



Learn Physics in Right Way

CUET(PG) Physics-2026
Solution-Mathematical Methods

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Q1. For particular integral of differential equation which of the following options are correct?

(A) $\frac{1}{f(D^2)} \sin ax = \frac{\sin ax}{f(-a^2)}$

(B) If $f(-a^2) = 0$, then $\frac{1}{f(D^2)} \sin ax = x \frac{\sin ax}{f'(-a^2)}$

(C) If $f(-a^2) = 0$, then $\frac{1}{f(D^2)} \sin ax = x \frac{\cos ax}{f'(-a^2)}$

(D) If $f'(-a^2) = 0$, then $\frac{1}{f(D^2)} \sin ax = x^2 \frac{\sin ax}{f''(-a^2)}$

Choose the **correct** answer from the options given below:

(a) A, B and C only

(b) A, B and D only

(c) A, C and D only

(d) B, C and D only

Ans.: (b)

Q2. Match List-I with List-II.

List-I	List-II
(A) $\vec{\nabla} \cdot \vec{A} = 0$	(I) $\vec{A}$ is conservative
(B) $\oint \vec{A} \cdot d\vec{r} = 0$	(II) $\vec{A}$ is irrotational
(C) $\vec{A} = \vec{\nabla} \phi$	(III) $\vec{A}$ is solenoidal
(D) $\vec{\nabla} \times \vec{A} = 0$	(IV) $\vec{A}$ point in the direction of maximum increase of the function ϕ

Choose the **correct** answer from the options given below:

(a) A-III, B-II, C-I, D-IV

(b) A-II, B-III, C-IV, D-I

(c) A-IV, B-III, C-I, D-II

(d) A-III, B-I, C-IV, D-II

Ans.: (d)

Q3. Match List-I with List-II.

List-I	List-II
(A) $ \sqrt{3} + i $	(I). $\sqrt{2}$
(B) Principal argument of $\sqrt{3} + i$	(II). 2
(C) $\left \frac{(1+i)^2}{1-i} \right $	(III). $\frac{3\pi}{4}$
(D) Principal argument of $\frac{(1+i)^2}{1-i}$	(IV). $\frac{\pi}{6}$

Choose the **correct** answer from the options given below:

(a) A-IV, B-II, C-III, D-I

(b) A-II, B-III, C-I, D-IV

(c) A-II, B-III, C-IV, D-I

(d) A-II, B-IV, C-I, D-III

Ans.: (d)**Solution.:**

(A) $|\sqrt{3} + i| = \sqrt{3+1} = 2$

(B) Principal argument of $\sqrt{3} + i = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = \frac{\pi}{6}$

(C) $\left| \frac{(1+i)^2}{1-i} \right| = \frac{|(1+i)^2|}{|1-i|} = \frac{|1+i|^2}{|1-i|} = \frac{(\sqrt{2})^2}{\sqrt{2}} = \sqrt{2}$

(D) $\frac{(1+i)^2}{1-i} = \frac{2i}{1-i} = \frac{2i(1+i)}{2} = -1+i.$

Principal argument of $\frac{(1+i)^2}{1-i} = \pi - \frac{\pi}{4} = \frac{3\pi}{4}$

Q4. The locus represented by $|z-4| + |z+4| = 10$ is (Where, $z = x+iy; i = \sqrt{-1}$)

(a) Circle

(b) Ellipse

(c) Parabola

(d) Hyperbola

Ans.: (2)**Solution.:** The equation $|z-4| + |z+4| = 10$ represents the locus of points where the sum of distances from two fixed points (4,0) and (-4,0) is a constant ($10 > 8$). This is the standard definition of an **ellipse**.

Q5. For the differential equation $(D^2 + 9)y = \cos 3x$, y can be written as:

(a) $A \cos 3x + B \sin 3x + \frac{x}{6} \cos 3x$

(b) $Ae^{3x} + 3 \cos 3x$

(c) $A \cos 3x + B \sin 3x + \frac{x}{6} \sin 3x$

(d) $A \cos 3x + B \sin 3x - \frac{x}{18} \sin 3x$

Ans.: (c)

Solution.: Characteristic Equation: $\lambda^2 + 9 = 0 \Rightarrow \lambda = \pm 3i$

Complementary Function: $y_c = A \cos 3x + B \sin 3x$

Particular Integral: $y_p = \frac{1}{D^2 + 9} \cos 3x = x \frac{1}{2D} \cos 3x = \frac{x}{6} \sin 3x$

General Solution: $y = y_c + y_p = A \cos 3x + B \sin 3x + \frac{x}{6} \sin 3x$

Q6. The temperature of the points in space is given by $T(x, y, z) = x^3 + y^2 + z$. A mosquito located at $(0, 1, 2)$ desires to fly in such a direction that it will get warm as soon as possible. In what direction should it move?

(a) $\frac{1}{\sqrt{2}}(2\hat{j} + \hat{k})$

(b) $\frac{1}{\sqrt{5}}(\hat{j} + 2\hat{k})$

(c) $\frac{1}{\sqrt{5}}(2\hat{j} + \hat{k})$

(d) $\frac{1}{\sqrt{14}}(3\hat{i} + 2\hat{j} + \hat{k})$

Ans.: (c)

Solution.: $\vec{\nabla}T = 3x^2\hat{x} + 2y\hat{y} + \hat{z} \Rightarrow \vec{\nabla}T|_{(0,1,2)} = 2\hat{y} + \hat{z}$

Unit Direction: $\hat{n} = \frac{\vec{\nabla}T|_{(0,1,2)}}{|\vec{\nabla}T|} = \frac{2\hat{y} + \hat{z}}{\sqrt{4+1}} = \frac{1}{\sqrt{5}}(2\hat{y} + \hat{z})$

Q7. Evaluate: $\oint_C (2xyz dx + x^2z dy + 2y dy + x^2y dz)$, where C is the curve $x^2 + y^2 + z^2 = 9$

(a) 3

(b) 6

(c) 9

(d) 0

Ans.: (d)

Solution.: $2xyz dx + x^2z dy + 2y dy + x^2y dz = (2xyz\hat{x} + (x^2z + 2y)\hat{y} + x^2y\hat{z}) \cdot (dx\hat{x} + dy\hat{y} + dz\hat{z})$

Where $\vec{F} = 2xyz\hat{x} + (x^2z + 2y)\hat{y} + x^2y\hat{z}$ and $d\vec{l} = dx\hat{x} + dy\hat{y} + dz\hat{z}$

$$\oint_C (2xyz dx + x^2z dy + 2y dy + x^2y dz) = \oint_C \vec{F} \cdot d\vec{l} = \int_S (\vec{\nabla} \times \vec{F}) \cdot d\vec{a}$$

$$\vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2xyz & (x^2z + 2y) & x^2y \end{vmatrix} = \hat{x}(x^2 - x^2) - \hat{y}(2xy - 2xy) + \hat{z}(2xz - 2xz) = 0$$

$$\Rightarrow \oint_C (2xyz dx + x^2z dy + 2y dy + x^2y dz) = \oint_C \vec{F} \cdot d\vec{l} = \int_S (\vec{\nabla} \times \vec{F}) \cdot d\vec{a} = 0$$

Q8. Consider 1st order differential equation $\sin x \frac{dy}{dx} + 2y = \tan x$. What is the integrating factor for this equation?

(a) $\sin^2\left(\frac{x}{2}\right)$ (b) $\cos^2\left(\frac{x}{2}\right)$

(c) $\tan^2\left(\frac{x}{2}\right)$ (d) $\cot^2\left(\frac{x}{2}\right)$

Ans.: (c)

Solution.:

$$\sin x \frac{dy}{dx} + 2y = \tan x \quad \sin x \frac{dy}{dx} + 2y = \tan x \Rightarrow \frac{dy}{dx} + \frac{2}{\sin x} y = \frac{\tan x}{\sin x} \Rightarrow \frac{dy}{dx} + (2 \csc x) y = \sec x$$

$$\text{Integrating Factor (I.F.): } I.F. = e^{\int 2 \csc x dx} = e^{2 \ln \left| \tan\left(\frac{x}{2}\right) \right|} = e^{\ln \tan^2\left(\frac{x}{2}\right)} = \tan^2\left(\frac{x}{2}\right)$$

Q9. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): For closed surface S, $\iint_S \vec{f} \cdot \hat{n} ds = \iiint_V \text{div } \vec{f} dv$

Reason (R): $\oint \vec{F} \cdot d\vec{r} = \iint \text{div } \vec{r} \cdot \hat{n} ds$

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
- (c) (A) is correct but (R) is not correct
- (d) (A) is not correct but (R) is correct

Ans.: (c)

Solution.: **Assertion (A):** Gauss's Divergence Theorem.

