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CUET(PG) Physics-2025

Solution-Mathematical Methods

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Q1. For the differential equation $\left(1+\frac{d^2y}{dx^2}\right)^{\frac{2}{3}} = y\frac{d^2y}{dx^2}$ the order, degree and linearity respectively are:

(a) 3, 2 and non-linear
(b) 2, 3 and non-linear
(c) 2,3 and linear
(d) 3, 2 and linear

Ans.1: (b)

Solution.: $\left(1+\frac{d^2y}{dx^2}\right)^{\frac{2}{3}} = y\frac{d^2y}{dx^2} \Rightarrow \left(1+\frac{d^2y}{dx^2}\right)^{2} = y^3\left(\frac{d^2y}{dx^2}\right)^{3}$

order 2, degree 3 and non-linear.

Q8. Match the List-I with List-II

List-I (Expressions)		List-II (Values)	
A.	i^{49}	I.	1
B.	i^{38}	II.	$-i$
C.	i^{103}	III.	i
D.	i^{92}	IV.	-1

Choose the correct answer from the options given below:

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

Ans.8: (c)

Solution.: $i^{49} = \left(i^4\right)^{12} i = 1.i = i$; $i^{38} = \left(i^4\right)^{9} i^2 = 1.(-1) = -1$

$i^{103} = \left(i^4\right)^{25} i^3 = 1.(-i) = -i$; $i^{92} = \left(i^4\right)^{23} = 1$

Q16. If $\vec{A}=\vec{\nabla}\phi$ and $\phi = xy + yz + zx$, then the true statements are:

(A) $\vec{\nabla}\cdot\vec{A} = 0$ (B) $\vec{\nabla}\cdot\vec{A} \neq 0$ (C) $\vec{\nabla}\times\vec{A} = 0$ (D) $\vec{\nabla}\times\vec{A} \neq 0$

Choose the correct answer from the option given below:

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

Ans.16: (a)

Solution.: $\because \phi = xy + yz + zx \Rightarrow \vec{A}=\vec{\nabla}\phi = y\hat{x} + z\hat{y} + x\hat{z} \Rightarrow \vec{\nabla}\cdot\vec{A} = 0$

$\because \vec{A}=\vec{\nabla}\phi \Rightarrow \vec{\nabla}\times\vec{A} = \vec{\nabla}\times\vec{\nabla}\phi = 0$

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Q17. The real and imaginary parts of $\log(x+iy)$ are:

(a) Real part = $\log(x^2+y^2)$ and Imaginary part = $\tan^{-1}\left(\frac{y}{x}\right)$

(b) Real part = $\log(x^2+y^2)$ and Imaginary part = $\tan^{-1}\left(\frac{x}{y}\right)$

(c) Real part = $\log\sqrt{x^2+y^2}$ and Imaginary part = $\tan^{-1}\left(\frac{x}{y}\right)$

(d) Real part = $\log\sqrt{x^2+y^2}$ and Imaginary part = $\tan^{-1}\left(\frac{y}{x}\right)$

Ans.17: (d)

Q22. If $\left|\vec{A}+\vec{B}\right|=\left|\vec{A}-\vec{B}\right|$ then the angle between vectors $\vec{A}$ and $\vec{B}$ is:

(a) 0 (b) $\pi/4$ (c) $\pi/2$ (d) $3\pi/4$

Ans.22: (c)

Solution.:

$$\because \left|\vec{A}+\vec{B}\right|=\left|\vec{A}-\vec{B}\right| \Rightarrow \left|\vec{A}+\vec{B}\right|^2=\left|\vec{A}-\vec{B}\right|^2 \Rightarrow A^2+B^2+2\vec{A}.\vec{B}=A^2+B^2-2\vec{A}.\vec{B}$$

$$\Rightarrow 4\vec{A}.\vec{B}=0 \Rightarrow \vec{A}.\vec{B}=0 \Rightarrow \theta=\frac{\pi}{2}$$

Q27. If $x=r\cos\theta, y=\sin\theta$ then Match the List-I with List-II

List-I	**List-II**
(A) $\frac{\partial r}{\partial x}$	I. $\frac{1}{r}$
(B) $\frac{\partial r}{\partial y}$	II. $\frac{y}{r}$
(C) $\frac{\partial(x,y)}{\partial(r,\theta)}$	III. $\frac{x}{r}$
(D) $\frac{\partial(r,\theta)}{\partial(x,y)}$	IV. r

Choose the correct answer from the options given below:

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

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

Ans.27: (b)

Solution.: $x = r\cos\theta, y = \sin\theta \Rightarrow \frac{\partial x}{\partial r} = \cos\theta = \frac{x}{r}$ and $\Rightarrow \frac{\partial y}{\partial r} = \sin\theta = \frac{y}{r}$

$$\frac{\partial(x,y)}{\partial(r,\theta)} = \begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \theta} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \theta} \end{vmatrix} = \begin{vmatrix} \cos\theta & -r\sin\theta \\ \sin\theta & r\cos\theta \end{vmatrix} = r \text{ and } \frac{\partial(r,\theta)}{\partial(x,y)} = \frac{1}{r}.$$

