges reside only on the surface of the conductor but, for a conductor of arbitrary shape, the surface charge density at a point is inversely proportional to the local curvature of the surface.

Q. 23. What is electrostatic shielding ? What is a Faraday cage ? ***(2 marks)***

Ans. The use of a conducting box to protect sensitive instruments from stray electric fields, or the use of a conducting wire cage to protect a person near a high-voltage installation or from lightning strike, is called electrostatic shielding.

The hollow conductor or the conducting wire cage that shields its interior from external electric fields is called a Faraday cage or Faraday shield.

Chapter 8. Electrostatics

Q. 24. What do you mean by a polar molecule and a nonpolar molecule ? Give one example of each. ***(2 marks)***

Ans. A **polar molecule** is one with a permanent electric dipole moment that arises from the finite separation of the centres of the net positive charge and the net negative charge in the molecule, even in the absence of an external electric field.

Examples : Gaseous hydrogen halides (HF, HCl, etc.); NH_3, NO_2, N_2O, water molecules; all heteronuclear diatomic molecules (with any covalent bond between two *different* atoms).

A **nonpolar molecule** is one which does not have a permanent electric dipole moment because in the absence of an external electric field, the centres of the net positive charge and the net negative charge in the molecule coincide.

Examples : H_2, CO_2, N_2, polyethylene, polystyrene.

Q. 25. A metal sheet is introduced between the plates of a charged parallel-plate capacitor. What is its effect on the capacitance of the capacitor? ***(2 marks)***

Ans. Suppose the parallel-plate capacitor has capacitance C_0, plates of area A and separation d. Assume the metal sheet introduced has the same area A.

Case (1) : Finite thickness t. Free electrons in the sheet will migrate towards the positive plate of the capacitor. Then, the metal sheet is attracted towards whichever capacitor plate is closest and gets stuck to it, so that its potential is the same as that of that plate. The gap between the capacitor plates is reduced to $d-t$, so that the capacitance increases.

Case (2) : Negligible thickness. The thin metal sheet divides the gap into two of thicknesses d_1 and d_2 of capacitances $C_1=\varepsilon_0 A/d_1$ and $C_2=\varepsilon_0 A/d_2$ in series. Their effective capacitance is

$$C=\frac{C_1C_2}{C_1+C_2}=\frac{\varepsilon_0 A}{d_1+d_2}=\frac{\varepsilon_0 A}{d}=C_0$$

i.e., the capacitance remains unchanged.

Q. 26. A capacitor has some dielectric between its plates and the capacitor is connected to a DC source. The battery is now disconnected and then the dielectric is removed. State whether the capacitance, the energy stored in it, the electric field, charge stored and voltage will increase, decrease or remain constant. ***(2 marks)***

Ans. Assume a parallel-plate capacitor, of plate area A and plate separation d is filled with a dielectric of relative permittivity (dielectric constant) k. Its capacitance is $C = \frac{k\varepsilon_0 A}{d}$ ... (1)

If it is charged to a voltage (potential) V, the charge on its plates is $Q = CV$.

Since the battery is disconnected after it is charged, the charge Q on its plates, and consequently the product CV, remain unchanged.

On removing the dielectric completely, its capacitance becomes from Eq. (1),

$$C' = \frac{\varepsilon_0 A}{d} = \frac{1}{k} C \quad \text{... (2)}$$

that is, its capacitance decreases by the factor k. Since $C'V' = CV$, its new voltage is

$$V' = \frac{C}{C'} V = kV \quad \text{... (3)}$$

so that its voltage increases by the factor k. The stored potential energy, $U = \frac{1}{2} QV$, so that Q remaining constant, U increases by the factor k.

The electric field, $E = V/d$, so that E also increases by a factor k.

Chapter 9. Current electricity

Q. 27. What are the disadvantages of a potentiometer (over a voltmeter) ? ***(2 marks)***

Ans. Disadvantages of a potentiometer over a voltmeter :

(1) The use of a potentiometer is an indirect measurement method while a voltmeter is a direct reading instrument.

(2) A potentiometer is unwieldy while a voltmeter is portable.

(3) Unlike a voltmeter, the use of a potentiometer in measuring an unknown emf requires a standard source of emf and calibration.

Q. 28. State the function of the shunt in modifying a galvanometer to an ammeter. ***($\frac{1}{2}$ mark each)***

Ans. Functions of the shunt in an ammeter :

(1) It lowers the effective resistance of the ammeter.