Reason (R): Statement incorrectly mixes line integral notation with surface/volume concepts and gives an invalid form of the theorem.

Q10. Find the volume of parallelopiped if $\vec{a} = -3\hat{i} + 7\hat{j} + 5\hat{k}$, $\vec{b} = -3\hat{i} + 7\hat{j} - 3\hat{k}$ and $\vec{c} = 7\hat{i} - 5\hat{j} - 3\hat{k}$ are the three co-terminous edge of the parallelopiped.

- (a) 68 units (b) 272 units
(c) 148 units (d) 488 units

Ans.: (b)

Solution.: The volume is given by the absolute value of the scalar triple product $|\vec{a} \cdot (\vec{b} \times \vec{c})|$.

$$\vec{a} \cdot (\vec{b} \times \vec{c}) = \begin{vmatrix} -3 & 7 & 5 \\ -3 & 7 & -3 \\ 7 & -5 & -3 \end{vmatrix} = -3(-21-15) - 7(9+21) + 5(15-49) = 108 - 210 - 170 = -272$$

So, volume $|-272| = 272$ units

Q11. The ratio of volume of tetrahedron having $\vec{A} + \vec{B}$, $\vec{B} + \vec{C}$, $\vec{C} + \vec{A}$ as concurrent edge to that of volume of tetrahedron having $\vec{A}, \vec{B}, \vec{C}$ as concurrent edges is:

- (a) $\frac{4}{3}$ (b) $\frac{2}{1}$ (c) $\frac{8}{1}$ (d) $\frac{4}{1}$

Ans.: (b)

Solution.: Tetrahedron having $\vec{A}, \vec{B}, \vec{C}$ as concurrent edges have volume

$$V_1 = \frac{1}{6} [\vec{A} \cdot (\vec{B} \times \vec{C})]$$

Tetrahedron having $\vec{A} + \vec{B}$, $\vec{B} + \vec{C}$, $\vec{C} + \vec{A}$ as concurrent edges have volume

$$V_2 = \frac{1}{6} [(\vec{A} + \vec{B}) \cdot ((\vec{B} + \vec{C}) \times (\vec{C} + \vec{A}))]$$

$$\begin{aligned} (\vec{A} + \vec{B}) \cdot ((\vec{B} + \vec{C}) \times (\vec{C} + \vec{A})) &= (\vec{A} + \vec{B}) \cdot (\vec{B} \times \vec{C} + \vec{B} \times \vec{A} + \vec{C} \times \vec{A}) = (\vec{A} + \vec{B}) \cdot (\vec{B} \times \vec{C} - \vec{A} \times \vec{B} + \vec{C} \times \vec{A}) \\ &= \vec{A} \cdot (\vec{B} \times \vec{C}) - \vec{A} \cdot (\vec{A} \times \vec{B}) + \vec{A} \cdot (\vec{C} \times \vec{A}) + \vec{B} \cdot (\vec{B} \times \vec{C}) - \vec{B} \cdot (\vec{A} \times \vec{B}) + \vec{B} \cdot (\vec{C} \times \vec{A}) \\ &= \vec{A} \cdot (\vec{B} \times \vec{C}) + \vec{B} \cdot (\vec{C} \times \vec{A}) = \vec{A} \cdot (\vec{B} \times \vec{C}) + \vec{A} \cdot (\vec{B} \times \vec{C}) = 2\vec{A} \cdot (\vec{B} \times \vec{C}) \end{aligned}$$

$$\because \vec{A} \cdot (\vec{A} \times \vec{B}) = 0, \vec{A} \cdot (\vec{C} \times \vec{A}) = 0, \vec{B} \cdot (\vec{B} \times \vec{C}) = 0, \vec{B} \cdot (\vec{A} \times \vec{B}) = 0$$

$$V_2 = \frac{1}{6} [2\vec{A} \cdot (\vec{B} \times \vec{C})]$$

Thus $V_2 : V_1 = 2 : 1$



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Solution- Mechanics and General Properties of Matter

Solution-Mechanics and General Properties of Matter
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Q12. The differential equation of planetary motion may be represented as:

(Here symbols carry their usual meanings)

(a) $\frac{d^2u}{d\theta^2} = -u - \frac{m^2}{l^2u^2} f\left(\frac{1}{u}\right)$

(b) $\frac{d^2u}{d\theta^2} = u - \frac{m^2}{l^2u^2} f\left(\frac{1}{u}\right)$

(c) $\frac{d^2u}{d\theta^2} = u + \frac{m^2}{l^2u^2} f\left(\frac{1}{u}\right)$

(d) $\frac{d^2u}{d\theta^2} = -u + f\left(\frac{1}{u}\right)$

Ans.: (a)

Q13. A satellite moves around the Earth in a circular motion at a distance of R from Earth's center. The satellite takes 24 hrs. to complete one rotation around the Earth. If the satellite is taken to an orbit of radius $\frac{R}{2}$ from Earth's center, then it will take time T for one rotation, the value of T is:

(a) $T = 12$ hrs.

(b) $T = 6$ hrs.

(c) $T = 6\sqrt{2}$ hrs.

(d) $T = 12\sqrt{2}$ hrs.

Ans.: (c)

Solution.: $T^2 \propto R^3 \Rightarrow \left(\frac{T_2}{T_1}\right)^2 = \left(\frac{R_2}{R_1}\right)^3 \Rightarrow \left(\frac{T}{24}\right)^2 = \left(\frac{R/2}{R}\right)^3 \Rightarrow \left(\frac{T}{24}\right)^2 = \frac{1}{8}$

$\Rightarrow \frac{T}{24} = \frac{1}{2\sqrt{2}} \Rightarrow T = \frac{12}{\sqrt{2}} = 6\sqrt{2}$ hrs

Q14. The motion of a particle under influence of central force is represented as $r = a \sin \theta$. The magnitude of the central force is proportional to:

(a) $\frac{1}{r^3}$

(b) $\frac{1}{r^5}$

(c) $\frac{1}{r^4}$

(d) $\frac{1}{r^2}$

Ans.: (b)

Solution.: $u = \frac{1}{r} = \frac{1}{a \sin \theta} = \frac{1}{a} \csc \theta \Rightarrow \frac{du}{d\theta} = -\frac{1}{a} \csc \theta \cot \theta$

$\frac{d^2u}{d\theta^2} = -\frac{1}{a} [-\csc^3 \theta - \csc \theta \cot^2 \theta] = \frac{1}{a} \csc \theta [\csc^2 \theta + \cot^2 \theta]$

$\frac{d^2u}{d\theta^2} + u = \frac{1}{a} \csc \theta [\csc^2 \theta + \cot^2 \theta + 1] = \frac{2}{a} \csc^3 \theta = 2a^2u^3$

$\therefore F(r) \propto u^2 \left(\frac{d^2u}{d\theta^2} + u \right) \propto u^2 (2a^2u^3) \propto u^5 \propto \frac{1}{r^5}$

Q15. Water is falling in a streamline from a circular tap downward under gravity, which of the following statements are true?

- (A) The horizontal cross-sectional area decreases.
- (B) The horizontal cross-sectional area increases.
- (C) The velocity of water increases.
- (D) Horizontal cross sectional area is equal throughout.

Choose the **correct** answer from the options given below:

- (a) C only
- (b) B and C only
- (c) A and C only
- (d) C and D only

Ans.: (c)

Solution.:

- As water falls, it accelerates due to gravity, so **velocity increases** (C is TRUE).
- By the equation of continuity $A.v = \text{constant}$, as velocity v increases, the horizontal cross-sectional area A **decreases** (A is TRUE).

Q16. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): When an aeroplane is flying in air horizontally, the air pressure below the aeroplane is higher compared to the above of it.

Reason (R): As per Bernoulli's theorem the total energy (Pressure + kinetic + Potential) is conserved for the flow of an ideal fluid.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
- (c) (A) is correct but (R) is not correct
- (d) (A) is not correct but (R) is correct

Ans.: (a)

Q17. Match List-I with List-II.

