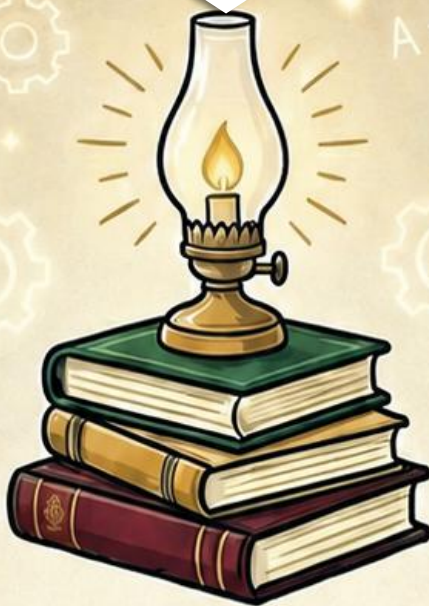




$$A = \frac{m}{(m^2 + c)^2}$$



NIOS PYQ's SOLUTIONS

$$\sqrt{a} = bc^2$$

$$\sqrt{h-x^2}$$

PREVIOUS YEARS' QUESTIONS & ANSWERS



APRIL 2026

Your Path to Success

(SET – A)

SECTION – A

Q1. The proper use of lubricants cannot reduce:

- (A) Static friction
- (B) Inertia
- (C) Sliding friction
- (D) Rolling friction

Answer: (B) Inertia

Q2. A long spring is stretched by 2 cm. Its potential energy is V . If the spring is stretched by 10 cm, its potential energy would be:

- (A) $V/25$
- (B) $V/5$
- (C) $5V$
- (D) $25V$

Answer: (D) $25V$

Q3. Bernoulli's theorem is based on conservation of:

- (A) Mass
- (B) Momentum
- (C) Energy
- (D) Kinetic Energy

Answer: (C) Energy

Q4. In a container having water filled up to a height h , a hole is made in the bottom. The velocity of water flowing out of the hole is:

- (A) independent of h
- (B) proportional to h^2
- (C) proportional to $h^{1/2}$
- (D) proportional to h^3

Answer: (C) proportional to $h^{1/2}$

Q5. The internal energy of an ideal gas depends on:

- (A) Pressure
- (B) Temperature
- (C) Volume
- (D) Size of molecule

Answer: (B) Temperature

Q6. 110 J of heat is added to a gaseous system and its internal energy increases by 40 J. Then the amount of work done is:

- (A) 150 J
- (B) 70 J
- (C) 110 J
- (D) 40 J

Answer: (B) 70 J



Q7. Motion of an oscillating liquid column in a U-tube is:

- (A) periodic but not simple harmonic
- (B) non-periodic
- (C) simple harmonic and time period is independent of the density of the liquid
- (D) simple harmonic and time period is directly proportional to the density of the liquid

Answer: (C) simple harmonic and time period is independent of the density of the liquid

Q8. Sound waves of wavelength λ , travelling in a medium with a speed of v m/s, enter into another medium where its speed is $2v$ m/s. The wavelength of sound waves in the second medium is:

- (A) λ
- (B) $\lambda/2$
- (C) 2λ
- (D) 4λ

Answer: (C) 2λ

Q9. A spherical shell has uniform surface charge density. What is the electric field inside a spherical shell?

- (A) Zero
- (B) Less than zero
- (C) Directly proportional to the distance from the centre
- (D) Greater than zero

Answer: (A) Zero

Q10. If two streams, one of electrons and another of protons, move parallel to each other in the same direction, then they:

- (A) Attract each other
- (B) Repel each other
- (C) Do not interact
- (D) Neither attract nor repel

Answer: (B) Repel each other

Q11. Which of the following is the correct definition of interference?

- (A) It is superposition of light waves.
- (B) It is superposition of light waves from two incoherent sources.
- (C) It is redistribution of energy due to superposition of light waves from two coherent sources.
- (D) It is superposition of light waves from two coherent sources.

Answer: (C) It is redistribution of energy due to superposition of light waves from two coherent sources

Q12. Two coherent monochromatic light beams of intensities I and $4I$ superimpose. The maximum and minimum possible intensities in the resulting beam are:



- (A) 5I and I (B) 5I and 3I
(C) 3I and I (D) 9I and I

Answer: (D) 9I and I

Q13. An object is immersed in a fluid. In order that the object becomes invisible, it should:

- (A) Behave as a perfect reflector
(B) Absorb all the light falling on it
(C) Have refractive index one
(D) Have refractive index exactly matching with that of the surrounding fluid

Answer: (D) Have refractive index exactly matching with that of the surrounding fluid

Q14. Which of the following spectral series in hydrogen atom gives spectral line of 4800 Å?

- (A) Lyman (B) Balmer
(C) Paschen (D) Brackett

Answer: (B) Balmer

Q15. A proton, a neutron, an electron, and an α -particle have the same energy. Then their de Broglie wavelengths compare as:

- (A) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ (B) $\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$
(C) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$ (D) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

Answer: (B) $\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$

Q16. Electrical Conductivity of a semiconductor:

- (A) decreases with rise in its temperature
(B) increases with rise in its temperature
(C) does not change with rise in its temperature
(D) first increases and then decreases with rise in its temperature

Answer: (B) increases with rise in its temperature

Q17. (a) Surface tension of liquid _____ with rise in temperature of the liquid. **decreases**

(b) If the liquid neither rises nor falls in a capillary tube, then angle of contact is _____. **90°**

Q18. (a) The phenomenon of rise or fall of a liquid in a capillary tube is known as _____. **capillarity (capillary action)**

(b) Property of liquid surface by virtue of which it behaves like an elastic stretched membrane and tends to have minimum surface area known as _____. **surface tension**



Q19. (a) _____ waves do not transfer any energy and momentum in the material medium.

