

JEE Main 2025

Physics

Chapter-wise Previous Year Questions

January 2025 Session • All 10 Shifts • 22, 23, 24, 28 & 29 January

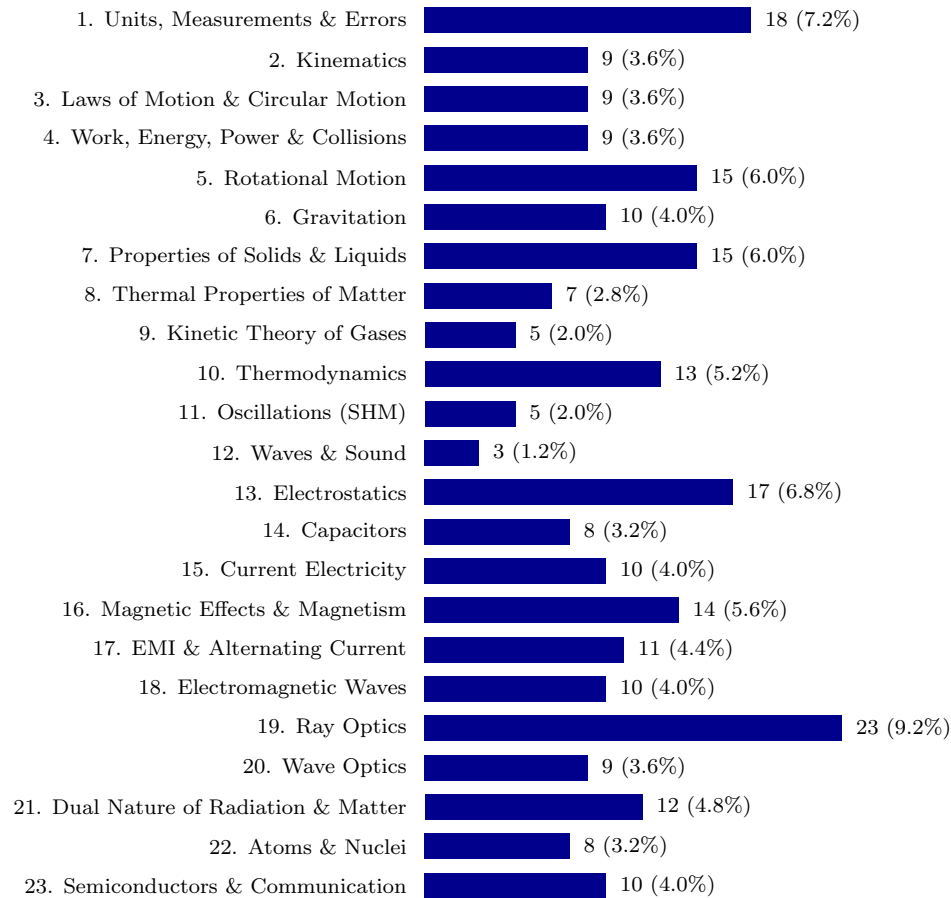
250 Questions • 23 Chapters

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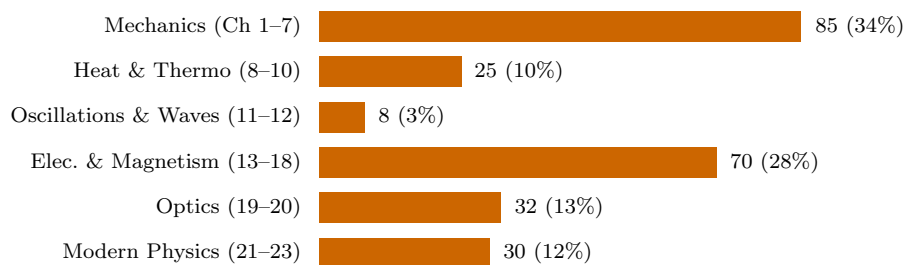
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Chapter-wise Weightage

Questions per chapter (out of 250)



Weightage by unit



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1. Units, Measurements & Errors

18 questions

Dimensional Analysis

Q1. [22 Jan S1] If B is magnetic field and μ_0 is permeability of free space, then the dimensions of (B/μ_0) is

- (A) $ML^2T^{-2}A^{-1}$ (B) $MT^{-2}A^{-1}$
(C) $LT^{-2}A^{-1}$ (D) $L^{-1}A$

Q2. [22 Jan S2] Which one of the following is the correct dimensional formula for the capacitance in F? M, L, T and C stand for unit of mass, length, time and charge,

- (A) $[F] = [C^2M^{-1}L^{-2}T^2]$
(B) $[F] = [CM^{-2}L^{-2}T^{-2}]$
(C) $[F] = [CM^{-1}L^{-2}T^2]$
(D) $[F] = [C^2M^{-2}L^2T^2]$

Q3. [23 Jan S1] The electric flux is $\phi = \alpha\sigma + \beta\lambda$ where λ and σ are linear and surface charge density, respectively. $\left(\frac{\alpha}{\beta}\right)$ represents

- (A) charge (B) displacement
(C) area (D) electric field

Q4. [23 Jan S1] The position of a particle moving on x -axis is given by $x(t) = A \sin t + B \cos^2 t + Ct^2 + D$, where t is time. The dimension of $\frac{ABC}{D}$ is

- (A) L^3T^{-2} (B) L^2
(C) L^2T^{-2} (D) L

Q5. [23 Jan S2] Match List - I with List - II.

List - I**List - II**

- | | |
|--------------------------------|--------------------------|
| (A) Permeability of free space | (I) $[ML^2T^{-2}]$ |
| (B) Magnetic field | (II) $[MT^{-2}A^{-1}]$ |
| (C) Magnetic moment | (III) $[MLT^{-2}A^{-2}]$ |
| (D) Torsional constant | (IV) $[L^2A]$ |

Choose the correct answer from the options given below :

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

Q6. [24 Jan S2] The energy E and momentum p of a moving body of mass m are related by some equation. Given that c represents the speed of light, identify the correct equation

- (A) $E^2 = pc^2 + m^2c^4$ (B) $E^2 = pc^2 + m^2c^2$
(C) $E^2 = p^2c^2 + m^2c^4$ (D) $E^2 = p^2c^2 + m^2c^2$

Q7. [28 Jan S2] Match List - I with List - II.

List - I**List - II**

- | | |
|----------------------------|---------------------------|
| (A) Angular Impulse | (I) $[M^0L^2T^{-2}]$ |
| (B) Latent Heat | (II) $[ML^2T^{-3}A^{-1}]$ |
| (C) Electrical resistivity | (III) $[ML^2T^{-1}]$ |
| (D) Electromotive force | (IV) $[ML^3T^{-3}A^{-2}]$ |

Choose the correct answer from the options given below :

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

Q8. [29 Jan S1] The pair of physical quantities not having same dimensions is :

- (A) Pressure and (B) Surface tension and Young's modulus impulse
(C) Angular momentum (D) Torque and energy and Planck's constant

Q9. [29 Jan S1] The expression given below shows the variation of velocity (v) with time (t), $v = At^2 + \frac{Bt}{C+t}$. The dimension of ABC is :

- (A) $[M^0L^2T^{-2}]$ (B) $[M^0L^1T^{-3}]$
(C) $[M^0L^2T^{-3}]$ (D) $[M^0L^1T^{-2}]$

Q10. [29 Jan S2] Match List - I with List - II.

List - I**List - II**

- | | |
|------------------------------|-------------------------|
| (A) Young's Modulus | (I) $ML^{-1}T^{-1}$ |
| (B) Torque | (II) $ML^{-1}T^{-2}$ |
| (C) Coefficient of Viscosity | (III) $M^{-1}L^3T^{-2}$ |
| (D) Gravitational Constant | (IV) ML^2T^{-2} |

Choose the correct answer from the options given below :

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

Errors & Measuring Instruments

Q11. [22 Jan S1] Given below are two statements :

Statement I : In vernier callipers, one vernier scale division is always smaller than one main scale division.

Statement II : The vernier constant is given by one main scale division multiplied by the number of vernier scale divisions.

In the light of the above statements, choose the correct answer from the options given below.

- (A) Statement I is false but Statement II is true
(B) Statement I is true but Statement II is false
(C) Both Statement I and Statement II are false
(D) Both Statement I and Statement II are true

Q12. [22 Jan S2] The maximum percentage error in the measurement of density of a wire is [Given,

mass of wire = (0.60 ± 0.003) g, radius of wire = (0.50 ± 0.01) cm, length of wire = (10.00 ± 0.05) cm]

- (A) 5 (B) 8
(C) 4 (D) 7

Q13. [23 Jan S2] The energy of a system is given as $E(t) = \alpha^2 e^{-\beta t}$, where t is the time and $\beta = 0.3 \text{ s}^{-1}$. The errors in the measurement of α and t are 1.2% and 1.6%, respectively. At $t = 5$ s, maximum percentage error in the energy is :

- (A) 8.4% (B) 11.6%
(C) 6% (D) 4%

Q14. [24 Jan S1] For an experimental expression $y = \frac{32.3 \times 1125}{27.4}$, where all the digits are significant. Then to report the value of y we should write

- (A) $y = 1326.2$ (B) $y = 1330$
(C) $y = 1326.186$ (D) $y = 1326.19$

Q15. [24 Jan S1] The least count of a screw gauge is 0.01 mm. If the pitch is increased by 75% and number of divisions on the circular scale is reduced by 50%, the new least count will be $\text{_____} \times 10^{-3}$ mm.

Q16. [28 Jan S1] A tiny metallic rectangular sheet has length and breadth of 5 mm and 2.5 mm, respectively. Using a specially designed screw gauge which has pitch of 0.75 mm and 15 divisions in the circular scale, you are asked to find the area of the sheet. In this measurement, the maximum fractional error will be $\frac{x}{100}$ where x is _____ .

Q17. [28 Jan S1] In a measurement, it is asked to find modulus of elasticity per unit torque applied on the system. The measured quantity has dimension of $[M^a L^b T^c]$. If $b = 3$, the value of c is _____ .

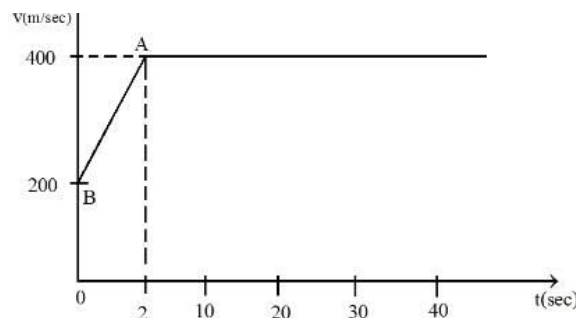
Q18. [29 Jan S2] A physical quantity Q is related to four observables a, b, c, d as follows : $Q = \frac{ab^4}{cd}$ where, $a = (60 \pm 3) \text{ Pa}$; $b = (20 \pm 0.1) \text{ m}$; $c = (40 \pm 0.2) \text{ Nsm}^{-2}$ and $d = (50 \pm 0.1) \text{ m}$, then the percentage error in Q is $\frac{x}{1000}$, where $x = \text{_____}$.

2. Kinematics

9 questions

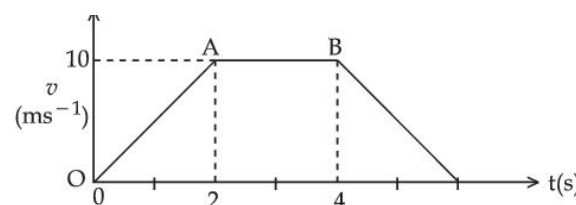
Graphs of Motion

Q1. [23 Jan S1] The motion of an airplane is represented by velocity-time graph as shown below. The distance covered by airplane in the first 30.5 second is _____ km .



- (A) 6 (B) 9
(C) 3 (D) 12

Q2. [28 Jan S2] The velocity-time graph of an object moving along a straight line is shown in figure. What is the distance covered by the object between $t = 0$ to $t = 4$ s ?



- (A) 10 m (B) 30 m
(C) 13 m (D) 11 m

Projectile Motion

Q3. [22 Jan S1] A particle is projected at an angle of 30° from horizontal at a speed of 60 m/s. The height traversed by the particle in the first second is h_0 and height traversed in the last second, before it reaches the maximum height, is h_1 . The ratio $h_0 : h_1$ is _____ . [Take, $g = 10 \text{ m/s}^2$]

Q4. [23 Jan S2] A ball having kinetic energy KE, is projected at an angle of 60° from the horizontal. What will be the kinetic energy of ball at the highest point of its flight ?

- (A) $\frac{KE}{16}$ (B) $\frac{KE}{4}$
(C) $\frac{KE}{2}$ (D) $\frac{KE}{8}$

Q5. [29 Jan S1] Two projectiles are fired with same initial speed from same point on ground at angles of $(45^\circ - \alpha)$ and $(45^\circ + \alpha)$, respectively, with the horizontal direction. The ratio of their maximum heights attained is :

- (A) $\frac{1 - \tan \alpha}{1 + \tan \alpha}$ (B) $\frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$
(C) $\frac{1 + \sin \alpha}{1 - \sin \alpha}$ (D) $\frac{1 + \sin 2\alpha}{1 - \sin 2\alpha}$

Vectors & Relative Motion

Q6. [23 Jan S1] Two particles are located at equal distance from origin. The position vectors of those are represented by $\vec{A} = 2\hat{i} + 3n\hat{j} + 2\hat{k}$ and $\vec{B} =$

$2\hat{i} - 2\hat{j} + 4p\hat{k}$, respectively. If both the vectors are at right angle to each other, the value of n^{-1} is _____.

Q7. [24 Jan S2] The position vector of a moving body at any instant of time is given as $\vec{r} = (5t^2\hat{i} - 5t\hat{j})$ m. The magnitude and direction of velocity at $t = 2$ s is,

- (A) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1} 4$ with -ve Y axis
 (B) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1} 4$ with +ve X axis
 (C) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1} 4$ with +ve X axis
 (D) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1} 4$ with -ve Y axis

Q8. [29 Jan S1] The maximum speed of a boat in still water is 27 km/h. Now this boat is moving downstream in a river flowing at 9 km/h. A man in the boat throws a ball vertically upwards with speed of 10 m/s. Range of the ball as observed by an observer at rest on the river bank, is _____ cm. (Take $g = 10 \text{ m/s}^2$)

Q9. [29 Jan S2] Two cars P and Q are moving on a road in the same direction. Acceleration of car P increases linearly with time whereas car Q moves with a constant acceleration. Both cars cross each other at time $t = 0$, for the first time. The maximum possible number of crossing(s) (including the crossing at $t = 0$) is _____.

3. Laws of Motion & Circular Motion

9 questions

Newton's Laws & Friction

Q1. [23 Jan S2] A massless spring gets elongated by amount x_1 under a tension of 5 N. Its elongation is x_2 under the tension of 7 N. For the elongation of $(5x_1 - 2x_2)$, the tension in the spring will be

- (A) 39 N (B) 11 N
 (C) 20 N (D) 15 N

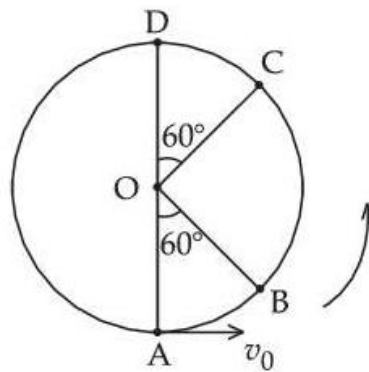
Q2. [28 Jan S2] A balloon and its content having mass M is moving up with an acceleration 'a'. The mass that must be released from the content so that the balloon starts moving up with an acceleration '3a' will be (Take 'g' as acceleration due to gravity)

- (A) $\frac{3Ma}{2a + g}$ (B) $\frac{3Ma}{2a - g}$
 (C) $\frac{2Ma}{3a + g}$ (D) $\frac{2Ma}{3a - g}$

Circular Motion

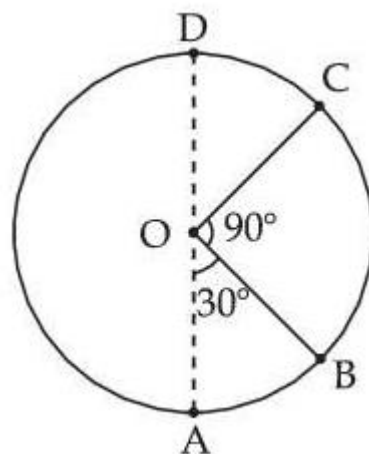
Q3. [22 Jan S1] A bob of mass m is suspended at a

point O by a light string of length l and left to perform vertical motion (circular) as shown in figure. Initially, by applying horizontal velocity v_0 at the point 'A', the string becomes slack when the bob reaches at the point 'D'. The ratio of the kinetic energy of the bob at the points B and C is _____.



- (A) 3 (B) 2
 (C) 1 (D) 4

Q4. [22 Jan S2] A body of mass 100 g is moving in circular path of radius 2 m on vertical plane as shown in figure. The velocity of the body at point A is 10 m/s. The ratio of its kinetic energies at point B and C is : (Take acceleration due to gravity as 10 m/s^2)



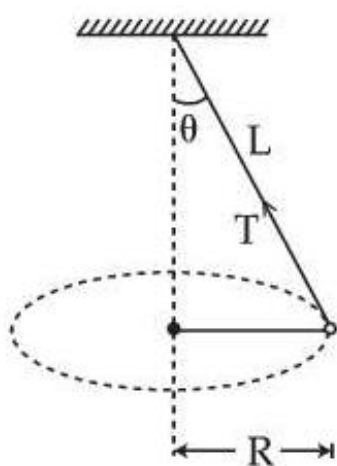
- (A) $\frac{3 - \sqrt{2}}{2}$ (B) $\frac{2 + \sqrt{2}}{3}$
 (C) $\frac{2 + \sqrt{3}}{3}$ (D) $\frac{3 + \sqrt{3}}{2}$

Q5. [22 Jan S2] A tube of length 1 m is filled completely with an ideal liquid of mass $2M$, and closed at both ends. The tube is rotated uniformly in horizontal plane about one of its ends. If the force exerted by the liquid at the other end is F then angular velocity of the tube is $\sqrt{\frac{F}{\alpha M}}$ in SI unit. The value of α is _____.