Q35. If $\vec{A} = \vec{\nabla} \times \vec{F}$, then $\iint_S \vec{A} \cdot \hat{n} dS$ (for any closed surface S) is:

(a) 0 (b) 4S (c) 3S (d) 4V

Ans.35: (a)

Solution.: $\iint_S \vec{A} \cdot \hat{n} dS = \iint_S (\vec{\nabla} \times \vec{F}) \cdot \hat{n} dS = \oint_{line} \vec{F}.d\vec{l} = 0$

Q37. The projection of vector $\vec{A} = \hat{i} - 2\hat{j} + \hat{k}$ on vector $\vec{B} = 4\hat{i} - 4\hat{j} + 7\hat{k}$ is:

(a) $\frac{17}{9}$ (b) $\frac{17}{7}$ (c) $\frac{19}{7}$ (d) $\frac{19}{9}$

Ans.37: (d)

Solution.: $\vec{A} = \hat{i} - 2\hat{j} + \hat{k}, \vec{B} = 4\hat{i} - 4\hat{j} + 7\hat{k} \Rightarrow \vec{A}.\vec{B} = |\vec{A}||\vec{B}|\cos\theta \Rightarrow |\vec{A}|\cos\theta = \frac{\vec{A}.\vec{B}}{|\vec{B}|}$

$$\Rightarrow |\vec{A}|\cos\theta = \frac{4+8+7}{\sqrt{16+16+49}} = \frac{19}{9}$$

Q46. The eigen values of matrix A are 1, -2, 3. The eigen values of $3I - 2A + A^2$ are:

(A) 2 (B) 6 (C) 8 (D) 11

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) A, B, C and D (d) B, C and D only

Ans.46: (a)

Solution.:

$3I - 2A + A^2 = 3 - 2\lambda + \lambda^2$

$\lambda = 1: \quad 3 - 2\lambda + \lambda^2 = 3 - 2 + 1 = 2; \quad \lambda = -2: \quad 3 - 2\lambda + \lambda^2 = 3 + 4 + 4 = 11$

$\lambda = 3: \quad 3 - 2\lambda + \lambda^2 = 3 - 6 + 9 = 6$

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Q47. For particular Integral, Match the List-I with List-II

A.	$\frac{1}{D^2-1}x^2$	I.	$-\frac{x^2e^x}{4}$
B.	$\frac{1}{D^2+D+1}\cos x$	II.	$\sin x$
C.	$\frac{1}{(D-1)^2}e^x$	III.	$\frac{x^2e^x}{2}$
D.	$\frac{1}{D^2-3D^2+4D-2}e^x$	IV.	$-(x^2+2)$

Choose the correct answer from the options given below:

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

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

Ans.47: (c)

Solution.: $\frac{1}{D^2-1}x^2=-(1-D^2)^{-1}x^2=-(1+D^2)x^2=-(x^2+D^2x^2)=-(x^2+2)$

$$\frac{1}{D^2+D+1}\cos x=\frac{1}{-1^2+D+1}\cos x=\frac{1}{D}\cos x=\sin x$$

$$\frac{1}{(D-1)^2}e^x=x\frac{1}{2(D-1)}e^x=x^2\frac{1}{2}e^x$$

$$\frac{1}{D^2-3D^2+4D-2}e^x=\frac{1}{-2D^2+4D-2}e^x=x\frac{1}{-4D+4}e^x=x^2\frac{1}{-4}e^x=-\frac{1}{4}x^2e^x$$

Q57. If any two rows (or columns) of a determinant are identical then the value of the determinant is:

(a) 1 (b) 0 (c) ∞ (d) unchanged

Ans.57: (b)

Q72. For an even function, the Fourier coefficients are:

(A) $a_0\neq 0$ (B) $a_n\neq 0$ (C) $a_n=0$ (D) $b_n=0$

Choose the correct answer from the options given below:

(a) A, C and D only (b) A, B and D only

(c) C and D only (d) B and D only

Ans.72: (b)

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Solution- Mechanics and General Properties of Matter

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Q9. A skater is using very low-friction rollerblades. A friend throws a Frisbee straight at her. In which case does the Frisbee impart the greatest impulse to the skater:

(a) she catches the Frisbee and holds it (b) she catches it momentarily but drops it

(c) she catches it and at once throws it back to her friend (d) she can't catch it at all

Ans.9: (c)

Solution.: Impulse = change in momentum of the Frisbee.

(a) catches and holds it:

Frisbee momentum changes from initial to zero, so impulse $= m\Delta v$

(b) catches momentarily but drops it:

final momentum is not zero (since it drops), so less momentum change.

(c) catches and throws it back:

changes Frisbee momentum from initial to opposite direction, so impulse magnitude $= m\left(v_f - v_i\right)$ with sign reversal, which is **larger** than just stopping it.

(d) can't catch it:

impulse almost zero relative to her.