Stationary (Standing)

(b) Resonance is an example of _____ vibration. **forced**

Q20. (a) Maximum displacement of the oscillating particle on either side of its mean position is called its _____. **amplitude**

(b) State of a particle regarding its position and direction of motion at any instant is known as _____. **phase**

Q21. (a) Name the physical quantity whose SI unit is V·m.

Answer: Electric flux is defined as $\phi = \vec{E} \cdot \vec{A}$, where electric field E has SI units of V/m and area A has units of m^2 . Therefore, electric flux has SI units of $\frac{V}{m} \times m^2 = V \cdot m$.

(b) One end of a copper wire is connected to a neutral pith ball and the other end to a negatively charged plastic rod. What will be the nature of charge acquired by the pith ball?

Answer: Since copper is a good conductor, and the plastic rod carries a negative charge, the excess electrons on the negatively charged rod repel each other and flow through the conducting copper wire away from the rod, moving toward the neutral pith ball at the other end. As a result, the pith ball gains an excess of electrons and acquires a negative charge.

Q22. (a) Which of the following options are correct? In a region of constant potential:

- (A) The electric field is uniform.
- (B) The electric field is zero.
- (C) There can be charge inside the region.
- (D) The electric field shall necessarily change if a charge is placed outside the region.

Answer: (A) and (B) are correct

(b) What is the geometrical shape of equipotential surface due to a single isolated charge?

Answer: Concentric spheres (centred at the point charge)

Q23. (a) Locus of particles of the medium vibrating in the same phase at any instant is known as _____. **wavefront**

(b) What is the phase difference between two points on the same wavefront?

Answer: Zero

Q24. (a) When a ray of light enters from one medium to another, then which of the following does not change? Frequency / Wavelength / Amplitude



Answer: (a) When light travels from one medium to another, its speed changes (due to the change in refractive index), which causes its wavelength to change correspondingly. Its amplitude may also change slightly due to partial reflection/absorption. However, the frequency of light is determined solely by the source and remains unchanged as it passes from one medium into another.

(b) A double convex lens of refractive index μ_1 is immersed in a liquid of refractive index μ_2 . The lens will act as a transparent plane sheet when: $\mu_1 > \mu_2$ / $\mu_1 = \mu_2$ / $\mu_1 < \mu_2$

By the Lensmaker's formula, the focal length of a lens depends on the relative refractive index of the lens material with respect to the surrounding medium: $\frac{1}{f} = \left(\frac{\mu_1}{\mu_2} - 1\right) \left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

If $\mu_1 = \mu_2$, then $\left(\frac{\mu_1}{\mu_2} - 1\right) = 0$, which makes $\frac{1}{f} = 0$, i.e., $f = \infty$. A lens with infinite focal length does not converge or diverge light rays, and hence behaves like a plane transparent sheet (glass slab) with no lens action.

Q25. (a) In Rutherford's scattering experiment, the target was bombarded by _____. **alpha (α) particles**

(b) What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atom?

Answer: According to Bohr's model, the radius of the n th orbit is given by: $r_n \propto n^2$ For ground state, $n = 1$; for first excited state, $n = 2$.

$$\frac{r_2}{r_1} = \frac{(2)^2}{(1)^2} = \frac{4}{1}$$

Q26. (a) For a given photosensitive material and with a source of constant frequency of incident radiation, how does the photocurrent vary with intensity of incident light?

Answer: According to the experimental observations of the photoelectric effect, when the frequency of incident radiation is kept constant (above the threshold frequency), the photocurrent (which is proportional to the number of photoelectrons emitted per second) increases linearly (directly proportional) with the intensity of the incident light, since a higher intensity means a greater number of incident photons per second, and hence more photoelectrons are ejected per second.

Photocurrent is directly proportional to (increases linearly with) the intensity of incident light

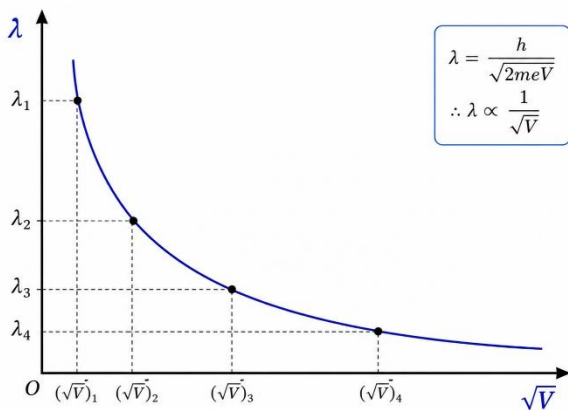
(b) Show on a graph the variation of de Broglie wavelength (λ) associated with an electron with the square root of accelerating potential (V).