List-I System (with radius R and Mass M)	List-II Moment of Inertia
(A) Solid cylinder about the central axis	(I) $\frac{1}{2}MR^2$
(B) Solid sphere about its diameter	(II) MR^2
(C) Circular ring about the central axis	(III) $\frac{1}{2}MR^2$
(D) Circular ring about its diameter	(IV) $\frac{2}{5}MR^2$

Choose the **correct** answer from the options given below:

- (a) A-III, B-IV, C-II, D-I (b) A-III, B-IV, C-I, D-II
(c) A-III, B-II, C-I, D-IV (d) A-I, B-III, C-II, D-IV

Ans.: (a)

Solution.: (A) Solid cylinder about the central axis $\rightarrow$ (III) $\frac{1}{2}MR^2$

(B) Solid sphere about its diameter $\rightarrow$ (IV) $\frac{2}{5}MR^2$

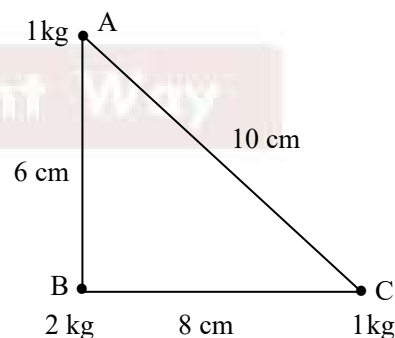
(C) Circular ring about the central axis $\rightarrow$ (II) MR^2

(D) Circular ring about its diameter $\rightarrow$ (I) $\frac{1}{2}MR^2$

Q18. Three particles of masses 2 kg, 1 kg and 1 kg are placed at the three corners of a right angle triangle of sides 8 cm, 6 cm and 10 cm as shown in the figure.

The center of mass of the system is located at:

- (a) 2 cm from B along BC and 1.5 cm above BC
(b) 1.5 cm from B along BC and 2 cm above BC
(c) $\frac{8}{3}$ cm from B along BC and 2 cm above BC
(d) $\frac{8}{3}$ cm from B along BC and 5 cm above BC



Ans.: (a)

Solution.: Coordinates of points: $B(0,0)$; $C(8,0)$; $A(0,8)$

$$X_{cm} = \frac{2(0) + 1(8) + 1(0)}{4} = 2 \text{ cm}, \quad Y_{cm} = \frac{2(0) + 1(0) + 1(6)}{4} = 1.5 \text{ cm}$$

Q19. Two particles are in static equilibrium with mutual potential energy $V = \frac{a}{r^2} - \frac{b}{r}$ ($a > 0, b > 0$, and $r \neq 0$). The separation between the particles is:

- (a) $\frac{a}{b}$ (b) $\frac{2a}{b}$
(c) $\frac{a}{2b}$ (d) $\frac{2b}{a}$

Ans.: (b)

Solution.: At equilibrium,

$$\frac{dV}{dr} = 0 \Rightarrow -\frac{2a}{r^3} + \frac{b}{r^2} = 0 \Rightarrow \frac{2a}{r^3} = \frac{b}{r^2} \Rightarrow \frac{2a}{r} = b \Rightarrow r = \frac{2a}{b} \quad \because V = \frac{a}{r^2} - \frac{b}{r}$$

Q20. The velocity profile of a liquid flowing through a capillary (under streamline motion) is:

- (a) Parabolic (b) Straight line
(c) Circular (d) Hyperbolic

Ans.: (a)

Q21. The product of generalised co-ordinate and its conjugate momentum has the dimension of:

- (a) Force (b) Energy
(c) Angular momentum (d) Linear momentum

Ans.: (c)

Solution.: The product pq has dimensions of Action or Angular Momentum ($kg - m^2 / \text{sec}$).

Q68. Which of the statements are true?

- (A) Gravitational force is conservative force
(B) Frictional force is non conservative force
(C) Centrifugal force is pseudo force
(D) Coriolis force is non-pseudo force

Choose the **correct** answer from the options given below:

- (a) A, C and D only (b) B, C and D only
(c) A, B and C only (d) A, B, C and D only

Ans.: (c)



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CUET(PG) Physics-2026
Solution- Oscillations, Waves and Optics

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Q22. A beam of light of wavelength 600 nm is focused by a converging lens of diameter 20.0 cm at a distance of 10 cm from it. The diameter of the central bright disc in the diffraction pattern will be:

- (a) $3.6 \times 10^{-5} \text{ cm}$ (b) $7.3 \times 10^{-5} \text{ cm}$
(c) $1.22 \times 10^{-5} \text{ cm}$ (d) $2.44 \times 10^{-5} \text{ cm}$

Ans.: (b)

Solution.: The diameter of the Airy disc (central bright disc) formed by a circular aperture is:

$$d = 2.44 \frac{\lambda f}{D}.$$

$$\Rightarrow d = 2.44 \frac{(600 \times 10^{-7} \text{ cm}) 10 \text{ cm}}{20 \text{ cm}} = 7.3 \times 10^{-5} \text{ cm}$$

Q24. Which of the following statements are correct?

- (A) If the image is virtual, the corresponding object is virtual.
(B) The image of a virtual object is virtual.
(C) If the final rays are converging, we have a real image.
(D) The image formed by a concave mirror is certainly real if the object is virtual.
(E) Total internal reflection can take place only if light goes from optically rarer medium to denser medium.

Choose the **correct** answer from the options given below:

- (a) A, B, D only (b) A, B, C, E only
(c) B, C, E only (d) C, D only

Ans.: (d)

Solution.:

(A) False: A virtual image can be formed by a real object (e.g., a plane mirror).

(B) False: A virtual object can form a real image (e.g., light falling on a convex lens or concave mirror).

(C) True: If rays converge to a point after refraction/reflection, a real image is formed.

(D) True: A virtual object lies behind the mirror ($u > 0$). Using $\frac{1}{v} + \frac{1}{u} = -\frac{1}{f}$ gives

$\frac{1}{v} = -\frac{1}{f} - \frac{1}{u} < 0$, so v is always negative (in front of the mirror), making the image real.

(E) False: Total internal reflection occurs only when light goes from an optically **denser** to a **rarer** medium.

Q25. Which of the following statements are true for sound waves?

- (A) A wave going in a solid may be transverse
- (B) A wave going in a solid may be longitudinal
- (C) A wave moving in a gas must be longitudinal
- (D) A standing wave is produced on a clamped at one end and free at other. The length of the string must be integral multiple of $\frac{\lambda}{2}$
- (E) Longitudinal wave cannot have a unique wavelength

Choose the **correct** answer from the options given below:

- (a) A, D and E only
- (b) A, B and C only
- (c) A, B and E only
- (d) B, C and D only

Ans.: (b)

Solution.:

(A) True: Sound/elastic waves in solids can be transverse (shear waves).

(B) True: Sound waves in solids can also be longitudinal (compressional waves).

(C) True: Fluids (gases) lack shear strength, so sound waves in gases must be purely longitudinal.

(D) False: For a string clamped at one end and free at the other, $L = (2n-1)\frac{\lambda}{4}$, which is an odd multiple of $\frac{\lambda}{4}$, not an integral multiple of $\frac{\lambda}{2}$.

(E) False: Longitudinal waves can certainly have a unique wavelength.

Q26. The rays of different colours fail to converge at a point after going through a converging lens. This defect is called:

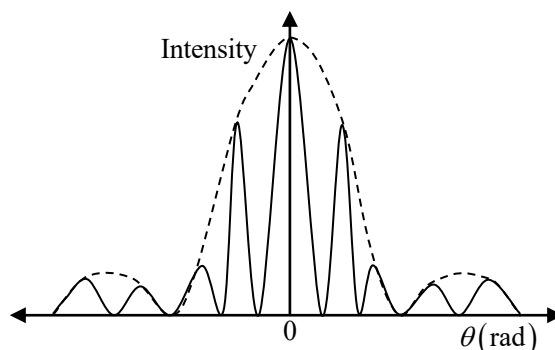
- (a) distortions
- (b) chromatic aberrations
- (c) spherical aberration
- (d) coma

Ans.: (b)

Solution.:

Chromatic aberration occurs because a lens has different focal lengths for different wavelengths of light, preventing all colors from focusing at a single point.

Q27. The intensity pattern in the figure is representation of:



- (a) Single slit diffraction pattern
- (b) Double slit diffraction pattern
- (c) Diffraction pattern due to grating
- (d) Fresnel diffraction pattern

Ans.: (b)

Solution.: The image shows a double-slit diffraction pattern (Fraunhofer double-slit), where fine Young's interference fringes are modulated by a broader single-slit diffraction envelope.

Q28. Which of the following equations represents a wave travelling along y-axis?

- (a) $y = A \cos ky \sin \omega t$
- (b) $y = A \sin ky \cos \omega t$
- (c) $x = A \sin(ky - \omega t)$
- (d) $y = A \sin(kx - \omega t)$

Ans.: (c)

Solution.:

A plane progressive wave traveling along the positive y-axis is represented as a function of $(ky - \omega t)$. Here, the spatial position variable must be y, while x represents the displacement perpendicular to the direction of propagation.

$$x = A \sin(ky - \omega t)$$

Q29. Match List-I with List-II.

