NEW

TOP 500

MOST IMPORTANT PYQs

JEE Main – Physics

Index

Chapter: Mathematics in Physics

Q1. Mathematics in Physics, 2024 (09 Apr Shift 2)

The resultant of two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to $\vec{A}$ and its magnitude is half that of $\vec{B}$. The angle between vectors $\vec{A}$ and $\vec{B}$ is ______ $\circ$.

Q2. Mathematics in Physics, 2024 (06 Apr Shift 1)

To find the spring constant (k) of a spring experimentally, a student commits 2% positive error in the measurement of time and 1% negative error in measurement of mass. The percentage error in determining value of k is :

(1) 5%
(2) 1%
(3) 3%
(4) 4%

Q3. Mathematics in Physics, 2024 (05 Apr Shift 1)

The angle between vector $\vec{Q}$ and the resultant of $(2\vec{Q}+2\vec{P})$ and $(2\vec{Q}-2\vec{P})$ is :

(1) $\tan^{-1}\frac{(2\vec{Q}-2\vec{P})}{2\vec{Q}+2\vec{P}}$
(2) 0°
(3) $\tan^{-1}(\mathrm{P}/\mathrm{Q})$
(4) $\tan^{-1}(2\mathrm{Q}/\mathrm{P})$

Q4. Mathematics in Physics, 2024 (01 Feb Shift 2)

Match List - I with List - II.

List - I (Number)		List - II (Signficant figure)	
(A)	1001	(I)	3
(B)	010.1	(II)	4
(C)	100.100	(III)	5
(D)	0.0010010	(IV)	6

Choose the correct answer from the options given below:

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

Q5. Mathematics in Physics, 2023 (06 Apr Shift 1)

The length of a metallic wire is increased by 20% and its area of cross-section is reduced by 4%. The percentage change in resistance of the metallic wire is ________.

Q6. Mathematics in Physics, 2022 (25 Jul Shift 2)

The maximum error in the measurement of resistance, current and time for which current flows in an electrical circuit are $1\%, 2\%$ and 3% respectively. The maximum percentage error in the detection of the dissipated heat will be:

(1) 2
(2) 4
(3) 6
(4) 8

Q7. Mathematics in Physics, 2022 (27 Jun Shift 1)

A silver wire has a mass (0.6 ± 0.006)g, radius (0.5 ± 0.005) mm and length (4 ± 0.04) cm. The maximum percentage error in the measurement of its density will be

(1) 7%
(2) 3%
(3) 4%
(4) 6%

Q8. Mathematics in Physics, 2021 (31 Aug Shift 2)

Statement I: If three forces $\overrightarrow{F_1}$, $\overrightarrow{F_2}$ and $\overrightarrow{F_3}$ are represented by three sides of a triangle and $\overrightarrow{F_1}+\overrightarrow{F_2}=-\overrightarrow{F_3}$, then these three forces are concurrent forces and satisfy the condition for equilibrium.

Statement II: A triangle made up of three forces $\overrightarrow{F_1}$, $\overrightarrow{F_2}$ and $\overrightarrow{F_3}$ as its sides were taken in the same order, satisfies the condition for translatory equilibrium.

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

(1) Both Statement I and Statement II are true.
(2) Statement I is true but Statement II is false.
(3) Both Statement I and Statement II are false.
(4) Statement I is false but Statement II is true.

Q9. Mathematics in Physics, 2021 (31 Aug Shift 2)

Statement-I : Two forces $\left(\vec{P}+\vec{Q}\right)$ and $\left(\vec{P}-\vec{Q}\right)$ where $\vec{P}\perp\vec{Q}$, when act at an angle θ_1 each other, the magnitude of their resultant is $\sqrt{3(P^2+Q^2)}$, when they act at an angle θ_2, the magnitude of their resultant becomes $\sqrt{2(P^2+Q^2)}$. This is possible only when $\theta_1<\theta_2$.

Statement-II : In the situation given above.
$\theta_1=60^\circ$ and $\theta_2=90^\circ$

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

(1) Statement I is false but Statement II is true.
(2) Both Statement I and Statement II are true.
(3) Both Statement I and Statement II are false.
(4) Statement I is true but Statement II is false.

Q10. Mathematics in Physics, 2021 (22 Jul Shift 1)

Three students S_1, S_2 and S_3 perform an experiment for determining the acceleration due to gravity (g) using a simple pendulum. They use different lengths of pendulum and record time for different number of oscillations. The observations are as shown in the table.

Student No.	Length of pendulum (cm)	Number of oscillations (n)	Total time for n oscillations	Time period (s)
1.	64.0	8	128.0	16.0
2.	64.0	4	64.0	16.0
3.	20.0	4	36.0	9.0

(Least count of length $=0.1$ m, least count for time $=0.1$ s)

If E_1, E_2 and E_3 are the percentage errors in g for students 1, 2 and 3, respectively, then the minimum percentage error is obtained by student no ____ .

Chapter: Units and Dimensions

Q11. Units and Dimensions, 2024 (05 Apr Shift 1)

If G be the gravitational constant and u be the energy density then which of the following quantity have the dimensions as that of the $\sqrt{\mathrm{uG}}$:

(1) pressure gradient per unit mass
(2) Gravitational potential
(3) Energy per unit mass
(4) Force per unit mass

Q12. Units and Dimensions, 2024 (04 Apr Shift 1)

The equation of stationary wave is : $y=2a\sin\left(\frac{2\pi nt}{\lambda}\right)\cos\left(\frac{2\pi x}{\lambda}\right)$. Which of the following is NOT correct :

(1) The dimensions of n/λ is [T]
(2) The dimensions of n is $\left[\mathrm{LT}^{-1}\right]$
(3) The dimensions of x is [L]
(4) The dimensions of nt is [L]

Q13. Units and Dimensions, 2024 (30 Jan Shift 1)

Match List-I with List-II.

	List-I		List-II
A.	Coefficient of viscosity	I.	$[ML^2\ T^{-2}]$
B.	Surface Tension	II.	$[ML^2\ T^{-1}]$
C.	Angular momentum	III.	$[ML^{-1}\ T^{-1}]$
D.	Rotational kinetic energy	IV.	$[ML^0\ T^{-2}]$

(1) A-II, B-I, C-IV, D-III (2) A-I, B-II, C-III, D-IV
(3) A-III, B-IV, C-II, D-I (4) A-IV, B-III, C-II, D-I

Q14. Units and Dimensions, 2024 (27 Jan Shift 1)

Given below are two statements:

Statement (I) : Planck's constant and angular momentum have the same dimensions.

Statement (II) : Linear momentum and moment of force have the same dimensions.

In 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) Both Statement I and Statement II are false
(3) Both Statement I and Statement II are true (4) Statement I is false but Statement II is true

Q15. Units and Dimensions, 2022 (27 Jul Shift 2)

An expression of energy density is given by $u = \frac{\alpha}{\beta}\sin\left(\frac{\alpha x}{kt}\right)$, where $\alpha,\ \beta$ are constants, x is displacement, k is Boltzmann constant and t is the temperature. The dimensions of β will be

(1) $[ML^2\ T^{-2}\theta^{-1}]$ (2) $[M^0L^2T^{-2}]$
(3) $[M^0L^0T^0]$ (4) $[M^0L^2T^0]$

Q16. Units and Dimensions, 2022 (25 Jul Shift 1)

If momentum $[P]$, area $[A]$ and time $[T]$ are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is

(1) $[PA^{-1}T^0]$ (2) $[PAT^{-1}]$
(3) $[PA^{-1}T]$ (4) $[PA^{-1}T^{-1}]$

Q17. Units and Dimensions, 2021 (26 Aug Shift 2)

Match List - I with List - II :

	List - I		List - II
a	Magnetic induction	i	$ML^2\ T^{-2}\ A^{-1}$
b	Magnetic flux	ii	$M^0\ L^{-1}\ A$
c	Magnetic permeability	iii	$MT^{-2}\ A^{-1}$
d	Magnetization	iv	$MLT^{-2}\ A^{-2}$

Choose the most appropriate answer from the options given below :

(1) (a) – (iii), (b) – (ii), (c) – (iv), (d) – (i) (2) (a) – (iii), (b) – (i), (c) – (iv), (d) – (ii)
(3) (a) – (ii), (b) – (iv), (c) – (i), (d) – (iii) (4) (a) – (ii), (b) – (i), (c) – (iv), (d) – (iii)

Q18. Units and Dimensions, 2021 (27 Jul Shift 2)

Match List I with List II.

	List-I		List-II
a	Capacitance, C	i	$M^1\ L^1\ T^{-3}\ A^{-1}$

b Permittivity of free space, ε_0 ii $\mathrm{M}^{-1} \mathrm{~L}^{-3} \mathrm{~T}^4 \mathrm{~A}^2$

c Permeability of free space, μ_0 iii $\mathrm{M}^{-1} \mathrm{~L}^{-2} \mathrm{~T}^4 \mathrm{~A}^2$

d Electric field, E iv $\mathrm{M}^1 \mathrm{L}^1 \mathrm{T}^{-2} \mathrm{A}^{-2}$

Choose the correct answer from the options given below

(1) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)
(2) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)
(3) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iii), (d) $\rightarrow$ (i)
(4) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

Q19. Units and Dimensions, 2020 (04 Sep Shift 2)

A quantity x is given by $\left(1 F v^2 / W L^4\right)$ in terms of moment of inertia I, force F, velocity v, work W and length L. The dimensional formula for x is same as that of :

(1) planck's constant
(2) force constant
(3) energy density
(4) coefficient of viscosity

Q20. Units and Dimensions, 2020 (09 Jan Shift 1)

A quantity f is given by $f=\sqrt{\frac{h c^5}{G}}$ where c is speed of light, G univasal gravitational constant and h is the Planck's constant. Dimension of f is that of:

(1) area
(2) energy
(3) momentum
(4) volume

Q21. Units and Dimensions, 2020 (08 Jan Shift 1)

The dimension of stopping potential V_0 in photoelectric effect in units of Planck's constant ' h ', speed of light ' c ' and Gravitational constant ' G ' and ampere A is:

(1) $h^{\frac{1}{3}} G^{\frac{2}{3}} c^{\frac{1}{3}} A^{-1}$
(2) $h^0 c^5 G^{-1} A^{-1}$
(3) $h^{-\frac{2}{3}} c^{-\frac{1}{3}} G^{\frac{4}{3}} A^{-1}$
(4) $h^2 G^{\frac{3}{2}} c^{\frac{1}{3}} A^{-1}$

Chapter: Motion In One Dimension

Q22. Motion In One Dimension, 2024 (06 Apr Shift 2)

A body projected vertically upwards with a certain speed from the top of a tower reaches the ground in t_1. If it is projected vertically downwards from the same point with the same speed, it reaches the ground in t_2. Time required to reach the ground, if it is dropped from the top of the tower, is :

(1) $\sqrt{t_1 t_2}$
(2) $\sqrt{t_1+t_2}$
(3) $\sqrt{t_1-t_2}$
(4) $\sqrt{\frac{t_1}{t_2}}$

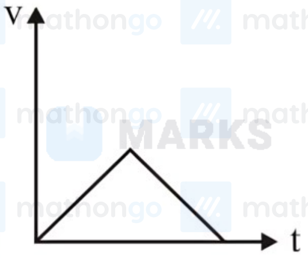
Q23. Motion In One Dimension, 2024 (31 Jan Shift 1)

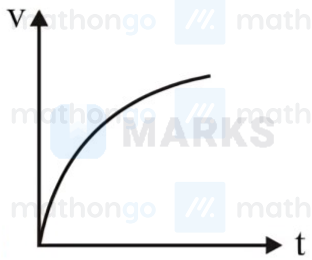
The relation between time 't' and distance 'x' is $t=\alpha x^2+\beta x$, where α and β are constants. The relation between acceleration (a) and velocity (v) is:

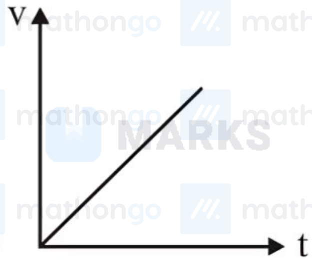
(1) $a=-2 \alpha v^3$
(2) $a=-5 \alpha v^5$
(3) $a=-3 \alpha v^2$
(4) $a=-4 \alpha v^4$

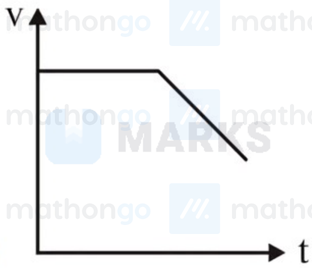
Q24. Motion In One Dimension, 2024 (31 Jan Shift 1)

A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball?

(1)


(2)


(3)


(4)


Q25. Motion In One Dimension, 2024 (27 Jan Shift 1)

A particle starts from origin at $t = 0$ with a velocity $5\hat{i}\ m\ s^{-1}$ and moves in $x - y$ plane under action of a force which produces a constant acceleration of $\left(3\hat{i} + 2\hat{j}\right)\ m\ s^{-2}$. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}\ m\ s^{-1}$. The value of α is _______.

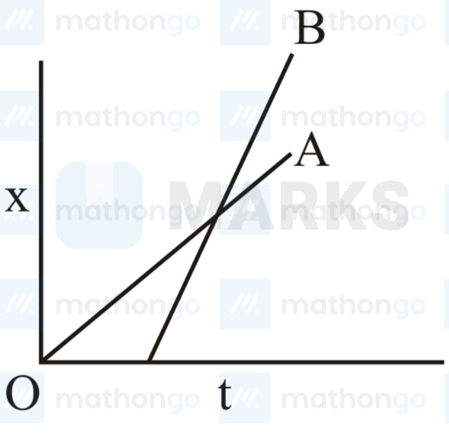
Q26. Motion In One Dimension, 2024 (27 Jan Shift 2)

A bullet is fired into a fixed target looses one third of its velocity after travelling 4 cm. It penetrates further $D \times 10^{-3}$ m before coming to rest. The value of D is :

(1) 32
(2) 5
(3) 3
(4) 4

Q27. Motion In One Dimension, 2023 (10 Apr Shift 1)

The position-time graphs for two students A and B returning from the school to their homes are shown in figure.



(A) A lives closer to the school
(B) B lives closer to the school
(C) A takes lesser time to reach home
(D) A travels faster than B
(E) B travels faster than A

Choose the correct answer from the options given below

(1) (A), (C) and (D) only
(2) (A), (C) and (E) only
(3) (B) and (E) only
(4) (A) and (E) only

Q28. Motion In One Dimension, 2023 (06 Apr Shift 1)

A particle of mass 10 g moves in a straight line with retardation $2x$, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is $\left(\frac{10}{x}\right)^{-n}$ J. The value of n will be ________.

Q29. Motion In One Dimension, 2023 (01 Feb Shift 2)

For a train engine moving with speed of 20 ms^{-1}, the driver must apply brakes at a distance of 500 m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}$ ms^{-1}. The value of x is ______. (Assuming same retardation is produced by brakes)

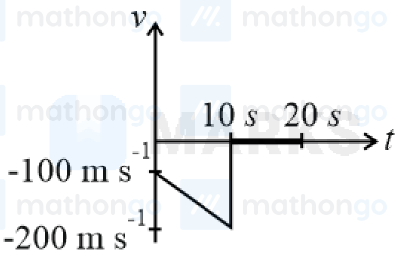
Q30. Motion In One Dimension, 2022 (29 Jul Shift 2)

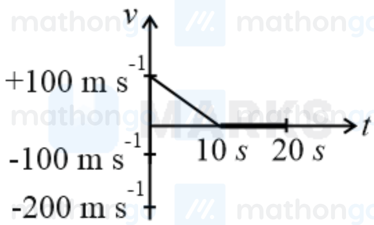
A juggler throws balls vertically upwards with same initial velocity in air. When the first ball reaches its highest position, he throws the next ball. Assuming the juggler throws n balls per second, the maximum height the balls can reach is

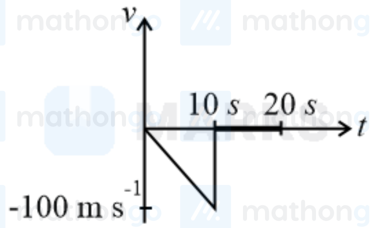
(1) $\frac{g}{2n}$
(2) $\frac{g}{n}$
(3) $2gn$
(4) $\frac{g}{2n^2}$

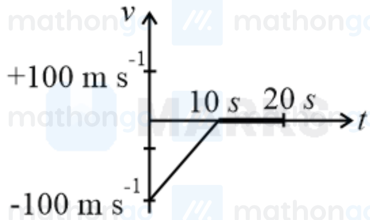
Q31. Motion In One Dimension, 2022 (27 Jul Shift 1)

A bullet is shot vertically downwards with an initial velocity of $100 \mathrm{~m~s}^{-1}$ from a certain height. Within 10 s, the bullet reaches the ground and instantaneously comes to rest due to the perfectly inelastic collision. The velocity-time curve for total time $\mathrm{t}=20$ s will be : (Take $g=10 \mathrm{~m~s}^{-2}$)

(1)


(2)


(3)


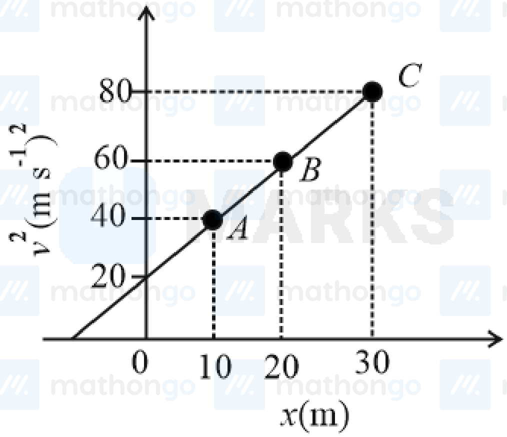
(4)


Q32. Motion In One Dimension, 2022 (24 Jun Shift 1)

From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6 s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5 s. A third ball released, from the rest from the same location, will reach the ground in _____ s.