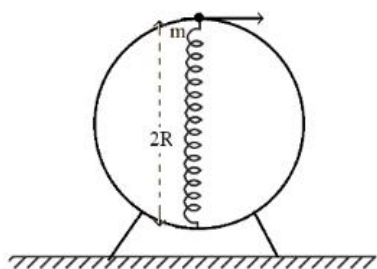
Q6. [24 Jan S1] A car of mass 'm' moves on a banked road having radius 'r' and banking angle θ . To avoid slipping from banked road, the maximum permissible speed of the car is v_0 . The coefficient of friction μ between the wheels of the car and the banked road is

- (A) $\mu = \frac{v_0^2 + rg \tan \theta}{rg - v_0^2 \tan \theta}$ (B) $\mu = \frac{v_0^2 - rg \tan \theta}{rg + v_0^2 \tan \theta}$
 (C) $\mu = \frac{v_0^2 + rg \tan \theta}{rg + v_0^2 \tan \theta}$ (D) $\mu = \frac{v_0^2 - rg \tan \theta}{rg - v_0^2 \tan \theta}$

Q7. [24 Jan S2] A string of length L is fixed at one end and carries a mass of M at the other end. The mass makes $\left(\frac{3}{\pi}\right)$ rotations per second about the vertical axis passing through end of the string as shown. The tension in the string is _____ ML .



Q8. [28 Jan S1] A bead of mass 'm' slides without friction on the wall of a vertical circular hoop of radius 'R' as shown in figure. The bead moves under the combined action of gravity and a massless spring (k) attached to the bottom of the hoop. The equilibrium length of the spring is 'R'. If the bead is released from top of the hoop with (negligible) zero initial speed, velocity of bead, when length of spring becomes 'R', would be (spring constant is 'k', g is acceleration due to gravity)



- (A) $\sqrt{2Rg + \frac{4kR^2}{m}}$ (B) $\sqrt{2Rg + \frac{kR^2}{m}}$
 (C) $2\sqrt{gR + \frac{kR^2}{m}}$ (D) $\sqrt{3Rg + \frac{kR^2}{m}}$

Q9. [29 Jan S1] A body of mass 'm' connected to a massless and unstretchable string goes in vertical circle of radius 'R' under gravity g . The other end of the string is fixed at the center of circle. If velocity at top of circular path is $n\sqrt{gR}$, where, $n \geq 1$, then ratio of kinetic energy of the body at bottom to that at top of the circle is

- (A) $\frac{n}{n+4}$ (B) $\frac{n^2+4}{n^2}$
 (C) $\frac{n^2}{n^2+4}$ (D) $\frac{n+4}{n}$

4. Work, Energy, Power & Collisions

9 questions

Work, Energy & Power

Q1. [22 Jan S2] A ball of mass 100 g is projected with velocity 20 m/s at 60° with horizontal. The decrease in kinetic energy of the ball during the motion from point of projection to highest point is

- (A) 15 J (B) zero
 (C) 5 J (D) 20 J

Q2. [22 Jan S2] A force $\vec{F} = 2\hat{i} + b\hat{j} + \hat{k}$ is applied on a particle and it undergoes a displacement $\hat{i} - 2\hat{j} - \hat{k}$. What will be the value of b , if work done on the particle is zero.

- (A) $\frac{1}{3}$ (B) 2
 (C) 0 (D) $\frac{1}{2}$

Q3. [23 Jan S1] A force $\vec{f} = x^2y\hat{i} + y^2\hat{j}$ acts on a particle in a plane $x + y = 10$. The work done by this force during a displacement from (0, 0) to (4m, 2m) is _____ Joule (round off to the nearest integer)

Q4. [24 Jan S1] A force $F = \alpha + \beta x^2$ acts on an object in the x -direction. The work done by the force is 5 J when the object is displaced by 1 m. If the constant $\alpha = 1$ N then β will be

- (A) 15 N/m² (B) 10 N/m²
 (C) 8 N/m² (D) 12 N/m²

Q5. [28 Jan S1] Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: In a central force field, the work done is independent of the path chosen.

Reason R: Every force encountered in mechanics does not have an associated potential energy.

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

- (A) Both A and R are true but R is NOT the correct explanation of A

- (B) A is true but R is false
 (C) A is false but R is true
 (D) Both A and R are true and R is the correct explanation of A

Q6. [28 Jan S2] A body of mass 4 kg is placed on a plane at a point P having coordinate (3, 4) m. Under the action of force $\vec{F} = (2\hat{i} + 3\hat{j})\text{N}$, it moves to a new point Q having coordinates (6, 10)m in 4 sec. The average power and instantaneous power at the end of 4 sec are in the ratio of :

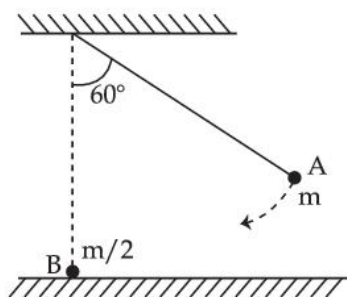
- (A) 13 : 6 (B) 6 : 13
 (C) 1 : 2 (D) 4 : 3

Q7. [29 Jan S2] A sand dropper drops sand of mass $m(t)$ on a conveyer belt at a rate proportional to the square root of speed (v) of the belt, i.e. $\frac{dm}{dt} \propto \sqrt{v}$. If P is the power delivered to run the belt at constant speed then which of the following relationship is true ?

- (A) $P \propto v$ (B) $P \propto \sqrt{v}$
 (C) $P^2 \propto v^5$ (D) $P^2 \propto v^3$

Collisions

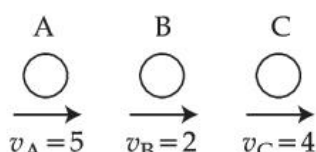
Q8. [29 Jan S1] As shown below, bob A of a pendulum having massless string of length 'R' is released from 60° to the vertical. It hits another bob B of half the mass that is at rest on a friction less table in the center. Assuming elastic collision, the magnitude of the velocity of bob A after the collision will be (take g as acceleration due to gravity.)



- (A) $\frac{2}{3}\sqrt{Rg}$ (B) $\frac{1}{3}\sqrt{Rg}$
 (C) $\frac{4}{3}\sqrt{Rg}$ (D) $\sqrt{Rg}$

Q9. [29 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) :



Three identical spheres of same mass undergo one dimensional motion as shown in figure with initial

velocities $v_A = 5 \text{ m/s}$, $v_B = 2 \text{ m/s}$, $v_C = 4 \text{ m/s}$. If we wait sufficiently long for elastic collision to happen, then $v_A = 4 \text{ m/s}$, $v_B = 2 \text{ m/s}$, $v_C = 5 \text{ m/s}$ will be the final velocities.

Reason (R) : In an elastic collision between identical masses, two objects exchange their velocities.

In the light of the above statements, choose the correct answer from the options given below :

- (A) (A) is false but (R) is true
 (B) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (C) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
 (D) (A) is true but (R) is false

5. Rotational Motion

15 questions

Centre of Mass

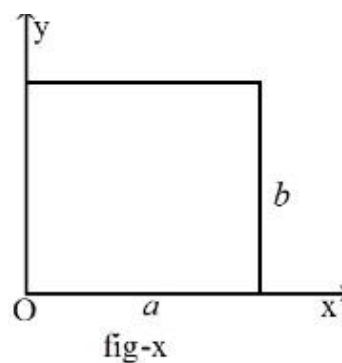
Q1. [23 Jan S1] Consider a circular disc of radius 20 cm with centre located at the origin. A circular hole of radius 5 cm is cut from this disc in such a way that the edge of the hole touches the edge of the disc. The distance of centre of mass of residual or remaining disc from the origin will be

- (A) 0.5 cm (B) 2.0 cm
 (C) 1.5 cm (D) 1.0 cm

Q2. [24 Jan S2] A solid sphere is rolling without slipping on a horizontal plane. The ratio of the linear kinetic energy of the centre of mass of the sphere and rotational kinetic energy is :

- (A) $\frac{2}{5}$ (B) $\frac{3}{4}$
 (C) $\frac{4}{3}$ (D) $\frac{5}{2}$

Q3. [28 Jan S1] The center of mass of a thin rectangular plate (fig - x) with sides of length a and b , whose mass per unit area (σ) varies as $\sigma = \frac{\sigma_0 x}{ab}$ (where σ_0 is a constant), would be _____.

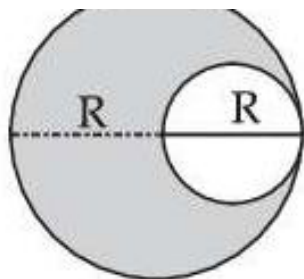


- (A) $(\frac{2}{3}a, \frac{b}{2})$ (B) $(\frac{1}{3}a, \frac{b}{2})$
 (C) $(\frac{a}{2}, \frac{b}{2})$ (D) $(\frac{2}{3}a, \frac{2}{3}b)$

Moment of Inertia

Q4. [22 Jan S1] A uniform circular disc of radius 'R'

and mass 'M' is rotating about an axis perpendicular to its plane and passing through its centre. A small circular part of radius $R/2$ is removed from the original disc as shown in the figure. Find the moment of inertia of the remaining part of the original disc about the axis as given above.



- (A) $\frac{9}{32}MR^2$ (B) $\frac{13}{32}MR^2$
 (C) $\frac{17}{32}MR^2$ (D) $\frac{7}{32}MR^2$

Q5. [28 Jan S1] The moment of inertia of a solid disc rotating along its diameter is 2.5 times higher than the moment of inertia of a ring rotating in similar way. The moment of inertia of a solid sphere which has same radius as the disc and rotating in similar way, is n times higher than the moment of inertia of the given ring. Here, $n = \underline{\hspace{1cm}}$. Consider all the bodies have equal masses.

Torque & Angular Momentum

Q6. [22 Jan S1] The position vectors of two 1 kg particles, (A) and (B), are given by $\vec{r}_A = (\alpha_1 t^2 \hat{i} + \alpha_2 t \hat{j} + \alpha_3 t \hat{k})$ m and $\vec{r}_B = (\beta_1 t \hat{i} + \beta_2 t^2 \hat{j} + \beta_3 t \hat{k})$ m, respectively; ($\alpha_1 = 1$ m/s², $\alpha_2 = 3n$ m/s, $\alpha_3 = 2$ m/s, $\beta_1 = 2$ m/s, $\beta_2 = -1$ m/s², $\beta_3 = 4p$ m/s), where t is time, n and p are constants. At $t = 1$ s, $|\vec{v}_A| = |\vec{v}_B|$ and velocities $\vec{v}_A$ and $\vec{v}_B$ of the particles are orthogonal to each other. At $t = 1$ s, the magnitude of angular momentum of particle (A) with respect to the position of particle (B) is $\sqrt{L}$ kg m² s⁻¹. The value of L is $\underline{\hspace{1cm}}$.

Q7. [22 Jan S2] The torque due to the force $(2\hat{i} + \hat{j} + 2\hat{k})$ about the origin, acting on a particle whose position vector is $(\hat{i} + \hat{j} + \hat{k})$, would be

- (A) $\hat{i} - \hat{j} + \hat{k}$ (B) $\hat{j} + \hat{k}$
 (C) $\hat{i} - \hat{k}$ (D) $\hat{i} + \hat{k}$

Q8. [23 Jan S2] A circular disk of radius R meter and mass M kg is rotating around the axis perpendicular to the disk. An external torque is applied to the disk such that $\theta(t) = 5t^2 - 8t$, where $\theta(t)$ is the angular position of the rotating disc as a function of time t . How much power is delivered by the applied torque, when $t = 2$ s ?

- (A) $72 MR^2$ (B) $8 MR^2$
 (C) $108 MR^2$ (D) $60 MR^2$

Q9. [24 Jan S1] An object of mass 'm' is projected from origin in a vertical xy plane at an angle 45° with the x -axis with an initial velocity v_0 . The magnitude and direction of the angular momentum of the object with respect to origin, when it reaches at the maximum height, will be [g is acceleration due to gravity]

- (A) $\frac{mv_0^3}{4\sqrt{2}g}$ along positive z -axis (B) $\frac{mv_0^3}{2\sqrt{2}g}$ along negative z -axis
 (C) $\frac{mv_0^3}{2\sqrt{2}g}$ along positive z -axis (D) $\frac{mv_0^3}{4\sqrt{2}g}$ along negative z -axis

Q10. [28 Jan S1] Two iron solid discs of negligible thickness have radii R_1 and R_2 and moment of inertia I_1 and I_2 , respectively. For $R_2 = 2R_1$, the ratio of I_1 and I_2 would be $1/x$, where $x = \underline{\hspace{1cm}}$.

Q11. [28 Jan S2] A uniform rod of mass 250 g having length 100 cm is balanced on a sharp edge at 40 cm mark. A mass of 400 g is suspended at 10 cm mark. To maintain the balance of the rod, the mass to be suspended at 90 cm mark, is

- (A) 290 g (B) 200 g
 (C) 300 g (D) 190 g

Q12. [29 Jan S1] The coordinates of a particle with respect to origin in a given reference frame is (1, 1, 1) meters. If a force of $\vec{F} = \hat{i} - \hat{j} + \hat{k}$ acts on the particle, then the magnitude of torque (with respect to origin) in z -direction is $\underline{\hspace{1cm}}$.

Rolling Motion

Q13. [23 Jan S1] A solid sphere of mass 'm' and radius 'r' is allowed to roll without slipping from the highest point of an inclined plane of length 'L' and makes an angle 30° with the horizontal. The speed of the particle at the bottom of the plane is v_1 . If the angle of inclination is increased to 45° while keeping L constant. Then the new speed of the sphere at the bottom of the plane is v_2 . The ratio $v_1^2 : v_2^2$ is

- (A) $1 : \sqrt{3}$ (B) $1 : 2$
 (C) $1 : 3$ (D) $1 : \sqrt{2}$

Q14. [24 Jan S1] A uniform solid cylinder of mass 'm' and radius 'r' rolls along an inclined rough plane of inclination 45° . If it starts to roll from rest from the top of the plane then the linear acceleration of the cylinder's axis will be

- (A) $\frac{1}{\sqrt{2}}g$ (B) $\sqrt{2}g$
 (C) $\frac{\sqrt{2}g}{3}$ (D) $\frac{1}{3\sqrt{2}}g$

Q15. [24 Jan S2] A solid sphere and a hollow sphere of the same mass and of same radius are rolled on an inclined plane. Let the time taken to reach the bottom by the solid sphere and the hollow sphere

be t_1 and t_2 , respectively, then

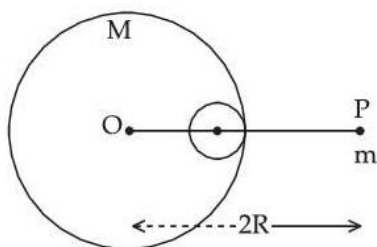
- (A) $t_1 > t_2$ (B) $t_1 = 2t_2$
 (C) $t_1 < t_2$ (D) $t_1 = t_2$

6. Gravitation

10 questions

Gravitational Field & Acceleration due to Gravity

Q1. [22 Jan S1] A small point of mass m is placed at a distance $2R$ from the centre 'O' of a big uniform solid sphere of mass M and radius R . The gravitational force on 'm' due to M is F_1 . A spherical part of radius $R/3$ is removed from the big sphere as shown in the figure and the gravitational force on m due to remaining part of M is found to be F_2 . The value of ratio $F_1 : F_2$ is



- (A) 11 : 10 (B) 16 : 9
 (C) 12 : 9 (D) 12 : 11

Q2. [24 Jan S2] Acceleration due to gravity on the surface of earth is 'g'. If the diameter of earth is reduced to one third of its original value and mass remains unchanged, then the acceleration due to gravity on the surface of the earth is _____ g.

Q3. [29 Jan S1] Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Time period of a simple pendulum is longer at the top of a mountain than that at the base of the mountain.

Reason (R) : Time period of a simple pendulum decreases with increasing value of acceleration due to gravity and vice-versa.

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

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
 (C) (A) is true but (R) is false
 (D) (A) is false but (R) is true

Satellites & Orbital Motion

Q4. [22 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : A simple pendulum is taken to a planet of mass and radius, 4 times and 2 times, respectively, than the Earth. The time period of the pendulum remains same on earth and the planet.

Reason (R) : The mass of the pendulum remains unchanged at Earth and the other planet.

In the light of the above statements, choose the correct answer from the options given below :

- (A) (A) is false but (R) is true
 (B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
 (C) (A) is true but (R) is false
 (D) Both (A) and (R) are true and (R) is the correct explanation of (A)

Q5. [23 Jan S2] If a satellite orbiting the Earth is 9 times closer to the Earth than the Moon, what is the time period of rotation of the satellite? Given rotational time period of Moon = 27 days and gravitational attraction between the satellite and the moon is neglected.