Answer: The de Broglie wavelength of an electron accelerated through potential V is given by: $\lambda =$

$$\frac{h}{\sqrt{2meV}} = \frac{h}{\sqrt{2me}} \times \frac{1}{\sqrt{V}}$$



This shows that $\lambda \propto \frac{1}{\sqrt{V}}$, i.e., λ is inversely proportional to $\sqrt{V}$.



Q27. (a) A photo diode is operated in _____. **reverse bias**

(b) A narrow region near the junction has deficiency of mobile charges. This region is called _____ region. **depletion region**

Q28. (a) When forward bias is applied on a p-n junction diode, the width of the depletion region _____. **decreases**

(b) Zener diode is used as _____. **a voltage regulator**

SECTION – B

Q29. Explain why passengers are thrown forward from their seats when a speeding bus stops suddenly.

Answer: When a speeding bus is moving, both the bus and the passengers standing/sitting inside it are moving with the same velocity. When the bus suddenly stops (due to sudden braking), the lower part of the passenger's body, being in contact with the seat/floor of the bus, stops abruptly along with the bus due to friction. However, by Newton's First Law of Motion (the Law of Inertia), the upper part of the passenger's body has a natural tendency to continue moving forward with its original velocity, since no sufficient external force acts on it instantaneously to stop it. This mismatch causes the passenger's body to be thrown forward relative to the bus.

OR

Why do the passengers fall in the backward direction when a bus suddenly starts moving from the rest position?

Answer: When a bus is at rest, both the bus and the passengers inside it are at rest. When the bus suddenly starts moving forward, the lower part of a passenger's body (in contact with the floor/seat) is set into forward motion along with the bus due to friction and contact forces. However, by Newton's First Law of Motion, the upper part of the passenger's body, due to its inertia of rest, tends to remain



at rest and resists this sudden change in motion. As a result, relative to the bus (which has now started moving forward), the passenger's body appears to fall backward.

Q30. What are conservative forces? Give one example for conservative force.

Answer: A conservative force is a force for which the work done in moving an object from one point to another depends only on the initial and final positions of the object, and is completely independent of the path taken between these two points. Equivalently, the work done by a conservative force in moving an object along any closed path (returning to the starting point) is always zero. For conservative forces, the total mechanical energy (kinetic + potential) of the system is conserved.

Example: Gravitational force is a conservative force.

Q31. Calculate the change in internal energy of a system when:

(a) The system absorbs 2000 J of heat and produces 500 J of work.

Answer: By the First Law of Thermodynamics: $\Delta U = \Delta Q - W$

Here, $\Delta Q = 2000$ J (heat absorbed by system), $W = 500$ J (work done by the system)

$$\Delta U = 2000 - 500 = 1500 \text{ J}$$

(b) The system absorbs 1100 J of heat and 400 J of work is done on it.

Answer: Here, $\Delta Q = 1100$ J (heat absorbed), and since work is done ON the system (not by the system), $W = -400$ J (work done by the system is negative)

$$\Delta U = \Delta Q - W = 1100 - (-400) = 1100 + 400 = 1500 \text{ J}$$

Q32. The resistivity of a conducting wire of length l and area of cross-section A is $2 \times 10^{-8} \Omega \cdot \text{m}$.

What will be the resistivity of the same metallic wire of length $2l$ and area of cross-section $2A$?

Answer: Resistivity (ρ) is an intrinsic property of the material of the wire it depends only on the nature (material) of the conductor and its temperature, and is completely independent of the dimensions of the wire (its length or cross-sectional area). Since the same metallic wire (same material) is used, even though its length and area have both been doubled, the resistivity remains unchanged.

The resistivity remains $2 \times 10^{-8} \Omega \cdot \text{m}$ (unchanged)

OR

A potential difference of 8 V is applied across the ends of a conducting wire of length 3 cm and area of cross-section 2 cm^2 . The resulting current in the wire is 0.15 A. Calculate the resistance and resistivity of the wire.

Answer: Given: $V = 8$ V, $l = 3 \text{ cm} = 0.03 \text{ m}$, $A = 2 \text{ cm}^2 = 2 \times 10^{-4} \text{ m}^2$, $I = 0.15 \text{ A}$

Resistance (using Ohm's Law): $R = \frac{V}{I} = \frac{8}{0.15} = 53.33 \Omega$



$$\text{Resistivity: } \rho = \frac{RA}{l} = \frac{53.33 \times 2 \times 10^{-4}}{0.03}$$

$$\rho = \frac{0.010667}{0.03} = 0.3556 \, \Omega \cdot \text{m}$$

Resistance $\approx 53.33 \, \Omega$; **Resistivity** $\approx 0.356 \, \Omega \cdot \text{m}$

Q33. What are Anti-Stokes lines?

Answer: In Raman scattering, when incident light interacts with molecules of a sample, most photons scatter elastically (Rayleigh scattering), but a small fraction scatter inelastically. Anti-Stokes lines are the spectral lines observed in Raman spectra whose frequency is higher than the frequency of the incident radiation. These lines arise when incident photons interact with molecules that are already in an excited vibrational/rotational energy state; the molecule loses this extra vibrational energy to the scattered photon, causing the scattered photon to gain energy (and hence have a higher frequency / shorter wavelength) than the incident photon.