Q11. The gravitational field at a point in space is:

(a) Force per unit mass (b) Force per unit charge

(c) Mass per unit volume (d) Mass per unit charge

Ans.11: (a)

Q29. Moment of inertia of a solid cone about its vertical axis is:

(a) $MR^2/10$ (b) $3MR^2/10$ (c) $5MR^2/10$ (d) $7MR^2/10$

Ans.29: (b)

Q33. The engine of a rocket in outer space, far from any planet is turned on. The rocket ejects burnt fuel at constant rate. In the first second of firing, it ejects 1/100 of its initial mass at relative speed of $2000\,m/s$. The initial acceleration of the rocket is:

(a) 5 m/s^2 (b) –10 m/s^2 (c) +20 m/s^2 (d) –30 m/s^2

Ans.33: (c)

Solution.: Rocket thurst equation: Thurst $F = v_{exhaust} \times \dfrac{dm}{dt}$ and acceleration $a = \dfrac{F}{M}$.

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Here $v_{exhaust} = 2000\,m/s$, $\Delta m = \frac{1}{100}M_0$ and $\Delta t = 1\sec$, so $\frac{dm}{dt} \approx \frac{\Delta m}{1s} = \frac{M_0}{100} kg/s$

Thus $F = 2000 \times \frac{M_0}{100} = 20M_0\ N \Rightarrow a_0 = \frac{F}{M_0} = 20\,m/s^2$

Q52. For a force $\vec{F}$ to be conservative, the relations to be satisfied are:

(A) $\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} = 0$ (B) $\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} = 0$

(C) $\frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x} = 0$ (D) $\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y} = \frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z} = \frac{\partial F_x}{\partial z} - \frac{\partial F_y}{\partial x} \neq 0$

Choose the correct answer from the options given below:

(a) A and B only (b) A, B and C only

(c) B, C and D only (d) A, B, C and D only

Ans.52: (b)

Solution.: For conservative force $\vec{\nabla} \times \vec{F} = 0 \Rightarrow \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ F_x & F_y & F_z \end{vmatrix} = 0$

Q53. For a system of particles, if the external net force acting on the system is zero, the system's center of mass is:

(a) at rest (b) moving at a constant velocity

(c) accelerating (d) rotating

Ans.53: (b)

Solution.: The center of mass of a system behaves like a point particle with the total mass of the system, subject to Newton's second law: $M\vec{a}_{cm} = \vec{F}_{ext}$

If the **net external force** $\vec{F}_{ext}$ is zero, then: $\vec{a}_{cm} = 0$

This means the velocity of the center of mass is constant. It could be zero (rest) or non-zero (constant velocity)-both are special cases of constant velocity.

Q54. If the torque remains constant while the angle changes, the work done is equal to:

(a) ratio of torque and angular displacement

(b) ratio of the angular displacement and square root of torque

(c) product of torque and angular displacement

(d) product of torque and square root of angular displacement

Ans.54: (c)

Solution.: We know from rotational dynamics: $W = \tau \Delta\theta$

where W is the work done, τ is torque, and $\Delta\theta$ is angular displacement.

If τ is constant, then the work done equals torque multiplied by angular displacement.

Q63. A 1500 kg car travelling east with a speed of 25 m/s collides at an intersection with a 2500 kg van traveling north at a speed of 20 m/s. The direction of wreckage after collision, assuming that the vehicles undergo a perfectly inelastic collision is:

(a) 58.2° (b) 47.2° (c) 53.1° (d) 50.6°

Ans.63: (c)

Solution.: Since vehicles undergo a perfectly inelastic collision, so the two vehicles stick together after collision.

Momenta Before collision:

Car(east): $p_x = m_c v_c = 1500 \times 25 = 37500\, kg.m$ and $p_y = 0$.

Van(north): $p_y = m_v v_v = 2500 \times 20 = 50000\, kg.m$ and $p_x = 0$.

Total Momenta After collision:

$P_x = 37500\, kg.m$ and $P_y = 50000\, kg.m$. Total mass $M_T = 1500 + 2500 = 4000\, kg$.

Let $\vec{V}$ be velocity of combined mass after collision.

$$V_x = \frac{P_x}{M_T} = \frac{37500}{4000} = 9.375\, m/s \quad \text{and} \quad V_y = \frac{P_y}{M_T} = \frac{50000}{4000} = 12.5\, m/s$$

Direction from east $\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{12.5}{9.375}\right) = \tan^{-1}(1.3333) \approx 53.1^0$

Q65. The place at which plane of vibration of Foucault's pendulum does not rotate at all, is:

(a) Pole (b) Equator

(c) Tropic of Cancer (d) Tropic of Capricorn

Ans.65: (b)

Solution.: For Foucault's pendulum, the angular rotation of the plane of oscillation is $\omega = \omega_E \sin\phi$, where ω_E = angular velocity of earth, ϕ = latitude of the place.

At equator $\phi = 0^0$ so $\omega = 0$.