(2) It shunts off a larger fraction of the line current, thus protecting the sensitive meter movement of the basic galvanometer.

(3) With a shunt of proper value, a galvanometer can be modified into an ammeter of practically any desired range.

Q. 29. State the functions of the series resistance in modifying a galvanometer into a voltmeter. ***($\frac{1}{2}$ mark each)***

Ans. Functions of the high series resistance in a voltmeter :

(1) It increases the effective resistance of the voltmeter.

(2) It drops off a larger fraction of the measured potential difference, thus protecting the sensitive meter movement of the basic galvanometer.

(3) With a resistance of proper value, a galvanometer can be modified to a voltmeter of any desired range.

Chapter 10. Magnetic fields due to electric current

Q. 30. State under what conditions will a charged particle moving through a uniform magnetic field travel in (i) a straight line (ii) a circular path (iii) a helical path. ***(1 mark each)***

Ans.

(i) A charged particle travels undeviated through a magnetic field $\vec{B}$, if its velocity $\vec{v}$ is parallel or antiparallel to $\vec{B}$. In this case, the magnetic force on the charge is zero.

(ii) A charged particle travels in a circular path within a magnetic field $\vec{B}$, if its velocity $\vec{v}$ is perpendicular to $\vec{B}$.

(iii) A charged particle travels in a helical path through a magnetic field $\vec{B}$, if its velocity $\vec{v}$ is inclined at an angle θ to $\vec{B}$, $0 < \theta < 90°$. In this case, the component of $\vec{v}$ parallel to $\vec{B}$ is unaffected by the magnetic field. The radius and pitch of the helix are determined respectively by the perpendicular and parallel components of $\vec{v}$.

Chapter 11. Magnetic materials

Q. 31. What is the gyromagnetic ratio of an orbital electron ? State its dimensions and the SI unit. ***(2 marks)*** *OR*

What is the gyromagnetic ratio? Write the necessary formula.

(July '22) (2 marks)

Ans. The ratio of the magnitude of the orbital magnetic moment to that of the orbital angular momentum of an electron in an atom is called its

gyromagnetic ratio γ_o. If $\vec{M}_o$ is the orbital magnetic moment of the electron with orbital angular momentum $\vec{L}_o$,

$$\gamma_o = \frac{M_o}{L_o} = \frac{e}{2m_e}$$

where e and m_e are the electronic charge and electron mass, respectively.

Dimensions : $[\gamma_o] = \frac{[\text{charge}]}{[\text{mass}]} = \frac{[\text{TI}]}{[\text{M}]} = [\text{M}^{-1}\text{TI}]$.

SI unit : The coulomb per kilogram (C/kg).

Q. 32. What is a diamagnetic material ? Give two examples. ***(2 marks)***

Ans. A material which is weakly repelled by a magnet and whose atoms/molecules do not possess a net magnetic moment in the absence of an external magnetic field is called a **diamagnetic material.**

A diamagnetic material placed in a uniform magnetic field acquires a small net induced magnetic moment directed *opposite* to the field.

Examples : Bismuth, copper, gold, silver, antimony, mercury, water, air, hydrogen, lead, silicon, nitrogen, sodium chloride.

Q. 33. What is a paramagnetic material ? Give two examples. ***(2 marks)***

Ans. A material which is weakly attracted by a magnet and whose atoms possess a net magnetic moment with all atomic magnetic moments randomly directed in the absence of an external magnetic field but are capable of being aligned in the direction of the applied magnetic field is called a **paramagnetic material.**

Examples : Aluminium, platinum, chromium, manganese, sodium, calcium, magnesium, lithium, tungsten, niobium, copper chloride, oxygen.

Chapter 12. Electromagnetic induction

Q. 34. If a copper disc swings between the poles of a magnet, the pendulum comes to rest very quickly. Explain the reason. What happens to the mechanical energy of the pendulum ? ***(2 marks)***

Ans. As the copper disc enters and leaves the magnetic field, the changing magnetic flux through it induces eddy current in the disc. In both cases, Fleming's right hand rule shows that opposing magnetic force damps the motion. After a few swings, the mechanical energy becomes zero and the motion comes to a stop.

Joule heating due to the eddy current warms up the disc. Thus, the mechanical energy of the pendulum is transformed into thermal energy.