The pendulum under-going simple harmonic motion with time period T is placed in a lift.

List-I Condition	List-II New time period
(A) Lift is moving upward with acceleration $g/4$	(I) T
(B) Lift is moving downward with acceleration $g/4$	(II) $\frac{2T}{\sqrt{5}}$
(C) Lift is moving upward with constant velocity	(III) $\frac{T}{\sqrt{\cos \theta}}$
(D) Lift is falling freely in an inclined plane of inclination θ	(IV) $\frac{2T}{\sqrt{3}}$

Choose the **correct** answer from the options given below:

(a) A-IV, B-II, C-III, D-I

(b) A-II, B-IV, C-I, D-III

(c) A-II, B-I, C-IV, D-III

(d) A-II, B-IV, C-III, D-I

Ans.: (b)

Solution.:

(A) Upward acceleration $g/4$: $g_{\text{eff}} = g + g/4 = \frac{5g}{4} \Rightarrow T' = T \sqrt{\frac{g}{g_{\text{eff}}}} = T \sqrt{\frac{g}{5g/4}} = \frac{2T}{\sqrt{5}} \rightarrow \text{(II)}$

(B) Downward acceleration $g/4$: $g_{\text{eff}} = g - g/4 = \frac{3g}{4} \Rightarrow T' = T \sqrt{\frac{g}{g_{\text{eff}}}} = T \sqrt{\frac{g}{3g/4}} = \frac{2T}{\sqrt{3}} \rightarrow \text{(IV)}$

(C) Constant velocity, $a = 0$: $g_{\text{eff}} = g \Rightarrow T' = T \sqrt{\frac{g}{g_{\text{eff}}}} = T \sqrt{\frac{g}{g}} = T \rightarrow \text{(I)}$

(D) Freely sliding down an inclined plane $g/4$: $g_{\text{eff}} = g \cos \theta$

$$\Rightarrow T' = T \sqrt{\frac{g}{g_{\text{eff}}}} = T \sqrt{\frac{g}{g \cos \theta}} = \frac{T}{\sqrt{\cos \theta}} \rightarrow \text{(III)}$$

Q30. Two bodies of equal mass m are connected to two identical springs of spring constant k as shown in fig 1 and fig 2. The springs are suspended vertically. They execute oscillations with the period T_1 (fig. 1) and T_2 (fig. 2) respectively.

The ratio of T_1 and T_2 is:

- (a) $\sqrt{2} : 1$
- (b) $2 : 1$
- (c) $1 : 2$
- (d) $1 : \sqrt{2}$

Ans.: (b)

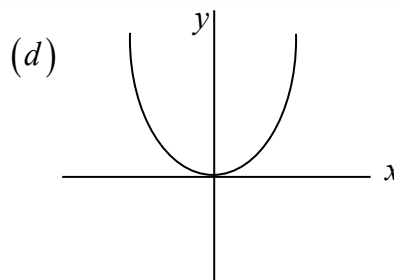
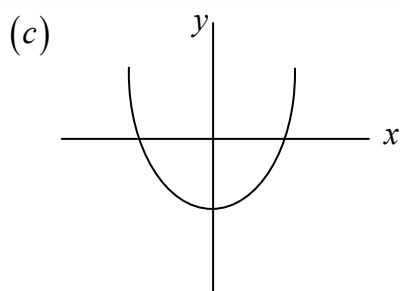
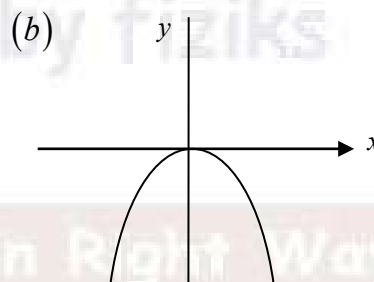
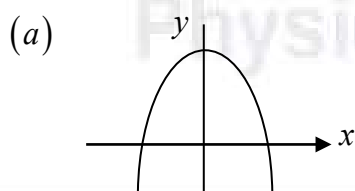
Solution.:

Fig. 1 (Series Connection): $k_{eq1} = \frac{k}{2} \Rightarrow T_1 = 2\pi\sqrt{\frac{m}{k/2}} = 2\pi\sqrt{\frac{2m}{k}}$

Fig. 2 (Parallel Connection): $k_{eq2} = 2k \Rightarrow T_2 = 2\pi\sqrt{\frac{m}{2k}} = 2\pi\sqrt{\frac{m}{2k}}$

$$\Rightarrow \frac{T_1}{T_2} = \frac{\sqrt{2}}{1/\sqrt{2}} = \frac{2}{1} \Rightarrow T_1 : T_2 = 2 : 1$$

Q31. A particle moves under two simple harmonic motion $x = a \sin \omega t$, $y = a \cos 2\omega t$ [consider a is +ve constant] The trajectory of the particle is:



Ans.: (a)

Solution.: Given $x = a \sin \omega t$, $y = a \cos 2\omega t$

$$\sin \omega t = \frac{x}{a}, y = a(1 - 2 \sin^2 \omega t) \Rightarrow y = a \left(1 - 2 \frac{x^2}{a^2}\right) \Rightarrow y = a - \frac{2}{a} x^2$$

This represents a downward-opening parabola with its vertex at $(0, a)$ on the $+y$ axis.

Q32. A particle is subjected to two simple harmonic motion $y_1 = a \sin \omega t$ and $y_2 = b \sin(\omega t + \pi)$.

The maximum speed of the particle is:

- (a) $(a+b)\omega$ (b) $(a-b)\omega$
(c) $(\sqrt{a^2+b^2})\omega$ (d) $(\sqrt{a^2-b^2})\omega$

Ans.: (b)

Solution.: Resultant Amplitude: $y = y_1 + y_2 = a \sin \omega t + b \sin(\omega t + \pi) = (a-b) \sin \omega t$

Maximum Speed: $v_{\max} = A_{\text{net}} \omega = (a-b)\omega$

Q33. When the width of the slit decreases in a single slit diffraction experiment, then the fringe width (β):

- (a) increases
(b) decreases
(c) does not change
(d) does not change but intensity of the fringes decreases

Ans.: (a)

Solution.: The angular width of the central maximum in single-slit diffraction is $\theta \approx \frac{\lambda}{a}$.

Decreasing the slit width (a) causes the diffraction pattern to spread out, thereby increasing the fringe width (β).



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Solution- Electricity and Magnetism

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Q34. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): If a magnetic north pole of a bar magnet is moving towards a circular conducting loop, the current will flow in the loop in the clockwise direction from the magnet.

Reason (R): An induced current has a direction such that the magnetic field due to the induced current opposes the change in the magnetic flux that induces the current.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
- (c) (A) is correct but (R) is not correct
- (d) (A) is not correct but (R) is correct

Ans.: (d)

Solution.:

Assertion (A): When a magnetic north pole approaches a circular loop, the induced magnetic field opposes the increase in flux by pointing towards the magnet (North pole facing the magnet). Looking from the side of the magnet, the current flows in the **anticlockwise** direction. Therefore, Assertion (A) is incorrect.

Reason (R): This is the precise statement of Lenz's law, which is correct.

Q35. A charge $+Q$ is enclosed by a cube of side L . Which of the following statements are true?

(A) The total electric flux through all surfaces $= \frac{Q}{\epsilon_0}$

(B) The electric flux through one surface $= \frac{QL^2}{\epsilon_0}$

(C) The electric flux through one surface $= \frac{Q}{6\epsilon_0}$

(D) The electric fields come out through the surfaces

Choose the **correct** answer from the options given below:

- (a) A, B and D only
- (b) B, C and D only
- (c) A, C and D only
- (d) A, B and C only

Ans.: (c)

Solution.:

(A) **True:** According to Gauss's Law, the total electric flux through a closed surface enclosing a charge Q is $\frac{Q}{\epsilon_0}$.

(B) **False:** The flux through one surface is not $\frac{QL^2}{\epsilon_0}$. This expression has incorrect dimensions.

(C) **True:** By symmetry, the total flux is equally distributed among the 6 faces of the cube. So, the flux through one surface is $\frac{Q}{6\epsilon_0}$.

(D) **True:** Electric field lines originate from a positive charge and go outwards. Since the charge is inside the cube, the electric field lines will come out through the surfaces.