- (A) 1 day (B) 27 days
 (C) 81 days (D) 3 days

Q6. [23 Jan S2] A satellite of mass $\frac{M}{2}$ is revolving around earth in a circular orbit at a height of $\frac{R}{3}$ from earth surface. The angular momentum of the satellite is $M\sqrt{\frac{GMR}{x}}$. The value of x is _____, where M and R are the mass and radius of earth, respectively. (G is the gravitational constant)

Q7. [24 Jan S1] A satellite is launched into a circular orbit of radius 'R' around the earth. A second satellite is launched into an orbit of radius $1.03 R$. The time period of revolution of the second satellite is larger than the first one approximately by

- (A) 2.5% (B) 4.5%
 (C) 3% (D) 9%

Q8. [28 Jan S2] Earth has mass 8 times and radius 2 times that of a planet. If the escape velocity from the earth is 11.2 km/s, the escape velocity in km/s from the planet will be :

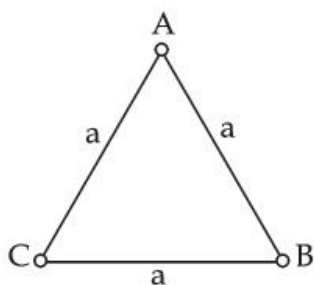
- (A) 11.2 (B) 8.4
 (C) 5.6 (D) 2.8

Q9. [29 Jan S2] Two planets, A and B are orbiting a common star in circular orbits of radii R_A and R_B , respectively, with $R_B = 2R_A$. The planet B is $4\sqrt{2}$ times more massive than planet A. The ratio $\left(\frac{L_B}{L_A}\right)$ of angular momentum (L_B) of planet B to that of

planet A (L_A) is closest to integer ____.

Gravitational Interaction & Angular Momentum

Q10. [29 Jan S2] Three equal masses m are kept at vertices (A, B, C) of an equilateral triangle of side a in free space. At $t = 0$, they are given an initial velocity $\vec{V}_A = V_0 \vec{AC}$, $\vec{V}_B = V_0 \vec{BA}$ and $\vec{V}_C = V_0 \vec{CB}$. Here, $\vec{AC}$, $\vec{CB}$ and $\vec{BA}$ are unit vectors along the edges of the triangle. If the three masses interact gravitationally, then the magnitude of the net angular momentum of the system at the point of collision is :



- (A) $3 a m V_0$ (B) $\frac{\sqrt{3}}{2} a m V_0$
 (C) $\frac{1}{2} a m V_0$ (D) $\frac{3}{2} a m V_0$

7. Properties of Solids & Liquids

15 questions

Elasticity

Q1. [24 Jan S2] The increase in pressure required to decrease the volume of a water sample by 0.2% is $P \times 10^5 \text{ N m}^{-2}$. Bulk modulus of water is $2.15 \times 10^9 \text{ N m}^{-2}$. The value of P is ____.

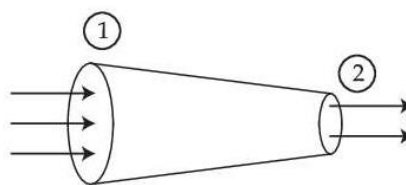
Q2. [28 Jan S2] The volume contraction of a solid copper cube of edge length 10 cm, when subjected to a hydraulic pressure of $7 \times 10^6 \text{ Pa}$, would be ____ mm^3 . (Given bulk modulus of copper = $1.4 \times 10^{11} \text{ N m}^{-2}$)

Q3. [29 Jan S1] The fractional compression ($\frac{\Delta V}{V}$) of water at the depth of 2.5 km below the sea level is ____%. Given, the Bulk modulus of water = $2 \times 10^9 \text{ N m}^{-2}$, density of water = 10^3 kg m^{-3} , acceleration due to gravity = $g = 10 \text{ m s}^{-2}$.

- (A) 1.75 (B) 1.25
 (C) 1.5 (D) 1.0

Fluid Mechanics (Pressure, Buoyancy, Flow)

Q4. [22 Jan S2] A tube of length L is shown in the figure. The radius of cross section at the point (1) is 2 cm and at the point (2) is 1 cm, respectively. If the velocity of water entering at point (1) is 2 m/s, then velocity of water leaving the point (2) will be



- (A) 2 m/s (B) 4 m/s
 (C) 6 m/s (D) 8 m/s

Q5. [23 Jan S2] Water flows in a horizontal pipe whose one end is closed with a valve. The reading of the pressure gauge attached to the pipe is P_1 . The reading of the pressure gauge falls to P_2 when the valve is opened. The speed of water flowing in the pipe is proportional to

- (A) $P_1 - P_2$ (B) $\sqrt{P_1 - P_2}$
 (C) $(P_1 - P_2)^2$ (D) $(P_1 - P_2)^4$

Q6. [28 Jan S2] A 400 g solid cube having an edge of length 10 cm floats in water. How much volume of the cube is outside the water? (Given : density of water = 1000 kg m^{-3})

- (A) 600 cm^3 (B) 400 cm^3
 (C) 4000 cm^3 (D) 1400 cm^3

Q7. [29 Jan S1] In a hydraulic lift, the surface area of the input piston is 6 cm^2 and that of the output piston is 1500 cm^2 . If 100 N force is applied to the input piston to raise the output piston by 20 cm, then the work done is ____ kJ.

Surface Tension

Q8. [22 Jan S1] Two soap bubbles of radius 2 cm and 4 cm, respectively, are in contact with each other. The radius of curvature of the common surface, in cm, is ____.

Q9. [22 Jan S2] A small rigid spherical ball of mass M is dropped in a long vertical tube containing glycerine. The velocity of the ball becomes constant after some time. If the density of glycerine is half of the density of the ball, then the viscous force acting on the ball will be (consider g as acceleration due to gravity)

- (A) Mg (B) $\frac{3}{2}Mg$
 (C) $2Mg$ (D) $\frac{Mg}{2}$

Q10. [23 Jan S2] An air bubble of radius 1.0 mm is observed at a depth of 20 cm below the free surface of a liquid having surface tension 0.095 J/m^2 and density 10^3 kg/m^3 . The difference between pressure inside the bubble and atmospheric pressure is ____ N/m^2 . (Take $g = 10 \text{ m/s}^2$)

Q11. [24 Jan S1] An air bubble of radius 0.1 cm lies at a depth of 20 cm below the free surface of a liquid of density 1000 kg/m^3 . If the pressure inside the bubble is 2100 N/m^2 greater than the atmospheric

pressure, then the surface tension of the liquid in SI unit is (use $g = 10 \text{ m/s}^2$)

- (A) 0.1 (B) 0.05
(C) 0.02 (D) 0.25

Q12. [24 Jan S1] The amount of work done to break a big water drop of radius 'R' into 27 small drops of equal radius is 10 J. The work done required to break the same big drop into 64 small drops of equal radius will be

- (A) 20 J (B) 15 J
(C) 5 J (D) 10 J

Viscosity

Q13. [28 Jan S1] In the experiment for measurement of viscosity ' η ' of given liquid with a ball having radius R, consider following statements.

- A. Graph between terminal velocity V and R will be a parabola.
B. The terminal velocities of different diameter balls are constant for a given liquid.
C. Measurement of terminal velocity is dependent on the temperature.
D. This experiment can be utilized to assess the density of a given liquid.
E. If balls are dropped with some initial speed, the value of η will change.

Choose the correct answer from the options given below:

- (A) C, D and E Only (B) A, C and D Only
(C) A, B and E Only (D) B, D and E Only

Surface Tension & Viscosity

Q14. [23 Jan S1] Given below are two statements:
Statement I: The hot water flows faster than cold water.

Statement II: Soap water has higher surface tension as compared to fresh water.

In the light above statements, choose the correct answer from the options given below

- (A) Both Statement I and Statement II are false
(B) Statement I is false but Statement II is true
(C) Both Statement I and Statement II are true
(D) Statement I is true but Statement II is false

Q15. [28 Jan S1] Consider following statements:

- A. Surface tension arises due to extra energy of the molecules at the interior as compared to the molecules at the surface, of a liquid.
B. As the temperature of liquid rises, the coefficient of viscosity increases.
C. As the temperature of gas increases, the coefficient of viscosity increases
D. The onset of turbulence is determined by Reynold's number.
E. In a steady flow two stream lines never intersect.

Choose the correct answer from the options given below:

- (A) C, D, E Only (B) A, D, E Only
(C) A, B, C Only (D) B, C, D Only

8. Thermal Properties of Matter

7 questions

Calorimetry & Change of State

Q1. [22 Jan S1] An amount of ice of mass 10^{-3} kg and temperature -10°C is transformed to vapour of temperature 110°C by applying heat. The total amount of work required for this conversion is, (Take, specific heat of ice = $2100 \text{ Jkg}^{-1}\text{K}^{-1}$, specific heat of water = $4180 \text{ Jkg}^{-1}\text{K}^{-1}$, specific heat of steam = $1920 \text{ Jkg}^{-1}\text{K}^{-1}$, Latent heat of ice = $3.35 \times 10^5 \text{ Jkg}^{-1}$ and Latent heat of steam = $2.25 \times 10^6 \text{ Jkg}^{-1}$)

- (A) 3043 J (B) 3024 J
(C) 3003 J (D) 3022 J

Q2. [23 Jan S1] A gun fires a lead bullet of temperature 300 K into a wooden block. The bullet having melting temperature of 600 K penetrates into the block and melts down. If the total heat required for the process is 625 J , then the mass of the bullet is _____ grams. (Latent heat of fusion of lead = $2.5 \times 10^4 \text{ Jkg}^{-1}$ and specific heat capacity of lead = $125 \text{ Jkg}^{-1}\text{K}^{-1}$)

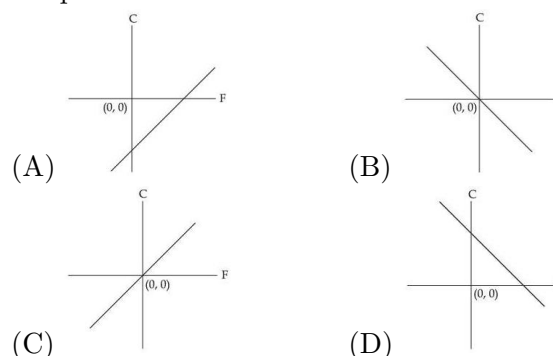
- (A) 15 (B) 5
(C) 10 (D) 20

Q3. [24 Jan S2] The temperature of a body in air falls from 40°C to 24°C in 4 minutes. The temperature of the air is 16°C . The temperature of the body in the next 4 minutes will be :

- (A) $\frac{42}{3}^\circ\text{C}$ (B) $\frac{28}{3}^\circ\text{C}$
(C) $\frac{56}{3}^\circ\text{C}$ (D) $\frac{14}{3}^\circ\text{C}$

Temperature Scales

Q4. [24 Jan S2] Which of the following figure represents the relation between Celsius and Fahrenheit temperatures ?



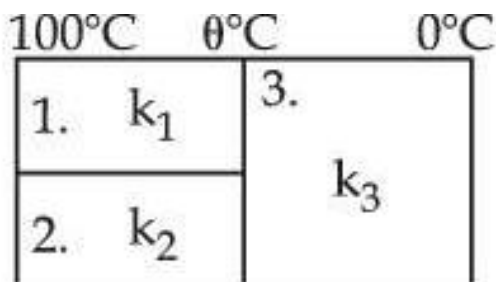
Heat Transfer & Thermal Radiation

Q5. [22 Jan S1] Two spherical bodies of same materi-

als having radii 0.2 m and 0.8 m are placed in same atmosphere. The temperature of the smaller body is 800 K and temperature of the bigger body is 400 K. If the energy radiated from the smaller body is E , the energy radiated from the bigger body is (assume, effect of the surrounding temperature to be negligible),

- (A) E (B) $16E$
(C) $64E$ (D) $256E$

Q6. [22 Jan S1] Three conductors of same length having thermal conductivity k_1 , k_2 and k_3 are connected as shown in figure. Area of cross sections of 1st and 2nd conductor are same and for 3rd conductor it is double of the 1st conductor. The temperatures are given in the figure. In steady state condition, the value of θ is _____ °C. (Given : $k_1 = 60 \text{ Js}^{-1}\text{m}^{-1}\text{K}^{-1}$, $k_2 = 120 \text{ Js}^{-1}\text{m}^{-1}\text{K}^{-1}$, $k_3 = 135 \text{ Js}^{-1}\text{m}^{-1}\text{K}^{-1}$)



Newton's Law of Cooling

Q7. [29 Jan S2] A cup of coffee cools from 90°C to 80°C in t minutes when the room temperature is 20°C. The time taken by the similar cup of coffee to cool from 80°C to 60°C at the same room temperature is :

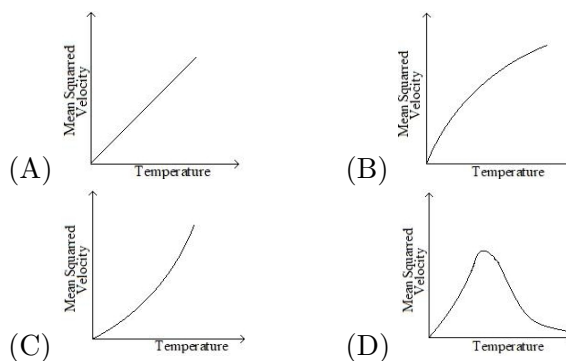
- (A) $\frac{5}{13}t$ (B) $\frac{13}{10}t$
(C) $\frac{10}{13}t$ (D) $\frac{13}{5}t$

9. Kinetic Theory of Gases

5 questions

Kinetic Theory of Gases

Q1. [28 Jan S1] For a particular ideal gas which of the following graphs represents the variation of mean squared velocity of the gas molecules with temperature?



Q2. [28 Jan S2] The ratio of vapour densities of two gases at the same temperature is $\frac{4}{25}$, then the ratio of r.m.s. velocities will be :

- (A) $\frac{25}{4}$ (B) $\frac{5}{2}$
(C) $\frac{4}{25}$ (D) $\frac{2}{5}$

Q3. [28 Jan S2] The kinetic energy of translation of the molecules in 50 g of CO₂ gas at 17°C is

- (A) 3986.3 J (B) 3582.7 J
(C) 4102.8 J (D) 4205.5 J

Q4. [29 Jan S1] A container of fixed volume contains a gas at 27°C. To double the pressure of the gas, the temperature of gas should be raised to _____ °C.

Specific Heats & Degrees of Freedom

Q5. [22 Jan S2] For a diatomic gas, if $\gamma_1 = \left(\frac{C_p}{C_v}\right)$ for rigid molecules and $\gamma_2 = \left(\frac{C_p}{C_v}\right)$ for another diatomic molecules, but also having vibrational modes. Then, which one of the following options is correct ? (C_p and C_v are specific heats of the gas at constant pressure and volume)

- (A) $\gamma_2 = \gamma_1$ (B) $2\gamma_2 = \gamma_1$
(C) $\gamma_2 < \gamma_1$ (D) $\gamma_2 > \gamma_1$

10. Thermodynamics

13 questions

Thermodynamic Variables & Entropy

Q1. [22 Jan S2] Given are statements for certain thermodynamic variables,

- (A) Internal energy, volume (V) and mass (M) are extensive variables.
(B) Pressure (P), temperature (T) and density (ρ) are intensive variables.
(C) Volume (V), temperature (T) and density (ρ) are intensive variables.
(D) Mass (M), temperature (T) and internal energy are extensive variables.

Choose the correct answer from the options given below :

- (A) (A) and (B) Only (B) (D) and (A) Only
(C) (C) and (D) Only (D) (B) and (C) Only

Q2. [23 Jan S2] Water of mass m gram is slowly heated to increase the temperature from T_1 to T_2 . The change in entropy of the water, given specific heat of water is $1 \text{ Jkg}^{-1}\text{K}^{-1}$, is :

- (A) $m \ln \left(\frac{T_2}{T_1} \right)$ (B) zero
(C) $m(T_2 - T_1)$ (D) $m \ln \left(\frac{T_1}{T_2} \right)$

Thermodynamic Processes & First Law

Q3. [23 Jan S1] Match the LIST-I with LIST-II

LIST-I

- A. Pressure varies inversely with volume of an ideal gas.
B. Heat absorbed goes partly to increase internal energy and partly to do work.
C. Heat is neither absorbed nor released by a system.
D. No work is done on or by a gas.

LIST-II

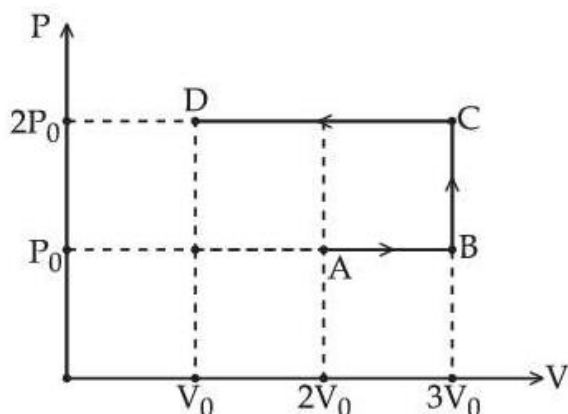
- I. Adiabatic process
II. Isochoric process
III. Isothermal process
IV. Isobaric process

Choose the correct answer from the options given below :

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

Q4. [23 Jan S1] An ideal gas initially at 0°C temperature, is compressed suddenly to one fourth of its volume. If the ratio of specific heat at constant pressure to that at constant volume is $3/2$, the change in temperature due to the thermodynamic process is ____ K.

Q5. [23 Jan S2] Using the given P-V diagram, the work done by an ideal gas along the path ABCD is :



- (A) $3P_0V_0$ (B) $-3P_0V_0$
(C) $4P_0V_0$ (D) $-4P_0V_0$

Q6. [24 Jan S1] An ideal gas goes from an initial state to final state. During the process, the pressure of gas increases linearly with temperature.