Q33. Motion In One Dimension, 2021 (31 Aug Shift 2)

A particle is moving with constant acceleration a. Following graph shows v^2 versus x (displacement) plot. The acceleration of the particle is _________ $\mathrm{m~s}^{-2}$.



Q34. Motion In One Dimension, 2021 (27 Jul Shift 1)

A ball is thrown up with a certain velocity so that it reaches a height h. Find the ratio of the two different times of the ball reaching $\frac{h}{3}$ in both the directions.

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

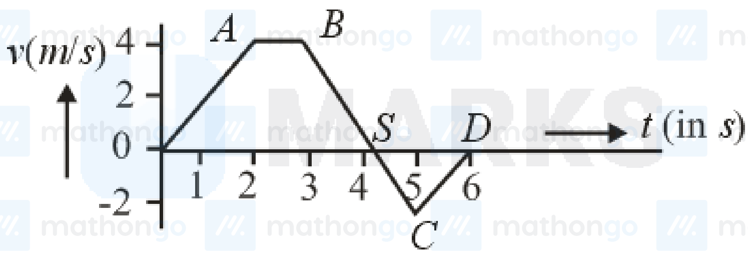
Q35. Motion In One Dimension, 2021 (25 Jul Shift 2)

The relation between time t and distance x for a moving body is given as $t = mx^2 + nx$, where m and n are constants. The retardation of the motion is: (When v stands for velocity)

(1) $2mv^3$
(2) $2mnv^3$
(3) $2nv^3$
(4) $2n^2v^3$

Q36. Motion In One Dimension, 2020 (05 Sep Shift 2)

The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6 s is :

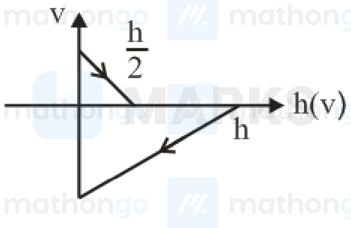


(1) $\frac{37}{3}$m
(2) 12m
(3) 11m
(4) $\frac{49}{4}$m

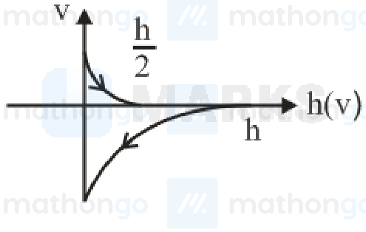
Q37. Motion In One Dimension, 2020 (04 Sep Shift 1)

A tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $h/2$. The velocity versus height of the ball during its motion may be represented graphically by: (graphs are drawn schematically and on not to scale)

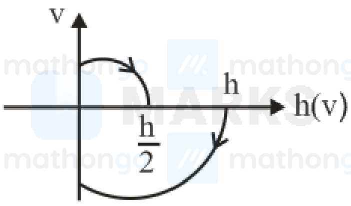
(1)



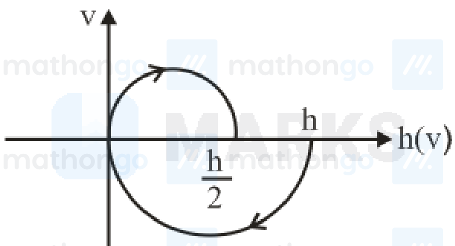
(2)



(3)



(4)



Q38. Motion In One Dimension, 2020 (02 Sep Shift 1)

Train A and train B are running on parallel tracks in the opposite directions with speed of $36\ \text{km}\ \text{hour}^{-1}$ and $72\ \text{km}\ \text{hour}^{-1}$, respectively. A person is walking in train A in the direction opposite to its motion with a speed of $1.8\ \text{km}\ \text{hour}^{-1}$. Speed $\left(\text{in}\ \text{m s}^{-1}\right)$ of this person as observed from train B will be close to: (take the distance between the tracks as negligible)

(1) $29.5\ \text{m s}^{-1}$
(2) $28.5\ \text{m s}^{-1}$
(3) $31.5\ \text{m s}^{-1}$
(4) $30.5\ \text{m s}^{-1}$

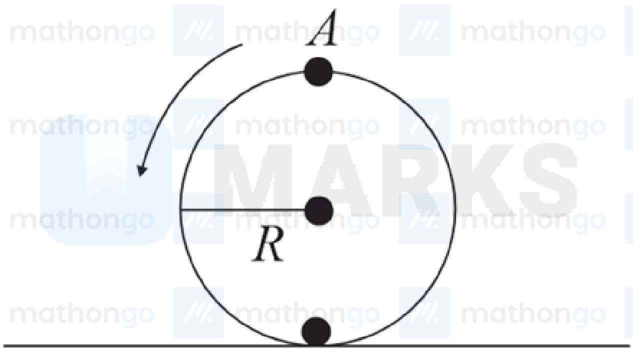
Q39. Motion In One Dimension, 2020 (08 Jan Shift 1)

A particle is moving along the x -axis with its coordinate with time t given by $x(t)=10+8t-3t^2$. Another particle is moving along the y -axis with its coordinate as a function of time given by $y(t)=5-8t^3$. At $t=1$ s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then $v\left(\text{in m s}^{-1}\right)$ is __________.

Chapter: Motion In Two Dimensions

Q40. Motion In Two Dimensions, 2023 (13 Apr Shift 1)

A disc is rolling without slipping on a surface. The radius of the disc is R. At $t=0$, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is



(1) $2R$
(2) $R\sqrt{(\pi^2+4)}$
(3) $\mathrm{R}\sqrt{(\pi^2+1)}$
(4) $2R\sqrt{(1+4\pi^2)}$

Q41. Motion In Two Dimensions, 2023 (08 Apr Shift 2)

The trajectory of projectile, projected from the ground is given by $y=x-\frac{x^2}{20}$. Where x and y are measured in meter. The maximum height attained by the projectile will be.

(1) $200 \mathrm{~m}$ (2) $10 \mathrm{~m}$
(3) $5 \mathrm{~m}$ (4) $10 \sqrt{2} \mathrm{~m}$

Q42. Motion In Two Dimensions, 2022 (29 Jul Shift 1)

An object is projected in the air with initial velocity u at an angle θ. The projectile motion is such that the horizontal range R, is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be _____ degree.

Q43. Motion In Two Dimensions, 2022 (26 Jul Shift 1)

If the initial velocity in horizontal direction of a projectile is unit vector $\hat{i}$ and the equation of trajectory is $y=5 x(1-x)$. The y component vector of the initial velocity is _____ $\hat{j}$
(Take $g=10 \mathrm{~m} \mathrm{~s}^{-2}$)

Q44. Motion In Two Dimensions, 2022 (27 Jun Shift 1)

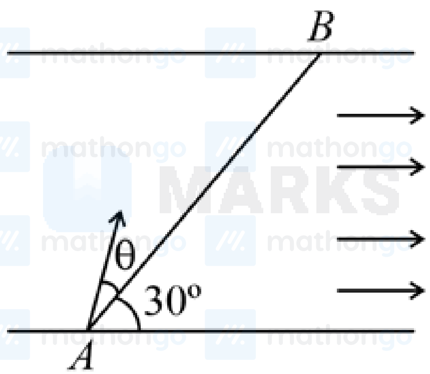
A projectile is launched at an angle α with the horizontal with a velocity $20 \mathrm{~m} \mathrm{~s}^{-1}$. After $10 \mathrm{~s}$, its inclination with horizontal is β. The value of $\tan \beta$ will be : $\left(g=10 \mathrm{~m} \mathrm{~s}^{-2}\right)$.
(1) $\tan \alpha+5 \sec \alpha$ (2) $\tan \alpha-5 \sec \alpha$
(3) $2 \tan \alpha-5 \sec \alpha$ (4) $2 \tan \alpha+5 \sec \alpha$

Q45. Motion In Two Dimensions, 2022 (27 Jun Shift 1)

A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15 \sqrt{2} \mathrm{~km} \mathrm{~h}^{-1}$, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is
(1) $30 \mathrm{~km} \mathrm{~h}^{-1}$ (2) $\frac{25}{\sqrt{2}} \mathrm{~km} \mathrm{~h}^{-1}$
(3) $\frac{30}{\sqrt{2}} \mathrm{~km} \mathrm{~h}^{-1}$ (4) $25 \mathrm{~km} \mathrm{~h}^{-1}$

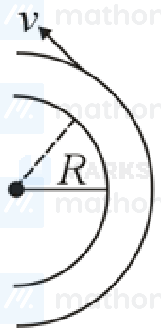
Q46. Motion In Two Dimensions, 2021 (27 Jul Shift 2)

A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of the river. The magnitude of the velocity of the swimmer is the same as that of the river. The angle θ with the line $A B$ should be _______$^{\circ}$, so that the swimmer reaches point B.



Q47. Motion In Two Dimensions, 2021 (17 Mar Shift 1)

A modern grand-prix racing car of mass m is travelling on a flat track in a circular arc of radius R with a speed v. If the coefficient of static friction between the tyres and the track is μ_{s}, then the magnitude of negative lift F_{L} acting downwards on the car is:



(1) $m\left(\frac{v^2}{\mu_s R}+g\right)$
(2) $m\left(\frac{v^2}{\mu_s R}-g\right)$
(3) $m\left(g-\frac{v^2}{\mu_s R}\right)$
(4) $-m\left(g+\frac{v^2}{\mu_s R}\right)$

Q48. Motion In Two Dimensions, 2021 (16 Mar Shift 2)

A swimmer can swim with velocity of $12 \mathrm{~km} / \mathrm{h}$ in still water. Water flowing in a river has velocity $6 \mathrm{~km} / \mathrm{h}$. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is ________ $^{\circ}$.
(Round off to the Nearest Integer) (find the angle in degree)

Q49. Motion In Two Dimensions, 2021 (24 Feb Shift 2)

A particle is projected with velocity v_0 along x-axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e. $ma=-\alpha x^2$. The distance at which the particle stops:

(1) $\left(\frac{2 v_0}{3 \alpha}\right)^{\frac{1}{3}}$
(2) $\left(\frac{3 m v_0^2}{2 \alpha}\right)^{\frac{1}{3}}$
(3) $\left(\frac{3 v_0^2}{2 \alpha}\right)^{\frac{1}{2}}$
(4) $\left(\frac{2 v_0^2}{3 \alpha}\right)^{\frac{1}{2}}$

Chapter: Laws of Motion

Q50. Laws of Motion, 2024 (08 Apr Shift 2)

A given object takes n times the time to slide down 45° rough inclined plane as it takes the time to slide down an identical perfectly smooth 45° inclined plane. The coefficient of kinetic friction between the object and the surface of inclined plane is :

(1) $\sqrt{1-\frac{1}{n^2}}$
(2) $1-n^2$
(3) $1-\frac{1}{n^2}$
(4) $\sqrt{1-n^2}$

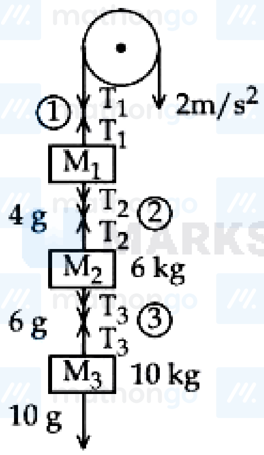
Q51. Laws of Motion, 2024 (06 Apr Shift 1)

A light string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 (where $m_2>m_1$). If the acceleration of the system is $\frac{g}{\sqrt{2}}$, then the ratio of the masses $\frac{m_1}{m_2}$ is:

(1) $\frac{1+\sqrt{5}}{\sqrt{5}-1}$
(2) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$
(3) $\frac{1+\sqrt{5}}{\sqrt{2}-1}$
(4) $\frac{\sqrt{3}+1}{\sqrt{2}-1}$

Q52. Laws of Motion, 2024 (05 Apr Shift 1)

Three blocks M_1, M_2, M_3 having masses 4 kg, 6 kg and 10 kg respectively are hanging from a smooth pully using rope 1,2 and 3 as shown in figure. The tension in the rope $1, T_1$ when they are moving upward with acceleration of $2 \mathrm{~ms}^{-2}$ is _____N (

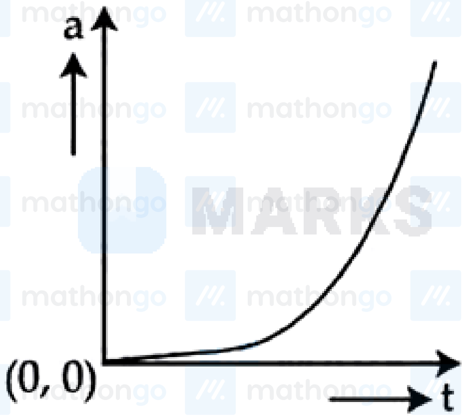


if $g = 10 \mathrm{~m/s^2}$).

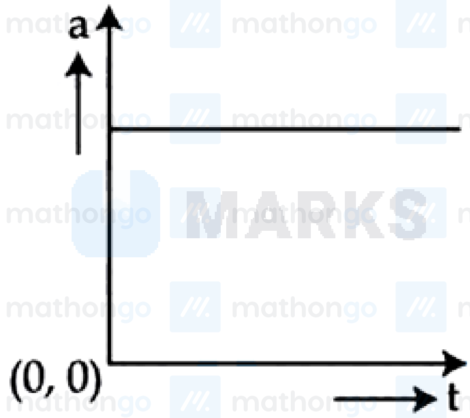
Q53. Laws of Motion, 2024 (04 Apr Shift 1)

A wooden block, initially at rest on the ground, is pushed by a force which increases linearly with time t. Which of the following curve best describes acceleration of the block with time:

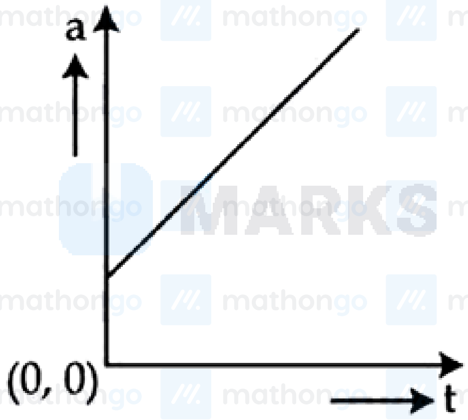
(1)



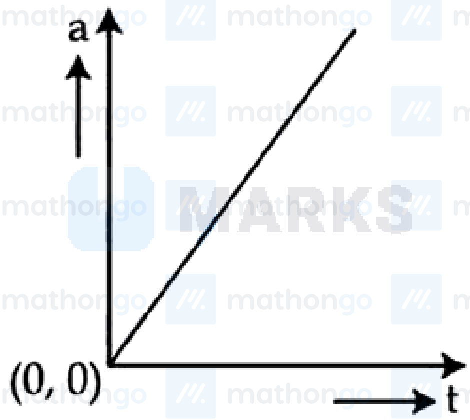
(2)



(3)

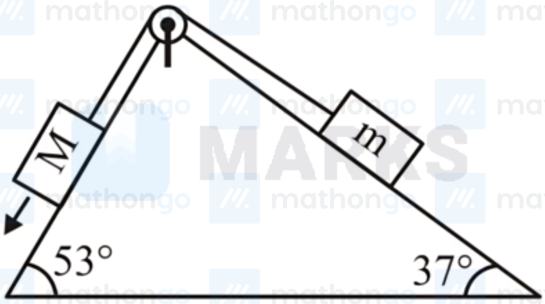


(4)



Q54. Laws of Motion, 2024 (31 Jan Shift 1)