Q36. Match List-I with List-II. [Symbols have their usual meaning]

List-I	List-II
(A) Parallel plate capacitor	(I) $C = 4\pi \epsilon_0 \frac{ab}{b-a}$
(B) Cylindrical capacitor formed by two co-axial cylinder of radii a and b	(II) $C = \frac{\epsilon_0 A}{d}$
(C) Spherical capacitor consisting of two concentric spherical shells of radii a and b	(III) $C = 4\pi \epsilon_0 a$
(D) An isolated sphere of radius a	(IV) $C = 2\pi \epsilon_0 \frac{L}{(b/a)}$

Choose the **correct** answer from the options given below:

- (a) A-II, B-IV, C-I, D-III (b) A-II, B-I, C-III, D-IV
(c) A-III, B-IV, C-I, D-II (d) A-IV, B-II, C-III, D-I

Ans.: (a)

Q37. Which of the following statements are true?

(A) The energy per unit time, per unit area, transported by the fields is called the Poynting vector

(B) The Poynting vector can be expressed as $\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$ (in SI unit)

(C) The total energy transported by the field is called the Poynting vector

(D) The differential form of Poynting's theorem $-\vec{\nabla} \cdot \vec{S} = \frac{\partial}{\partial t} (u_{mech} + u_{em})$

(u_{mech} = mechanical energy density, u_{em} -electromagnetic energy density)

Choose the **correct** answer from the options given below:

- (a) A, B and D only (b) C and D only
(c) A, B and C only (d) B and D only

Ans.: (a)

Solution.:

(A) True: The Poynting vector represents the energy per unit time, per unit area, transported by electromagnetic fields.

(B) True: In SI units, $\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$.

(C) False: The Poynting vector is the energy flux density, not the total energy.

(D) True: This is the differential form of Poynting's theorem, representing energy conservation.

Q38. The displacement current (i_d):

- (A) involves motion of free charges (B) can produce magnetic field
(C) is introduced by Maxwell (D) can produce Joule heating
(E) in the capacitor have the same value as the real current i charging the capacitor ($i_d = i$)

Choose the **correct** answer from the options given below:

- (a) A, B and C only (b) B, C and E only
(c) C, D and E only (d) A, D and E only

Ans.: (b)

Solution.:

(A) False: Displacement current is not due to the motion of free charges, but due to a time-varying electric field.

(B) True: A time-varying electric field (displacement current) produces a magnetic field, just like a conduction current.

(C) True: Maxwell introduced the concept of displacement current to make Ampere's circuital law consistent for time-varying fields.

(D) False: Displacement current does not involve the motion of charges, so it does not produce Joule heating.

(E) True: For a charging capacitor, the displacement current between the plates is equal to the conduction current in the wires.

Q39. Match List-I with List-II.

The circuits are connected to alternating emf sources.

List-I	List-II
(A) Pure resistive circuit	(I) The current leads the potential by 90° phase difference
(B) Pure inductive circuit	(II) The current and the potential difference are in phase
(C) Pure capacitive circuit	(III) The current and the potential differ by 90° phase [Lag or lead will depend on value of L and C]
(D) Pure inductive - capacitive (LC) circuit	(IV) The current lags the potential by 90° phase difference

Choose the **correct** answer from the options given below:

- (a) A-II, B-IV, C-III, D-I (b) A-II, B-I, C-IV, D-III
(c) A-II, B-IV, C-I, D-III (d) A-I, B-II, C-III, D-IV

Ans.: (c)

Solution.: (A) Pure resistive circuit: Current and potential difference are in phase $\rightarrow II$

(B) Pure inductive circuit: Current lags potential by $90^\circ \rightarrow IV$

(C) Pure capacitive circuit: Current leads potential by $90^\circ \rightarrow I$

(D) Pure LC circuit: Phase difference depends on values of L and C $\rightarrow III$

Q40. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): The electrostatic force between two positively charged particles q_1 and q_2

separated by a distance d is given by $\vec{F} = \frac{1}{\epsilon_0} \frac{q_1 q_2}{d^2} \hat{d} \ (d \neq 0)$

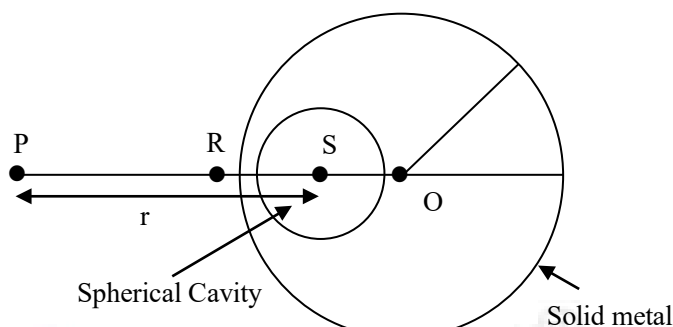
Reason (R): Two similar charges repel each other and apply forces according to the Coulomb's Law.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
(c) (A) is correct but (R) is not correct
(d) (A) is not correct but (R) is correct

Ans.: (d)

Q41. A solid metal sphere with a spherical cavity has a total charge $+Q$. S is the center of the spherical cavity, R is just outside the metal sphere and P is little away from the metal sphere as shown in figure. The relation between the magnitude of the electric field (E) at S , R and P are:



(a) $E_P < E_R < E_S$

(b) $E_R > E_P > E_S$

(c) $E_R < E_P < E_S$

(d) $E_P > E_R > E_S$

Ans.: (b)

Solution.: Point S is inside a cavity within a conductor, where the electric field is zero ($E_S = 0$).

For points outside the metal sphere, $E \propto \frac{1}{r^2}$. Since point R is closer to the surface than P ($r_R < r_P$), hence $E_R > E_P > E_S$.

Q42. Eight (8) electrons (of charge $-e$) are equally spaced and fixed on the perimeter around a circle of radius r . If there is no other charge nearby, the electric field E and the electric potential V at the centre of the circle will be:

(a) $V = \frac{-1}{32\pi\epsilon_0} \frac{e}{r}$; $\vec{E} = 0$

(b) $V = \frac{-8}{4\pi\epsilon_0} \frac{e}{r}$; $\vec{E} = \frac{8}{4\pi\epsilon_0} \frac{e}{r^2} \hat{r}$

(c) $V = \frac{-8}{4\pi\epsilon_0} \frac{e}{r}$; $\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{e}{r^2} \hat{r}$

(d) $V = \frac{-2}{\pi\epsilon_0} \frac{e}{r}$; $\vec{E} = 0$

Ans.: (d)

Solution.: By symmetry, diametrically opposite charges create equal and opposite electric fields at the center, so $\vec{E} = 0$

Potential is a scalar sum:

$$V = 8 \times \left(-\frac{1}{4\pi\epsilon_0} \frac{e}{r} \right) = \frac{-2}{\pi\epsilon_0} \frac{e}{r}$$

Q43. The electric field just outside a charged infinite plane conductor with surface charge density σ is given by:

(a) $\frac{\sigma}{2\epsilon_0}$

(b) $\frac{\sigma}{\epsilon_0}$

(c) $\frac{\sigma}{\epsilon_0 d}$

(d) $\frac{\sigma}{4\pi\epsilon_0}$

Ans.: (b)

Solution.: The electric field just outside a charged conductor surface is $E = \frac{\sigma}{\epsilon_0}$.

Q44. A charge $+Q$ is placed in front of an infinite metal plate at a distance r . If another charge is placed at the same point instead of the 1st one, it experiences twice the force, then the value of the 2nd charge is:

(a) $4Q$

(b) $\sqrt{2}Q$

(c) $2Q$

(d) $\frac{Q}{\sqrt{2}}$

Ans.: (c)

Solution.: The electric field just outside a charged conductor surface is $E = \frac{\sigma}{\epsilon_0}$.