A. The work done by gas during the process is zero.

B. The heat added to gas is different from change in its internal energy.

C. The volume of the gas is increased.

D. The internal energy of the gas is increased.

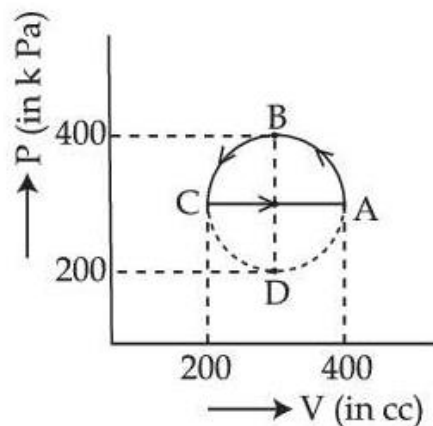
E. The process is isochoric (constant volume process)

Choose the correct answer from the options given below:

- (A) A, D, E Only (B) A, B, C, D Only
(C) E Only (D) A, C Only

Q7. [24 Jan S1] The temperature of 1 mole of an ideal monoatomic gas is increased by 50°C at constant pressure. The total heat added and change in internal energy are E_1 and E_2 , respectively. If $\frac{E_1}{E_2} = \frac{x}{9}$ then the value of x is ____.

Q8. [24 Jan S2] The magnitude of heat exchanged by a system for the given cyclic process ABCA (as shown in figure) is (in SI unit) :



- (A) 5π (B) zero
(C) 40π (D) 10π

Q9. [24 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : In an insulated container, a gas is adiabatically shrunk to half of its initial volume. The temperature of the gas decreases.

Reason (R) : Free expansion of an ideal gas is an irreversible and adiabatic process.

In the light of the above statements, choose the correct answer from the options given below :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) (A) is false but (R) is true
(C) (A) is true but (R) is false
(D) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

Q10. [29 Jan S1] The workdone in an adiabatic change in an ideal gas depends upon only :

- (A) change in its specific heat
(B) change in its pressure
(C) change in its volume
(D) change in its temperature

Q11. [29 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

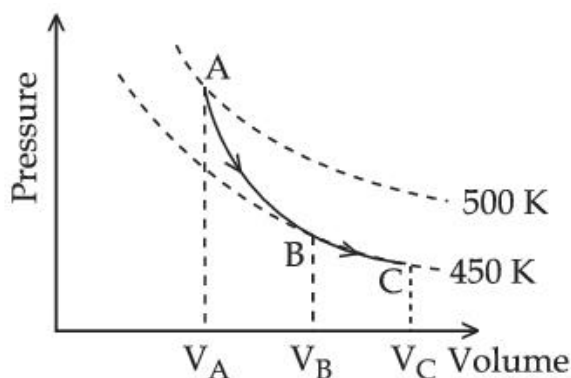
Assertion (A) : With the increase in pressure of an ideal gas, the volume falls off more rapidly in an isothermal process in comparison to the adiabatic process.

Reason (R) : In isothermal process, $PV = \text{constant}$, while in adiabatic process $PV^\gamma = \text{constant}$. Here γ is the ratio of specific heats, P is the pressure and V is the volume of the ideal gas.

In the light of the above statements, choose the correct answer from the options given below :

- (A) (A) is true but (R) is false
(B) Both (A) and (R) are true and (R) is the correct explanation of (A)
(C) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
(D) (A) is false but (R) is true

Q12. [29 Jan S2] A poly-atomic molecule ($C_V = 3R$, $C_P = 4R$, where R is gas constant) goes from phase space point $A(P_A = 10^5 \text{ Pa}, V_A = 4 \times 10^{-6} \text{ m}^3)$ to point $B(P_B = 5 \times 10^4 \text{ Pa}, V_B = 6 \times 10^{-6} \text{ m}^3)$ to point $C(P_C = 10^4 \text{ Pa}, V_C = 8 \times 10^{-6} \text{ m}^3)$. A to B is an adiabatic path and B to C is an isothermal path. The net heat absorbed per unit mole by the system is :



- (A) $500R(\ln 3 + \ln 4)$
(B) $400R \ln 4$
(C) $450R(\ln 4 - \ln 3)$
(D) $500R \ln 2$

Heat Engines & Carnot Cycle

Q13. [28 Jan S1] A Carnot engine (E) is working between two temperatures 473K and 273K. In a new system two engines - engine E_1 works between 473K to 373K and engine E_2 works between 373K to 273K. If η_{12} , η_1 and η_2 are the efficiencies of the engines E, E_1 and E_2 , respectively, then

- (A) $\eta_{12} < \eta_1 + \eta_2$
(B) $\eta_{12} = \eta_1 + \eta_2$
(C) $\eta_{12} \geq \eta_1 + \eta_2$
(D) $\eta_{12} = \eta_1 \eta_2$

11. Oscillations (SHM)

5 questions

Simple Harmonic Motion

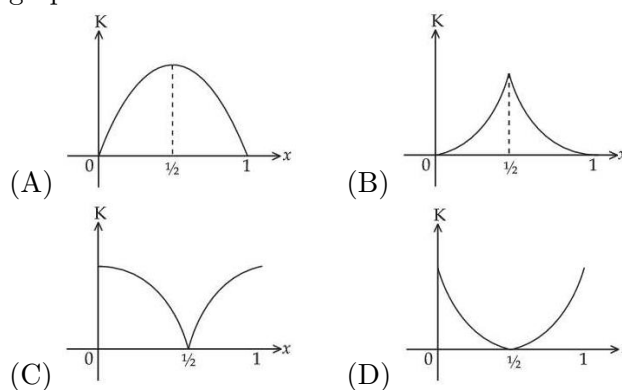
Q1. [23 Jan S1] A light hollow cube of side length 10 cm and mass 10 g, is floating in water. It is pushed down and released to execute simple harmonic oscillations. The time period of oscillations is $y\pi \times 10^{-2} \text{ s}$, where the value of y is (Acceleration due to gravity, $g = 10 \text{ m/s}^2$, density of water $= 10^3 \text{ kg/m}^3$)

- (A) 4
(B) 6
(C) 1
(D) 2

Q2. [24 Jan S1] A particle is executing simple harmonic motion with time period 2 s and amplitude 1 cm. If D and d are the total distance and displacement covered by the particle in 12.5 s, then $\frac{D}{d}$ is

- (A) $\frac{16}{5}$
(B) 10
(C) $\frac{15}{4}$
(D) 25

Q3. [24 Jan S2] A particle oscillates along the x -axis according to the law, $x(t) = x_0 \sin^2\left(\frac{t}{2}\right)$ where $x_0 = 1 \text{ m}$. The kinetic energy (K) of the particle as a function of x is correctly represented by the graph



Q4. [28 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Knowing initial position x_0 and initial momentum p_0 is enough to determine the position and momentum at any time t for a simple harmonic motion with a given angular frequency ω .

Reason (R) : The amplitude and phase can be expressed in terms of x_0 and p_0 .

In the light of the above statements, choose the correct answer from the options given below :

- (A) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

- (B) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (C) (A) is false but (R) is true
 (D) (A) is true but (R) is false

Q5. [29 Jan S2] Two bodies A and B of equal mass are suspended from two massless springs of spring constant k_1 and k_2 , respectively. If the bodies oscillate vertically such that their amplitudes are equal, the ratio of the maximum velocity of A to the maximum velocity of B is

- (A) $\frac{k_2}{k_1}$ (B) $\frac{k_1}{k_2}$
 (C) $\sqrt{\frac{k_1}{k_2}}$ (D) $\sqrt{\frac{k_2}{k_1}}$

12. Waves & Sound

3 questions

Sound Waves & Organ Pipes

Q1. [22 Jan S1] A closed organ and an open organ tube are filled by two different gases having same bulk modulus but different densities ρ_1 and ρ_2 , respectively. The frequency of 9th harmonic of closed tube is identical with 4th harmonic of open tube. If the length of the closed tube is 10 cm and the density ratio of the gases is $\rho_1 : \rho_2 = 1 : 16$, then the length of the open tube is :

- (A) $\frac{15}{9}$ cm (B) $\frac{20}{9}$ cm
 (C) $\frac{20}{7}$ cm (D) $\frac{15}{7}$ cm

Q2. [28 Jan S1] Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: A sound wave has higher speed in solids than gases.

Reason R: Gases have higher value of Bulk modulus than solids.

In the light of the above statements, choose the correct answer from the options given below

- (A) Both A and R are true and R is the correct explanation of A
 (B) Both A and R are true but R is NOT the correct explanation of A
 (C) A is true but R is false
 (D) A is false but R is true

Wave Motion

Q3. [23 Jan S2] The equation of a transverse wave travelling along a string is $y(x, t) = 4.0 \sin[20 \times 10^{-3}x + 600t]$ mm, where x is in mm and t is in second. The velocity of the wave is :

- (A) +30 m/s (B) -30 m/s
 (C) +60 m/s (D) -60 m/s

13. Electrostatics

17 questions

Coulomb's Law & Electric Field

Q1. [22 Jan S1] An electron is made to enter symmetrically between two parallel and equally but oppositely charged metal plates, each of 10 cm length. The electron emerges out of the electric field region with a horizontal component of velocity 10^6 m/s. If the magnitude of the electric field between the plates is 9.1 V/cm, then the vertical component of velocity of electron is (mass of electron = 9.1×10^{-31} kg and charge = 1.6×10^{-19} C)

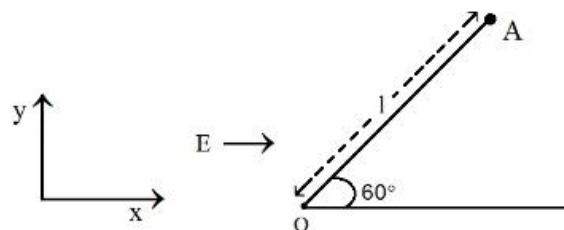
- (A) 16×10^6 m/s (B) 0
 (C) 16×10^4 m/s (D) 1×10^6 m/s

Q2. [23 Jan S1] A positive ion A and a negative ion B has charges 6.67×10^{-19} C and 9.6×10^{-10} C, and masses 19.2×10^{-27} kg and 9×10^{-27} kg respectively. At an instant, the ions are separated by a certain distance r . At that instant the ratio of the magnitudes of electrostatic force to gravitational force is $P \times 10^{-13}$, where the value of P is _____. (Take $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$ and universal gravitational constant as $6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$)

Q3. [24 Jan S2] A small uncharged conducting sphere is placed in contact with an identical sphere but having 4×10^{-8} C charge and then removed to a distance such that the force of repulsion between them is 9×10^{-3} N. The distance between them is (Take $\frac{1}{4\pi\epsilon_0}$ as 9×10^9 in SI units) :

- (A) 3 cm (B) 1 cm
 (C) 4 cm (D) 2 cm

Q4. [28 Jan S1] A particle of mass ' m ' and charge ' q ' is fastened to one end 'A' of a massless string having equilibrium length l , whose other end is fixed at point 'O'. The whole system is placed on a frictionless horizontal plane and is initially at rest. If uniform electric field is switched on along the direction as shown in figure, then the speed of the particle when it crosses the x-axis is



- (A) $\sqrt{\frac{2qEl}{m}}$ (B) $\sqrt{\frac{qEl}{m}}$
 (C) $\sqrt{\frac{qEl}{4m}}$ (D) $\sqrt{\frac{qEl}{2m}}$

Q5. [29 Jan S1] Match List - I with List - II.

List - I

- (A) Electric field inside (distance $r > 0$ from center) of a uniformly charged spherical shell with surface charge density σ , and radius R .
- (B) Electric field at distance $r > 0$ from a uniformly charged infinite plane sheet with surface charge density σ .
- (C) Electric field outside (distance $r > 0$ from center) of a uniformly charged spherical shell with surface charge density σ , and radius R .
- (D) Electric field between 2 oppositely charged infinite plane parallel sheets with uniform surface charge density σ .

List - II

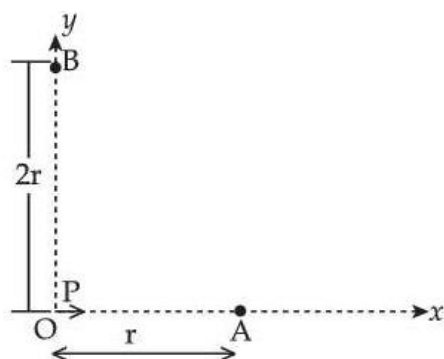
- (I) σ/ϵ_0
- (II) $\sigma/2\epsilon_0$
- (III) 0
- (IV) $\frac{\sigma}{\epsilon_0 r^2}$

Choose the correct answer from the options given below :

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

Electric Dipole

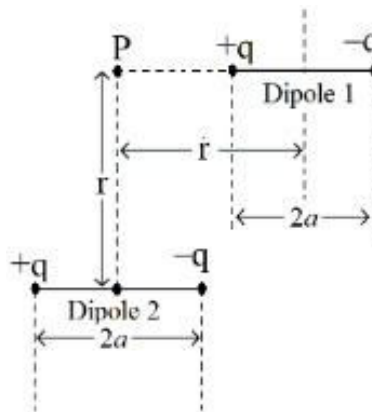
Q6. [22 Jan S2] For a short dipole placed at origin O, the dipole moment P is along x -axis, as shown in the figure. If the electric potential and electric field at A are V_0 and E_0 , respectively, then the correct combination of the electric potential and electric field, respectively, at point B on the y -axis is given by



- (A) zero and $\frac{E_0}{16}$
- (B) $\frac{V_0}{2}$ and $\frac{E_0}{16}$
- (C) zero and $\frac{E_0}{8}$
- (D) V_0 and $\frac{E_0}{4}$

Q7. [23 Jan S1] A point particle of charge Q is located at P along the axis of an electric dipole 1 at a distance r as shown in the figure. The point P is also on the equatorial plane of a second electric

dipole 2 at a distance r . The dipoles are made of opposite charge q separated by a distance $2a$. For the charge particle at P not to experience any net force, which of the following correctly describes the situation?



- (A) $\frac{a}{r} \sim 3$
- (B) $\frac{a}{r} \sim 20$
- (C) $\frac{a}{r} \sim 0.5$
- (D) $\frac{a}{r} \sim 10$

Q8. [23 Jan S2] Two point charges $-4 \mu\text{C}$ and $4 \mu\text{C}$, constituting an electric dipole, are placed at $(-9, 0, 0)$ cm and $(9, 0, 0)$ cm in a uniform electric field of strength 10^4 NC^{-1} . The work done on the dipole in rotating it from the equilibrium through 180° is :

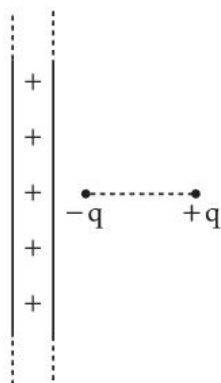
- (A) 16.4 mJ
- (B) 12.4 mJ
- (C) 18.4 mJ
- (D) 14.4 mJ

Q9. [28 Jan S2] An electric dipole of dipole moment $6 \times 10^{-6} \text{ Cm}$ is placed in uniform electric field of magnitude 10^6 V/m . Initially, the dipole moment is parallel to electric field. The work that needs to be done on the dipole to make its dipole moment opposite to the field, will be _____ J.

Q10. [29 Jan S1] An electric dipole of mass m , charge q , and length l is placed in a uniform electric field $\vec{E} = E_0 \hat{i}$. When the dipole is rotated slightly from its equilibrium position and released, the time period of its oscillations will be :

- (A) $\frac{1}{2\pi} \sqrt{\frac{2ml}{qE_0}}$
- (B) $2\pi \sqrt{\frac{ml}{qE_0}}$
- (C) $2\pi \sqrt{\frac{ml}{2qE_0}}$
- (D) $\frac{1}{2\pi} \sqrt{\frac{ml}{2qE_0}}$

Q11. [29 Jan S2] An electric dipole is placed at a distance of 2 cm from an infinite plane sheet having positive charge density σ_0 . Choose the correct option from the following.



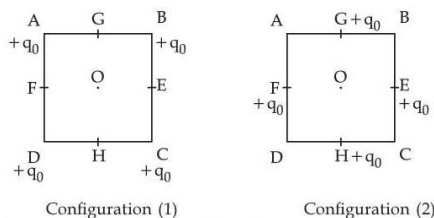
- (A) Potential energy and torque both are maximum.
 (B) Torque on dipole is zero and net force acts towards the sheet.
 (C) Potential energy of dipole is minimum and torque is zero.
 (D) Torque on dipole is zero and net force is directed away from the sheet.

Electric Potential & Potential Energy

Q12. [23 Jan S2] Two charges $7 \mu\text{C}$ and $-4 \mu\text{C}$ are placed at $(-7 \text{ cm}, 0, 0)$ and $(7 \text{ cm}, 0, 0)$ respectively. Given, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$, the electrostatic potential energy of the charge configuration is :

- (A) -1.2 J (B) -1.8 J
 (C) -1.5 J (D) -2.0 J

Q13. [24 Jan S2] In the first configuration (1) as shown in the figure, four identical charges (q_0) are kept at the corners A, B, C and D of square of side length 'a'. In the second configuration (2), the same charges are shifted to mid points G, E, H and F, of the square. If $K = \frac{1}{4\pi\epsilon_0}$, the difference between the potential energies of configuration (2) and (1) is given by :



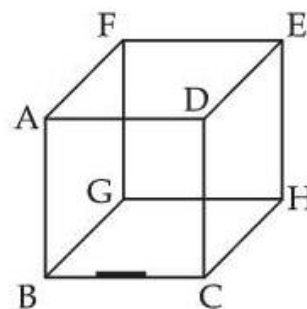
- (A) $\frac{Kq_0^2}{a} (4\sqrt{2} - 2)$
 (B) $\frac{Kq_0^2}{a} (3 - \sqrt{2})$
 (C) $\frac{Kq_0^2}{a} (3\sqrt{2} - 2)$
 (D) $\frac{Kq_0^2}{a} (4 - 2\sqrt{2})$

Q14. [28 Jan S1] Three infinitely long wires with linear charge density λ are placed along the x-axis, y-axis and z-axis respectively. Which of the following denotes an equipotential surface?