Q66. The S.I. unit of compressibility is:

(a) N/m^2 (b) $N/m^2\, s$ (c) m^2/N (d) Ns/m^2

Ans.66: (c)

Solution.: compressibility $= -\frac{1}{V}\frac{dV}{dP}$

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Solution- Oscillations, Waves and Optics

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Q21. Two thin convex lenses of focal lengths $2\,cm$ and $6\,cm$ are separated by a distance of $4\,cm$ in air. Arrange the following cardinal points in ascending order on basis of their distance from second lens:

(A) First Principal Point (B) First Focal Point

(C) Second Focal Point (D) Second Nodal Point

Choose the correct answer from the options given below:

(a) A, B, C, D (b) A, C, B, D

(c) B, A, D, C (d) C, B, D, A

Ans.21: (b)

Solution.: $f_1 = 2\,cm, f_2 = 6\,cm,\ d = 4\,cm$

Equivalent focal length $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} = \frac{1}{2} + \frac{1}{6} - \frac{4}{2\times 6} = \frac{3}{6} + \frac{1}{6} - \frac{2}{6} = \frac{2}{6} = \frac{1}{3} \Rightarrow F = 3\,cm$

Position of cardinal points from second lens

H_1 from lens $1 = \frac{Fd}{f_2} = \frac{3\times 4}{6} = 2\,cm$, H_1 from lens $2 = 2 - 4 = -2\,cm$

H_2 from lens $1 = -\frac{Fd}{f_1} = -\frac{3\times 4}{2} = -6\,cm$

Focal points:

F_2 from lens $2 = H_2 + F = -6 + 3 = -3\,cm$

F_1 from lens $2 = H_1 - F = -2 - 3 = -5\,cm$

Q26. When light ray refracts on entering from one medium to another medium of different refractive indices, it follows:

(a) Minimum distance (b) Minimum time

(c) Maximum time (d) Maximum distance

Ans.26: (b)

Q30. Match the List-I with List-II

List I		List II	
A.	Compton Effect	I.	Diffraction
B.	Colors in thin film	II.	Interference
C.	Double Refraction	III.	Polarization
D.	Bragg's Equation	IV.	Scattering

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Choose the correct answer from the options given below:

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

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

Ans.30: (a)

Q31. True conditions for sustained interference of light waves are:

(A) Two interfering sources must be coherent

(B) Two interfering waves must be propagated along the same line

(C) Two interfering waves must have equal amplitude

(D) If the interfering waves are polarized, they must be in the same state of polarization

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) A, B, C and D (d) B, C and D only

Ans.31: (c)

Q32. A $20g$ of cane sugar is dissolved in water to make 50 cc of solution. A $20cm$ length of tube filled with this solution causes +53°30' optical rotation. What will be the specific rotation?

(a) 66.9 degree $\left(\text{decimeter}\right)^{-1}\left(g/cc\right)^{-1}$ (b) 7.09 degree $\left(\text{decimeter}\right)^{-1}\left(g/cc\right)^{-1}$

(c) 76.9 degree $\left(\text{decimeter}\right)^{-1}\left(g/cc\right)^{-1}$ (d) 6.69 degree $\left(\text{decimeter}\right)^{-1}\left(g/cc\right)^{-1}$

Ans.32: (a)

Solution.: Specific rotation $\left[\alpha\right]=\dfrac{\theta}{l.c}$

where concentration $c=\dfrac{\text{mass of solute (g)}}{\text{volume of solution (mL)}}$ in g/ml or g/cc, l in dm.

$c=\dfrac{20\text{ g}}{50\text{ mL}}=0.4\text{ g/mL}$. So $\left[\alpha\right]=\dfrac{53.5^0}{\left(2\,dm\right)\times 0.4\text{ g/mL}}=68.875\left(\text{decimeter}\right)^{-1}\left(g/cc\right)^{-1}$

Q34. The resolving power of grating:

(A) increases with increase in total number of lines ruled on grating

(B) increases with increase in total width of grating

(C) increases with increasing the order or spectrum as in Echelon grating

(D) increases with decreasing the order of spectrum as in Echelon grating

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) B and D only (d) A and D only

Ans.34: (b)

Solution.: Resolving power of diffraction grating $R = \frac{\lambda}{\Delta\lambda} = mN$

where $m =$ order number, $m =$ total number of lines illuminated on the grating

(A) increases with increase in total number of lines ruled on grating:

True $\because R \propto N$

(B) increases with increase in total width of grating

True $\because R \propto W$ where $W = Nd$, $d =$ grating spacing

(C) increases with increasing the order or spectrum as in Echelon grating

True $\because R \propto m$

(D) increases with decreasing the order of spectrum as in Echelon grating: **False**

Q51. Displacement of a particle at any instant of time t is $y = 5\sin(100\pi t + \phi)$. The frequency of oscillation of the particle is:

(a) $100\,Hz$ (b) $25\,Hz$ (c) $200\,Hz$ (d) $50\,Hz$

Ans.51: (d)

Solution.: $\omega = 2\pi f = 100\pi \Rightarrow f = 50Hz$

Q58. A siren on a tall pole radiates sound waves uniformly in all directions. At a distance of $15m$ from the siren, the sound intensity is $0.250W/m^2$. The intensity of sound at distance $75m$ from siren is:

(a) $0.250W/m^2$ (b) $0.010W/m^2$

(c) $0.100W/m^2$ (d) $6.250W/m^2$

Ans.58: (b)

Solution.: For a point source radiating uniformly in all directions, intensity $I \propto \frac{1}{r^2}$

Thus $\frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2 \Rightarrow \frac{I_2}{0.250} = \left(\frac{15}{75}\right)^2 \Rightarrow I_2 = 0.250 \times \frac{1}{25} = 0.010\,W/m^2$

Q60. A tuning fork of unknown frequency sounded with a tuning fork of frequency 256 Hz produces 4 beats per second. If a small quantity of wax is fixed on first fork so that it produces 3 beats per second with tuning fork, what will be the frequency of first fork (in Hz)?