OR

What is dispersion of light? Would you prefer small angled or large angled prism to produce dispersion?

Answer: Dispersion of light is the phenomenon in which white light (composed of a mixture of different wavelengths/colors) splits into its constituent colors (forming a spectrum, i.e., VIBGYOR) when it passes through a prism (or any other dispersive medium). This occurs because the refractive index of the prism material is different for different wavelengths of light violet light (shorter wavelength) is refracted (bent) more than red light (longer wavelength), causing the different colors to separate out at different angles.

Preference: A large-angled prism would be preferred to produce greater dispersion, because the amount of dispersion (angular separation between colors) increases as the angle of the prism increases a larger prism angle results in a greater difference in the angles of deviation for different colors, thereby producing more pronounced (larger) dispersion of the spectrum.

Q34. The angle of the minimum deviation for a 60° glass prism is 39° . Calculate the refractive index of the material of the prism. (Take $\sin 49.5^\circ = 0.760$)

Answer: Given: Prism angle $A = 60^\circ$, angle of minimum deviation $\delta_m = 39^\circ$

The refractive index of the prism material is given by: $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$$\frac{A+\delta_m}{2} = \frac{60^\circ+39^\circ}{2} = \frac{99^\circ}{2} = 49.5^\circ$$

$$\frac{A}{2} = \frac{60^\circ}{2} = 30^\circ$$



$$\mu = \frac{\sin 49.5^\circ}{\sin 30^\circ} = \frac{0.760}{0.5} = 1.52$$

Answer: Refractive index $\mu = 1.52$

Q35. Define:

(a) Stopping potential

Answer: Stopping potential is the minimum negative (retarding) potential that must be applied to the collector plate (anode) relative to the emitter (photosensitive cathode) in a photoelectric effect experiment, which is just sufficient to stop even the most energetic photoelectrons (those emitted with maximum kinetic energy) from reaching the collector, thereby reducing the photoelectric current to exactly zero.

(b) Threshold frequency

Answer: Threshold frequency is the minimum frequency of incident electromagnetic radiation that is required to cause the emission of photoelectrons from the surface of a given photosensitive metal. Below this frequency, no photoelectric emission takes place at all, no matter how high the intensity of the incident light is.

Q36. Complete the truth table for the following logic gate.

Answer: The given logic gate symbol (with a flat input side and curved output inputs A, B and output Y) is an AND gate. The output of an AND gate is HIGH (1) only when both inputs A and B are HIGH (1); in all other cases, the output is LOW (0).

Completed Truth Table (AND Gate):

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

OR

Complete the truth table for the following logic gate.

Answer: The given logic gate symbol (a curved-back shape with a small circle/bubble at the output tip inputs A, B and output Y) is a NOR gate, which is a NOT-OR gate: it first performs the OR operation on inputs A and B, and then inverts (negates) the result. The output $Y = A \bar{+} B$.

Completed Truth Table (NOR Gate):



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

Explanation:

- When $A = 0, B = 0$: $A + B = 0$, so NOR output = $\bar{0} = 1$
- When $A = 0, B = 1$: $A + B = 1$, so NOR output = $\bar{1} = 0$
- When $A = 1, B = 0$: $A + B = 1$, so NOR output = $\bar{1} = 0$
- When $A = 1, B = 1$: $A + B = 1$, so NOR output = $\bar{1} = 0$

Q37. Explain why efficiency of Carnot engine cannot be 100%.

Answer: The efficiency of a Carnot engine operating between a source at temperature T_1 (higher temperature) and a sink at temperature T_2 (lower temperature) is given by: $\eta = 1 - \frac{T_2}{T_1}$

For the efficiency to be exactly 100% (i.e., $\eta = 1$), we would require either $T_2 = 0$ K (the sink temperature must be absolute zero) or $T_1 = \infty$ (the source temperature must be infinitely high).

However, according to the Third Law of Thermodynamics, it is impossible to actually reach absolute zero temperature (0 K) through any finite number of processes absolute zero is unattainable in practice. Similarly, having an infinitely hot source ($T_1 = \infty$) is also physically impossible.

Since neither of these two extreme conditions ($T_2 = 0$ or $T_1 = \infty$) can ever be practically achieved, the efficiency of a Carnot engine (or any real heat engine) can never actually reach 100% some heat must always be rejected to the sink, which is at a temperature above absolute zero.

Q38. What is meant by positive work, negative work, and zero work? Give examples of each type.

Work done by a force is given by $W = Fd \cos \theta$, where F is the magnitude of force, d is the magnitude of displacement, and θ is the angle between the direction of force and the direction of displacement.

Answer: Positive work: When the angle θ between the applied force and the displacement is less than 90° (i.e., $0^\circ \leq \theta < 90^\circ$), $\cos \theta$ is positive, and hence the work done is positive.

Example: When a man lifts a bucket vertically upward using a rope, the applied force (upward) and the displacement (upward) are in the same direction ($\theta = 0^\circ$), so the work done by the man is positive.



Negative work: When the angle θ between the applied force and the displacement lies between 90° and 180° (i.e., $90^\circ < \theta \leq 180^\circ$), $\cos \theta$ is negative, and hence the work done is negative.

Example: When a body slides down an inclined plane, the frictional force acts up the incline (opposing the motion), while the displacement of the body is down the incline. Since the force and displacement are in opposite directions ($\theta = 180^\circ$), the work done by friction is negative.