- (A) $(x^2 + y^2)(y^2 + z^2)(z^2 + x^2) = \text{constant}$
 (B) $xy + yz + zx = \text{constant}$
 (C) $(x + y)(y + z)(z + x) = \text{constant}$
 (D) $xyz = \text{constant}$

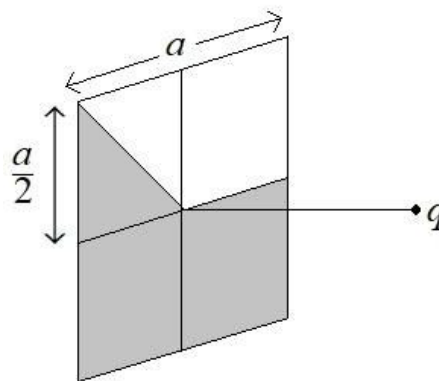
Gauss's Law & Electric Flux

Q15. [22 Jan S1] A line charge of length $\frac{a}{2}$ is kept at the center of an edge BC of a cube ABCDEFGH having edge length 'a' as shown in the figure. If the density of line charge is $\lambda \text{ C per unit length}$, then the total electric flux through all the faces of the cube will be _____. (Take, ϵ_0 as the free space permittivity)



- (A) $\frac{\lambda a}{16\epsilon_0}$ (B) $\frac{\lambda a}{2\epsilon_0}$
 (C) $\frac{\lambda a}{4\epsilon_0}$ (D) $\frac{\lambda a}{8\epsilon_0}$

Q16. [24 Jan S1] A square loop of sides $a = 1 \text{ m}$ is held normally in front of a point charge $q = 1 \text{ C}$. The flux of the electric field through the shaded region is $\frac{5}{p} \times \frac{1}{\epsilon_0} \frac{\text{Nm}^2}{\text{C}}$, where the value of p is _____.



Q17. [29 Jan S2] A point charge causes an electric flux of $-2 \times 10^4 \text{ Nm}^2\text{C}^{-1}$ to pass through a spherical Gaussian surface of 8.0 cm radius, centred on the charge. The value of the point charge is : (Given $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$)

(A) $17.7 \times 10^{-8} \text{ C}$ (B) $-15.7 \times 10^{-8} \text{ C}$
 (C) $-17.7 \times 10^{-8} \text{ C}$ (D) $15.7 \times 10^{-8} \text{ C}$

14. Capacitors

8 questions

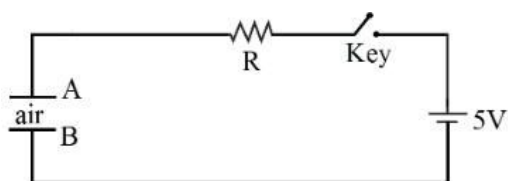
Capacitors & Dielectrics

Q1. [22 Jan S1] A parallel-plate capacitor of capacitance $40 \mu\text{F}$ is connected to a 100 V power supply. Now the intermediate space between the plates is filled with a dielectric material of dielectric constant $K = 2$. Due to the introduction of dielectric material, the extra charge and the change in the electrostatic energy in the capacitor, respectively, are

- (A) 4 mC and 0.2 J (B) 2 mC and 0.2 J
(C) 8 mC and 2.0 J (D) 2 mC and 0.4 J

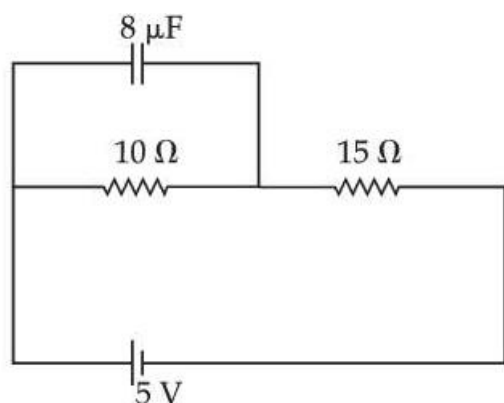
Q2. [23 Jan S1] Identify the valid statements relevant to the given circuit at the instant when the key is closed.

- A. There will be no current through resistor R.
B. There will be maximum current in the connecting wires.
C. Potential difference between the capacitor plates A and B is minimum.
D. Charge on the capacitor plates is minimum.
Choose the correct answer from the options given below:



- (A) A, B, D Only (B) A, C Only
(C) B, C, D Only (D) C, D Only

Q3. [23 Jan S2] At steady state the charge on the capacitor, as shown in the circuit below, is _____ μC .



Q4. [24 Jan S1] Consider a parallel plate capacitor of area A (of each plate) and separation 'd' between the plates. If E is the electric field and ϵ_0 is the permittivity of free space between the plates, then potential energy stored in the capacitor is

- (A) $\frac{1}{2}\epsilon_0 E^2 Ad$ (B) $\epsilon_0 E^2 Ad$
(C) $\frac{3}{4}\epsilon_0 E^2 Ad$ (D) $\frac{1}{4}\epsilon_0 E^2 Ad$

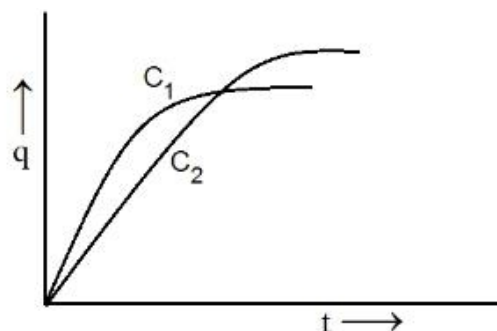
Q5. [24 Jan S1] A parallel plate capacitor was made with two rectangular plates, each with a length of $l = 3 \text{ cm}$ and breadth of $b = 1 \text{ cm}$. The distance between the plates is $3 \mu\text{m}$. Out of the following, which are the ways to increase the capacitance by a factor of 10?

- A. $l = 30 \text{ cm}$, $b = 1 \text{ cm}$, $d = 1 \mu\text{m}$
B. $l = 3 \text{ cm}$, $b = 1 \text{ cm}$, $d = 30 \mu\text{m}$
C. $l = 6 \text{ cm}$, $b = 5 \text{ cm}$, $d = 3 \mu\text{m}$
D. $l = 1 \text{ cm}$, $b = 1 \text{ cm}$, $d = 10 \mu\text{m}$
E. $l = 5 \text{ cm}$, $b = 2 \text{ cm}$, $d = 1 \mu\text{m}$

Choose the correct answer from the options given below:

- (A) C only
(B) B and D only
(C) A only
(D) C and E only

Q6. [28 Jan S1] Two capacitors C_1 and C_2 are connected in parallel to a battery. Charge-time graph is shown below for the two capacitors. The energy stored with them are U_1 and U_2 , respectively. Which of the given statements is true?



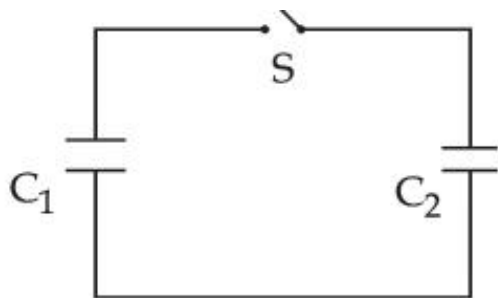
- (A) $C_1 > C_2$, $U_1 < U_2$
(B) $C_1 > C_2$, $U_1 > U_2$
(C) $C_2 > C_1$, $U_2 > U_1$
(D) $C_2 > C_1$, $U_2 < U_1$

Q7. [28 Jan S2] A parallel plate capacitor of capacitance $1 \mu\text{F}$ is charged to a potential difference of 20 V . The distance between plates is $1 \mu\text{m}$. The energy density between plates of capacitor is.

- (A) $2 \times 10^2 \text{ J/m}^3$ (B) $1.8 \times 10^3 \text{ J/m}^3$
(C) $2 \times 10^{-4} \text{ J/m}^3$ (D) $1.8 \times 10^5 \text{ J/m}^3$

Q8. [29 Jan S2] A capacitor, $C_1 = 6 \mu\text{F}$ is charged to a potential difference of $V_0 = 5 \text{ V}$ using a 5 V battery. The battery is removed and another capacitor, $C_2 = 12 \mu\text{F}$ is inserted in place of the battery. When the switch 'S' is closed, the charge flows between the capacitors for some time until equilibrium condition is reached. What are the charges (q_1

and q_2) on the capacitors C_1 and C_2 when equilibrium condition is reached.



- (A) $q_1 = 20 \mu\text{C}$, $q_2 = 10 \mu\text{C}$
 (B) $q_1 = 15 \mu\text{C}$, $q_2 = 30 \mu\text{C}$
 (C) $q_1 = 10 \mu\text{C}$, $q_2 = 20 \mu\text{C}$
 (D) $q_1 = 30 \mu\text{C}$, $q_2 = 15 \mu\text{C}$

15. Current Electricity

10 questions

Cells, EMF & Internal Resistance

Q1. [22 Jan S1] Given below are two statements :
 Statement-I : The equivalent emf of two nonideal batteries connected in parallel is smaller than either of the two emfs.

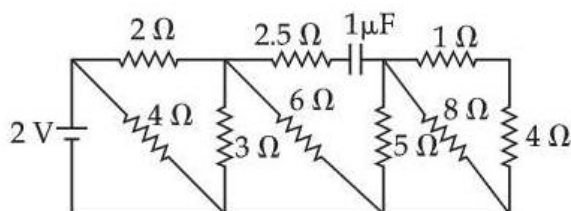
Statement-II : The equivalent internal resistance of two nonideal batteries connected in parallel is smaller than the internal resistance of either of the two batteries.

In the light of the above statements, choose the correct answer from the options given below.

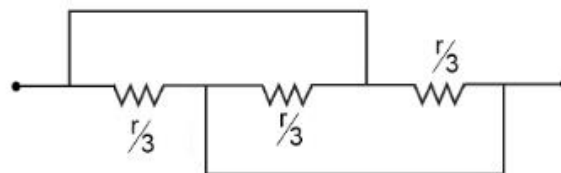
- (A) Both Statement-I and Statement-II are true
 (B) Both Statement-I and Statement-II are false
 (C) Statement-I is true but Statement-II is false
 (D) Statement-I is false but Statement-II is true

Circuits & Kirchhoff's Laws

Q2. [22 Jan S2] The net current flowing in the given circuit is ____ A.

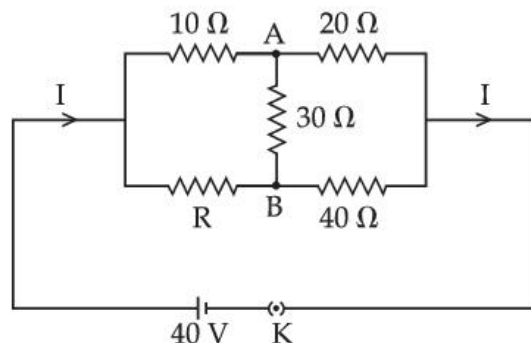


Q3. [28 Jan S1] Find the equivalent resistance between two ends of the following circuit



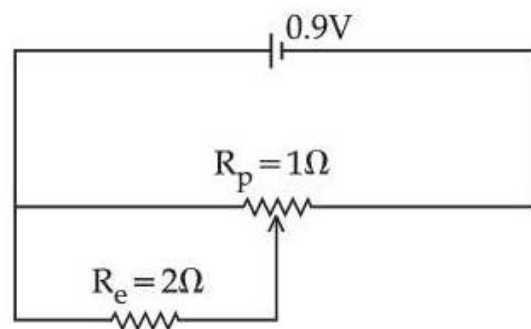
- (A) $\frac{r}{6}$ (B) $\frac{r}{9}$
 (C) r (D) $\frac{r}{3}$

Q4. [28 Jan S2] The value of current I in the electrical circuit as given below, when potential at A is equal to the potential at B, will be ____ A.



Meters & Potentiometer

Q5. [22 Jan S1] Sliding contact of a potentiometer is in the middle of the potentiometer wire having resistance $R_p = 1 \Omega$ as shown in the figure. An external resistance of $R_e = 2 \Omega$ is connected via the sliding contact. The electric current in the circuit is :

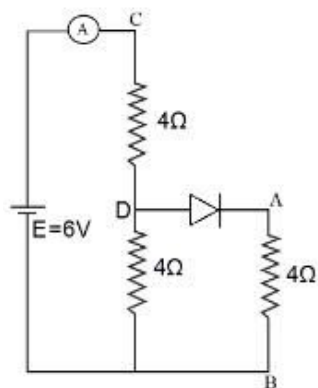


- (A) 0.9 A (B) 1.0 A
 (C) 0.3 A (D) 1.35 A

Q6. [23 Jan S1] Refer to the circuit diagram given in the figure, which of the following observations are correct?

- A. Total resistance of circuit is 6Ω .
 B. Current in Ammeter is 1A
 C. Potential across AB is 4 Volts.
 D. Potential across CD is 4 Volts
 E. Total resistance of the circuit is 8Ω .

Choose the correct answer from the options given below:



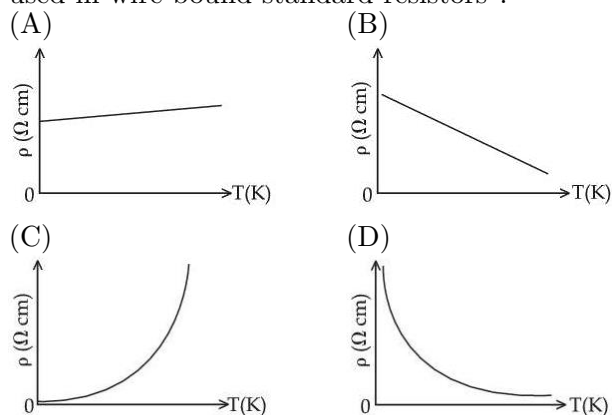
- (A) A, C and D Only (B) A, B and C Only
(C) B, C and E Only (D) A, B and D Only

Q7. [23 Jan S2] A galvanometer having a coil of resistance $30\ \Omega$ need 20 mA of current for full-scale deflection. If a maximum current of 3 A is to be measured using this galvanometer, the resistance of the shunt to be added should be $\frac{30}{X}\ \Omega$, where X is :

- (A) 596 (B) 298
(C) 447 (D) 149

Resistance & Resistivity

Q8. [22 Jan S1] Which of the following resistivity (ρ) v/s temperature (T) curves is most suitable to be used in wire bound standard resistors ?



Q9. [24 Jan S1] A wire of resistance $9\ \Omega$ is bent to form an equilateral triangle. Then the equivalent resistance across any two vertices will be _____ ohm.

Q10. [28 Jan S1] A wire of resistance R is bent into a equilateral triangle and an identical wire is bent into a square. The ratio of resistance between the two end points of an edge of the triangle to that of the square is

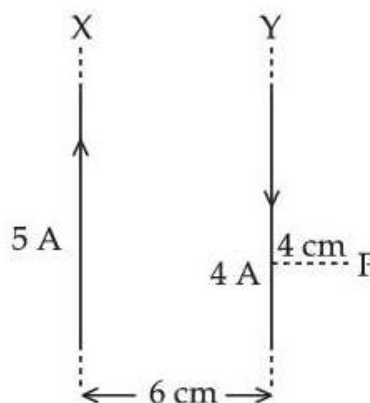
- (A) $27/32$ (B) $32/27$
(C) $9/8$ (D) $8/9$

16. Magnetic Effects of Current & Magnetism

14 questions

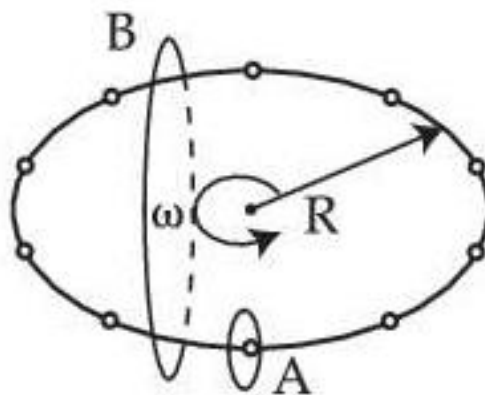
Magnetic Field due to Current

Q1. [22 Jan S2] Two long parallel wires X and Y, separated by a distance of 6 cm, carry currents of 5 A and 4 A, respectively, in opposite directions as shown in the figure. Magnitude of the resultant magnetic field at point P at a distance of 4 cm from wire Y is $x \times 10^{-5}$ T. The value of x is _____. Take permeability of free space as $\mu_0 = 4\pi \times 10^{-7}$ SI units.



Q2. [24 Jan S1] A current of 5 A exists in a square loop of side $\frac{1}{\sqrt{2}}$ m. Then the magnitude of the magnetic field B at the centre of the square loop will be $p \times 10^{-6}$ T, where value of p is _____. [Take $\mu_0 = 4\pi \times 10^{-7}$ TmA $^{-1}$].