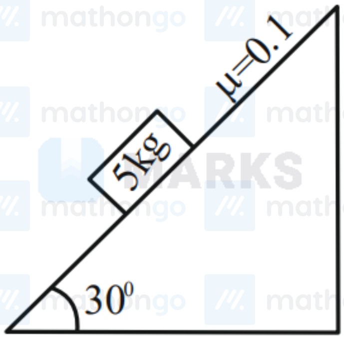
In the given arrangement of a doubly inclined plane two blocks of masses M and m are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of m, for which $M = 10$ kg will move down with an acceleration of $2 \mathrm{~m\,s^{-2}}$, is: (take $g = 10 \mathrm{~m\,s^{-2}}$ and $\tan 37^\circ = \frac{3}{4}$)



(1) 9 kg
(2) 4.5 kg
(3) 6.5 kg
(4) 2.25 kg

Q55. Laws of Motion, 2024 (31 Jan Shift 2)

A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If $\overrightarrow{F_1}$ is the force required to just move the block up the inclined plane and $\overrightarrow{F_2}$ is the force required to just prevent the block from sliding down, then the value of $\left|\overrightarrow{F_1}\right| - \left|\overrightarrow{F_2}\right|$ is: [Use $g = 10 \text{ m s}^{-2}$]



(1) $25\sqrt{3}$ N
(2) $5\sqrt{3}$ N
(3) $\frac{5\sqrt{3}}{2}$ N
(4) 10 N

Q56. Laws of Motion, 2024 (29 Jan Shift 2)

A stone of mass 900 g is tied to a string and moved in a vertical circle of radius 1 m making 10 rpm. The tension in the string, when the stone is at the lowest point is (if $\pi^2 = 9.8$ and $g = 9.8 \text{ m s}^{-2}$)

(1) 97 N
(2) 9.8 N
(3) 8.82 N
(4) 17.8 N

Q57. Laws of Motion, 2024 (27 Jan Shift 1)

A train is moving with a speed of 12 m s^{-1} on rails which are 1.5 m apart. To negotiate a curve radius 400 m, the height by which the outer rail should be raised with respect to the inner rail is (Given, $g = 10 \text{ m s}^{-2}$):

(1) 6.0 cm
(2) 5.4 cm
(3) 4.8 cm
(4) 4.2 cm

Q58. Laws of Motion, 2023 (11 Apr Shift 1)

A coin placed on a rotating table just slips when it is placed at a distance of 1 cm from the centre. If the angular velocity of the table is halved, it will just slip when placed at a distance of ______ from the centre:

(1) 8 cm
(2) 4 cm
(3) 1 cm
(4) 2 cm

Q59. Laws of Motion, 2023 (01 Feb Shift 1)

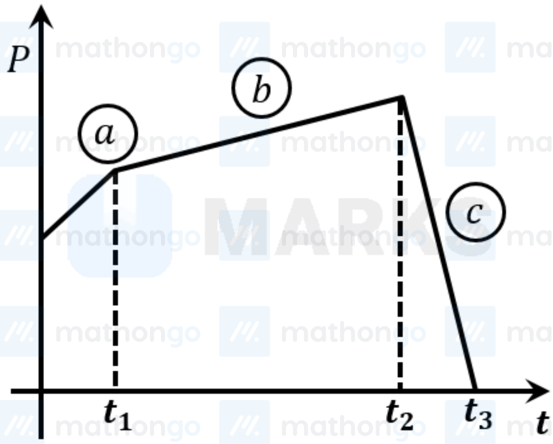
A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30 N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10 s. Coefficient of kinetic friction is (given, $g = 10 \mathrm{~m~s^{-2}}$):

(1) 0.60
(2) 0.75
(3) 0.50
(4) 0.25

Q60. Laws of Motion, 2023 (30 Jan Shift 1)

The figure represents the momentum time $(p-t)$ curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively ?

If $(t_3 - t_2) < t_1$



(1) c and a
(2) b and c
(3) c and b
(4) a and b

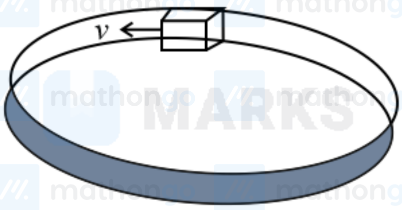
Q61. Laws of Motion, 2023 (29 Jan Shift 2)

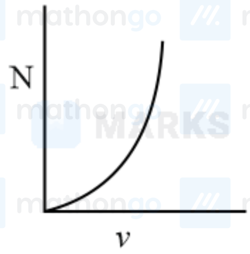
The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction between the object and the incline plane is:

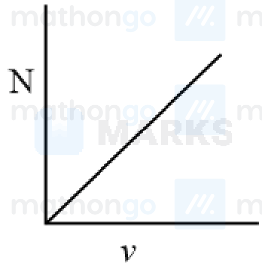
(1) $\sqrt{\frac{1}{1-n^2}}$
(2) $\sqrt{1-\frac{1}{n^2}}$
(3) $1+\frac{1}{n^2}$
(4) $1-\frac{1}{n^2}$

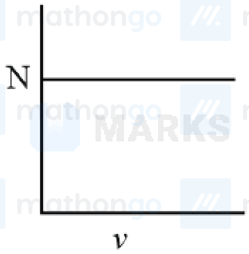
Q62. Laws of Motion, 2022 (29 Jul Shift 1)

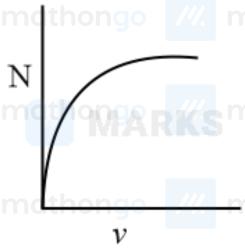
A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v)?



(1)


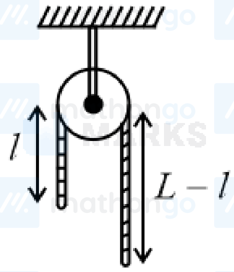
(2)


(3)


(4)


Q63. Laws of Motion, 2022 (28 Jul Shift 2)

A uniform metal chain of mass m and length L passes over a massless and frictionless pulley. It is released from rest with a part of its length l is hanging on one side and rest of its length $L-l$ is hanging on the other side of the pulley. At a certain point of time, when $l=\frac{L}{x}$, the acceleration of the chain is $\frac{g}{2}$. The value of x is _____.



(1) 6
(2) 2
(3) 1.5
(4) 4

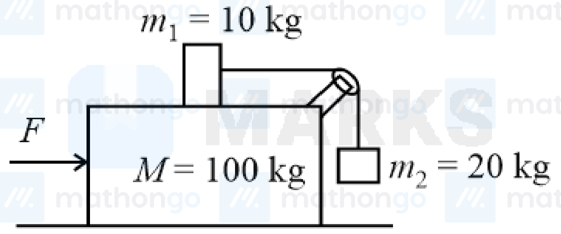
Q64. Laws of Motion, 2022 (27 Jul Shift 2)

A block A takes 2 s to slide down a frictionless incline of 30° and length l, kept inside a lift going up with uniform velocity v. If the incline is changed to 45°, the time taken by the block, to slide down the incline, will be approximately:

(1) 2.66 s
(2) 0.83 s
(3) 1.68 s
(4) 0.70 s

Q65. Laws of Motion, 2022 (26 Jul Shift 1)

Three masses $M=100$ kg, $m_1=10$ kg and $m_2=20$ kg are arranged in a system as shown in figure. All the surfaces are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of $2\ \mathrm{ms}^{-2}$. The value of F is
(Take $g=10\ \mathrm{ms}^{-2}$)



(1) 3360 N
(2) 3380 N
(3) 3120N
(4) 3240N

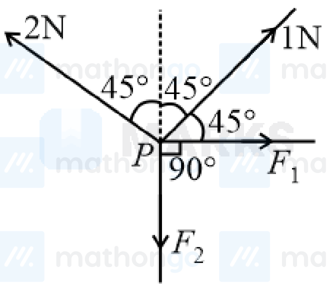
Q66. Laws of Motion, 2022 (26 Jul Shift 1)

A monkey of mass 50 kg climbs on a rope which can withstand the tension (T) of 350 N. If monkey initially climbs down with an acceleration of 4 m s^{-2} and then climbs up with an acceleration of 5 m s^{-2}. Choose the correct option $\left(\text{g} = 10 \text{ m s}^{-2}\right)$

(1) $T = 700$ N while climbing upward
(2) $T = 350$ N while going downward
(3) Rope will break while climbing upward
(4) Rope will break while going downward

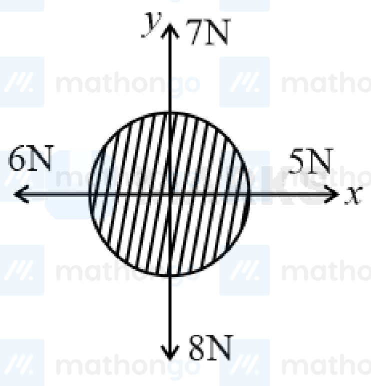
Q67. Laws of Motion, 2022 (25 Jul Shift 1)

Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is $1 : x$ where $x =$_____ .



Q68. Laws of Motion, 2022 (25 Jul Shift 2)

For a free body diagram shown in the figure, the four forces are applied in the 'x' and 'y' directions. What additional force must be applied and at what angle with positive x-axis so that the net acceleration of body is zero?

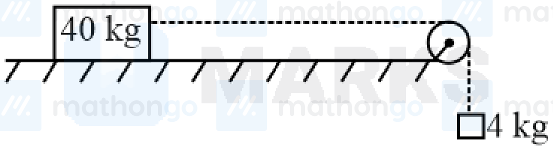


(1) $\sqrt{2}$ N, 45°
(2) $\sqrt{2}$ N, 135°
(3) $\frac{2}{\sqrt{3}}$ N, 30°
(4) 2 N, 45°

Q69. Laws of Motion, 2022 (29 Jun Shift 2)

A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below.

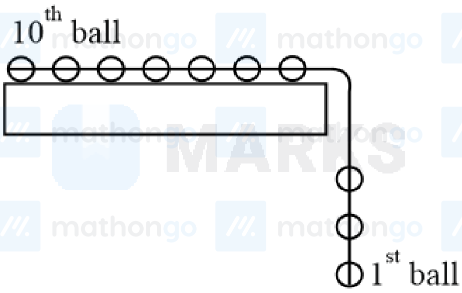
The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is: (Given $g = 10 \text{ m s}^{-2}$.)



(1) $\frac{8}{11}$ m s^{-2}
(2) 1 m s^{-2}
(3) $\frac{1}{5}$ m s^{-2}
(4) $\frac{4}{5}$ m s^{-2}

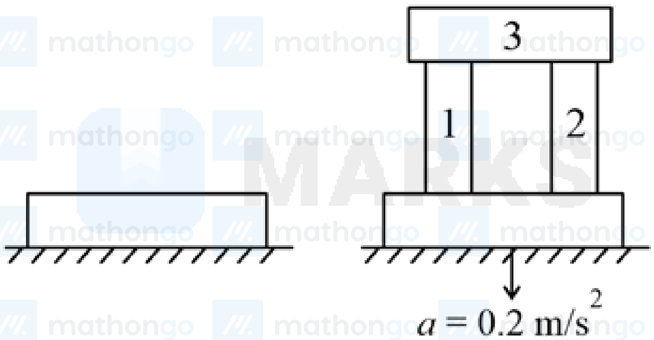
Q70. Laws of Motion, 2022 (26 Jun Shift 2)

A system to 10 balls each of mass 2 kg are connected via massless and unstretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7^{th} and 8^{th} ball is ______ N when 6^{th} ball just leaves the table.



Q71. Laws of Motion, 2021 (20 Jul Shift 1)

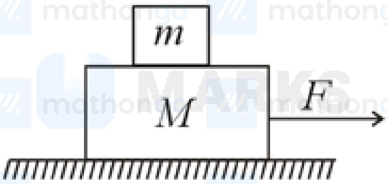
A steel block of 10 kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration $0.2 \mathrm{~m} \mathrm{~s}^{-2}$. The normal reaction R' by the floor if mass of the iron cylinders are equal and of 20 kg each is (in N),
[Take $g=10 \mathrm{~m} \mathrm{~s}^{-2}$ and $\mu_s=0.2$]



(1) 716
(2) 686
(3) 714
(4) 684

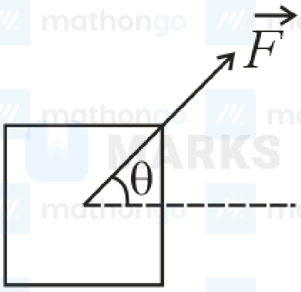
Q72. Laws of Motion, 2021 (17 Mar Shift 1)

Two blocks ($m=0.5$ kg and $M=4.5$ kg) are arranged on a horizontal frictionless table as shown in the figure. The coefficient of static friction between the two blocks is $\frac{3}{7}$. Then the maximum horizontal force that can be applied on the larger block so that the blocks move together is N. (Round off to the Nearest Integer) [Take g as $9.8 \mathrm{~m} \mathrm{~s}^{-2}$]



Q73. Laws of Motion, 2021 (16 Mar Shift 1)

A block of mass m slides along a floor while a force of magnitude F is applied to it at an angle θ as shown in figure. The coefficient of kinetic friction is μ_K. Then, the block's acceleration a is given by : (g is acceleration due to gravity)

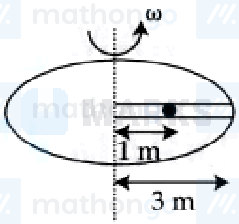


(1) $-\frac{F}{m}\cos\theta-\mu_K\left(g-\frac{F}{m}\sin\theta\right)$
(2) $\frac{F}{m}\cos\theta-\mu_K\left(g-\frac{F}{m}\sin\theta\right)$
(3) $\frac{F}{m}\cos\theta-\mu_K\left(g+\frac{F}{m}\sin\theta\right)$
(4) $\frac{F}{m}\cos\theta+\mu_K\left(g-\frac{F}{m}\sin\theta\right)$

Chapter: Work Power Energy

Q74. Work Power Energy, 2024 (08 Apr Shift 2)

A circular table is rotating with an angular velocity of $\omega \mathrm{rad/s}$ about its axis (see figure). There is a smooth groove along a radial direction on the table. A steel ball is gently placed at a distance of $1 \mathrm{~m}$ on the groove. All the surfaces are smooth. If the radius of the table is $3 \mathrm{~m}$, the radial velocity of the ball w.r.t. the table at the time ball leaves the table is $x\sqrt{2}\omega \mathrm{m/s}$, where the



value of x is _____.

Q75. Work Power Energy, 2024 (05 Apr Shift 2)

A body is moving unidirectionally under the influence of a constant power source. Its displacement in time t is proportional to :

(1) t
(2) $t^{3/2}$
(3) t^2
(4) $t^{2/3}$

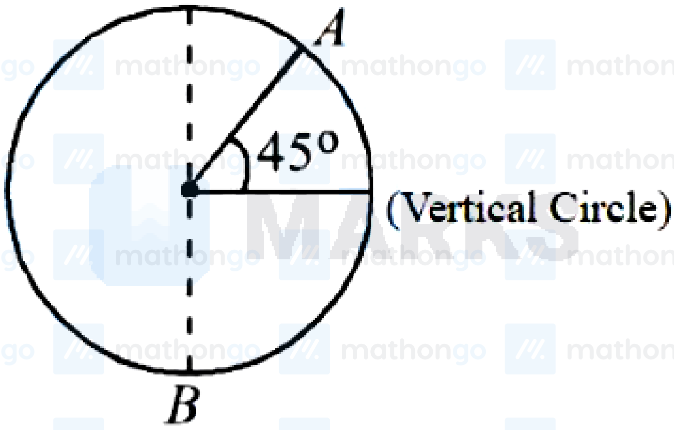
Q76. Work Power Energy, 2024 (04 Apr Shift 1)

If a rubber ball falls from a height h and rebounds upto the height of $h/2$. The percentage loss of total energy of the initial system as well as velocity ball before it strikes the ground, respectively, are :

(1) $50\%, \sqrt{2gh}$
(2) $50\%, \sqrt{gh}$
(3) $40\%, \sqrt{2gh}$
(4) $50\%, \sqrt{\frac{gh}{2}}$

Q77. Work Power Energy, 2024 (04 Apr Shift 2)

A body of m kg slides from rest along the curve of vertical circle from point A to B in friction less path. The velocity of the



body at B is:

(given, $R = 14$ m, $g = 10$ m/s^2 and $\sqrt{2} = 1.4$)

(1) 16.7 m/s
(2) 19.8 m/s
(3) 10.6 m/s
(4) 21.9 m/s

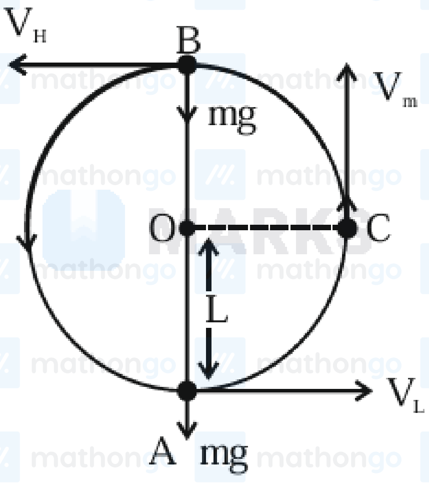
Q78. Work Power Energy, 2024 (31 Jan Shift 2)

A body of mass 2 kg begins to move under the action of a time dependent force given by $\vec{F} = \left(6t\,\hat{i} + 6t^2\,\hat{j}\right)$ N. The power developed by the force at the time t is given by:

(1) $\left(6t^4 + 9t^5\right)$ W
(2) $\left(3t^3 + 6t^5\right)$ W
(3) $\left(9t^5 + 6t^3\right)$ W
(4) $\left(9t^3 + 6t^5\right)$ W

Q79. Work Power Energy, 2024 (29 Jan Shift 2)

A bob of mass m is suspended by a light string of length L. It is imparted a minimum horizontal velocity at the lowest point A such that it just completes half circle reaching the top most position B. The ratio of kinetic energies $\frac{(K.E.)_A}{(K.E.)_B}$ is :



(1) 3 : 2
(2) 5 : 1
(3) 2 : 5
(4) 1 : 5

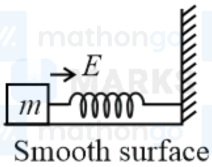
Q80. Work Power Energy, 2024 (27 Jan Shift 2)

A ball suspended by a thread swings in a vertical plane so that its magnitude of acceleration in the extreme position and lowest position are equal. The angle (θ) of thread deflection in the extreme position will be :

(1) $\tan^{-1}\left(\sqrt{2}\right)$
(2) $2\tan^{-1}\left(\frac{1}{2}\right)$
(3) $\tan^{-1}\left(\frac{1}{2}\right)$
(4) $2\tan^{-1}\left(\frac{1}{\sqrt{5}}\right)$

Q81. Work Power Energy, 2022 (28 Jul Shift 1)

A block of mass 'm' (as shown in figure) moving with kinetic energy E compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be nE N m^{-1} for $n =$_____.



