JEE Main 2025 (January)

Chapter-wise Qs Bank

Physics

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Content

Questions

Solutions

Q1. Two particles are located at equal distance from origin. The position vectors of those are represented by $\bar{A} = 2\hat{i} + 3n\hat{j} + 2\hat{k}$ and $\bar{B} = 2\hat{i} - 2\hat{j} + 4p\hat{k}$, respectively. If both the vectors are at right angle to each other, the value of n^{-1} is _____.

Q2. 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

(1) $y = 1326.19$

(2) $y = 1330$

(3) $y = 1326.186$

(4) $y = 1326.2$

Q3. The maximum percentage error in the measurment of density of a wire is [Given, mass of wire $= (0.60 \pm 0.003)$g radius of wire $= (0.50 \pm 0.01)$cm length of wire $= (10.00 \pm 0.05)$cm]

(1) 8

(2) 5

(3) 4

(4) 7

Q4. The energy of a system is given as $\mathrm{E(t)} = \alpha^3 \mathrm{e}^{-\beta t}$, where t is the time and $\beta = 0.3\ \mathrm{s}^{-1}$. 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 :

(1) 6%

(2) 8.4%

(3) 11.6%

(4) 4%

Q5. A physical quantity Q is related to four observables a, b, c, d as follows :
$\mathrm{Q} = \frac{\mathrm{ab}^4}{\mathrm{cd}}$
where, $\mathrm{a} = (60 \pm 3)\mathrm{Pa}$; $\mathrm{b} = (20 \pm 0.1)\mathrm{m}$; $\mathrm{c} = (40 \pm 0.2)\mathrm{Nsm}^{-2}$ and $\mathrm{d} = (50 \pm 0.1)\mathrm{m}$, then the percentage error in Q is $\frac{x}{1000}$, where $x =$ ________.

Q1. 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,

(1) $[\mathrm{F}]=\left[\mathrm{C}^2 \mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^2\right]$

(2) $[\mathrm{F}]=\left[\mathrm{C}^2 \mathrm{M}^{-2} \mathrm{~L}^2 \mathrm{~T}^2\right]$

(3) $[\mathrm{F}]=\left[\mathrm{CM}^{-2} \mathrm{~L}^{-2} \mathrm{~T}^{-2}\right]$

(4) $[\mathrm{F}]=\left[\mathrm{CM}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^2\right]$

Q2. The position of a particle moving on x-axis is given by $x(t)=A \sin t+B \cos ^2 t+C t^2+D$, where t is time. The dimension of $\frac{A B C}{D}$ is

(1) $L^2 T^{-2}$

(2) L^2

(3) L

(4) $L^3 \mathrm{~T}^{-2}$

Q3. 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

(1) electric field

(2) area

(3) charge

(4) displacement

Q4. In a measurement, it is asked to find modulus of elasticity per unit torque applied on the system. The measured quantity has dimension of $\left[M^a L^b T^c\right]$. If $b=-3$, the value of c is ________

Q5. The pair of physical quantities not having same dimensions is :

(1) Pressure and Young's modulus

(2) Surface tension and impulse

(3) Torque and energy

(4) Angular momentum and Planck's constant

Q6. 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

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

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

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

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

Q7. If B is magnetic field and μ_0 is permeability of free space, then the dimensions of (B/μ_0) is

(1) $\mathrm{ML^2\,T^{-2}\,A^{-1}}$

(2) $\mathrm{MT^{-2}\,A^{-1}}$

(3) $\mathrm{L^{-1}\,A}$

(4) $\mathrm{LT^{-2}\,A^{-1}}$

Q8. Match List - I with List - II.

	List - I		List - II
(A)	Permeability of free space	(I)	$\left[\mathrm{M\,L^2\,T^{-2}}\right]$
(B)	Magnetic field	(II)	$\left[\mathrm{M\,T^{-2}\,A^{-1}}\right]$
(C)	Magnetic moment	(III)	$\left[\mathrm{M\,L\,T^{-2}\,A^{-2}}\right]$
(D)	Torsional constant	(IV)	$\left[\mathrm{L^2\,A}\right]$

Choose the correct answer from the options given below :

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

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

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

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

Q9. Match List - I with List - II.

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

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

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

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

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

Q10. The expression given below shows the variation of velocity (v) with time (t), $v = \mathrm{At}^2 + \frac{\mathrm{Bt}}{\mathrm{C+t}}$. The dimension of ABC is :

(1) $[M^0 L^1 T^{-3}]$

(2) $[M^0 L^2 T^{-2}]$

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

(4) $[M^0 L^2 T^{-3}]$

Q11. Match List - I with List - II.

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

Choose the correct answer from the options given below :

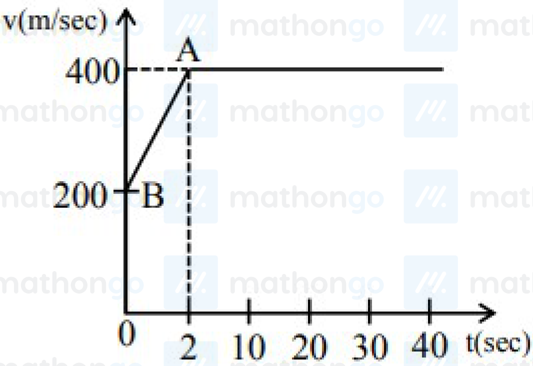
(1) (A)-(I), (B)-(III), (C)-(II), (D)-(IV)

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

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

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

Q1. 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.



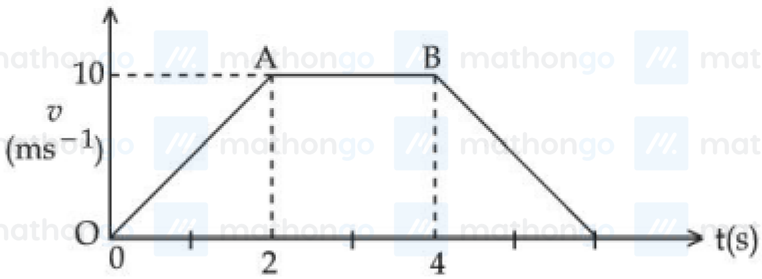
(1) 12

(2) 3

(3) 6

(4) 9

Q2. 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 ?



(1) 30 m

(2) 11 m

(3) 10 m

(4) 13 m

Q3. Two cars P and Q are moving on a road in the same direction. Accleration of car P increases linearly with time whereas car Q moves with a constant accleration. 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 ________.

Q4. The maximum speed of a boat in still water is $27\ \mathrm{km/h}$. Now this boat is moving downstream in a river flowing at $9\ \mathrm{km/h}$. A man in the boat throws a ball vertically upwards with speed of $10\ \mathrm{m/s}$. Range of the ball as observed by an observer at rest on the river bank, is _______ cm. (Take $\mathrm{g} = 10\ \mathrm{m/s^2}$)

Q1. A particle is projected at an angle of 30° from horizontal at a speed of $60 \mathrm{~m/s}$. 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, $g = 10 \mathrm{~m/s}^2$]

Q2. A ball of mass 100 g is projected with velocity $20 \mathrm{~m/s}$ at 60° with horizontal. The decrease in kinetic energy of the ball during the motion from point of projection to highest point is

(1) 5 J

(2) 15 J

(3) 20 J

(4) zero

Q3. 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 :

(1) $\frac{1-\tan \alpha}{1+\tan \alpha}$

(2) $\frac{1-\sin 2\alpha}{1+\sin 2\alpha}$

(3) $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$

(4) $\frac{1+\sin \alpha}{1-\sin \alpha}$

Q4. The position vector of a moving body at any instant of time is given as $\vec{r} = \left(5t^2\hat{i} - 5t\hat{j}\right)$ m. The magnitude and direction of velocity at $t = 2$ s is,

(1) $5\sqrt{15} \mathrm{~m/s}$, making an angle of $\tan^{-1} 4$ with - ve Y axis

(2) $5\sqrt{15} \mathrm{~m/s}$, making an angle of $\tan^{-1} 4$ with + ve X axis

(3) $5\sqrt{17} \mathrm{~m/s}$, making an angle of $\tan^{-1} 4$ with + ve X axis

(4) $5\sqrt{17} \mathrm{~m/s}$, making an angle of $\tan^{-1} 4$ with - ve Y axis

Q1. 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,

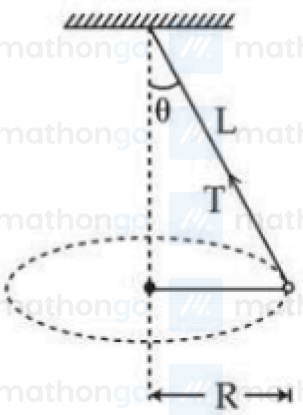
(1) 39 N

(2) 15 N

(3) 11 N

(4) 20 N

Q2.



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.

Q3. 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

(1) $\mu = \frac{\mathrm{v}_{\mathrm{o}}^2 + \mathrm{rg} \tan \theta}{\mathrm{rg} + \mathrm{v}_{\mathrm{o}}^2 \tan \theta}$

(2) $\mu = \frac{v_0^2 - rg \tan \theta}{rg - v_0^2 \tan \theta}$

(3) $\mu = \frac{v_0^2 - rg \tan \theta}{rg + v_0^2 \tan \theta}$

(4) $\mu = \frac{v_o^2 + rg \tan \theta}{\mathrm{rg} - \mathrm{v}_{\mathrm{o}}^2 \tan \theta}$

Q1. A force $\overrightarrow{\mathrm{F}}=2\hat{i}+\mathrm{b}\hat{j}+\hat{k}$ 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.

(1) 0

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

(3) 2

(4) $\frac{1}{3}$

Q2. A force $\mathrm{f}=\mathrm{x}^2\mathrm{y}\hat{\mathrm{i}}+\mathrm{y}^2\hat{\mathrm{j}}$ acts on a particle in a plane $\mathrm{x}+\mathrm{y}=10$. The work done by this force during a displacement from $(0,0)$ to $(4\ \mathrm{m}, 2\ \mathrm{m})$ is ________ Joule (round off to the nearest integer)

Q3. A force $\mathrm{F}=\alpha+\beta\mathrm{x}^2$ 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

(1) $15\ \mathrm{N/m^2}$

(2) $12\ \mathrm{N/m^2}$

(3) $8\ \mathrm{N/m^2}$

(4) $10\ \mathrm{N/m^2}$

Q4. 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 ?

(1) $\frac{(\mathrm{KE})}{8}$

(2) $\frac{(\mathrm{KE})}{2}$

(3) $\frac{(\mathrm{KE})}{16}$

(4) $\frac{(\mathrm{KE})}{4}$

Q5. 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

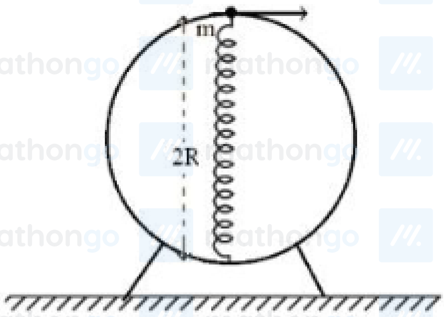
(1) A is false but R is true

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

(3) A is true but R is false

(4) Both A and R are true and R is the correct explanation of A

Q6. 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 the length of spring becomes ' R ', would be (spring constant is ' k ', g is accleration due to gravity)



(1) $\sqrt{3 \mathrm{Rg}+\frac{\mathrm{kR}^2}{\mathrm{~m}}}$

(2) $2 \sqrt{\mathrm{gR}+\frac{\mathrm{kR}^2}{\mathrm{~m}}}$

(3) $\sqrt{2 \mathrm{Rg}+\frac{\mathrm{kR}^2}{\mathrm{~m}}}$

(4) $\sqrt{2 \mathrm{Rg}+\frac{4 \mathrm{kR}^2}{\mathrm{~m}}}$

Q7. 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 $\overrightarrow{\mathrm{F}}=(2 \hat{i}+3 \hat{j})$N, it moves to a new point Q having coordinates $(6,10)$m in 4 sec. The average power and instanteous power at the end of 4 sec are in the ratio of :

(1) 13 : 6

(2) 4 : 3

(3) 1 : 2

(4) 6 : 13

Q8. 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. $\frac{\mathrm{dm}}{\mathrm{dt}} \propto \sqrt{v}$. If P is the power delivered to run the belt at constant speed then which of the following relationship is true?

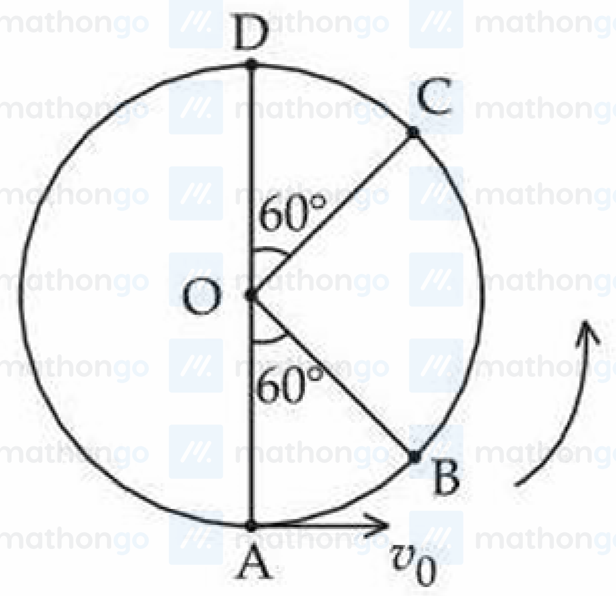
(1) $\mathrm{P} \propto \sqrt{v}$

(2) $\mathrm{P} \propto v$

(3) $\mathrm{P}^2 \propto v^5$

(4) $P^2 \propto v^3$

Q9. 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 ______ -.



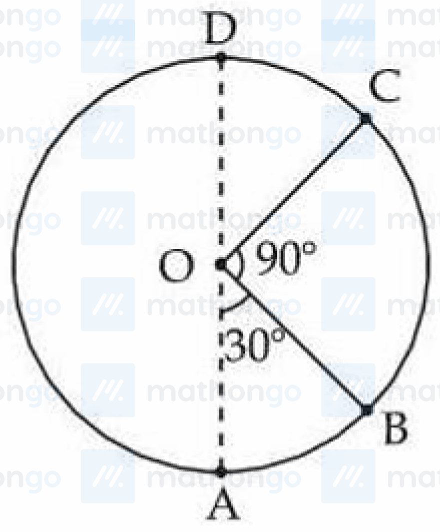
(1) 1

(2) 2

(3) 4

(4) 3

Q10. 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 $10 \mathrm{~m/s}$. The ratio of its kinetic energies at point B and C is :



(Take acceleration due to gravity as $10 \mathrm{~m/s}^2$)

(1) $\frac{2+\sqrt{2}}{3}$

(2) $\frac{2+\sqrt{3}}{3}$

(3) $\frac{3+\sqrt{3}}{2}$

(4) $\frac{3-\sqrt{2}}{2}$

Q11. A body of mass ' m ' connected to a massless and unstretchable string goes in verticle 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, $n \geqslant 1$, then ratio of kinetic energy of the body at bottom to that at top of the circle is

(1) $\frac{n^2}{n^2+4}$

(2) $\frac{n^2+4}{n^2}$

(3) $\frac{n+4}{n}$

(4) $\frac{n}{n+4}$

Q1. 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 ________

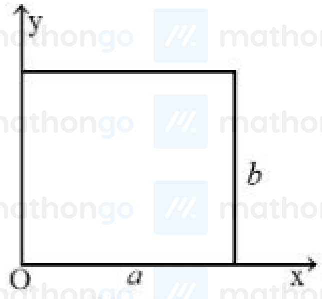


fig-x

(1) $\left(\frac{2}{3}a, \frac{b}{2}\right)$

(2) $\left(\frac{a}{2}, \frac{b}{2}\right)$

(3) $\left(\frac{1}{3}a, \frac{b}{2}\right)$

(4) $\left(\frac{2}{3}a, \frac{2}{3}b\right)$

Q2. 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

(1) 2.0 cm

(2) 1.5 cm

(3) 1.0 cm

(4) 0.5 cm

Q3. 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

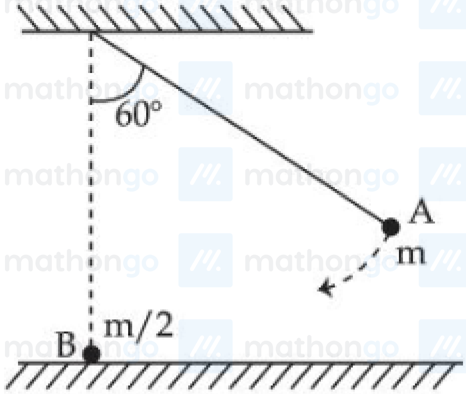
(1) 190 g

(2) 200 g

(3) 300 g

(4) 290 g

Q4. 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.)



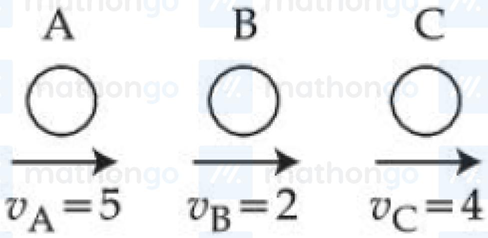
(1) $\frac{4}{3} \sqrt{\mathrm{Rg}}$

(2) $\frac{2}{3} \sqrt{\mathrm{Rg}}$

(3) $\sqrt{\mathrm{Rg}}$

(4) $\frac{1}{3} \sqrt{\mathrm{Rg}}$

Q5. 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 $v_{\mathrm{A}} = 5\ \mathrm{m/s}, v_{\mathrm{B}} = 2\ \mathrm{m/s}, v_{\mathrm{C}} = 4\ \mathrm{m/s}$. If we wait sufficiently long for elastic collision to happen, then $v_{\mathrm{A}} = 4\ \mathrm{m/s}, v_{\mathrm{B}} = 2\ \mathrm{m/s}, v_{\mathrm{C}} = 5\ \mathrm{m/s}$ 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 :

(1) (A) is false but (R) is true

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

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

(4) (A) is true but (R) is false

Q6. 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)

(1) $\frac{2Ma}{3a+g}$

(2) $\frac{3Ma}{2a-g}$

(3) $\frac{3Ma}{2a+g}$

(4) $\frac{2Ma}{3a-g}$

Q1. 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

(1) $\hat{i}-\hat{k}$

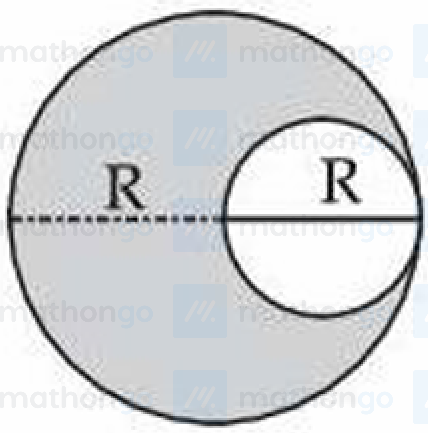
(2) $\hat{i}+\hat{k}$

(3) $\hat{j}+\hat{k}$

(4) $\hat{i}-\hat{j}+\hat{k}$

Q2. The coordinates of a particle with respect to origin in a given reference frame is $(1,1,1)$ meters. If a force of $\overrightarrow{\mathrm{F}}=\hat{i}-\hat{j}+\hat{k}$ acts on the particle, then the magnitude of torque (with respect to origin) in z-direction is _______.

Q3. 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 $\mathrm{R}/2$ 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.



(1) $\frac{7}{32}\mathrm{MR}^2$

(2) $\frac{9}{32}\mathrm{MR}^2$

(3) $\frac{17}{32}\mathrm{MR}^2$

(4) $\frac{13}{32}\mathrm{MR}^2$

Q4. 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

(1) $t_1>t_2$

(2) $t_1=t_2$

(3) $t_1<t_2$

(4) $t_1 = 2t_2$

Q5. Two iron solid discs of negligible thickness have radii R_1 and R_2 and moment of intertia 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 = ________ -

Q6. 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

(1) $\frac{1}{\sqrt{2}}$ g

(2) $\frac{1}{3\sqrt{2}}$ g

(3) $\frac{\sqrt{2}\,g}{3}$

(4) $\sqrt{2}g$

Q7. 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]

(1) $\frac{mv_o^3}{2\sqrt{2}g}$ along negative z-axis

(2) $\frac{mv_o^3}{4\sqrt{2}g}$ along positive z-axis

(3) $\frac{mv_o^3}{4\sqrt{2}g}$ along negative z-axis

(4) $\frac{mv_o^3}{2\sqrt{2}g}$ along positive z-axis

Q8. 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 :

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

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

(3) $\frac{5}{2}$

(4) $\frac{2}{5}$

Q9. 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 = ________
(Consider all the bodies have equal masses)

Q10. 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 ?

(1) $72\mathrm{MR}^2$

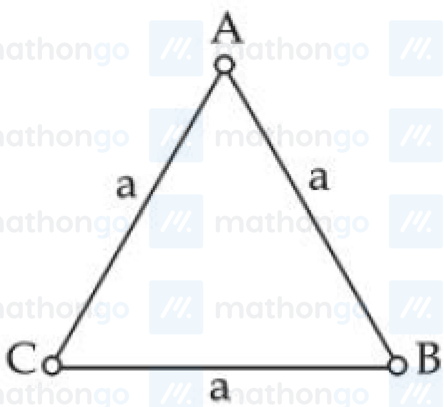
(2) $8\mathrm{MR}^2$

(3) $108\mathrm{MR}^2$

(4) $60\mathrm{MR}^2$

Q11. The position vectors of two 1 kg particles, (A) and (B), are given by
$\overrightarrow{\mathrm{r}}_{\mathrm{A}} = \left(\alpha_1 \mathrm{t}^2 \hat{i} + \alpha_2 \mathrm{t}\ \hat{j} + \alpha_3 \mathrm{t} \hat{k}\right)$ m and $\overrightarrow{\mathrm{r}}_{\mathrm{B}} = \left(\beta_1 \mathrm{t} \hat{i} + \beta_2 \mathrm{t}^2 \hat{j} + \beta_3 \mathrm{t} \hat{k}\right)$ m, respectively;
$\left(\alpha_1 = 1\ \mathrm{m/s^2}, \alpha_2 = 3\mathrm{n}\ \mathrm{m/s}, \alpha_3 = 2\ \mathrm{m/s},\ \ \beta_1 = 2\ \mathrm{m/s}, \beta_2 = -1\ \mathrm{m/s^2}, \beta_3 = 4\mathrm{p}\ \mathrm{m/s}\right)$, where t is time, n and p are constants. At $t = 1$ s, $\left|\overrightarrow{V_A}\right| = \left|\vec{V}_B\right|$ 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 $\sqrt{\mathrm{L}}\mathrm{kgm}^2\ \mathrm{s}^{-1}$. The value of L is _______.

Q12.



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 $\vec{V}_A = V_0 \overrightarrow{AC}, \vec{V}_B = V_0 \overrightarrow{BA}$ and $\vec{V}_C = V_0 \overrightarrow{CB}$. Here, $\overrightarrow{AC}, \overrightarrow{CB}$ and $\overrightarrow{BA}$ 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 :

(1) $3\mathrm{amV}_0$

(2) $\frac{3}{2}$ a mV_0

(3) $\frac{\sqrt{3}}{2}$ a mV_0

(4) $\frac{1}{2}$ a mV_0

Q13. 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

(1) $1 : \sqrt{2}$

(2) $1 : \sqrt{3}$

(3) $1 : 3$

(4) $1 : 2$

Q1. Earth has mass 8 times and radius 2 times that of a planet. If the escape velocity from the earth is $11.2 \mathrm{~km/s}$, the escape velocity in $\mathrm{km/s}$ from the planet will be :

(1) 2.8

(2) 11.2

(3) 5.6

(4) 8.4

Q2. 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 $\ldots\ldots$ g.

Q3. 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

(1) 9%

(2) 3%

(3) 4.5%

(4) 2.5%

Q4. 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.

(1) 27 days

(2) 1 day

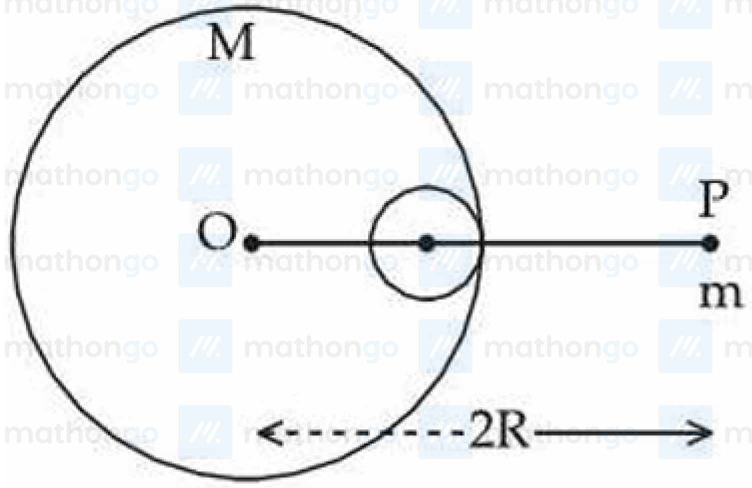
(3) 81 days

(4) 3 days

Q5. 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 ________.

Q6. 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 $\mathrm{R}/3$ 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



(1) 12 : 11

(2) 11 : 10

(3) 12 : 9

(4) 16 : 9

Q7. 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)

Q1. The volume contraction of a solid copper cube of edge length 10 cm , when subjected to a hydraulic pressure of 7×10^6 Pa, would be ____ mm^3.
(Given bulk modulus of copper $= 1.4 \times 10^{11}\ N\ m^{-2}$)

Q2. The increase in pressure required to decrease the volume of a water sample by 0.2% is $P \times 10^5 Nm^{-2}$. Bulk modulus of water is $2.15 \times 10^9 Nm^{-2}$. The value of P is ......

Q3. The fractional compression $\left(\frac{\Delta V}{V}\right)$ of water at the depth of 2.5 km below the sea level is ______ %. Given, the Bulk modulus of water $= 2 \times 10^9\ N\ m^{-2}$, density of water $= 10^3\ kgm^{-3}$, acceleration due to gravity $= g = 10\ m\ s^{-2}$.

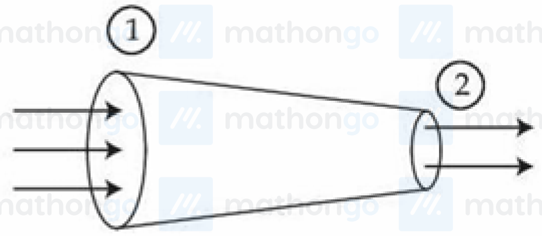
(1) 1.25

(2) 1.0

(3) 1.75

(4) 1.5

Q1.



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 $2 \mathrm{~m/s}$, then velocity of water leaving the point (2) will be

(1) $4 \mathrm{~m/s}$

(2) $2 \mathrm{~m/s}$

(3) $6 \mathrm{~m/s}$

(4) $8 \mathrm{~m/s}$

Q2. 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 ______.

Q3. 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

(1) Statement I is true but Statement II is false

(2) Statement I is false but Statement II is true

(3) Both Statement I and Statement II are false

(4) Both Statement I and Statement II are true

Q4. A tube of length 1 m is filled completely with an ideal liquid of mass 2 M , 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 __________.

Q5. In a hydraulic lift, the surface area of the input piston is $6 \mathrm{~cm}^2$ and that of the output piston is $1500 \mathrm{~cm}^2$. If 100 N force is applied to the input piston to raise the output piston by 20 cm, then the work done is _______ kJ.

Q6. 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 $= 1000 \mathrm{~kg~m}^{-3}$)

(1) $1400 \mathrm{~cm}^3$

(2) $600 \mathrm{~cm}^3$

(3) $4000 \mathrm{~cm}^3$

(4) $400 \mathrm{~cm}^3$

Q7. 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

(1) $P_1 - P_2$

(2) $(P_1 - P_2)^4$

(3) $(\mathrm{P}_1 - \mathrm{P}_2)^2$

(4) $\sqrt{\mathrm{P}_1 - \mathrm{P}_2}$

Q8. 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 $0.095 \mathrm{~J/m}^2$ and density $10^3 \mathrm{~kg/m}^3$. The difference between pressure inside the bubble and atmospheric pressure is _____ $\mathrm{N/m}^2$. (Take $\mathrm{g} = 10 \mathrm{~m/s}^2$)

Q9. 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

(1) 15 J

(2) 5 J

(3) 20 J

(4) 10 J

Q10. An air bubble of radius 0.1 cm lies at a depth of 20 cm below the free surface of a liquid of density $1000 \mathrm{~kg/m}^3$. If the pressure inside the bubble is $2100 \mathrm{~N/m}^2$ greater than the atmospheric pressure, then the surface tension of the liquid in SI unit is (use $\mathrm{g} = 10 \mathrm{~m/s}^2$)

(1) 0.1

(2) 0.05

(3) 0.02

(4) 0.25

Q11. 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)

(1) 2 Mg

(2) Mg

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

(4) $\frac{\mathrm{Mg}}{2}$

Q12. 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:

(1) A, B and E Only

(2) B, D and E Only

(3) A, C and D Only

(4) C, D and E Only

Q13. 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:

(1) C, D, E Only

(2) A, D, E Only

(3) B, C, D Only

(4) A, B, C Only

Q14. 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 ____ $\pi \times 10^{-13}\ \mathrm{m}^3/\mathrm{s}$.

Q1. 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 $\frac{\mathrm{D}}{\mathrm{d}}$ is

(1) $\frac{16}{5}$

(2) 10

(3) $\frac{15}{4}$

(4) 25

Q2. 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

(1) $\frac{\mathrm{k}_1}{\mathrm{k}_2}$

(2) $\sqrt{\frac{\mathrm{k}_1}{\mathrm{k}_2}}$

(3) $\sqrt{\frac{\mathrm{k}_2}{\mathrm{k}_1}}$

(4) $\frac{\mathrm{k}_2}{\mathrm{k}_1}$

Q3. 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 :

(1) (A) is false but (R) is true

(2) (A) is true but (R) is false

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

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

Q4. 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 :

(1) (A) is false but (R) is true

(2) (A) is true but (R) is false

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

(4) Both (A) and (R) are true and (R) is the correct explanation of (A)

Q5. 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 $y\pi \times 10^{-2}$ s, where the value of y is (Acceleration due to gravity, $g = 10 \mathrm{~m/s^2}$, density of water $= 10^3 \mathrm{~kg/m^3}$)

(1) 6

(2) 2

(3) 4

(4) 1

Q6. 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 :

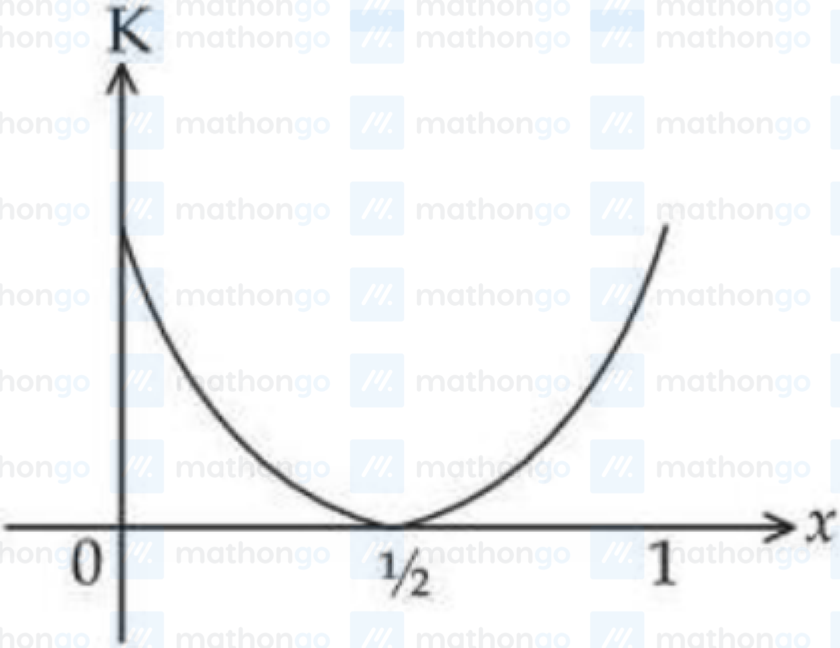
(1) Both (A) and (R) are true and (R) is the correct explanation of (A)

(2) (A) is true but (R) is false

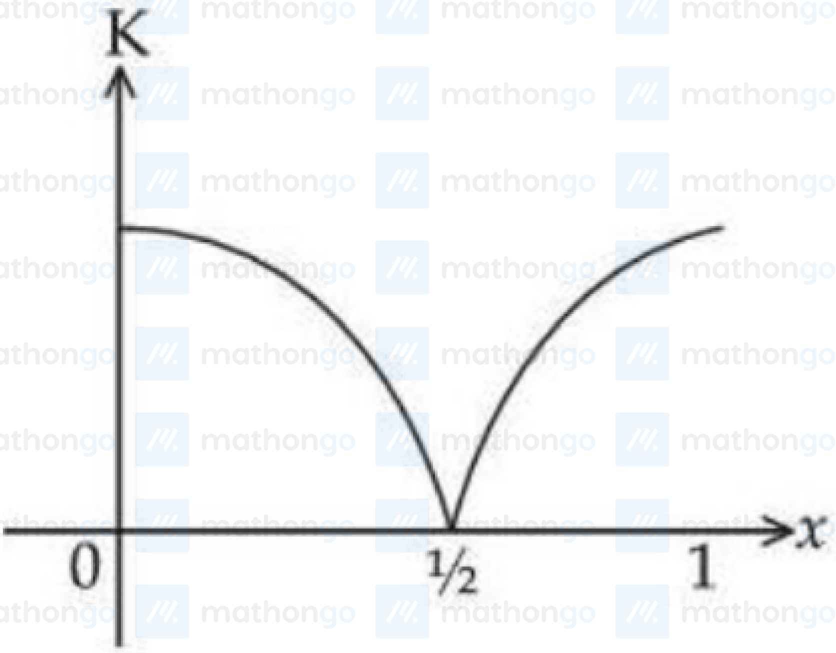
(3) (A) is false but (R) is true

(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

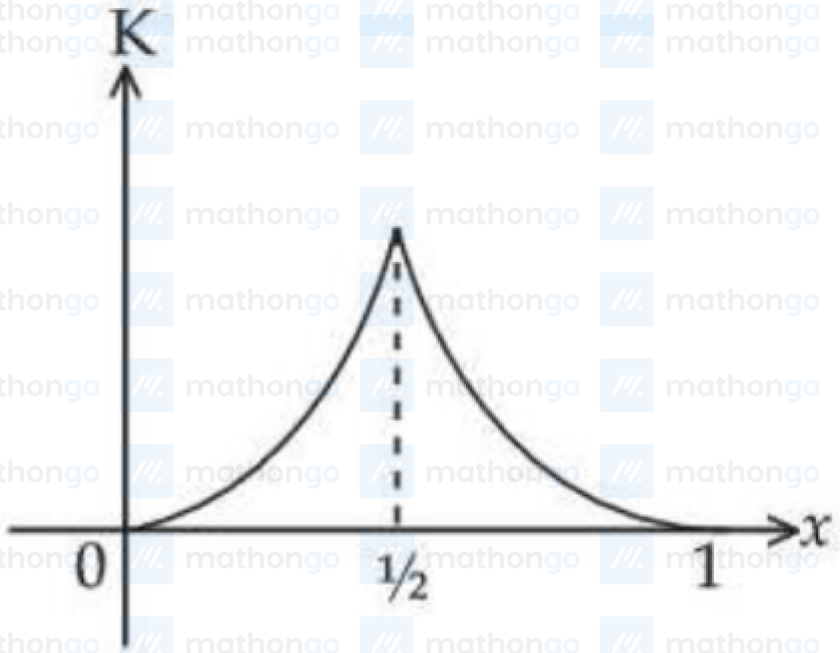
Q7. A particle oscillates along the x-axis according to the law, $x(\mathrm{t}) = x_0 \sin^2\left(\frac{\mathrm{t}}{2}\right)$ where $x_0 = 1 \mathrm{~m}$. The kinetic energy (K) of the particle as a function of x is correctly represented by the graph



(1)



(2)



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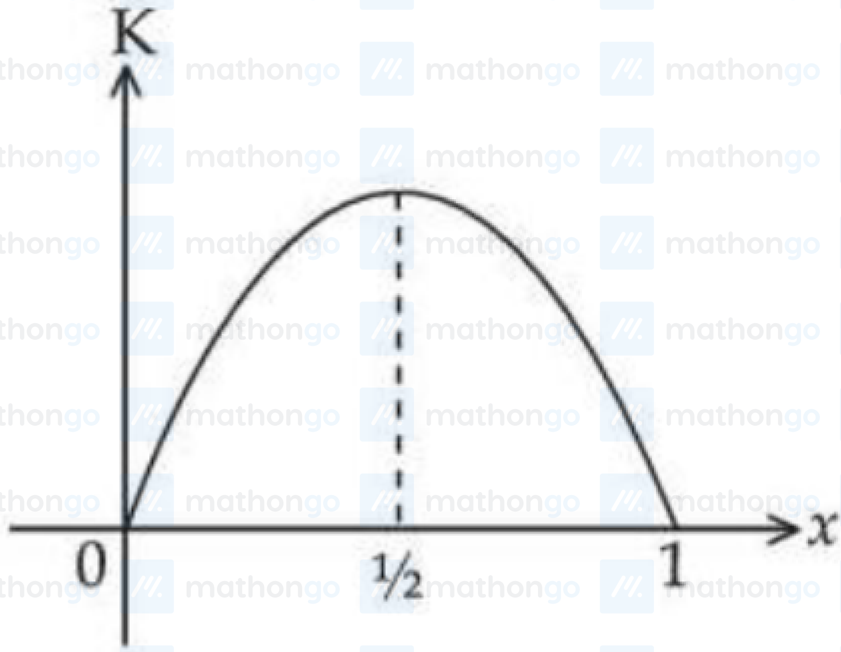


(4)

Q1. The equation of a transverse wave travelling along a string is $y(x, t) = 4.0 \sin\left[20 \times 10^{-3} x + 600t\right] \mathrm{mm}$, where x is in mm and t is in second. The velocity of the wave is :

(1) $-60 \mathrm{~m/s}$

(2) $-30 \mathrm{~m/s}$

(3) $+30 \mathrm{~m/s}$

(4) $+60 \mathrm{~m/s}$

Q2. A closed organ and an open organ tube are filled by two different gases having same bulk modulus but different densities ρ_1 and $\rho_{2'}$, respectively. The frequency of 9^{th} harmonic of closed tube is identical with 4^{th} 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 :

(1) $\frac{15}{7}$ cm

(2) $\frac{20}{7}$ cm

(3) $\frac{15}{9}$ cm

(4) $\frac{20}{9}$ cm

Q3. 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

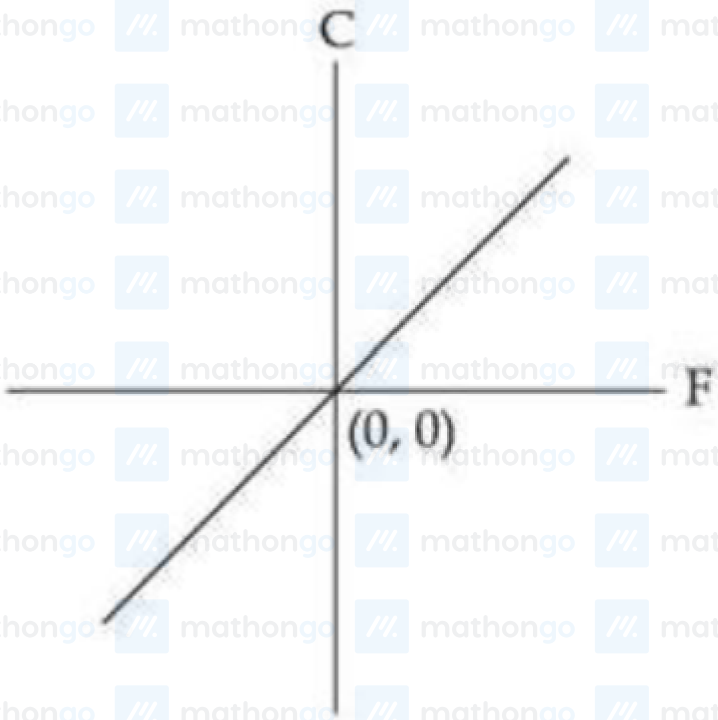
(1) Both A and R are true but R is NOT the correct explanation of A

(2) A is true but R is false

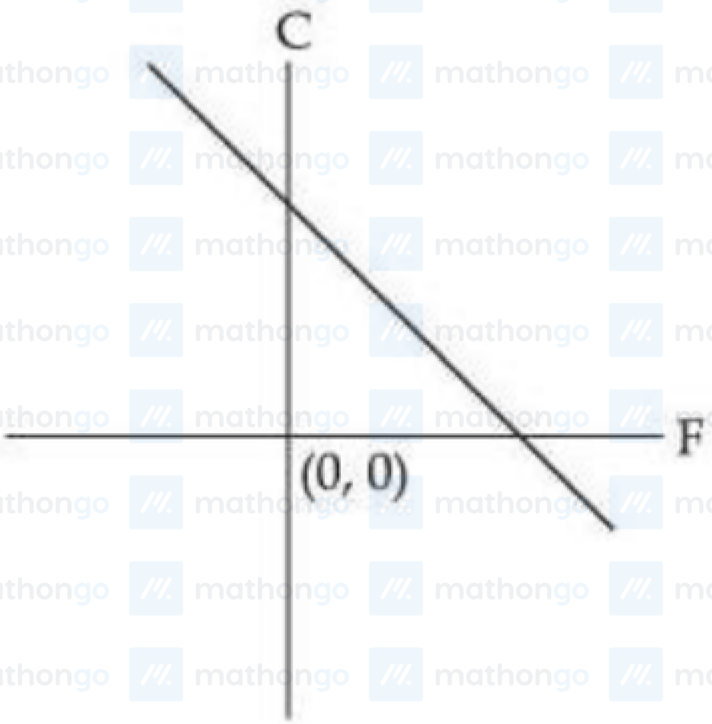
(3) A is false but R is true

(4) Both A and R are true and R is the correct explanation of A

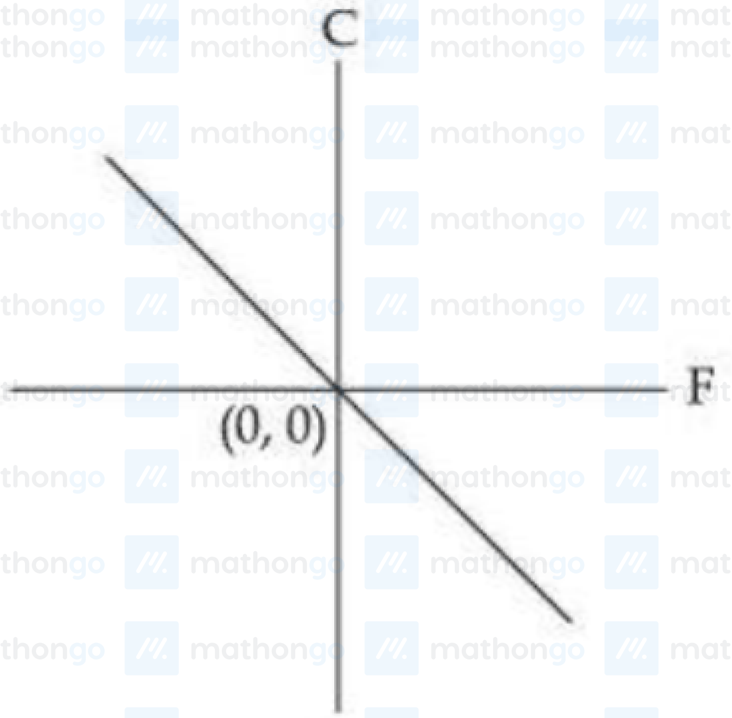
Q1. Which of the following figure represents the relation between Celsius and Fahrenheit temperatures ?