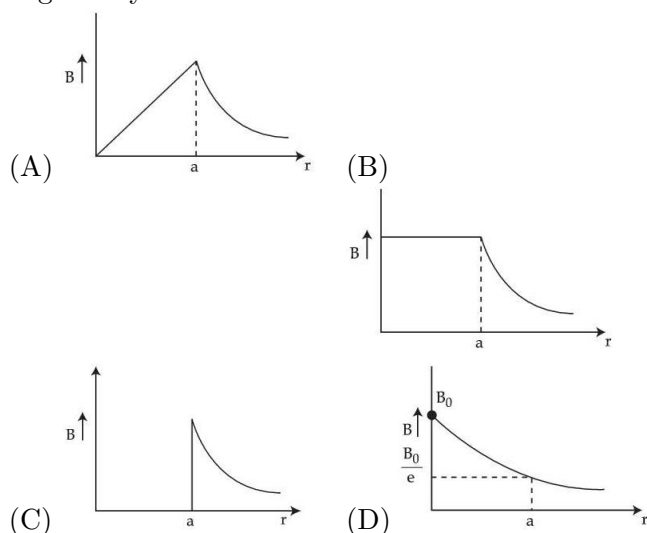
Q3. [24 Jan S2] N equally spaced charges each of value q , are placed on a circle of radius R . The circle rotates about its axis with an angular velocity ω as shown in the figure. A bigger Amperian loop B encloses the whole circle where as a smaller Amperian loop A encloses a small segment. The difference between enclosed currents, $I_A - I_B$, for the given Amperian loops is



- (A) $\frac{N}{\pi}q\omega$ (B) $\frac{2\pi}{N}q\omega$
(C) $\frac{N}{2\pi}q\omega$ (D) $\frac{N^2}{2\pi}q\omega$

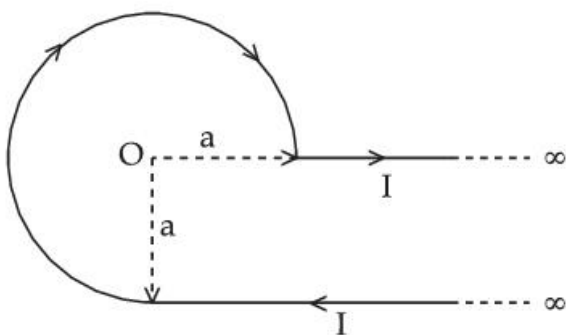
Q4. [24 Jan S2] A long straight wire of a circular cross-section with radius 'a' carries a steady current I . The current I is uniformly distributed across this

cross-section. The plot of magnitude of magnetic field B with distance r from the centre of the wire is given by



Q5. [24 Jan S2] A tightly wound long solenoid carries a current of 1.5 A. An electron is executing uniform circular motion inside the solenoid with a time period of 75 ns. The number of turns per metre in the solenoid is _____. [Take mass of electron $m_e = 9 \times 10^{-31}$ kg, charge of electron $|q_e| = 1.6 \times 10^{-19}$ C, $\mu_0 = 4\pi \times 10^{-7}$ N/A², 1 ns = 10^{-9} s]

Q6. [28 Jan S2] An infinite wire has a circular bend of radius a , and carrying a current I as shown in figure. The magnitude of magnetic field at the origin O of the arc is given by :



- (A) $\frac{\mu_0 I}{4\pi a} \left[\frac{3\pi}{2} + 2 \right]$ (B) $\frac{\mu_0 I}{4\pi a} \left[\frac{3\pi}{2} + 1 \right]$
 (C) $\frac{\mu_0 I}{2\pi a} \left[\frac{\pi}{2} + 2 \right]$ (D) $\frac{\mu_0 I}{4\pi a} \left[\frac{\pi}{2} + 1 \right]$

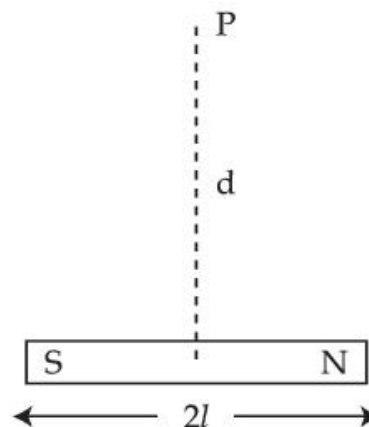
Q7. [29 Jan S1] Consider a long straight wire of a circular cross-section (radius a) carrying a steady current I . The current is uniformly distributed across this cross-section. The distances from the centre of the wire's cross-section at which the magnetic field [inside the wire, outside the wire] is half of the maximum possible magnetic field, any where due to the wire, will be

- (A) $[a/2, 3a]$ (B) $[a/4, 2a]$
 (C) $[a/4, 3a/2]$ (D) $[a/2, 2a]$

Q8. [29 Jan S2] The magnetic field inside a 200 turns solenoid of radius 10 cm is 2.9×10^{-4} Tesla. If the solenoid carries a current of 0.29 A, then the length of the solenoid is _____ π cm.

Magnetism & Matter (Bar Magnet)

Q9. [28 Jan S2] A bar magnet has total length $2l = 20$ units and the field point P is at a distance $d = 10$ units from the centre of the magnet. If the relative uncertainty of length measurement is 1%, then uncertainty of the magnetic field at point P is :



- (A) 3% (B) 5%
 (C) 4% (D) 10%

Q10. [29 Jan S2] Match List - I with List - II.

List - I

List - II

- | | |
|------------------------|-------------------------------|
| (A) Magnetic induction | (I) Ampere meter ² |
| (B) Magnetic intensity | (II) Weber |
| (C) Magnetic flux | (III) Gauss |
| (D) Magnetic moment | (IV) Ampere meter |

Choose the correct answer from the options given below :

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

Moving Charges in Magnetic Field

Q11. [22 Jan S2] A proton is moving undeflected in a region of crossed electric and magnetic fields at a constant speed of 2×10^5 ms⁻¹. When the electric field is switched off, the proton moves along a circular path of radius 2 cm. The magnitude of electric field is $x \times 10^4$ N/C. The value of x is _____. Take the mass of the proton = 1.6×10^{-27} kg.

Q12. [24 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : An electron in a certain region of uniform magnetic field is moving with constant velocity in a straight line path.

Reason (R) : The magnetic field in that region is along the direction of velocity of the electron.

In the light of the above statements, choose the correct answer from the options given below :

- (A) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
 (B) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (C) (A) is true but (R) is false
 (D) (A) is false but (R) is true

Q13. [28 Jan S1] Consider a long thin conducting wire carrying a uniform current I . A particle having mass “ M ” and charge “ q ” is released at a distance “ a ” from the wire with a speed v_0 along the direction of current in the wire. The particle gets attracted to the wire due to magnetic force. The particle turns round when it is at distance x from the wire. The value of x is [μ_0 is vacuum permeability]

- (A) $a \left[1 - \frac{mv_0}{q\mu_0 I} \right]$ (B) $\frac{a}{2}$
 (C) $a \left[1 - \frac{mv_0}{2q\mu_0 I} \right]$ (D) $a e^{-\frac{4\pi mv_0}{q\mu_0 I}}$

Moving Coil Galvanometer

Q14. [23 Jan S1] Consider a moving coil galvanometer (MCG):

- A. The torsional constant in moving coil galvanometer has dimensions [ML^2T^{-2}]
 B. Increasing the current sensitivity may not necessarily increase the voltage sensitivity.
 C. If we increase number of turns (N) to its double ($2N$), then the voltage sensitivity doubles.
 D. MCG can be converted into an ammeter by introducing a shunt resistance of large value in parallel with galvanometer.
 E. Current sensitivity of MCG depends inversely on number of turns of coil.

Choose the correct answer from the options given below:

- (A) B, D, E Only (B) A, D Only
 (C) A, B, E Only (D) A, B Only

17. Electromagnetic Induction & Alternating Current

11 questions

Alternating Current

Q1. [22 Jan S2] A series LCR circuit is connected to an alternating source of emf E . The current amplitude at resonant frequency is I_0 . If the value of resistance R becomes twice of its initial value then amplitude of current at resonance will be

- (A) $2I_0$ (B) I_0
 (C) $\frac{I_0}{\sqrt{2}}$ (D) $\frac{I_0}{2}$

Q2. [23 Jan S2] In a series LCR circuit, a resistor of 300Ω , a capacitor of 25 nF and an inductor of 100 mH are used. For maximum current in the circuit, the angular frequency of the ac source is $\times 10^4 \text{ radians s}^{-1}$.

Q3. [24 Jan S1] An alternating current is given by $I = I_A \sin \omega t + I_B \cos \omega t$. The r.m.s. current will be

- (A) $\sqrt{\frac{I_A^2 + I_B^2}{2}}$ (B) $\frac{\sqrt{I_A^2 + I_B^2}}{2}$
 (C) $\frac{|I_A + I_B|}{\sqrt{2}}$ (D) $\sqrt{I_A^2 + I_B^2}$

Q4. [29 Jan S1] Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Choke coil is simply a coil having a large inductance but a small resistance. Choke coils are used with fluorescent mercury-tube fittings. If household electric power is directly connected to a mercury tube, the tube will be damaged.

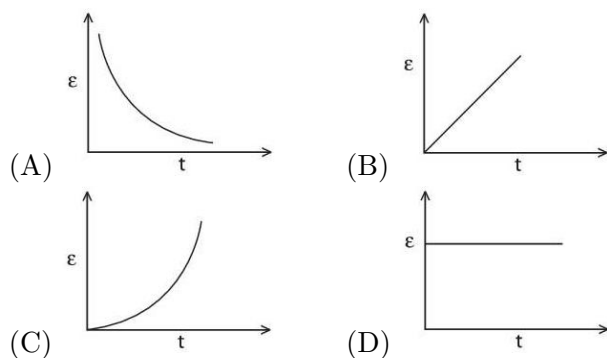
Reason (R) : By using the choke coil, the voltage across the tube is reduced by a factor $\left(R / \sqrt{R^2 + \omega^2 L^2} \right)$, where ω is frequency of the supply across resistor R and inductor L . If the choke coil were not used, the voltage across the resistor would be the same as the applied voltage.

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

- (A) Both (A) and (R) are true but (R) is not the correct explanation of (A)
 (B) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (C) (A) is false but (R) is true
 (D) (A) is true but (R) is false

Electromagnetic Induction

Q5. [22 Jan S2] A rectangular metallic loop is moving out of a uniform magnetic field region to a field free region with a constant speed. When the loop is partially inside the magnetic field, the plot of magnitude of induced emf (ε) with time (t) is given by



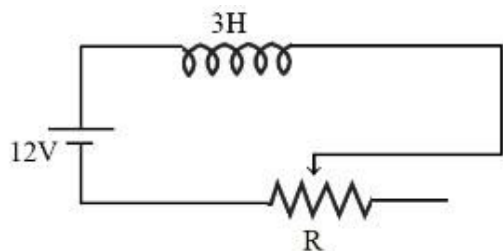
Q6. [23 Jan S1] Regarding self-inductance:

- A. The self-inductance of the coil depends on its geometry.
- B. Self-inductance does not depend on the permeability of the medium.
- C. Self-induced e.m.f. opposes any change in the current in a circuit.
- D. Self-inductance is electromagnetic analogue of mass in mechanics.
- E. Work needs to be done against self-induced e.m.f. in establishing the current.

Choose the correct answer from the options given below:

- (A) B, C, D, E only (B) A, C, D, E only
- (C) A, B, C, D only (D) A, B, C, E only

Q7. [23 Jan S1] In the given circuit the sliding contact is pulled outwards such that electric current in the circuit changes at the rate of 8 A/s. At an instant when R is 12 Ω , the value of the current will be ____ A.

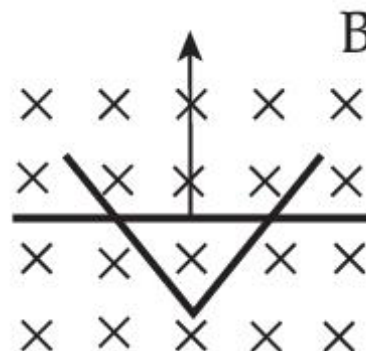


Q8. [28 Jan S2] A uniform magnetic field of 0.4 T acts perpendicular to a circular copper disc 20 cm in radius. The disc is having a uniform angular velocity of 10π rad s^{-1} about an axis through its centre and perpendicular to the disc. What is the potential difference developed between the axis of the disc and the rim? ($\pi = 3.14$)

- (A) 0.0628 V (B) 0.1256 V
- (C) 0.5024 V (D) 0.2512 V

Q9. [28 Jan S2] A conducting bar moves on two conducting rails as shown in the figure. A constant magnetic field B exists into the page. The bar starts to move from the vertex at time $t = 0$ with

a constant velocity. If the induced EMF is $E \propto t^n$, then value of n is ____.



Q10. [29 Jan S1] Consider I_1 and I_2 are the currents flowing simultaneously in two nearby coils 1 & 2, respectively. If L_1 = self inductance of coil 1, M_{12} = mutual inductance of coil 1 with respect to coil 2, then the value of induced emf in coil 1 will be

- (A) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} + M_{12} \frac{dI_2}{dt}$ (B) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - M_{12} \frac{dI_2}{dt}$
- (C) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - M_{12} \frac{dI_2}{dt}$ (D) $\varepsilon_1 = -L_1 \frac{dI_2}{dt} - M_{12} \frac{dI_1}{dt}$

Q11. [29 Jan S1] A coil of area A and N turns is rotating with angular velocity ω in a uniform magnetic field $\vec{B}$ about an axis perpendicular to $\vec{B}$. Magnetic flux φ and induced emf ε across it, at an instant when $\vec{B}$ is parallel to the plane of coil, are :

- (A) $\varphi = AB$, $\varepsilon = 0$ (B) $\varphi = 0$, $\varepsilon = 0$
- (C) $\varphi = 0$, $\varepsilon = NAB\omega$ (D) $\varphi = AB$, $\varepsilon = NAB\omega$

18. Electromagnetic Waves

10 questions

Displacement Current

Q1. [22 Jan S2] A parallel plate capacitor of area $A = 16$ cm² and separation between the plates 10 cm, is charged by a DC current. Consider a hypothetical plane surface of area $A_0 = 3.2$ cm² inside the capacitor and parallel to the plates. At an instant, the current through the circuit is 6 A. At the same instant the displacement current through A_0 is ____ mA.

Q2. [23 Jan S2] A time varying potential difference is applied between the plates of a parallel plate capacitor of capacitance 2.5 μ F. The dielectric constant of the medium between the capacitor plates is 1. It produces an instantaneous displacement current of 0.25 mA in the intervening space between the capacitor plates, the magnitude of the rate of change of the potential difference will be ____ Vs⁻¹.

EM Waves & Spectrum

Q3. [23 Jan S1] The electric field of an electromagnetic wave in free space is $\vec{E} = 57 \cos [7.5 \times 10^6 t - 5 \times 10^{-3} (3x + 4y)] (4\hat{i} - 3\hat{j})$ N/C. The associated magnetic field in Tesla is

- (A) $\vec{B} = -\frac{57}{3 \times 10^8} \cos [7.5 \times 10^6 t - 5 \times 10^{-3} (3x + 4y)] (5\hat{i} - 4\hat{j})$
 (B) $\vec{B} = \frac{57}{3 \times 10^8} \cos [7.5 \times 10^6 t - 5 \times 10^{-3} (3x + 4y)] (5\hat{k})$
 (C) $\vec{B} = -\frac{57}{3 \times 10^8} \cos [7.5 \times 10^6 t - 5 \times 10^{-3} (3x + 4y)] (\hat{k})$
 (D) $\vec{B} = \frac{57}{3 \times 10^8} \cos [7.5 \times 10^6 t - 5 \times 10^{-3} (3x + 4y)] (\hat{k})$

Q4. [23 Jan S2] A plane electromagnetic wave of frequency 20 MHz travels in free space along the $+x$ direction. At a particular point in space and time, the electric field vector of the wave is $E_y = 9.3 \text{ Vm}^{-1}$. Then, the magnetic field vector of the wave at that point is

- (A) $B_z = 3.1 \times 10^{-8} \text{ T}$ (B) $B_z = 1.55 \times 10^{-8} \text{ T}$
 (C) $B_z = 9.3 \times 10^{-8} \text{ T}$ (D) $B_z = 6.2 \times 10^{-8} \text{ T}$

Q5. [24 Jan S2] Arrange the following in the ascending order of wavelength (λ) :

- (A) Microwaves (λ_1) (B) Ultraviolet rays (λ_2) (C) Infrared rays (λ_3) (D) X-rays (λ_4)

Choose the most appropriate answer from the options given below :

- (A) $\lambda_4 < \lambda_3 < \lambda_2 < \lambda_1$ (B) $\lambda_4 < \lambda_2 < \lambda_3 < \lambda_1$
 (C) $\lambda_3 < \lambda_4 < \lambda_2 < \lambda_1$ (D) $\lambda_4 < \lambda_3 < \lambda_1 < \lambda_2$

Q6. [28 Jan S1] Due to presence of an em-wave whose electric component is given by $E = 100 \sin(\omega t - kx) \text{ NC}^{-1}$, a cylinder of length 200 cm holds certain amount of em-energy inside it. If another cylinder of same length but half diameter than previous one holds same amount of em-energy, the magnitude of the electric field of the corresponding em-wave should be modified as

- (A) $50 \sin(\omega t - kx) \text{ NC}^{-1}$ (B) $200 \sin(\omega t - kx) \text{ NC}^{-1}$
 (C) $400 \sin(\omega t - kx) \text{ NC}^{-1}$ (D) $25 \sin(\omega t - kx) \text{ NC}^{-1}$

Q7. [28 Jan S2] The magnetic field of an E.M. wave is given by $\vec{B} = \left(\frac{\sqrt{3}}{2} \hat{i} + \frac{1}{2} \hat{j} \right) 30 \sin \left[\omega \left(t - \frac{z}{c} \right) \right]$ (S.I. Units). The corresponding electric field in S.I. units is :

- (A) $\vec{E} = \left(\frac{1}{2} \hat{i} + \frac{\sqrt{3}}{2} \hat{j} \right) 30c \sin \left[\omega \left(t + \frac{z}{c} \right) \right]$ (B) $\vec{E} = \left(\frac{\sqrt{3}}{2} \hat{i} - \frac{1}{2} \hat{j} \right) 30c \sin \left[\omega \left(t + \frac{z}{c} \right) \right]$
 (C) $\vec{E} = \left(\frac{3}{4} \hat{i} + \frac{1}{4} \hat{j} \right) 30c \cos \left[\omega \left(t - \frac{z}{c} \right) \right]$ (D) $\vec{E} = \left(\frac{1}{2} \hat{i} - \frac{\sqrt{3}}{2} \hat{j} \right) 30c \sin \left[\omega \left(t - \frac{z}{c} \right) \right]$

Q8. [29 Jan S1] Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Electromagnetic waves carry energy

but not momentum.