Force on $F_1 = +QE = \frac{\sigma}{\epsilon_0}Q$ and $F_2 = q'E = \frac{\sigma}{\epsilon_0}q'$.

$$\therefore F_2 = 2F_1 \Rightarrow \frac{\sigma}{\epsilon_0}q' = 2\frac{\sigma}{\epsilon_0}Q \Rightarrow q' = 2Q$$

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Solution- Kinetic Theory, Thermodynamics

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Q70. Two carnot engines A and B are operated in series. Engine A absorbs heat at 250 K and rejects heat to a sink at temperature T. Engine B absorbs half of the heat rejected by engine A and rejects the heat to the sink at 100 K. If the work done in both the case is equal, then the value of T will be:

- (a) 200 K (b) 175 K
(c) 150 K (d) 300 K

Ans.: (a)

Solution.:

$$W_A = Q_{1A} - Q_{2A}, \quad T_{1A} = 250K, \quad T_{2A} = T$$

$$\therefore \frac{Q_{1A}}{T_{1A}} = \frac{Q_{2A}}{T_{2A}} \Rightarrow Q_{2A} = \frac{Q_{1A}}{T_{1A}} T_{2A} = \frac{Q_{1A}}{250} T \Rightarrow W_A = Q_{1A} \left(1 - \frac{T}{250} \right)$$

$$W_B = Q_{1B} - Q_{2B}, \quad Q_{1B} = \frac{1}{2} Q_{2A} = \frac{1}{2} \left(\frac{Q_{1A}}{250} T \right), \quad T_{1B} = T, \quad T_{2B} = 100K$$

$$\therefore \frac{Q_{1B}}{T_{1B}} = \frac{Q_{2B}}{T_{2B}} \Rightarrow Q_{2B} = \frac{Q_{1B}}{T_{1B}} T_{2B} = \frac{Q_{1B}}{T} 100 \Rightarrow W_B = Q_{1B} \left(1 - \frac{100}{T} \right) = \frac{1}{2} \left(\frac{Q_{1A}}{250} T \right) \left(1 - \frac{100}{T} \right)$$

$$\therefore W_B = W_A$$

$$\Rightarrow \frac{1}{2} \left(\frac{Q_{1A}}{250} T \right) \left(1 - \frac{100}{T} \right) = Q_{1A} \left(1 - \frac{T}{250} \right) \Rightarrow \frac{T-100}{2} = 250 - T \Rightarrow T - 100 = 500 - T$$

$$\Rightarrow T - 100 = 500 - 2T \Rightarrow 3T = 600 \quad \Rightarrow T = 200K$$

Q71. On the resistance scale for a platinum resistance thermometer, the temperature is defined as:(where symbols carry their usual meanings)

$$(a) \theta_R = \frac{R_{100} - R_0}{R_\theta - R_0} \times 100$$

$$(b) \theta_R = \frac{(R_\theta - R_0)}{R_{100} - R_0} \times 100$$

$$(c) \theta_R = \frac{R_\theta - R_0}{R_{100} - R_0}$$

$$(d) \theta_R = \frac{R_{100} - R_0}{R_\theta - R_0}$$

Ans.: (b)

Q72. Which of the following statements are true?

- (A) For indistinguishable particles, a specification of the total number of particles in each energy state defines a microstate
- (B) In Bose-Einstein condensation bosons accumulate in lower energy levels and large number of them occupy ground state
- (C) For a system of distinguishable particles, a specification of energy state and energy level of each particles defines a microstate
- (D) A given microstate may consist of a number of macrostates
- (E) Entropy is proportional to logarithm of the thermodynamic probability

Choose the **correct** answer from the options given below:

- (a) A, B and C only
- (b) B, C and E only
- (c) A, C and D only
- (d) A, B, D and E only

Ans.: (b)

Solution.:

(A) False: For indistinguishable particles, specifying the occupation number of each energy level (not state) defines a macrostate, while quantum numbers or wavefunctions define microstates.

(B) True: Below the critical temperature, a macroscopically large fraction of bosons condense into the ground state.

(C) True: For distinguishable particles (classical system), specifying the exact state and energy level of each individual particle uniquely defines a microstate.

(D) False: A **macrostate** consists of a number of **microstates** (W), not the other way around.

(E) True: Boltzmann's entropy formula states $S = k_B \ln \Omega$ is the thermodynamic probability (number of microstates).

Q73. Two moles of a perfect monoatomic gas, initially kept in a cylinder at a standard pressure and temperature are made to expand until its volume is doubled. Which of the following statement is correct?

- (A) Heat transfer will be maximum in adiabatic process
- (B) Heat transfer will be minimum in isobaric process
- (C) Change in internal energy is greatest in isothermal process
- (D) Change in internal energy is least in isobaric process
- (E) Maximum work is done if the expansion is isobaric

Choose the **correct** answer from the options given below:

- (a) E only
- (b) A, B and E only
- (c) C and D only
- (d) A, B and D only

Ans.: (a)

Solution.: For a given volume expansion ($\Delta V = V_f - V_i > 0$):

Work Done (W):

The area under the P-V curve is maximum for an **isobaric process** ($W = p\Delta V$).

Thus, **(E)** is correct.

Heat Transfer (Q):

$Q = 0$ in an adiabatic process, so heat transfer is zero (minimum), thus **(A)** false.

Heat transfer is maximum in isobaric, thus **(B)** false.

Internal Energy ($\Delta U = nC_v\Delta T$):

For an isothermal process, $\Delta T = 0$ (least change), while the change in temperature is maximum for isobaric, making **(C)** and **(D)** false.

Q74. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): At a constant temperature, increase in pressure makes the sequence of phase changes (gas, liquid, solid) for water which is different from that of most other materials.

Reason (R): Volume of water increases as temperature increases from 0°C to 4°C .

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
- (c) (A) is correct but (R) is not correct
- (d) (A) is not correct but (R) is correct

Ans.: (c)

Solution.:

Assertion (A) is Correct: Water expands upon freezing, giving ice a negative $\frac{dP}{dT}$ slope for the solid-liquid phase boundary. Increasing pressure at constant temperature near 0°C melts ice into liquid water, which is anomalous behavior compared to most substances.

Reason (R) is Incorrect: The density of water is maximum at 4°C . Therefore, as temperature increases from 0°C to 4°C , the **volume of water decreases** (it contracts), not increases.

Q75. The average energy of a molecule obeying Maxwell's Law is:

(a) $\frac{1}{2}K_B T$

(b) $\frac{3}{2}K_B T$

(c) $K_B T$

(d) $2K_B T$

Ans.: (b)

Solution.:

According to the Maxwell-Boltzmann distribution and the Law of Equipartition of Energy, a monoatomic gas molecule in 3 dimensions has 3 translational degrees of freedom, each contributing $\frac{1}{2}K_B T$ to the average kinetic energy:

$$\langle E \rangle = 3 \left(\frac{1}{2} K_B T \right) = \frac{3}{2} K_B T$$

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Solution- Modern Physics

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Q23. Match List-I with List-II.

List-I	List-II
(A) Becquerel	(I) neutron
(B) Rutherford	(II) nuclear fission
(C) Chadwick	(III) radioactivity
(D) Hahn and Strassmann	(IV) alpha particle

Choose the **correct** answer from the options given below:

(a) A-I, B-IV, C-II, D-III

(b) A-III, B-IV, C-I, D-II

(c) A-II, B-III, C-I, D-IV

(d) A-IV, B-I, C-III, D-II

Ans.: (b)

Solution.:

(A) **Becquerel**: Discovered natural radioactivity → (III)

(B) **Rutherford**:

Discovered the atomic nucleus through alpha particle scattering experiments → (IV)

(C) **Chadwick**: Discovered the neutron → (I)

(D) **Hahn and Strassmann**: Discovered nuclear fission → (II)

Q45. Relationship between energy and momentum for a relativistic particle is: (Here ' m ' is the rest mass of the particle, and other symbols have their usual meanings)

(a) $E^2 = (mc^2)^2 + p^2c^2$

(b) $E = mc^2 + pc$

(c) $E^2 = (mc^2)^2 - p^2c^2$

(d) $E = mc^2 - pc$

Ans.: (a)

Solution.:

$$E^2 = (mc^2)^2 + p^2c^2 = m^2c^4 + p^2c^2$$

Q46. Match List-I with List-II.

List-I Quantity	List-II Operator
(A) Linear momentum, P	(I) $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + U(x)$
(B) Kinetic energy, $KE = \frac{P^2}{2m}$	(II) $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2}$
(C) Total energy, E	(III) $i\hbar \frac{\partial}{\partial t}$
(D) Total energy, H (Hamiltonian)	(IV) $\frac{\hbar}{i} \frac{\partial}{\partial x}$

Choose the **correct** answer from the options given below:

(a) A-IV, B-II, C-III, D-I

(b) A-I, B-II, C-IV, D-III

(c) A-II, B-IV, C-III, D-I

(d) A-III, B-I, C-II, D-IV

Ans.: (a)

Solution.:

(A) Linear momentum (P): $\frac{\hbar}{i} \frac{\partial}{\partial x} \rightarrow \text{(IV)}$

(B) Kinetic energy ($KE = \frac{P^2}{2m}$): $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} \rightarrow \text{(II)}$

(C) Total energy (E): $i\hbar \frac{\partial}{\partial t} \rightarrow \text{(III)}$

(D) Hamiltonian (H): $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + U(x) \rightarrow \text{(I)}$

Q47. A particle confined along x -axis has the wave function $\psi = ax$ between $x=0$ and $x=1$. $\psi = 0$ elsewhere. The expectation value of the particle's position will be:

(a) $\frac{3}{4}$

(b) $\frac{1}{2}$

(c) $\frac{2}{3}$

(d) $\frac{4}{5}$

Ans.: (a)

Solution.: Normalize $\psi(x)$: $\int_0^1 |\psi(x)|^2 dx = a^2 \int_0^1 x^2 dx = \frac{a^2}{3} = 1 \Rightarrow a^2 = 3$

Calculate Expectation Value $\langle x \rangle = \int_0^1 x |\psi(x)|^2 dx = a^2 \int_0^1 x^3 dx = 3 \times \frac{1}{4} = \frac{3}{4}$

Q48. Spacecraft A is moving at $0.5c$ with respect to earth. If spacecraft B is to pass A at relative speed of $0.3c$ in the same direction, what speed must B have with respect to the earth?