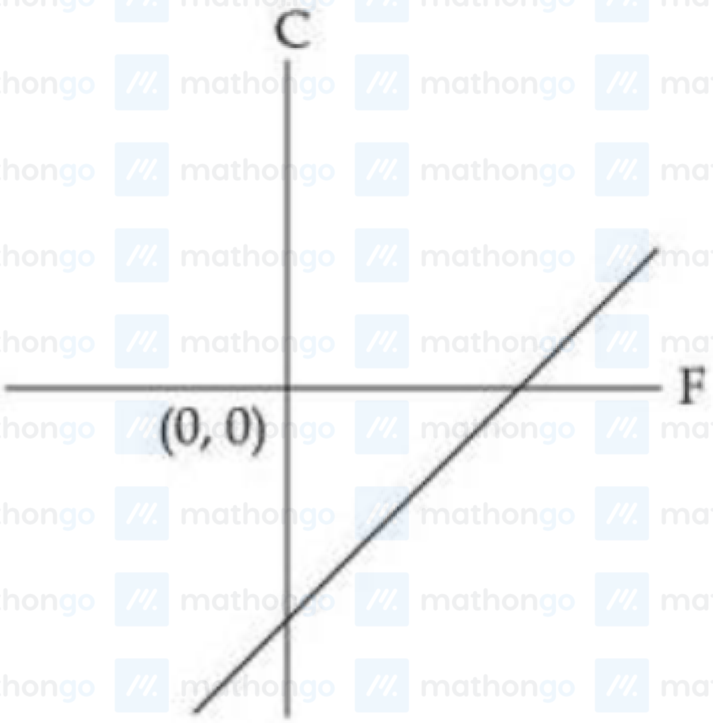
(1)



(2)



(3)



(4)

Q2. 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 $= 2100 \mathrm{Jkg}^{-1} \mathrm{~K}^{-1}$, specific heat of water $= 4180 \mathrm{Jkg}^{-1} \mathrm{~K}^{-1}$, specific heat of steam $= 1920 \mathrm{Jkg}^{-1} \mathrm{~K}^{-1}$, Latent heat of ice $= 3.35 \times 10^{5} \mathrm{Jkg}^{-1}$ and Latent heat of steam $= 2.25 \times 10^{6} \mathrm{~Jkg}^{-1}$)

(1) 3043 J

(2) 3024 J

(3) 3003 J

(4) 3022 J

Q3. 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 $= 2.5 \times 10^4 \mathrm{JKg}^{-1}$ and specific heat capacity of lead $= 125 \mathrm{JKg}^{-1}\ \mathrm{K}^{-1}$)

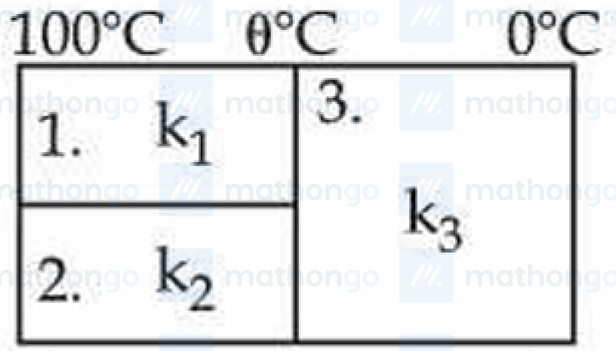
(1) 10

(2) 20

(3) 5

(4) 15

Q4. 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 1^{st} and 2^{nd} conductor are same and for 3^{rd} conductor it is double of the 1^{st} conductor. The temperatures are given in the figure. In steady state condition, the value of θ is _______ °C.

(Given : $k_1 = 60 \mathrm{Js}^{-1}\ \mathrm{m}^{-1}\ \mathrm{K}^{-1}, k_2 = 120 \mathrm{Js}^{-1}\ \mathrm{m}^{-1}\ \mathrm{K}^{-1}, k_3 = 135 \mathrm{Js}^{-1}\ \mathrm{m}^{-1}\ \mathrm{K}^{-1}$)

Q5. Two spherical bodies of same materials 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),

(1) 16 E

(2) E

(3) 64 E

(4) 256 E

Q6. A cup of coffee cools from $90^{\circ}C$ to $80^{\circ}C$ in t minutes when the room temperature is $20^{\circ}C$. The time taken by the similar cup of coffee to cool from $80^{\circ}C$ to $60^{\circ}C$ at the same room temperature is :

(1) $\frac{13}{10}t$

(2) $\frac{10}{13}t$

(3) $\frac{5}{13}t$

(4) $\frac{13}{5}t$

Q7. The temperature of a body in air falls from $40^{\circ}C$ to $24^{\circ}C$ in 4 minutes. The temperature of the air is $16^{\circ}C$. The temperature of the body in the next 4 minutes will be:

(1) $\frac{14}{3}{}^{\circ}C$

(2) $\frac{42}{3}{}^{\circ}C$

(3) $\frac{28}{3}{}^{\circ}C$

(4) $\frac{56}{3}{}^{\circ}C$

Q1. 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 :

(1) (B) and (C) Only

(2) (C) and (D) Only

(3) (D) and (A) Only

(4) (A) and (B) Only

Q2. 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:

(1) E Only

(2) A, B, C, D Only

(3) A, D, E Only

(4) A, C Only

Q3. 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 an adiabatic process.
In the light of the above statements, choose the correct answer from the options given below :

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

(2) (A) is false but (R) is true

(3) (A) is true but (R) is false

(4) Both (A) and (R) are true and (R) is the correct explanation of (A)

Q4. A container of fixed volume contains a gas at $27^{\circ}\mathrm{C}$. To double the pressure of the gas, the temperature of gas should be raised to ______ $^{\circ}\mathrm{C}$.

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

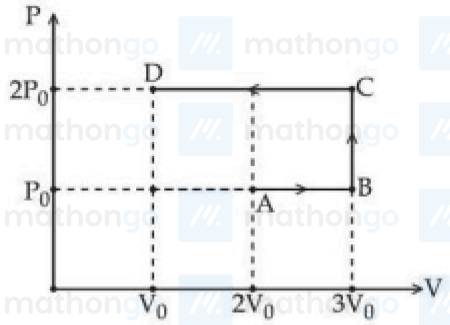
(1) $\gamma_2 = \gamma_1$

(2) $2\gamma_2 = \gamma_1$

(3) $\gamma_2 < \gamma_1$

(4) $\gamma_2 > \gamma_1$

Q6.



Using the given $\mathrm{P}-\mathrm{V}$ diagram, the work done by an ideal gas along the path ABCD is :

(1) $3P_0 V_0$

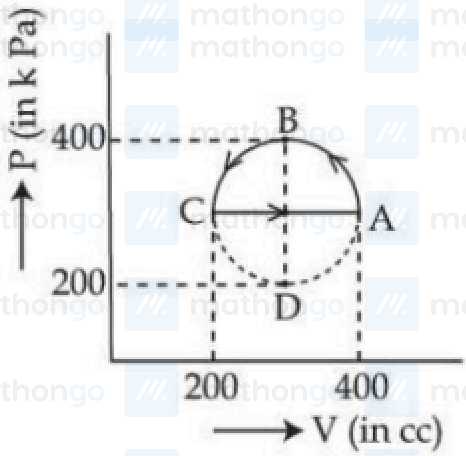
(2) $-4P_0 V_0$

(3) $-3P_0 V_0$

(4) $4P_0 V_0$

Q7. The temperature of 1 mole of an ideal monoatomic gas is increased by $50^{\circ}\mathrm{C}$ 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. The magnitude of heat exchanged by a system for the given cyclic process ABCA (as shown in figure) is (in SI unit) :



(1) 5π

(2) 40π

(3) 10π

(4) zero

Q9. An ideal gas initially at $0^\circ C$ 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 thermodynamics process is ________ K.

Q10. Match the LIST-I with LIST-II

	LIST-I		LIST-II
A.	Pressure varies inversely with volume of an ideal gas.	I.	Adiabatic process
B.	Heat absorbed goes partly to increase internal energy and partly to do work.	II.	Isochoric process
C.	Heat is neither absorbed nor released by a system.	III.	Isothermal process
D.	No work is done on or by a gas.	IV.	Isobaric process

Choose the correct answer from the options given below:

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

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

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

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

Q11. The workdone in an adiabatic change in an ideal gas depends upon only :

(1) change in its temperature

(2) change in its volume

(3) change in its pressure

(4) change in its specific heat

Q12. 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 the 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, $\mathrm{PV}=$ constant, while in adiabatic process $\mathrm{PV}^{\gamma}=$ 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 :

(1) Both (A) and (R) are true and (R) is the correct explanation of (A)

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

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

Q13. 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 $1 \mathrm{Jkg}^{-1} \mathrm{~K}^{-1}$, is :

(1) $\mathrm{m} \ln \left(\frac{\mathrm{T}_2}{\mathrm{~T}_1}\right)$

(2) zero

(3) $\mathrm{m} \ln \left(\frac{\mathrm{T}_1}{\mathrm{~T}_2}\right)$

(4) $\mathrm{m}\left(\mathrm{T}_2-\mathrm{T}_1\right)$

Q14. A Carnot engine (E) is working between two temperatures 473 K and 273 K. In a new system two engines - engine E_1 works between 473 K to 373 K and engine E_2 works between 373 K to 273 K.
If η_{12}, η_1 and η_2 are the efficiencies of the engines E, E_1 and E_2, respectively, then

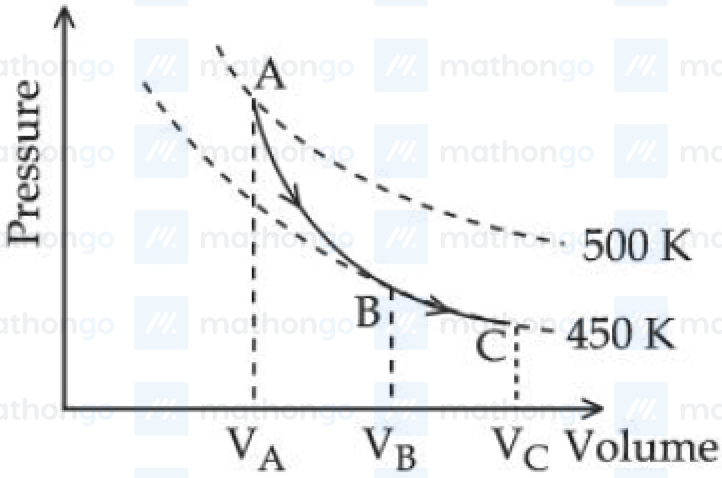
(1) $\eta_{12}=\eta_1 \eta_2$

(2) $\eta_{12} \geq \eta_1 + \eta_2$

(3) $\eta_{12} = \eta_1 + \eta_2$

(4) $\eta_{12} < \eta_1 + \eta_2$

Q15.



A poly-atomic molecule ($C_V = 3R, C_P = 4R$, where R is gas constant) goes from phase space point A $\left(P_A = 10^5 \text{ Pa}, V_A = 4 \times 10^{-6} \text{ m}^3\right)$ to point B $\left(P_B = 5 \times 10^4 \text{ Pa}, V_B = 6 \times 10^{-6} \text{ m}^3\right)$ to point C $\left(P_C = 10^4 \text{ Pa}, V_C = 8 \times 10^{-6} \text{ m}^3\right)$. 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 :

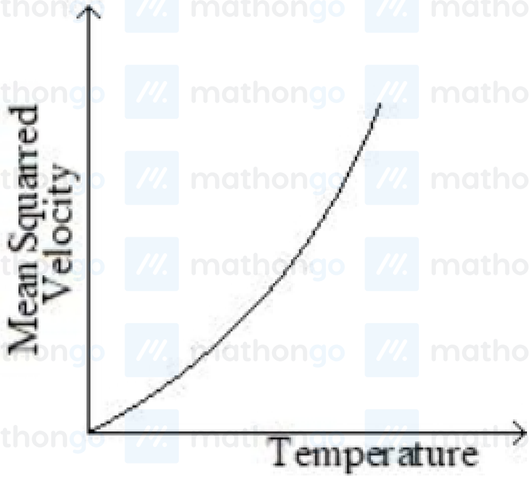
(1) $500R(\ln 3 + \ln 4)$

(2) $450R(\ln 4 - \ln 3)$

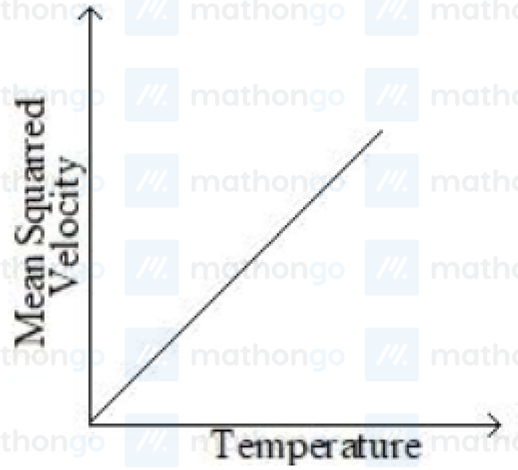
(3) $500R \ln 2$

(4) $400R \ln 4$

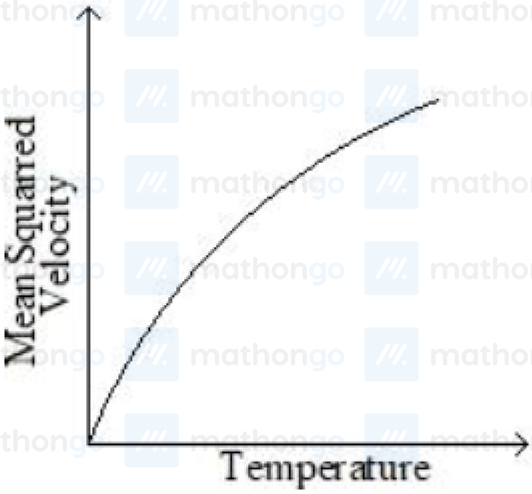
Q1. For a particular ideal gas which of the following graphs represents the variation of mean squared velocity of the gas molecules with temperature?



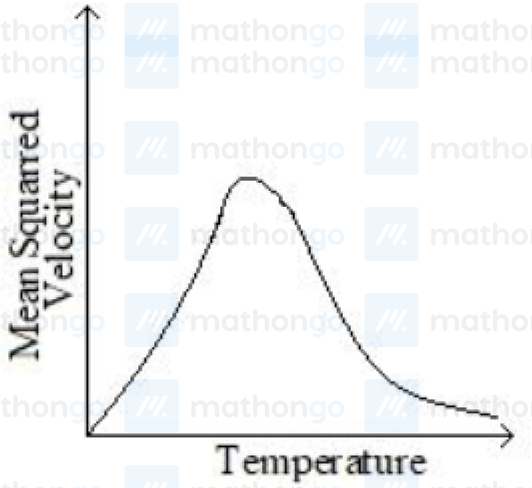
(1)



(2)



(3)



(4)

Q2. 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:

(1) $\frac{25}{4}$

(2) $\frac{2}{5}$

(3) $\frac{5}{2}$

(4) $\frac{4}{25}$

Q3. The kinetic energy of translation of the molecules in 50 g of CO_2 gas at $17^{\circ}C$ is

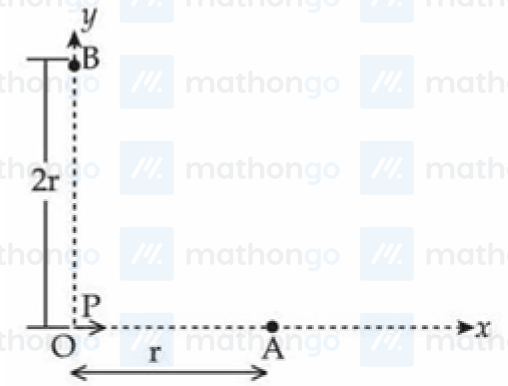
(1) 4205.5 J

(2) 4102.8 J

(3) 3582.7 J

(4) 3986.3 J

Q1. 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



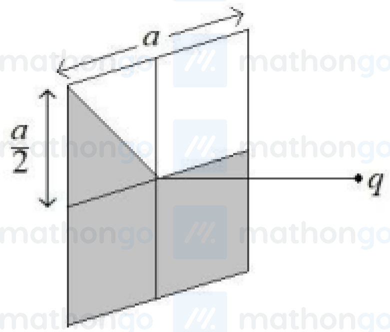
(1) V_0 and $\frac{E_0}{4}$

(2) zero and $\frac{E_0}{16}$

(3) zero and $\frac{E_0}{8}$

(4) $\frac{V_0}{2}$ and $\frac{E_0}{16}$

Q2. A square loop of sides $a = 1$ m is held normally in front of a point charge $q = 1C$. The flux of the electric field through the shaded region is $\frac{5}{p} \times \frac{1}{\varepsilon_0} \frac{Nm^2}{C}$, where the value of p is _____.



Q3. A point charge causes an electric flux of $-2 \times 10^4 Nm^2C^{-1}$ to pass through a spherical Gaussian surface of 8.0 cm radius, centred on the charge. The value of the point charge is :
(Given $\epsilon_0 = 8.85 \times 10^{-12} C^2\ N^{-1}\ m^{-2}$)

(1) $15.7 \times 10^{-8}C$

(2) $17.7 \times 10^{-8}C$

(3) $-15.7 \times 10^{-8}C$

(4) $-17.7 \times 10^{-8}C$

Q4. 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 $P \times 10^{45}$, where the value of $10P$ is ________
(Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \mathrm{Nm}^2\mathrm{C}^{-1}$ and universal gravitational constant as $6.67 \times 10^{-11} \mathrm{Nm}^2 \mathrm{~kg}^{-2}$)
Assume that charge may not be an integral multiple of electrons.

Q5. 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)

(1) 3 cm

(2) 2 cm

(3) 4 cm

(4) 1 cm

Q6. 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 $9.1 \mathrm{~V/cm}$, then the vertical component of velocity of electron is (mass of electron $= 9.1 \times 10^{-31}$ kg and charge of electron $= 1.6 \times 10^{-19}$C)

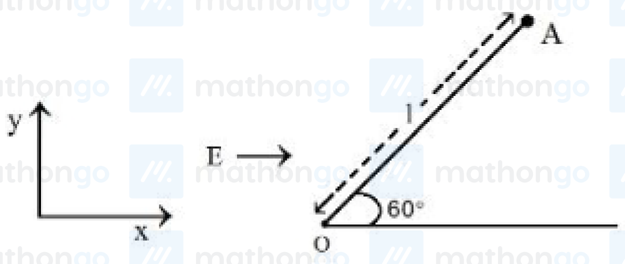
(1) 0

(2) $1 \times 10^6 \mathrm{~m/s}$

(3) $16 \times 10^6 \mathrm{~m/s}$

(4) $16 \times 10^4 \mathrm{~m/s}$

Q7. 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



(1) $\sqrt{\frac{\mathrm{qE}l}{2 \mathrm{~m}}}$

(2) $\sqrt{\frac{\mathrm{qE}l}{\mathrm{m}}}$

(3) $\sqrt{\frac{\mathrm{qE}l}{4\mathrm{~m}}}$

(4) $\sqrt{\frac{2q\mathrm{El}}{\mathrm{m}}}$

Q8. Match List - I with List - II.

List - I		List - II
(A)	Electric field inside (distance $r>0$ from center) of a uniformly charged spherical shell with surface charge density σ, and radius R.	(I) σ/ϵ_0
(B)	Electric field at distance $r>0$ from a uniformly charged infinite plane sheet with surface charge density σ.	(II) $\sigma/2\epsilon_0$
(C)	Electric field outside (distance $r>0$ from center) of a uniformly charged spherical shell with surface charge density σ, and radius R.	(III) 0
(D)	Electric field between 2 oppositely charged infinite plane parallel sheets with uniform surface charge density σ.	(IV) $\frac{\sigma R^2}{\epsilon_0 r^2}$

Choose the correct answer from the options given below :

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

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

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

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

Q9. Two charges $7\mu c$ and $-4\mu c$ are placed at $(-7\text{ cm}, 0, 0)$ and $(7\text{ cm}, 0, 0)$ respectively. Given, $\epsilon_0 = 8.85\times10^{-12}\mathrm{C}^2\mathrm{~N}^{-1}\mathrm{~m}^{-2}$, the electrostatic potential energy of the charge configuration is :

(1) -1.8 J

(2) -2.0 J

(3) -1.5 J

(4) -1.2 J

Q10. Two point charges $-4\mu c$ and $4\mu c$, 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 :

(1) 18.4 mJ

(2) 14.4 mJ

(3) 12.4 mJ

(4) 16.4 mJ

Q11. An electric dipole of dipole moment 6×10^{-6}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.

Q12. An electric dipole of mass m, charge q, and length l is placed in a uniform electric field $\overrightarrow{E} = E_0 \hat{i}$. When the dipole is rotated slightly from its equilibrium position and released, the time period of its oscillations will be:

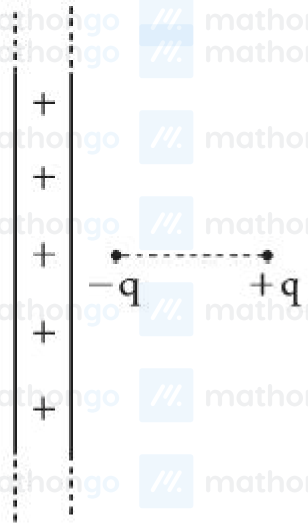
(1) $\frac{1}{2\pi} \sqrt{\frac{ml}{2qE_0}}$

(2) $2\pi \sqrt{\frac{ml}{qE_0}}$

(3) $\frac{1}{2\pi} \sqrt{\frac{2 ml}{qE_0}}$

(4) $2\pi \sqrt{\frac{ml}{2qE_0}}$

Q13. An electric dipole is placed at a distance of 2 cm from an infinite plane sheet having positive charge density σ_o. Choose the correct option from the following.



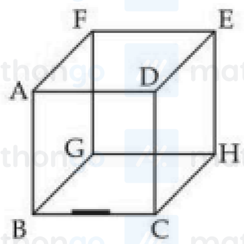
(1) Potential energy and torque both are maximum.

(2) Torque on dipole is zero and net force is directed away from the sheet.

(3) Torque on dipole is zero and net force acts towards the sheet.

(4) Potential energy of dipole is minimum and torque is zero.

Q14. 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 λ 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)



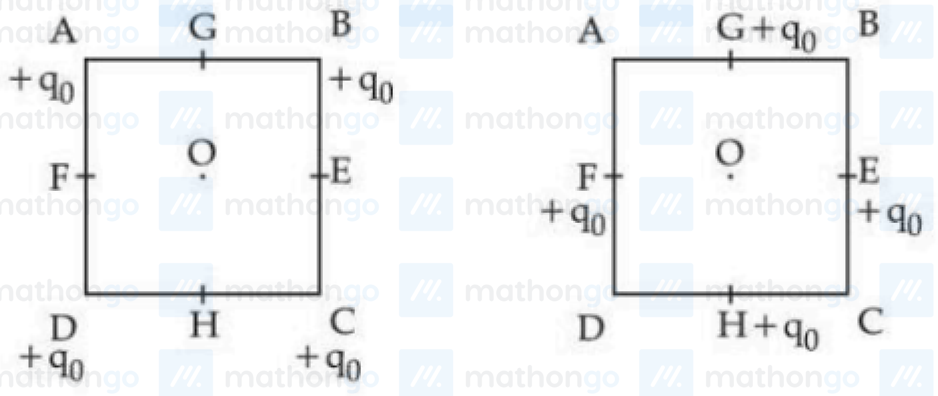
(1) $\frac{\lambda a}{2\epsilon_0}$

(2) $\frac{\lambda a}{4\epsilon_0}$

(3) $\frac{\lambda a}{16\epsilon_0}$

(4) $\frac{\lambda a}{8\epsilon_0}$

Q15.



Configuration (1) Configuration (2)

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 $K = \frac{1}{4\pi\varepsilon_0}$, the difference between the potential energies of configuration (2) and (1) is given by :

(1) $\frac{Kq_0^2}{a}(4\sqrt{2} - 2)$

(2) $\frac{Kq_0^2}{a}(3 - \sqrt{2})$

(3) $\frac{Kq_0^2}{a}(4 - 2\sqrt{2})$

(4) $\frac{Kq_0^2}{a}(3\sqrt{2} - 2)$

Q16. 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?

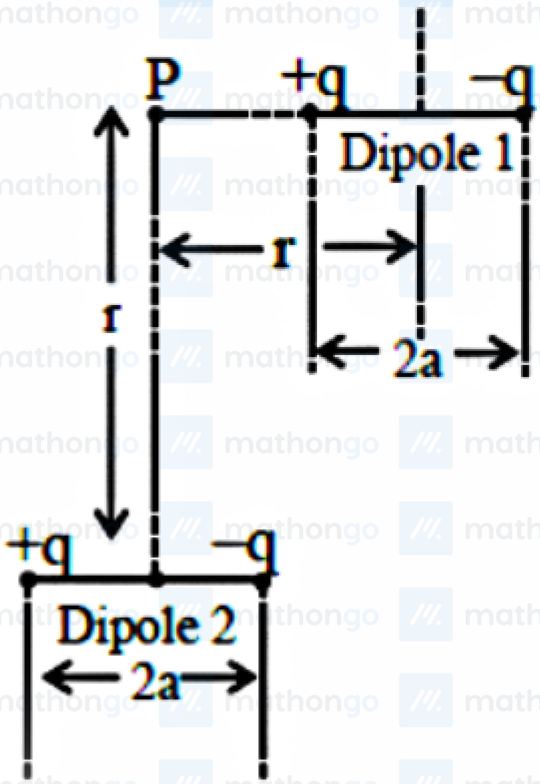
(1) $xyz =$ constant

(2) $xy + yz + zx =$ constant

(3) $(x^2 + y^2)(y^2 + z^2)(z^2 + x^2) =$ constant

(4) $(x + y)(y + z)(z + x) =$ constant

Q17. 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?



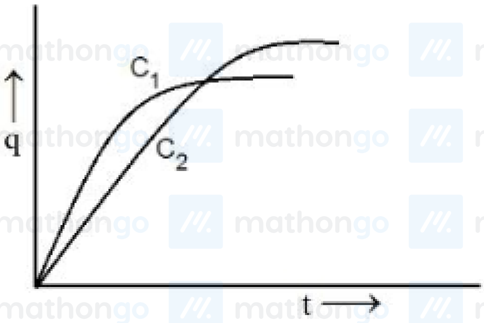
(1) $\frac{a}{r} \sim 10$

(2) $\frac{a}{r} \sim 20$

(3) $\frac{a}{r} \sim 0.5$

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

Q1. 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?



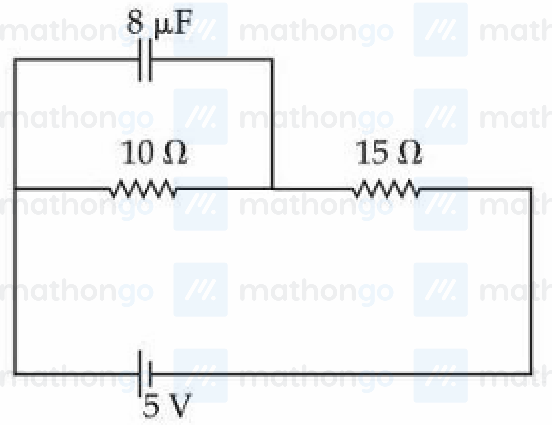
(1) $C_2 > C_1, U_2 < U_1$

(2) $C_1 > C_2, U_1 > U_2$

(3) $C_1 > C_2, U_1 < U_2$

(4) $C_2 > C_1, U_2 > U_1$

Q2. At steady state the charge on the capacitor, as shown in the circuit below, is ________ μC.



Q3. A parallel-plate capacitor of capacitance 40μ 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

(1) 4 mC and 0.2 J

(2) 8 mC and 2.0 J

(3) 2 mC and 0.4 J

(4) 2 mC and 0.2 J

Q4. 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

(1) $\varepsilon_0 \mathrm{E}^2 \mathrm{Ad}$

(2) $\frac{1}{2} \varepsilon_0 \mathrm{E}^2 \mathrm{Ad}$

(3) $\frac{1}{4} \varepsilon_0 \mathrm{E}^2 \mathrm{Ad}$

(4) $\frac{3}{4} \varepsilon_0 \mathrm{E}^2 \mathrm{Ad}$

Q5. A parallel plate capacitor of capacitance 1μ F is charged to a potential difference of 20 V. The distance between plates is 1μ m. The energy density between plates of capacitor is.

(1) $2 \times 10^{-4} \mathrm{~J} / \mathrm{m}^3$

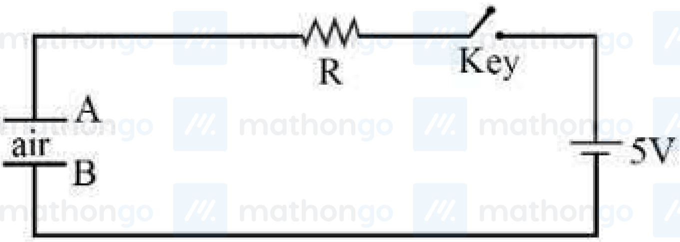
(2) $1.8 \times 10^5 \mathrm{~J} / \mathrm{m}^3$

(3) $1.8 \times 10^3 \mathrm{~J} / \mathrm{m}^3$

(4) $2 \times 10^2 \mathrm{~J} / \mathrm{m}^3$

Q6. 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 $7 \times 10^8 \mathrm{~V} / \mathrm{s}$ then the integer value of the distance between the parallel plates is $\left(\text{ Take, } \epsilon_0 = 9 \times 10^{-12} \frac{\mathrm{F}}{\mathrm{m}}, \pi = \frac{22}{7}\right)$ ________ μm.

Q7. 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:

(1) A, C Only

(2) A, B, D Only

(3) C, D Only

(4) B, C, D Only

Q8. A parallel plate capacitor was made with two rectangular plates, each with a length of $l = 3$ cm and breath of $\mathrm{b} = 1$ cm. The distance between the plates is 3μ m. Out of the following, which are the ways to increase the capacitance by a factor of 10 ?

A. $l = 30 \text{ cm}, \text{ b} = 1 \text{ cm}, \text{ d} = 1\mu \text{ m}$
B. $l = 3 \text{ cm}, \text{ b} = 1 \text{ cm}, \text{ d} = 30\mu \text{ m}$
C. $l = 6 \text{ cm}, \text{ b} = 5 \text{ cm}, \text{ d} = 3\mu \text{ m}$
D. $l = 1 \text{ cm}, \text{ b} = 1 \text{ cm}, \text{ d} = 10\mu \text{ m}$
E. $l = 5 \text{ cm}, \text{ b} = 2 \text{ cm}, \text{ d} = 1\mu \text{ m}$
Choose the correct answer from the options given below:

(1) A only

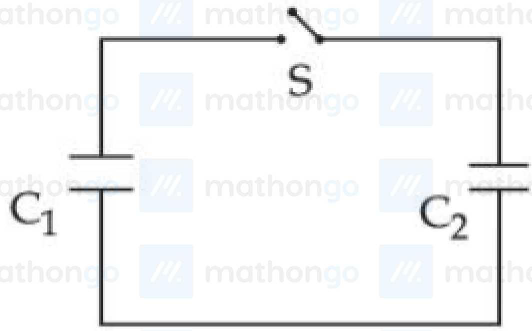
(2) C only

(3) B and D only

(4) C and E only

Q9. A time varying potential difference is applied between the plates of a parallel plate capacitor of capacitance 2.5μ 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}.

Q10. A capacitor, $C_1 = 6\mu$ F is charged to a potential difference of $\text{V}_0 = 5$ V using a 5 V battery. The battery is removed and another capacitor, $\text{C}_2 = 12\mu$ 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.



(1) $q_1 = 10\mu\text{C}, \text{q}_2 = 20\mu\text{C}$

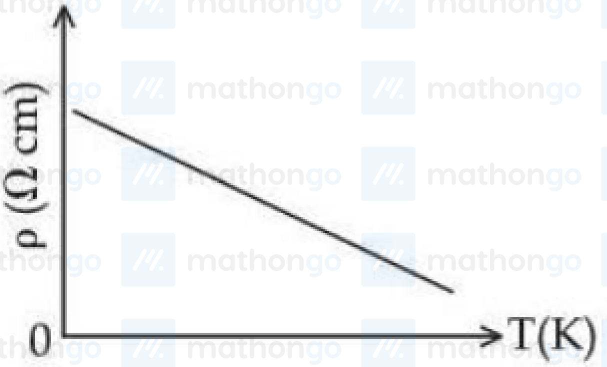
(2) $\text{q}_1 = 30\mu\text{C}, \text{q}_2 = 15\mu\text{C}$

(3) $\text{q}_1 = 20\mu\text{C}, \text{q}_2 = 10\mu\text{C}$

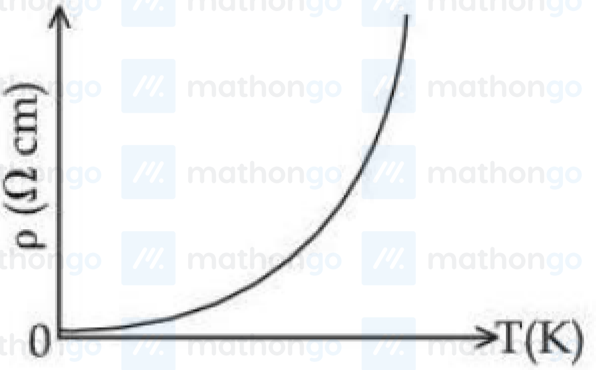
(4) $\text{q}_1 = 15\mu\text{C}, \text{q}_2 = 30\mu\text{C}$

Q1. Which of the following resistivity (ρ) v/s temperature (T) curves is most suitable to be used in wire bound standard resistors?

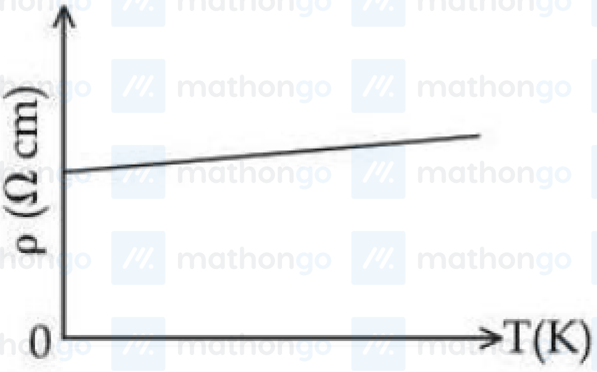
(1)



(2)



(3)



(4)

Q2. The difference of temperature in a material can convert heat energy into electrical energy. To harvest the heat energy, the material should have

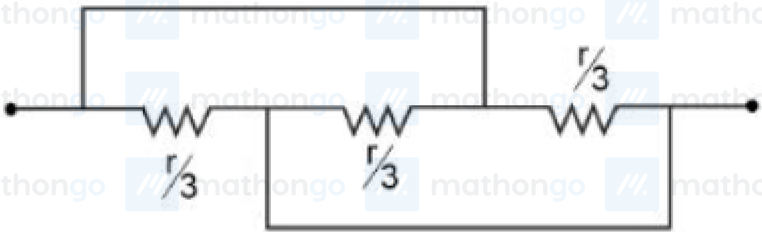
(1) high thermal conductivity and high electrical conductivity

(2) low thermal conductivity and low electrical conductivity

(3) high thermal conductivity and low electrical conductivity

(4) low thermal conductivity and high electrical conductivity

Q3. Find the equivalent resistance between two ends of the following circuit



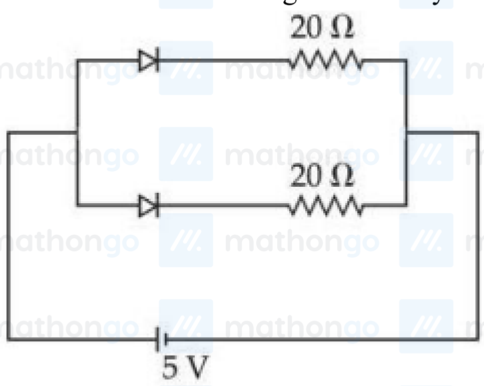
(1) $\frac{r}{9}$

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

(3) r

(4) $\frac{r}{6}$

Q4. What is the current through the battery in the circuit shown below



(1) 1.5 A

(2) 0.5 A

(3) 0.25 A

(4) 1.0 A

Q5. A wire of resistance 9Ω is bent to form an equilateral triangle. Then the equivalent resistance across any two vertices will be ______ ohm.

Q6. A wire of resistance R is bent into an 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
Options

(1) 8/9

(2) $27/32$

(3) $32/27$

(4) $9/8$

Q7. 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.

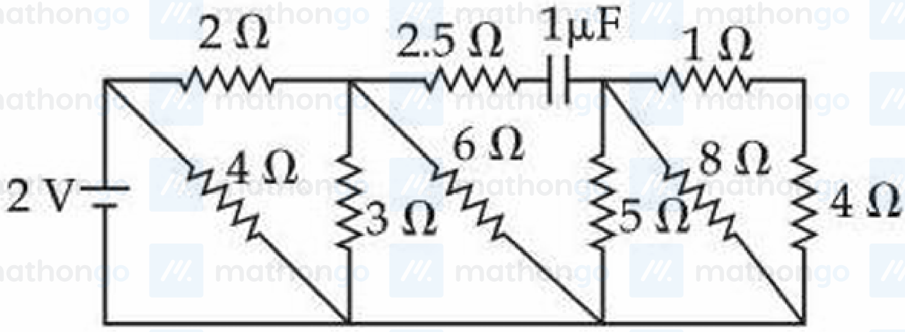
(1) Both Statement-I and Statement-II are false

(2) Statement-I is false but Statement-II is true

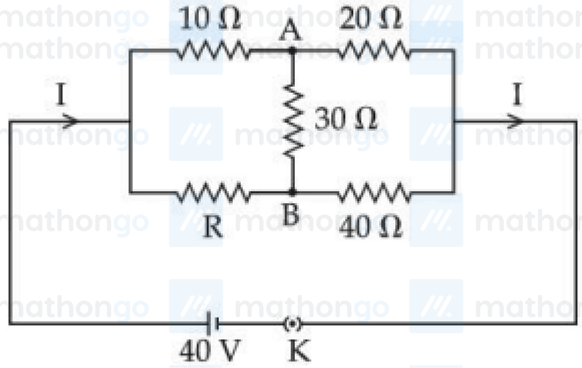
(3) Both Statement-I and Statement-II are true

(4) Statement-I is true but Statement-II is false

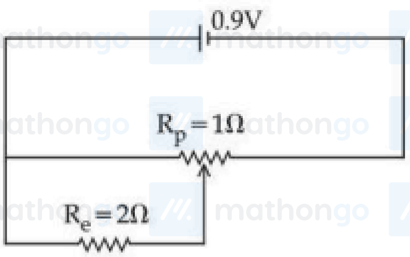
Q8. The net current flowing in the given circuit is_______ A.



Q9. 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.



Q10.



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 :

(1) 0.9 A

(2) 1.35 A

(3) 0.3 A

(4) 1.0 A

Q11. A galvanometer having a coil of resistance 30Ω 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 to the galvanometer should be $\frac{30}{X}\Omega$, where X is

Options

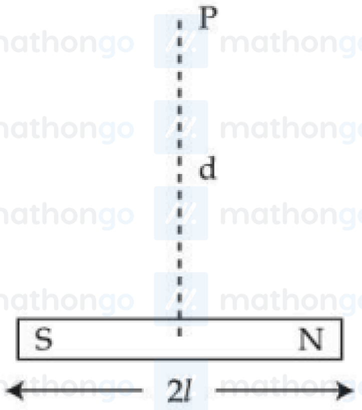
(1) 596

(2) 149

(3) 298

(4) 447

Q1.