Zero work: When the angle θ between the applied force and the displacement is exactly 90° , $\cos 90^\circ = 0$, and hence the work done is zero, regardless of the magnitudes of force and displacement.

Example: When a coolie carries a load on his head and walks along a horizontal platform, the force exerted by the coolie (supporting the load, acting vertically upward) is perpendicular to the horizontal displacement of the coolie. Since $\theta = 90^\circ$, the work done by the coolie against gravity in this horizontal motion is zero.

OR

State whether the following quantities are positive or negative or zero. Explain.

(a) Work done by friction on a body sliding down an inclined plane.

Answer: As the body slides down the inclined plane, the frictional force acts up the incline, opposing the motion of the body (which is directed down the incline). Since the force (friction) and the displacement (down the incline) are in exactly opposite directions, the angle between them is $\theta = 180^\circ$, and $\cos 180^\circ = -1$.

Negative (since the friction force opposes the direction of motion)

(b) Work done by a man lifting a bucket out of a well by means of a rope tied to the bucket.

Answer: The man applies an upward force on the rope (and hence on the bucket) to lift it out of the well, and the bucket's displacement is also in the upward direction. Since the force and displacement are in the same direction, $\theta = 0^\circ$, and $\cos 0^\circ = 1$.

Positive (since the force and displacement are in the same direction)

(c) Work done by a coolie walking on a horizontal platform with a load on his head.

Answer: The coolie exerts an upward force on the load (to support its weight against gravity) while walking horizontally, so his displacement is horizontal. Since the force (vertical) is perpendicular to the displacement (horizontal), $\theta = 90^\circ$, and $\cos 90^\circ = 0$.

Zero (since the force and displacement are perpendicular to each other)

Q39. For the circuit shown below calculate the value of current I and equivalent resistance R .



Answer: The circuit has a $10\ \Omega$ resistor in series with a battery of 12 V , and this series combination is connected to a parallel combination of $3\ \Omega$ and $6\ \Omega$ resistors.

Step 1: Find the equivalent resistance of the parallel combination ($3\ \Omega$ and $6\ \Omega$): $\frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} = \frac{2}{6} +$

$$\frac{1}{6} = \frac{3}{6} = \frac{1}{2}$$

$$R_p = 2\ \Omega$$

Step 2: Find the total equivalent resistance R ($10\ \Omega$ in series with the parallel combination): $R = 10 + R_p = 10 + 2 = 12\ \Omega$

Step 3: Find the current I using Ohm's Law: $I = \frac{V}{R} = \frac{12}{12} = 1\text{ A}$

Equivalent resistance $R = 12\ \Omega$; Current $I = 1\text{ A}$

OR

The following Wheatstone bridge is balanced. Calculate:

(a) The value of equivalent resistance R in the circuit, and

(b) The current in the arms AB and DC .

Answer: Given: All resistances in the bridge network are equal, $r = 1\ \Omega$ each; battery EMF = 5 V , connected across points A and D .

The circuit forms a Wheatstone bridge, with two possible current paths from A to D : one path passing through point B (upper path: $A \rightarrow B \rightarrow D$), and another path passing through point C (lower path: $A \rightarrow C \rightarrow D$), with a bridge arm connecting B and C .

Since the Wheatstone bridge is balanced: The condition for a balanced Wheatstone bridge is that the ratio of resistances in one path equals the ratio of resistances in the other path (i.e., $\frac{R_{AB}}{R_{BD}} = \frac{R_{AC}}{R_{CD}}$). Since all the arm resistances are equal ($r = 1\ \Omega$ each), this balance condition is automatically satisfied. As a result, no current flows through the bridge arm (connecting B and C), and this bridge arm can be effectively removed/ignored for calculating the equivalent resistance.

Step 1: Calculate the equivalent resistance R

With the bridge arm carrying no current, we are left with two independent parallel paths from A to D :

- Path 1 (through B): $R_{AB} + R_{BD} = r + r = 2r = 2\ \Omega$
- Path 2 (through C): $R_{AC} + R_{CD} = r + r = 2r = 2\ \Omega$

These two paths (each $2\ \Omega$) are in parallel with each other: $\frac{1}{R} = \frac{1}{2r} + \frac{1}{2r} = \frac{1}{2} + \frac{1}{2} = 1$

$$R = \frac{2r \times 2r}{2r + 2r} = \frac{4r^2}{4r} = r$$

$$R = r = 1\ \Omega$$



Step 2: Calculate the total current drawn from the battery: $I_{total} = \frac{V}{R} = \frac{5}{1} = 5 \text{ A}$

Step 3: Calculate the current in each branch (path A-B-D and path A-C-D)

Since both parallel paths (A-B-D and A-C-D) have exactly equal resistance (2Ω each), the total current of 5 A splits equally between the two paths:

$$I_{AB} = I_{BD} = \frac{I_{total}}{2} = \frac{5}{2} = 2.5 \text{ A (in the path through B)}$$

$$I_{AC} = I_{CD} = \frac{I_{total}}{2} = \frac{5}{2} = 2.5 \text{ A (in the path through C)}$$

Equivalent resistance $R = 1 \Omega$; Current in arm AB = 2.5 A; Current in arm DC = 2.5 A

Q40. What happens to the interference pattern obtained in the Young's Double Slit Experiment when:

(a) The separation between the two slits is gradually increased.