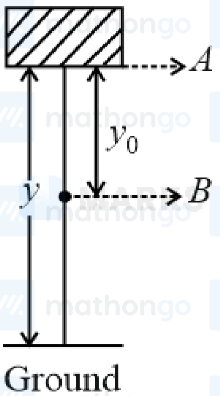
Q82. Work Power Energy, 2022 (25 Jul Shift 1)

A body of mass 0.5 kg travels on straight line path with velocity $v = \left(3x^2 + 4\right)$ m s^{-1}. The net work done by the force during its displacement from $x = 0$ to $x = 2$ m is

(1) 64 J
(2) 60 J
(3) 120 J
(4) 128 J

Q83. Work Power Energy, 2022 (29 Jun Shift 2)

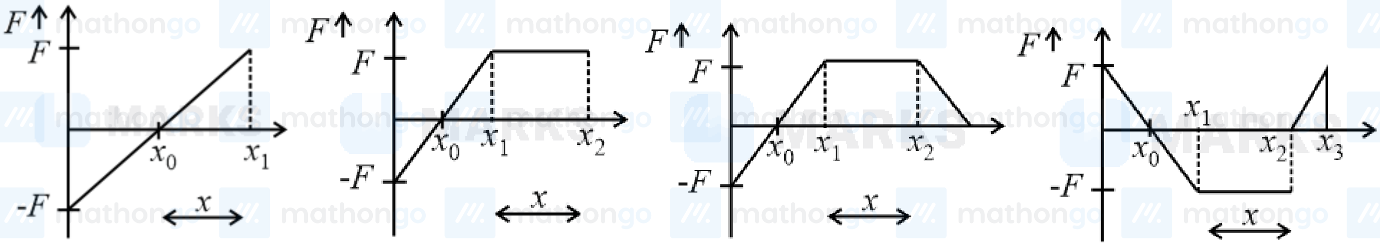
In the given figure, the block of mass m is dropped from the point $'A'$. The expression for kinetic energy of block when it reaches point $'B'$ is



(1) mgy_0
(2) $\frac{1}{2}mgy_0^2$
(3) $\frac{1}{2}mgy^2$
(4) $mg(y - y_0)$

Q84. Work Power Energy, 2022 (26 Jun Shift 2)

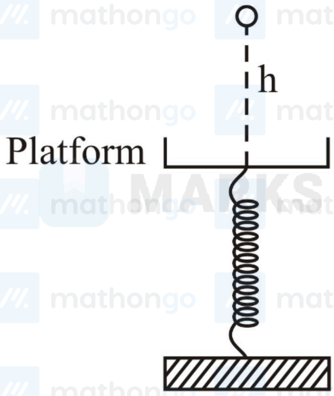
Arrange the four graphs in descending order of total work done; where W_1, W_2, W_3 and W_4 are the work done corresponding to figure a, b, c and d respectively.



(1) $W_3 > W_2 > W_1 > W_4$
(2) $W_3 > W_2 > W_4 > W_1$
(3) $W_2 > W_3 > W_4 > W_1$
(4) $W_2 > W_3 > W_1 > W_4$

Q85. Work Power Energy, 2022 (24 Jun Shift 1)

A ball of mass 100 g is dropped from a height $h=10$ cm on a platform fixed at the top of a vertical spring (as shown in figure). The ball stays on the platform and the platform is depressed by a distance $\frac{h}{2}$. The spring constant is _____ $\mathrm{N\,m^{-1}}$ (Use $g=10\ \mathrm{m\,s^{-2}}$)



Q86. Work Power Energy, 2022 (24 Jun Shift 2)

Potential energy as a function of r is given by $U=\frac{A}{r^{10}}-\frac{B}{r^{5}}$, where r is the interatomic distance, A and B are positive constants. The equilibrium distance between the two atoms will be :

(1) $\left(\frac{A}{B}\right)^{\frac{1}{5}}$

(2) $\left(\frac{B}{A}\right)^{\frac{1}{5}}$

(3) $\left(\frac{2A}{B}\right)^{\frac{1}{5}}$

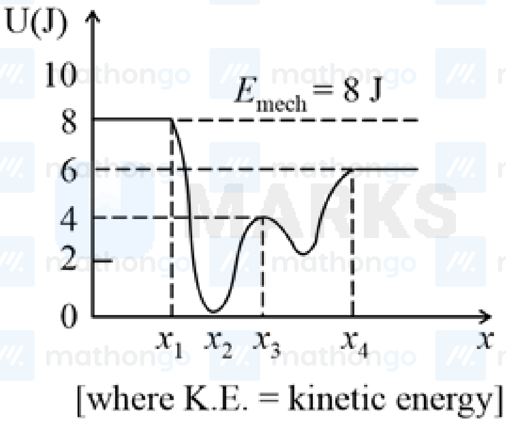
(4) $\left(\frac{B}{2A}\right)^{\frac{1}{5}}$

Q87. Work Power Energy, 2021 (01 Sep Shift 2)

An engine is attached to a wagon through a shock absorber of length 1.5 m. The system with a total mass of 40,000 kg is moving with a speed of 72 $\mathrm{km\ h^{-1}}$ when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, the spring constant is _________ $\times 10^5\ \mathrm{N\,m^{-1}}$.

Q88. Work Power Energy, 2021 (27 Jul Shift 2)

Given below is the plot of a potential energy function U(x) for a system, in which a particle is in one dimensional motion, while a conservative force F(x) acts on it. Suppose that $E_{mech}=8$ J, the incorrect statement for this system is :



(1) at $x > x_4$, K. E. is constant throughout the region.

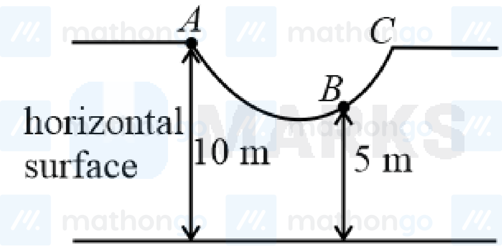
(2) at $x < x_1$, K. E. is smallest and the particle is moving at the slowest speed.

(3) at $x = x_2$, K. E. is greatest and the particle is moving at the fastest speed.

(4) at $x = x_3$, K. E. $= 4$ J

Q89. Work Power Energy, 2021 (18 Mar Shift 1)

As shown in the figure, a particle of mass 10 kg is placed at a point A. When the particle is slightly displaced to its right, it starts moving and reaches the point B. The speed of the particle at B is $x \mathrm{~m~s}^{-1}$. (Take $g = 10 \mathrm{~m~s}^{-2}$) The value of x to the nearest integer is



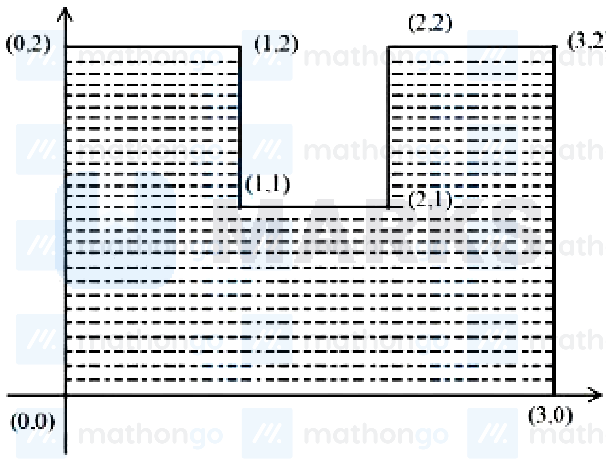
Q90. Work Power Energy, 2021 (25 Feb Shift 1)

The potential energy (U) of a diatomic molecule is a function dependent on r (interatomic distance) as $U = \frac{\alpha}{r^{10}} - \frac{\beta}{r^5} - 3$ where, α and β are positive constants. The equilibrium distance between two atoms will be $\left(\frac{2\alpha}{\beta}\right)^{\frac{a}{b}}$, where $a =$_______ .

Chapter: Center of Mass Momentum and Collision

Q91. Center of Mass Momentum and Collision, 2024 (08 Apr Shift 1)

A uniform thin metal plate of mass 10 kg with dimensions is shown. The ratio of x and y coordinates of center of mass of plate



in $\frac{n}{9}$. The value of n is _________

Q92. Center of Mass Momentum and Collision, 2024 (01 Feb Shift 2)

A uniform rod AB of mass 2 kg and Length 30 cm at rest on a smooth horizontal surface. An impulse of force 0.2 N s is applied to end B. The time taken by the rod to turn through at right angles will be $\frac{\pi}{x}$ s, where $x =$ _____.

Q93. Center of Mass Momentum and Collision, 2024 (30 Jan Shift 1)

A spherical body of mass 100 g is dropped from a height of 10 m from the ground. After hitting the ground, the body rebounds to a height of 5 m. The impulse of force imparted by the ground to the body is given by: (given $g = 9.8 \mathrm{~m~s}^{-2}$)

(1) 4.32 kg m s^{-1}
(2) 43.2 kg m s^{-1}
(3) 23.9 kg m s^{-1}
(4) 2.39 kg m s^{-1}

Q94. Center of Mass Momentum and Collision, 2023 (13 Apr Shift 1)

Two bodies are having kinetic energies in the ratio 16 : 9. If they have same linear momentum, the ratio of their masses respectively is:

(1) 3 : 4
(2) 9 : 16
(3) 16 : 9
(4) 4 : 3

Q95. Center of Mass Momentum and Collision, 2023 (11 Apr Shift 2)

A nucleus disintegrates into two nuclear parts, in such a way that ratio of their nuclear sizes is $1 : 2^{1/3}$. Their respective speed have a ratio of $n : 1$. The value of n is_________

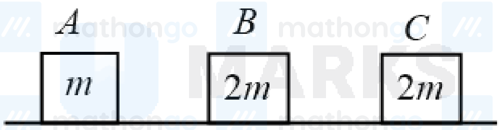
Q96. Center of Mass Momentum and Collision, 2022 (27 Jun Shift 1)

Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates $(0, 0)$ cm and $(x, 0)$ cm respectively. The block of 10 kg is moved on the same line through a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is

(1) 4 cm towards the 10 kg block
(2) 2 cm away from the 10 kg block
(3) 2 cm towards the 10 kg block
(4) 4 cm away from the 10 kg block

Q97. Center of Mass Momentum and Collision, 2021 (27 Jul Shift 1)

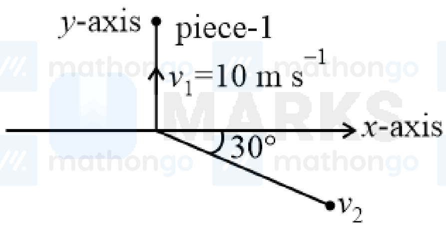
Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are m, $2m$ and $2m$ respectively. A moves towards B with a speed of 9 m s^{-1} and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along the same straight line. The final speed of C is :



(1) 6 m s^{-1}
(2) 9 m s^{-1}
(3) 4 m s^{-1}
(4) 3 m s^{-1}

Q98. Center of Mass Momentum and Collision, 2021 (18 Mar Shift 1)

A ball of mass 10 kg moving with a velocity $10\sqrt{3} \text{ m s}^{-1}$ along the x -axis, hits another ball of mass 20 kg which is at rest. After the collision, first ball comes to rest while the second ball disintegrates into two equal pieces. One piece starts moving along y -axis with a speed of 10 m s^{-1}. The second piece starts moving at an angle of 30° with respect to the x -axis. The velocity of the ball moving at 30° with x -axis is $x \text{ m s}^{-1}$. The configuration of pieces after the collision is shown in the figure below. The value of x to the nearest integer is



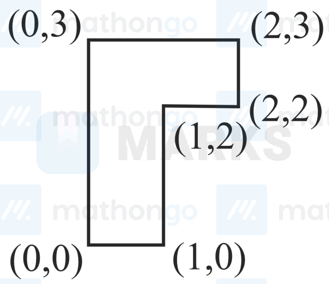
Q99. Center of Mass Momentum and Collision, 2020 (09 Jan Shift 2)

A particle of mass m is projected with a speed u from the ground at an angle $\theta = \frac{\pi}{3}$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is:

(1) $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$
(2) $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$
(3) $\frac{5}{8}\frac{u^2}{g}$
(4) $2\sqrt{2}\frac{u^2}{g}$

Q100. Center of Mass Momentum and Collision, 2020 (08 Jan Shift 1)

The coordinates of the centre of mass of a uniform flag-shaped lamina (thin flat plate) of mass 4 kg. (The coordinates of the same are shown in the figure) are:



(1) $(1.25 \text{ m}, 1.50 \text{ m})$
(2) $(0.75 \text{ m}, 1.75 \text{ m})$
(3) $(0.75 \text{ m}, 0.75 \text{ m})$
(4) $(1 \text{ m}, 1.75 \text{ m})$

Q101. Center of Mass Momentum and Collision, 2020 (08 Jan Shift 2)

As shown in figure. When a spherical cavity (centred at O) of radius 1 is cut out of a uniform sphere of radius R (centred at C), the centre of mass of remaining (shaded part of sphere is at G, i.e., on the surface of the cavity. R can be determined by the equation:

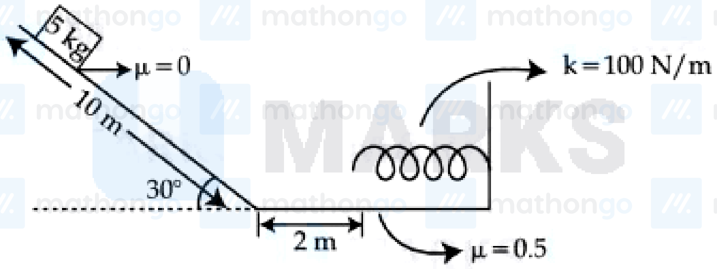
(1) $\left(R^2+R+1\right)(2-R)=1$
(2) $\left(R^2-R-1\right)(2-R)=1$
(3) $\left(R^2-R+1\right)(2-R)=1$
(4) $\left(R^2+R-1\right)(2-R)=1$

Chapter: Rotational Motion

Q102. Rotational Motion, 2024 (09 Apr Shift 2)

A circular disc reaches from top to bottom of an inclined plane of length l. When it slips down the plane, if takes t s. When it rolls down the plane then it takes $\left(\frac{\alpha}{2}\right)^{1/2} t$ s, where α is __________

Q103. Rotational Motion, 2024 (08 Apr Shift 2)



A block is simply released from the top of an inclined plane as shown in the figure above. The maximum compression in the spring when the block hits the spring is :

(1) $\sqrt{6}$ m
(2) $\sqrt{5}$ m
(3) 1 m
(4) 2 m

Q104. Rotational Motion, 2024 (06 Apr Shift 1)

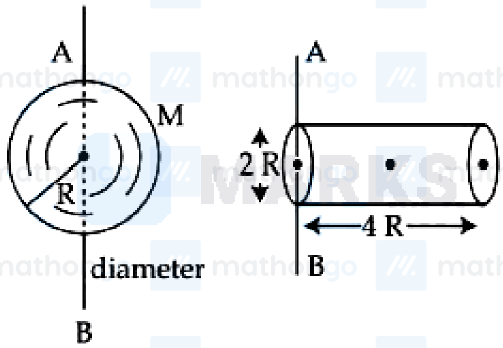
If the radius of earth is reduced to three-fourth of its present value without change in its mass then value of duration of the day of earth will be ______ hours 30 minutes.