A bar magnet has total length $2l = 20$ units and the field point P is at a distance $\mathrm{d} = 10$ 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 :

(1) 4%

(2) 15%

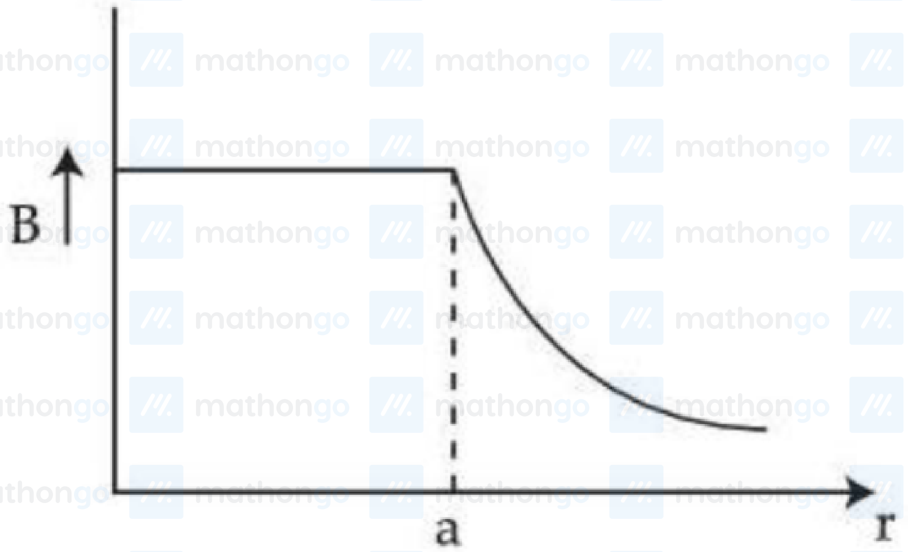
(3) 5%

(4) 10%

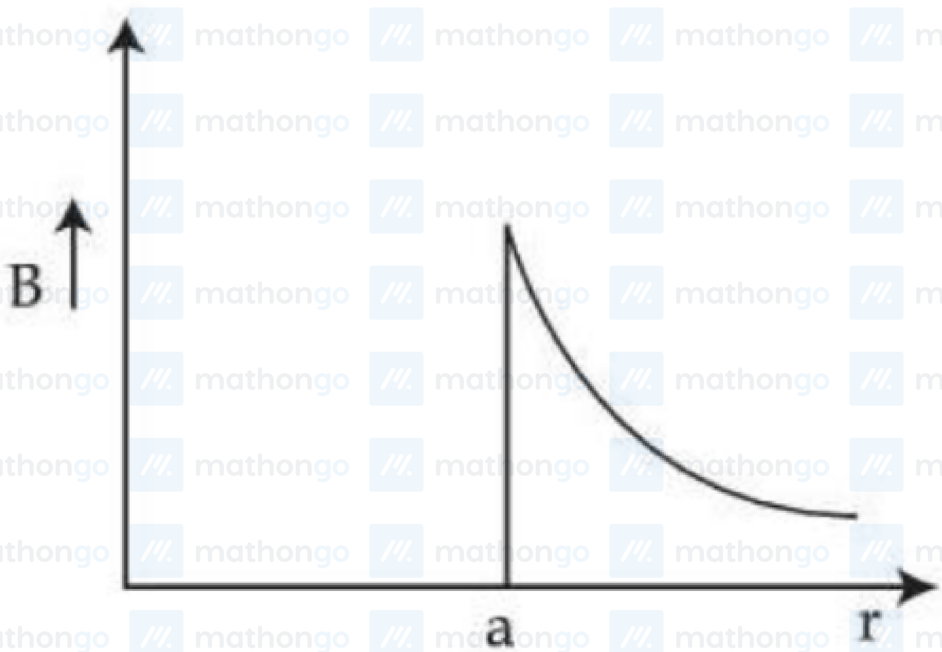
Q1. The magnetic field inside a 200 turns solenoid of radius 10 cm is 2.9×10^{-4}Tesla. If the solenoid carries a current of 0.29 A, then the length of the solenoid is ________ π cm.

Q2. A current of 5A 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 _____.
$\left[\text{ Take } \mu_0 = 4\pi \times 10^{-7}\text{TmA}^{-1}\right]$.

Q3. 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



(1)



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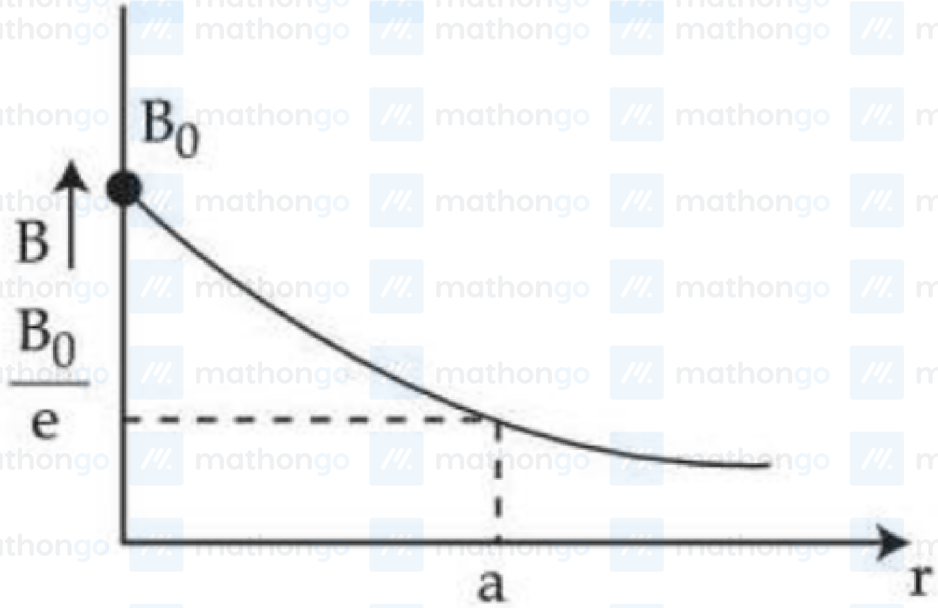

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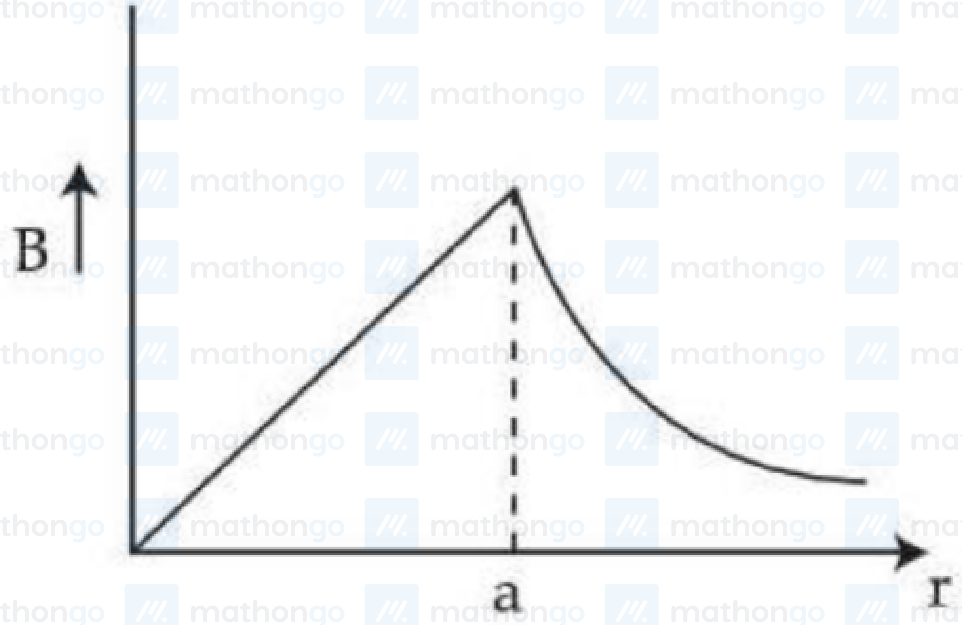
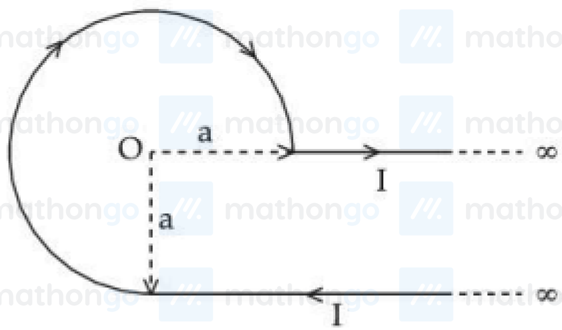


(4)

Q4.



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 :

(1) $\frac{\mu_0}{4\pi}\frac{I}{a}\left[\frac{\pi}{2}+1\right]$

(2) $\frac{\mu_0}{4\pi}\frac{\mathrm{I}}{\mathrm{a}}\left[\frac{3\pi}{2}+2\right]$

(3) $\frac{\mu_0}{2\pi}\frac{\mathrm{I}}{\mathrm{a}}\left[\frac{\pi}{2}+2\right]$

(4) $\frac{\mu_0}{4\pi}\frac{\mathrm{I}}{\mathrm{a}}\left[\frac{3\pi}{2}+1\right]$

Q5. 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

(1) $[a/4, 3a/2]$

(2) $[a/4, 2a]$

(3) $[\mathrm{a}/2, 2\mathrm{a}]$

(4) $[a/2, 3a]$

Q6. 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 :

(1) $\sqrt{\frac{\mathrm{h}}{\pi \mathrm{eB}}}$

(2) $\sqrt{\frac{2h}{\pi eB}}$

(3) $\sqrt{\frac{h}{2\pi eB}}$

(4) $\sqrt{\frac{4\,\mathrm{h}}{\pi eB}}$

Q7. A proton is moving undeflected in a region of crossed electric and magnetic fields at a constant speed of $2\times10^5\ \mathrm{ms}^{-1}$. When the electric field is switched off, the proton moves along a circular path of radius 2 cm. The magnitude of electric field is $x\times10^4\ \mathrm{N/C}$. The value of x is _______ Take the mass of the proton $=1.6\times10^{-27}$ kg.

Q8. Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : A 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 :

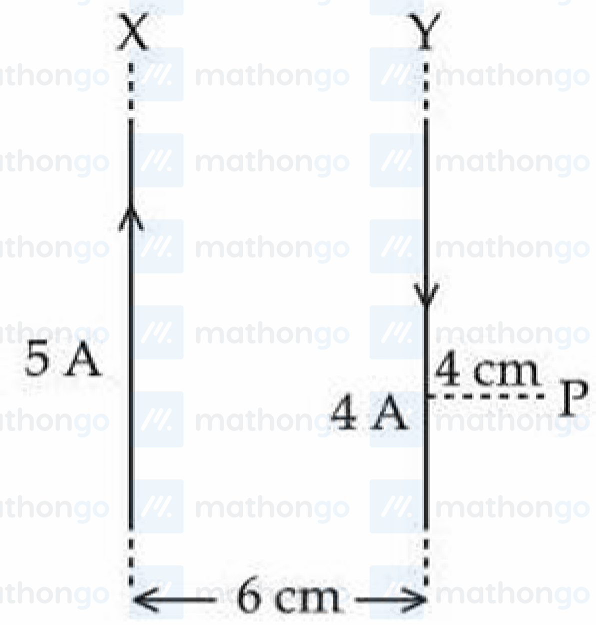
(1) (A) is true but (R) is false

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

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

(4) (A) is false but (R) is true

Q9. Two long parallel wires X and Y, separated by a distance of 6 cm , carry currents of 5A and 4A, 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.



Q10. Consider a moving coil galvanomenter (MCG):

A. The torsional constant in moving coil galvanometer has dimentions $\left[ML^2 T^{-2}\right]$

B. Increasing the current sensitivity may not necessarily increase the voltage sensitivity.

C. If we increase number of turns (N) to its double (2 N), 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:

(1) A, D Only

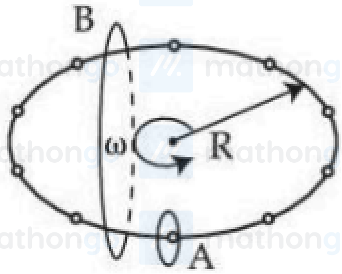
(2) A, B, E Only

(3) B, D, E Only

(4) A, B Only

Q11. 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,
$\mu_0 = 4\pi \times 10^{-7} \frac{N}{A^2}$, $1 \text{ ns} = 10^{-9}$ s]

Q12.



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

(1) $\frac{2\pi}{N} q\omega$

(2) $\frac{N^2}{2\pi} q\omega$

(3) $\frac{N}{\pi} q\omega$

(4) $\frac{N}{2\pi} q\omega$

Q13. 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]

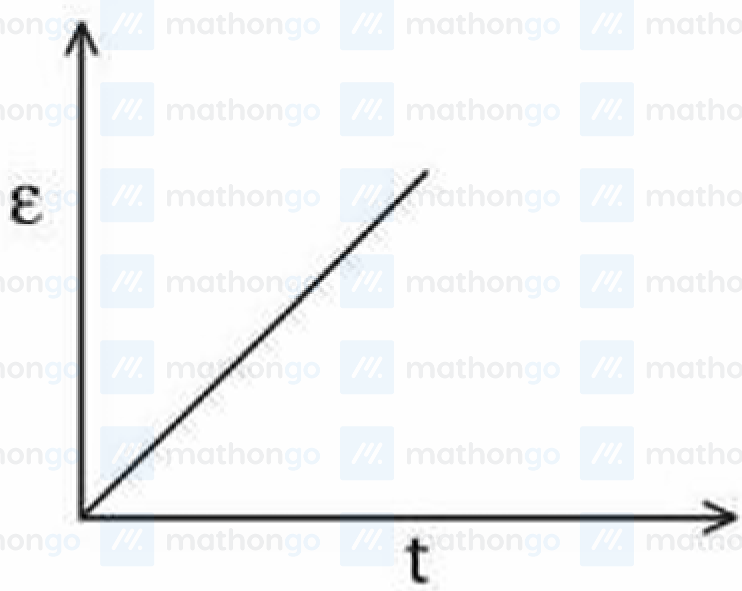
(1) $ae^{-\frac{4\pi m v_0}{q\mu_0 I}}$

(2) $a\left[1 - \frac{mv_0}{2q\mu_0 I}\right]$

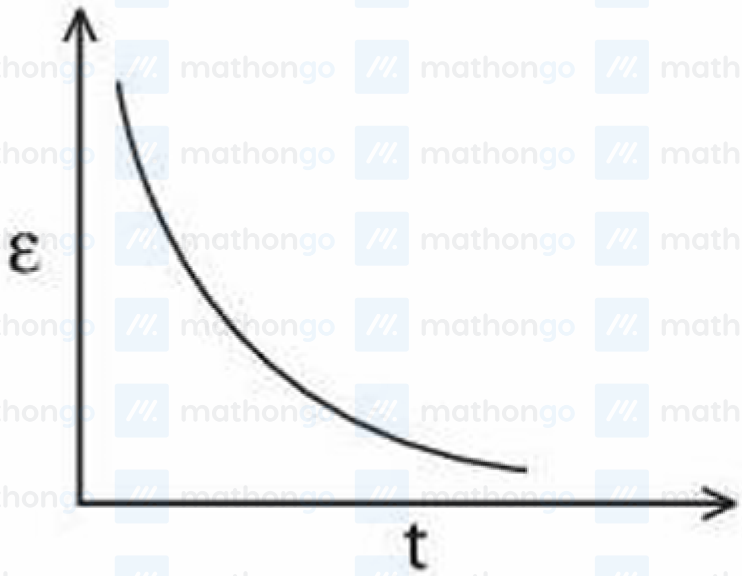
(3) $a\left[1 - \frac{mv}{q\mu_0 I}\right]$

(4) $\frac{a}{2}$

Q1. 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 magnate field, the plot of magnitude of induced emf (ε) with time (t) is given by



(1)



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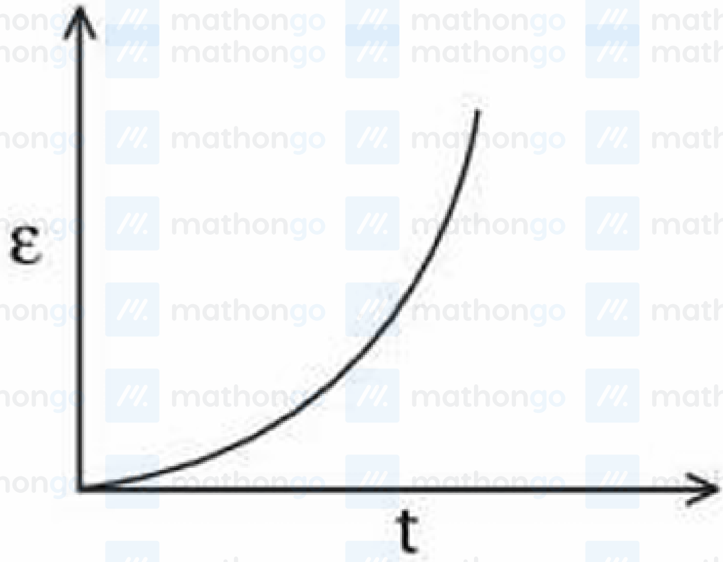
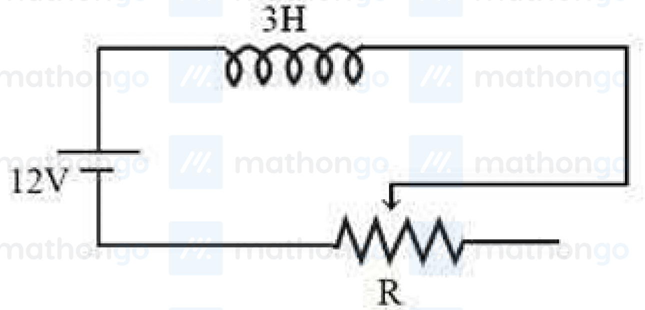


(3)

(4)

Q2.



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 12Ω, the value of the current in the circuit will be ______ A.

Q3. 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 $10\pi \mathrm{rads}^{-1}$ 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 ? ($\pi = 3.14$)

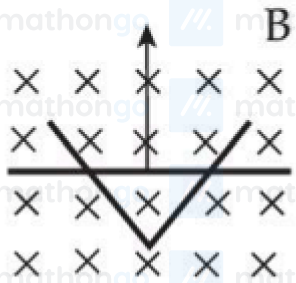
(1) 0.5024 V

(2) V

(3) 0.2512 V

(4) 0.1256 V

Q4.



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 _.

Q5. 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 :

(1) $\varphi = \mathrm{AB}, \varepsilon = 0$

(2) $\varphi = 0, \varepsilon = 0$

(3) $\varphi = 0, \varepsilon = \mathrm{NAB}\omega$

(4) $\varphi = \mathrm{AB}, \varepsilon = \mathrm{NAB}\omega$

Q6. 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:

(1) A, B, C, E only

(2) B, C, D, E only

(3) A, C, D, E only

(4) A, B, C, D only

Q7. Consider I_1 and I_2 are the currents flowing simultaneously in two nearby coils 1 & 2, respectively. If $\mathrm{L}_1 =$ self inductance of coil $1, \mathrm{M}_{12} =$ mutual inductance of coil 1 with respect to coil 2, then the value of induced emf in coil 1 will be

Options

(1) $\varepsilon_1 = -L_1 \frac{\mathrm{dI}_2}{dt} - \mathrm{M}_{12} \frac{\mathrm{dI}_1}{dt}$

(2) $\varepsilon_1 = -L_1 \frac{\mathrm{dI}_1}{dt} - \mathrm{M}_{12} \frac{\mathrm{dI}_2}{dt}$

(3) $\varepsilon_1 = -L_1 \frac{\mathrm{dI}_1}{dt} - \mathrm{M}_{12} \frac{\mathrm{dI}_1}{dt}$

(4) $\varepsilon_1 = -L_1 \frac{\mathrm{dI}_1}{dt} + \mathrm{M}_{12} \frac{\mathrm{dI}_2}{\mathrm{dt}}$

Q1. 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

(1) $2\mathrm{I}_0$

(2) I_0

(3) $\frac{\mathrm{I}_0}{2}$

(4) $\frac{\mathrm{I}_0}{\sqrt{2}}$

Q2. 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 _____ $\times 10^4$ radians s^{-1}.

Q3. An alternating current is given by $\mathrm{I}=\mathrm{I}_{\mathrm{A}} \sin \omega \mathrm{t}+\mathrm{I}_{\mathrm{B}} \cos \omega \mathrm{t}$. The r.m.s current will be

(1) $\frac{\left|\mathrm{I}_{\mathrm{A}}+\mathrm{I}_{\mathrm{B}}\right|}{\sqrt{2}}$

(2) $\sqrt{\frac{\mathrm{I}_{\mathrm{A}}^2+\mathrm{I}_{\mathrm{B}}^2}{2}}$

(3) $\sqrt{\mathrm{I}_{\mathrm{A}}^2+\mathrm{I}_{\mathrm{B}}^2}$

(4) $\frac{\sqrt{\mathrm{I}_{\mathrm{A}}^2+\mathrm{I}_{\mathrm{B}}^2}}{2}$

Q4. 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 :

(1) (A) is true but (R) is false

(2) Both (A) and (R) are true and (R) is the correct explanation of (A)

(3) (A) is false but (R) is true

(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Q1. 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:

(1) μf

(2) f

(3) $\frac{f}{(\mu-1)}$

(4) $\frac{f}{\mu}$

Q2. 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.]

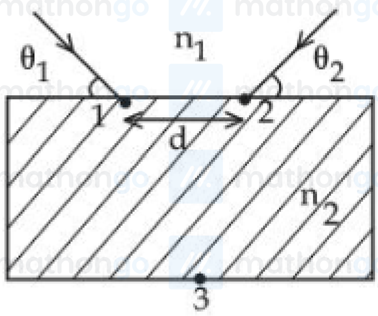
(1) 137.5 nm

(2) 275 nm

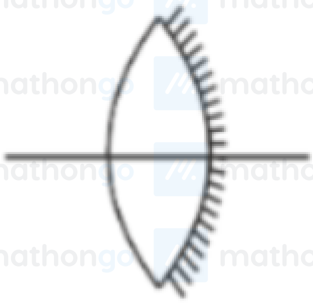
(3) 94.8 nm

(4) 68.7 nm

Q3. 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, $\mathrm{d} = 4\sqrt{3}$ cm and $\theta_1 = \theta_2 = \cos^{-1}\left(\frac{\mathrm{n}_2}{2\mathrm{n}_1}\right)$, where refractive index of the block $\mathrm{n}_2 >$ refractive index of the outside medium n_1, then the thickness of the block is ________ cm.



Q4. 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 ?



(1) R/μ

(2) $R/(2\mu-3)$

(3) μR

(4) $\mathrm{R}/(2\mu-1)$

Q5. 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 $\mathrm{PO}=\mathrm{PI}$. The distance PO equals to

(1) 5 R

(2) 3 R

(3) 1.5 R

(4) 2 R

Q6. What is the relative decrease in focal length of a lens for an increase in optical power by 0.1 D from 2.5D ? ['D' stands for dioptre]

(1) 0.01

(2) 0.04

(3) 0.40

(4) 0.1

Q7. 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 :

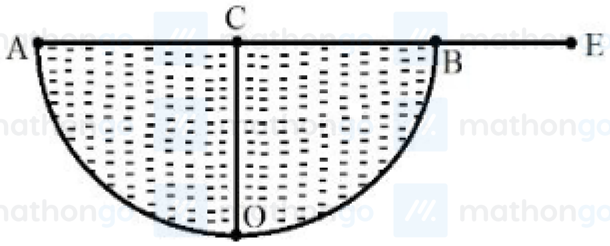
(1) 1.8 cm

(2) 0.9 cm

(3) 2.8 cm

(4) 2.5 cm

Q8. 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



(1) $\sqrt{3}$

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

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

(4) $\sqrt{2}$

Q9. 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 :

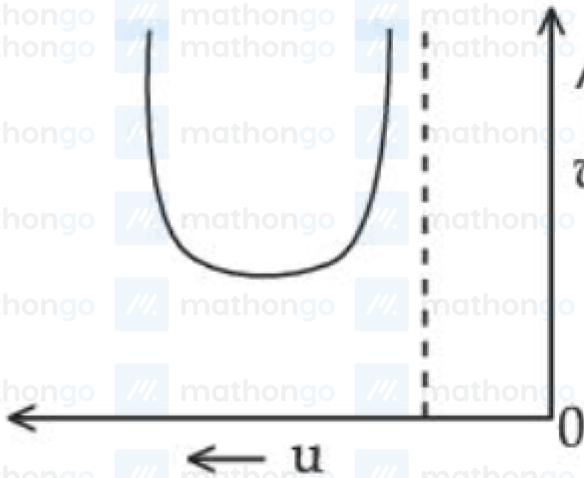
(1) 30 cm

(2) 3.75 cm

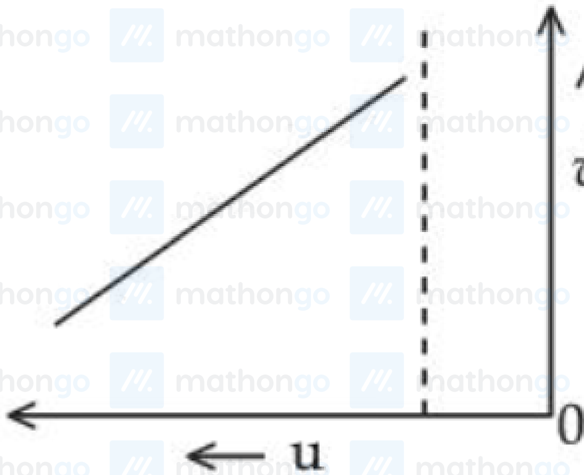
(3) 15 cm

(4) 7.5 cm

Q10. 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 $|\mathrm{u}| > f$, is



(1)



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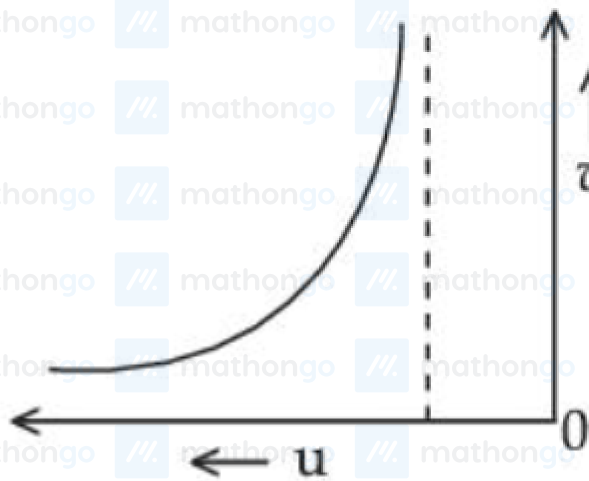

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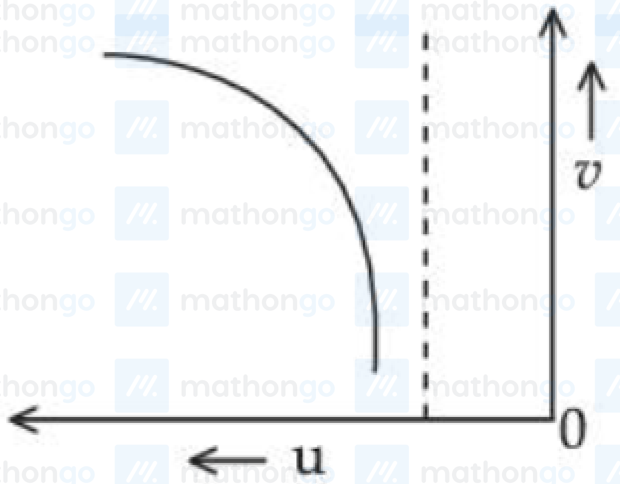
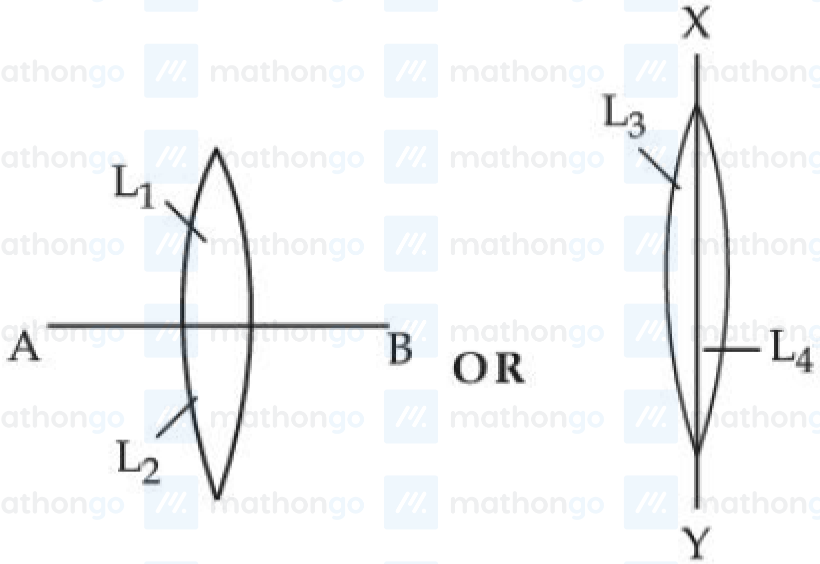


(4)

Q11. 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



(1) 1:1

(2) 1:2

(3) 1:4

(4) 2:1

Q12. 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

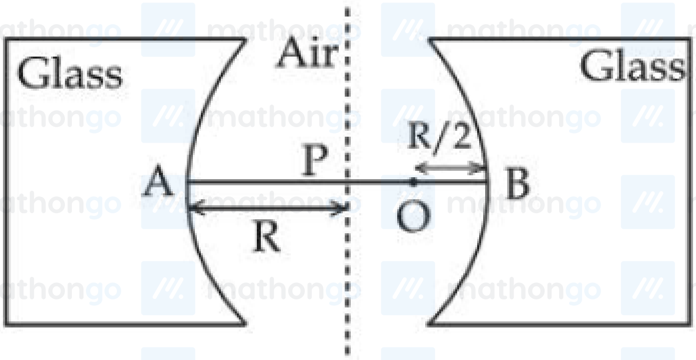
(1) 24 cm

(2) 96 cm

(3) 48 cm

(4) 72 cm

Q13.



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 :

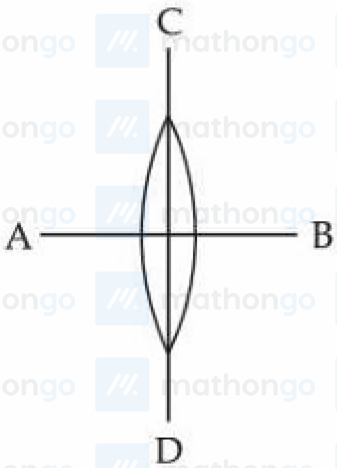
(1) 0.214 R

(2) 0.411 R

(3) 0.124 R

(4) 0.114 R

Q14. 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 4 D then the power of a part of the divided lens is



(1) D

(2) 8D

(3) 2D

(4) 4D

Q15. 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

(1) 0.20 m

(2) 0.25 m

(3) 0.15 m

(4) 0.10 m

Q16. 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

(1) 1 : 2

(2) 1 : 3

(3) 3 : 5

(4) 2 : 3

Q17. 5 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?

(1) 60°

(2) 58°

(3) 48°

(4) 50°

Q18. 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

(1) 3

(2) 16/3

(3) 4

(4) 1.5

Q19. 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 100 a is _______ m/s^2.

Q20. 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?

(1) $\frac{h \tan(i-r)}{\tan r}$

(2) $\frac{h \sin(i-r)}{\cos r}$

(3) h

(4) $\frac{h \cos(i-r)}{\sin r}$

Q21. 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

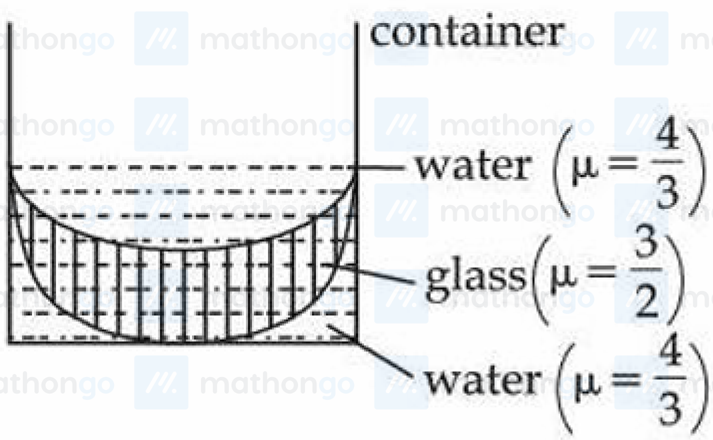
(1) $\sin^{-1}\left(\frac{1}{6}\right)$

(2) $\sin^{-1}\left(\frac{1}{3}\right)$

(3) $\sin^{-1}\left(\frac{-5}{6}\right)$

(4) $\sin^{-1}\left(\frac{2}{3}\right)$

Q22. 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 is



(1) $\frac{1}{6}\left(\frac{1}{|\mathrm{R}_1|}-\frac{1}{|\mathrm{R}_2|}\right)$

(2) $-\frac{1}{6}\left(\frac{1}{|\mathrm{R}_1|}+\frac{1}{|\mathrm{R}_2|}\right)$

(3) $\frac{1}{6}\left(\frac{1}{|R_1|}+\frac{1}{|R_2|}\right)$

(4) $-\frac{1}{6}\left(\frac{1}{|\mathrm{R}_1|}-\frac{1}{|\mathrm{R}_2|}\right)$

Q23. Given a thin convex lens (refractive index μ_2), kept in a liquid (refractive index $\mu_1, \mu_1 < \mu_2$) 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?

(1) $\frac{\mu_1|\mathrm{R}_1|\cdot|\mathrm{R}_2|}{\mu_2(|\mathrm{R}_1|+|\mathrm{R}_2|)-\mu_1|\mathrm{R}_2|}$

(2) $\frac{\mu_1|\mathrm{R}_1|\cdot|\mathrm{R}_2|}{\mu_2(|\mathrm{R}_1|+|\mathrm{R}_2|)-\mu_1|\mathrm{R}_1|}$

(3) $\frac{(\mu_2+\mu_1)|\mathrm{R}_1|}{(\mu_2-\mu_1)}$

(4) $\frac{\mu_1|\mathrm{R}_1|\cdot|\mathrm{R}_2|}{\mu_2(2|\mathrm{R}_1|+|\mathrm{R}_2|)-\mu_1\sqrt{|\mathrm{R}_1|\cdot|\mathrm{R}_2|}}$

Q24. 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 :

(1) $\frac{1}{3}$ cm

(2) $\frac{4}{3}$ cm

(3) 1 cm

(4) $\frac{2}{3}$ cm

Q1. 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 :

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

(2) (A) is true but (R) is false

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

(4) (A) is false but (R) is true

Q2. Which of the following phenomena can not be explained by wave theory of light?

(1) Compton effect

(2) Refraction of light

(3) Reflection of light

(4) Diffraction of light

Q3. 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 ...... $\times 10^{14}$.

Q4. 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 :

(1) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(2) Both (A) and (R) are true and (R) is the correct explanation of (A)

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

Q5. The width of one of the two slits in Young's double slit experiment is d while that of the other slit is x d. 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.)

(1) 4

(2) 5

(3) 3

(4) 2

Q6. 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

(1) 5

(2) 4

(3) 6

(4) 8

Q7. Young's double slit inteference 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 :

(1) 0.23 mm

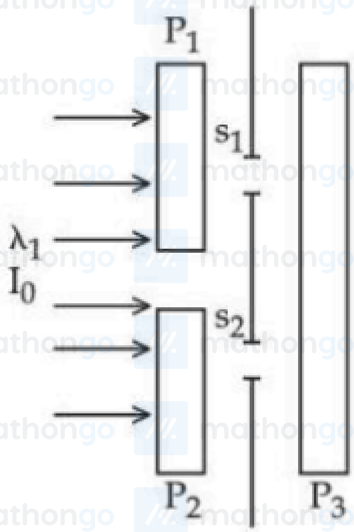
(2) 0.33 mm

(3) 0.63 mm

(4) 0.46 mm

Q8. A double slit interference experiment performed with a light of wavelength 600 nm forms an interference fringe pattern on a screen with 10 th bright fringe having its centre at a distance of 10 mm from the central maximum. Distance of the centre of the same 10th bright fringe from the central maximum when the source of light is replaced by another source of wavelength 660 nm would be _________ mm.

Q9. 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



(1) $\frac{I_0}{2}$

(2) $\frac{I_0}{4}$

(3) $\frac{I_0}{3}$

(4) I_0

Q1. 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 _________ $\left(\mathrm{h}=6.63 \times 10^{-34} \mathrm{~J.s}\right)$

(1) Visible radiation

(2) Gamma rays

(3) Infra-red radiation

(4) X-rays

Q2. 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

(1) $\mathrm{E}^{2}=\mathrm{pc}^{2}+\mathrm{m}^{2} \mathrm{c}^{2}$

(2) $\mathrm{E}^{2}=\mathrm{p}^{2} \mathrm{c}^{2}+\mathrm{m}^{2} \mathrm{c}^{2}$

(3) $\mathrm{E}^{2}=\mathrm{pc}^{2}+\mathrm{m}^{2} \mathrm{c}^{4}$

(4) $\mathrm{E}^{2}=\mathrm{p}^{2} \mathrm{c}^{2}+\mathrm{m}^{2} \mathrm{c}^{4}$

Q3. 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 $\mathrm{hc}=1242 \mathrm{eVnm}$ where h is the Planck's constant and c is the speed of light in vacuum.)

(1) 300 nm

(2) 400 nm

(3) 600 nm

(4) 200 nm

Q4. 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 :

(1) (A) is false but (R) is true

(2) (A) is true but (R) is false

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Q5. 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 excited state to that in the ground state is

(1) 3

(2) 16

(3) 9

(4) 4

Q6. An electron of mass ' m ' with an initial velocity $\overrightarrow{\mathrm{v}} = \mathrm{v}_0 \hat{i}$ $(\mathrm{v}_0 > 0)$ enters an electric field $\overrightarrow{\mathrm{E}} = -\mathrm{E}_{\mathrm{o}} \hat{\mathrm{k}}$. If the initial de Broglie wavelength is λ_0, the value after time t would be

(1) $\frac{\lambda_0}{\sqrt{1+\frac{\mathrm{e}^2 \mathrm{E_0}^2 \mathrm{t}^2}{\mathrm{m}^2 \mathrm{v_0}^2}}}$

(2) $\lambda_{\mathrm{o}} \sqrt{1+\frac{\mathrm{e}^2 \mathrm{E}_0^2 \mathrm{t}^2}{\mathrm{m}^2 \mathrm{v}_{\mathrm{o}}^2}}$

(3) $\frac{\lambda_0}{\sqrt{1-\frac{\mathrm{e}^2 \mathrm{E_o}^2 \mathrm{t}^2}{\mathrm{m}^2 \mathrm{v}_{\mathrm{o}}^2}}}$

(4) λ_0

Q7. 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.