Answer: The fringe width in Young's double slit experiment is given by: $\beta = \frac{\lambda D}{d}$

where λ is the wavelength of light, D is the distance between the slits and the screen, and d is the separation between the two slits.

Since $\beta \propto \frac{1}{d}$, as the separation d between the two slits is gradually increased, the fringe width β decreases, meaning the bright and dark fringes become closer together (more closely spaced). If d is increased sufficiently, the fringes may become so close together that they are no longer individually distinguishable/resolvable.

(b) White light is used in place of monochromatic light.

Answer: Since white light consists of a mixture of different wavelengths (colors, from violet to red), and the fringe width $\beta = \frac{\lambda D}{d}$ depends on the wavelength λ , each color produces its own fringe pattern with a slightly different fringe width. The central bright fringe (at the point of zero path difference) remains white, since all colors constructively interfere there simultaneously. However, moving away from the center, the fringes of different colors get displaced by different amounts (since violet light, having a shorter wavelength, produces narrower fringes, while red light, having a longer wavelength, produces wider fringes). As a result, a few colored fringes are visible near the center, but farther away from the center, the fringes of different colors overlap with one another, and the pattern becomes hazy/indistinct, eventually appearing as a uniform white illumination (general glow) rather than a distinct fringe pattern.

(c) The experiment is performed in water instead of air.



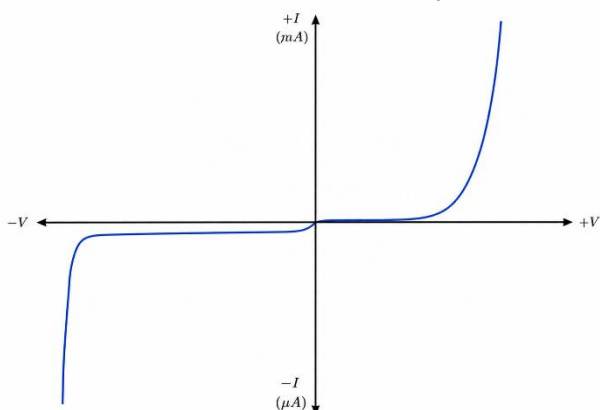
Answer: When the experiment is performed in a medium like water (having refractive index n greater than that of air), the wavelength of light decreases according to the relation: $\lambda_{water} = \frac{\lambda_{air}}{n}$

Since the fringe width is given by $\beta = \frac{\lambda D}{d}$, and the wavelength decreases when going from air to water, the fringe width also decreases proportionally (by the same factor n). This means the fringes become more closely spaced (closer together) than they were in air, though the overall interference pattern (alternating bright and dark fringes) continues to be observed, just with a smaller fringe width.

Q41. Define forward bias and reverse bias. Plot the variation of current with applied voltage for forward and reverse bias for p-n junction diode.

Answer: Forward bias: When the p-n junction diode is connected such that the p-type region (having majority holes) is connected to the positive terminal of the external battery, and the n-type region (having majority electrons) is connected to the negative terminal, the diode is said to be forward biased. In this configuration, the applied external voltage opposes the built-in potential barrier at the junction, reducing the width of the depletion region and allowing majority charge carriers to easily cross the junction, resulting in a significant flow of current through the diode.

Reverse bias: When the p-n junction diode is connected such that the p-type region is connected to the negative terminal of the external battery, and the n-type region is connected to the positive terminal, the diode is said to be reverse biased. In this configuration, the applied external voltage adds to the built-in potential barrier, increasing the width of the depletion region. This severely restricts the flow of majority carriers, and only a very small current (due to minority charge carriers) flows through the diode, known as the reverse saturation current until the breakdown voltage is reached, beyond which the current increases sharply.



Forward bias curve: Starting at the origin, the current remains very close to zero for small forward voltages, until a certain "knee" or threshold voltage (approximately 0.7 V for silicon diodes, or 0.3 V for germanium diodes) is reached. Beyond this threshold voltage, the current rises very rapidly and



steeply (almost exponentially, appearing nearly vertical on the graph) with only a small further increase in voltage.

Reverse bias curve: For reverse voltages, the current remains extremely small and nearly constant (in the microampere range) over a wide range of reverse voltage this is the small reverse saturation current due to minority carriers. This continues until the reverse breakdown voltage is reached, at which point the current increases suddenly and sharply (a nearly vertical drop on the graph, in the negative/reverse current direction), corresponding to reverse breakdown (Zener or avalanche breakdown) of the diode.

Q42. State and prove the Law of Conservation of linear momentum using Newton's Third Law of motion.

Answer: Statement: The Law of Conservation of Linear Momentum states that in the absence of any external force acting on a system of particles, the total linear momentum of the system remains constant (conserved), regardless of internal interactions (such as collisions) taking place within the system.

Proof: Consider two bodies, body 1 (mass m_1) and body 2 (mass m_2), moving along the same straight line, with initial velocities u_1 and u_2 respectively. They collide with each other, and after the collision, they move with final velocities v_1 and v_2 respectively.

Let the collision last for a small time interval t .