[c = Speed of light in air]

- (a) $0.2c$ (b) $0.8c$
(c) $0.6c$ (d) $0.7c$

Ans.: (d)

Solution.: Relativistic Velocity Addition: Velocity of A w.r.t. Earth: $v = 0.5c$

Velocity of B w.r.t. A: $u' = 0.3c$

$$\text{Velocity of B w.r.t. Earth: } u = \frac{u' + v}{1 + \frac{u'v}{c^2}} = \frac{0.3c + 0.5c}{1 + (0.3)(0.5)} = \frac{0.8c}{1.15} \approx 0.7c$$

Q49. The binding energy E_b in MeV of the nucleus A_ZX with $N = A - Z$ neutrons is given by:

- (a) $E_b = \left[m({}^A_ZX) - Zm({}^1_1H) - Nm(n) \right] / (931.49 \text{ MeV/u})$
(b) $E_b = \left[m({}^A_ZX) - Zm({}^1_1H) - Nm(n) \right] (931.49 \text{ MeV/u})$
(c) $E_b = \left[Zm({}^1_1H) + Nm(n) - m({}^A_ZX) \right] / (931.49 \text{ MeV/u})$
(d) $E_b = \left[Zm({}^1_1H) + Nm(n) - m({}^A_ZX) \right] (931.49 \text{ MeV/u})$

Ans.: (d)

Solution.: Binding energy is the energy equivalent to the mass defect

$$\Delta m = Zm({}^1_1H) + Nm(n) - m({}^A_ZX)$$

$$\text{Expressed in MeV: } E_b = \left[Zm({}^1_1H) + Nm(n) - m({}^A_ZX) \right] (931.49 \text{ MeV/u})$$

Q50. In relation to photoelectric effect which of the following statements are correct?

- (A) The energies of electrons liberated by light depend upon the frequency of the light.
(B) The stopping potential depends upon the frequency of light.
(C) The stopping potential is same for the all intensities of light of the same frequency.
(D) Photoelectron current is proportional to the light intensity for all retarding voltages.
(E) Maximum kinetic energy of photoelectron is inversely proportional to the frequency of incident light.

Choose the **correct** answer from the options given below:

- (a) A, B, C and D only (b) A, B, C and E only
(c) B, C and D only (d) A, C, D and E only

Ans.: (a)

Solution.:

- (A) True: Kinetic energy of emitted electrons depends on frequency ($K_{\max} = h\nu - \Phi$).
- (B) True: Stopping potential is directly related to maximum kinetic energy ($eV_0 = K_{\max}$).
- (C) True: Stopping potential is independent of intensity.
- (D) True: Photoelectric current is proportional to light intensity (provided voltage is non-retarding/above threshold).
- (E) False: $K_{\max}$ is directly proportional to frequency, not inversely.

Q51. In the radioactive decay, the relation between mean life time ($\bar{T}$) and half-life ($T_{1/2}$) is given by:

- (a) $\bar{T} = 1.96T_{1/2}$ (b) $\bar{T} = 1.44T_{1/2}$ (c) $\bar{T} = 4.62T_{1/2}$ (d) $\bar{T} = 5.92T_{1/2}$

Ans.: (b)

Q52. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A): In many-electron atom the orbital motion of electron creates magnetic field that interact with their magnetic moments.

Reason (R): If the angular momentum of individual electrons are specified, the total angular momentum can be known.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

- (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (b) Both (A) and (R) are correct but (R) is **not** the correct explanation of (A)
- (c) (A) is correct but (R) is not correct
- (d) (A) is not correct but (R) is correct

Ans.: (c)

Solution.: Assertion (A) is CORRECT: In a multi-electron atom, an electron's orbital motion creates an internal magnetic field B in its rest frame. This magnetic field interacts with the electron's intrinsic magnetic dipole moment (spin), giving rise to **spin-orbit coupling**.

Reason (R) is INCORRECT: Simply specifying the individual angular momentum quantum numbers of electrons (e.g., l_1, s_1, l_2, s_2) is **not sufficient** to completely determine the total angular momentum J of the atom without knowing the specific coupling scheme (L-S coupling vs. j-j coupling) and the relative vector orientations (i.e., how the individual momenta couple together to yield allowable values of L , S , and J)

Q53. Which of the following statements are correct?

- (A) Wave function of a particle in a box $\psi_n = A \sin \frac{\sqrt{2mE_n}}{\hbar} x$
- (B) Normalized wave function of the particle $\psi_n = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$
- (C) ψ_n cannot be negative
- (D) Wave function of a particle in a box $\psi_n = A \sin \frac{n\pi x}{L}$
- (E) $|\psi_n|^2$ can be less than zero

Choose the **correct** answer from the options given below:

- (a) A, C, D and E only (b) A, D and E only
- (c) A, B and D only (d) B, D and E only

Ans.: (c)

Solution.:

(C) Incorrect: Wave functions alternate signs (positive/negative regions).

(E) Incorrect: Probability density $|\psi_n|^2 \geq 0$ always.

Q69. For single particle in a cubical box, the energies of the first excited state in terms of

$C \left(= \frac{\pi^2 \hbar^2}{2mV^{2/3}} \right)$ (where V = volume) will be:

- (a) 6 C (b) C
- (c) 3 C (d) 2 C

Ans.: (a)

Solution.: 1D box energy constant given as $C = \frac{\pi^2 \hbar^2}{2mL^2}$, $L = V^{1/3}$

For a 3D cubical box, $E = C(n_x^2 + n_y^2 + n_z^2)$

Ground state quantum numbers are (1,1,1): $E_1 = C(1+1+1) = 3C$

First excited state quantum numbers are degenerate sets: (2,1,1), (1,2,1), (1,1,2)

$$E_{\text{first excited state}} = C(2^2 + 1^2 + 1^2) = 6C$$



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Q54. Match List-I with List-II.

List-I Crystal System	List-II Number of lattices
(A) Monoclinic	(I) 4
(B) Triclinic	(II) 2
(C) Cubic	(III) 1
(D) Orthorhombic	(IV) 3

Choose the **correct** answer from the options given below:

- (a) A-I, B-II, C-III, D-IV (b) A-II, B-III, C-IV, D-I
(c) A-III, B-IV, C-I, D-II (d) A-IV, B-III, C-II, D-I

Ans.: (c)

Solution.:

Q55. In a $p - n$ junction diode:

- (A) Thermal electron current and recombination electron currents are small when there is no bias.
(B) In no bias condition, there is no net current.
(C) When an external voltage is applied to make p end negative, the result is a large current (net electron current) from n to p .
(D) When p end is more positive, there will a large net electron current from n to p .

Choose the **correct** answer from the options given below:

- (a) A, B and D only (b) A, B and C only
(c) B, C and D only (d) A, C and D only

Ans.: (a)

Solution.:

- (A) True:** In unbiased conditions, thermal generation and recombination currents are small and balance each other.
(B) True: Net current is zero under zero bias.
(C) False: Reverse bias (p negative) results in a very small leakage current, not a large current.
(D) True: Forward bias (p positive) leads to a large net current across the junction.

Q56. Second neighbour distance in a simple cubic lattice is:

- (a) a (b) $1.414a$
(c) $\frac{a}{2}$ (d) $0.707a$

Ans.: (b)

Solution.: Nearest neighbor distance = a

Second neighbor distance = diagonal of a square face = $\sqrt{2}a = 1.414a$

Q57. Which of the following is not a part of the NOR gate truth table (S_1S_2Q) where, S_1, S_2 are inputs and Q is the output?

- (a) 111 (b) 001
(c) 010 (d) 100

Ans.: (a)

Solution.: NOR truth table output $Q = \overline{S_1 + S_2}$

$$(1,1) \rightarrow 0; \quad (0,0) \rightarrow 1; \quad (0,1) \rightarrow 0; \quad (1,0) \rightarrow 0$$

Q58. In an inverted operational amplifier, the phase difference between the output voltage signal and input signal is:

- (a) 180° (b) 0°
(c) $+90^\circ$ (d) -90°

Ans.: (a)

Q59. Which of the following represents the input characteristics of a common base (CB) configuration of BJT?