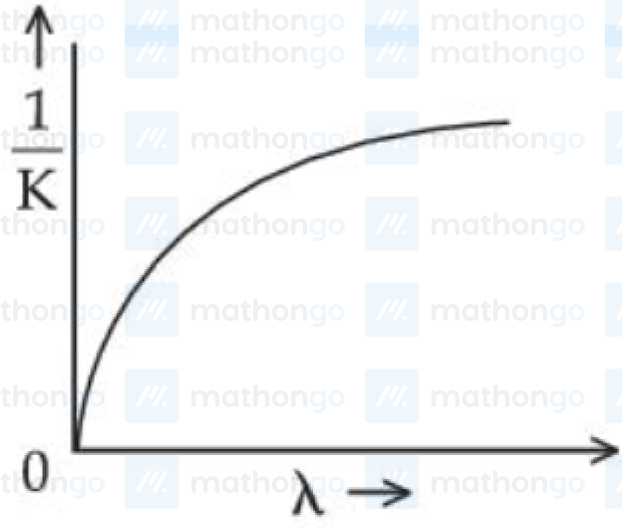
(1) $\frac{1}{\mathrm{c}} \sqrt{\frac{\mathrm{E}}{\mathrm{m}_{\mathrm{p}}}}$

(2) $\frac{1}{\mathrm{c}} \sqrt{\frac{2\mathrm{E}}{\mathrm{m}_{\mathrm{p}}}}$

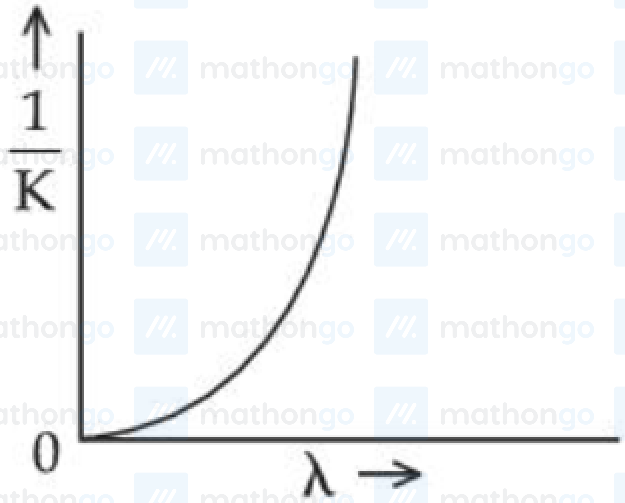
(3) $\frac{1}{2c} \sqrt{\frac{E}{m_p}}$

(4) $\frac{1}{\mathrm{c}} \sqrt{\frac{\mathrm{E}}{2\, \mathrm{m}_{\mathrm{p}}}}$

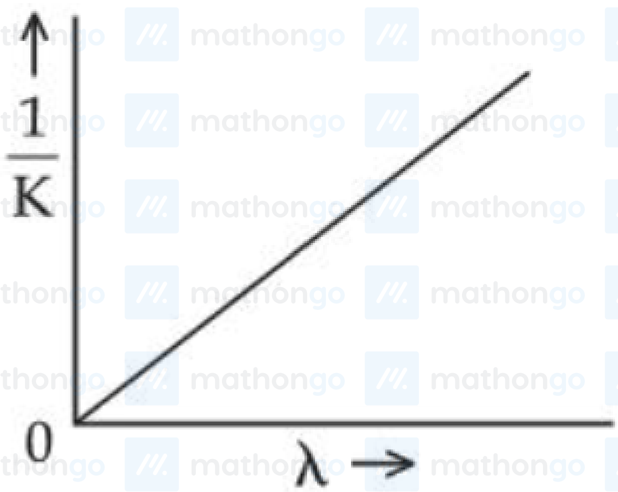
Q8. If λ and K are de Broglie wavelength and kinetic energy, respectively, of a particle with constant mass. The correct graphical representation for the particle will be



(1)



(2)



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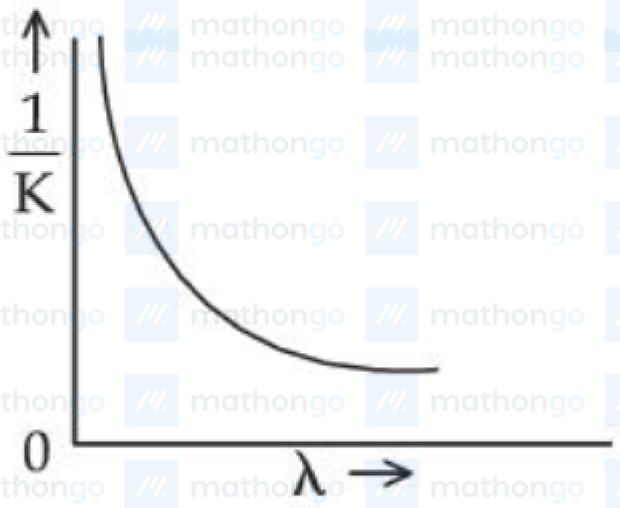


(4)

Q9. 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

(1) Both Cs and Li

(2) Neither Cs nor Li

(3) Cs only

(4) Li only

Q10. 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)

(1) 3 eV

(2) 2 eV

(3) 6 eV

(4) 5 eV

Q11. 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) $\mathrm{V}_0 \mathrm{v/s} \nu$ is linear.
(B) The slope of $\mathrm{V}_0 \mathrm{v/s} \nu$ curve $= \frac{\phi_0}{\mathrm{h}}$
(C) h constant is related to the slope of $\mathrm{V}_0 \mathrm{v/s} \nu$ line.
(D) The value of electric charge of electron is not required to determine h using the $V_0 \mathrm{v/s} \nu$ curve.
(E) The work function can be estimated without knowing the value of h.
Choose the correct answer from the options given below :

(1) (C) and (D) only

(2) (A), (C) and (E) only

(3) (A), (B) and (C) only

(4) (D) and (E) only

Q12. In an experiment with photoelectric effect, the stopping potential,

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

(2) decreases with increase in the intensity of the incident light

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

(4) is $\left(\frac{1}{e}\right)$ times the maximum kinetic energy of the emitted photoelectrons

Q1. The frequency of revolution of the electron in Bohr's orbit varies with n, the principal quantum number as

(1) $\frac{1}{n^4}$

(2) $\frac{1}{n^2}$

(3) $\frac{1}{\mathrm{n}}$

(4) $\frac{1}{n^3}$

Q2. 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 :

(1) $\lambda_4 < \lambda_3 < \lambda_2 < \lambda_1$

(2) $\lambda_3 < \lambda_4 < \lambda_2 < \lambda_1$

(3) $\lambda_4 < \lambda_3 < \lambda_1 < \lambda_2$

(4) $\lambda_4 < \lambda_2 < \lambda_3 < \lambda_1$

Q3. The number of spectral lines emitted by atomic hydrogen that is in the 4^{th} energy level, is

(1) 3

(2) 1

(3) 6

(4) 0

Q4. During the transition of electron from state A to state C of a Bohr atom, the wavelength of emitted radiation is 2000Å and it becomes 6000Å 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

(1) 4000Å

(2) 2000Å

(3) 3000Å

(4) 6000Å

Q1. Choose the correct nuclear process from the below options
[p: proton, n : neutron, e^{-}: electron, e^{+}: positron, v : neutrino, $\bar{v}$: antineutrino]

(1) $\mathrm{n} \rightarrow \mathrm{p}+\mathrm{e}^{+}+\bar{v}$

(2) $\mathrm{n} \rightarrow \mathrm{p}+\mathrm{e}^{+}+\boldsymbol{v}$

(3) $\mathrm{n} \rightarrow \mathrm{p}+\mathrm{e}^{-}+\boldsymbol{v}$

(4) $\mathrm{n} \rightarrow \mathrm{p}+\mathrm{e}^{-}+\bar{v}$

Q2. 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 :

(1) (A) is true but (R) is false

(2) (A) is false but (R) is true

(3) Both (A) and (R) are true and (R) is the correct explanation of (A)

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

Q3. 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 ?

(1) $1/8$

(2) 8

(3) 4

(4) $1/4$

Q1. 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 $\mathrm{E}_y = 9.3\mathrm{Vm}^{-1}$. Then, the magnetic field vector of the wave at that point is

(1) $\mathrm{B}_z = 6.2 \times 10^{-8}$ T

(2) $\mathrm{B}_z = 3.1 \times 10^{-8}$ T

(3) $\mathrm{B}_z = 1.55 \times 10^{-8}$ T

(4) $\mathrm{B}_z = 9.3 \times 10^{-8}$ T

Q2. 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 :

(1) Both (A) and (R) are true and (R) is the correct explanation of (A)

(2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(3) (A) is false but (R) is true

(4) (A) is true but (R) is false

Q3. 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

(1) $\mathrm{E}_x,\ \mathrm{B}_y$

(2) $\mathrm{E}_y,\ \mathrm{B}_z$

(3) $\mathrm{E}_z,\ \mathrm{B}_y$

(4) $\mathrm{E}_y,\ \mathrm{B}_x$

Q4. A parallel plate capacitor of area $A = 16\ \mathrm{cm}^2$ and separation between the plates 10 cm , is charged by a DC current. Consider a hypothetical plane surface of area $\mathrm{A}_0 = 3.2\ \mathrm{cm}^2$ inside the capacitor and parallel to the plates. At an instant, the current through the circuit is 6A. At the same instant the displacement current through A_0 is ________ mA.

Q5. The electric field of an electromagnetic wave in free space is $\overrightarrow{\mathrm{E}} = 57\cos\left[7.5 \times 10^6\mathrm{t} - 5 \times 10^{-3}(3x + 4y)\right](4\hat{i} - 3\hat{j})N/C$.
The associated magnetic field in Tesla is

(1) $\overrightarrow{\mathrm{B}} = \frac{57}{3\times10^8}\cos\left[7.5 \times 10^6\mathrm{t} - 5 \times 10^{-3}(3x + 4y)\right](\hat{k})$

(2) $\overrightarrow{\mathrm{B}}=-\frac{57}{3\times10^8}\cos\left[7.5\times10^6\mathrm{t}-5\times10^{-3}(3x+4y)\right](\hat{k})$

(3) $\overrightarrow{\mathrm{B}}=-\frac{57}{3\times10^8}\cos\left[7.5\times10^6\mathrm{t}-5\times10^{-3}(3x+4y)\right](5\hat{k})$

(4) $\overrightarrow{\mathrm{B}}=\frac{57}{3\times10^8}\cos\left[7.5\times10^6\mathrm{t}-5\times10^{-3}(3x+4y)\right](5\hat{k})$

Q6. Due to presence of an em-wave whose electric component is given by $\mathrm{E}=100\sin(\omega\mathrm{t}-\mathrm{kx})\mathrm{NC}^{-1}$, 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

(1) $400\sin(\omega\mathrm{t}-\mathrm{kx})\mathrm{NC}^{-1}$

(2) $200\sin(\omega t-kx)\mathrm{NC}^{-1}$

(3) $50\sin(\omega\mathrm{t}-\mathrm{kx})\mathrm{NC}^{-1}$

(4) $25\sin(\omega\mathrm{t}-\mathrm{kx})\mathrm{NC}^{-1}$

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

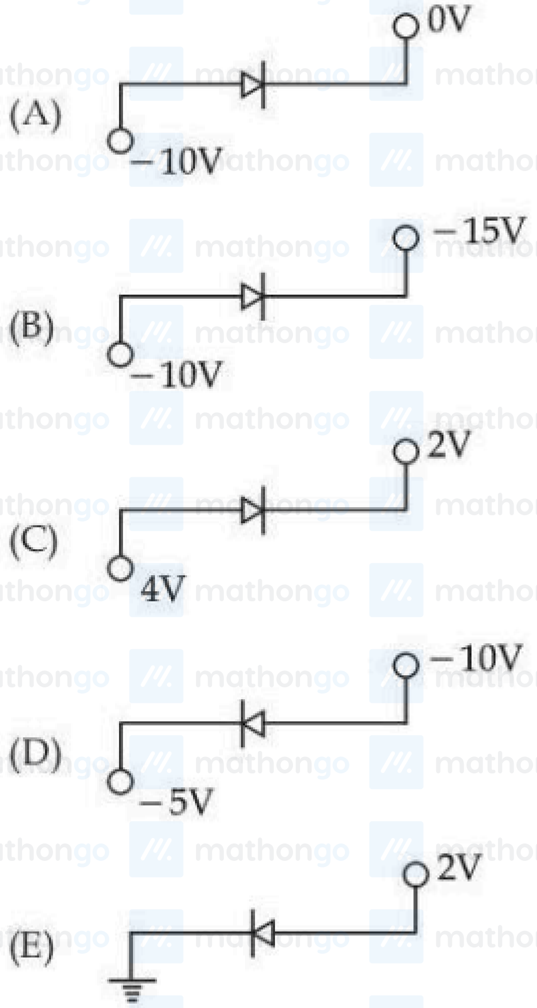
(1) $\overrightarrow{\mathrm{E}}=\left(\frac{1}{2}\hat{i}-\frac{\sqrt{3}}{2}\hat{j}\right)30\mathrm{c}\sin\left[\omega\left(\mathrm{t}-\frac{z}{\mathrm{c}}\right)\right]$

(2) $\overrightarrow{\mathrm{E}}=\left(\frac{3}{4}\hat{i}+\frac{1}{4}\hat{j}\right)30\mathrm{c}\cos\left[\omega\left(\mathrm{t}-\frac{z}{\mathrm{c}}\right)\right]$

(3) $\overrightarrow{\mathrm{E}}=\left(\frac{1}{2}\hat{i}+\frac{\sqrt{3}}{2}\hat{j}\right)30\mathrm{c}\sin\left[\omega\left(\mathrm{t}+\frac{z}{\mathrm{c}}\right)\right]$

(4) $\overrightarrow{\mathrm{E}}=\left(\frac{\sqrt{3}}{2}\hat{i}-\frac{1}{2}\hat{j}\right)30\mathrm{c}\sin\left[\omega\left(\mathrm{t}+\frac{z}{\mathrm{c}}\right)\right]$

Q1. Which of the following circuits represents a forward biased diode?



Choose the correct answer from the options given below :

(1) (A) and (D) only

(2) (B), (D) and (E) only

(3) (C) and (E) only

(4) (B), (C) and (E) only

Q2. Refer to the circuit diagram given in the figure. which of the following observations are correct?

A. Total resistance of circuit is 6Ω

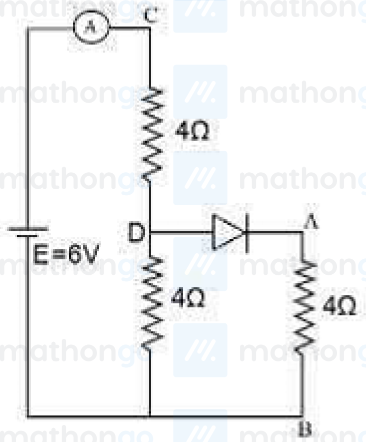
B. Current in Ammeter is 1 A

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:



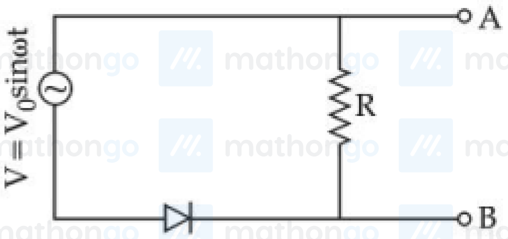
(1) A, B and D Only

(2) A, B and C Only

(3) A, C and D Only

(4) B, C and E Only

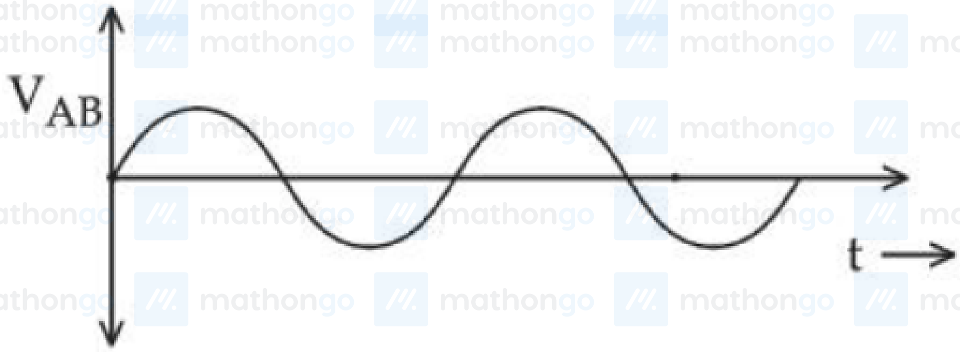
Q3.



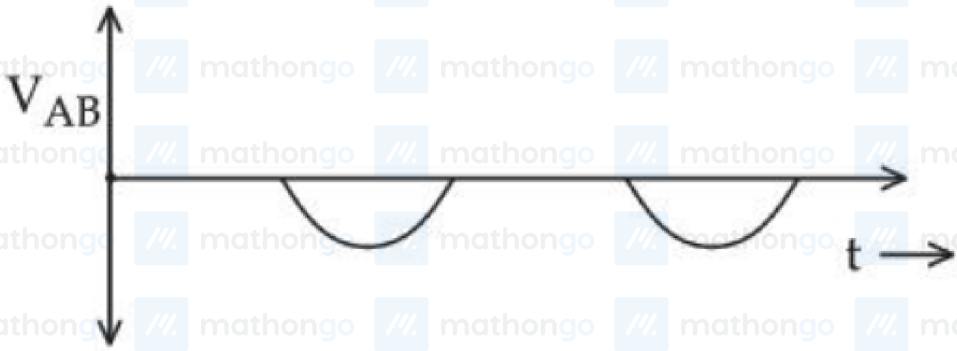
In the circuit shown here, assuming threshold voltage of diode is negligibly small, then voltage V_{AB} is correctly represented by :

(1) V_{AB} would be zero at all times

(2)



(3)



(4)

Q4. 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:

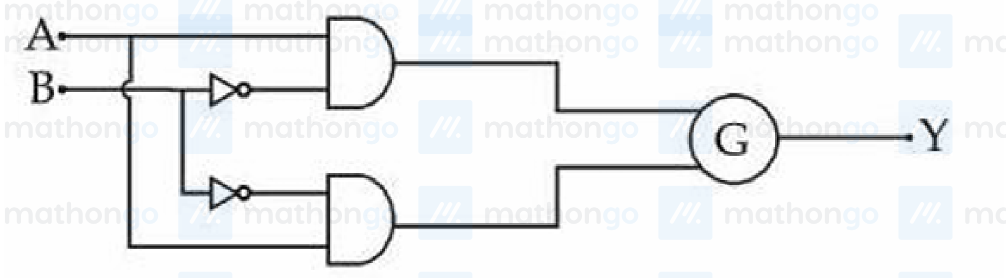
(1) B, E Only

(2) B, D, E Only

(3) A, C Only

(4) A, C, E Only

Q5.



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

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

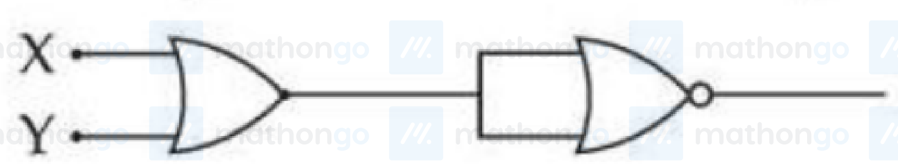
(1) OR Gate

(2) AND Gate

(3) NOR Gate

(4) NAND Gate

Q6. The output of the circuit is low (zero) for :



(A) $\mathrm{X}=0, \mathrm{Y}=0$
(B) $X=0, Y=1$
(C) $X=1, Y=0$
(D) $\mathrm{X}=1, \mathrm{Y}=1$
Choose the correct answer from the options given below :

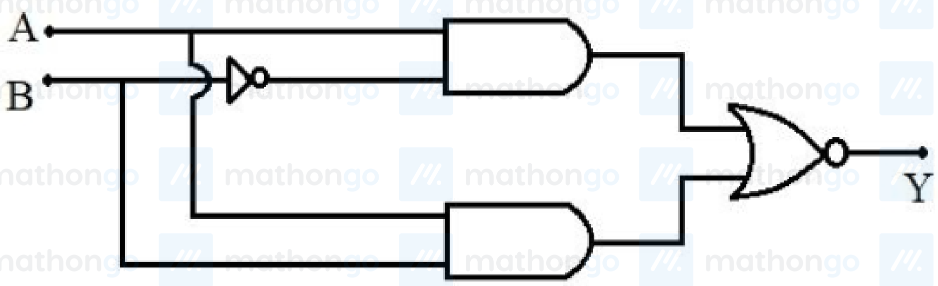
(1) (B), (C) and (D) only

(2) (A), (B) and (C) only

(3) (A), (C) and (D) only

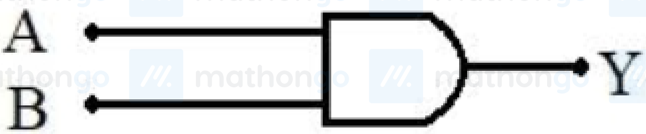
(4) (A), (B) and (D) only

Q7. Which of the following circuits has the same outpur as that of the given circuit?

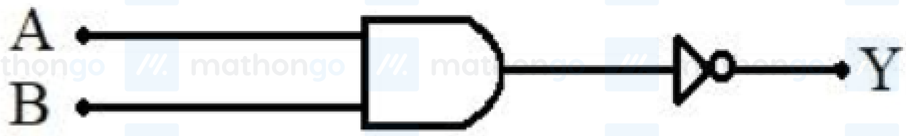


(1)

(2)

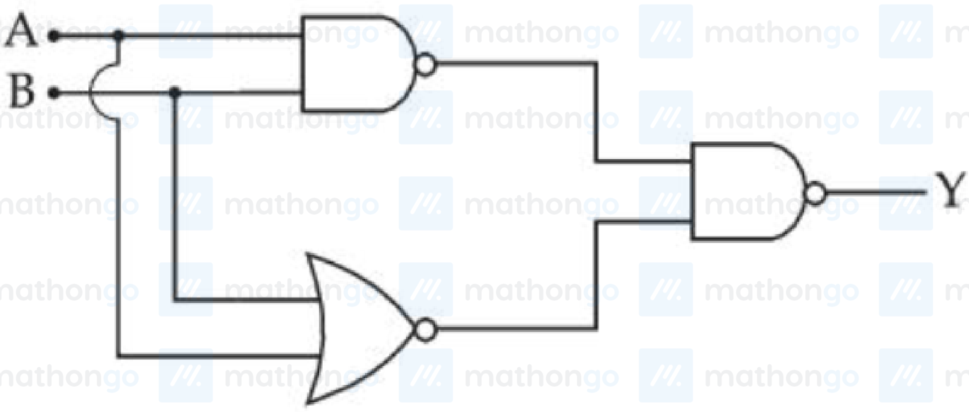


(3)



(4)

Q8.



For the circuit shown above, equivalent GATE is :

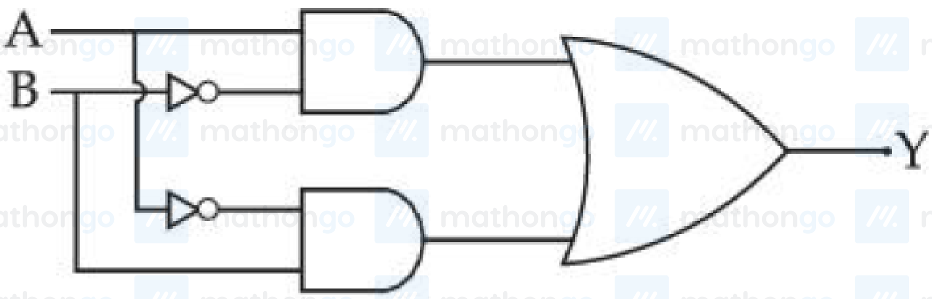
(1) OR gate

(2) NAND gate

(3) NOT gate

(4) AND gate

Q9. The truth table for the circuit given below is :



(1)

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

(2)

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

(3)

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

(4)

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

Q1. Given below are two statements :

Statement I : In a 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.

(1) Statement I is true but Statement II is false

(2) Statement I is false but Statement II is true

(3) Both Statement I and Statement II are false

(4) Both Statement I and Statement II are true

Q2. The least count of a screw guage 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 _____ $\times 10^{-3}$ mm

Q3. 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 _________.

Mathematics in Physics

1. (3) **2.** (2) **3.** (2) **4.** (1) **5.** (7700)

Units and Dimensions

1. (1) **2.** (1) **3.** (4) **4.** (0) **5.** (2) **6.** (4) **7.** (3) **8.** (2)
9. (4) **10.** (4) **11.** (3)

Motion In One Dimension

1. (1) **2.** (1) **3.** (3) **4.** (2000)

Motion In Two Dimensions

1. (5) **2.** (2) **3.** (2) **4.** (4)

Laws of Motion

1. (3) **2.** (36) **3.** (3)

Work Power Energy

1. (2) **2.** (152) **3.** (2) **4.** (4) **5.** (2) **6.** (1) **7.** (4) **8.** (3)
9. (2) **10.** (3) **11.** (2)

Center of Mass Momentum and Collision

1. (1) **2.** (3) **3.** (1) **4.** (4) **5.** (1) **6.** (1)

Rotational Motion

1. (1) **2.** (2) **3.** (4) **4.** (3) **5.** (16) **6.** (3) **7.** (3) **8.** (3)
9. (4) **10.** (4) **11.** (90) **12.** (3) **13.** (1)

Gravitation

1. (3) **2.** (9) **3.** (3) **4.** (2) **5.** (8) **6.** (1) **7.** (3)

Mechanical Properties of Solids

1. (50) **2.** (43) **3.** (1)

Mechanical Properties of Fluids

1. (4) **2.** (4) **3.** (1) **4.** (1) **5.** (5) **6.** (2) **7.** (4) **8.** (2190)
9. (1) **10.** (2) **11.** (4) **12.** (3) **13.** (1) **14.** (54)

Oscillations

1. (4) **2.** (2) **3.** (4) **4.** (4) **5.** (2) **6.** (1) **7.** (4)

Waves and Sound

1. (2) **2.** (4) **3.** (2)

Thermal Properties of Matter

1. (4) **2.** (1) **3.** (1) **4.** (40) **5.** (2) **6.** (4) **7.** (4)

Thermodynamics

1. (4) **2.** (3) **3.** (2) **4.** (327) **5.** (3) **6.** (3) **7.** (15) **8.** (1)
9. (273) **10.** (1) **11.** (1) **12.** (1) **13.** (1) **14.** (4) **15.** (2)

Kinetic Theory of Gases

1. (2) **2.** (3) **3.** (2)

Electrostatics

1. (2) **2.** (48) **3.** (4) **4.** (5) **5.** (2) **6.** (3) **7.** (2) **8.** (1)
9. (1) **10.** (2) **11.** (12) **12.** (4) **13.** (4) **14.** (4) **15.** (4) **16.** (3)
17. (4)

Capacitance

1. (4) **2.** (16) **3.** (1) **4.** (2) **5.** (3) **6.** (1320) **7.** (4) **8.** (4)
9. (100) **10.** (1)

Current Electricity

1. (4) **2.** (4) **3.** (1) **4.** (2) **5.** (2) **6.** (3) **7.** (2) **8.** (1)
9. (2) **10.** (4) **11.** (2)

Magnetic Properties of Matter

1. (1)

Magnetic Effects of Current

1. (8) **2.** (8) **3.** (4) **4.** (4) **5.** (3) **6.** (1) **7.** (2) **8.** (3)
9. (1) **10.** (4) **11.** (250) **12.** (4) **13.** (1)

Electromagnetic Induction

1. (4) **2.** (3) **3.** (3) **4.** (1) **5.** (3) **6.** (3) **7.** (2)

Alternating Current

1. (3) **2.** (2) **3.** (2) **4.** (2)

Ray Optics

1. (2) **2.** (1) **3.** (6) **4.** (4) **5.** (1) **6.** (2) **7.** (1) **8.** (4)
9. (3) **10.** (3) **11.** (2) **12.** (2) **13.** (4) **14.** (3) **15.** (4) **16.** (2)
17. (1) **18.** (1) **19.** (8) **20.** (2) **21.** (3) **22.** (4) **23.** (1) **24.** (4)

Wave Optics

1. (4) **2.** (1) **3.** (5) **4.** (2) **5.** (2) **6.** (1) **7.** (1) **8.** (11)
9. (2)

Dual Nature of Matter

1. (4) **2.** (4) **3.** (1) **4.** (4) **5.** (4) **6.** (1) **7.** (4) **8.** (2)
9. (3) **10.** (4) **11.** (2) **12.** (4)

Atomic Physics

1. (4) **2.** (4) **3.** (3) **4.** (3)

Nuclear Physics

1. (4) **2.** (1) **3.** (4)

Electromagnetic Waves

1. (2) **2.** (3) **3.** (2) **4.** (1200) **5.** (2) **6.** (2) **7.** (1)

Semiconductors

1. (4) **2.** (1) **3.** (4) **4.** (1) **5.** (3) **6.** (1) **7.** (2) **8.** (1)
9. (4)

Experimental Physics

1. (1) **2.** (35) **3.** (3)

Q1. $\overrightarrow{\mathrm{A}} \cdot \overrightarrow{\mathrm{B}}=0$

(3) $4-6 \mathrm{n}+8 \mathrm{p}=0$

$|\overrightarrow{\mathrm{A}}|=|\overrightarrow{\mathrm{B}}|$

$4+9 \mathrm{n}^2+4=4+4+16 \mathrm{p}^2$

$9 \mathrm{n}^2=16 \mathrm{p}^2$

$\mathrm{P}=+\frac{3}{4} \mathrm{n}$

$4-6 \mathrm{n} \pm 6 \mathrm{n}=0$

$12 \mathrm{n}=4$

$\mathrm{n}=\frac{1}{3}$

Q2. $y=\frac{32.3 \times 1125}{27.4}=1326.18$

(2) So we need to report to three significant digit.

So, $y=1330$

Q3. $\mathrm{d}=\frac{\mathrm{m}}{\text{vol.}}=\frac{\mathrm{m}}{\pi \mathrm{R}^2 \ell} \Rightarrow \frac{\mathrm{d} \rho}{\rho}=\frac{\mathrm{dm}}{\mathrm{m}}+\frac{2 \mathrm{dR}}{\mathrm{R}}+\frac{\mathrm{d} \ell}{\ell}$

(2) $\Rightarrow \frac{\mathrm{d} \rho}{\rho}=\left(\frac{0.003}{0.6}+\frac{2 \times 0.01}{0.5}+\frac{0.05}{10}\right) 100=5 \%$

Q4. $\mathrm{E}=\alpha^3 \mathrm{e}^{-\beta t}$

(1) $\ln \mathrm{E}=3 \ln \alpha-\beta \mathrm{t}$

$\left(\frac{\mathrm{dE}}{\mathrm{E}}\right)_{\max }=\frac{3 \mathrm{~d} \alpha}{\alpha}+\beta \frac{\mathrm{dt}}{\mathrm{t}} \times \mathrm{t}$

$=3 \times 1.2 \%+(0.3 \times 1.6 \times 5) \%$

$=6 \%$

Q5. $\mathrm{Q}=\frac{\mathrm{ab}^4}{\mathrm{cd}}$

(7700) $\Rightarrow \frac{\Delta \mathrm{Q}}{\mathrm{Q}} \times 100=\left[\frac{\Delta \mathrm{a}}{\mathrm{a}}+4 \frac{\Delta \mathrm{~b}}{\mathrm{b}}+\frac{\Delta \mathrm{c}}{\mathrm{c}}+\frac{\Delta \mathrm{d}}{\mathrm{d}}\right] \times 100$

$\Rightarrow \frac{\mathrm{x}}{1000}=\left[\frac{3}{60}+4\left(\frac{0.1}{20}\right)+\left(\frac{0.2}{40}\right)+\frac{0.1}{50}\right] \times 100$

$\Rightarrow \mathrm{x}=7700$

Q1.
(1)

$$\text{Energy } = \frac{Q^2}{2C}$$

$$\therefore \quad [\mathrm{F}] = \frac{\left[\mathrm{C}^2\right]}{\left[\mathrm{ML}^2\,\mathrm{T}^{-2}\right]}$$

$$= \left[\mathrm{C}^2 \mathrm{M}^{-1}\,\mathrm{L}^{-2}\,\mathrm{T}^{+2}\right]$$

Q2.
(1)

Dimension $[\mathrm{x}(\mathrm{t})] = [\mathrm{L}]$

$[\mathrm{A}] = [\mathrm{L}]$

$[\mathrm{B}] = [\mathrm{L}]$

$[\mathrm{C}] = \left[\mathrm{LT}^{-2}\right]$

$[\mathrm{D}] = [\mathrm{L}]$

$$\left[\frac{\mathrm{ABC}}{\mathrm{D}}\right] = \left[\frac{\mathrm{L} \times \mathrm{L} \times \mathrm{LT}^{-2}}{\mathrm{L}}\right] = \left[\mathrm{L}^2\,\mathrm{T}^{-2}\right]$$

Q3.
(4)

$$\alpha \equiv \frac{\phi}{\sigma}$$

$$\beta = \frac{\phi}{\lambda}$$

$$\frac{\alpha}{\beta} \equiv \frac{\lambda}{\sigma} \equiv \text{ displacement}$$

Q4.
(0)

$[\text{Modulus of elasticity}] = \mathrm{ML}^{-1}\,\mathrm{T}^{-2}$

$[\text{Torque}] = \mathrm{ML}^{2}\,\mathrm{T}^{-2}$

[Modulus of elasticity per unit torque]

$= \frac{\mathrm{ML}^{-1}\,\mathrm{T}^{-2}}{\mathrm{ML}^2\,\mathrm{T}^{-2}} = \mathrm{L}^{-3}$

Q5.
(2)

$[\text{Angular momentum }] = \mathrm{ML}^2\,\mathrm{T}^{-1}$

$[\text{Planck's Constant}] = \mathrm{ML}^2\,\mathrm{T}^{-1}$

$[\text{Torque}] = \mathrm{ML}^2\,\mathrm{T}^{-2}$

$[\text{Energy}] = \mathrm{ML}^2\,\mathrm{T}^{-2}$

$[\text{Surface tension}] = \mathrm{MT}^{-2}$

$[\text{Impulse}] = \mathrm{MLT}^{-1}$

$[\text{Pressure }] = \mathrm{ML}^{-1}\,\mathrm{T}^{-2}$

$[\text{Young's modulus}] = \mathrm{ML}^{-1}\,\mathrm{T}^{-2}$

Q6.
(4)

(A) Magnetic induction $\rightarrow$ Gauss (III)

(B) Magnetic intensity

$\left(\mathrm{H} = \frac{\mathrm{B}}{\mu}\right) \rightarrow$ Ampere / meter (IV)

(C) Magnetic flux $\rightarrow$ Weber (Wb) (II)

(D) Magnetic moment $\rightarrow$ Ampere-meter ^{2}

$(\overrightarrow{\mathrm{M}} = \mathrm{i}\,\overrightarrow{\mathrm{A}})$

Q7. For a current carrying loop at centre

(3)

$$B=\frac{\mu_0 i}{2R}$$

$$\therefore \quad \frac{B}{\mu_0} \equiv \frac{i}{R} \equiv \left[\mathrm{AL}^{-1}\right]$$

Q8. (A) $B=\frac{\mu_0 i}{2\pi r} \& qvB=F$

(2) $\mu_0 \equiv \frac{Br}{i} \equiv \frac{Fr}{qvi} \equiv \frac{\mathrm{MLT}^{-2}\times L}{\mathrm{A}^2\mathrm{TLT}^{-1}} \equiv \mathrm{MLT}^{-2} A^{-2}$

(B) $B \equiv \frac{F}{qV} \equiv \frac{\mathrm{MLT}^{-2}}{\mathrm{ATLT}^{-1}}=\mathrm{MT}^{-2}\ \mathrm{A}^{-1}$

(C) $M=iA \equiv \mathrm{AL}^2$

(D) $\tau=C\theta \Rightarrow C \equiv \mathrm{ML}^2\ \mathrm{T}^{-2}$

Q9. Angular impulse $=\left[\mathrm{ML}^2\ \mathrm{T}^{-1}\right]$

(4) Latent Heat $=\left[\mathrm{M}^0\ \mathrm{L}^2\ \mathrm{T}^{-2}\right]$

Electrical resistivity $=\left[\mathrm{ML}^3\ \mathrm{T}^{-3}\ \mathrm{A}^{-2}\right]$

Electromotive force $=\left[\mathrm{ML}^2\ \mathrm{T}^{-3}\ \mathrm{A}^{-1}\right]$

Q10. $\left[\mathrm{LT}^{-1}\right]=[\mathrm{A}]\left[\mathrm{T}^2\right]=\frac{[\mathrm{B}][\mathrm{T}]}{[\mathrm{C}]+[\mathrm{T}]}$

(4)

$[\mathrm{C}]=[\mathrm{T}]$

$[\mathrm{A}]=\left[\mathrm{LT}^{-3}\right]$

$[\mathrm{B}]=\left[\mathrm{LT}^{-1}\right]$

$[\mathrm{ABC}]=\left[\mathrm{L}^2\ \mathrm{T}^{-3}\right]$

Q11. (A) $[\mathrm{Y}]=\frac{\mathrm{F}}{\mathrm{A}\left(\frac{\Delta\ell}{\ell}\right)} \Rightarrow \frac{\mathrm{MLT}^{-2}}{\mathrm{L}^2}=\mathrm{ML}^{-1}\ \mathrm{T}^{-2}$

(3)

(B) Torque $(\vec{\tau})=\overrightarrow{\mathrm{r}}\times\overrightarrow{\mathrm{F}}$

$(\vec{\tau})=\mathrm{L}\times\mathrm{MLT}^{-2}=\mathrm{ML}^2\ \mathrm{T}^{-2}(\mathrm{IV})$

(C) Coefficient of viscosity $\Rightarrow F=\eta A\frac{dV}{dt}$

$\eta \rightarrow \mathrm{Pa}\cdot\mathrm{sec}$

$[\eta]=\frac{\mathrm{MLT}^{-2}}{\mathrm{L}^2}\times\mathrm{T}=\mathrm{ML}^{-1}\ \mathrm{T}^{-1}$

(D) Gravitational constant (G)

$$\mathrm{F}=\frac{\mathrm{GM}_1\mathrm{M}_2}{\mathrm{r}^2}$$

$$[\mathrm{G}]=\frac{\mathrm{F}\cdot\mathrm{r}^2}{\mathrm{m}_1\ \mathrm{m}_2}=\frac{\mathrm{MLT}^{-2}\times\mathrm{L}^2}{\mathrm{M}^2}=\mathrm{M}^{-1}\ \mathrm{L}^3\ \mathrm{T}^{-2}$$

Q1. Distance = area under the graph

(1) $d = 300 \times 2 + 400 \times 28.5$

$= 600 + 114000$

$= 12000 \text{ m}$

Q2. Distance travelled = displacement when direction of velocity remains constant

(1) $\Rightarrow$ Distance $=$ Area

$= \frac{1}{2}(2\text{ s} + 4\text{ s})(10\text{ m/s})$

$= 30\text{ m}$

Q3. $a_p = kt$, k is constant

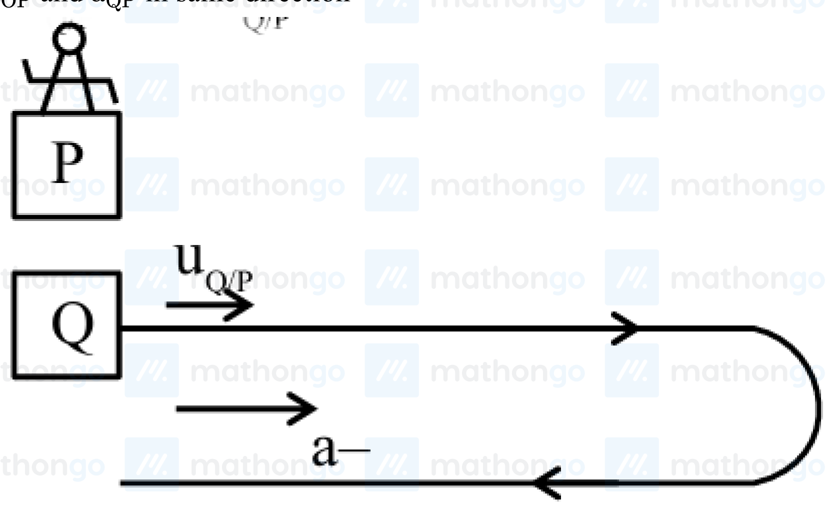
(3) $a_Q = a$, a is constant

$a_{QP} = a_Q - a_p = a - kt$

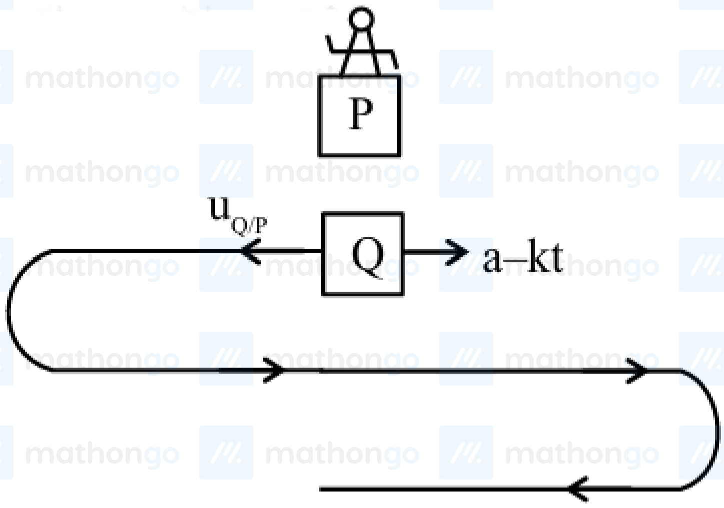
as initial velocities are not mentioned in question, so will have to assume two cases.