(a) 260 (b) 252

(c) 256 (d) 280

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Ans.60: (a)

Solution.: Beat frequency $= |f_1 - f_2|$.

Let $f =$ unknown frequency of the first fork, known fork frequency $= f$

Given initially $|f - 256| = 4$. So $f = 260\,Hz$ or $f = 252\,Hz$.

Adding wax decreases the frequency of the fork.

Case-I: $f = 260\,Hz$

After waxing $f_{new} = 260 - \delta$, so $|f_{new} - 256| = |260 - \delta - 256| = 3 \Rightarrow |4 - \delta| = 3 \Rightarrow \delta = 1$ or 7

Case-II: $f = 252\,Hz$

After waxing $f_{new} = 252 - \delta$, so

$|f_{new} - 256| = |252 - \delta - 256| = 3 \Rightarrow |-4 - \delta| = 3 \Rightarrow |4 + \delta| = 3 \Rightarrow \delta = -1$ or -7

Since $\delta > 0$, so only case-I is possible.

Q73. Ravi and Swati are twins and they are being separated at a rate of 0.80c. Ravi and Swati each send out a radio signal once a year while Ravi is away. How many signals does Ravi receive for a trip of 15 years?

(a) 3 signals (b) 5 signals

(c) 9 signals (d) No signal

Ans.73: (b)

Q75. Match List-I with List-II on basis of two simple harmonic signals of same frequency and various phase difference interacts with each other:

List-I (Lissajous Figure)		**List-II (Phase Difference)**	
A.	Right handed elliptically polarised vibrations	I.	Phase difference = $\pi/4$
B.	Left handed elliptically polarised vibrations	II.	Phase difference = $3\pi/4$
C.	Circularly polarized vibrations	III.	No phase difference
D.	Linearly polarized vibrations	IV.	Phase difference = $\pi/2$

Choose the correct answer from the options given below:

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

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

Ans.75: (c)

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Solution- Electricity and Magnetism

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Q2. A conducting sphere of radius R carries a total charge Q. The electric field at a distance $r > R$ from the center is:

(a) kQ/r^2 (b) $kQ/2R^2$

(c) kQ/R (d) 0

Ans.2: (a)

Q6. The electric field just outside a charged conductor is E. The electric field just inside the conductor is

(a) E (b) $E/2$ (c) $2E$ (d) 0

Ans.6: (d)

Q7. Inside a uniformly charged spherical shell, the value of the electric field at distance r from the center is:

(a) 0 (b) kQ/r (c) kQ/r^2 (d) constant

Ans.7: (a)

Q23. In the context of conductors in electrostatic equilibrium, the relationship between electric field and the conductor's surface is:

(a) Electric field is parallel to the surface (b) Electric field is perpendicular to the surface

(c) Electric field is tangential to the surface (d) Electric field is zero on the surface

Ans.23: (b)

Q28. A point charge $+Q$ is placed at the origin. The electric potential at point $(3a, 4a, 0)$ in terms of k, Q and a is:

(a) $kQ/5a$ (b) $kQ/3a$ (c) $kQ/7a$ (d) $kQ/2a$

Ans.28: (a)

Q42. A parallel-plate capacitor has a dielectric slab of thickness d and dielectric constant K inserted between the plates. The capacitance change compared to the vacuum case (when no slab is inserted) is:

(a) Increases by a factor of K (b) Decreases by a factor of K

(c) Increases by a factor of K^2 (d) Decreases by a factor of K^2

Ans.42: (a)

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Q45. If an electromagnetic wave is totally reflected, the radiation pressure in terms of average Poynting vector S_{av} is:

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

Ans.45: (b)

Q50. The electric potential inside a charged conducting sphere is constant. The charge distribution inside the sphere will be:

(a) Uniform (b) Non uniform

(c) Zero charge (d) Radially increasing

Ans.50: (c)

Q61. A long, straight wire carries a current of $10\,A$. The magnitude of the magnetic field at a distance of $5\,cm$ from the wire:

(a) $4\times10^{-5}T$ (b) $8\times10^{-5}T$

(c) $12\times10^{-5}T$ (d) $16\times10^{-5}T$

Ans.61: (a)

Solution.: $B=\frac{\mu_0 I}{2\pi r}=\frac{\mu_0}{4\pi}\frac{2I}{r}=10^{-7}\times\frac{2\times10}{5\times10^{-2}}=4\times10^{-5}T$

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Q4. In the steady state of temperature, the flow of heat across the body depends upon its:

(A) thermal capacity (B) thermal conductivity

(C) temperature difference across its opposite faces (D) thermal resistivity

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) A, B, C and D (d) B, C and D only

Ans.4: (d)

Q24. Specific heat of saturated water vapour at 100°C is

(a) zero (b) positive

(c) negative (d) sometimes positive, sometimes negative

Ans.24: (c)

Solution.: For water vapor at 100 °C, *c*sat is negative because adding heat under saturation conditions causes condensation (temperature drops), and removing heat causes superheating (temperature rises) — an unusual effect due to phase change equilibrium.