During the collision, let F_{21} be the force exerted by body 2 on body 1 (action), and let F_{12} be the force exerted by body 1 on body 2 (reaction).

By Newton's Third Law of Motion, action and reaction forces are equal in magnitude and opposite in direction: $F_{12} = -F_{21}$

Using the definition of force as rate of change of momentum:

$$\text{For body 1: } F_{21} = \frac{m_1 v_1 - m_1 u_1}{t}$$

$$\text{For body 2: } F_{12} = \frac{m_2 v_2 - m_2 u_2}{t}$$

$$\text{Substituting into Newton's Third Law relation: } \frac{m_2 v_2 - m_2 u_2}{t} = - \frac{m_1 v_1 - m_1 u_1}{t}$$

$$m_2 v_2 - m_2 u_2 = -m_1 v_1 + m_1 u_1$$

$$\text{Rearranging: } m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

This shows that the total momentum of the system before the collision ($m_1 u_1 + m_2 u_2$) is exactly equal to the total momentum of the system after the collision ($m_1 v_1 + m_2 v_2$), proving that the total linear



momentum of the system remains conserved (constant), provided no external force acts on the system.

Numerical: Aman weighs 60 kg and travels with a velocity of 1 m/s towards Manoj who weighs 40 kg and is moving with 1.5 m/s towards Aman. Calculate their momenta.

Answer: Momentum of Aman = $m_{Aman} \times v_{Aman} = 60 \times 1 = 60 \text{ kg} \cdot \text{m/s}$ (directed towards Manoj)

Momentum of Manoj = $m_{Manoj} \times v_{Manoj} = 40 \times 1.5 = 60 \text{ kg} \cdot \text{m/s}$ (directed towards Aman, i.e., in the opposite direction to Aman's momentum)

Momentum of Aman = $60 \text{ kg} \cdot \text{m/s}$; Momentum of Manoj = $60 \text{ kg} \cdot \text{m/s}$ (equal in magnitude, but in opposite directions, since they are moving towards each other)

OR

State and prove Newton's second law of motion.

Answer: Statement: Newton's Second Law of Motion states that the rate of change of momentum of a body is directly proportional to the applied external force, and this change in momentum takes place in the direction in which the force acts.

Proof: Consider a body of mass m moving with an initial velocity u . Suppose a constant force F acts on this body for a time interval t , changing its velocity to a final velocity v .

Initial momentum of the body: $p_1 = mu$

Final momentum of the body: $p_2 = mv$

Rate of change of momentum = $\frac{p_2 - p_1}{t} = \frac{mv - mu}{t} = \frac{m(v - u)}{t}$

By Newton's Second Law: $F \propto \frac{m(v - u)}{t}$

$F = k \cdot \frac{m(v - u)}{t}$

where k is a constant of proportionality. Since $\frac{v - u}{t} = a$ (the acceleration of the body): $F = k \cdot m \cdot a$

In the SI system of units, the unit of force (Newton) is defined such that the constant $k = 1$.

Therefore: $F = ma$

This is the mathematical form of Newton's Second Law of Motion, showing that force equals the product of mass and acceleration.

Numerical: A ball of mass 0.4 kg starts rolling on the ground at 20 m/s and comes to rest after 10 s. Calculate the force which stops the ball, assuming it to be of constant magnitude throughout.

Answer: Given: $m = 0.4 \text{ kg}$, $u = 20 \text{ m/s}$ (initial velocity), $v = 0 \text{ m/s}$ (final velocity, since it comes to rest), $t = 10 \text{ s}$



Acceleration: $a = \frac{v-u}{t} = \frac{0-20}{10} = -2 \text{ m/s}^2$

(The negative sign indicates that this is a deceleration, or retardation, since the ball is slowing down.)

Force: $F = ma = 0.4 \times (-2) = -0.8 \text{ N}$

The negative sign indicates that the force acts opposite to the direction of the ball's motion (i.e., it is a retarding/opposing force, such as friction).

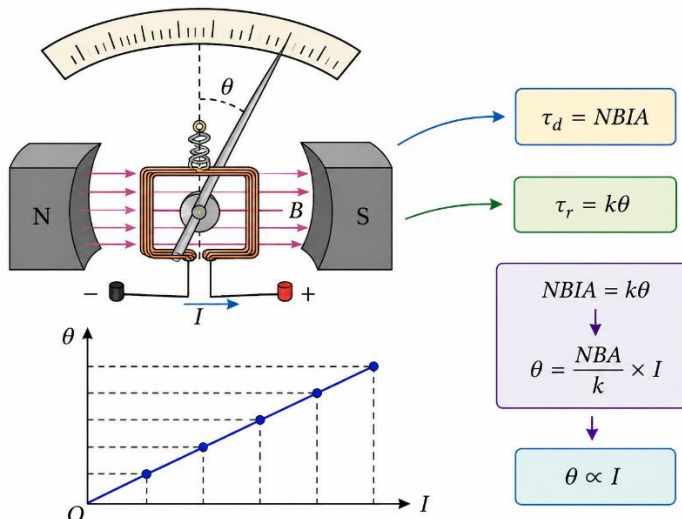
The magnitude of the force which stops the ball is **0.8 N**, acting opposite to the direction of motion of the ball

Q43. Show that the deflection produced in a galvanometer is directly proportional to the current flowing through it.