Case-I

u_{QP} and a_{QP} in same direction



Total number of crossing = 2 Case-II



u_{QP} and a_{QP} in opposite direction

Total number of crossing = 3

Q4. $\vec{v}_b = 9 + 27 = 36 \text{ km/hr}$

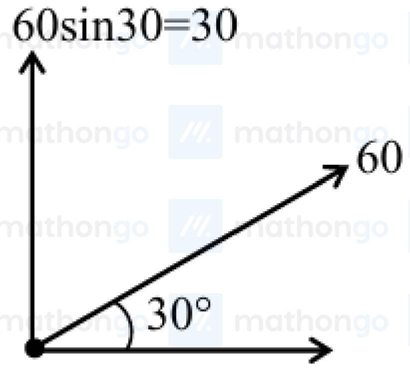
(2000)

$\vec{v}_b = 36 \times \frac{1000}{36000} = 10 \text{ m/sec}$

Time of flight $= \frac{2 \times 10}{10} = 2\text{sec}$

Range $= 10 \times 2 = 20 \text{ m} = 2000 \text{ cm}$

Q1.
(5)

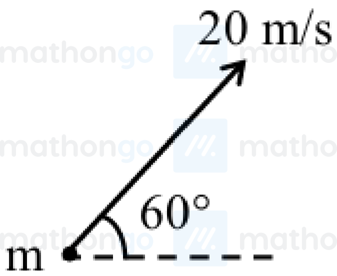


$$S_1 = 30 \times 1 - \frac{1}{2} \times 10 \times 1 = 25$$

$$S_3 = 30 + \left(\frac{-10}{2}\right) \times (2 \times 3 - 1) = 5$$

$$\frac{S_1}{S_3} = \frac{25}{5} = 5$$

Q2.
(2)



$$k_i = \frac{1}{2} mv^2$$

$$k_f = \frac{1}{2}\ m(v \cos 60^\circ)^2 = \frac{1}{8} mv^2$$

$$\Delta k = k_i - k_f = \frac{3}{8} mv^2 = \frac{3}{8} \times 0.1 \times 400 = 15\ J$$

Q3.
(2)

$$H_{Max} = \frac{(u \sin \theta)^2}{2\ g}$$

$$\frac{(H_{max})_1}{(H_{max})_2} = \frac{u^2 \sin^2(45 - \alpha)}{u^2 \sin^2(45 + \alpha)}$$

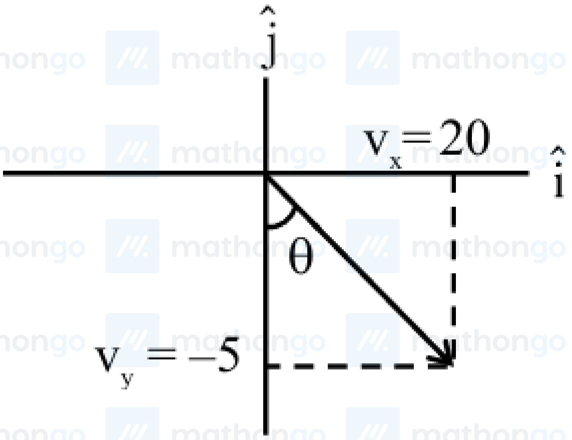
$$= \frac{\left(\frac{1}{\sqrt{2}} \cos \alpha - \frac{1}{\sqrt{2}} \sin \alpha\right)^2}{\left(\frac{1}{\sqrt{2}} \cos \alpha + \frac{1}{\sqrt{2}} \sin \alpha\right)^2}$$

$$= \frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$$

Q4. $\vec{r} = 5t^2\hat{i} - 5t_j$

(4) $\vec{v} = 10\hat{i} - 5\hat{j}$

$\vec{v} = 20\hat{i} - 5\hat{j}$ at $t = 2\text{sec}$



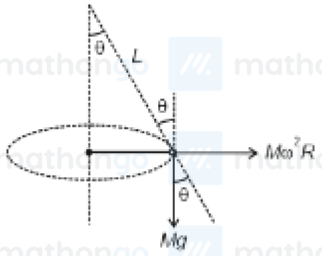
$\tan\theta = \dfrac{20}{5} = 4$

$\theta = \tan^{-1} 4$

From -veY-axis

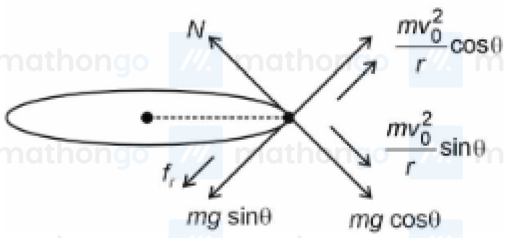
Q1. $kx_1 = 5$ N
(3) $kx_2 = 7$ N
$k(5x_1 - 2x_2) = 5kx_1 - 2kx_2$
$= 5 \times 5 - 2 \times 7 = 11$ N

Q2. $\omega = \frac{3}{\pi} \times 2\pi = 6 \text{rad/s}$
(36) $R = L\sin\theta$



and $T = M\sqrt{g^2 + \omega^4 R^2}$
Also, $T\sin\theta = M\omega^2 \cdot L\sin\theta$
$\Rightarrow \quad T = M(36)\text{L}$
$\Rightarrow \quad T = 36\text{ML}$

Q3. Given maximum possible speed = v_0
(3) For this



So, $N = mg\cos\theta + \frac{mv_0^2}{r}\sin\theta$
$f_r = \mu mg\cos\theta + \frac{\mu mv_0^2}{r}\sin\theta$
And $\frac{mv_0^2}{r}\cos\theta = mg\sin\theta + f_r$
$\Rightarrow \frac{mv_0^2}{r}\cos\theta - mg\sin\theta = \mu\left(mg\cos\theta + \frac{mv_0^2}{r}\sin\theta\right)$
$\Rightarrow \left(v_0^2 - gr\tan\theta\right) = \mu\left(v_0^2\tan\theta + gr\right)$
$\Rightarrow \mu = \frac{v_0^2 - gr\tan\theta}{gr + v_0^2\tan\theta}$

Q1. $w = 0$

(2) $\therefore \quad \vec{F} \cdot S = 0$

$(2\hat{i} + b\hat{j} + \hat{k}) \cdot (\hat{i} - 2\hat{j} - \hat{k}) = 0$

$2 - 2b - 1 = 0$

$b = \frac{1}{2}$

Q2. $y = 10 - x$

(152) $w = \int_0^4 x^2(10 - x)dx + \int_0^2 y^2 dy$

$= \frac{10x^3}{3} - \frac{x^4}{4}\Big|_0^4 + \frac{y^3}{3}\Big|_0^2$

$= \frac{640}{3} - \frac{256}{4} + \frac{8}{3}$

$= 216 \times 64$

$= 152 \text{ J}$

Q3. $F = \alpha + \beta x^2$

(2) Work done $\int dw = \int F \cdot dx$

$\Rightarrow \quad \Delta W = \int F \cdot dx = \int \left(\alpha + \beta x^2\right) dx$

$\Rightarrow \quad \Delta W = \left|\alpha x + \frac{\beta x^3}{3}\right|_0^1 = \alpha + \frac{\beta}{3} = 5$

Given $\alpha = 1$

So, $\frac{\beta}{3} = 4$

$\Rightarrow \beta = 12 \text{ N/m}^2$

Q4. Initial K.E,

(4) $\text{K.E.} = \frac{1}{2}\text{mu}^2$

Speed at heighest point

$\text{V} = \text{u}\cos 60^\circ = \frac{\text{u}}{2}$

$\therefore \text{KE}_2 = \frac{1}{2}\text{m}\left(\frac{\text{u}}{2}\right)^2$

$= \frac{1}{4} \times \frac{1}{2}\text{mu}^2$

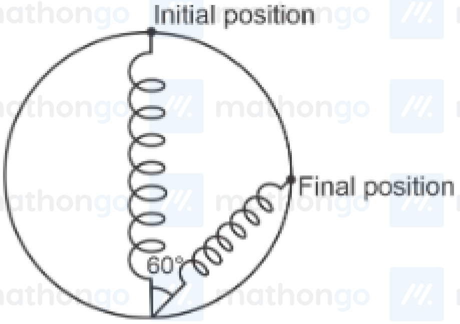
$= \frac{\text{KE}}{4}$

Q5. Assertion is correct as central forces are conservative in nature, i.e. work done is independent of path.

(2) Reason is true as some forces in mechanics like, friction are non-conservative because work done depends on path and only conservative forces have an associated potential energy.

Also, reason does not explain assertion.

Q6.
(1)



$$\text{Work done by gravity } = mg(2R - R\cos 60^\circ) = \frac{3mgR}{2}$$

$$\text{Work done by spring } = -\frac{1}{2}k\left(0^2 - R^2\right) = \frac{1}{2}kR^2$$

Net work = change in kinetic energy

i.e. $\frac{3mgR}{2} + \frac{kR^2}{2} = \frac{1}{2}mv^2$

or $v^2 = 3gR + \frac{kR^2}{m}$

or $v = \sqrt{3gR + \frac{kR^2}{m}}$

Q7.
(4)

$$\langle \mathrm{p} \rangle = \frac{(2\hat{\mathrm{i}} + 3\hat{\mathrm{j}}) \cdot (3\hat{\mathrm{i}} + 6\hat{\mathrm{j}})}{4} = 6$$

$$\vec{\mathrm{a}} = \left(\frac{\vec{\mathrm{F}}}{\mathrm{m}} = \frac{1}{2}\hat{\mathrm{i}} + \frac{3}{4}\hat{\mathrm{j}}\right)$$

$$\vec{\mathrm{v}} \text{ at t} = 4\text{sec} = \left(\frac{1}{2}\hat{\mathrm{i}} + \frac{3}{4}\hat{\mathrm{j}}\right) \times 4 = (2\hat{\mathrm{i}} + 3\hat{\mathrm{j}})$$

$$P_{\text{ins}} = (2\hat{\mathrm{i}} + 3)(2\hat{\mathrm{i}} + 3\hat{\mathrm{j}}) = 13$$

$$\frac{\langle \mathrm{P} \rangle}{P_{\text{ins}}} = \frac{6}{13}$$

Q8.
(3)

Power $= \vec{F} \cdot \vec{V}$

and $F = \frac{dp}{dt}$ = Rate of change of linear momentum

$F = V \cdot \frac{dm}{dt} = K_1 V^{\frac{3}{2}}, K$ is constant

Power $(P) = \left(KV^{\frac{3}{2}}\right) \cdot (V)$

$= KV^{\frac{5}{2}}$

So, $P^2 \propto V^5$

Q9.
(2)

$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mgh$

$\Rightarrow \frac{1}{2}\, m(5\, g\ell) = \frac{1}{2}mv_B^2 + mg\frac{\ell}{2}$

$\Rightarrow \frac{5mg\ell}{2} - \frac{mg\ell}{2} = KE_B$

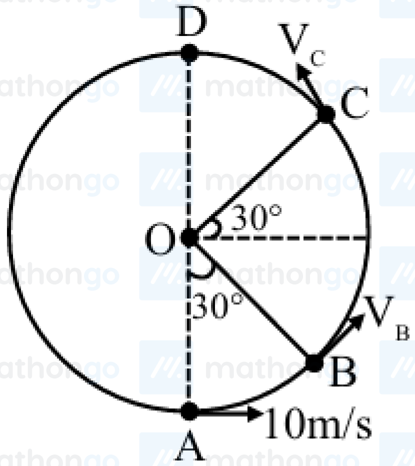
$\Rightarrow KE_B = 2mg\ell$

$\frac{1}{2}mv_C^2 = \frac{1}{2}mv_D^2 + mg\frac{\ell}{2}$

$\Rightarrow KE_C = \frac{1}{2}mg\ell + mg\frac{\ell}{2} = mg\ell$

$\Rightarrow \frac{KE_B}{KE_C} = 2$

Q10.
(3)



$\frac{1}{2}\, m \times 100 + 0 = \frac{1}{2}mV_B^2 + mg\left(R - \frac{R\sqrt{3}}{2}\right)$

$100 = V_B^2 + 2gR\left(1 - \frac{\sqrt{3}}{2}\right]$

$V_B^2 = 100 - 20(2 - \sqrt{3})$

$V_B^2 = 60 + 20\sqrt{3})$

$K.E_B = \frac{1}{2}mV_B^2 = \frac{m}{2}(60 + 20\sqrt{3})$

$\frac{1}{2}\, m(100) = \frac{1}{2}mV$

2

$100 = mg\left(\frac{3R}{2}\right)$

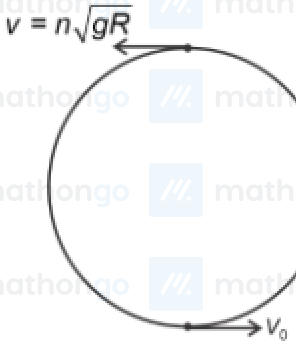
$100\ V_C^2 = 60$

$V_C^2 = 40$

$K.E_C = \frac{1}{2}mVV_C^2 = \frac{1}{2}\, m(40)$

$K.E_B = \frac{60 + 20\sqrt{3}}{40} = \frac{3}{2} + \frac{\sqrt{3}}{2} = \frac{3 + \sqrt{3}}{2}$

Q11.
(2)



$$v_0 = \sqrt{v^2 + 2g(2R)}$$

$$v_0 = \sqrt{n^2 gR + 4gR}$$

$$\therefore \quad \frac{k_{\text{bottom}}}{k_{\text{trog}}} = \frac{v_0^2}{v^2} = \frac{n^2 + 4}{n^2}$$

Q1. $dm = \sigma dA$

(1) $d = \sigma(dx)(dy) = \frac{\sigma_0 x}{ab}(dx)(dy)$

$$x_{com} = \frac{\int x dm}{\int dm} = \frac{\int x \frac{(\sigma_0 x)}{ab}(dx)(dy)}{\int_0 \frac{\sigma_0}{ab}(dx)(dy)}$$

$$= \frac{\int_0^a x^2 dx \int_0^b dy}{\int_0^b x dx \int_0^b dy} = \frac{2a}{3}$$

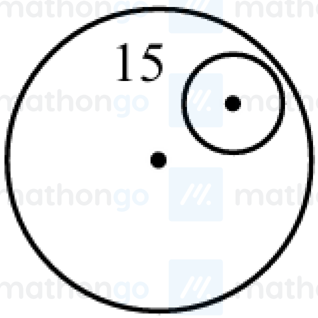
$$y_{com} = \frac{\int y dm}{\int dm} = \frac{\int y\left(\frac{\sigma_0 x}{ab}\right)(dx)(dy)}{\int \frac{\sigma_0 x}{ab}(dx)(dy)}$$

$= \frac{\int_0^a x dx \int_0^b y dy}{\int_0^a x dx \int_0^b dy} = \frac{b}{2}$

i.e., $\vec{r}_{\text{com}} \equiv \left(\frac{2a}{3}, \frac{b}{2}\right)$

Q2.

(3)



mass of disc $= \mathrm{m}$

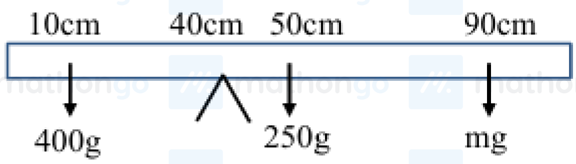
mass of cut part $= \frac{m}{16}$

$X_{com} = \frac{m \times 0 - \frac{m}{16} \times 15}{m - \frac{m}{16}}$

$= 1$ cm.

Q3.

(1)

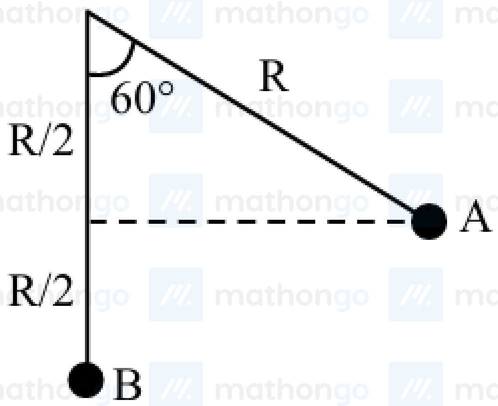


$\tau_{\text{Net}} = 0 \Rightarrow (400\text{ g} \times 30) = (250\text{ g} \times 10)(\text{mg} \times 50)$

$\text{m} = \frac{12000 - 2500}{50} = \frac{9500}{50}$

$\text{M} = 190\text{ g}$

Q4.
(4)



Velocity of a just before hitting :

$u=\sqrt{2\,g\frac{R}{2}}=\sqrt{gR}$

Just after collision, let velocity of A and B are v_1 and v_2 respectively

$\therefore$ by COM:

$mu=mv_1+\frac{m}{2}v_2$

$2v_1+v_2=2u\ldots(i)$

$e=1=\frac{v_2-v_1}{u}$

$\Rightarrow v_2-v_1=u..(ii)$

From (i) -(ii)

$\Rightarrow 3v_1=u\Rightarrow v_1=\frac{u}{3}=\frac{1}{3}\sqrt{gR}$

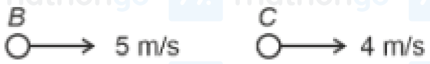
Q5. For A and B.

(1) Before collision

After collision

For B and C

Before collision



After collision

Final velocity

$V_A = 2$ m/s

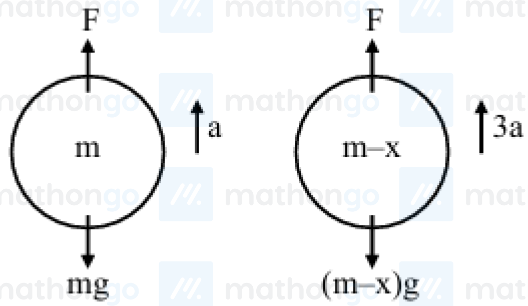
$V_B = 4$ m/s

$V_C = 5$ m/s

$\Rightarrow$ Velocity exchange for two identical mass in elastic collision.

Q6.

(1)



$F - mg = ma$
$F = ma + mg$
$F - (m - x)g = (m - x)3a$

Put F

$\mathrm{Ma + mg - mg + xg = 3ma - 3xa}$

$\mathrm{x = \dfrac{2ma}{g + 3a}}$

Q1. **(1)**

$\tau = \dot{r} \times \dot{F}$

$$\tau = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 2 & 1 & 2 \end{vmatrix}$$

$\tau = \hat{i}(2-1) - \hat{j}[0] + \hat{k}(1-2)$

$= \hat{i} - \hat{k}$

Q2. **(2)**

The torque $\vec{\tau}$ acting on the particle with respect to the origin can be calculated using the cross product of the position vector $\vec{r}$ and the force vector $\vec{F}$:

$\vec{\tau} = \vec{r} \times \vec{F}$

Given the position vector $\vec{r} = (1, 1, 1)\text{m}$ and the force vector $\vec{F} = \hat{i} - \hat{j} + \hat{k}$, we need to calculate the cross product:

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 1 & -1 & 1 \end{vmatrix}$$

Calculating the determinant, we have:

$\vec{\tau} = \hat{i}(1 \cdot 1 - 1 \cdot (-1)) - \hat{j}(1 \cdot 1 - 1 \cdot 1) + \hat{k}(1 \cdot (-1) - 1 \cdot 1)$

This simplifies to:

$\vec{\tau} = \hat{i}(1+1) - \hat{j}(1-1) + \hat{k}(-1-1)$

$\vec{\tau} = 2\hat{i} - 0\hat{j} - 2\hat{k}$

The torque vector is $\vec{\tau} = 2\hat{i} - 2\hat{k}$.

To find the magnitude of the torque in the z-direction, we look at the $\hat{k}$ component:

$\tau_z = -2$

The magnitude of torque in the z-direction is:

$|\tau_z| = 2\text{Nm}$

Thus, the magnitude of the torque in the z-direction is 2 Newton-meters.

Q3. **(4)**

Step 1: Moment of Inertia of the Original Disc

The moment of inertia of a uniform circular disc of mass M and radius R about its central axis (perpendicular to its plane) is given by:

$I_{\text{original}} = \frac{1}{2} MR^2$

Step 2: Moment of Inertia of the Removed Part

The removed part is a smaller disc of radius $R/2$.

Since, the original disc has uniform mass distribution, the mass of the smaller disc (proportional to its area) is:

The moment of inertia of a smaller disc about its own center is:

$$M_{\text{removed}} = M \times \frac{\pi(R/2)^2}{\pi R^2} = M \times \frac{1}{4} = \frac{M}{4}$$

$$I_{\text{removed,center}} = \frac{1}{2} M_{\text{removed}} \left(\frac{R}{2}\right)^2$$

$$I_{\text{removed opeter}} = \frac{1}{2} \times \frac{M}{4} \times \frac{R^2}{4} = \frac{1}{32} MR^2$$

$$I_{\text{removed}} = I_{\text{removed,ceater}} + M_{\text{removed}}\, d^2$$

$$I_{\text{remored}} = \frac{1}{32}MR^2 + \left(\frac{M}{4} \times \frac{R^2}{4}\right)$$

$$I_{\text{removed}} = \frac{1}{32}MR^2 + \frac{1}{16}MR^2$$

$$I_{\text{removed}} = \frac{1}{32}MR^2 + \frac{2}{32}MR^2 = \frac{3}{32}MR^2$$

Step 3: Moment of Inertia of the Remaining Part

The moment of inertia of the remaining part is:

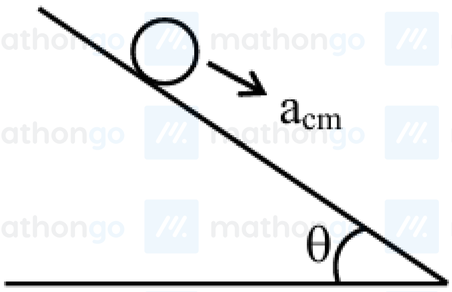
$$I_{\text{remaining}} = I_{\text{original}} - I_{\text{removed}}$$

$$I_{\text{remaining}} = \frac{1}{2}MR^2 - \frac{3}{32}MR^2$$

$$I_{\text{rvmaining}} = \frac{16}{32}MR^2 - \frac{3}{32}MR^2$$

$$I_{\text{remaining}} = \frac{13}{32}MR^2$$

Q4.
(3)



$$t = \sqrt{\frac{2\ell}{a_{cm}}}$$

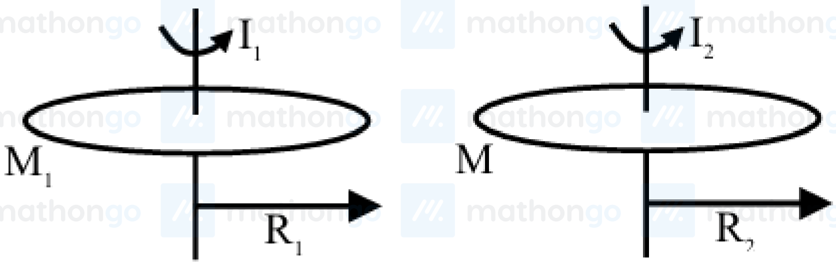
$$a_{cm} = \frac{g\sin\theta}{1 + \frac{I_{cm}}{MR^2}}$$

$$a_1 = a_{cm_1} = \frac{5\,g\sin\theta}{7} \ldots\ldots \text{ Solid}$$

$$a_2 = a_{cm_2} = \frac{3\,g\sin\theta}{5} \ldots\ldots \text{ Hollow}$$

$a_1 > a_2$
$t_1 < t_2$

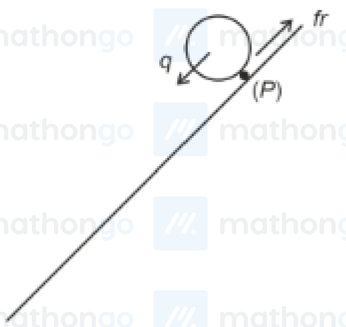
Q5.
(16)



Given $R_2 = 2R_1$

$M_1 = \sigma \times \pi R_1^2 = M_o$
$M_2 = \sigma \times \pi R_2^2 = M_o$
$M_2 = \sigma \times \pi R_2^2 = \sigma \times \pi [2R_1]^2 = \sigma \times 4\pi R_1^2 = 4M_o$
$\frac{I_1}{I_2} = \frac{\frac{M_1 R_1^2}{2}}{\frac{M_2 R_2^2}{2}} = \frac{M_1 R_1^2}{M_2 R_2^2} = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$

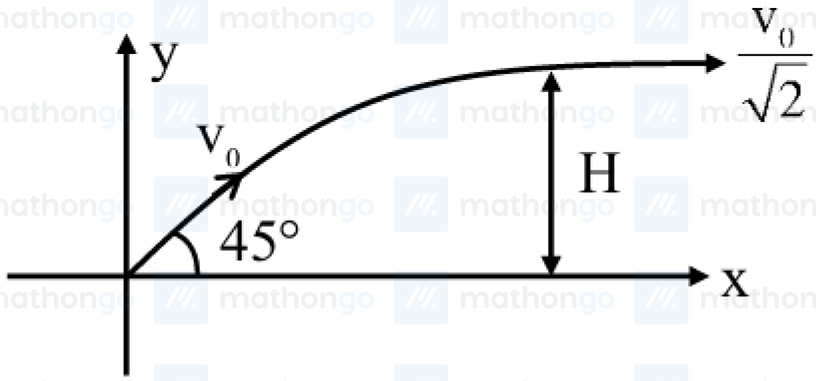
Q6.
(3)



For pure rolling about point '*P*'.

$\Rightarrow \quad a = \frac{2g}{3}\sin\theta = \frac{2g}{3\sqrt{2}} = \frac{\sqrt{2}}{3}g$

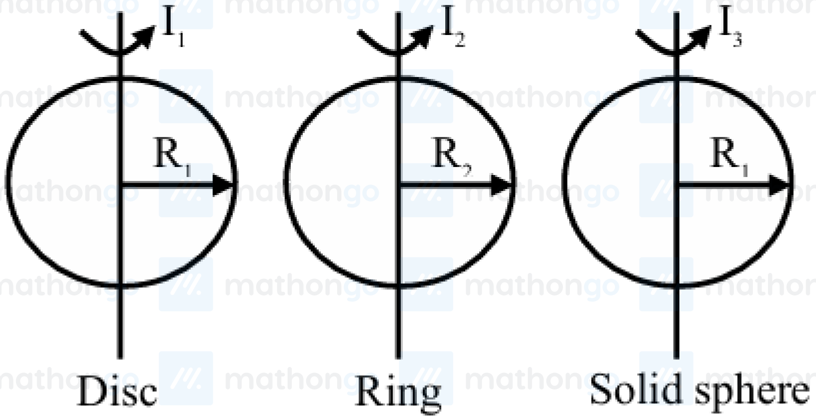
Q7.
(3)



$H = \frac{\left(\frac{v_0}{\sqrt{2}}\right)^2}{2\,g} = \frac{v_0^2}{4\,g}$
$L = mvh$
$L = m\frac{v_0}{\sqrt{2}}\frac{v_0^2}{4\,g}$

Q8.
(3)
$KE_{(T)} = \frac{1}{2}mv^2$
$KE_{(R)} = \frac{1}{2} \cdot \frac{2}{5}mR^2 \cdot \frac{v^2}{R^2} = \frac{1}{2}mv^2\left(\frac{2}{5}\right)$
So, $\frac{KE_{(T)}}{KE_{(R)}} = \frac{5}{2}$

Q9.
(4)



$\mathrm{I}_1=\frac{\mathrm{MR}_1^2}{4}, \mathrm{I}_2=\frac{\mathrm{MR}_2^2}{2}, \mathrm{I}_3=\frac{2 \mathrm{MR}_1^2}{5}$

According to problem

$\frac{\mathrm{I}_1}{\mathrm{I}_2}=2.5 \Rightarrow \frac{\frac{\mathrm{MR}_1^2}{4}}{\frac{\mathrm{MR}_2^2}{2}}=\frac{5}{2} \Rightarrow \frac{\mathrm{R}_1^2}{\mathrm{R}_2^2}=5 \ldots$

Now we are provided with information that

$\frac{\mathrm{I}_3}{\mathrm{I}_2}=\mathrm{n}$

$\Rightarrow \frac{\frac{2 \mathrm{MR}_1^2}{5}}{\frac{\mathrm{MR}_2^2}{2}}=\mathrm{n} \Rightarrow \frac{4 \mathrm{R}_1^2}{5 \mathrm{R}_2^2}=\mathrm{n}$

From Eq', (1) and (2)

$\Rightarrow n=4$

Q10. $\theta=5 \mathrm{t}^2-8 \mathrm{t}$
(4) $\omega=\frac{\mathrm{d} \theta}{\mathrm{dt}}=10 \mathrm{t}-8$

$\alpha=\frac{\mathrm{d} \omega}{\mathrm{dt}}=10$

$\therefore \mathrm{p}=\tau \omega$

$=(\mathrm{I} \alpha) \omega$

$=\left(\frac{\mathrm{mR}^2}{2}\right) \alpha \omega$

$=\left(\frac{\mathrm{mR}^2}{2}\right)(10)(10$

Put $\mathrm{t}=2$

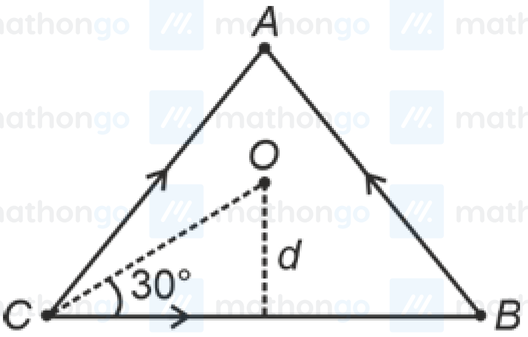
$\mathrm{p}=60 \mathrm{mR}^2$

Q11. At $t=1$
(90) $r_{AB}=-1 \hat{i}+(3 n+1) \hat{j}+(2-4 p) \hat{k}$

At $t=1$

$$v_A = 2\hat{i} + 3n\hat{j} + 2\hat{k}$$
$$v_B = 2\hat{i} - 2\hat{j} + 4p\hat{k}$$
$$\vec{v}_A - \vec{v}_B = 0, \quad 4 - 6n + 8p = 0$$
$$|v_A| = |v_B| \quad (3n)^2 + 4 = 4 + 16p^2$$
$$3n = -4p$$
$$4 + 16p = 0$$
$$p = -\frac{1}{4}, n = \frac{1}{3}$$
$$r_{AB} = -\hat{i} + 2\hat{j} + 3\hat{k}$$
$$v_A = 2\hat{i} + \hat{j} + 2\hat{k}$$
$$\therefore L = m\left|\vec{r}_{AB} \times \vec{v}_A\right| = 90$$

Q12.
(3)



$d = \frac{a}{2\sqrt{3}}$

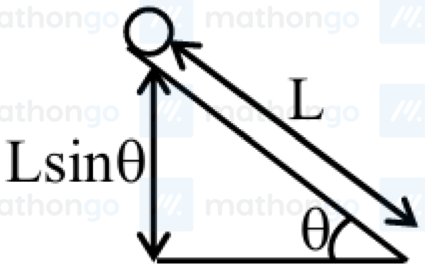
Angular momentum of one mass about point O

$$L = mvd$$
$$= mv_0 \cdot \frac{a}{2\sqrt{3}}$$

Net angular momentum about point O

$$L_{\text{net}} = 32$$
$$= \frac{\sqrt{3}mv_0 a}{2}$$

Q13.
(1)



using WET

$\mathrm{W_g = k_f - k_i}$

$\mathrm{Mg\, L \sin\theta = k_f - k_i}$

K.E. in pure rolling $\frac{1}{2}\mathrm{mV_{cm}^2} + \frac{1}{2}\mathrm{I_{cm}}\omega^2$

$$= \frac{1}{2}\mathrm{mV}^2 + \frac{1}{2} \times \frac{2}{5}\mathrm{mR}^2\frac{\mathrm{V}^2}{\mathrm{R}^2}$$

$$\frac{7}{10}\mathrm{mV}^2$$

$$\mathrm{mgL}\sin\theta = \tfrac{7}{10}\mathrm{mV}_\mathrm{f}^2 - 0$$

$$\mathrm{V}_\mathrm{f}^2 \propto \sin\theta$$

$$\left(\frac{\mathrm{V}_1}{\mathrm{V}_2}\right)^2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sin 30^\circ}{\sin 45^\circ} = \frac{1}{\sqrt{2}}$$

Q1.
(3)

$V_{\text{escape}} = \sqrt{\frac{2GM}{R}}$

$\frac{(V_{\text{escape}})_{\text{Planet}}}{(V_{\text{escape}})_{\text{Earth}}} = \sqrt{\left(\frac{M_P}{M_E}\right) \times \left(\frac{R_E}{R_P}\right)} = \frac{1}{2}$

$(V_{\text{escape}})_{\text{Planet}} = \frac{1}{2}(V_{\text{escape}})_{\text{Earth}} = 5.6 \text{ km/s}$

Q2.
(9)

$\because$ acceleration due to gravity on surface is given by

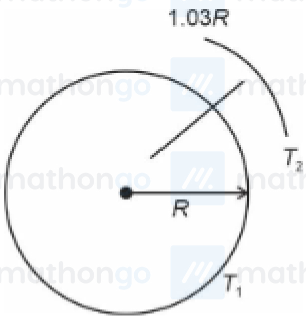
$g = \frac{GM}{R_e^2}$

Now since diameter is reduced to $1/3^{\text{rd}}$, radius also reduces to $1/3^{\text{rd}}$, keeping mass constant

New value of acceleration due to gravity on Earth's surface is

$g' = \frac{GM}{\left(\frac{R_e}{3}\right)^2} = 9\frac{GMe}{R_e^2} = 9\text{ g}$

Q3.
(3)



$T_1 \propto (R)^{3/2}$

and $T_2 \propto (1.03R)^{3/2}$

$\Rightarrow \quad T_2 = (1.03R)^{3/2} \cdot T_1 \approx 1.045T_1$

So T_2 will larger by 4.5% w.r.t. T_1.

Q4.
(2)

$T^2 \propto R^3$

$\left(\frac{T_m}{T_s}\right)^2 = \left(\frac{R}{R/9}\right)^3$

$\frac{T_m}{T_s} = (3)^3$

$\Rightarrow \ T_s = \left(\frac{27}{27}\right) = 1 \text{ day}$

Q5.
(8)

$L = mv_0R = m\sqrt{\frac{GM}{R}}R = m\sqrt{GMR}$

here M is mass of star

$\frac{L_B}{L_A} = \frac{m_B}{m_A}\sqrt{\frac{R_B}{R_A}}$

$= 4\sqrt{2}\sqrt{\frac{2}{1}}$

$\frac{L_B}{L_A} = 8$

Q6.
(1)

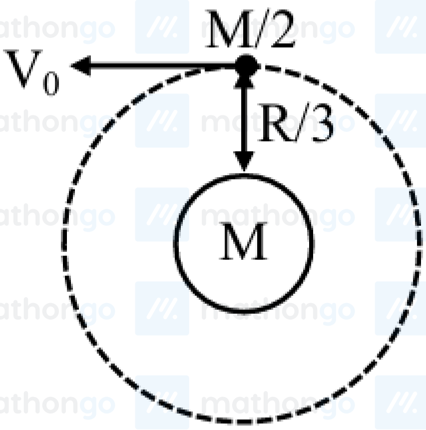
$$F_1 = \frac{GMm}{(2R)^2} \ldots\ldots (1)$$

$$F_2 = \frac{GMm}{(2R)^2} - \left(\frac{G\left(\frac{M}{27}\right)m}{\left(\frac{4R}{3}\right)^2}\right)$$

$$F_2 = \frac{11}{48}\frac{GMm}{R^2} \ldots\ldots (2)$$

$$F_1 : F_2 = 12 : 11$$

Q7.
(3)



orbital velocity $v_0 = \sqrt{\frac{GM}{4R/3}} = \sqrt{\frac{3GM}{4R}}$

Angular momentum of satellite $= \frac{M}{2} v_0 \frac{4R}{3}$

$= \frac{M}{2} \cdot \sqrt{\frac{3GM}{4R}} \cdot \frac{4R}{3}$

$= M\sqrt{\frac{GMR}{3}}$

$x = 3$

Q1. $B = \frac{\Delta P}{\frac{\Delta V}{V}}$
(50)

$\Delta V = \frac{7 \times 10^6}{1.4 \times 10^{11}} \times \left(10 \times 10^{-2}\right)^3$
$\Delta V = 50 \text{ mm}^3$

Q2. Since bulk modulus is given as
(43) $B = \frac{-\Delta P}{\left(\frac{\Delta V}{V}\right)}$

$2.15 \times 10^9 = \frac{-\Delta P}{-\left(\frac{0.2}{100}\right)}$

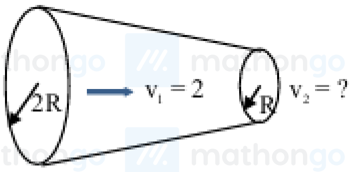
$\Delta P = 2.15 \times 10^9 \times 2 \times 10^{-3}$
$= 4.3 \times 10^6 = 43 \times 10^5 \text{ N/m}^2$

Q3. $B = \frac{\rho gh}{\left(\frac{\Delta v}{v}\right)}$
(1)

$\frac{\Delta v}{v} \times 100 = \frac{\rho gh}{B} \times 100$

$\frac{1000 \times 10 \times 2.5 \times 10^3}{2 \times 10^9} \times 100\%$
$= 1.25\%$

Q1.
(4)



$A_1 V_1 = A_2 V_2 \Rightarrow 2\pi(2R)^2 = V_2 \pi R^2$
$\therefore\ V_2 = 8\ \mathrm{m/s}$

Q2. $R = \frac{R_2 R_1}{R_2 - R_1} = \frac{4 \times 2}{2} = 4\ \mathrm{cm}$
(4)

Q3. Hot water is less viscous then cold water.
(1) Surfactant reduces surface tension.

Q4. Step 1: Consider the Force at a Distance x
(1) When the tube rotates with angular velocity ω, each element of the liquid experiences a centrifugal force.

The force at a distance x from the pivot can be found by considering the differential force due to an element of liquid.

$dF = \rho A dx \omega^2 x$

where ρ is the volumetric mass density of the liquid.

Step 2: Find the Volumetric Mass Density

Since the mass of the liquid is $2M$, the length of the tube is 1 m, and let the area of cross-section is A, the volumetric mass density is:

$\rho = \frac{2M}{AL} = \frac{2M}{A}$

Step 3: Calculate the Total Force at the Other End

The force at $x = L$ is obtained by integrating:

$$F = \int_0^L \rho x \omega^2 dx$$

$$F = 2M\omega^2 \int_0^1 x dx$$

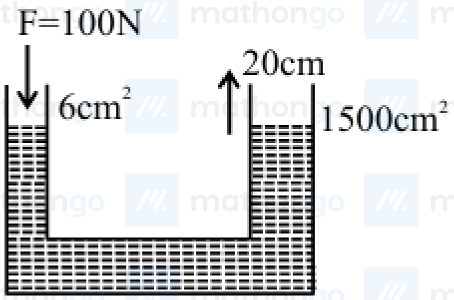
$$F = \frac{2M\omega^2}{2} = M\omega^2$$

Step 4: Solve for ω

$$\omega^2 = \frac{F}{M}$$

$$\omega = \sqrt{\frac{F}{M}}$$

Q5.
(5)



$$\frac{F_1}{A_1} = \frac{F_2}{A_2}, \frac{100}{6} = \frac{F}{1500}, F = \frac{50}{3} \times 1500$$

$$F = 50 \times 500 = 25 \times 10^3 \text{ N}$$

$$\omega = \vec{F} . \vec{S} = 25 \times 10^3 \times \frac{20}{100}$$

$$= 5 \times 10^3 = 5 \text{ kJ}$$

Q6. Volume of cube inside water
(2)

$$= \left(\frac{\text{Denslty of cube}}{\text{Denslty of water}}\right) \times \text{ Volume of cube}$$

$$= \frac{\text{Mass of cube}}{\text{Denslty of water}}$$

$$= \frac{400 \text{gm}}{1 \text{gm}/\text{cm}^3}$$

$$= 400 \text{ cm}^3$$

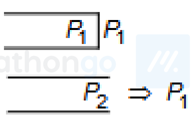
Volume of cube outside water

$$= \text{Volume of cube } - \text{Volume of cube inside water}$$

$$= 1000 \text{ cm}^3 - 400 \text{ cm}^3$$

$$= 600 \text{ cm}^3$$

Q7.
(4)

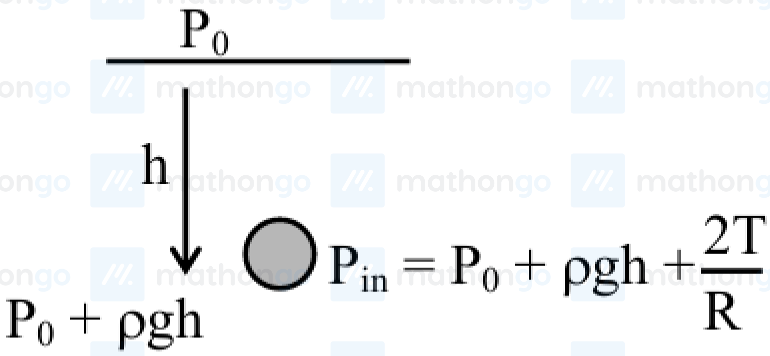


Using Bernoulli's theorem

$$P_1 - P_2 = \frac{1}{2} \rho v^2$$

$$v \propto \sqrt{P_1 - P_2}$$

Q8.
(2190)



$\Delta P = P_{in} - P_0$

$= \rho gh + \frac{2T}{R} = \frac{1000 \times 10 \times 20}{100} + \frac{2 \times 0.095}{10^{-3}}$

$= 2000 + 190$

$= 2190$

Q9.
(1)

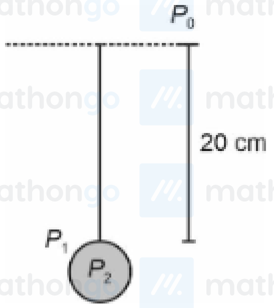
$W_1 = s4\pi\left(\frac{R}{3}\right)^2 \times 27 - 4\pi R^2 \cdot s$

$\Rightarrow W_1 = 4\pi R^2 \cdot s(2) = 10$ Joule

Now, $W_2 = s4\pi R^2(4-1) = 4\pi R^2 s \times 3$

$\Rightarrow \quad W_2 = 3 \times \frac{10}{2} = 15$ Joule

Q10.
(2)



$P_1 = P_0 + \rho gh = P_0 + 1000 \times 10 \times \frac{20}{100}$

$\Rightarrow P_1 = P_0 + 2000$

So, $P_2 - P_1 = \frac{2S}{R} = \left(\frac{2S}{1 \times 10^{-3}}\right)$

$\Rightarrow P_2 = P_0 + 2100$

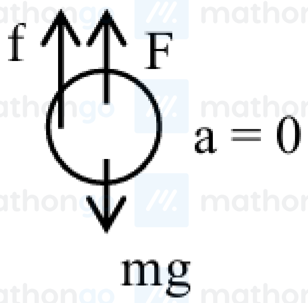
(given)

So, $P_0 + 2100 - P_0 - 2000 = 2S \times 10^3$

$\Rightarrow 100 = 2S \times 10^3$

$\Rightarrow s = \left(\frac{1}{20}\right) = 0.05$

Q11.
(4)



$$\mathrm{mg}-\mathrm{F_B}-\mathrm{f}=0$$
$$\Rightarrow \mathrm{mg}-\frac{\mathrm{mg}}{2}-\mathrm{f}=0$$
$$\therefore \mathrm{f}=\frac{\mathrm{mg}}{2}$$

Q12.
(3)
The terminal velocity of ball of radius R inside a liquid of viscosity η can be written as $V_T=\frac{2R^2g}{3n}(\sigma-\rho)$, where σ is the density of ball and δ is the density of the liquid.

Hence,
A is correct since $V_T \propto R^2$ gives a parabola on a graph
C is correct since $V_T\alpha\frac{1}{\eta}$ and η varies with temperature
D is correct since $V_T\alpha(\sigma-\rho)$ i.e., varies with density of liquid.