Reason (R) : Mass of a photon is zero.

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

- (A) (A) is true but (R) is false
 (B) (A) is false but (R) is true
 (C) Both (A) and (R) are true and (R) is the correct explanation of (A)
 (D) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Q9. [29 Jan S2] A plane electromagnetic wave propagates along the $+x$ direction in free space. The components of the electric field, $\vec{E}$ and magnetic field, $\vec{B}$ vectors associated with the wave in Cartesian frame are

- (A) E_y, B_x (B) E_z, B_y
 (C) E_y, B_z (D) E_x, B_y

Q10. [29 Jan S2] A parallel plate capacitor consisting of two circular plates of radius 10 cm is being charged by a constant current of 0.15 A. If the rate of change of potential difference between the plates is $7 \times 10^8 \text{ V/s}$ then the integer value of the distance between the parallel plates is (Take, $\epsilon_0 = 9 \times 10^{-12} \frac{\text{F}}{\text{m}}$, $\pi = \frac{22}{7}$) _____ μm .

19. Ray Optics

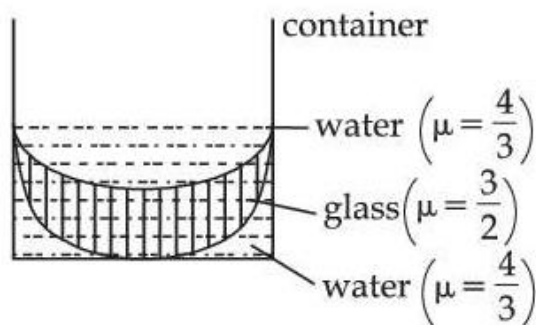
23 questions

Lenses

Q1. [22 Jan S1] Given is a thin convex lens of glass (refractive index μ) and each side having radius of curvature R . One side is polished for complete reflection. At what distance from the lens, an object be placed on the optic axis so that the image gets formed on the object itself?

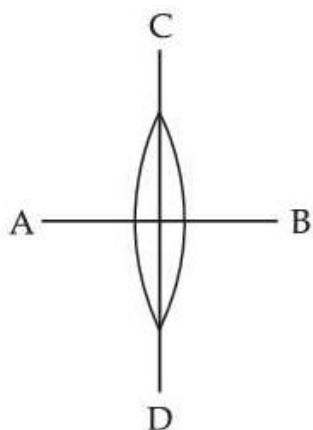
- (A) μR (B) $R/(\mu - 1)$
 (C) $R/(2\mu - 3)$ (D) R/μ

Q2. [22 Jan S1] In the diagram given below, there are three lenses formed. Considering negligible thickness of each of them as compared to $|R_1|$ and $|R_2|$, i.e., the radii of curvature for upper and lower surfaces of the glass lens, the power of the combination



- (A) $\frac{1}{6} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$ (B) $-\frac{1}{6} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$
 (C) $\frac{1}{6} \left(\frac{1}{|R_1|} + \frac{1}{|R_2|} \right)$ (D) $-\frac{1}{6} \left(\frac{1}{|R_1|} + \frac{1}{|R_2|} \right)$

Q3. [22 Jan S2] A symmetric thin biconvex lens is cut into four equal parts by two planes AB and CD as shown in figure. If the power of original lens is $4D$ then the power of a part of the divided lens is



- (A) $2D$ (B) $4D$
 (C) $8D$ (D) D

Q4. [23 Jan S1] Given a thin convex lens (refractive index μ_2), kept in a liquid (refractive index μ_1 , $\mu_1 < \mu_2$) having radii of curvatures $|R_1|$ and $|R_2|$. Its second surface is silver polished. Where should an object be placed on the optic axis so that a real and inverted image is formed at the same place?

- (A) $\frac{\mu_1 |R_1| \cdot |R_2|}{\mu_2 (|R_1| + |R_2|) - \mu_1 |R_2|}$
 (B) $\frac{\mu_1 |R_1| \cdot |R_2|}{\mu_2 (|R_1| + |R_2|) - \mu_1 |R_1|}$
 (C) $\frac{(\mu_2 + \mu_1) |R_1|}{(\mu_2 - \mu_1)}$
 (D) $\frac{\mu_1 |R_1| \cdot |R_2|}{\mu_2 (2|R_1| + |R_2|) - \mu_1 \sqrt{|R_1| \cdot |R_2|}}$

Q5. [24 Jan S1] What is the relative decrease in focal length of a lens for an increase in optical power by $0.1 D$ from $2.5 D$? ['D' stands for dioptre]

- (A) 0.04 (B) 0.1
 (C) 0.01 (D) 0.40

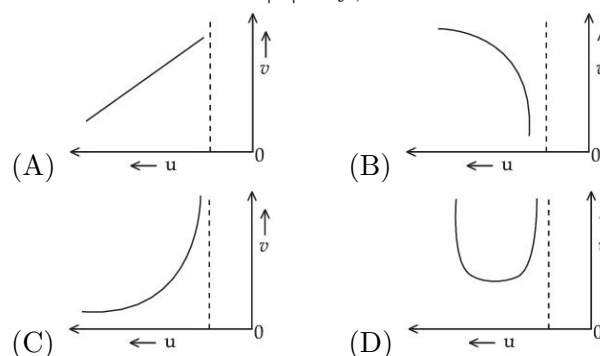
Q6. [24 Jan S1] A plano-convex lens having radius of curvature of first surface 2 cm exhibits focal length of f_1 in air. Another plano-convex lens with first surface radius of curvature 3 cm has focal length of f_2 when it is immersed in a liquid of refractive index 1.2 . If both the lenses are made of same glass of refractive index 1.5 , the ratio of f_1 and f_2 will be

- (A) $3 : 5$ (B) $1 : 3$
 (C) $2 : 3$ (D) $1 : 2$

Q7. [24 Jan S2] A photograph of a landscape is captured by a drone camera at a height of 18 km . The size of the camera film is $2 \text{ cm} \times 2 \text{ cm}$ and the area of the landscape photographed is 400 km^2 . The focal length of the lens in the drone camera is :

- (A) 2.5 cm (B) 1.8 cm
 (C) 2.8 cm (D) 0.9 cm

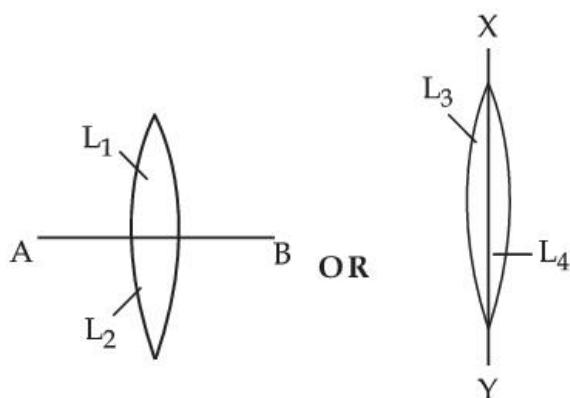
Q8. [29 Jan S1] Let u and v be the distances of the object and the image from a lens of focal length f . The correct graphical representation of u and v for a convex lens when $|u| > f$, is



Q9. [29 Jan S2] A convex lens made of glass (refractive index = 1.5) has focal length 24 cm in air. When it is totally immersed in water (refractive index = 1.33), its focal length changes to

- (A) 24 cm (B) 72 cm
 (C) 96 cm (D) 48 cm

Q10. [29 Jan S2] Two identical symmetric double convex lenses of focal length f are cut into two equal parts L_1, L_2 by AB plane and L_3, L_4 by XY plane as shown in figure respectively. The ratio of focal lengths of lenses L_1 and L_3 is



- (A) 1 : 2 (B) 2 : 1
(C) 1 : 1 (D) 1 : 4

Mirrors

Q11. [22 Jan S1] The driver sitting inside a parked car is watching vehicles approaching from behind with the help of his side view mirror, which is a convex mirror with radius of curvature $R = 2$ m. Another car approaches him from behind with a uniform speed of 90 km/hr. When the car is at a distance of 24 m from him, the magnitude of the acceleration of the image of the car in the side view mirror is 'a'. The value of $100a$ is _____ m/s^2 .

Q12. [23 Jan S2] A concave mirror of focal length f in air is dipped in a liquid of refractive index μ . Its focal length in the liquid will be :

- (A) $\frac{f}{\mu}$ (B) $\frac{f}{(\mu - 1)}$
(C) f (D) μf

Q13. [24 Jan S1] A thin plano convex lens made of glass of refractive index 1.5 is immersed in a liquid of refractive index 1.2. When the plane side of the lens is silver coated for complete reflection, the lens immersed in the liquid behaves like a concave mirror of focal length 0.2 m. The radius of curvature of the curved surface of the lens is

- (A) 0.10 m (B) 0.25 m
(C) 0.20 m (D) 0.15 m

Q14. [28 Jan S2] A concave mirror produces an image of an object such that the distance between the object and image is 20 cm. If the magnification of the image is '-3', then the magnitude of the radius of curvature of the mirror is :

- (A) 30 cm (B) 7.5 cm
(C) 3.75 cm (D) 15 cm

Prism & Dispersion

Q15. [23 Jan S2] The refractive index of the material of a glass prism is $\sqrt{3}$. The angle of minimum deviation is equal to the angle of the prism. What is the angle of the prism ?

- (A) 58° (B) 60°
(C) 48° (D) 50°

Q16. [28 Jan S1] A thin prism P_1 with angle 4° made of glass having refractive index 1.54, is combined with another thin prism P_2 made of glass having refractive index 1.72 to get dispersion without deviation. The angle of the prism P_2 in degrees is

- (A) $16/3$ (B) 4
(C) 1.5 (D) 3

Refraction at Surfaces

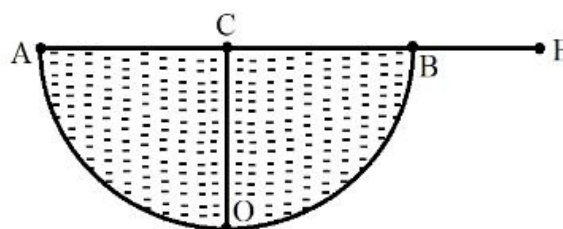
Q17. [23 Jan S1] A spherical surface of radius of curvature R , separates air from glass (refractive index = 1.5). The centre of curvature is in the glass medium. A point object 'O' placed in air on the optic axis of the surface, so that its real image is formed at 'I' inside glass. The line OI intersects the spherical surface at P and $PO = PI$. The distance PO equals to

- (A) $3R$ (B) $1.5R$
(C) $2R$ (D) $5R$

Q18. [23 Jan S1] What is the lateral shift of a ray refracted through a parallel-sided glass slab of thickness 'h' in terms of the angle of incidence 'i' and angle of refraction 'r', if the glass slab is placed in air medium?

- (A) $\frac{h \cos(i - r)}{\sin r}$ (B) h
(C) $\frac{h \tan(i - r)}{\tan r}$ (D) $\frac{h \sin(i - r)}{\cos r}$

Q19. [28 Jan S1] A hemispherical vessel is completely filled with a liquid of refractive index μ . A small coin is kept at the lowest point (O) of the vessel as shown in figure. The minimum value of the refractive index of the liquid so that a person can see the coin from point E (at the level of the vessel) is _____.



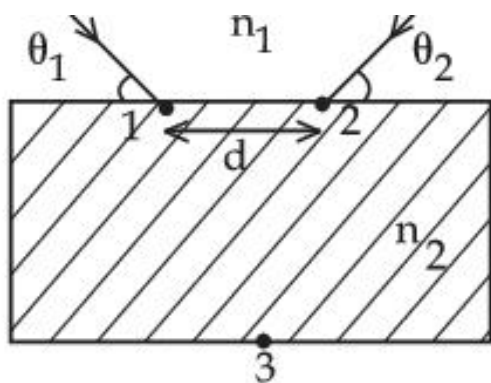
- (A) $\sqrt{3}$ (B) $\frac{3}{2}$
(C) $\sqrt{2}$ (D) $\frac{\sqrt{3}}{2}$

Q20. [28 Jan S2] In a long glass tube, mixture of two liquids A and B with refractive indices 1.3 and 1.4 respectively, forms a convex refractive meniscus towards A. If an object placed at 13 cm from the vertex of the meniscus in A forms an image with a

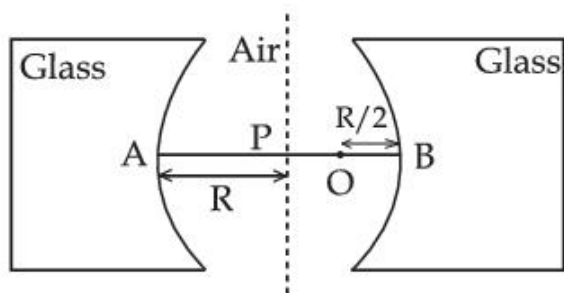
magnification of -2 then the radius of curvature of meniscus is :

- (A) $\frac{1}{3}$ cm (B) 1 cm
(C) $\frac{4}{3}$ cm (D) $\frac{2}{3}$ cm

Q21. [29 Jan S1] Two light beams fall on a transparent material block at point 1 and 2 with angle θ_1 and θ_2 , respectively, as shown in figure. After refraction, the beams intersect at point 3 which is exactly on the interface at other end of the block. Given : the distance between 1 and 2, $d = 4\sqrt{3}$ cm and $\theta_1 = \theta_2 = \cos^{-1}\left(\frac{n_2}{2n_1}\right)$, where refractive index of the block $n_2 >$ refractive index of the outside medium n_1 , then the thickness of the block is _____ cm.



Q22. [29 Jan S2] Two concave refracting surfaces of equal radii of curvature and refractive index 1.5 face each other in air as shown in figure. A point object O is placed midway, between P and B. The separation between the images of O, formed by each refracting surface is :



- (A) $0.214R$ (B) $0.411R$
(C) $0.124R$ (D) $0.114R$

Total Internal Reflection

Q23. [29 Jan S1] At the interface between two materials having refractive indices n_1 and n_2 , the critical angle for reflection of an em wave is θ_{1C} . The n_2 material is replaced by another material having refractive index n_3 such that the critical angle at the

interface between n_1 and n_3 materials is θ_{2C} . If $n_3 > n_2 > n_1$; $\frac{n_2}{n_3} = \frac{2}{5}$ and $\sin \theta_{2C} - \sin \theta_{1C} = \frac{1}{2}$, then θ_{1C} is

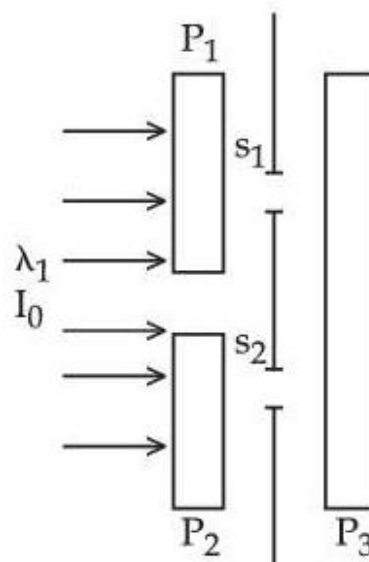
- (A) $\sin^{-1}\left(\frac{2}{3n_1}\right)$ (B) $\sin^{-1}\left(\frac{1}{6n_1}\right)$
(C) $\sin^{-1}\left(\frac{5}{6n_1}\right)$ (D) $\sin^{-1}\left(\frac{1}{3n_1}\right)$

20. Wave Optics

9 questions

Polarisation

Q1. [24 Jan S2] In a Young's double slit experiment, three polarizers are kept as shown in the figure. The transmission axes of P_1 and P_2 are orthogonal to each other. The polarizer P_3 covers both the slits with its transmission axis at 45° to those of P_1 and P_2 . An unpolarized light of wavelength λ and intensity I_0 is incident on P_1 and P_2 . The intensity at a point after P_3 where the path difference between the light waves from s_1 and s_2 is $\frac{\lambda}{3}$, is



- (A) $\frac{I_0}{4}$ (B) $\frac{I_0}{2}$
(C) I_0 (D) $\frac{I_0}{3}$

Thin Film Interference

Q2. [22 Jan S2] A transparent film of refractive index, 2.0 is coated on a glass slab of refractive index, 1.45. What is the minimum thickness of transparent film to be coated for the maximum transmission of Green light of wavelength 550 nm. [Assume that the light is incident nearly perpendicular to the glass surface.]

- (A) 94.8 nm (B) 275 nm
(C) 137.5 nm (D) 68.7 nm

Q3. [28 Jan S2] A thin transparent film with refractive index 1.4, is held on circular ring of radius

1.8 cm. The fluid in the film evaporates such that transmission through the film at wavelength 560 nm goes to a minimum every 12 seconds. Assuming that the film is flat on its two sides, the rate of evaporation is _____ $\pi \times 10^{-13} \text{ m}^3/\text{s}$.

Young's Double Slit Experiment

Q4. [22 Jan S1] Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion-(A) : If Young's double slit experiment is performed in an optically denser medium than air, then the consecutive fringes come closer.

Reason-(R) : The speed of light reduces in an optically denser medium than air while its frequency does not change.

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

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) (A) is true but (R) is false
- (C) (A) is false but (R) is true
- (D) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Q5. [22 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : In Young's double slit experiment, the fringes produced by red light are closer as compared to those produced by blue light.

Reason (R) : The fringe width is directly proportional to the wavelength of light.