Q36. The gas constant is:

(a) ratio of Boltzmann constant and Avogadro's number

(b) product of Boltzmann constant and Avogadro's number

(c) ratio of Avogadro's number and Boltzmann constant

(d) product of square of Boltzmann constant and Avogadro's number

Ans.36: (b)

Q44. Fermions have spin value equal to:

(a) zero (b) $\frac{1}{2}$ (c) 1 (d) 2

Ans.44: (b)

Q56. Which of the following statements are correct:

(A) Specific heat of saturated water vapour at 100°C is negative

(B) There is only one triple point of a substance

(C) Boiling point of every liquid rises with increase in pressure

(D) Latent heat cannot become zero

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) A, B, C and D (d) B, C and D only

Ans.56: (b)

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Q59. The molecular density of a gas is n and diameter of its molecule is d. The mean free path of molecule is:

(a) $\frac{\pi}{nd^2}$ (b) $\frac{1}{\pi nd}$

(c) $\frac{1}{\sqrt{2}\pi nd^2}$ (d) $\frac{\pi}{3\sqrt{2}\pi nd^2}$

Ans.59: (c)

Q62. Quantum statistics changes into classical statistics if: (Symbols have their usual meaning)

(a) $\frac{g_i}{n_1} = 1$ (b) $\frac{g_i}{n_i} \gg 1$

(c) $\frac{g_i}{n_i} \ll 1$ (d) $\frac{g_i}{n_i} = 0$

Ans.62: (b)

Q64. Degree of degeneracy will be large when:

(a) temperature is high, particle density is large

(b) temperature is high, particle density is small

(c) temperature is low, particle density is small

(d) temperature is low, particle density is large

Ans.64: (d)

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Q3. A particle of mass m is in an infinite square potential of length L. The wave function is superposed state of first two energy eigen states, given by

$$\psi(x)=\left(\frac{1}{\sqrt{3}}\right)\psi_{n=1}(x)+\left(\sqrt{\frac{2}{3}}\right)\psi_{n=2}(x)$$

Identify the correct statements:

(A) $\langle p\rangle=0$ (B) $\Delta p=\sqrt{3}\,h/2L$

(C) $\langle E\rangle=3h^2/8mL^2$ (D) $\Delta x=0$

Choose the correct answer from the options given below:

(a) A, B and D only (b) A, B and C only

(c) A, B, C and D (d) B, C and D only

Ans.3: (b)

Solution.: $\psi(x)=\left(\frac{1}{\sqrt{3}}\right)\psi_{n=1}(x)+\left(\sqrt{\frac{2}{3}}\right)\psi_{n=2}(x)$

Wave function is normalized: $\left(\frac{1}{\sqrt{3}}\right)^2+\left(\sqrt{\frac{2}{3}}\right)^2=\frac{1}{3}+\frac{2}{3}=1$

For an infinite square well (0 to L): $E_n=\frac{n^2h^2}{8mL^2}$

So, $E_1=\frac{h^2}{8mL^2}$, $E_2=\frac{4h^2}{8mL^2}=\frac{h^2}{2mL^2}$

(A) Since the stationary states $\psi_n(x)$ are real functions, $\langle p\rangle=\int\psi^*\left(-i\hbar\frac{\partial}{\partial x}\right)\psi\,dx$.

For real wavefunctions in symmetric well, $\langle p\rangle=0$.

(B) $\Delta p=\sqrt{\langle p^2\rangle-\langle p\rangle^2}=\sqrt{\langle p^2\rangle}$, $\langle p^2\rangle=2m\langle E\rangle=2m\left[\frac{1}{3}E_1+\frac{2}{3}E_2\right]$

$$\Rightarrow\langle E\rangle=\left[\frac{1}{3}\frac{h^2}{8mL^2}+\frac{2}{3}\frac{h^2}{2mL^2}\right]=\frac{1}{3}\frac{9h^2}{8mL^2}=\frac{3h^2}{8mL^2}\Rightarrow\langle p^2\rangle=2m\langle E\rangle=2m\frac{3h^2}{8mL^2}=\frac{3h^2}{4L^2}$$

Thus $\Delta p=\sqrt{\langle p^2\rangle-\langle p\rangle^2}=\sqrt{\langle p^2\rangle}=\sqrt{\frac{3h^2}{4L^2}}=\frac{\sqrt{3}h}{2L}$

(C) $\langle E\rangle=\frac{3h^2}{8mL^2}$

(D) $\Delta x\neq 0$ because $\Delta x.\Delta p\geq\frac{\hbar}{2}$

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Q5. In Compton scattering, Compton shift equals Compton wavelength if angle of scattering is:

(a) 0 (b) $\pi/4$ (c) $\pi/2$ (d) π

Ans.5: (c)

Solution.: $\lambda' - \lambda = \frac{h}{m_e c}(1-\cos\theta) \Rightarrow \Delta\lambda = \lambda_C(1-\cos\theta)$

$\because \Delta\lambda = \lambda_C \Rightarrow 1-\cos\theta = 1 \Rightarrow \cos\theta = 0 \Rightarrow \theta = \frac{\pi}{2}$