Q105. Rotational Motion, 2024 (06 Apr Shift 2)

Three balls of masses 2 kg, 4 kg and 6 kg respectively are arranged at centre of the edges of an equilateral triangle of side 2 m. The moment of intertia of the system about an axis through the centroid and perpendicular to the plane of triangle, will be _______ kgm^2.

Q106. Rotational Motion, 2024 (05 Apr Shift 1)

Ratio of radius of gyration of a hollow sphere to that of a solid cylinder of equal mass, for moment of Inertia about their

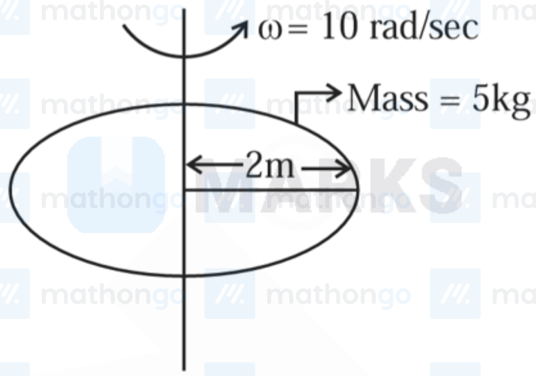


diameter axis AB as shown in figure is $\sqrt{8/x}$. The value of x is :

(1) 51
(2) 34
(3) 17
(4) 67

Q107. Rotational Motion, 2024 (30 Jan Shift 1)

Consider a disc of mass 5 kg, radius 2 m, rotating with angular velocity of 10 rad s^{-1} about an axis perpendicular to the plane of rotation. An identical disc is kept gently over the rotating disc along the same axis. The energy dissipated so that both the discs continue to rotate together without slipping is _________J.



Q108. Rotational Motion, 2024 (29 Jan Shift 1)

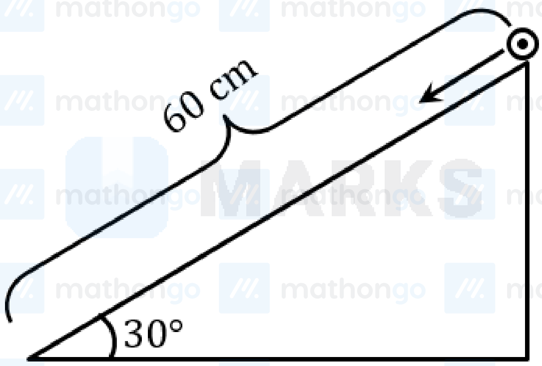
A cylinder is rolling down on an inclined plane of inclination 60°. Its acceleration during rolling down will be $\frac{x}{\sqrt{3}}\ \mathrm{m\,s^{-2}}$, where x = _______ (use $g = 10\ \mathrm{m\,s^{-2}}$).

Q109. Rotational Motion, 2024 (27 Jan Shift 1)

Four particles, each of mass $1\ \mathrm{kg}$ are placed at four corners of a square of side $2\ \mathrm{m}$. The moment of inertia of the system about an axis perpendicular to its plane and passing through one of its vertex is ______ $\mathrm{kg\ m^2}$.

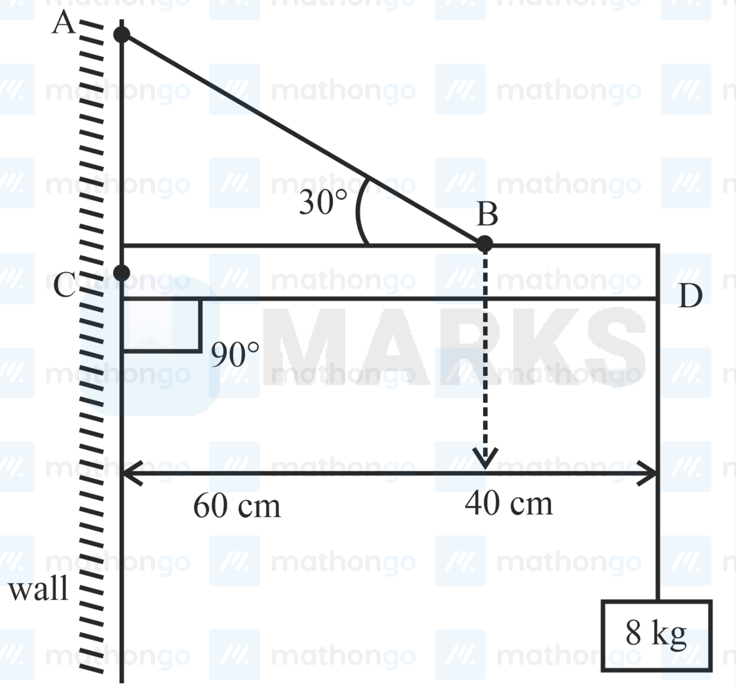
Q110. Rotational Motion, 2023 (01 Feb Shift 1)

A solid cylinder is released from rest from the top of an inclined plane of inclination 30° and length $60\ \mathrm{cm}$. If the cylinder rolls without slipping, its speed upon reaching the bottom of the inclined plane is ______ $\mathrm{m\,s^{-1}}$. (Given $g = 10\ \mathrm{m\,s^{-2}}$)



Q111. Rotational Motion, 2023 (25 Jan Shift 1)

An object of mass $8\ \mathrm{kg}$ is hanging from one end of a uniform rod CD of mass $2\ \mathrm{kg}$ and length $1\ \mathrm{m}$ pivoted at its end C on a vertical wall as shown in figure. It is supported by a cable AB such that the system is in equilibrium. The tension in the cable is:
(Take $g = 10\ \mathrm{m\,s^{-2}}$)

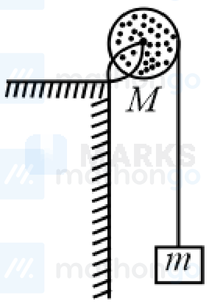


(1) 240 N
(2) 90 N
(3) 300 N
(4) 30 N

Q112. Rotational Motion, 2022 (28 Jun Shift 2)

A uniform disc with mass $M = 4$ kg and radius $R = 10$ cm is mounted on a fixed horizontal axle as shown in figure. A block with mass $m = 2$ kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the block, the cord does not slip and there is no friction at the axle. The tension in the cord is _____ N.

(Take $g = 10 \text{ ms}^{-2}$)



Q113. Rotational Motion, 2022 (25 Jun Shift 2)

Moment of Inertia (M.I.) of four bodies having same mass M and radius $2R$ are as follows

$I_1 =$ M.I. of solid sphere about its diameter

$I_2 =$ M.I. of solid cylinder about its axis

$I_3 =$ M.I. of solid circular disc about its diameter

$I_4 =$ M.I. of thin circular ring about its diameter

If $2(I_2 + I_3) + I_4 = xI_1$ then the value of x will be _____ .

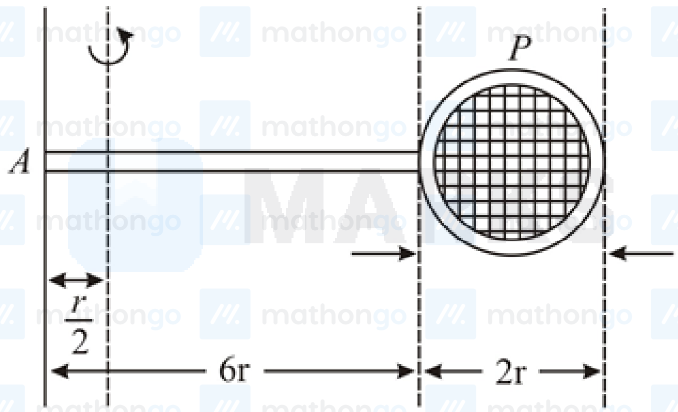
Q114. Rotational Motion, 2021 (27 Aug Shift 2)

Two discs have moments of intertia I_1 and I_2 about their respective axes perpendicular to the plane and passing through the centre. They are rotating with angular speeds, ω_1 and ω_2 respectively and are brought into contact face to face with their axes of rotation coaxial. The loss in kinetic energy of the system in the process is given by:

(1) $\frac{I_1 I_2}{(I_1+I_2)}(\omega_1-\omega_2)^2$
(2) $\frac{(\omega_1-\omega_2)^2}{2(I_1+I_2)}$
(3) $\frac{I_1 I_2}{2(I_1+I_2)}(\omega_1-\omega_2)^2$
(4) $\frac{(I_1-I_2)^2\omega_1\omega_2}{2(I_1+I_2)}$

Q115. Rotational Motion, 2021 (26 Aug Shift 1)

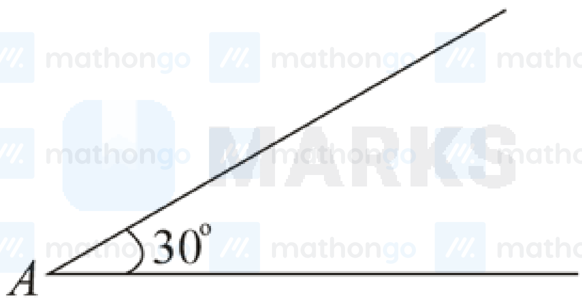
Consider a badminton racket with length scales as shown in the figure.



If the mass of the linear and circular portions of the badminton racket are same (M) and the mass of the threads are negligible, the moment of inertia of the racket about an axis perpendicular to the handle and in the plane of the ring at, $\frac{r}{2}$ distance from the end A of the handle will be ______Mr^2.

Q116. Rotational Motion, 2021 (17 Mar Shift 2)

A sphere of mass $2\ \mathrm{kg}$ and radius $0.5\ \mathrm{m}$ is rolling with an initial speed of $1\ \mathrm{m\ s^{-1}}$ goes up an inclined plane which makes an angle of 30° with the horizontal plane, without slipping. How low will the sphere take to return to the starting point A?



(1) $0.60\ \mathrm{s}$
(2) $0.52\ \mathrm{s}$
(3) $0.56\ \mathrm{s}$
(4) $0.80\ \mathrm{s}$

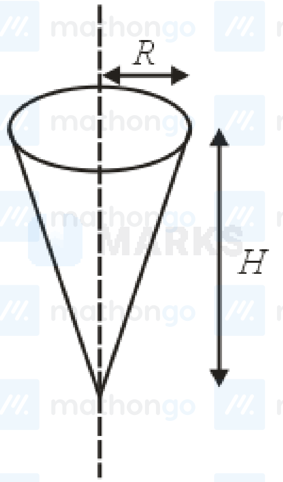
Q117. Rotational Motion, 2021 (26 Feb Shift 1)

Four identical solid spheres each of mass m and radius a are placed with their centres on the four corners of a square of side b. The moment of inertia of the system about one side of square where the axis of rotation is parallel to the plane of the square is :

(1) $\frac{8}{5}ma^2+mb^2$
(2) $\frac{4}{5}ma^2+2mb^2$
(3) $\frac{8}{5}ma^2+2mb^2$
(4) $\frac{4}{5}ma^2$

Q118. Rotational Motion, 2020 (06 Sep Shift 1)

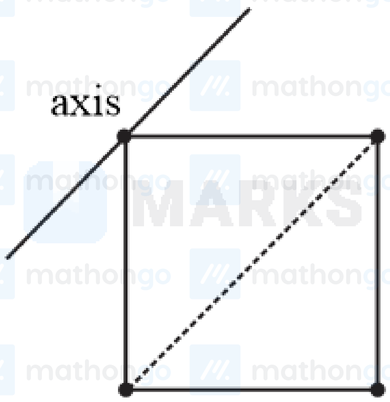
Shown in the figure is a hollow ice-cream cone (it is open at top). If its mass is M, radius of its top is R and height, H, then its moment of inertia about its axis is



(1) $\frac{MR^2}{2}$
(2) $\frac{M(R^2+H^2)}{4}$
(3) $\frac{MH^2}{3}$
(4) $\frac{MR^2}{3}$

Q119. Rotational Motion, 2020 (06 Sep Shift 1)

Four point masses, each of mass m, are fixed at the corners of a square of side I. The square is rotating with angular frequency ω, about an axis passing through one of the corners of the square and parallel to tis diagonal, as shown in the figure. The angular momentum of the square about the axis is



(1) $m\ell^2\omega$
(2) $4m\ell^2\omega$
(3) $3m\ell^2\omega$
(4) $2m\ell^2\omega$

Q120. Rotational Motion, 2020 (05 Sep Shift 1)

A force $\overrightarrow{F}=\left(\hat{i}+2\hat{j}+3\widehat{k}\right)$ N acts at a point $\left(4\hat{i}+3\hat{j}-\widehat{k}\right)$ m. Then the magnitude of torque about the point $\left(\hat{i}+2\hat{j}+\widehat{k}\right)$ m will be $\sqrt{x}\,\mathrm{N}-\mathrm{m}$.The value of x is..........

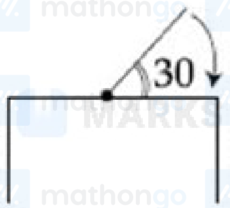
Q121. Rotational Motion, 2020 (03 Sep Shift 1)

Moment of inertia of a cylinder of mass m, length L and radius R about an axis passing through its centre and perpendicular to the axis of the cylinder is $I=M\left(\frac{R^2}{4}+\frac{L^2}{12}\right)$. If such a cylinder is to be made for a given mass of a material, the ratio $\frac{L}{R}$ for it to have minimum possible I is:

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

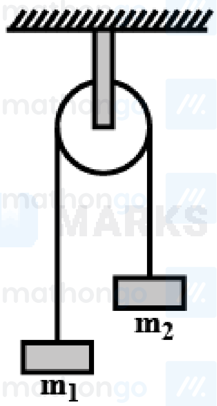
Q122. Rotational Motion, 2020 (09 Jan Shift 1)

One end of a straight uniform $1m$ long bar is pivoted on horizontal table. It is released from rest when it makes an angle 30^o from the horizontal (see figure). Its angular speed when it hits the table is given as $\sqrt{n}\ rad\ s^{-1}$, where n is an integer. The value of n is ____________



Q123. Rotational Motion, 2020 (09 Jan Shift 2)

A uniformly thick wheel with moment of inertia I and radius R is free to rotate about its centre of mass (see fig). A massless string is wrapped over its rim and two blocks of masses m_1 and $m_2(m_1 > m_2)$ are attached to the ends of the string. The system Is released from rest. The angular speed of the wheel when m_1 descends by a distance h is:



(1) $\left[\frac{2(m_1-m_2)gh}{(m_1+m_2)R^2+I}\right]^{\frac{1}{2}}$
(2) $\left[\frac{2(m_1+m_2)gh}{(m_1+m_2)R^2+I}\right]^{\frac{1}{2}}$
(3) $\left[\frac{(m_1-m_2)}{(m_1+m_2)R^2+I}\right]^{\frac{1}{2}} gh$
(4) $\left[\frac{m_1+m_2}{(m_1+m_2)R^2+I}\right]^{\frac{1}{2}} gh$

Chapter: Gravitation

Q124. Gravitation, 2024 (09 Apr Shift 2)

A satellite of 10^3 kg mass is revolving in circular orbit of radius $2R$. If $\frac{10^4 R}{6} J$ energy is supplied to the satellite, it would revolve in a new circular orbit of radius (use $g = 10\ \mathrm{m/s^2}, R =$ radius of earth)

(1) $2.5R$
(2) $3R$
(3) $4R$
(4) $6R$

Q125. Gravitation, 2024 (08 Apr Shift 1)

Two planets A and B having masses m_1 and m_2 move around the sun in circular orbits of r_1 and r_2 radii respectively. If angular momentum of A is L and that of B is 3 L, the ratio of time period $\left(\frac{T_A}{T_B}\right)$ is:

(1) $\left(\frac{r_2}{r_1}\right)^{\frac{3}{2}}$
(2) $\frac{1}{27}\left(\frac{m_2}{m_1}\right)^3$
(3) $27\left(\frac{m_1}{m_2}\right)^3$
(4) $\left(\frac{r_1}{r_2}\right)^3$

Q126. Gravitation, 2024 (05 Apr Shift 1)

In hydrogen like system the ratio of coul0mbian force and gravitational force between an electron and a proton is in the order of :

(1) 10^{39}
(2) 10^{29}
(3) 10^{19}
(4) 10^{36}

Q127. Gravitation, 2024 (05 Apr Shift 1)

Match List I with List II :

	List I		List II
(A)	Kinetic energy of planet	(I)	$-\frac{GMm}{a}$
(B)	Gravitation Potential energy of sun-planet system	(II)	$\frac{GMm}{2a}$
(C)	Total mechanical energy of planet	(III)	$\frac{Gm}{r}$
(D)	Escape energy at the surface of planet for unit mass object	(IV)	$-\frac{GMm}{2a}$

(Where a = radius of planet orbit, r = radius of planet, M = mass of Sun, m = mass of planet)

Choose the correct answer from the options given below :

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

Q128. Gravitation, 2024 (04 Apr Shift 2)

Correct formula for height of a satellite from earths surface is:

(1) $\left(\frac{T^2R^2}{4\pi^2 g}\right)^{1/3}-R$
(2) $\left(\frac{T^2R^2 g}{4\pi^2}\right)^{1/3}-R$
(3) $\left(\frac{T^2R^2 g}{4\pi^2}\right)^{-1/3}+R$
(4) $\left(\frac{T^2R^2 g}{4\pi}\right)^{1/2}-R$

Q129. Gravitation, 2024 (31 Jan Shift 1)

Four identical particles of mass m are kept at the four corners of a square. If the gravitational force exerted on one of the masses by the other masses is $\left(\frac{2\sqrt{2}+1}{32}\right)\frac{Gm^2}{L^2}$, the length of the sides of the square is

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

Q130. Gravitation, 2024 (29 Jan Shift 1)

At what distance above and below the surface of the earth a body will have same weight? (Take radius of earth as R)

(1) $\sqrt{5}\mathrm{R}-\mathrm{R}$
(2) $\frac{\sqrt{3}R-R}{2}$
(3) $\frac{R}{2}$
(4) $\frac{\sqrt{5}R-R}{2}$

Q131. Gravitation, 2024 (27 Jan Shift 2)

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

Assertion (A) : The angular speed of the moon in its orbit about the earth is more than the angular speed of the earth in its orbit about the sun.