In the light of the above statements, choose the correct answer from the options given below :

- (A) (A) is true but (R) is false
- (B) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (C) (A) is false but (R) is true
- (D) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

Q6. [23 Jan S2] The width of one of the two slits in Young's double slit experiment is d while that of the other slit is xd . If the ratio of the maximum to the minimum intensity in the interference pattern on the screen is 9 : 4 then what is the value of x ? (Assume that the field strength varies according to the slit width.)

- (A) 4
- (B) 5
- (C) 3
- (D) 2

Q7. [24 Jan S1] The Young's double slit interference experiment is performed using light consisting of

480 nm and 600 nm wavelengths to form interference patterns. The least number of the bright fringes of 480 nm light that are required for the first coincidence with the bright fringes formed by 600 nm light is

- (A) 5
- (B) 6
- (C) 4
- (D) 8

Q8. [24 Jan S2] Young's double slit interference apparatus is immersed in a liquid of refractive index 1.44. It has slit separation of 1.5 mm. The slits are illuminated by a parallel beam of light whose wavelength in air is 690 nm. The fringe-width on a screen placed behind the plane of slits at a distance of 0.72 m, will be :

- (A) 0.46 mm
- (B) 0.63 mm
- (C) 0.33 mm
- (D) 0.23 mm

Q9. [28 Jan S1] A double slit interference experiment performed with a light of wavelength 600 nm forms an interference fringe pattern on a screen with 10th bright fringe having its centre at a distance of 10 mm from the central maximum. Distance of the centre of the 10th bright fringe from the central maximum when the source of light is replaced by another source of wavelength 660 nm would be _____ mm.

21. Dual Nature of Radiation & Matter

12 questions

Photoelectric Effect

Q1. [22 Jan S1] The work functions of cesium (Cs) and lithium (Li) metals are 1.9 eV and 2.5 eV, respectively. If we incident a light of wavelength 550 nm on these two metal surfaces, then photo-electric effect is possible for the case of

- (A) Li only
- (B) Neither Cs nor Li
- (C) Both Cs and Li
- (D) Cs only

Q2. [22 Jan S2] A light source of wavelength λ illuminates a metal surface and electrons are ejected with maximum kinetic energy of 2 eV. If the same surface is illuminated by a light source of wavelength $\frac{\lambda}{2}$, then the maximum kinetic energy of ejected electrons will be (The work function of metal is 1 eV)

- (A) 6 eV
- (B) 3 eV
- (C) 5 eV
- (D) 2 eV

Q3. [23 Jan S2] In photoelectric effect, an em-wave is incident on a metal surface and electrons are ejected from the surface. If the work function of the metal is 2.14 eV and stopping potential is 2 V, what is the wavelength of the em-wave? (Given $hc = 1242 \text{ eV nm}$ where h is the Planck's constant and c is the speed of light in vacuum.)

- (A) 400 nm (B) 200 nm
(C) 600 nm (D) 300 nm

Q4. [24 Jan S2] In photoelectric effect, the stopping potential (V_0) v/s frequency (ν) curve is plotted. (h is the Planck's constant and ϕ_0 is work function of metal)

- (A) V_0 v/s ν is linear.
(B) The slope of V_0 v/s ν curve = $\frac{\phi_0}{h}$
(C) h constant is related to the slope of V_0 v/s ν line.
(D) The value of electric charge of electron is not required to determine h using the V_0 v/s ν curve.
(E) The work function can be estimated without knowing the value of h .

Choose the correct answer from the options given below :

- (A) (D) and (E) only (B) (A), (B) and (C) only
(C) (A), (C) and (E) (D) (C) and (D) only

Q5. [24 Jan S2] The ratio of the power of a light source S_1 to that the light source S_2 is 2. S_1 is emitting 2×10^{15} photons per second at 600 nm. If the wavelength of the source S_2 is 300 nm, then the number of photons per second emitted by S_2 is $\times 10^{14}$.

Q6. [29 Jan S1] Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Emission of electrons in photoelectric effect can be suppressed by applying a sufficiently negative electron potential to the photoemissive substance.

Reason (R) : A negative electric potential, which stops the emission of electrons from the surface of a photoemissive substance, varies linearly with frequency of incident radiation.

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

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) (A) is true but (R) is false
(C) (A) is false but (R) is true
(D) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Q7. [29 Jan S2] In an experiment with photoelectric effect, the stopping potential,

- (A) is $(\frac{1}{e})$ times the maximum kinetic energy of the emitted photoelectrons
(B) decreases with increase in the intensity of the incident light

(C) increases with increase in the wavelength of the incident light

(D) increases with increase in the intensity of the incident light

de Broglie Waves

Q8. [23 Jan S1] A sub-atomic particle of mass 10^{-30} kg is moving with a velocity 2.21×10^6 m/s. Under the matter wave consideration, the particle will behave closely like _____. ($h = 6.63 \times 10^{-34}$ J.s)

- (A) Infra-red radiation (B) Gamma rays
(C) X-rays (D) Visible radiation

Q9. [24 Jan S1] An electron of mass ' m ' with an initial velocity $\vec{v} = v_0 \hat{i}$ ($v_0 > 0$) enters an electric field $\vec{E} = -E_0 \hat{k}$. If the initial de Broglie wavelength is λ_0 , the value after time t would be

- (A) $\lambda_0 \sqrt{1 + \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}$ (B) $\frac{\lambda_0}{\sqrt{1 - \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}}$
(C) $\frac{\lambda_0}{\sqrt{1 + \frac{e^2 E_0^2 t^2}{m^2 v_0^2}}}$ (D) λ_0

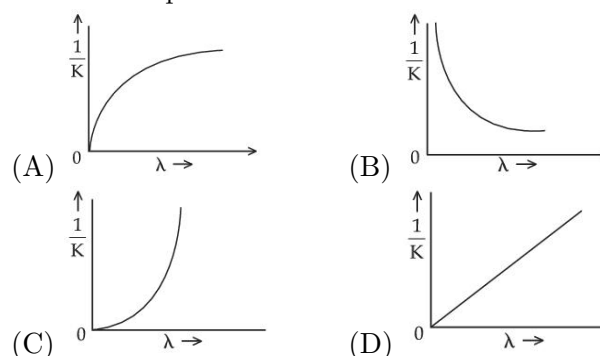
Q10. [28 Jan S1] A proton of mass ' m_p ' has same energy as that of a photon of wavelength ' λ '. If the proton is moving at non-relativistic speed, then ratio of its de Broglie wavelength to the wavelength of photon is.

- (A) $\frac{1}{c} \sqrt{\frac{E}{2m_p}}$ (B) $\frac{1}{c} \sqrt{\frac{2E}{m_p}}$
(C) $\frac{1}{c} \sqrt{\frac{E}{m_p}}$ (D) $\frac{1}{2c} \sqrt{\frac{E}{m_p}}$

Q11. [28 Jan S2] Which of the following phenomena can not be explained by wave theory of light ?

- (A) Refraction of light (B) Compton effect
(C) Reflection of light (D) Diffraction of light

Q12. [29 Jan S1] If λ and K are de Broglie wavelength and kinetic energy, respectively, of a particle with constant mass. The correct graphical representation for the particle will be



22. Atoms & Nuclei

8 questions

Bohr Model & Atomic Spectra

Q1. [22 Jan S1] An electron in the ground state of the hydrogen atom has the orbital radius of 5.3×10^{-11} m while that for the electron in third excited state is 8.48×10^{-10} m. The ratio of the de Broglie wavelengths of electron in the ground state to that in the excited state is

- (A) 9 (B) 4
(C) 16 (D) 3

Q2. [22 Jan S2] An electron projected perpendicular to a uniform magnetic field B moves in a circle. If Bohr's quantization is applicable, then the radius of the electronic orbit in the first excited state is :

- (A) $\sqrt{\frac{h}{2\pi eB}}$ (B) $\sqrt{\frac{h}{\pi eB}}$
(C) $\sqrt{\frac{2h}{\pi eB}}$ (D) $\sqrt{\frac{4h}{\pi eB}}$

Q3. [24 Jan S1] During the transition of electron from state A to state C of a Bohr atom, the wavelength of emitted radiation is $2000 \text{ \AA}$ and it becomes $6000 \text{ \AA}$ when the electron jumps from state B to state C. Then the wavelength of the radiation emitted during the transition of electrons from state A to state B is

- (A) $6000 \text{ \AA}$ (B) $2000 \text{ \AA}$
(C) $4000 \text{ \AA}$ (D) $3000 \text{ \AA}$

Q4. [28 Jan S2] The frequency of revolution of the electron in Bohr's orbit varies with n , the principal quantum number as

- (A) $\frac{1}{n}$ (B) $\frac{1}{n^2}$
(C) $\frac{1}{n^4}$ (D) $\frac{1}{n^3}$

Q5. [29 Jan S2] The number of spectral lines emitted by atomic hydrogen that is in the 4th energy level, is

- (A) 3 (B) 6
(C) 0 (D) 1

Nuclei & Radioactivity

Q6. [23 Jan S1] A radioactive nucleus n_2 has 3 times the decay constant as compared to the decay constant of another radioactive nucleus n_1 . If initial number of both nuclei are the same, what is the ratio of number of nuclei of n_2 to the number of nuclei of n_1 , after one half-life of n_1 ?

- (A) 8 (B) 4
(C) $1/8$ (D) $1/4$

Q7. [23 Jan S2] Given below are two statements. One is labelled as Assertion (A) and the other is labelled

as Reason (R).

Assertion (A) : The binding energy per nucleon is found to be practically independent of the atomic number A , for nuclei with mass numbers between 30 and 170.

Reason (R) : Nuclear force is long range.

In the light of the above statements, choose the correct answer from the options given below :

- (A) (A) is true but (R) is false
(B) (A) is false but (R) is true
(C) Both (A) and (R) are true and (R) is the correct explanation of (A)
(D) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

Q8. [28 Jan S1] Choose the correct nuclear process from the below options [p: proton, n: neutron, e^- : electron, e^+ : positron, ν : neutrino, $\bar{\nu}$: antineutrino]

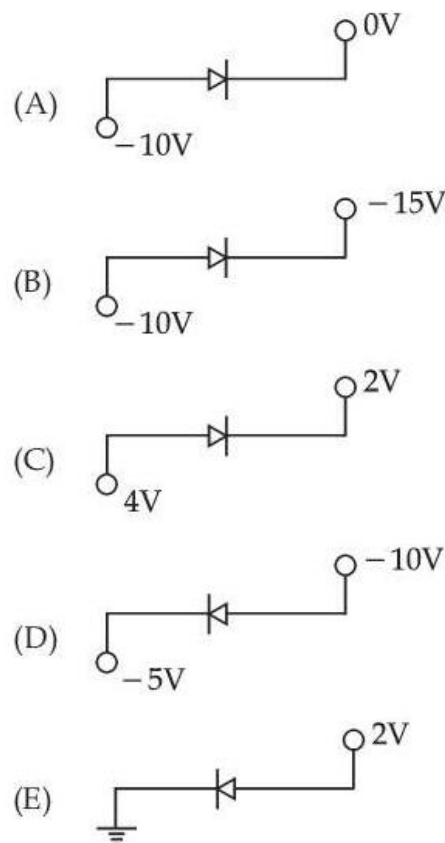
- (A) $n \rightarrow p + e^- + \bar{\nu}$ (B) $n \rightarrow p + e^+ + \nu$
(C) $n \rightarrow p + e^+ + \bar{\nu}$ (D) $n \rightarrow p + e^- + \nu$

23. Semiconductors & Communication

10 questions

Diodes & Junction Devices

Q1. [22 Jan S1] Which of the following circuits represents a forward biased diode?



Choose the correct answer from the options given

below :

- (A) (B), (D) and (E) (B) (C) and (E) only
 only
 (C) (B), (C) and (E) (D) (A) and (D) only
 only

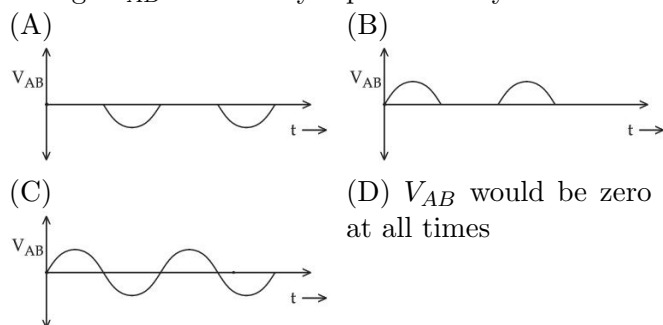
Q2. [24 Jan S1] Consider the following statements:

- A. The junction area of solar cell is made very narrow compared to a photo diode.
 B. Solar cells are not connected with any external bias.
 C. LED is made of lightly doped p-n junction.
 D. Increase of forward current results in continuous increase of LED light intensity.
 E. LEDs have to be connected in forward bias for emission of light.

Choose the correct answer from the options given below:

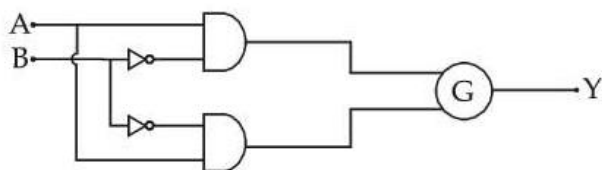
- (A) B, D, E Only (B) A, C, E Only
 (C) B, E Only (D) A, C Only

Q3. [28 Jan S2] In the circuit shown here, assuming threshold voltage of diode is negligibly small, then voltage V_{AB} is correctly represented by :



Logic Gates

Q4. [22 Jan S2]

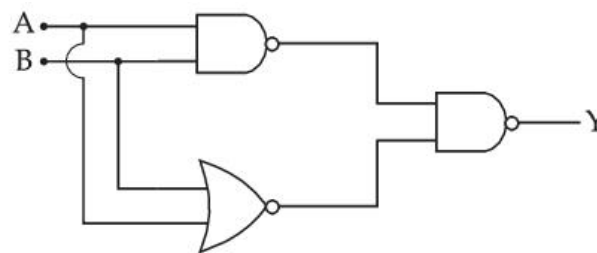


A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

To obtain the given truth table, following logic gate should be placed at G :

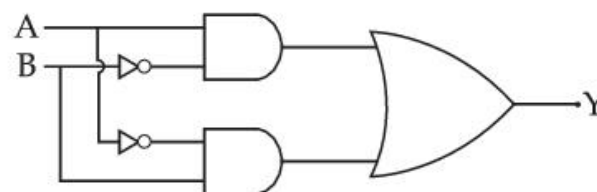
- (A) AND Gate (B) NOR Gate
 (C) OR Gate (D) NAND Gate

Q5. [29 Jan S1] For the circuit shown above, equivalent GATE is :



- (A) AND gate (B) NOT gate
 (C) OR gate (D) NAND gate

Q6. [29 Jan S2] The truth table for the circuit given below is :



(A)

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

(B)

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

(C)

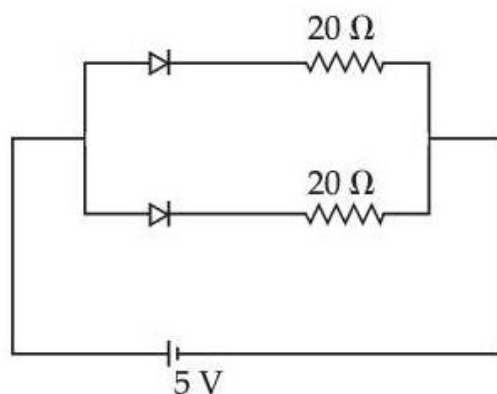
A	B	Y
0	0	0
1	1	1
1	0	1
0	1	1

(D)

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

Semiconductor Devices & Communication

Q7. [23 Jan S2] What is the current through the battery in the circuit shown below ?

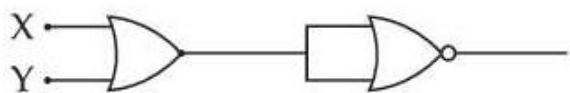


- (A) 0.25 A (B) 1.0 A
 (C) 1.5 A (D) 0.5 A

Q8. [24 Jan S2] The output of the circuit is low (zero) for :

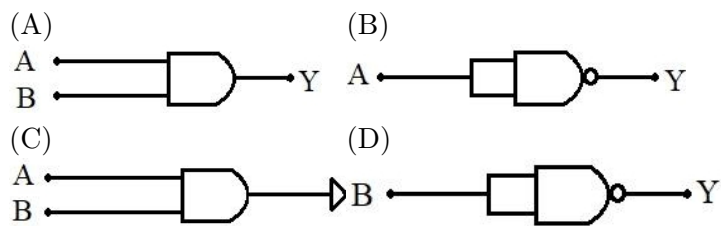
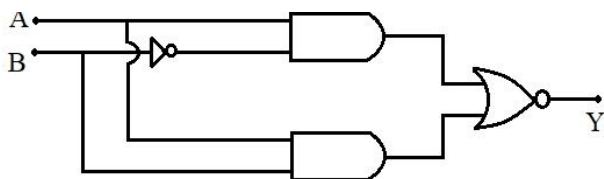
- (A) X=0, Y=0 (B) X=0, Y=1 (C) X=1, Y=0 (D) X=1, Y=1

Choose the correct answer from the options given below :



- (A) (A), (B) and (D) only
 (B) (A), (B) and (C) only
 (C) (A), (C) and (D) only
 (D) (B), (C) and (D) only

Q9. [28 Jan S1] Which of the following circuits has the same output as that of the given circuit?



Q10. [29 Jan S2] The difference of temperature in a material can convert heat energy into electrical energy. To harvest the heat energy, the material should have

- (A) low thermal conductivity and high electrical conductivity
 (B) high thermal conductivity and high electrical conductivity
 (C) high thermal conductivity and low electrical conductivity
 (D) low thermal conductivity and low electrical conductivity