Q10. Match the List-I with List-II

List-I (Type of decay in Radioactivity)		**List-II (Reason for stability)**	
A.	Alpha decay	I.	Nucleus has excess energy in an excited state
B.	Beta negative decay	II.	Nucleus has too many protons relative to the number of neutrons
C.	Gamma decay	III.	Nucleus is mostly heavier than $Pb(Z=82)$
D.	Positron Emission	IV.	Nucleus has too many neutrons relative to the number of protons

Choose the correct answer from the options given below:

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

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

Ans.10: (d)

Q12. The de-Broglie wavelength of an electron moving with a velocity of 10^7 m/s is:

(a) $7.3\times10^{-11}m$ (b) $1.3\times10^{-11}m$

(c) $7.3\times10^{-7}m$ (d) $3.1\times10^{-7}m$

Ans.12: (a)

Solution.: $\lambda = \frac{h}{p} = \frac{h}{m_e v} = \frac{6.63\times10^{-34}}{(9.1\times10^{-31})(10^7)} \approx 7.3\times10^{-11}m$

Q18. As water flows from a faucet, stream of water becomes narrower as it descends. The guiding principle for this observation is:

(a) Bernoulli's equation in fluid dynamics (b) Pascal's law

(c) Continuity equation in fluid dynamics (d) Archimedes's principle

Ans.18: (c)

Q19. The Schrodinger wave equation is:

(a) non-linear differential equation (b) linear differential equation

(c) second order equation in time (d) first order equation in space

Ans.19: (b)

Q25. When in a small pond a person in rowboat, throws an anchor overboard, what happens to the water level?

(a) Goes down (b) Goes up

(c) First goes up and then goes down (d) Remains same

Ans.25: (a)

Q38. Which of the following conditions will lead to Anomalous dispersion?

(a) Group velocity > Phase Velocity

(b) Group velocity < Phase Velocity

(c) Group velocity = Phase Velocity

(d) Doesn't depend on relation of group and phase velocity

Ans.38: (a)

Q48. Match List-I with List-II for the index of refraction for yellow light of sodium $(589\,nm)$

List-I (Materials)		**List-II (Refractive Indices)**	
A.	Ice	I.	1.309
B.	Rock salt (NaCl)	II.	1.460
C.	CCl4	III.	1.544
D.	Diamond	IV.	2.417

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Choose the correct answer from the options given below:

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

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

Ans.48: (b)

Q49. Wavelength of X-rays having the largest penetrating power is:

(a) 2Å (b) 6Å (c) 9Å (d) 12Å

Ans.49: (a)

Q55. Consider the following statements about light:

(A) photoelectric effect exhibits wave nature of light

(B) Compton effect exhibits wave nature of light

(C) photoelectric effect exhibits particle nature of light

(D) Compton effect exhibits particle nature of light

Choose the correct answer from the options given below:

(a) A and B only (b) B and C only

(c) A and D only (d) C and D only

Ans.55: (d)

Q68. The stopping potential for a fast-moving photo-electron is independent of:

(a) the frequency of incident photon

(b) the intensity of incident photon

(c) the wavelength of the incident photon

(d) type of metals

Ans.68: (b)

Q69. Match the List-I with List-II

List-I (Energy of a particle in a three-dimensional box of length L)		**List-II (Degeneracy of the states)**	
A.	$14h^2/(8mL^2)$	I.	1
B.	$11h^2/(8mL^2)$	II.	3
C.	$3h^2/(8mL^2)$	III.	6

Choose the correct answer from the options given below:

(a) A-I, B-II, C-III (b) A-I, B-III, C-II

(c) A-III, B-II, C-I (d) A-III, B-I, C-II

Ans.69: (c)

Solution.: For a cubical box of side L, the energy levels are:

$E_{n_x,n_y,n_z} = \left(n_x^2 + n_y^2 + n_z^2\right)\dfrac{h^2}{8mL^2}$ where $n_x, n_y, n_z = 1,2,3...$

(A) $E = 14h^2/\left(8mL^2\right) \Rightarrow n_x^2 + n_y^2 + n_z^2 = 14 \Rightarrow \left(n_x, n_y, n_z\right) = \left(1,2,3\right)$. So, permutation of $\left(1,2,3\right)$:

$\left(1,2,3\right)$, $\left(1,3,2\right)$, $\left(2,1,3\right)$, $\left(2,3,1\right)$, $\left(3,1,2\right)$, $\left(3,2,1\right)$. Total $= 6$

(B) $E = 11h^2/\left(8mL^2\right) \Rightarrow n_x^2 + n_y^2 + n_z^2 = 11 \Rightarrow \left(n_x, n_y, n_z\right) = \left(1,1,3\right)$. So, permutation of $\left(1,1,3\right)$:

$\left(1,1,3\right)$, $\left(1,3,1\right)$, $\left(3,1,1\right)$. Total $= 3$

(C) $E = 3h^2/\left(8mL^2\right) \Rightarrow n_x^2 + n_y^2 + n_z^2 = 3 \Rightarrow \left(n_x, n_y, n_z\right) = \left(1,1,1\right)$. Total $= 1$

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Q13. Arrange the following crystal structures in ascending order of their coordination number.