Reason (R): The moon takes less time to move around the earth than the time taken by the earth to move around the sun.

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

(1) (A) is correct but (R) is not correct
(2) Both (A) and (R) are correct and (R) is the correct explanation of A.
(3) Both (A) and (R) are correct but (R) is not the correct explanation of A.
(4) (A) is not correct but (R) is correct

Q132. Gravitation, 2023 (01 Feb Shift 1)

If earth has a mass nine times and radius twice to the of a planet P. Then $\frac{v_e}{3}\sqrt{x} ms^{-1}$ will be the minimum velocity required by a rocket to pull out of gravitational force of P, where ve is escape velocity on earth. The value of x is

(1) 2
(2) 3
(3) 18
(4) 1

Q133. Gravitation, 2023 (30 Jan Shift 1)

If the gravitational field in the space is given as $\left(-\frac{K}{r^2}\right)$. Taking the reference point to be at $r = 2$ cm with gravitational potential $V = 10 \text{ J kg}^{-1}$. Find the gravitational potentials at $r = 3$ cm in SI unit (Given, that $K = 6 \text{ J cm kg}^{-1}$)

(1) 9
(2) 11
(3) 12
(4) 10

Q134. Gravitation, 2022 (29 Jul Shift 2)

An object of mass 1 kg is taken to a height from the surface of earth which is equal to three times the radius of earth. The gain in potential energy of the object will be

[If, $g = 10 \text{ m s}^{-2}$ and radius of earth $= 6400$ km]

(1) 48 MJ
(2) 24 MJ
(3) 36 MJ
(4) 12 MJ

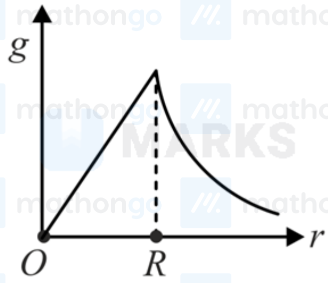
Q135. Gravitation, 2022 (29 Jun Shift 1)

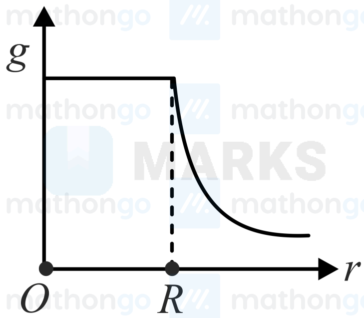
The escape velocity of a body on a planet A is 12 km s^{-1}. The escape velocity of the body on another planet B, whose density is four times and radius is half of the planet A, is

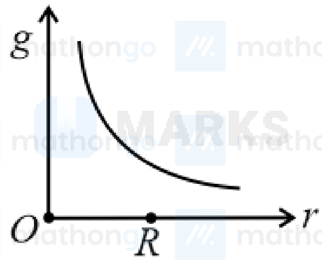
(1) 12 km s^{-1}
(2) 24 km s^{-1}
(3) 36 km s^{-1}
(4) 6 km s^{-1}

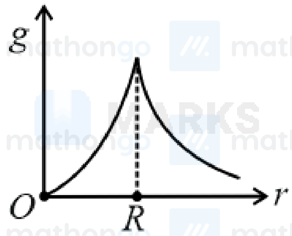
Q136. Gravitation, 2022 (26 Jun Shift 1)

The variation of acceleration due to gravity (g) with distance (r) from the center of the earth is correctly represented by (Given $R =$ radius of earth)

(1)


(2)


(3)


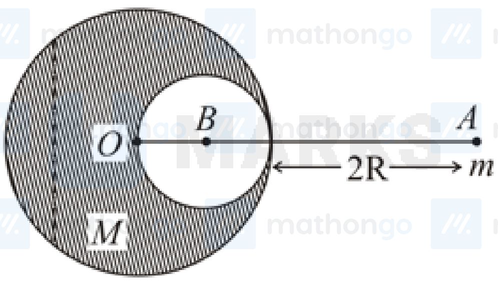
(4)


Q137. Gravitation, 2021 (16 Mar Shift 2)

If one wants to remove all the mass of the earth to infinity in order to break it up completely. The amount of energy that needs to be supplied will be $\frac{x}{5}\frac{GM^2}{R}$ where x is ________.
(Round off to the Nearest Integer)
(M is the mass of earth, R is the radius of earth, G is the gravitational constant)

Q138. Gravitation, 2021 (25 Feb Shift 1)

A solid sphere of radius R gravitationally attracts a particle placed at $3R$ from its centre with a force F_1. Now a spherical cavity of radius $\left(\frac{R}{2}\right)$ is made in the sphere (as shown in figure) and the force becomes F_2. The value of $F_1 : F_2$ is:



(1) 41 : 50
(2) 50 : 41
(3) 25 : 36
(4) 36 : 25

Q139. Gravitation, 2020 (06 Sep Shift 2)

Two planets have masses M and 16 M and their radii are a and 2a, respectively. The separation between the centres of the planets is 10a. A body of mass m is fired from the surface of the larger planet towards the smaller planet along the line joining their centres. For the body to be able to reach at the surface of smaller planet, the minimum firing speed needed is :

(1) $2\sqrt{\frac{GM}{a}}$
(2) $4\sqrt{\frac{GM}{a}}$
(3) $\sqrt{\frac{GM^2}{ma}}$
(4) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$

Q140. Gravitation, 2020 (05 Sep Shift 2)

The acceleration due to gravity on the earth's surface at the poles is g and angular velocity of the earth about the axis passing through the pole is ω. An object is weighed at the equator and at a height h above the poles by using a spring balance. If the weights are found to be same, then h is: ($h \ll R$, where R is the radius of the earth)
(1) $\frac{R^2\omega^2}{2g}$
(2) $\frac{R^2\omega^2}{g}$
(3) $\frac{R^2\omega^2}{4g}$
(4) $\frac{R^2\omega^2}{8g}$

Q141. Gravitation, 2020 (04 Sep Shift 1)

On the x-axis and at a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{\left(x^2+a^2\right)^{3/2}}$ in the x-direction. The magnitude of the gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity is:
(1) $\frac{A}{\left(x^2+a^2\right)^{1/2}}$
(2) $\frac{A}{\left(x^2+a^2\right)^{3/2}}$
(3) $A\left(x^2+a^2\right)^{1/2}$
(4) $A\left(x^2+a^2\right)^{3/2}$

Q142. Gravitation, 2020 (02 Sep Shift 1)

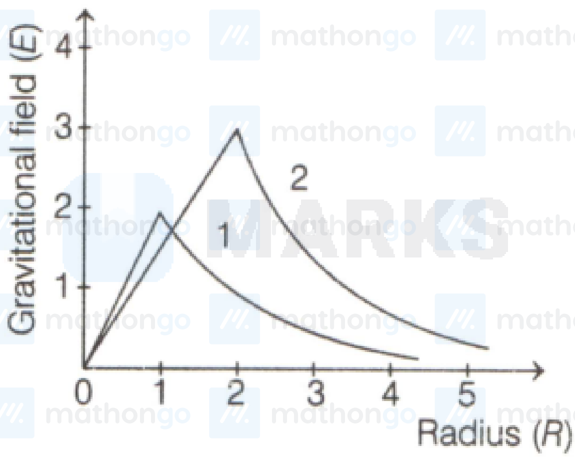
The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance r from its center. In that region, a small star is in a circular orbit of radius R. Then the period of revolution,T depends on R as:
(1) $T^2 \propto R$
(2) $T^2 \propto R^3$
(3) $T^2 \propto \frac{1}{R^3}$
(4) $T \propto R$

Q143. Gravitation, 2020 (09 Jan Shift 1)

A body A of mass m is moving in a circular orbit of radius R about a planet. Another body B of mass $\frac{m}{2}$ collides with A with a velocity which is half $\left(\frac{\vec{v}}{2}\right)$ the instantaneous velocity $\vec{v}$ of A. The collision is completely inelastic. Then, the combined body:
(1) continues to move in a circular orbit
(2) Escapes from the Planet's Gravitational field
(3) Falls vertically downwards towards the planet
(4) starts moving in an elliptical orbit around the planet

Q144. Gravitation, 2020 (08 Jan Shift 1)

Consider two solid spheres of radii $R_1=1$ m,$R_2=2$ m and masses M_1 and M_2, respectively. The gravitational field due to sphere (1) and (2) are shown. The value of $\frac{M_1}{M_2}$ is:



(1) $\frac{2}{3}$
(2) $\frac{1}{6}$
(3) $\frac{1}{2}$
(4) $\frac{1}{3}$

Q145. Gravitation, 2020 (07 Jan Shift 1)

A satellite of mass M is launched vertically upwards with an initial speed u from the surface of the earth. After it reaches height R ($R=$ radius of the earth), it ejects a rocket of mass $\frac{M}{10}$ so that subsequently the satellite moves in a circular orbit.

The kinetic energy of the rocket is (G is the gravitational constant; M_e is the mass of the earth):

(1) $\frac{M}{20}\left(u^2+\frac{113}{200}\frac{GM_e}{R}\right)$

(2) $5M\left(u^2-\frac{119}{200}\frac{GM_e}{R}\right)$

(3) $\frac{3M}{8}\left(u+\sqrt{\frac{5GM_e}{6R}}\right)^2$

(4) $\frac{M}{20}\left(u-\sqrt{\frac{2GM_e}{3R}}\right)^2$

Chapter: Mechanical Properties of Solids

Q146. Mechanical Properties of Solids, 2024 (05 Apr Shift 2)

Match List-I with List-II :

	List-I		List-II
(A)	A force that restores an elastic body of unit area to its original state	(I)	Bulk modulus
(B)	Two equal and opposite forces parallel to opposite faces	(II)	Young's modulus
(C)	Forces perpendicular everywhere to the surface per unit area same everywhere	(III)	Stress
(D)	Two equal and opposite forces perpendicular to opposite faces	(IV)	Shear modulus

Choose the correct answer from the options given below :

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

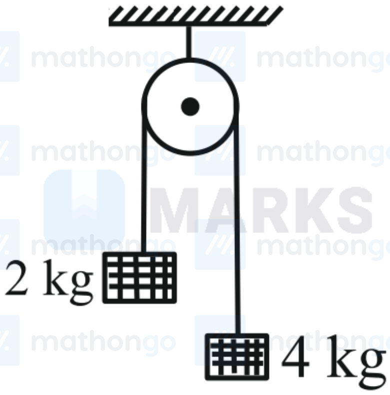
(2) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

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

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

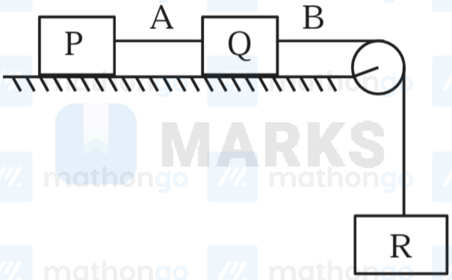
Q147. Mechanical Properties of Solids, 2024 (31 Jan Shift 2)

Two blocks of mass $2\ \mathrm{kg}$ and $4\ \mathrm{kg}$ are connected by a metal wire going over a smooth pulley as shown in figure. The radius of wire is $4.0\times10^{-5}\ \mathrm{m}$ and Young's modulus of the metal is $2.0\times10^{11}\ \mathrm{N\ m^{-2}}$. The longitudinal strain developed in the wire is $\frac{1}{\alpha\pi}$. The value of α is _____. [Use $g=10\ \mathrm{m\ s^{-2}}$]



Q148. Mechanical Properties of Solids, 2024 (30 Jan Shift 1)

Each of three blocks P, Q and R shown in figure has a mass of $3\ \mathrm{kg}$. Each of the wire A and B has cross-sectional area $0.005\ \mathrm{cm^2}$ and Young's modulus $2\times10^{11}\ \mathrm{N\ m^{-2}}$. Neglecting friction, the longitudinal strain on wire B is _____ $\times10^{-4}$. (Take $g=10\ \mathrm{m\ s^{-2}}$)



Q149. Mechanical Properties of Solids, 2024 (29 Jan Shift 2)

Two metallic wires P and Q have same volume and are made up of same material. If their area of cross sections are in the ratio $4 : 1$ and force F_1 is applied to P, an extension of Δl is produced. The force which is required to produce same extension in Q is F_2. The value of $\frac{F_1}{F_2}$ is ______.

Q150. Mechanical Properties of Solids, 2024 (27 Jan Shift 1)

If average depth of an ocean is 4000 m and the bulk modulus of water is $2 \times 10^9 \mathrm{~N~m}^{-2}$, then fractional compression $\frac{\Delta V}{V}$ of water at the bottom of ocean is $\alpha \times 10^{-2}$. The value of α is _______, (Given, $\mathrm{g}=10 \mathrm{~m~s}^{-2}, \rho=1000 \mathrm{~kg~m}^{-3}$)

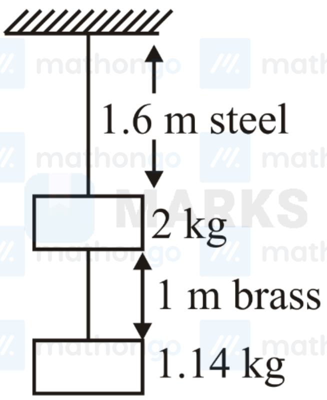
Q151. Mechanical Properties of Solids, 2023 (13 Apr Shift 1)

Under isothermal condition, the pressure of a gas is given by $P=aV^{-3}$, where a is a constant and V is the volume of the gas. The bulk modulus at constant temperature is equal to

(1) $3P$
(2) P
(3) $2P$
(4) $\frac{P}{2}$

Q152. Mechanical Properties of Solids, 2023 (10 Apr Shift 1)

Two wires each of radius 0.2 cm and negligible mass, one made of steel and the other made of brass are loaded as shown in the figure. The elongation of the steel wire is ______10^{-6} m. [Young's modulus for steel $=2 \times 10^{11} \mathrm{~N~m}^{-2}$ and $g=10 \mathrm{~m~s}^{-2}$]



Q153. Mechanical Properties of Solids, 2022 (27 Jul Shift 1)

A square aluminium (shear modulus is $25 \times 10^9 \mathrm{~Nm}^{-2}$) slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of 18.0×10^4 N. The lower edge is riveted to the floor. The displacement of the upper edge is _____ μm.

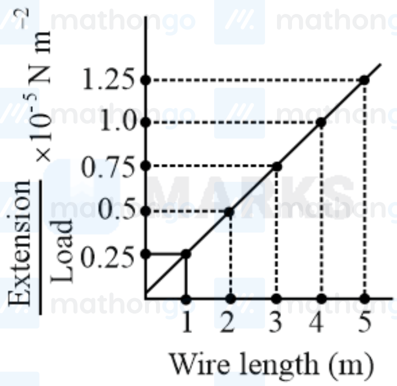
Q154. Mechanical Properties of Solids, 2022 (27 Jul Shift 2)

A steel wire of length 3.2 m $\left(Y_S=2.0 \times 10^{11} \mathrm{~N~m}^{-2}\right)$ and a copper wire of length 4.4 m $\left(Y_C=1.1 \times 10^{11} \mathrm{~N~m}^{-2}\right)$, both of radius 1.4 mm are connected end to end. When stretched by a load, the net elongation is found to be 1.4 mm. The load applied, in Newton, will be: (Given $\pi=\frac{22}{7}$)

(1) 360
(2) 180
(3) 1080
(4) 154

Q155. Mechanical Properties of Solids, 2022 (27 Jul Shift 2)

In an experiment to determine the Young's modulus, steel wires of five different lengths (1, 2, 3, 4 and 5) but of same cross-section $\left(2 \mathrm{~mm}^2\right)$ were taken and curves between extension and load were obtained. The slope (extension/load) of the curves were plotted with the wire length and the following graph is obtained. If the Young's modulus of given steel wires is $\mathrm{x} \times 10^{11} \mathrm{~N~m}^{-2}$, then the value of x is _____ .