Q13.
(1)
Surface tension arises due to extra energy of the molecules at the molecules at the surface as compared at the interior of a liquid. The coefficient of viscosity for a liquid decreases with rise in temperature where as it increases for gases with increase in temperature. The flow is turbulent for a Reynold's number greater than 2000. Stream lines never intersect in a steady flow.

Q14.
(54)
For a thin film interference, a fringe for transmission is formed.
When
$2\mu x=n\lambda$
$$\Rightarrow \frac{dx}{dt}=\left(\frac{dn}{dt}\right)\frac{\lambda}{2\mu}$$
$$=\left(\frac{1}{12}\right)\frac{560\times10^{-9}}{2\times1.4}=\frac{5}{3}\times10^{-8}\ \mathrm{m/s}$$
$V=$ Volume of film $=\pi R^2 x$
$$\frac{dV}{dt}=\pi R^2\frac{dx}{dt}$$
$$=\pi\left(1.8\times10^{-2}\right)^2\frac{5}{3}\times10^{-8}\ \mathrm{m^3/s}$$
$$=54\pi\times10^{-13}\ \mathrm{m^3/s}$$

Q1. A = 1 cm
(4)

$\mathrm{n} = \frac{12.5}{2} = 6.25$ cycles

$\therefore \mathrm{D} = 4 \times 6 + 1 = 25$

$\mathrm{d} = 1$

$\frac{D}{d} = 25$

Q2. $\mathrm{V}_1 = \mathrm{A}_1\omega_1$
(2)
$\mathrm{V}_2 = \mathrm{A}_2\omega_2$

$\mathrm{A}_1 = \mathrm{A}_2$

$$\frac{\mathrm{V}_1}{\mathrm{V}_2} = \frac{\omega_1}{\omega_2} = \frac{\sqrt{\frac{\mathrm{K}_1}{\mathrm{m}}}}{\sqrt{\frac{\mathrm{K}_2}{\mathrm{m}}}}$$

$$\frac{\mathrm{V}_1}{\mathrm{V}_2} = \sqrt{\frac{\mathrm{K}_1}{\mathrm{K}_2}}$$

Q3. $g = \frac{GM}{R^2}$
(4)

$$g' = \frac{G(4M)}{(2R)^2} = g$$

A is correct, R is correct ; but since $T = 2\pi\sqrt{\frac{\ell}{g}}$ doesn't depend on mass ; R doesn't explain A.

Q4. If we express position $x(t) = A\sin(\omega t + \phi)$
(4)
then $x_0 = A\sin\phi$

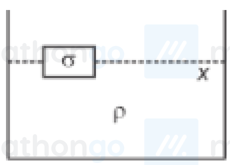
$v_0 = A\omega\cos\phi$

$\Rightarrow \tan\phi = \frac{\omega x_0}{v_0}$

$$A = \sqrt{x_0^2 + \frac{v_0^2}{\omega^2}}$$

Hence both position and linear momentum of a particle can be expressed as a function of time if we know initial momentum and position

Q5. Additional buoyant force
(2)



$g\rho a^2 x = \sigma a^3 A$

$A = \dfrac{\rho}{\sigma}\dfrac{g}{a}x$

$T = 2\pi\sqrt{\dfrac{\sigma a}{\rho g}}$

Now, $\sigma = \frac{10\times10^{-3}}{10^{-3}} = 10$

$\Rightarrow \quad T = 2\pi\sqrt{\dfrac{10\times0.1}{10^3\times10}}$

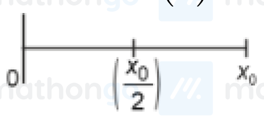
$= 2\pi\times10^{-2}$

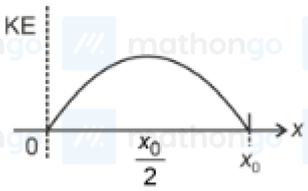
Q6. As h increases, g decreases, T increases
(1)

$\mathrm{T} = 2\pi\sqrt{\dfrac{\ell}{\mathrm{g}}}$

$\mathrm{g} = \dfrac{\mathrm{g_0R^2}}{(\mathrm{R}+\mathrm{h})^2}$

Q7. $x(t) = x_0\sin^2\left(\frac{t}{2}\right) = \frac{x_0}{2}(1-\cos t)$
(4)





Clearly $\frac{x_0}{2}$ is mean position.

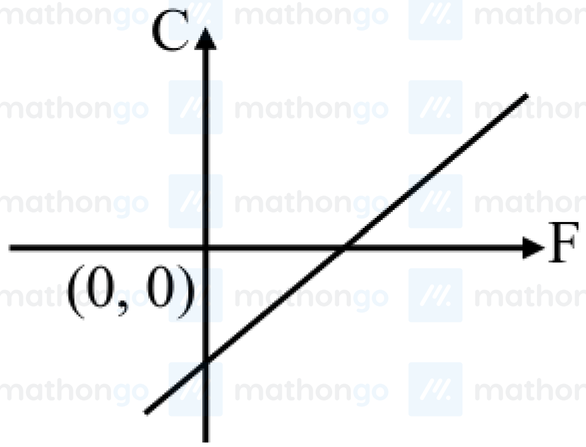
Q1. (2)
$k = 20 \times 10^{-3}\ \mathrm{mm}^{-1} = 20\ \mathrm{m}^{-1}$
$w = 600\ \mathrm{s}^{-1}$
$v = \frac{W}{k} = \frac{600}{20} = 30\ \mathrm{m/s}$
and $x \& t$ carry same sign
Therefore $\mathrm{v} = -30\ \mathrm{m/s}$

Q2. (4)
9^{th} harmonic of closed pipe $= \frac{9\ \mathrm{V}_1}{4\ell_1}$
4^{th} harmonic of open pipe $= \frac{2\ \mathrm{V}_2}{\ell_2}$
$\therefore \frac{9\ \mathrm{V}_1}{4\ell_1} = \frac{2\ \mathrm{V}_2}{\ell_2}$
$\therefore \frac{9}{4\ell_1}\sqrt{\frac{\mathrm{B}}{\rho_1}} = \frac{2}{\ell_2}\sqrt{\frac{\mathrm{B}}{\rho_2}} \Rightarrow \frac{\ell_2}{\ell_1} = \frac{8}{9}\sqrt{\frac{\rho_1}{\rho_2}}$
$\ell_2 = \ell_1 \times \frac{8}{9} \times \frac{1}{4} = \frac{20}{9}\ \mathrm{cm}$

Q3. (2)
Speed of sound in a medium depends on inertial and elastic properties as $v = \sqrt{\frac{B}{P}}$ for gases and $v = \sqrt{\frac{Y}{P}}$ for solids. Since the elastic property of solid happens to be many folds greater than that of gases, the speed of sound in solids i5 higher than in gases.
Also, bulk modulus of gases varies between 0 and ∞ $\left(B = -v\frac{dP}{dv}\right)$ hence reason is false.

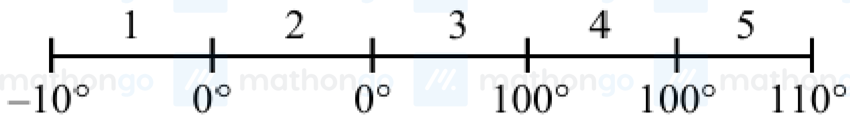
Q1. $\frac{C}{5}=\frac{F-32}{9} \Rightarrow C=\frac{5F}{9}-\frac{160}{9}$

(4)



Q2.

(1)



$\Delta Q_1 = m \times S_1 \times \Delta T = 10^{-3} \times 2100 \times 10 = 21$ J
$\Delta Q_2 = m \times L_f = 10^{-3} \times 3.35 \times 10^5 = 335$ J
$\Delta Q_3 = m \times S_w \times \Delta T = 10^{-3} \times 4180 \times 100 = 418$ J
$\Delta Q_4 = m \times L_v = 10^{-3} \times 2.25 \times 10^6 = 2250$ J
$\Delta Q_5 = m \times S_v \times \Delta T = 10^{-3} \times 1920 \times 10 = 19.2$ J
$\Delta Q_{net} = 3043.2$ J

Q3. $625 = ms\Delta T + mL$

(1) $625 = m\left[125 \times 300 + 2.5 \times 10^4\right]$

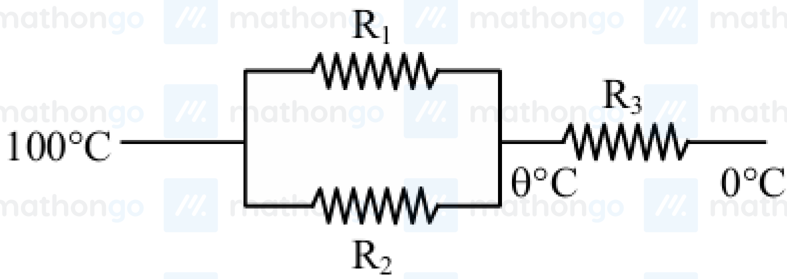
$625 = m[37500 + 25000]$

$625 = m[62500]$

$m = \frac{1}{100}$ kg

$M = 10$ grams

Q4.
(40)



$R_1 = \frac{2\,L}{K_1\,A}$

$R_2 = \frac{2\,L}{K_2\,A}$

$R_3 = \frac{L}{K_3\,A}$

$\frac{\theta - 100}{\frac{R_1 R_2}{R_1 + R_2}} + \frac{\theta - 0}{R_3} = 0$

$\theta = 40$

Q5. $\frac{d\theta}{dt} = \sigma e A T^4 \Rightarrow P \propto A T^4$

(2)

$\frac{P_{smaller}}{P_{larger}} = \frac{(0.2)^2 \times 800^4}{(0.8)^2 \times 400^4}$

$\frac{1}{16} \times 16 = 1$

$\therefore P_{larger} = P_{smaller}$

Q6. By using average form of Newton's law of cooling

(4)

$\frac{90-80}{t} = k\left(\frac{90+80}{2} - 20\right)$

$\frac{80-60}{t'} = k\left(\frac{80+60}{2} - 20\right)$

(i)/(ii)

$\frac{10 \times t'}{t \times 20} = \frac{65}{50}$

$t' = \frac{65}{50} \times 2t = \frac{65}{25}t = \frac{13}{5}t$

Q7. $\Delta T = T_2 - T_1 = 16^{\circ}\mathrm{C}$

(4) And $T_0 = 16^{\circ}\mathrm{C}$

$$\frac{\Delta T}{t_1} = -k\left(32 - 16^{\circ}\right)\ldots(i)$$

$$\frac{(24 - T_3)}{4} = -k\left(\frac{24 + T_3}{2} - 16\right)\ldots.(ii)$$

$$\frac{16}{4} = -k(16)$$

$$\Rightarrow \frac{(24 - T_3)}{4} = -k\left(12 + \frac{T_3}{2} - 16\right)$$

$$\Rightarrow \frac{16}{24 - T_3} = \frac{16}{T_3}T_2$$

$$\Rightarrow \frac{T_3}{2} - 4 = 24 - T_3$$

$$\Rightarrow \frac{3T_3}{2} = 28$$

$$\Rightarrow T_3 = \frac{56}{3}{}^{\circ}\mathrm{C}$$

Q1. Extensive variables depend on size and amount of system.
(4) Extensive : Volume, mass, internal energy

Intensive : Pressure, temperature, density

Q2. Given that
(3) $\mathrm{P} = \mathrm{kT}$

$\frac{\mathrm{P}}{\mathrm{T}} = \text{ constant}$

$\therefore$ Volume is constant or isochoric process.

$\therefore \mathrm{W_D} = 0$

$\therefore \mathrm{Q} = \Delta \mathrm{U}$

Also temperature increases hence internal energy increases.

Q3. If the container is insulated then temperature is expected to increase in adiabatic compression. So (A) is wrong.
(2) And free expansion is irreversible and adiabatic process. So (R) is correct.

Q4. $V = \text{ constant}$
(327) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$P_2 = 2P_1$

$T_2 = 2T_1$

$= 2 \times 300 = 600 \mathrm{~K}$

$\therefore = 327^{\circ}\mathrm{C}$

Q5. For rigid diatomic molecules
(3) $f = 5$

$\therefore \quad \gamma_1 = \frac{7}{5} = 1.4$

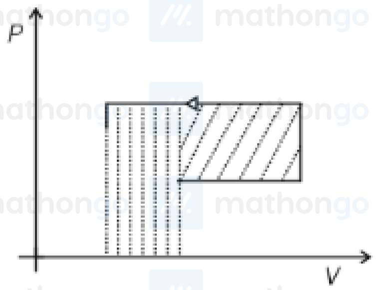
For non-rigid diatomic molecules

$f = 5 + 2 = 7$

$\gamma_2 = \frac{9}{7} = 1.28$

$\therefore \quad \gamma_1 > \gamma_2$

Q6.
(3)



Area under graph will be magnitude of graph and being counterclockwise graph it would be negative

Area $= 2P_0 \times V_0 + P_0 V_0 = 3P_0 V_0$

$\mathrm{W} = -3P_0 V_0$

Q7. Given that process is isobaric $\Delta \mathrm{T} = 50^{\circ}\mathrm{C}$
(15) Q in isobaric process $= \mathrm{nC_p} \Delta \mathrm{T} = \mathrm{E_1}$

$\Delta \mathrm{U}$ in isobaric process $= \mathrm{nC_v} \Delta \mathrm{T} = \mathrm{E_2}$

$\therefore \frac{E_1}{E_2} = \frac{C_P}{C_V} = \gamma$

Given, gas is monoatomic

$\therefore \gamma = 1 + \frac{2}{f}$

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

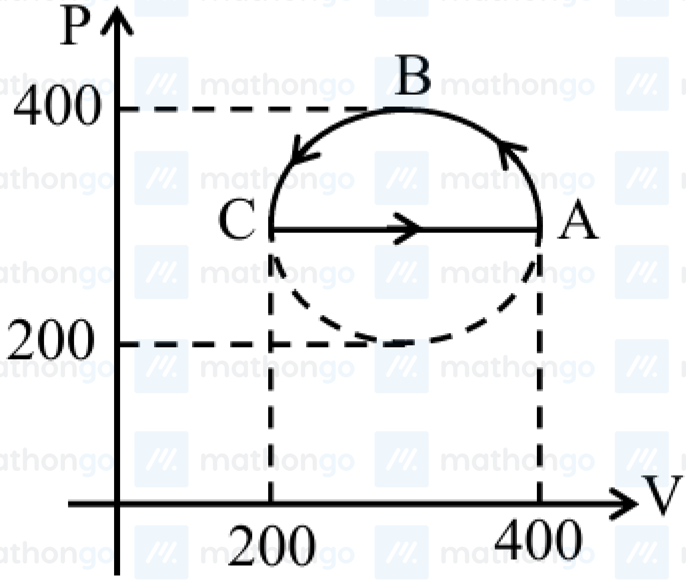
$= \frac{5}{3}$

Now, as per question.

$\frac{5}{3} = \frac{x}{9}$

$x = 15$

Q8.
(1)



$W = \frac{1}{2}\pi R^2$

$= \frac{1}{2} \times \pi \times \left(\frac{200}{2} \times 10^3\right) \times \frac{200}{2} \times 10^{-6}$

$= \frac{10\pi}{2} = 5\pi \text{ J}$

Q9.
(273)

$\gamma = \frac{3}{2}$

$Tv^{\gamma-1} = C$

$273\ V_0^{0.5} = T\left(\frac{V_0}{4}\right)^{0.5}$

$T = 273 \times 2 = 546$

$\Delta\ T = 273$

Q10.
(1)

$A \rightarrow P \propto \frac{1}{V}$

$\Rightarrow PV = \text{ constant}$

$\Rightarrow nRT = \text{ const. } \Rightarrow T = \text{ const.}$

Hence Isothermal III

$B \rightarrow IV$

$W \neq 0, \Delta U \neq 0, \Delta Q \neq 0$ [only isobaric]

$C \rightarrow I \Delta Q = 0$ Adiabatic

$D \rightarrow II$ $w = 0$ Isochoric

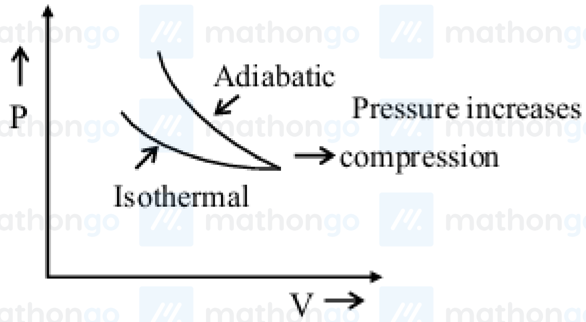
III IV I II

Q11. Work done in adiabatic process $= \frac{nR\Delta T}{1-\gamma}$

(1) So, depends upon change in temperature.

Q12.

(1)



$$\left(\frac{dP}{dV}\right)_{\text{Adiabatic}} > \left(\frac{dP}{dV}\right)_{\text{Isothermal}}$$

Q13. $dQ = msdT$

(1) $dS = \frac{dQ}{T} = \frac{msdT}{T}$

$$\Delta S = \int \frac{msdT}{T} = ms \ln \frac{T_f}{T_i}$$

$$\Delta S = m \ln \frac{T_2}{T_1}$$

Q14. Efficiencies of a carnot engine $\eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$

(4) $\Rightarrow \eta_1 = 1 - \frac{373\text{ K}}{473\text{ K}} = \frac{100}{473}$

$$\eta_2 = 1 - \frac{273\text{ K}}{373\text{ K}} = \frac{100}{373}$$

$$\eta_{12} = 1 - \frac{273\text{ K}}{473\text{ K}} = \frac{100}{473}$$

$$\eta_{12} - \eta_1 = \frac{200}{473} - \frac{100}{473} = \frac{100}{473} < \frac{100}{373}$$

$\Rightarrow \eta_{12} - \eta_1 < \eta_2$

or $\eta_{12} < \eta_1 + \eta_2$

Q15. $\Delta Q_{AB} = 0$ adiabatic

(2) $\Delta Q_{BC} = \Delta W_{BC}$

$$= nRT\ell n\left(\frac{V_C}{V_B}\right) = 450R\ell n\left(\frac{8 \times 10^{-6}}{6 \times 10^{-6}}\right)$$

$$= 450R\ell n\left(\frac{4}{3}\right) = 450R(\ln 4 - \ell n3)$$

$\therefore \Delta Q = \Delta Q_{AB} + \Delta Q_{BC}$

$\Delta Q = 450R(\ell n4 - \ell n3)$

Q1. $V_{ms} = \sqrt{\frac{3RT}{M}}$
(2)
$V_{rms}^2 = 3RT/M$

Hence we can conclude that V_{rms}^2 is directly proportional to temperature

$y = mx$

$\Rightarrow$ Graph will be straight line

Q2. (Vapor density) $= \left(\frac{\text{Molar mass}}{2}\right)$, I.e, $vd = \frac{M}{2}$
(3)
$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$\frac{v_2}{v_1} = \sqrt{\frac{M_1}{M_2}} = \sqrt{\frac{25}{4}} = \frac{5}{2}$

Q3. Kinetic energy of translation $= \frac{3}{2}nRT$
(2)
$n = \frac{50\text{ g}}{44\text{ g}} = \frac{25}{22}$ mol

$T = 17^\circ\text{C} = 290\text{ K}$

$\Rightarrow$ Kinetic energy of translation

$= \frac{3}{2}\left(\frac{25}{22}\right)(8.3)(290)\text{J}$

$= 4102.8\text{ J}$

Q1. Given:
(2) - The electric potential of A is V_0
- The electric field of A is E_0.

We need to determine the electric potential and electric field at point 8.

Step El: Electric Potential of a Dipole

The electric potential V due to a short dipole at a point at distance r is:

$V=\frac{1}{4\pi\varepsilon_0}\cdot\frac{p\cdot\hat{r}}{r^2}$

On the axial line (Point A at distance r):

On the equatorial line (Point B at distance 2r):

Since the dipole potential is given by:

$V_A=\frac{1}{4\pi\varepsilon_0}\cdot\frac{p}{r^2}=V_0$

$V=\frac{1}{4\pi c_0}\cdot\frac{p\cos\theta}{r^2}$

and on the equatorial line $\theta=90^\circ\Rightarrow\cos 90^\circ=0$,

$V_g=0$

Thus, the electric potential at 8 is zero.

Step 2: Electric Field of a Dipole

The magnitude of the electric field at a distance r from a dipole:

On the axial line:

$B_{\pi kul}=\frac{1}{4\pi c_0}\cdot\frac{2p}{r^3}$

Given that of A (on the axial line of r), the field is E_0 :

$E_A=E_n=\frac{1}{4\pi\varepsilon_0}\cdot\frac{2p}{r^1}$

On the equatorial line:

$E_{\text{nquatiol}}=\frac{1}{4\pi c_0}\cdot\frac{p}{r^3}$

At B (distance 2r):

$E_s=\frac{1}{4\pi c_0}\cdot\frac{p}{(2r)^3}=\frac{1}{4\pi c_0}\cdot\frac{p}{6r^3}$

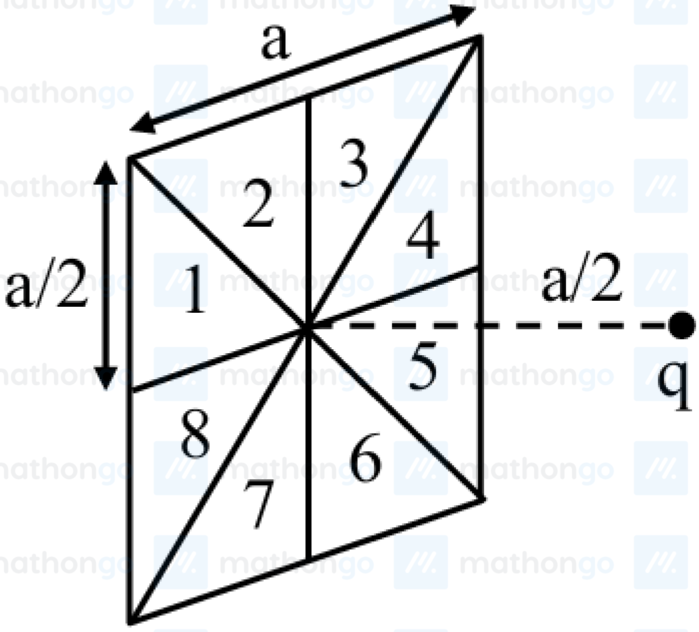
Since $E_0=\frac{1}{4m_1}\cdot\frac{2p}{p}$, we con express E_n in terms of E_0 :

$E_n=\frac{E_0}{16}$

Final Answer:

- Electric potential at $\mathrm{E}=0$
- Electric field ot $\mathrm{B}=\frac{N_y}{10}$

Q2.
(48)



Total flux through square $= \frac{q}{\epsilon_0}\left(\frac{1}{6}\right)$

Lets divide square is 8 equal parts.

Flux is same for each part.

$\therefore$ Flux through shaded portion is $\frac{5}{8}$ (Total flux)

$= \frac{5}{8} \times \frac{q}{\epsilon_0}\frac{1}{6} = \frac{5}{48}\frac{1}{\epsilon_0}$

$\therefore$ required Ans. is 48

Q3.
(4)

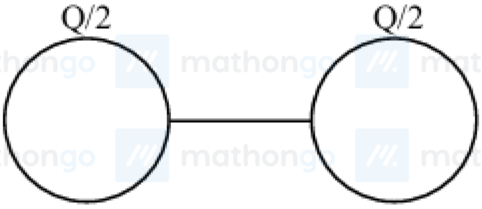
$$\text{Flux } (\phi) = \frac{\theta_{\text{inc}}}{\epsilon_0}$$

$$\theta_{\text{inc}} = \epsilon_0\phi$$
$$= -17.7 \times 10^{-8}\text{C}$$

Q4.
(5)

$$F_e = \frac{kq_1q_2}{r^2}$$
$$F_g = \frac{Gm_1m_2}{r^2}$$
$$\frac{F_e}{F_g} = \frac{kq_1q_2}{Gm_1m_2}$$
$$= \frac{9 \times 10^9 \times 6.67 \times 10^{-19} \times 9.6 \times 10^{-10}}{6.67 \times 10^{-11} \times 19.2 \times 10^{-27} \times 9 \times 10^{-27}}$$
$$= \frac{10^{-20}}{2 \times 10^{-65}}$$

Q5.
(2)



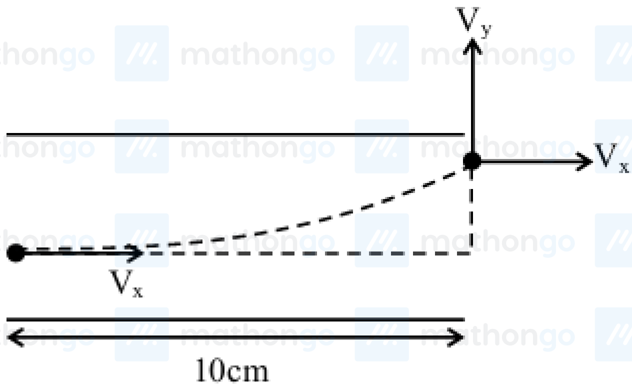
$$F = \frac{k\left(\frac{\theta}{2}\right)\left(\frac{\theta}{2}\right)}{r^2}$$

$$9 \times 10^{-3} = \frac{9 \times 10^9 \times \left(4 \times 10^{-8}\right) \times 4 \times 10^{-8}}{4 \times r^2}$$

$$r^2 = \frac{9 \times 10^9 \times 16 \times 10^{-16}}{4 \times 9 \times 10^{-3}} = 4 \times 10^{-4}$$

$$r = 2 \times 10^{-2}\ \mathrm{m} \Rightarrow 2\ \mathrm{cm}$$

Q6.
(3)



$$\Rightarrow t = \frac{\ell}{V_x} = \frac{10 \times 10^{-2}}{10^6} = 10^{-7}$$

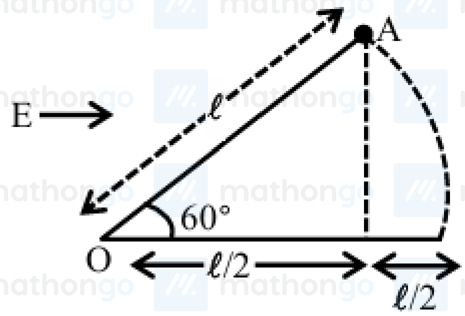
$$\Rightarrow V_y = u_y + a_y t$$

$$\Rightarrow V_y = 0 + \frac{eE}{m} \times 10^{-7}$$

$$\Rightarrow V_y = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31}} \times 9.1 \times 10^{-2} \times 10^{-7}$$

$$\Rightarrow V_y = 16 \times 10^6$$

Q7.
(2)



$W_{all} = \Delta k$
$W_e = k_f - k_i$
$qE\frac{\ell}{2} = \frac{1}{2}mv^2 - 0$
$v = \sqrt{\frac{qE\ell}{m}}$

Q8. Inside uniformly charged spherical shell, $E = 0$
(1) $\therefore A \to III$
For uniformly charged infinite plate
$E = \frac{\sigma}{2\varepsilon_0}$
$\therefore B \to II$
Outside of spherical shell
$E = \frac{Q}{4\pi\varepsilon_0 r_2} = \frac{\sigma R^2}{\varepsilon_0 r^2}$
$\therefore C \to IV$
Between two plates $E = \frac{\sigma}{\varepsilon_0}$
$\therefore D \to I$

Q9. P.E. of two charges
(1) $u = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$
$r = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$
$= 14\ \text{cm}$
$\therefore u = \frac{9 \times 10^9 \times 7 \times 10^{-6} \times (-4) \times 10^{-6}}{14 \times 10^{-2}}$
$= -1.8\ \text{J}$

Q10. $U = -PE\cos\theta$
(2) $w_{ext} = \Delta U = U_f - U_i = -PE\cos 180^\circ + PE\cos 0^\circ$
$w_{ext} = 2PE$
$= 2 \times \left(4 \times 10^{-6}\right)(18) \times 10^4$
$= 144 \times 10^{-2}$
$= 14.4\ \text{mJ}$

Q11. Work done in rotating a dipole $= \Delta U$

(12)

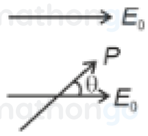
$$W = \left(-PE\cos\theta_f\right) - \left(-PE\cos\theta_i\right)$$

or $$= 2PE \quad \left(\because \theta_f = 180^\circ \text{ and } \theta_i = 0^\circ\right)$$

$$= \left(2 \times 6 \times 10^{-6} \times 10^{6}\right) \mathrm{J} = 12 \mathrm{~J}$$

Q12.

(4)



$\tau = PE_0 \sin\theta$

If θ is small

$$\tau = -\left(PE_0\right)\theta$$

$$I = m\left(\frac{l}{2}\right)^2 \cdot 2 = \frac{ml^2}{2}$$

$$T = 2\pi\sqrt{\frac{ml^2}{2 \cdot PE_0}} = 2\pi\sqrt{\frac{ml^2}{2 \cdot q/E_0}}$$

$$T = 2\pi\sqrt{\frac{ml}{2qE_0}}$$

Q13. Electric field due to sheet $E = \frac{\sigma}{2\varepsilon_0}$

(4) and torque on dipole $\dot{\tau} = \dot{P} \times \dot{E}$

here $\vec{\tau} = 0$

and $U = -\vec{P} \cdot \vec{E} \rightarrow$ should be minimum

Q14. Charge of the line charge $= \dfrac{a\lambda}{2}$

(4) Portion of wire inside cube $= \dfrac{1}{4}$

$$\therefore \quad q_{en} = \frac{1}{4}\left(\frac{a\lambda}{2}\right) = \frac{a\lambda}{8}$$

$$\phi = \frac{q_{en}}{\varepsilon_0} = \frac{a\lambda}{8\varepsilon_0}$$

Q15.

(4)

$$u_{\oplus} = \left(2\frac{Kq_0}{a} + \frac{Kq_0}{\sqrt{2}a}\right) q_0 \times 2$$

$$u_0 = \left(2\frac{Kq_0\sqrt{2}}{a} + \frac{Kq_0}{a}\right) q_0 \times 2$$

So, $$\Delta u = u_2 - u_1 = 2q_0\frac{kq_0}{a}\left[2\sqrt{2} + 1 - 2 - \frac{1}{\sqrt{2}}\right]$$

$$\Rightarrow \quad \Delta u = \frac{2q_0^2}{4\pi\varepsilon_0 a}\left[\frac{4 - \sqrt{2} - 1}{\sqrt{2}}\right] = \frac{2q_0^2}{4\pi\varepsilon_0 a}\frac{(3 - \sqrt{2})}{\sqrt{2}}$$

$$\Rightarrow \quad \Delta u = \frac{2kq_0^2}{a}\left[\frac{3 - \sqrt{2}}{\sqrt{2}}\right] = \frac{kq_0^2}{a}(3\sqrt{2} - 2)$$

Q16. Potential due to an infinite wire is $V = 2k\lambda \ln r$, where r is the distance from the wire.

(3) Taking the point in space $P(x, y, z)$

Distance from wire along x-axis is $r_x = \sqrt{y^2 + z^2}$

Distance from wire along y-axis is $r_y = \sqrt{x^2 + z^2}$

Distance from wire along z-axis is $r_z = \sqrt{x^2 + y^2}$

$\Rightarrow$ Potential at P due to wire along x-axis is

$V_x = 2k\lambda \ln r_x$

Potential at P due to wire along y-axis is

$V_y = 2k\lambda \ln r_y$

Potential at P due to wire along z-axis is

$V_z = 2k\lambda \ln r_z$

$\Rightarrow$ Not potential at $P = V = V_x + V_y + V_z$

or $\quad V = 2k\lambda \ln r_x + 2k\lambda \ln r_y + 2k\lambda \ln r_z$

i.e. $V = 2k\lambda \ln(r_x r_y r_z)$

or

$$V = 2k\lambda \ln\left(\sqrt{y^2+z^2}\sqrt{z^2+x^2}\sqrt{x^2+y^2}\right)$$

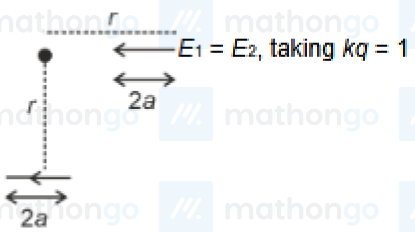
$$= k\lambda \ln(y^2+z^2)\,(z^2+x^2)\,(x^2+y^2)$$

$\Rightarrow$ For equipotential surface

$(x^2+y^2)\,(y^2+z^2)\,(z^2+x^2) = \text{ constant}$

Q17.

(4)



$$\Rightarrow \frac{1}{(r-a)^2} - \frac{1}{(r+a)^2} = \frac{2a}{(a^2+r^2)^{3/2}}$$

$$\frac{4ar}{(r^2-a^2)^2} = \frac{2a}{(a^2+r^2)^{3/2}}$$

$$(r^2-a^2)^2 = 2r(a^2+r^2)^{3/2}$$

$$\left(1-\frac{a^2}{r^2}\right)^2 = 2\left(1+\frac{a^2}{r^2}\right)^{3/2}$$

$$(1-x^2)^2 = 2(1+x^2)^{3/2}\left(x = \frac{a}{i}\right)$$

$$\frac{(1-x^2)^2}{(1+x^2)^{3/2}} = 2$$

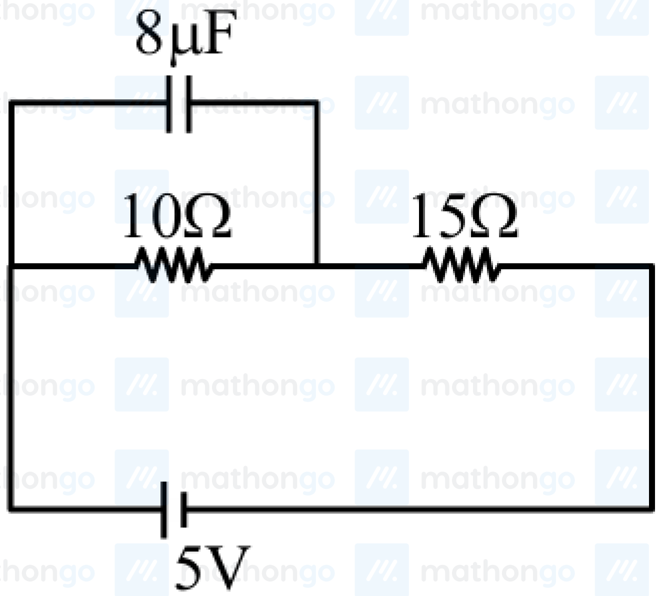
Now for $\mathrm{X} = 3$

We get $\frac{64}{10\sqrt{10}} \approx 2 \Rightarrow \frac{a}{r} \approx 3$

[But for $a > r$ point charge will between the dipole where $\vec{E} \neq 0$]

Q1.
(4)
For a capacitor at steady state
$q = CV$ and $U = \frac{1}{2}CV^2$
Since C_1 and C_2 are connected in parallel, $V_1 = V_2$.
Also from graph $q_1 < q_2$
$\Rightarrow \quad C_1V_1 < C_2V_2$
i.e. $C_1 < C_2$ or $C_2 > C_1$
$$\frac{U_1}{U_2} = \frac{C_1V_1^2}{C_2V_2^2} = \frac{C_1}{C_2} < 1$$
or $U_1 < U_2$ or $U_2 > U_1$

Q2.
(16)



$$\mathrm{i} = \left(\frac{5}{25}\right)$$
$$\mathrm{Q} = \mathrm{CV}$$
$$\mathrm{Q} = \left(8 \times 10^{-6}\right)\left(\frac{5}{25} \times 10\right)$$
$$\mathrm{Q} = \left(\frac{8 \times 5 \times 10^{-2}}{25}\right) = 16\mu\mathrm{C}$$

Q3.
(1)
$\Delta \mathrm{q} = (\mathrm{KC} - \mathrm{C})\mathrm{V}$
$= 40 \times 10^{-6} \times 100$
$= 4000 \times 10^{-3} = 4\mathrm{mC}$
$\Delta \mathrm{U} = \frac{1}{2}\mathrm{C}'\mathrm{V}^2 - \frac{1}{2}\mathrm{CV}^2 = \frac{1}{2}(\mathrm{K} - 1)\mathrm{CV}^2$
$= \frac{1}{2}\mathrm{CV}^2(2 - 1)$
$= \frac{1}{2}\mathrm{CV}^2 = \frac{1}{2} \times 40 \times 10^{-6} \times 10000$
$= 0.2\ \mathrm{J}$

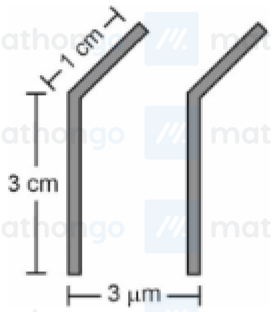
Q4. We know energy density
(2) $\rho_{\mathrm{av}}=\frac{1}{2}\varepsilon_0 E^2$
So potential energy $=\rho_{av}\times$ Volume
$\Rightarrow$ P.E. $=\frac{1}{2}\varepsilon_0 E^2 A d$

Q5.
(3)
$$\begin{aligned}\text{Energy density } & =\frac{1}{2}\varepsilon_0 E^2 \\ & =\frac{1}{2}\varepsilon_0\left(\frac{V}{d}\right)^2 \\ & =\frac{1}{2}\left(8.85\times10^{-12}\right)\left(\frac{20}{10^{-6}}\right)^2 \mathrm{~J/m^3} \\ & \simeq 1.8\times10^3 \mathrm{~J/m^3}\end{aligned}$$

Q6. $Q=cV$
(1320) $V=\frac{Q}{c}=\frac{it}{\left(\frac{\varepsilon_0 A}{d}\right)}$

$d=\frac{\varepsilon_0\pi r^2}{i}\left(\frac{v}{t}\right)$
Putting values
$$d=\frac{9\times10^{-12}\times\frac{22}{7}\times(0.1)^2}{0.15}\times\left(7\times10^8\right)$$
$=1320\mu$ m

Q7. Capacitor behaves like closed circuit at $t=0$ and charge is zero.
(4) AX, B✓, C✓, D✓

Q8.
(4)


We know $C=\frac{A\varepsilon_0}{d}$
$=\frac{b\ell\varepsilon_0}{d}$
So to increase the capacitance by 10 factor $\left(\frac{A}{d}\right)$ has to increase by 10 fator.
For option (A) $\quad C'=\frac{(30\ell)b\varepsilon_0}{\left(\frac{d}{3}\right)}=30\mathrm{C}$
For option (B) $\quad C'=\frac{\ell b\varepsilon_0}{10d}=\frac{C}{10}$
For option (C) $\quad C'=\frac{(2\ell)5b\varepsilon_0}{d}=10\mathrm{C}$
For option (D) $\quad C'=\frac{\left(\frac{\ell}{3}\right)b\varepsilon_0}{\left(\frac{10d}{3}\right)}=\frac{C}{10}$

For option (E) $C' = \frac{\left(\frac{\ell}{3}\right)5(2b)\varepsilon_0}{\left(\frac{d}{3}\right)} = 10C$

Clearly (C) and (E) are the situation for 10 C

Q9.
(100)

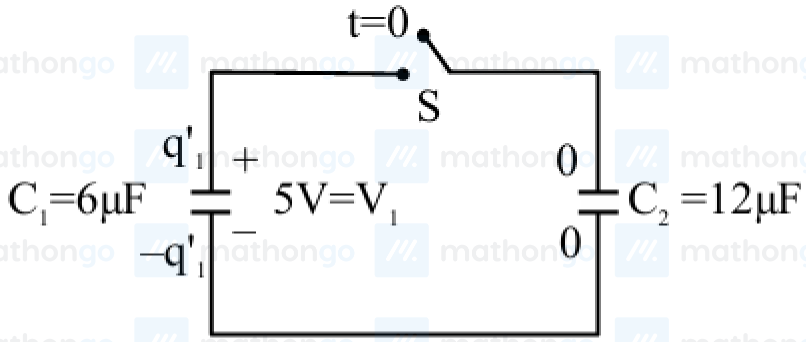
$\frac{\mathrm{CdV}}{\mathrm{dt}} = \mathrm{I_d}$

$\frac{\mathrm{dV}}{\mathrm{dt}} = \frac{\mathrm{I_d}}{\mathrm{C}}$

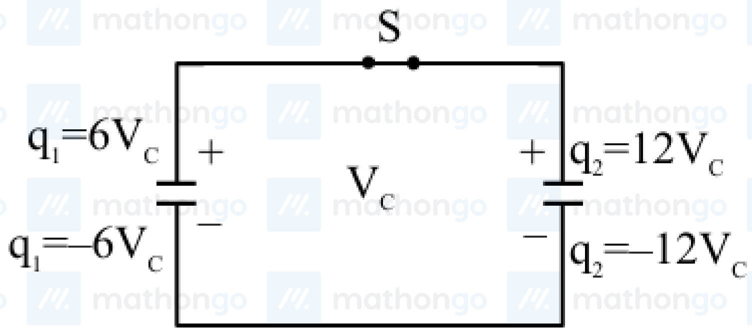
$= \frac{0.25 \times 10^{-3}}{2.5 \times 10^{-6}}$

$= 100$

Q10.
(1)



$\mathrm{q}_1' = 6 \times 5 = 30\mu\mathrm{C}$



Finally

$6\ \mathrm{V_C} + 12\ \mathrm{V_c} = 30 + 0$

$18\ \mathrm{V_C} = 30$

$\mathrm{V_C} = \frac{30}{18} = \frac{5}{3}\mathrm{Volt}$

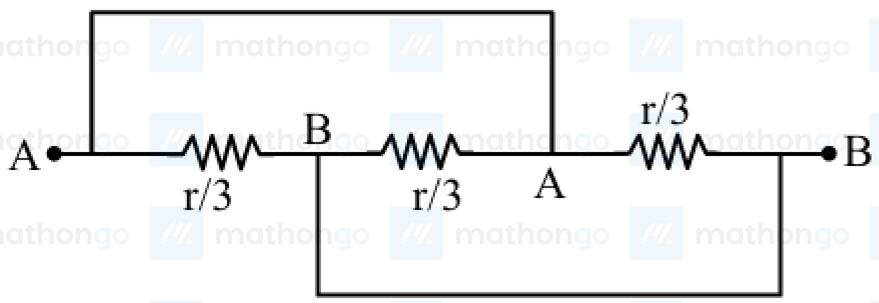
$\Rightarrow \mathrm{q}_1 = \frac{6 \times 5}{3} = 10\mu\mathrm{C}$

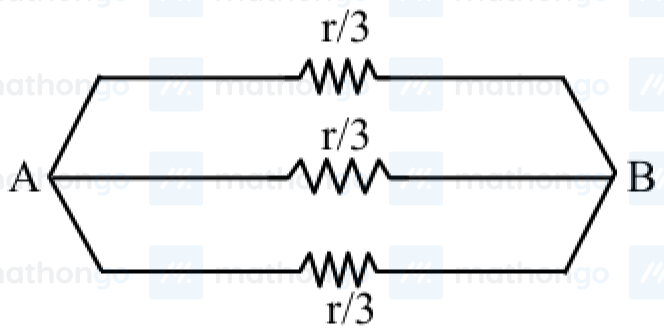
$\Rightarrow \mathrm{q}_2 = \frac{12 \times 5}{3} = 20\mu\mathrm{C}$

Q1. Resistivity is independent of temperature for wire bound resistors
(4)

Q2. Material should have low thermal conductivity and high electrical conductivity.
(4)

Q3.
(1)





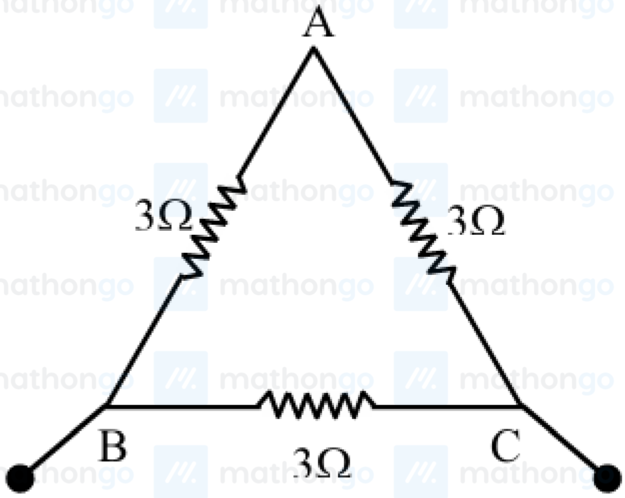
All are in parallel

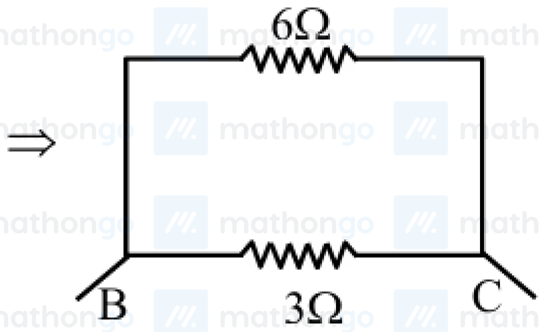
$R_{eq} = \frac{r/3}{3} = r/9$

Q4. Both are forward biased
(2) hence $R_{eq} = 10\Omega$

$i = \frac{V}{R} = \frac{5}{10} = \frac{1}{2}$ A

Q5.
(2)



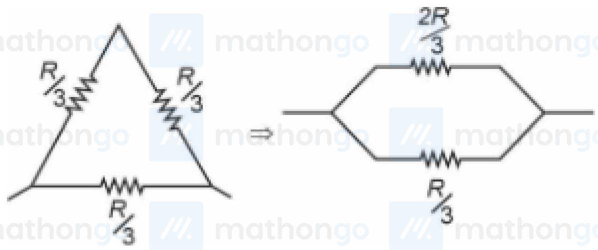


9Ω is the resistance of whole wire

$\therefore$ resistance of each wire $= 3 \Omega$.