(A) Diamond

(B) Sodium Chloride

(C) Cesium Chloride

(D) Zinc with hexagonal closed packed structure

Choose the correct answer from the options given below:

(a) A, B, C, D

(b) D, B, C, A

(c) B, A, D, C

(d) C, B, D, A

Ans.13: (a)

Solution.: (A) Diamond-**4**, (B) Sodium Chloride-**6**, (C) Cesium Chloride-**8**

(D) Zinc with hexagonal closed packed structure-**12**

Q14. Match the List-I with List-II

List-I (Logic Gates)	**List-II (Expressions)**
A. EX-OR	I. $A\bar{B}+\bar{A}B$
B. NAND	II. $A+B$
C. OR	III. $\overline{AB}$
D. EX-NOR	IV. $\overline{A}\overline{B}+AB$

Choose the correct answer from the options given below:

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

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

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

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

Ans.14: (b)

Q15. Brillouin zone is:

(A) Wigner-Seitz cell of reciprocal lattice

(B) Primitive unit cell

(C) The locus of all k-values in the reciprocal lattice which are Bragg reflected

(D) Wigner-Seitz cell of direct lattice

The correct statement are:

(a) A, B and D only

(b) A, B and C only

(c) A, B, C and D

(d) B, C and D only

Ans.15: (b)

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Q20. If the load resistance decreases in a zener regulator, the series current:

(a) decreases (b) stays the same

(c) increases (d) equals the source voltage divided by the series resistance

Ans.20: (b)

Q39. Subtract $(29.A)_{16}$ from $(4F.B)_{16}$

(a) $(26.1)_{16}$ (b) $(26.A)_{16}$ (c) $(4F.A)_{16}$ (d) $(16.1)_{16}$

Ans.39: (a)

Solution.: $(4F.B)_{16} = 4\times16^{1} + 15\times16^{0} + 15\times16^{-1} = 79.9375$

$$(29.A)_{16} = 2\times16^{1} + 9\times16^{0} + 10\times16^{-1} = 41.625$$

$$(4F.B)_{16} - (26.1)_{16} = 79.9375 - 41.625 = (38.3125)_{10} = (26.5)_{16}$$

Q40. According to the Dulong and Petit's law, the atomic heat of an element at constant volume:

(a) increases with increase of temperature (b) decreases with increase of temperature

(c) becomes zero at absolute zero (d) is constant

Ans.40: (d)

Q41. The first maxima for Bragg's diffraction pattern by a crystal is observed at 30° when X-rays wavelength of $0.32\,nm$ are used. The distance between the atomic planes is:

(a) $0.32\,nm$ (b) $0.48\,nm$ (c) $0.84\,\text{Å}$ (d) $0.48\,\text{Å}$

Ans.41: (a)

Solution.: $2d\sin\theta = n\lambda \Rightarrow \lambda = 2d\sin 30^{0} \Rightarrow d = \lambda = 0.32\,nm \quad \because n = 1$

Q43. Match the List-I with List-II

List-I (Configuration of Bipolar Transistors)		**List-II (Characteristics)**	
A.	Common Base	I.	Current Gain but no Voltage Gain
B.	Common Emitter	II.	Voltage Gain but no Current Gain
C.	Common Collector	III.	Both Current and Voltage Gain

Choose the correct answer from the options given below:

(a) A-I, B-II, C-III (b) A-II, B-III, C-I

(c) A-I, B-III, C-II (d) A-III, B-II, C-I

Ans.43: (b)

Q67. The lattice constant of a simple cubic lattice having interplanar spacing 3Å for (002) plane is:

(a) 4.2Å (b) 6.0Å (c) 6.2Å (d) 4.0Å

Ans.67: (b)

Solution.: $d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}} \Rightarrow d_{002} = \frac{a}{\sqrt{0+0+4}} \Rightarrow a = 2d_{002} = 2\times 3\text{Å} = 6.0\text{Å}$

Q70. In a controlled current source with OP-Amp the circuit acts as:

(a) voltage amplifier (b) current-to-voltage converter

(c) voltage-to-current converter (d) current amplifier

Ans.70: (c)

Q71. In a semiconductor, intrinsic concentration of charge carriers varies with:

(a) $T^{1/2}$ (b) T (c) $T^{3/2}$ (d) $T^{-1/2}$

Ans.71: (c)

Q74. Arrange the following numbers in ascending order:

(A) $(10110.011)_2$ (B) $(32)_{10}$

(C) $(5F.8)_{16}$ (D) F_{16}

Choose the correct answer from the options given below:

(a) A, B, C, D (b) D, A, B, C

(c) B, A, D, C (d) C, B, D, A

Ans.74: (b)

Solution.:

(A) $(10110.011)_2 = 1\times 2^4 + 0\times 2^3 + 1\times 2^2 + 1\times 2^1 + 0\times 2^0 . (0\times 2^{-1} + 1\times 2^{-2} + 1\times 2^{-3}) = (22.375)_{10}$

(B) $(32)_{10}$

(C) $(5F.8)_{16} = 5\times 16^1 + 15\times 16^0 . (8\times 16^{-1}) = (95.5)_{10}$

(D) $F_{16} = (15)_{10}$

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