Q156. Mechanical Properties of Solids, 2022 (26 Jul Shift 2)

The area of cross section of the rope used to lift a load by a crane is $2.5 \times 10^{-4}\ m^2$. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, the required area of cross section of the rope should be
(take $g = 10\ ms^{-2}$)

(1) $6.25 \times 10^{-4}\ m^2$
(2) $10 \times 10^{-4}\ m^2$
(3) $1 \times 10^{-4}\ m^2$
(4) $1.67 \times 10^{-4}\ m^2$

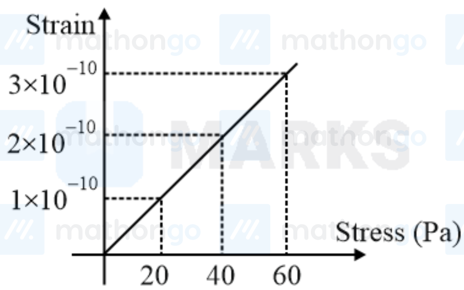
Q157. Mechanical Properties of Solids, 2022 (29 Jun Shift 1)

A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1 kg and 2 kg are suspended respectively from its free end. Then the value of L is equal to

(1) $\sqrt{L_1 L_2}$
(2) $\frac{L_1+L_2}{2}$
(3) $2L_1 - L_2$
(4) $3L_1 - L_2$

Q158. Mechanical Properties of Solids, 2022 (26 Jun Shift 1)

The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of 5×10^{-4} is _____ $kJ\ m^{-3}$. Assume that material is elastic upto the linear strain of 5×10^{-4},



Q159. Mechanical Properties of Solids, 2020 (07 Jan Shift 1)

Speed of a transverse wave on a straight wire (mass 6.0 g, length 60 cm and area of cross-section $1.0\ mm^2$ is $90\ m\ s^{-1}$. If the Young's modulus of wire is $16 \times 10^{11}\ N\ m^{-2}$, the extension of wire over its natural length is:

(1) 0.03 mm
(2) 0.02 mm
(3) 0.04 mm
(4) 0.01 mm

Chapter: Mechanical Properties of Fluids

Q160. Mechanical Properties of Fluids, 2024 (06 Apr Shift 2)

Pressure inside a soap bubble is greater than the pressure outside by an amount : (given : R = Radius of bubble S = Surface tension of bubble)

(1) $\frac{2S}{R}$ (2) $\frac{4R}{S}$
(3) $\frac{S}{R}$ (4) $\frac{4\,\mathrm{S}}{\mathrm{R}}$

Q161. Mechanical Properties of Fluids, 2024 (05 Apr Shift 1)

Given below are two statements : Statement I : When a capillary tube is dipped into a liquid, the liquid neither rises nor falls in the capillary. The contact angle may be 0°. Statement II : The contact angle between a solid and a liquid is a property of the material of the solid and liquid as well. In the light of the above statement, choose the correct answer from the options given below.

(1) Both Statement I and Statement II are false
(2) Both Statement I and Statement II are true
(3) Statement I is false but Statement II is true
(4) Statement I is true and Statement II is false

Q162. Mechanical Properties of Fluids, 2024 (29 Jan Shift 1)

Given below are two statements:

Statement I : If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in hot water.

Statement II : If a capillary tube is immersed first in cold water and then in hot water, the height of capillary rise will be smaller in cold water.

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

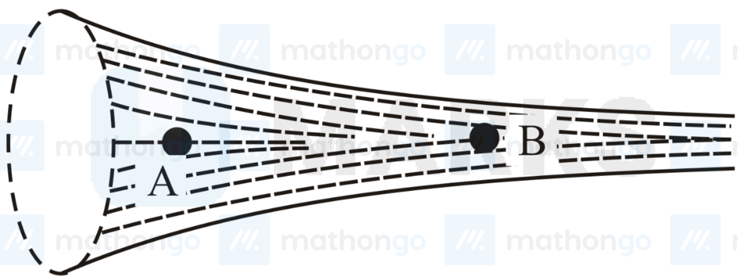
(1) Both Statement I and Statement II are true
(2) Both Statement I and Statement II are false
(3) Statement I is true but Statement II is false
(4) Statement I is false but Statement II is true

Q163. Mechanical Properties of Fluids, 2024 (29 Jan Shift 2)

A small liquid drop of radius R is divided into 27 identical liquid drops. If the surface tension is T, then the work done in the process will be :

(1) $8\pi R^2 T$
(2) $3\pi R^2 T$
(3) $\frac{1}{8}\pi R^2 T$
(4) $4\pi R^2 T$

Q164. Mechanical Properties of Fluids, 2023 (13 Apr Shift 1)



The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross-section. Cross-sectional areas at A is $1.5\ \mathrm{cm}^2$, and B is $25\ \mathrm{mm}^2$, if the speed of liquid at B is $60\ \mathrm{cm\ s}^{-1}$ then $(P_A - P_B)$ is

(Given P_A and P_B are liquid pressures at A and B points.

Density $\rho = 1000\ \mathrm{kg\ m}^{-3}$

A and B are on the axis of tube)

(1) 135 Pa
(2) 27 Pa
(3) 175 Pa
(4) 36 Pa

Q165. Mechanical Properties of Fluids, 2023 (13 Apr Shift 2)

Given below are two statements: one is labelled as

Assertion A and the other is labelled as **Reason R**

Assertion A : A spherical body of radius (5 ± 0.1) mm having a particular density is falling through a liquid of constant density. The percentage error in the calculation of its terminal velocity is 4%.

Reason R : The terminal velocity of the spherical body falling through the liquid is inversely proportional to its radius. 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

Q166. Mechanical Properties of Fluids, 2023 (06 Apr Shift 1)

A small ball of mass M and density ρ is dropped in a viscous liquid of density ρ_0. After some time, the ball falls with a constant velocity. What is the viscous force on the ball?

(1) $F = Mg\left(1 + \frac{\rho_0}{\rho}\right)$
(2) $F = Mg\left(1 + \frac{\rho}{\rho_0}\right)$
(3) $F = Mg\left(1 - \frac{\rho_0}{\rho}\right)$
(4) $F = Mg(1 \pm \rho\rho_0)$

Q167. Mechanical Properties of Fluids, 2023 (06 Apr Shift 2)

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

Assertion A: When you squeeze one end of a tube to get toothpaste out from the other end, Pascal's principle is observed.

Reason R: A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

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

(1) Both A and R are correct but R is NOT the correct explanation of A
(2) A is not correct but R is correct
(3) A is correct but R is not correct
(4) Both A and R is correct and R is the correct explanation of A

Q168. Mechanical Properties of Fluids, 2022 (28 Jul Shift 2)

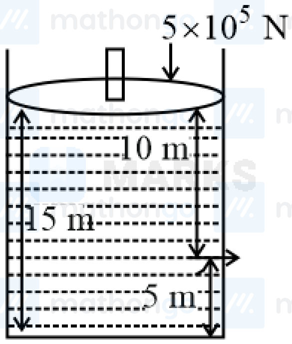
A pressure-pump has a horizontal tube of cross-sectional area $10 \ \text{cm}^2$ for the outflow of water at a speed of 20 m s^{-1}. The force exerted on the vertical wall just in front of the tube which stops water horizontally flowing out of the tube, is: [given : density of water $= 1000 \ \text{kg m}^{-3}$]

(1) 300 N
(2) 500 N
(3) 250 N
(4) 400 N

Q169. Mechanical Properties of Fluids, 2022 (28 Jul Shift 2)

Consider a cylindrical tank of radius 1 m is filled with water. The top surface of water is at 15 m from the bottom of the cylinder. There is a hole on the wall of cylinder at a height of 5 m from the bottom. A force of 5×10^5 N is applied an the top surface of water using a piston. The speed of efflux from the hole will be :

(given atmospheric pressure $P_A = 1.01 \times 10^5 \ Pa$, density of water $\rho_w = 1000 \ \text{kg m}^{-3}$ and gravitational acceleration $g = 10 \text{ m s}^{-2}$)



(1) $11.6 \mathrm{~m} \mathrm{~s}^{-1}$
(2) $10.8 \mathrm{~m} \mathrm{~s}^{-1}$
(3) $17.8 \mathrm{~m} \mathrm{~s}^{-1}$
(4) $14.4 \mathrm{~m} \mathrm{~s}^{-1}$

Q170. Mechanical Properties of Fluids, 2022 (26 Jul Shift 1)

A water drop of radius $1 \mathrm{~cm}$ is broken into 729 equal droplets. If surface tension of water is 75 dyne cm^{-1}, then the gain in surface energy upto first decimal place will be
[Given $\pi=3.14$]
(1) $8.5 \times 10^{-4} \mathrm{~J}$
(2) $8.2 \times 10^{-4} \mathrm{~J}$
(3) $7.5 \times 10^{-4} \mathrm{~J}$
(4) $5.3 \times 10^{-4} \mathrm{~J}$

Q171. Mechanical Properties of Fluids, 2022 (28 Jun Shift 2)

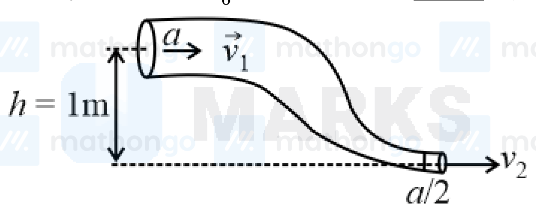
A water drop of radius $1 \mu\mathrm{m}$ falls in a situation where the effect of buoyant force is negligible. Co-efficient of viscosity of air is $1.8 \times 10^{-5} \mathrm{~N} \mathrm{~s} \mathrm{~m}^{-2}$ and its density is negligible as compared to that of water $10^{6} \mathrm{~g} \mathrm{~m}^{-3}$. Terminal velocity of the water drop is
(Take acceleration due to gravity $=10 \mathrm{~m} \mathrm{~s}^{-2}$)
(1) $145.4 \times 10^{-6} \mathrm{~m} \mathrm{~s}^{-1}$
(2) $123.4 \times 10^{-6} \mathrm{~m} \mathrm{~s}^{-1}$
(3) $118.0 \times 10^{-6} \mathrm{~m} \mathrm{~s}^{-1}$
(4) $132.6 \times 10^{-6} \mathrm{~m} \mathrm{~s}^{-1}$

Q172. Mechanical Properties of Fluids, 2022 (27 Jun Shift 1)

The velocity of a small ball of mass m and density d_1, when dropped in a container filled with glycerine, becomes constant after some time. If the density of glycerine is d_2, then the viscous force acting on the ball, will be
(1) $mg\left(1-\frac{d_1}{d_2}\right)$
(2) $mg\left(1-\frac{d_2}{d_1}\right)$
(3) $mg\left(\frac{d_1}{d_2}-1\right)$
(4) $mg\left(\frac{d_2}{d_1}-1\right)$

Q173. Mechanical Properties of Fluids, 2022 (26 Jun Shift 1)

An ideal fluid of density $800 \mathrm{~kg} \mathrm{~m}^{-3}$, flows smoothly through a bent pipe (as shown in figure) that tapers in cross-sectional area from a to $\frac{a}{2}$. The pressure difference between the wide and narrow sections of pipe is 4100 Pa. At wider section, the velocity of fluid is $\frac{\sqrt{x}}{6} \mathrm{~m} \mathrm{~s}^{-1}$ for $x=$_____ . (Given $g=10 \mathrm{~m} \mathrm{~s}^{-2}$)



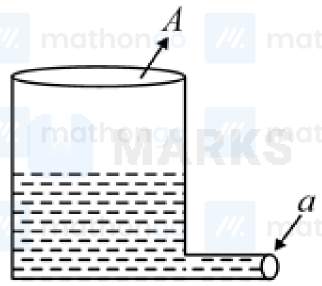
Q174. Mechanical Properties of Fluids, 2021 (26 Aug Shift 1)

Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a $U-$shaped tube open at both ends. If this $U-$tube contains water, what is the difference in the level of two limbs of the tube.
[Take surface tension of water $T = 7.3 \times 10^{-2}$ N m^{-1}, angle of contact $= 0$, $g = 10$ m s^{-2} and density of water $= 1.0 \times 10^3$ kg m^{-3}]

(1) 5.34 mm
(2) 3.62 mm
(3) 2.19 mm
(4) 4.97 mm

Q175. Mechanical Properties of Fluids, 2021 (27 Jul Shift 1)

A light cylindrical vessel is kept on a horizontal surface. Area of the base is A. A hole of cross-sectional area a is made just at its bottom side. The minimum coefficient of friction necessary to prevent sliding the vessel due to the impact force of the emerging liquid is



(1) $\frac{A}{2a}$
(2) None of these
(3) $\frac{2a}{A}$
(4) $\frac{a}{A}$

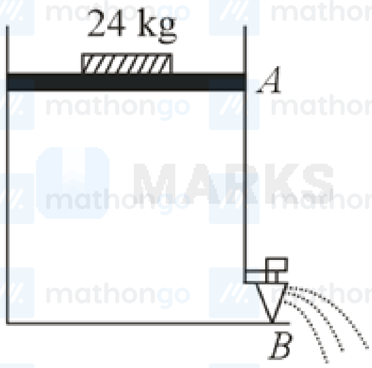
Q176. Mechanical Properties of Fluids, 2021 (20 Jul Shift 2)

Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is

(1) $2^{\frac{1}{3}} : 1$
(2) $1 : 2^{\frac{1}{3}}$
(3) $2 : 1$
(4) $1 : 2$

Q177. Mechanical Properties of Fluids, 2021 (18 Mar Shift 2)

Consider a water tank as shown in the figure. It's cross-sectional area is 0.4 m^2. The tank has an opening B near the bottom whose cross-section area is 1 cm^2. A load of 24 kg is applied on the water at the top when the height of the water level is 40 cm above the bottom, the velocity of water coming out the opening B is v m s^{-1}. The value of v, to the nearest integer, is ___ .[Take the value of g to be 10 m s^{-2}]



Q178. Mechanical Properties of Fluids, 2021 (24 Feb Shift 1)

A hydraulic press can lift 100 kg when a mass m is placed on the smaller piston. It can lift kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass m on the smaller piston.