Chapter 13. AC circuits

Q. 35. The total impedance of a circuit decreases when a capacitor is added in series with *L* and *R*. Explain why. ***(Sept. '21) (2 marks)***

Ans. The impedance of an *LR* circuit is

$$Z_{LR} = \sqrt{R^2 + X_L^2}$$

where X_L is the reactance of the inductor.

When a capacitor of reactance X_C is added to the circuit in series, the impedance of the *LCR* circuit is

$$Z_{LCR} = \sqrt{R^2 + (X_L - X_C)^2}$$

where $|X_L - X_C|$ is the net reactance of the inductor and capacitor because the current lags behind the voltage in phase by $\pi/2$ rad in the inductor while the current leads the voltage in phase by $\pi/2$ rad in the capacitor. The decrease in the net reactance decreases the total impedance, i.e., $Z_{LCR} < Z_{LR}$.

Q. 36. State the characteristics of a series *LCR* resonant circuit. ***(2 marks)***

Ans. Characteristics of a series *LCR* resonant circuit :

(1) Resonance occurs when inductive reactance $X_L (= 2\pi f L)$ equals capacitive reactance $X_C \left(= \frac{1}{2\pi f C} \right)$. Resonant frequency, $f_r = \frac{1}{2\pi\sqrt{LC}}$.

(2) Impedance is minimum and the circuit is purely resistive.

(3) Current is maximum.

(4) Frequencies, other than the resonant frequency (f_r) are rejected. Since, only f_r is accepted, it is called an acceptor circuit.

Chapter 14. Dual nature of radiation and matter

Q. 37. In photoelectric effect, an increase in the intensity of the incident radiation does not change the maximum kinetic energy of the emitted electrons. Explain what happens to the extra energy of the incident radiation. ***(2 marks)***

Ans. When electromagnetic radiation with frequency greater than the threshold frequency is incident on a metal surface, there is emission of electrons. It is observed that the number of electrons emitted per second is far less than the number of photons incident per second, i.e., not every incident photon is effective in liberating an electron. The photons that are not effective in liberation of electrons are reflected (or scattered) or absorbed resulting in a rise in the temperature of the metal surface. The maximum kinetic energy of a photoelectron depends on the frequency of the incident radiation and the threshold frequency for the metal. It has nothing to do with the intensity of the incident radiation. The increase in intensity results in increase in the number of electrons emitted per second.

Chapter 15. Structure of atoms and nuclei

Q. 38. State any two limitations of Bohr's atomic model.

(Sept. '21) (2 marks)

Ans. Bohr's atomic model cannot explain

(1) the relative intensities of spectral lines even in the hydrogen spectrum

(2) the atomic spectra of many-electron atoms of higher elements

(3) the Zeeman effect and Stark effect, and associated molecular bonding.

Q. 39. Show that the frequency of the first line in the Lyman series is equal to the difference between the limiting frequencies of the Lyman and Balmer series. ***(3 marks)***

Ans. For the first line in the Lyman series,

$$\frac{1}{\lambda_{L1}} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(1 - \frac{1}{4}\right) = \frac{3R}{4}$$

$\therefore \; v_{L1} = \dfrac{c}{\lambda_{L1}} = \dfrac{3Rc}{4}$, where v denotes the frequency, c the speed of light in free space and R the Rydberg constant.

For the Lyman series limit,

$$\frac{1}{\lambda_{L\infty}} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right) = R$$

$$\therefore \; v_{L\infty} = \frac{c}{\lambda_{L\infty}} = Rc$$

For the Balmer series limit,

$$\frac{1}{\lambda_{B\infty}} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right) = \frac{R}{4}$$

$$\therefore\ v_{B\infty} = \frac{c}{\lambda_{B\infty}} = \frac{Rc}{4}$$

$$\therefore\ v_{L\infty} - v_{B\infty} = Rc - \frac{Rc}{4} = \frac{3Rc}{4} = v_{L1}$$

Hence the result.

Chapter 16. Semiconductor devices

Q. 40. State any two advantages of a full-wave rectifier. ***(2 marks)***

Ans.

(1) A full-wave rectifier rectifies both halves of each cycle of the ac input.

(2) Efficiency of a full-wave rectifier is twice that of a half-wave rectifier.

(3) The ripple in a full-wave rectifier is less than that in a half-wave rectifier.