Answer: In a moving coil galvanometer, a rectangular coil of N turns and area A , carrying a current I , is placed in a uniform radial magnetic field of strength B .

The deflecting torque acting on the current-carrying coil due to the magnetic field is given by:

$$\tau_{\text{deflecting}} = NBIA$$



This deflecting torque causes the coil (along with the attached pointer) to rotate, and this rotation is opposed by a restoring torque provided by a spring (or suspension) attached to the coil. The restoring torque is proportional to the angle of deflection θ of the coil: $\tau_{\text{restoring}} = k\theta$

where k is the torsional constant (torque per unit twist) of the spring/suspension.

At equilibrium (i.e., when the coil comes to rest at its final deflected position), the deflecting torque exactly balances the restoring torque: $NBIA = k\theta$

Solving for θ : $\theta = \frac{NBA}{k} \times I$

Since N (number of turns), B (magnetic field strength), A (area of the coil), and k (torsional constant of the spring) are all constants for a given galvanometer, we can write: $\theta \propto I$



This proves that the deflection θ produced in a galvanometer is directly proportional to the current I flowing through it.

Numerical: A galvanometer with a coil of resistance $12\ \Omega$ shows a full scale deflection for a current of $2.5\ \text{mA}$. How will you convert it into an ammeter of range $0 - 2\ \text{A}$?

Answer: Given: Galvanometer resistance $G = 12\ \Omega$, full-scale deflection current $I_g = 2.5\ \text{mA} = 2.5 \times 10^{-3}\ \text{A}$, desired ammeter range: 0 to $2\ \text{A}$

To convert a galvanometer into an ammeter of a higher range, a small resistance called a shunt (S) must be connected in parallel with the galvanometer coil. This shunt provides a low-resistance bypass path for the majority of the current, allowing only a small fraction of the total current (equal to I_g) to pass through the galvanometer at full-scale deflection, while the rest of the current passes through the shunt.

At full-scale deflection, total current $I = 2\ \text{A}$ must be shared such that $I_g = 2.5 \times 10^{-3}\ \text{A}$ flows through the galvanometer, and the remaining current $(I - I_g)$ flows through the shunt.

Since the galvanometer and the shunt are connected in parallel, the potential difference across both must be equal: $I_g G = (I - I_g)S$

Solving for S : $S = \frac{I_g G}{I - I_g}$

$$S = \frac{(2.5 \times 10^{-3})(12)}{2 - 2.5 \times 10^{-3}}$$

$$S = \frac{0.03}{1.9975}$$

$$S \approx 0.01502\ \Omega$$

A shunt resistance of approximately $0.015\ \Omega$ (or $1.5 \times 10^{-2}\ \Omega$) must be connected in parallel with the galvanometer to convert it into an ammeter of range $0 - 2\ \text{A}$.

OR

Show that voltage leads current by $\pi/2$ in an inductive circuit.

Answer: Consider a pure inductor of inductance L connected across an AC source with instantaneous voltage: $V = V_0 \sin(\omega t)$

By Kirchhoff's voltage law, applying Faraday's law of electromagnetic induction to the inductor: $V =$

$$L \frac{dI}{dt}$$

$$V_0 \sin(\omega t) = L \frac{dI}{dt}$$

$$dI = \frac{V_0}{L} \sin(\omega t) dt$$

$$\text{Integrating both sides with respect to time: } I = \frac{V_0}{L} \int \sin(\omega t) dt = \frac{V_0}{L} \left(\frac{-\cos(\omega t)}{\omega} \right)$$



$$I = -\frac{V_0}{\omega L} \cos(\omega t)$$

Let $I_0 = \frac{V_0}{\omega L}$ (this is the peak/maximum current, and the quantity ωL is called the inductive reactance X_L).

$$I = -I_0 \cos(\omega t)$$

Using the trigonometric identity $-\cos(\omega t) = \sin\left(\omega t - \frac{\pi}{2}\right)$: $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

Comparing this expression for current with the given expression for voltage, $V = V_0 \sin(\omega t)$, we observe that the current I lags behind the voltage V by a phase angle of $\frac{\pi}{2}$ (i.e., 90°).

Equivalently, this means the voltage V leads the current I by a phase angle of $\frac{\pi}{2}$ in a purely inductive AC circuit.

Numerical: A transformer has 100 turns in its primary windings and 500 turns in its secondary windings. If the primary voltage and current are respectively 120 V and 3 A, what are the secondary voltage and current?

Answer: Given: $N_p = 100$ (turns in primary), $N_s = 500$ (turns in secondary), $V_p = 120$ V (primary voltage), $I_p = 3$ A (primary current)

Step 1: Calculate secondary voltage using the transformer turns ratio formula: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$$V_s = V_p \times \frac{N_s}{N_p} = 120 \times \frac{500}{100} = 120 \times 5 = 600 \text{ V}$$

Step 2: Calculate secondary current using the principle of conservation of energy (for an ideal transformer, input power = output power): $V_p I_p = V_s I_s$

$$I_s = \frac{V_p I_p}{V_s} = \frac{120 \times 3}{600} = \frac{360}{600} = 0.6 \text{ A}$$

Secondary voltage = **600 V**; Secondary current = **0.6 A**





Thank you!



We hope you found this material helpful. We wish you the very best for your examination.



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