- (a) I_B versus V_{BE} (b) I_E versus V_{BE}
(c) I_C versus V_{CE} (d) I_C versus V_{CB}

Ans.: (b)

Q60. Which of the following represents the current gain of a common collector (CC) configuration of BJT?

- (a) α (b) β
(c) $1 + \beta$ (d) $\frac{\beta}{1 + \beta}$

Ans.: (c)

Solution.: Current gain of Common Collector (CC) configuration is $= \frac{I_E}{I_B} = 1 + \beta$

Q61. Which one is **not** correct for zener diode?

- (a) similar to tunnel diode
- (b) used in voltage-regulation circuit
- (c) involves tunneling of p -side valence-band electron of the junction to the conduction band of n -side
- (d) electron near the junction is accelerated by the electric field, ionizing atoms and creating fresh electron-hole pair

Ans.: (a)

Solution.: Statement (a) is incorrect because Zener diode operates primarily via avalanche breakdown / heavy doping field emission under high reverse voltage, whereas a Tunnel diode relies on negative differential resistance under forward bias due to degenerate doping.

Q62. If $y = \overline{A+B} + \overline{AB} + B$, then:

- (A) $y = 0$
- (B) $y = 1$
- (C) $y = A + \overline{A}$
- (D) $y = A + \overline{B}$

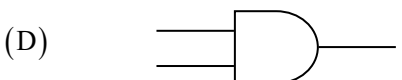
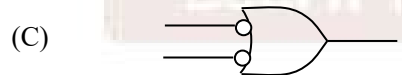
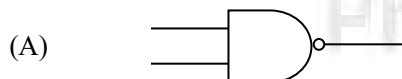
Choose the **correct** answer from the options given below:

- (a) D only
- (b) A and C only
- (c) B and C only
- (d) B, C and D only

Ans.: (c)

Solution.: $y = \overline{A+B} + \overline{AB} + B = \overline{A}.\overline{B} + \overline{A} + \overline{B} + B = \overline{A}(\overline{B} + 1) + 1 = \overline{A} + 1 = 1$ also $y = A + \overline{A}$.

Q63. Four gates are represented below:



Sequentially they are known as

Choose the **correct** answer from the options given below:

- (a) NAND, NOR, NAND, AND
- (b) NOR, NAND, NOR, AND
- (c) NAND, NOR, NOR, AND
- (d) AND, NOR, NAND, OR

Ans.: (a)

Q64. The numbers are given in Decimal (10), Binary (2), Octal (8), and Hexadecimal (16) bases. Which of the followings are correct?

- (A) $(43)_8 = (23)_{16}$ (B) $(23.25)_{10} = (10111.01)_2$
(C) $(B7)_{16} = (1011\ 0111)_2$ (D) $(1001.1)_2 = (9.5)_{10}$

Choose the **correct** answer from the options given below:

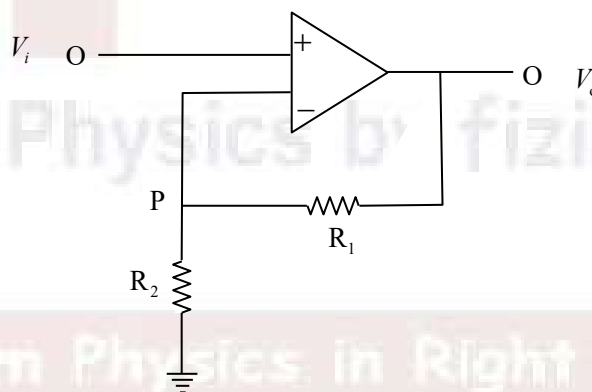
- (a) A only (b) A and B only
(c) A, B and C only (d) A, B, C and D

Ans.: (d)

Solution.:

- (A) $(43)_8 = 4 \times 8 + 3 \times 8^0 = (35)_{10}$, $(23)_{16} = 2 \times 16 + 3 \times 16^0 = (35)_{10}$
(B) $(10111.01)_2 = 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 0 \times 2^{-1} + 1 \times 2^{-2} = (23.25)_{10}$
(C) $(B7)_{16} = (1011\ 0111)_2$ $B = (1011)_2$, $7 = (0111)_2$
(D) $(1001.1)_2 = 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 0 \times 2^{-1} = (9.5)_{10}$

Q65. An ideal OPAMP circuit is given below where $R_1 = 1k\Omega$, $R_2 = 1k\Omega$, and emf $V_i = \sin \omega t$ in volt.



- (A) The current through $R_1 \neq$ The current through R_2
(B) The potential at P, $V_p = V_i$
(C) Amplitude of V_o is $2V$
(D) The output voltage are in opposite phase with input emf.

Choose the **correct** answer from the options given below:

- (a) A and C only (b) B and C only
(c) B and D only (d) A, C and D only

Ans.: (b)

Solution.: Circuit is a non-inverting operational amplifier configuration:

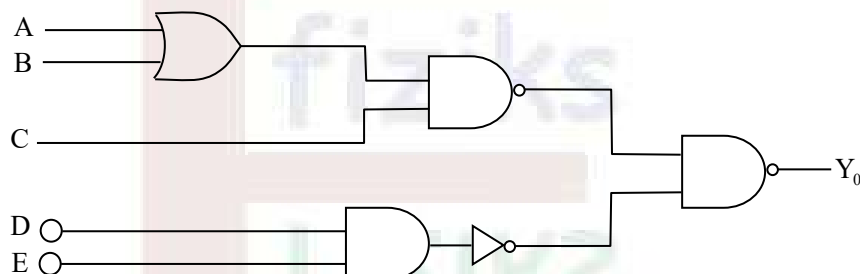
Potential at non-inverting terminal $= V_i = \sin \omega t$

By virtual ground/short concept, $V_p = V_i = \sin \omega t$ **(B) is correct.**

$$\text{Gain } A_v = 1 + \frac{R_1}{R_2} = 1 + \frac{1}{1} = 2$$

Output voltage $V_0 = 2V_i = 2 \sin \omega t$ (Amplitude = 2V, in-phase with input) **(C) is correct**

Q66. A, B, C, D, E are inputs and Y_0 is output



The output Y_0 for the above logic gate circuit is given by:

(a) $Y_0 = (A + B) \cdot C + DE$

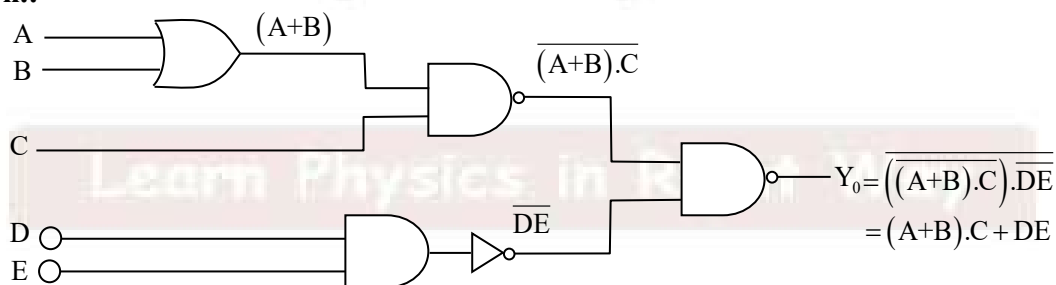
(b) $Y_0 = (\overline{A + B}) \cdot \overline{C} + DE$

(c) $Y_0 = (A + B + C) + DE$

(d) $Y_0 = (AB + C) \cdot DE$

Ans.: (a)

Solution.:



Q67. Which of the following statements are correct?

- (A) Sinusoidal oscillator provide output sine wave signals
(B) Non sinusoidal oscillator generate rectangular or square wave signal
(C) Loop gain with negative feedback = $\frac{A_v}{1 - \beta A_v}$
(D) Loop gain with positive feedback = $\frac{A_v}{1 + \beta A_v}$
(E) When the feedback signal is in phase with input signal, the feedback is negative

Choose the **correct** answer from the options given below:

- (a) A, C, D and E only (b) C, D and E only
(c) A and B only (d) A, C and D only

Ans.: (c)

Solution.:

(A) True: Sinusoidal oscillator provide output sine wave signals

(B) True: Non sinusoidal oscillator generate rectangular or square wave signal

(C) False: Since loop gain with negative feedback = $\frac{A_v}{1 + \beta A_v}$

(D) False: Since loop gain with positive feedback = $\frac{A_v}{1 - \beta A_v}$

(E) False: Since when the feedback signal is in phase with input signal, the feedback is positive

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