Ripple factors for a full-wave and half-wave rectifiers are respectively, 0.482 and 1.21.

Q. 41. Why do we need filters in a power supply? ***(2 marks)***

Ans. A rectifier — half-wave or full-wave — outputs a pulsating dc which is not directly usable in most electronic circuits. These circuits require nearly pure dc as produced by batteries. Unlike pure dc waveform of a battery, a rectifier output has an ac ripple riding on a dc waveform.

The circuit used in a dc power supply to remove the ripple is called a **filter**. A filter circuit can produce smoother waveform that approximates the waveform produced by a battery. The most common technique used for filtering is a capacitor connected across the output of a rectifier.

Q. 42. State any four advantages of a photodiode. ***(2 marks)***

Ans. Advantages of a photodiode :

(1) Quick response to light and hence high operational speed.

(2) Excellent linear response over a wide dynamic range.

(3) Low cost.

(4) Wide spectral response.

(5) Compact, lightweight, mechanically rugged and long life.

Q. 43. State the principle and any two uses of a solar cell.

(2 marks)

Ans. Principle : A solar cell works on the photovoltaic effect in which an emf is produced between the two layers of a *pn*-junction as a result of irradiation.

Uses of solar cells :

(1) A solar cell array consisting of a set of solar cells is used during daylight hours to power an electrical equipment as well as to recharge batteries which can then be used during night.

(2) Solar cell arrays are used to power electrical equipment on a satellite as well as at remote places on the Earth where electric power lines are absent.

(3) Large-scale solar power generation systems linked with commercial power grid.

(4) Independent power supply systems for radar detectors, monitoring systems, radio relay stations, roadlights and roadsigns.

Assignments

1. Explain the effect of temperature on the angle of contact (or surface tension of a liquid). **(Ch. 2)** ***(2 marks)***

2. What is a barometer? Explain the use of a simple mercury barometer to measure atmospheric pressure. **(Ch. 2)** ***(3 marks)***

3. Write a note on free expansion in thermodynamic process.

(Ch. 4) ***(Sept. '21) (2 marks)***

4. Show that a linear SHM is the projection of a uniform circular motion on its diameter. **(Ch. 5)** ***(3 marks)***

5. Show that the total energy of a particle performing linear SHM is directly proportional to (1) the square of the amplitude (2) the square of the frequency. **(Ch. 5)** ***(2 marks)***

6. Represent graphically the variations of KE, PE and TE of a particle performing linear SHM with respect to its displacement.

(Ch. 5) ***(2 marks)***

7. Plot the graphs of displacement, velocity and acceleration against time for a particle performing linear SHM starting from the positive extreme position. **(Ch. 5)** *(3 marks)*

8. Give any two applications of resonance. **(Ch. 6)** *(2 marks)*

9. Give any two disadvantages of resonance. **(Ch. 6)** *(2 marks)*

10. Draw neat labelled diagrams for the modes of vibration of an air column in a pipe when it is (a) open at both ends (b) closed at one end. **(Ch. 6)** *(3 marks)*

11. Prove that a pipe of length $2L$ open at both ends has the same fundamental frequency as a pipe of length L closed at one end. **(Ch. 6)** *(2 marks)*

12. Two organ pipes open at both ends and of same length but different diameters produce sounds of different frequencies. Why? **(Ch. 6)** *(2 marks)*

13. The pth overtone of an organ pipe open at both ends has a frequency n. When one end of the pipe is closed, the qth overtone has a frequency N. Show that $N = \frac{(2q+1)n}{2(p+1)}$. **(Ch. 6)** *(2 marks)*

14. When two tuning forks of slightly different frequencies are sounded together to produce beats, what is the effect on the beat frequency if the prongs of the tuning fork with higher frequency are (i) waxed a little (ii) filed a little? **(Ch. 6)** *(2 marks)*

15. State any two advantages of a potentiometer over a voltmeter. **(Ch. 9)** ***(Sept. '21)*** *(2 marks)*

16. What is the gyromagnetic ratio of an orbital electron? State its dimensions and the SI unit. **(Ch. 11)** *(2 marks)*

17. What is a ferromagnetic material? Give two examples. **(Ch. 11)** *(2 marks)*

18. Write a short note on domains in a ferromagnetic material. **(Ch. 11)** *(2 marks)*

19. State the characteristics of a parallel LC resonant circuit. **(Ch. 13)** *(2 marks)*