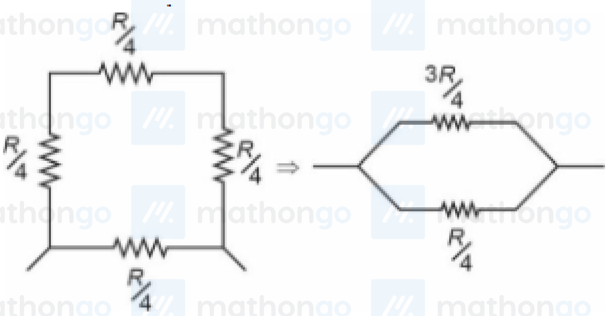
$\therefore$ Equivalent resistance $= 2 \Omega$

Q6. For the wire bent into an equilateral triangle, each side has a resistance $\frac{R}{3}$.
(3)



$R_{\text{eq}} = \frac{\left(\frac{2R}{3}\right)\left(\frac{R}{3}\right)}{\frac{2R}{3} + \frac{R}{3}} = \frac{2R}{9} = R_1$ (lets say)

For the wire bent into a square, each side has a resistance $\frac{R}{4}$.



$$R_{eq} = \frac{\left(\frac{3R}{4}\right)\left(\frac{R}{4}\right)}{\frac{3R}{4}+\frac{R}{4}} = \frac{3R}{16} = R_3 \text{ (lets say)}$$

$$\Rightarrow \frac{R_1}{R_3} = \frac{\frac{2R}{9}}{\frac{3R}{16}} = \frac{32}{27}$$

Q7. In parallel connections

(2) $\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$

$\frac{E_{eq}}{r_{eq}} = \frac{E_1}{r_1} + \frac{E_2}{r_2}$

If $E_1 = E_2$ and $r_1 = r_2, E_{eq} = E_1 = E_2$

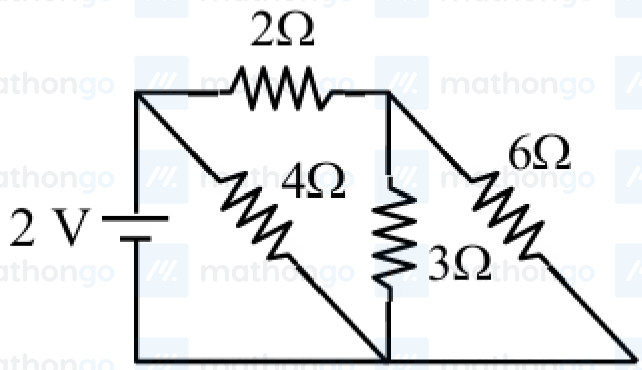
$\therefore$ Statement 1 is false.

r_{eq} is less then both r_1 and r_2

$\therefore$ Statement II is true

Q8.

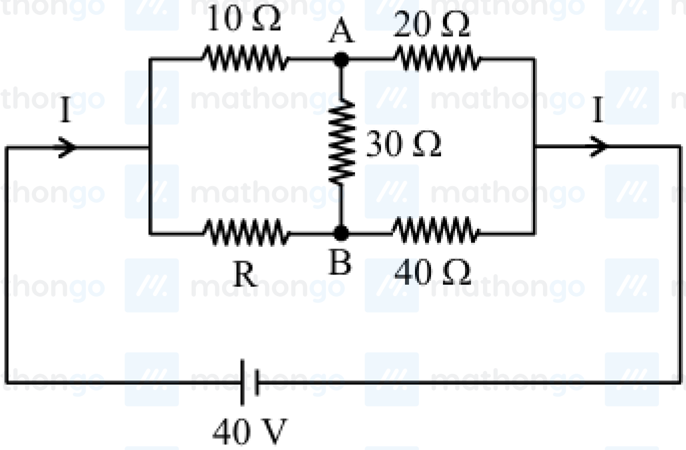
(1)



$R_{eq} = 2\Omega$

$I = \frac{2}{2} = 1$ A

Q9.
(2)



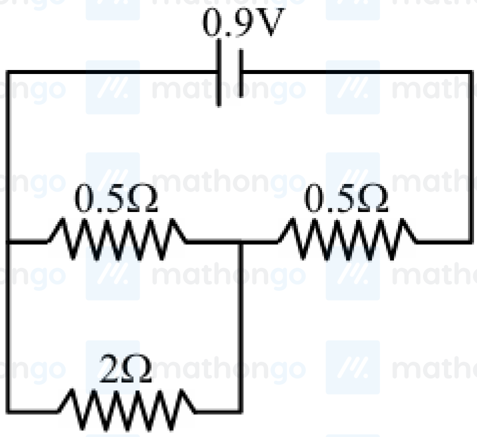
$V_A = V_B \Rightarrow$ the bridge is balanced

$\Rightarrow \frac{10}{R} = \frac{20}{40}$

$R = 20\Omega$

$I = \frac{40}{20} = 2\text{ A}$

Q10. The circuit can be considered as
(4)



$\therefore R_{eq} = 0.5 + \frac{0.5 \times 2}{2 + 0.5} = \left(\frac{5}{10} + \frac{10}{25}\right)\Omega$

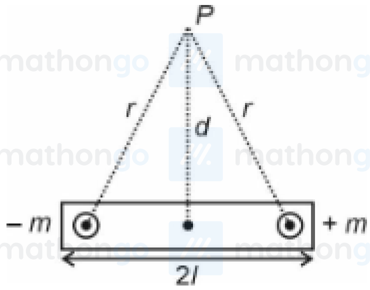
$= \frac{45}{50} = \frac{9}{10} = 0.9$

$\therefore i = \frac{0.9}{0.9} = 1\text{ A}$

Q11. $(I - I_g) R = I_g G$
(2) $(3 - 0.02) \times R = 0.02 \times G \Rightarrow R = \frac{30}{149}$

$\Rightarrow 149 =$ Required X

Q1.
(1)



Magnetic field at $P, B = \frac{\mu_0}{4\pi}\frac{m(2l)}{r^3}$, where m is the pole strength

$$\Rightarrow\left(\frac{\Delta B}{B}\times 100\right)=\left(\frac{\Delta l}{l}\right)\times 100+3\left|\frac{\Delta r}{r}\right|\times 100$$
$$=1\%+3\%=4\%$$

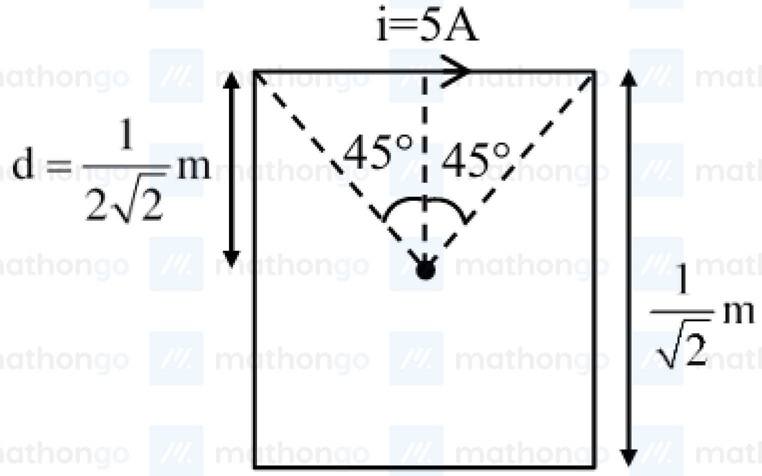
Q1. Assuming long solenoid
(8)

$$B = \mu_0\left(\frac{N}{\ell}\right)i$$

$$\ell = \frac{\mu_0 Ni}{B} = \frac{\left(4\pi \times 10^{-7}\right)(200)(0.29)}{2.9 \times 10^{-4}}\ m$$

$$= 8\pi\ cm$$

Q2.
(8)



Square loop

Let B be the magnetic field due to single side

$$\text{then } B = \frac{\mu_0 i}{4\pi\ d}(\sin\theta_1 + \sin\theta_2)$$

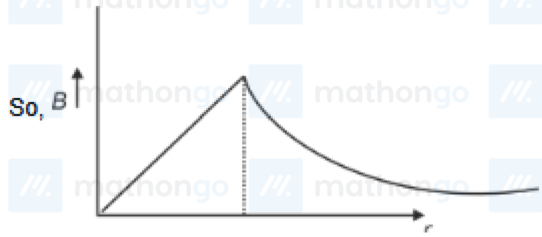
$$= \frac{10^{-7} \times 5 \times 2}{\frac{1}{2\sqrt{2}}} \times \frac{1}{\sqrt{2}} = 2 \times 10^{-6}$$

$$\therefore B_{\text{net}} \text{ at centre } O = 4B$$
$$= 8 \times 10^{-6}$$

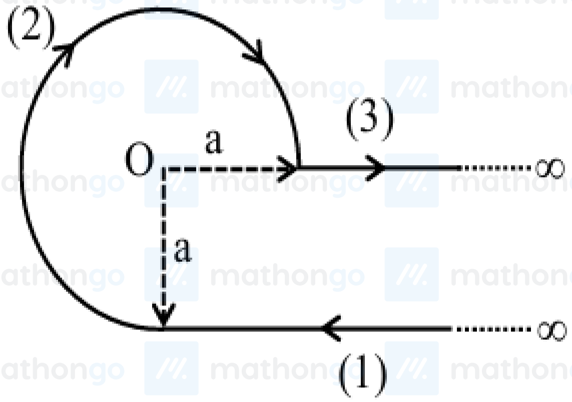
Q3. We know inside the wire
(4)

$$B = \frac{\mu_0 I}{2\pi R^2} \cdot r \qquad (O < r < R)$$

$$\text{And } B = \frac{\mu_0 I}{2\pi r} \qquad \text{for } (R < r)$$



Q4.
(4)



$B_1 = \frac{\mu_0 i}{4\pi a} \otimes$

$B_2 = \frac{\mu_0}{4\pi} \frac{i}{a} \left(\frac{3\pi}{2}\right) \otimes$

$B_3 = 0$

$B = \frac{\mu_0}{4\pi} \frac{i}{a} \left(1 \frac{3\pi}{2}\right) \otimes$

Q5. Maximum possible magnetic field is at the surface
(3)

$B_{max} = \frac{\mu_0 I}{2\pi a}$

$\frac{B_{max}}{2} = \frac{\mu_0 I}{4\pi a}$

It can be obtained inside as well as outside the wire For inside,

$\frac{\mu_0 I}{4\pi a} = \frac{\mu_0 I r}{2\pi a^2}$

$\Rightarrow r = \frac{a}{2}$

For outside

$\frac{\mu_0 I}{4\pi a} = \frac{\mu_0 I}{2\pi r}$

$\Rightarrow r = 2a$

Correct answer $\left[\frac{a}{2}, 2a\right]$

Q6. $mvr = \frac{nh}{2\pi}$...(i)
(1) $r = \frac{vm}{Bq}$....(ii)

$n = 2$

$mr\left(\frac{rBq}{m}\right) = \frac{2h}{2\pi}$

$r = \sqrt{\frac{h}{\pi Bq}}$

$q = e$

$r = \sqrt{\frac{h}{\pi Be}}$

Q7. $Bvq = Eq$
(2) $E = Bv$

$r = \frac{vm}{Bq}$

$B = \frac{mv}{rq}$

$E = \left(\frac{mv}{rq}\right) v = \frac{mv^2}{rq}$

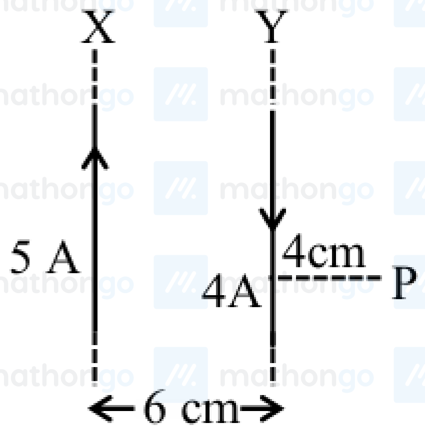
$= \frac{1.6 \times 10^{-27} \times 4 \times 10^{10}}{2 \times 10^{-2} \times 1.6 \times 10^{-19}}$

$= 2 \times 10^4\ \mathrm{N/C}$

$x = 2$

Q8. If the electron's velocity is along the direction of magnetic field then magnetic force on electron is zero and it
(3) will not accelerate.

Q9.
(1)



$B = \frac{\mu_0(5)}{2\pi \times .01} - \frac{\mu_0 4}{2\pi \times 0.04}$

$= -\frac{100\mu_0}{4\pi}$

$= -100 \times 10^{-7}$

$= -1 \times 10^{-5}\ \mathrm{T}$

Q10. (A) $\tau = \mathrm{C}\theta \Rightarrow \left[\mathrm{ML}^2\ \mathrm{T}^{-2}\right] = [\mathrm{C}][1]$
(4) (B) $\mathrm{C.S} = \frac{\theta}{\mathrm{I}} = \frac{\mathrm{BNA}}{\mathrm{C}}$;

V.S. $= \frac{\mathrm{BNA}}{\mathrm{RC}}$ [R also depends on ' N ']

(C) V.S. $\propto \frac{\mathrm{NAB}}{\mathrm{CR}}$ $\quad \mathrm{R} \rightarrow \mathrm{NR}$

(D) False [Theory]

(E) E [False]

$\mathrm{C.S} \propto \mathrm{N}$

$\Rightarrow \because \mathrm{C.S.} = \frac{\mathrm{NAB}}{\mathrm{C}}$

Q11. Since time period of a revolving charge is $\frac{2\pi m}{qB}$
(250) Where B $=$ magnetic field

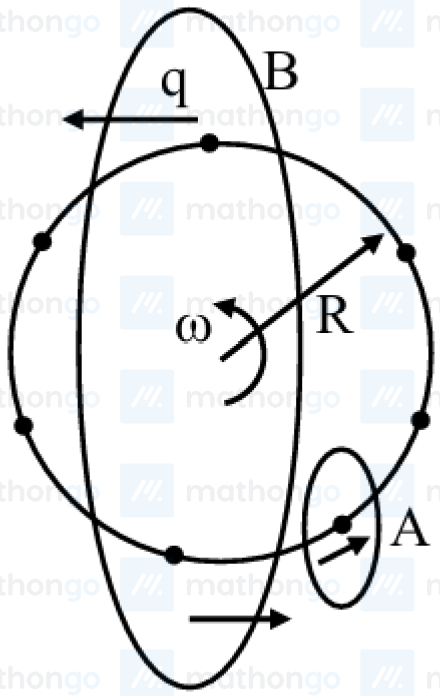
due to a solenoid $= \mu_0 \mathrm{nI}$

$$\therefore \mathrm{T} = \frac{2\pi \mathrm{~m}}{\mathrm{q}\left(\mu_0 \mathrm{nI}\right)}$$

$$75 \times 10^{-9} = \frac{(2\pi)\left(9 \times 10^{-31}\right)}{1.6 \times 10^{-19} \times 4\pi \times 10^{-7} \times \mathrm{n} \times 1.5}$$

$\mathrm{N} = 250$

Q12.
(4)

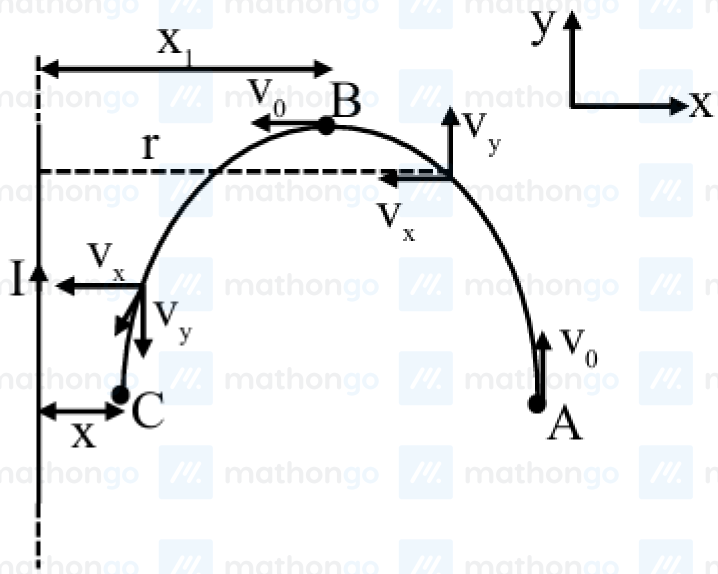


$$I_A = \frac{Nq}{\frac{2\pi}{\omega}}$$

$$I_A = \frac{Nq\omega}{2\pi}, I_B = 0$$

$$I_A = I_B = \frac{Nq\omega}{2\pi}$$

Q13.
(1)



$A \rightarrow B$

$\vec{V} = -v_x\hat{i} + v_y\hat{j}$

$\vec{B} = \frac{\mu_0 I}{2\pi r}(-\hat{k})$

$\overrightarrow{\mathrm{F}} = \mathrm{q}(\overrightarrow{\mathrm{v}} \times \overrightarrow{\mathrm{B}}) = \frac{\mu_0 \mathrm{Iq}}{2\pi r}\left[-\mathrm{v_x}\hat{\mathrm{j}} - \mathrm{v_y}\hat{\mathrm{i}}\right]$

$\mathrm{a_x} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \cdot \frac{v_y}{\mathrm{r}}$

$\mathrm{a_y} = -\frac{\mu_0 \mathrm{Iq}}{2\pi m} \cdot \frac{v_x}{\mathrm{r}}$

$\frac{\mathrm{v_x dv_x}}{\mathrm{dr}} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \frac{\mathrm{v_y}}{\mathrm{r}}$

$\frac{\mathrm{v_x dv_x}}{\mathrm{v_y}} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \frac{\mathrm{dr}}{\mathrm{r}}$

$\int_0^{\mathrm{v_0}} \frac{\mathrm{v_x dv_x}}{\sqrt{\mathrm{v_0^2 - v_x^2}}} = -\frac{\mu_0 \mathrm{Iq}^{\mathrm{x_1}}}{2\pi \mathrm{~m}} \int_{\mathrm{a}}^{\mathrm{dr}} \frac{\mathrm{r}}{2}$

Let, $\mathrm{z^2 = v_0^2 - v_x^2}$

$\mathrm{2zdz = -2v_x dv_x}$

$\mathrm{zdz = -v_x dv_x}$

$\frac{\mathrm{v_x dv}_x}{\sqrt{\mathrm{v_0^2 - v_x^2}}} = \frac{-\mathrm{zdz}}{\mathrm{z}} = -\mathrm{dz}$

then integral becomes

$-\int_{\mathrm{v_0}}^{0} \mathrm{dz} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \ln \frac{\mathrm{x_1}}{\mathrm{a}}$

$\mathrm{v_0} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \ln \frac{\mathrm{x_1}}{\mathrm{a}}$

$\mathrm{x_1} = \mathrm{a}e^{-\frac{2\pi \mathrm{mv}}{\mu_0}} \mathrm{H_0 q}\Big| \ldots\ldots$

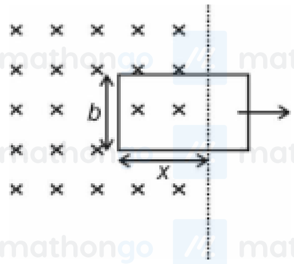
For $\mathrm{B} \rightarrow \mathrm{C}$

$$\overrightarrow{\mathrm{v}} = -v_x \hat{\mathrm{i}} - v_y \hat{\mathrm{j}}$$
$$\overrightarrow{\mathrm{B}} = \frac{\mu_0 \mathrm{I}}{2\pi \mathrm{r}}(-\hat{\mathrm{k}})$$
$$\overrightarrow{\mathrm{F}} = \mathrm{q}(\overrightarrow{\mathrm{v}} \times \overrightarrow{\mathrm{B}}) = \frac{\mu_0 \mathrm{Iq}}{2\pi r}\left(-v_x \hat{j} + v_y \hat{\mathrm{i}}\right)$$
$$\mathrm{a_x} = +\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \frac{\mathrm{v_y}}{\mathrm{r}} \quad \mathrm{a_y} = -\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \cdot \frac{\mathrm{v_x}}{\mathrm{r}}$$
$$\frac{\mathrm{v_x dv_x}}{\mathrm{dr}} = \frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \frac{\mathrm{v_y}}{\mathrm{r}}$$
$$\int_{v_0}^{0} \frac{\mathrm{v_x dv_x}}{\sqrt{\mathrm{v_0^2 - v_x^2}}} = \frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \int_{\mathrm{x_1}}^{\mathrm{x}} \frac{dr}{r}$$
$$\frac{\mu_0 \mathrm{Iq}}{2\pi \mathrm{~m}} \ln \frac{\mathrm{x}}{\mathrm{x_1}} = -\int_0^{\mathrm{v_0}} \mathrm{dz} = -\mathrm{v_0}$$
$$\mathrm{x} = \mathrm{x_1} \mathrm{e}^{-\frac{2\pi \mathrm{~m_0}}{\mu_0 \mathrm{Iq}}} \ldots \ldots (2)$$

From equation 1 and 2

$$X = ae^{-\frac{4\pi \mathrm{mv_0}}{\mu_0 \mathrm{Iq}}}$$

Q1.
(4)



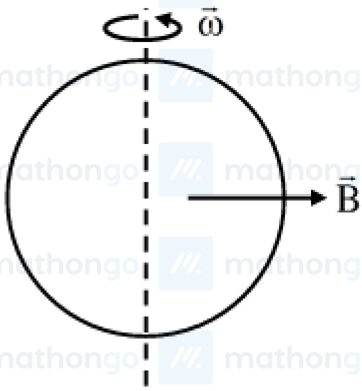
$$E = -\frac{d\phi}{dt}$$
$\phi = Bbx$
$|E| = Bbv$

Q2.
(3)
$\varepsilon - \frac{\mathrm{LdI}}{\mathrm{dt}} - \mathrm{IR} = 0$
$12 - 3 \times (-8) - \mathrm{I} \times 12 = 0$
$\mathrm{I} = 3$

Q3.
(3)
$\mathrm{B} = 0.4\ \mathrm{T}$
$\mathrm{r} = 20\ \mathrm{cm}$
$\omega = 10\pi \mathrm{rad/s}$
$\mathrm{E} = \frac{1}{2}\mathrm{B}\omega \mathrm{R}^2$
$= 0.2512\ \mathrm{V}$

Q4.
(1)
As the bar moves without change in orientation, the length of bar will be proportional to its distance from the vertex.
i.e. $I = c(vt)$
induced emf $E = B/v$
$= cBv^2t$
$\Rightarrow n = 1$

Q5.
(3)



$\phi = \mathrm{BAN} \cdot \cos(\omega \mathrm{t})$
$\varepsilon = \frac{-\mathrm{d}\phi}{\mathrm{dt}} = \mathrm{BA}\omega\,\mathrm{N} \cdot \sin(\omega \mathrm{t})$
When B is parallel to plane, $\underline{\omega t} = \frac{\pi}{2}$
$\Rightarrow \phi = 0, \varepsilon = \mathrm{BA}\omega\,\mathrm{N}$

Q6. (A) $L = \mu_f \mu_0 n^2 \mathrm{Al}$
(3) (B) $L = \mu_r \mu_v n^2 \mathrm{Al} X$
(C) ✓
(D) ✓
(E) ✓

Q7. $\phi_1 = \mathrm{L_1 I_1 + M_{12} I_2}$
(2) $\varepsilon_1 = -\frac{\mathrm{d}\phi_1}{\mathrm{dt}} = -\mathrm{L}_1 \frac{\mathrm{dI}}{1} \frac{\mathrm{I}_{12}}{\mathrm{dt}} - \mathrm{M}_{12} \frac{\mathrm{d}I_2}{\mathrm{dt}}$

Q1. Initially, $I_0 = \frac{\varepsilon_m}{R}$
(3) Finally, $I_0^1 = \frac{\varepsilon_m}{2R} = \frac{I_0}{2}$

Q2. $\omega = \frac{1}{\sqrt{LC}}$
(2)

$$\omega = \frac{1}{\sqrt{25 \times 10^{-9} \times 100 \times 10^{-3}}}$$

$$\omega = \frac{10^{+6}}{5 \times 10} = 2$$

Q3. $\frac{1}{\sqrt{2}}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$
(2)

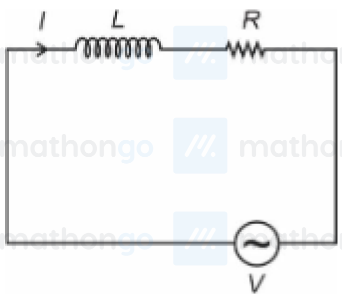
$$i = i_1 \sin \omega t + i_2 \sin(\omega t + 90)$$

$$i = \sqrt{i_1^2 + i_2^2} \sin(\omega t + \phi)$$

$$i_{ms} = \frac{i_0}{\sqrt{2}}$$

$$= \frac{\sqrt{i_1^2 + i_2^2}}{\sqrt{2}}$$

Q4.
(2)

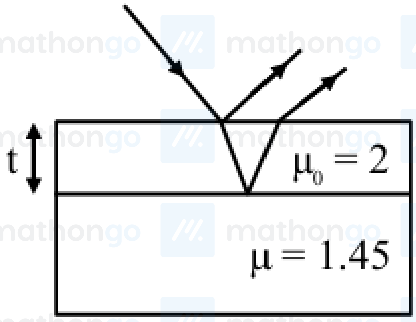


$$I = \frac{V}{\sqrt{R^2 + \omega^2 L^2}}$$

$$V_R = \frac{R}{\sqrt{R^2 + \omega^2 L^2}} V$$

Q1. Focal length of mirror will not change because focal length of mirror doesn't depend on medium.
(2)

Q2.
(1)

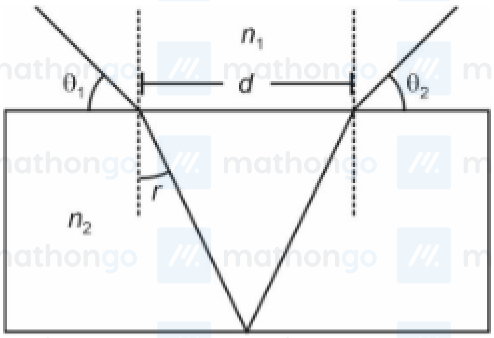


For transmitted green light to be maxima, reflected green should be minima.

$\Delta P = 2\mu_0 t = n\lambda$

$\Rightarrow t = \frac{n\lambda}{2\mu_0} \therefore t_{min} = \frac{\lambda}{2\mu_0} = \frac{550}{2 \times 2} = 137.5$

Q3.
(6)



$n_1 \sin(90 - \theta_1) = n_2 \sin r$

$n_1 \times \frac{n_2}{2n_1} = n_2 \sin r$

$\sin r = \frac{1}{2}$

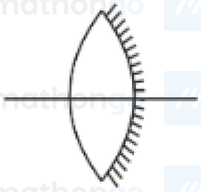
$r = 30^\circ$

$\tan r = \left(\frac{d/2}{t}\right)$

$t = \frac{d}{2 \tan r} = \frac{d\sqrt{3}}{2} = \frac{(4\sqrt{3})\sqrt{3}}{2}$

$= 6$ cm

Q4.
(4)

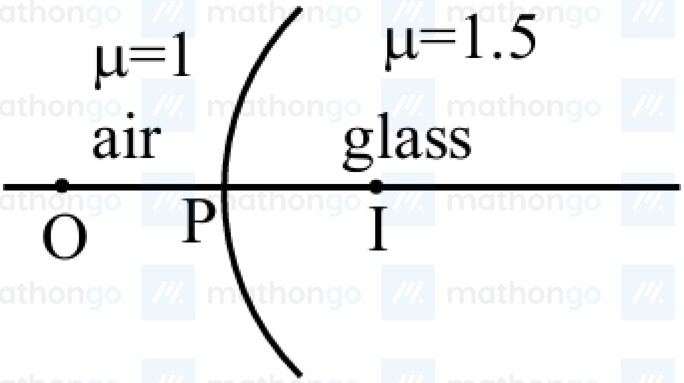


$$-\frac{1}{f_{eq}} = \frac{2}{f_l} - \frac{1}{f_m}$$
$$= 2(\mu - 1)\frac{2}{R} + \frac{2}{R}$$
$$-\frac{1}{f_{eq}} = \frac{2(2\mu - 1)}{R}$$
$$f_{eq} = -\frac{R}{2(2\mu - 1)}$$

For concave mirror, object should be at $2f$ for the image to be at same point

Distance $= \frac{R}{(2\mu-1)}$

Q5.
(1)



$\mathrm{PO} = \mathrm{u} = -\mathrm{x}$
$\mathrm{PI} = \mathrm{v} = \mathrm{x}$
$\mathrm{PO} = \mathrm{PI}$
$$\frac{\mu_2}{\mathrm{v}} - \frac{\mu_1}{\mathrm{u}} = \frac{\mu_2 - \mu_1}{\mathrm{R}}$$
$$\frac{1.5}{\mathrm{x}} + \frac{1}{\mathrm{x}} = \frac{1}{2\mathrm{R}}$$
$$\frac{5}{2\mathrm{x}} = \frac{1}{2\mathrm{R}}$$
$\mathrm{X} = 5\mathrm{R}$

Q6. Initial optical power, $P_1 = 2.5\mathrm{D}$
(2) Final optical power, $P_2 = 2.5D + 0.1D = 2.6D$

Step 1: Relation Between Focal Length and Power

The focal length f (in meters) of a lens is related to its optical power P by:

$P = \frac{1}{f}$

So,

$$f_1 = \frac{1}{P_1} = \frac{1}{2.5} = 0.4 \text{ m}$$

$$f_2 = \frac{1}{P_2} = \frac{1}{2.6} \approx 0.3846 \text{ m}$$

Step 2: Relative Decrease in Focal Length

The relative decrease in focal length is given by:

$\frac{\Delta f}{f_1} = \frac{f_1 - f_2}{f_1}$

Substituting the values:

$$\frac{\Delta f}{f_1} = \frac{0.4 - 0.3846}{0.4}$$

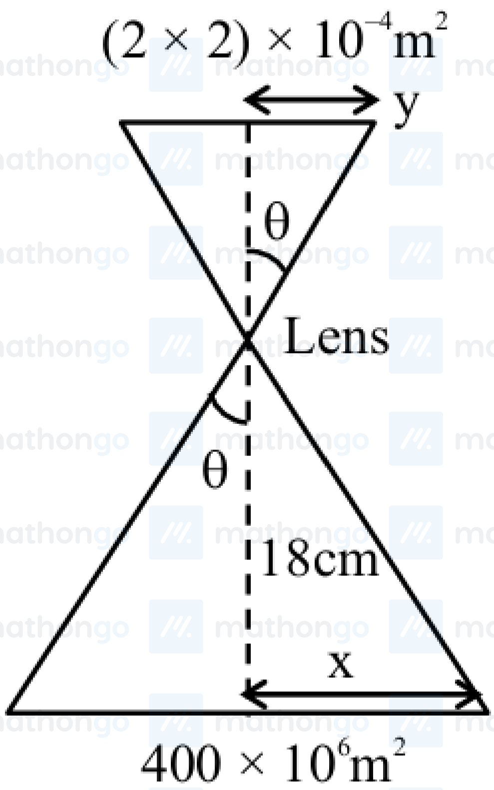
$$= \frac{0.0154}{0.4}$$

$= 0.0385$ which is approx 0.04

Final Answer: 0.04

Q7.

(1)



H = 18 km

Size of camera film = 2 cm × 2 cm

$A_{\text{image}} = 400 \text{ km}^2$

$x = 20 \times 10^3 \text{ m} = 2 \times 10^4 \text{ m}$

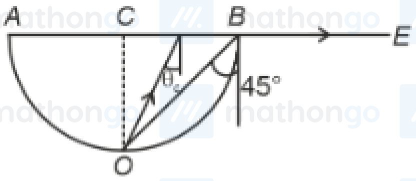
$y = 2 \times 10^{-2} \text{ m}$

$\frac{x}{y} = 10^6 = \frac{18\text{Km}}{\text{f}}$

$\text{f} = 18 \times 10^{-3} \text{ m} = 18 \text{ mm}$

$\text{f} = 1.8 \text{ cm}$

Q8.
(4)



For the rays from coin to reach the point E, the refracted rays must grazing the surface, i.e. they must be incident at critical angle θ_c inside the liquid.

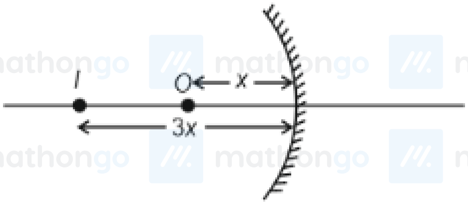
$\mu = \frac{1}{\sin \theta_c}$

μ is minimum when θ_c is maximum.

Maximum value of $\theta_c = 45^\circ$

$\Rightarrow \mu$ has a minimum value of $\sqrt{2}$.

Q9.
(3)



$m = -3 = -\frac{u}{v}$

$u = -x$

$v = -3x$

$\Rightarrow 2x = 20 \text{ cm}$

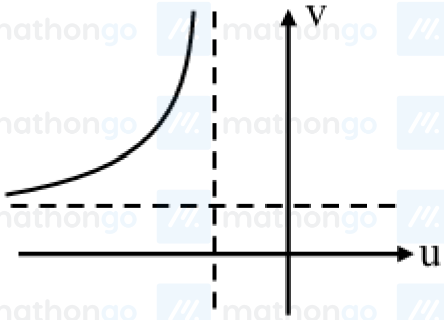
$x = 10 \text{ cm}$

$f = \frac{uV}{u+V} = \frac{(-10)(-30)}{(-10)+(-30)} = -7.5 \text{ cm}$

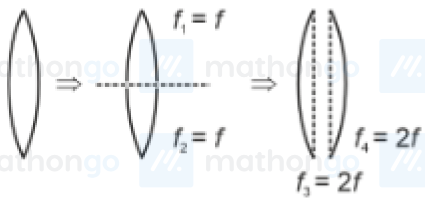
$f = -\frac{R}{2}$

$R = -2f = 15 \text{ cm}$

Q10. $(u+f)(v-f) = f^2$
(3)



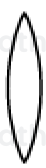
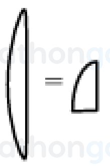
Q11.
(2)



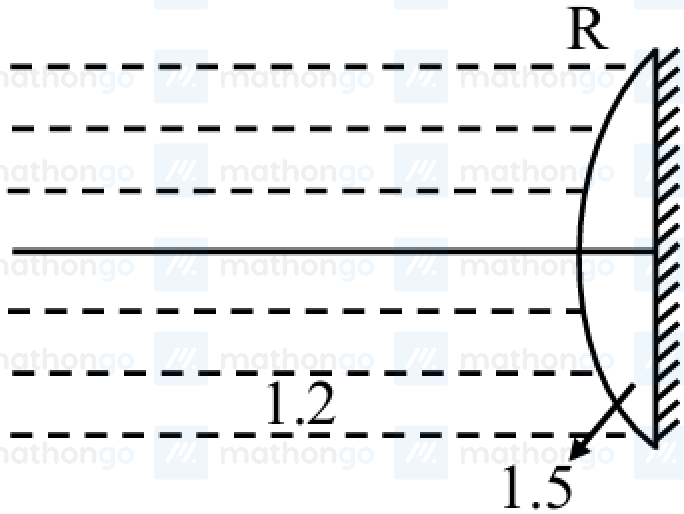
so $\frac{f_1}{f_3} = 1 : 2$

Q12.
(2)
$$\frac{1}{8}=\left(\frac{\mu_\ell}{\mu_s}-1\right)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$$
$$\frac{1}{24}=(1.5-1)\left[\frac{2}{R}\right]\ldots(i)$$
$$\frac{1}{f'}=\left(\frac{1.5}{1.33}-1\right)\left(\frac{2}{R}\right)$$
$$\frac{1}{f'}=\left(\frac{1.5\times 3}{4}-1\right)\frac{2}{R}\ldots(ii)$$
(i) divided by (ii)
$$\frac{f'}{24}=4$$
$$f'=96\text{ cm}$$

Q13. For B
(4)
$$\frac{\mu_2}{V}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$
$$\frac{1.5}{V}+\frac{1}{\frac{R}{2}}=\frac{0.5}{-R}$$
$$\frac{1.5}{V}=-\frac{1}{2R}-\frac{2}{R}$$
$$\frac{1.5}{V}=\frac{-5}{2R}\Rightarrow V_B=-0.6R$$
For A
$$\frac{1.5}{V}+\frac{2}{3R}=\frac{0.5}{-R}$$
$$\frac{1.5}{V}=-\frac{1}{2R}-\frac{2}{3R}$$
$$\frac{1.5}{V}=-\frac{7}{6R}$$
$$V_A=-\frac{9}{7}R$$
Distance between images
$$=2R-\left(0.6R+\tfrac{9}{7}R\right)=0.114R$$

Q14.
(3)

$$\frac{1}{f_1}=(\mu-1)\frac{2}{R}=P=4D$$

$$\frac{1}{f_2}=(\mu-1)\frac{1}{R}=\frac{P}{2}=2D$$

Q15.
(4)



$$\frac{1.5}{\mathrm{v}}=\frac{1.5-1.2}{\mathrm{R}}$$
$$\mathrm{v}=\frac{1.5\mathrm{R}}{0.3}=5\mathrm{R}$$
$$\frac{1.2}{\mathrm{f}}-\frac{1.5}{5\mathrm{R}}=\frac{1.2-1.5}{-\mathrm{R}}$$
$$\frac{1.2}{\mathrm{f}}=\frac{0.3}{\mathrm{R}}\times 2 \Rightarrow \mathrm{f}=2\mathrm{R} \Rightarrow \mathrm{R}=0.1$$

Q16. Both lenses are plano-convex, so the second surface is plane ($R=\infty$), which simplifies the lens maker's
(2) formula:

$\frac{1}{f}=\left(\frac{n}{n_n}-1\right)\left(\frac{1}{R}-0\right)$

where:

- In is the refractive index of the lens material,
- n_n is the refractive index of the surrounding medium,
- R is the radius of eurvature of the curved surface.

Step E Calculate f_1 (Lens in Air)

For Lens 1 in Air:

$$\frac{1}{f_1}=\left(\frac{1.5}{1}-1\right)\left(\frac{1}{2}\right)$$
$$\frac{1}{f_1}=(1.5-1)\times\frac{1}{2}$$
$$\frac{1}{f_1}=0.5\times\frac{1}{2}=\frac{0.5}{2}=\frac{1}{4}$$
$$f_1=4\ \mathrm{cm}$$

Step 2: Calculate fz (Lens in Liquid)

For Lens 2in Liquid:

$$\frac{1}{T_2}=\left(\frac{1.5}{1.2}-1\right)\left(\frac{1}{3}\right)$$
$$\frac{1}{T_2}=\left(\frac{1.5-1.2}{1.2}\right)\times\frac{1}{3}$$
$$\frac{1}{T_2}=\left(\frac{0.3}{1.2}\right)\times\frac{1}{3}$$
$$\frac{1}{T_2}=\frac{0.3}{3.6}$$
$$f_2=\frac{3.6}{1.3}=12\text{ cm}$$

Step 3: Find the Ratio $\frac{4}{12}$

$\frac{f_1}{f_2}=\frac{4}{12}=\frac{1}{3}$

Final Answer:

$\frac{1}{3}$

Q17.
(1)
$$\mu=\frac{\sin\left(\frac{A+\delta_{\min}}{2}\right)}{\sin\frac{A}{2}}$$

Given $\delta_{\min}=\mathrm{A}$

$$\sqrt{3}=\frac{\sin A}{\sin\frac{A}{2}}=\frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$
$$\cos\frac{A}{2}=\frac{\sqrt{3}}{2}$$
$$A=60^{\circ}$$

Q18. For dispersion without deviation,
(1)
$$\left(\mu_1-1\right)A_1=\left(\mu_2-1\right)A_2$$
$$\Rightarrow\quad(1.54-1)4^{\circ}=(1.72-1)A_2$$
$$\text{Or }A_2=\frac{0.54}{0.72}\times 4=3^{\circ}$$

Q19. Image distance, $v=\frac{uf}{u-f}=\frac{-24\cdot 1}{-24-1}=\frac{24}{25}$
(8)
Magnification, $\mathrm{m}=\frac{-\mathrm{v}}{\mathrm{u}}=-\frac{24}{25(-24)}=\frac{1}{25}$

Mirror formula, $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

Differentiating wrt time gives,

$$\frac{-ldv}{v^2}\frac{dt}{dt}+\frac{1}{u^2}\frac{du}{dt}=0\text{ here, }\frac{dv}{dt}=v_1;\ \frac{du}{dt}=v_0$$
$$\Rightarrow v_1=-\frac{v^2}{u^2}v_0=-\frac{\frac{24^2}{25}}{24^2}\times 25=-\frac{1}{25}$$

Again, differentiating wrt time gives,

$$\Rightarrow a_{\mathrm{I}}=-2\frac{vv'u-vu'}{u^2}v_{\mathrm{O}}=-2\frac{vv_{\mathrm{I}}u-vv_0}{u^2}v_{\mathrm{O}}$$

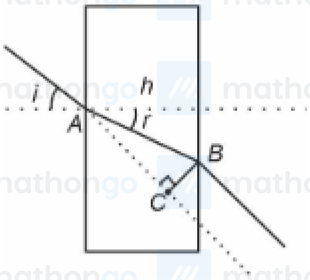
$$\Rightarrow a_{\mathrm{I}}=-2\frac{\frac{24}{25}-\frac{1}{25}-24-\frac{24}{25}25}{-24^2}25$$

$$\Rightarrow a_{\mathrm{I}}=-\frac{2}{25}\ \mathrm{ms}^{-2}$$

Thus, $100\mathrm{a_I}=100\times\frac{2}{25}=8$

Q20.

(2)



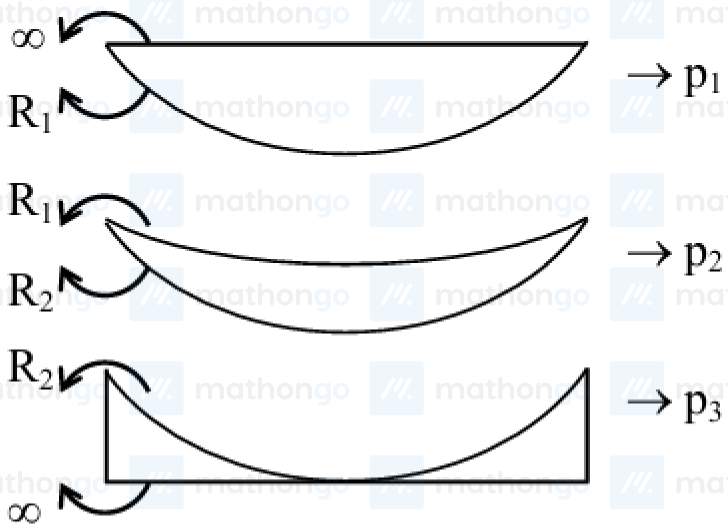
$$AB=h\sec r$$
$$BC=h\sec r\sin(\bar{i}-r)$$
$$BC=\frac{h\sin(i-r)}{\cos r}$$

Q21.

(3)

$$\sin\theta_{1C}=\frac{n_1}{n_2}$$
$$\sin\theta_{2C}=\frac{n_1}{n_3}$$
$$\sin\theta_{2C}-\sin\theta_{1C}=\frac{1}{2}$$
$$\mathrm{n_1}\frac{\mathrm{n_2}}{\mathrm{n_3}}-\frac{\mathrm{n_1}}{\mathrm{n_2}}=\frac{1}{2}$$
$$\mathrm{n_1}\frac{\mathrm{n_2}}{\mathrm{n_3}}-\mathrm{n_1}=\frac{\mathrm{n_2}}{2}$$
$$\mathrm{n_1}\left(\frac{2}{5}-1\right)=\frac{\mathrm{n_2}}{2}$$
$$\frac{\mathrm{n_1}}{\mathrm{n_2}}=\frac{-5}{6}$$
$$=\sin^{-1}\left(-\frac{5}{6}\right)$$

Q22.
(4)



$$\Rightarrow p_{\text{eq}} = \mathrm{p}_1 + \mathrm{p}_2 + \mathrm{p}_3$$

$$\Rightarrow \mathrm{p}_1 = \left(\frac{4}{3} - 1\right)\left(\frac{1}{\infty} - \frac{1}{-|\mathrm{R}_1|}\right)$$

$$\Rightarrow \mathrm{p}_1 = \left(\frac{1}{3|\mathrm{R}_1|}\right)$$

$$\Rightarrow \mathrm{p}_2 = \left(\frac{1}{2}\right)\left(\frac{1}{-|\mathrm{R}_1|} - \frac{1}{-|\mathrm{R}_2|}\right)$$

$$\Rightarrow \mathrm{p}_2 = \frac{1}{2}\left(\frac{1}{|\mathrm{R}_2|} - \frac{1}{|\mathrm{R}_1|}\right)$$

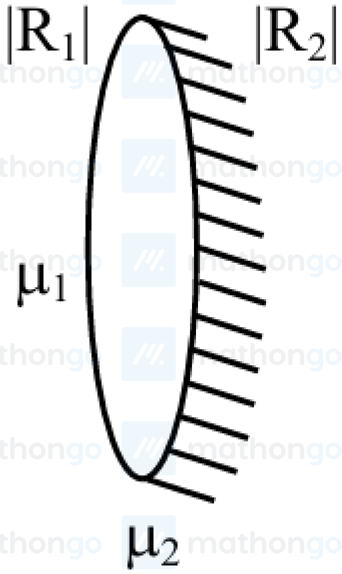
$$\Rightarrow \mathrm{p}_3 = \left(\frac{1}{3}\right)\left(\frac{1}{-|\mathrm{R}_2|} - \frac{1}{\infty}\right) = -\frac{1}{3|\mathrm{R}_2|}$$

$$\Rightarrow \mathrm{p}_{\text{eq}} = \frac{1}{3}\left(\frac{1}{|\mathrm{R}_1|} - \frac{1}{|\mathrm{R}_2|}\right) - \frac{1}{2}\left(\frac{1}{|\mathrm{R}_1|} - \frac{1}{|\mathrm{R}_2|}\right)$$

$$= -\frac{1}{6}\left(\frac{1}{|\mathrm{R}_1|} - \frac{1}{|\mathrm{R}_2|}\right)$$

Q23.

(1)



$$\frac{1}{f_{eq}} = \frac{2}{f_L} - \frac{1}{f_m}$$

$$f_m = -\frac{|R_2|}{2}$$

$$\frac{1}{f_L} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{f_{eq}} = 2\left(\frac{\mu_2 - \mu_1}{\mu_1}\right)\left(\frac{R_1 + R_2}{R_1 R_2}\right) + \frac{2}{R_2}$$

$$= \frac{2}{R_2}\left[\frac{(\mu_2 - \mu_1)(R_1 + R_2) + \mu_1 R_1}{\mu_1 R_1}\right]$$

$$= \frac{2}{R_2}\left[\frac{\mu_2 R_1 + \mu_2 R_2 - \mu_1 R_1 - \mu_1 R_2 + \mu_1 R_1}{\mu_1 R_1}\right]$$

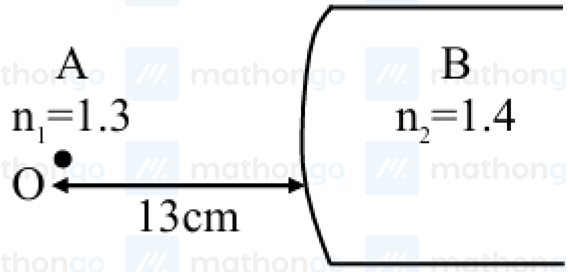
$$\frac{1}{f_{eq}} = \frac{2\left[\mu_2 R_1 + \mu_2 R_2 - \mu_1 R_2\right]}{\mu_1 R_1 R_2}$$

For same size of image

$u = 2f$

$$u = \frac{\mu_1 R_1 R_2}{\mu_2 R_1 + \mu_2 R_2 - \mu_1 R_2}$$

Q24.
(4)



$$\frac{n_2}{v}-\frac{n_1}{u}\frac{n_2-n_1}{R}$$
$$\frac{1.4}{v}-\frac{1.3}{-13}=\frac{0.1}{R}$$
$$\frac{1.4}{v}=\frac{1-R}{10R}$$
$$\frac{1.4}{v}=\frac{1-R}{10R}$$
$$m=\frac{v/n_2}{u/n_1}$$
$$-2\times\frac{(-13)}{1.3}=\frac{10R}{1-R}$$
$$R=\frac{2}{3}\text{ cm}$$

Q1. $\beta=\frac{\lambda D}{d}$
(4) $\lambda_{\text{red}}>\lambda_{\text{blue}}$
Assertion is false
Reason is true

Q2. Compton effect refers to scattering of a photon by free electrons. This phenomenon provides an evidence for
(1) particle nature of light.

Q3. Since power emitting by a source is given as
(5)

$$=\frac{\text{Total energy emitted}}{\text{time}}$$

$$=\frac{\left(E_1\text{ photon }\right)\times\text{ Number of photons }(N)}{t}$$

$$P_1=\left(E_1\right)n$$

$$\frac{\mathrm{P}_1}{\mathrm{P}_2}=\frac{\left(\mathrm{E}_1\right)\mathrm{n}_1}{\left(\mathrm{E}_2\right)\mathrm{n}_2}=\frac{\left(\frac{\mathrm{hC}}{\lambda_1}\right)\mathrm{n}_1}{\left(\frac{\mathrm{hC}}{\lambda_2}\right)\mathrm{n}_2}$$

$$\frac{\mathrm{P}_1}{\mathrm{P}_2}=\left(\frac{\lambda_2}{\lambda_1}\right)\frac{\mathrm{n}_1}{\mathrm{n}_2}$$

Substituting the given values

$$2=\left(\frac{300}{600}\right)\times\frac{2\times10^{15}}{\mathrm{n}_2}$$

$$\mathrm{n}_2=\frac{1}{2}\times10^{15}=5\times10^{14}\text{ Photon /sec}$$

Q4. $\beta(\text{ fringe width })=\frac{\lambda D}{d}$
(2) In denser medium, $\lambda\downarrow\Rightarrow\beta\downarrow\Rightarrow$ fringe come closer
Also, $\mu=\frac{\mathrm{c}}{\mathrm{V}}\Rightarrow\mathrm{V}=\frac{\mathrm{c}}{\mu}$
Frequency remains same,
$\Rightarrow\mu=\frac{\lambda_{\text{vac.}}\mathrm{f}}{\lambda_{\text{med}}\mathrm{f}}\Rightarrow\lambda_{\text{med}}=\frac{\lambda_{\text{vac.}}}{\mu}$

Q5. $\mathrm{I}\propto(\text{ width })^2$
(2)

$$\left(\frac{\sqrt{\mathrm{I}_1}+\sqrt{\mathrm{I}_2}}{\sqrt{\mathrm{I}_1}-\sqrt{\mathrm{I}_2}}\right)^2=\frac{9}{4}$$

$$\frac{\sqrt{\mathrm{I}_1}+\sqrt{\mathrm{I}_2}}{\sqrt{\mathrm{I}_1}-\sqrt{\mathrm{I}_2}}=\frac{3}{2}$$

$$\frac{(\mathrm{x}+1)\mathrm{d}}{(\mathrm{x}-1)\mathrm{d}}=\frac{3}{2}$$

$$\Rightarrow3\mathrm{x}-3=2\mathrm{x}+2$$

$$\mathrm{x}=5$$

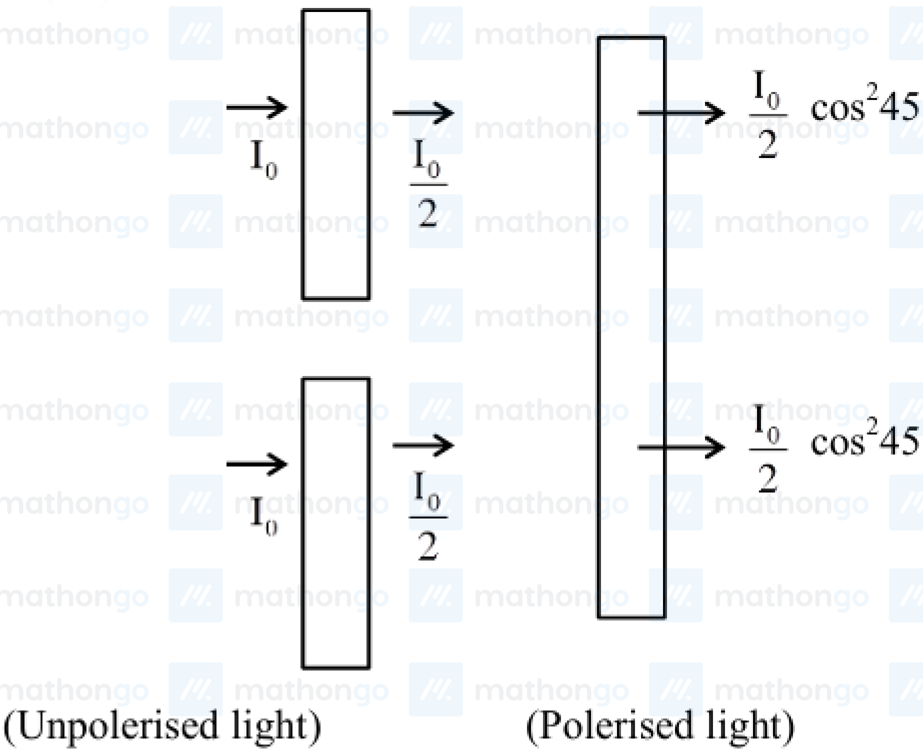
Q6. $\frac{n_1\lambda_1D}{d}=\frac{n_2\lambda_2D}{d}$
(1) $n480=m600$
$n_{\min}=5$

Q7.
(1)
$$\Delta W=\frac{\lambda D}{d\cdot\mu}=\frac{690\times10^{-9}\times0.72}{1.5\times10^{-3}\times1.44}$$
$$\Rightarrow \Delta W=2.3\times10^{-4}\ \mathrm{m}=0.23\ \mathrm{mm}$$

Q8. Position of the n^{th} bright fringe w.r.t. central maxima
(11) in a YDSE is $y_n=n\frac{\lambda D}{d}$.

$$\Rightarrow \quad \frac{y'_{10}}{y_{10}}=\frac{\lambda'}{\lambda}$$
$$\text{or} \quad y'_{10}=\frac{\lambda'}{\lambda}y_{10}$$
$$=\left(\frac{660\ \mathrm{nm}}{600\ \mathrm{nm}}\right)10\ \mathrm{mm}$$
$$=11\ \mathrm{mm}$$

Q9.
(2)



after passing through third poleriser, Intensity of both the waves must be $\frac{I_0}{4}$
now, at a point where path diff is $\frac{\lambda}{3}$, phase difference

$$\Delta\phi=2\,\mathrm{K}\left(\frac{\Delta x}{\lambda}\right)=\frac{2\pi}{3}$$
$$\therefore I_{res}=\sqrt{\left(\frac{I_0}{4}\right)^2+\left(\frac{I_0}{4}\right)^2+2\left(\frac{I_0}{4}\right)^2\cos\frac{2\pi}{3}}$$
$$=\frac{I_0}{4}$$

Q1. $\lambda=\frac{\mathrm{h}}{\mathrm{p}}=\frac{6.63\times10^{-34}}{10^{-30}\times2.21\times10^{6}}$
(4) $=3\times10^{-10}\ \mathrm{m}$

Hence particle will behave as x-ray.

Q2. We need to check the dimensions only.
(4) With momentum the dimension

$E^2=p^2C^2$

And with mass $E^2=m^2c^4$

So $E^2=p^2C^2+m^2c^4$ (dimensionally)

Q3. $\phi=2.14$
(1) $V_S=2\ \mathrm{V}$

Using photoelectric equation.

$\frac{hc}{\lambda}=2.14+2=4.14\mathrm{eV}$

$\lambda=\frac{1242}{4.14}=300\ \mathrm{nm}$

Q4. Negative potential will slow the electrons and if it is sufficient, it will make the photocurrent zero.
(4) $\mathrm{eVs}=hf-\phi_0$

Q5. $\lambda=\frac{\mathrm{h}}{\mathrm{mv}}$
(4) $\mathrm{mvr}=\frac{\mathrm{nh}}{2\pi}$

$\mathrm{mv}=\frac{\mathrm{nh}}{2\pi\mathrm{r}}$

$\lambda=\frac{2\pi\mathrm{rh}}{\mathrm{nh}}$

$\lambda\propto\frac{\mathrm{r}}{\mathrm{n}}$

$\frac{\lambda_1}{\lambda_4}=\frac{\mathrm{r}_1\mathrm{n}_4}{\mathrm{n}_1\mathrm{r}_4}=\frac{5.3\times10^{-11}\times4}{1\times84.8\times10^{-11}}$

$\frac{\lambda_1}{\lambda_4}=\frac{1}{4}$

Q6. $\overrightarrow{\mathrm{v}}=\mathrm{v}_0\hat{\mathrm{i}}-\frac{\mathrm{E}_0\mathrm{e}}{\mathrm{m}}t\hat{\mathrm{k}}$
(1) $|\overrightarrow{\mathrm{v}}|=\sqrt{\mathrm{v}_0^2+\frac{\mathrm{E}_0^2\mathrm{e}^2\mathrm{t}^2}{\mathrm{m}^2}}$

$\lambda_0=\frac{\mathrm{h}}{\mathrm{mv}_0}$

$\lambda'=\frac{\mathrm{h}}{\mathrm{mv}_0\sqrt{1+\frac{\mathrm{E}_0^2\mathrm{e}^2\mathrm{t}^2}{\mathrm{v}_0^2\ \mathrm{m}^2}}}$

$\lambda'=\frac{\lambda_0}{\sqrt{1+\frac{\mathrm{E}_0^2\mathrm{e}^2\mathrm{t}^2}{\mathrm{v}_0^2\ \mathrm{m}^2}}}$

Q7. Energy of photon $= E = \frac{hc}{\lambda}$

(4) $\Rightarrow$ Wavelength of photon $= \lambda = \frac{hc}{E}$

Energy of proton $= E = \frac{1}{2} m_p v^2 = \frac{P^2}{2m_p}$

$\Rightarrow$ Linear momentum of proton $= P = \sqrt{2m_p E}$

Or de-Broglie wavelength of proton

$$= \lambda_p = \frac{h}{P} = \frac{h}{\sqrt{2m_p E}}$$

$$\text{Ratio } \frac{\lambda_p}{\lambda} = \frac{h}{\sqrt{2m_p E}} \times \frac{E}{hc}$$

$$= \frac{1}{c}\sqrt{\frac{E}{2m_p}}$$

Q8. $\lambda = \frac{\mathrm{h}}{\mathrm{mv}} = \frac{\mathrm{h}}{\sqrt{2\mathrm{mK}}}$

(2)

$$\lambda^2 = \frac{\mathrm{h}^2}{2\,\mathrm{m}}\left(\frac{1}{\mathrm{k}}\right)$$

$\mathrm{Y} = \mathrm{cx}^2$

Upward facing parabola passing through origin.

Q9. Step 1: Calculate the Energy of the Incident Photon

(3) The energy of a photon is given by the equation:

$E = \frac{hc}{\lambda}$ where:

$h = 6.626 \times 10^{-34}\ \mathrm{J \cdot s}$ (Planck's constant),

$c = 3.0 \times 10^8\ \mathrm{m/s}$ (speed of light),

$\lambda = 550\ \mathrm{nm} = 550 \times 10^{-9}\ \mathrm{m}$

First, calculate the photon energy in joules:

$$E = \frac{\left(6.626 \times 10^{-34}\right)\left(3.0 \times 10^8\right)}{550 \times 10^{-9}}$$

$$E = \frac{1.9878 \times 10^{-25}}{550 \times 10^{-9}}$$

$$E = 3.615 \times 10^{-19}\ \mathrm{J}$$

Convert this to electron volts (eV) using $1\mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$:

$$E = \frac{3.615 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$E \approx 2.26\mathrm{eV}$$

Step 2: Compare Photon Energy with Work Functions

Cesium ($\phi_{\mathrm{Cs}} = 1.9\mathrm{eV}$)

Since $E_{\text{photon}} = 2.26\mathrm{eV}$ is greater than $\phi_{\mathrm{Cs}} = 1.9\mathrm{eV}$,photoelectric emission occurs.

Lithium ($\phi_{\mathrm{Li}} = 2.5\mathrm{eV}$)

Since $E_{\text{photon}} = 2.26\mathrm{eV}$ is less than $\phi_{\mathrm{Li}} = 2.5\mathrm{eV}$, photoelectric emission does not occur.

Conclusion:

Photoelectric effect is possible only for Cesium (Cs), but not for Lithium (Li).

Q10. Einstein's photoelectric equation

(4) $\mathrm{KE}=\frac{hc}{\lambda}=\phi_0$

$2\mathrm{eV}=\frac{hc}{\lambda}-1\mathrm{eV}$

$\frac{hc}{\lambda}=3\mathrm{eV}$

$\mathrm{KE}'=\frac{hc}{(\lambda/2)}-\phi_0=6\mathrm{eV}-1\mathrm{eV}$

$=5\mathrm{eV}$

Q11. $\mathrm{hv}=\phi+\mathrm{KE}_{\max}$

(2) $\mathrm{KE}_{\max}=\mathrm{eV}_0$

$\mathrm{V}_0=\frac{\mathrm{hv}-\phi}{\mathrm{e}}$

(A) $\mathrm{V}_0\mathrm{v}/\mathrm{sV}$ is linear correct

(B) Slope

$\mathrm{v}_0=\left(\frac{\mathrm{h}}{\mathrm{e}}\right)\mathrm{v}-\frac{\phi}{\mathrm{e}}$ Wrong

Slope $\frac{h}{e}$

(C) Correct

(D) Incorrect

(E) Correct

Q12. From Einstein photoelectric equation

(4) $\frac{hc}{\lambda}=\phi+eV_S$

Maximum K.E. $=(\mathrm{K})_{\max}=eVs$

So, $V_S=\frac{(\mathrm{K})_{\max}}{e}$

Q1.
(4)
$f = \frac{v}{2\pi r} = \left(\frac{V_0}{n}\right)\left(\frac{1}{2\pi r_0 n^2}\right)$

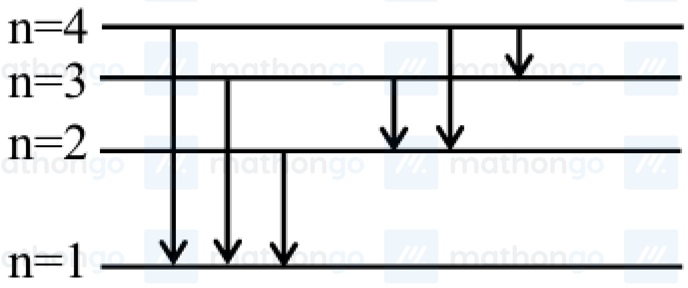
$f = \frac{V_0}{2\pi r_0} = \left(\frac{1}{n^3}\right) = f_0\left(\frac{1}{n^3}\right)$

Q2.
(4)

γ-rays	X-rays	U.V rays	Visible rays	IR rays	Micro waves	Radio waves

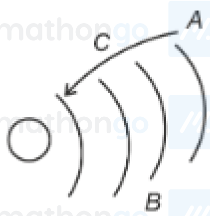
$\lambda \uparrow$

Q3.
(3)



Total possible transition = 6

Q4.
(3)



For A to C

$\frac{hc}{\lambda_1} = E_0 z^2\left(\frac{1}{n_c^2} - \frac{1}{n_A^2}\right)$....(i)

And $\frac{hc}{\lambda_2} = E_0 z^2\left(\frac{1}{n_c^2} - \frac{1}{n_B^2}\right)$

So for A and B....(ii)

$\frac{hc}{\lambda_3} = E_0 z^2\left(\frac{1}{n_B^2} - \frac{1}{n_A^2}\right)$

Clearly subtracting equation (ii) from equation (i)

$hc\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = E_0 z^2\left[\frac{1}{n_B^2} - \frac{1}{n_A^2}\right] = \frac{hc}{\lambda_3}$

$\Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{(6000 - 2000)}{6000 \times 2000} = \frac{1}{3000}$

$\lambda_3 = 3000Å$

Q1. For all nuclear processes, charge must be conserved. Also, when a release of an electron (e^{-}) is always
(4) accompanied by a release of an antineutrino ($\bar{v}$)

Hence, $n \rightarrow p+\mathrm{e}^{-}+\overline{\mathrm{v}}$ is the correct answer.

Q2. From graph between B.E/N \& A we can see BE/N is almost constant ⇒ correct
(1) Reason ⇒ incorrect as nuclear forces are short range forces.

Q3. $\mathrm{N}_2=\mathrm{N}_0 \mathrm{e}^{-3 \lambda t}$
(4) $\mathrm{N}_1=\mathrm{N}_0 \mathrm{e}^{-\lambda \mathrm{t}}$

$\frac{\mathrm{N}_2}{\mathrm{~N}_1}=\mathrm{e}^{-2 \lambda \mathrm{t}}$

$\mathrm{t}_{\text {half lifeofN }} \mathrm{t}$

$\mathrm{t}=\frac{\ln 2}{\lambda}{ }_{\mathrm{n}} 1$

$\frac{\mathrm{N}_0}{2}=\mathrm{N}_0 \mathrm{e}^{-\lambda \mathrm{t}}$

$\lambda \mathrm{t}=\ln 2$

$\mathrm{t}=\frac{\ln 2}{\lambda}$

$=\mathrm{e}^{-2 \lambda \frac{\ln 2}{\lambda}}$

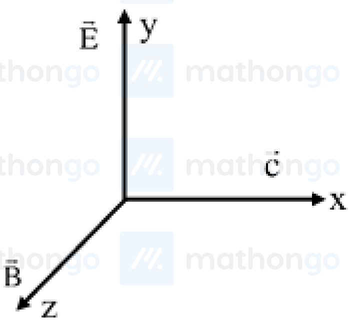
$\frac{\mathrm{N}_2}{\mathrm{~N}_1}=\frac{1}{4}$

Q1. $E = BC$
(2) $9.3 = B \times 3 \times 10^8$

$$B = \frac{9.3}{3 \times 10^8} = 3.1 \times 10^{-8}\ T$$

Q2. EM wave carry both energy and momentum. Rest mass of photon is zero.
(3)

Q3.
(2)



Direction of propogation

$= \overrightarrow{E} \times \overrightarrow{B}$

Q4. $i_d = i_c$
(1200) $\therefore$ Total displacement current $= 6$ A

Through A_0

$$i = \left(\frac{A_0}{A}\right) 6$$

$$= \frac{3.2}{16} \times 6 = 1.2\ A = 1200\ mA$$

Q5. $\overrightarrow{K} = 3\hat{i} + 4\hat{j}$
(2)

$$\hat{K} = \frac{3\hat{i} + 4\hat{j}}{5}$$

$$\hat{E} = \frac{4\hat{i} - 3\hat{j}}{5}$$

$$\hat{B} = \hat{K} \times \hat{E}$$

$$\hat{B} = -\hat{Z}$$

$$B_0 = \frac{E_0}{C} = \frac{57}{3 \times 10^8}$$

Q6. Energy density of an $EM_{\text{wave}} = \frac{1}{2}\varepsilon E_0^2$, whare E_0 is the amplitude of the wave.
(2) Since total energy is same for both cylinders

$$\left(\frac{1}{2}\varepsilon E_1^2\right)\pi R_1^2 L_1 = \left(\frac{1}{2}\varepsilon E_2^2\right)\pi R_2^2 L_2$$

$$\Rightarrow E_1^2 R_1^2 L_1 = E_2^2 R_2^2 L_2$$

$$\text{or } E_2 = \frac{E_1 R_1}{R_2}\sqrt{\frac{L_1}{L_2}} = \frac{100\ d}{(d/2)}\sqrt{\frac{L_1}{L1}} = 200\ N/C$$

$$[\because L_1 = L_2 = 200\ cm]$$

$\Rightarrow$ The amplitude of corresponding EM wave is 200 N/C
or the wave is $E = 200\sin(\omega t - kx)\mathrm{NC}^{-1}$

Q7. **(1)**

$$\overrightarrow{\mathrm{B}} = \left(\frac{\sqrt{3}}{2}\hat{\mathrm{i}} + \frac{1}{2}\hat{\mathrm{j}}\right) 30\sin\left[\omega\left(\mathrm{t} - \frac{\mathrm{z}}{\mathrm{c}}\right)\right]$$

$\overrightarrow{\mathrm{E}} = \overrightarrow{\mathrm{B}} \times \overrightarrow{\mathrm{c}}$ and $\mathrm{E} = \mathrm{B_0 c}$

Here $\overrightarrow{\mathrm{E}}\left(\frac{\sqrt{3}}{2}(-\hat{\mathrm{j}}) + \frac{1}{2}\hat{\mathrm{i}}\right)$

$\mathrm{E_0} = 30\mathrm{c}$

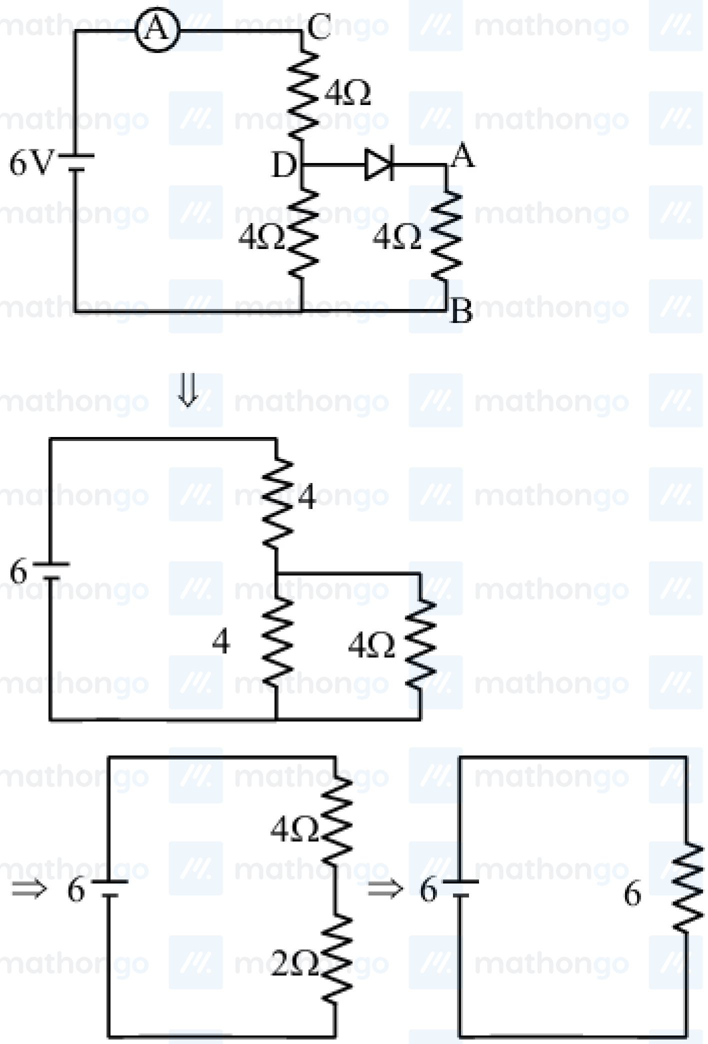
$$\overrightarrow{\mathrm{E}} = \left(\frac{1}{2}\hat{\mathrm{i}} - \frac{\sqrt{3}}{2}\hat{\mathrm{j}}\right) 30\mathrm{c}\sin\left[\omega\left(\mathrm{t} - \frac{\mathrm{z}}{\mathrm{c}}\right)\right]$$

Q1. For forward bias potential of p side should be higher than n side.

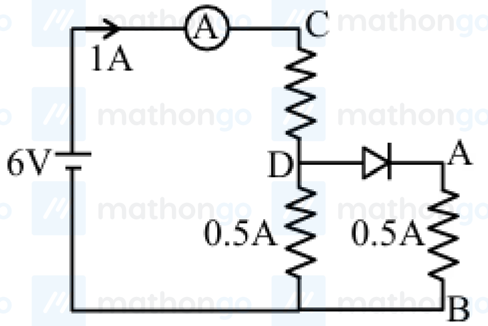
(4)

Q2.

(1)



Current through ammeter $= 1$ A



$R_{net} = 6\Omega$

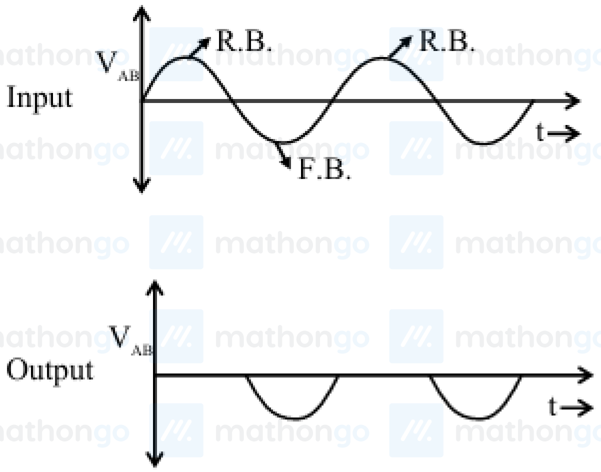
$V_{AB} = 0.5 \times 4 = 2$volt

$V_{CD} = 1 \times 4 = 4$volt

A, B \& D are correct

Q3. $V = V_0 \sin \omega t$

(4)

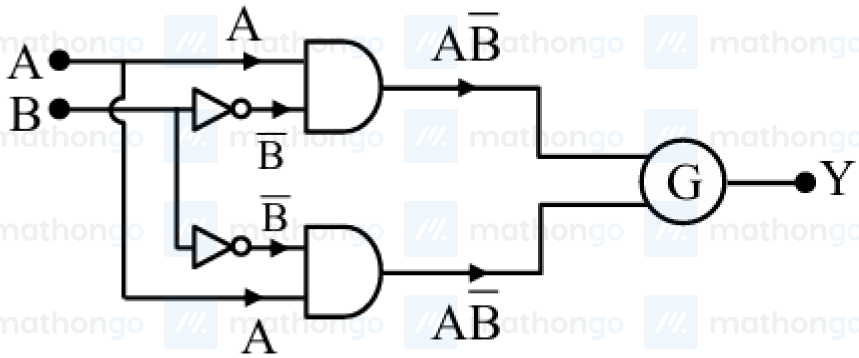


Q4. Clearly statement ' A ' is wrong as for solar cell junction area are mode wide. LED connected in forward biase

(1) and its intensity increases upto certain value of current and further there is no charge as intensity saturates. Also solar cells are not connected with any external bias.

Q5.

(3)

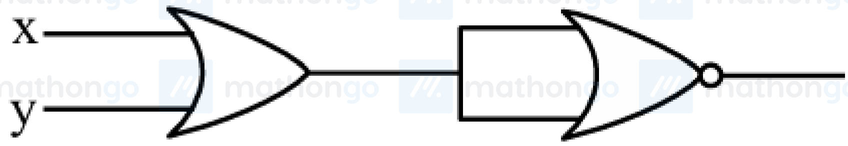


∴ Truth table

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

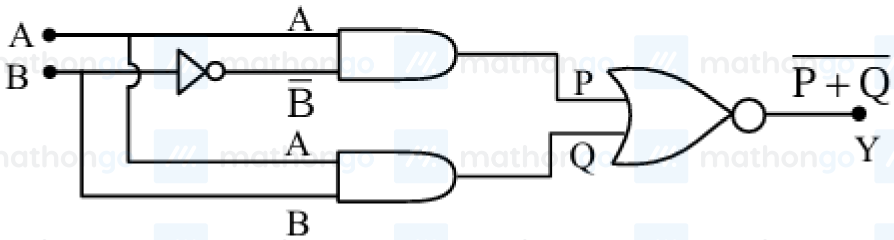
For NOR gate : $\overline{AB} = \vec{A} + B$

Q6.
(1)



x	y	
0	0	1
0	1	0
1	0	0
1	1	0

Q7.
(2)



$P = A \cdot \overline{B}$

$Q = A \cdot B$

$Y = \overline{P+Q} = \overline{A \cdot \overline{B} + A \cdot B}$

$= \overline{A \cdot (B + \overline{B})} = \overline{A \cdot I}$

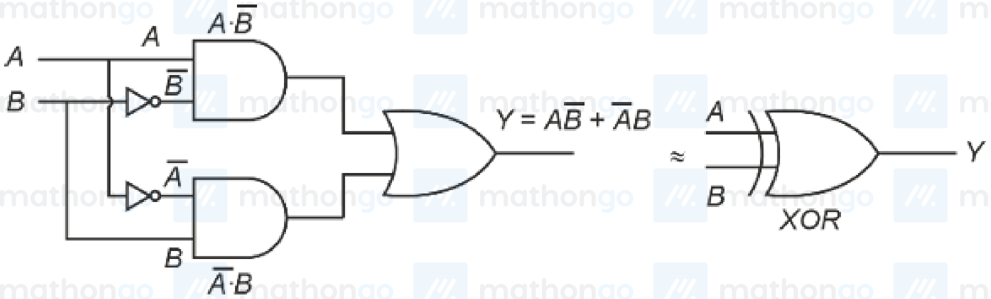
$Y = \overline{A}$

Q8.
(1)

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

$\Rightarrow$ OR Gate

Q9.
(4)



Q1. **(1)** In general one vernier scale division is smaller than one main scale division but in some modified cases it may be not correct. Also least count is given by one main scale division / number of vernier scale division for normal vernier calliper.

Q2. **(35)** Given least count of Screw Gauge $= 0.01 \text{ mm}$

$$\text{L.C} = \frac{(\text{ pitch })}{\text{No. of circular turn}} = \frac{\text{P}}{\text{N}} = 0.01 \text{ mm}$$

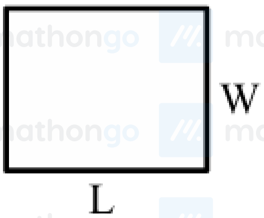
$$\text{New pitch} = \frac{\text{P}(1+0.75)}{\text{N}(1-0.5)} = \frac{\text{P}}{\text{N}}\left[\frac{1.75}{0.5}\right]$$

$= (0.01)3.5$

$= 0.035 \text{ mm}$

$= 35 \times 10^{-3} \text{ mm}$

Q3. **(3)**



Since least count of the instrument can be calculated as

$$\text{Least count} = \frac{\text{pitch length}}{\text{No. of division on circular scale}}$$

$$= \frac{0.75}{15} = 0.05 \text{ mm.}$$

Here we are provided $\text{L} = 5 \text{ mm} \& \text{ W} = 2.5 \text{ mm L} = 5 \text{ mm} \& \text{ W} = 2.5 \text{ mm}$

$\because$ We know that

$\text{A} = \text{L. W}$

For calculating fractional error, we can write

$\frac{\text{dA}}{\text{A}} = \frac{\text{dL}}{\text{L}} + \frac{\text{dW}}{\text{W}}$

Here $\text{dL} = \text{dW} = 0.05 \text{ mm}$

$$\frac{\text{dA}}{\text{A}} = \frac{0.05}{5} + \frac{0.05}{2.5}$$

$$\Rightarrow \frac{\text{dA}}{\text{A}} = \frac{1}{100} + \frac{2}{100} = \frac{3}{100}$$

So, $x = 3$