Q179. Mechanical Properties of Fluids, 2020 (06 Sep Shift 2)

A fluid is flowing through a horizontal pipe of varying cross-section, with $v\ ms^{-1}$ at a point where the pressure is P Pascal. At another point where pressure $\frac{P}{2}$ Pascal its speed is $V\ ms^{-1}$. If the density of the fluid is $\rho\,kg-m^{-3}$ and the flow is streamline, then V is equal to

(1) $\sqrt{\frac{P}{\rho}+v}$
(2) $\sqrt{\frac{2P}{\rho}+v^2}$
(3) $\sqrt{\frac{P}{2\rho}+v^2}$
(4) $\sqrt{\frac{P}{\rho}+v^2}$

Q180. Mechanical Properties of Fluids, 2020 (03 Sep Shift 1)

When a long glass capillary tube of radius 0.015 cm is dipped in a liquid, the liquid rises to a height of 15 cm within it. If the contact angle between the liquid and glass to close to 0°, the surface tension of the liquid, in milliNewton m^{-1}, is $\left[\rho_{(\text{liqued})}=900\ kg\ m^{-3}, g=10\ m\ s^{-2}\right]$ (Given answer in closed integer)

Q181. Mechanical Properties of Fluids, 2020 (02 Sep Shift 2)

A capillary tube made of glass of radius 0.15 mm is dipped vertically in a beaker filled with methylene iodide (surface tension $=0.05\ N\ m^{-1}$, density $=667\ kg\ m^{-3}$) which rises to height h in the tube. It is observed that the two tangents drawn from observed that the two tangents drawn from liquid-glass interfaces (from opp. sides of the capillary) make an angle of 60º with one another. Then h is close to ($g=10\ m\ s^{-2}$)

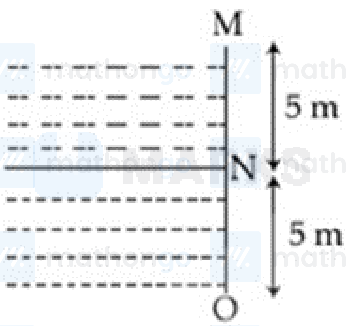
(1) 0.049 m
(2) 0.087 m
(3) 0.137 m
(4) 0.172 m

Q182. Mechanical Properties of Fluids, 2020 (09 Jan Shift 2)

A small spherical droplet of density d is floating exactly half immersed in a liquid of density ρ and surface tension T. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet):

(1) $r=\sqrt{\frac{2T}{3(d+\rho)g}}$
(2) $r=\sqrt{\frac{T}{(d-\rho)g}}$
(3) $r=\sqrt{\frac{T}{(d+\rho)g}}$
(4) $r=\sqrt{\frac{3T}{(2d-\rho)g}}$

Q183. Mechanical Properties of Fluids, 2020 (08 Jan Shift 2)



Two liquids of densities ρ_1 and $\rho_2(\rho_2=2\rho_1)$ are filled up behind a square wall of side 10m as shown in figure. Each liquid has a height of 5m. The ratio of the forces due to these liquids exerted on upper part MN to that at the lower part NO is (Assume that the liquids are not mixing):

(1) $\frac{1}{3}$
(2) $\frac{2}{3}$
(3) $\frac{1}{2}$
(4) $\frac{1}{4}$

Chapter: Oscillations

Q184. Oscillations, 2024 (09 Apr Shift 1)

The position, velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes of $4\ \mathrm{m}, 2\ \mathrm{ms}^{-1}$ and $16\ \mathrm{ms}^{-2}$ at a certain instant. The amplitude of the motion is $\sqrt{x},\ \mathrm{m}$ where x is ________

Q185. Oscillations, 2024 (31 Jan Shift 1)

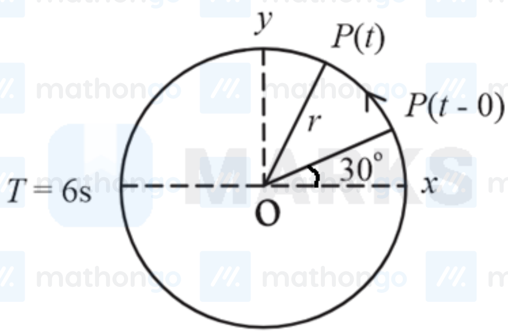
A particle performs simple harmonic motion with amplitude A. Its speed is increased to three times at an instant when its displacement is $\frac{2A}{3}$. The new amplitude of motion is $\frac{nA}{3}$. The value of n is _____.

Q186. Oscillations, 2024 (30 Jan Shift 2)

A simple pendulum is placed at a place where its distance from the earth's surface is equal to the radius of the earth. If the length of the string is $4\ \mathrm{m}$, then the time period of small oscillations will be _________s.
[take $g = \pi^2\ \mathrm{m\ s}^{-2}$]

Q187. Oscillations, 2023 (08 Apr Shift 2)

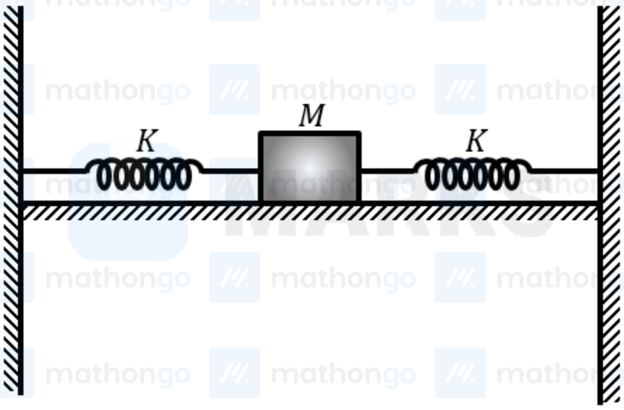
For particle P revolving round the centre O with radius of circular path r and regular velocity ω, as shown in below figure, the projection of OP on the x-axis at time t is



(1) $x(t) = r\ \cos\left(\omega t - \frac{\pi}{6}\right)$
(2) $x(t) = r\ \cos\left(\omega t + \frac{\pi}{6}\right)$
(3) $x(t) = r\ \sin\left(\omega t + \frac{\pi}{6}\right)$
(4) $x(t) = r\ \cos(\omega t)$

Q188. Oscillations, 2023 (31 Jan Shift 1)

In the figure given below. a block of mass $M = 490\ \mathrm{g}$ placed on a frictionless table is connected with two springs having same spring constant $(K = 2\ \mathrm{N\ m}^{-1})$. If the block is horizontally displaced through $X\ \mathrm{m}$ then the number of complete oscillations it will make in 14π seconds will be ______.



Q189. Oscillations, 2023 (25 Jan Shift 2)

A particle executes simple harmonic motion between $x=-A$ and $x=+A$. If time taken by particle to go from $x=0$ to $\frac{A}{2}$ is 2 s; then time taken by particle in going from $x=\frac{A}{2}$ to A is:

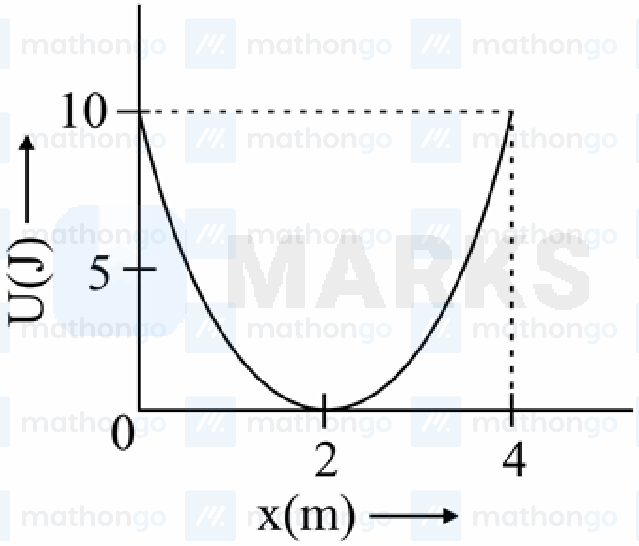
(1) 3 s
(2) 2 s
(3) 1.5 s
(4) 4 s

Q190. Oscillations, 2022 (28 Jul Shift 2)

The potential energy of a particle of mass 4 kg in motion along the x-axis is given by $\mathrm{U}=4(1-\cos 4\mathrm{x})$ J. The time period of the particle for small oscillation $(\sin\theta \simeq \theta)$ $\left(\frac{\pi}{\mathrm{K}}\right)$ s. The value of K is ____ .

Q191. Oscillations, 2021 (01 Sep Shift 2)

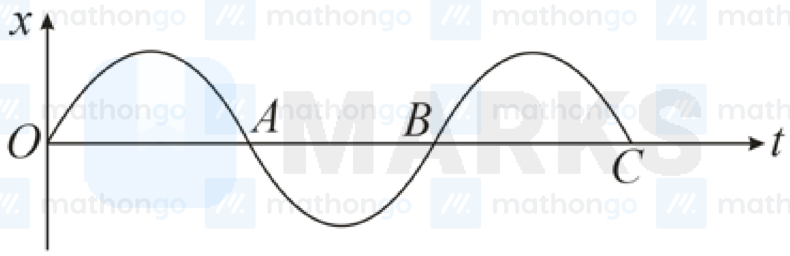
A mass of 5 kg is connected to a spring. The potential energy curve of the simple harmonic motion executed by the system is shown in the figure. A simple pendulum of length 4 m has the same period of oscillation as the spring system. What is the value of acceleration due to gravity on the planet where these experiments are performed ?



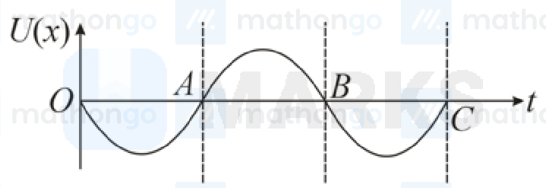
(1) $4 \mathrm{~m~s}^{-2}$
(2) $8 \mathrm{~m~s}^{-2}$
(3) $5 \mathrm{~m~s}^{-2}$
(4) $10 \mathrm{~m~s}^{-2}$

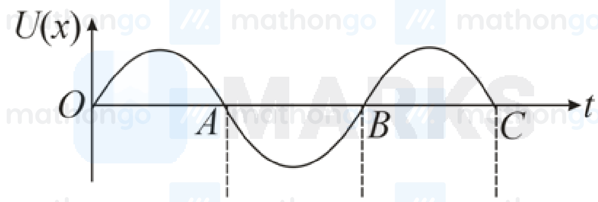
Q192. Oscillations, 2021 (27 Aug Shift 1)

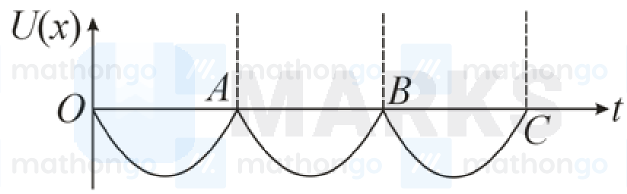
The variation of displacement with time of a particle executing free simple harmonic motion is shown in the figure.

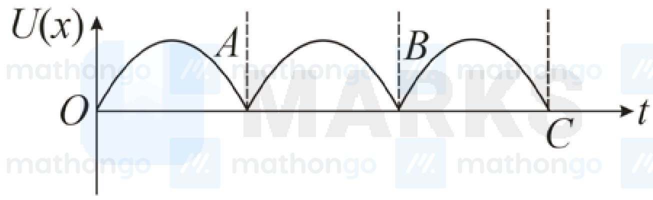


The potential energy $U(x)$ versus time (t) plot of the particle is correctly shown in figure:

(1) 

(2) 

(3) 

(4) 

Q193. Oscillations, 2021 (27 Aug Shift 2)

Two simple harmonic motion, are represented by the equations

$y_1 = 10\sin\left(3\pi t + \frac{\pi}{3}\right)$; $y_2 = 5\left(\sin 3\pi t + \sqrt{3}\cos 3\pi t\right)$

Ratio of amplitude of y_1 to $y_2 = x : 1$. The value of x is

Q194. Oscillations, 2021 (20 Jul Shift 2)

A particle is making simple harmonic motion along the X-axis. If at a distances x_1 and x_2 from the mean position the velocities of the particle are v_1 and v_2, respectively. The time period of its oscillation is given as:

(1) $T = 2\pi\sqrt{\frac{x_2^2+x_1^2}{v_1^2-v_2^2}}$

(2) $T = 2\pi\sqrt{\frac{x_2^2+x_1^2}{v_1^2+v_2^2}}$

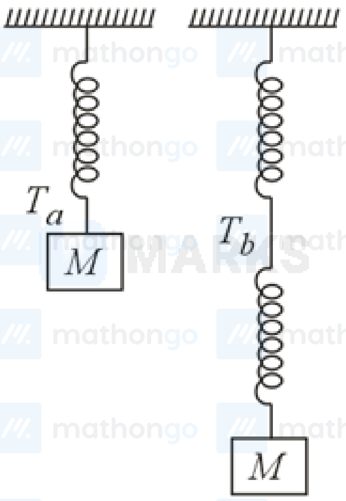
(3) $T = 2\pi\sqrt{\frac{x_2^2-x_1^2}{v_1^2+v_2^2}}$

(4) $T = 2\pi\sqrt{\frac{x_2^2-x_1^2}{v_1^2-v_2^2}}$

Q195. Oscillations, 2021 (17 Mar Shift 1)

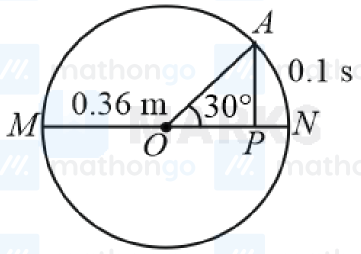
Consider two identical springs each of spring constant k and negligible mass compared to the mass M as shown. Fig. 1 shows one of them and Fig. 2 shows their series combination. The ratios of time period of oscillation of the two SHM is $\frac{T_b}{T_a} = \sqrt{x}$, where value of x is ______.

(Round off to the Nearest Integer)



Q196. Oscillations, 2021 (25 Feb Shift 2)

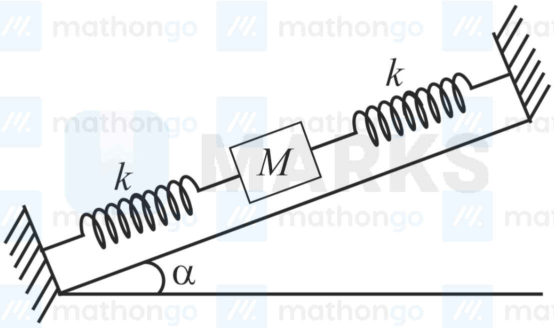
The point A moves with a uniform speed along the circumference of a circle of radius 0.36 m and covers 30° in 0.1 s. The perpendicular projection P from A on the diameter MN represents the simple harmonic motion of P. The restoration force per unit mass when P touches M will be :



(1) 0.49 N
(2) 9.87 N
(3) 50 N
(4) 100 N

Q197. Oscillations, 2021 (24 Feb Shift 2)

In the given figure, a body of mass M is held between two massless springs, on a smooth inclined plane. The free ends of the springs are attached to firm supports. If each spring has spring constant k, the frequency of oscillation of given body is:



(1) $\frac{1}{2\pi}\sqrt{\frac{2k}{Mg\sin\alpha}}$
(2) $\frac{1}{2\pi}\sqrt{\frac{k}{Mg}\sin\alpha}$
(3) $\frac{1}{2\pi}\sqrt{\frac{k}{2M}}$
(4) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$

Q198. Oscillations, 2020 (06 Sep Shift 1)

An object of mass m is suspended at the end of a massless wire of length L and area of cross-section, A. Young modulus of the material of the wire is Y. If the mass is pulled down slightly its frequency of oscillation along the vertical direction is :

(1) $f=\frac{1}{2\pi}\sqrt{\frac{mL}{YA}}$
(2) $f=\frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$
(3) $f=\frac{1}{2\pi}\sqrt{\frac{mA}{VL}}$
(4) $f=\frac{1}{2\pi}\sqrt{\frac{YL}{mA}}$

Q199. Oscillations, 2020 (05 Sep Shift 2)

A ring is hung on a nail. It can oscillate, without slipping or sliding (i) in its plane with a time period T_1 and (ii) back and forth in a direction perpendicular to its plane, with a period T_2. The ratio $\frac{T_1}{T_2}$ will be :

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

Chapter: Waves and Sound

Q200. Waves and Sound, 2022 (26 Jul Shift 2)

A transverse wave is represented by $y=2\sin(\omega t-kx)$ cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity, will be

(1) 4π (2) 2π
(3) π (4) 2

Q201. Waves and Sound, 2022 (29 Jun Shift 2)

In an experiment to determine the velocity of sound in air at room temperature using a resonance tube, the first resonance is observed when the air column has a length of $20.0\ \mathrm{cm}$ for a tuning fork of frequency $400\ \mathrm{Hz}$ is used. The velocity of the sound at room temperature is $336\ \mathrm{m\ s^{-1}}$. The third resonance is observed when the air column has a length of _____ cm

Q202. Waves and Sound, 2022 (28 Jun Shift 1)

The velocity of sound in a gas, in which two wavelengths $4.08\ \mathrm{m}$ and $4.16\ \mathrm{m}$ produce 40 beats in 12 s, will be
(1) $282.8\ \mathrm{m\ s^{-1}}$ (2) $175.5\ \mathrm{m\ s^{-1}}$
(3) $353.6\ \mathrm{m\ s^{-1}}$ (4) $707.2\ \mathrm{m\ s^{-1}}$

Q203. Waves and Sound, 2022 (26 Jun Shift 2)

A set of 20 tuning forks is arranged in a series of increasing frequencies. If each fork gives 4 beats with respect to the preceding fork and the frequency of the last fork is twice the frequency of the first, then the frequency of last fork is _____ Hz.

Q204. Waves and Sound, 2022 (25 Jun Shift 1)

The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is $20\ \mathrm{cm}$. The length of the open organ pipe is _____ cm

Q205. Waves and Sound, 2022 (24 Jun Shift 2)

Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by $y=\left(10\cos\pi x\sin\frac{2\pi t}{T}\right)$ cm. The amplitude of the particle at $x=\frac{4}{3}\ \mathrm{cm}$ will be _____ cm.

Q206. Waves and Sound, 2021 (31 Aug Shift 1)

A wire having a linear mass density $9.0\times10^{-4}\ \mathrm{kg\ m^{-1}}$ is stretched between two rigid supports with a tension of 900 N. The wire resonates at a frequency of $500\ \mathrm{Hz}$. The next higher frequency at which the same wire resonates is $550\ \mathrm{Hz}$. The length of the wire is ___________ m.

Q207. Waves and Sound, 2021 (26 Aug Shift 1)

Two travelling waves produces a standing wave represented by equation.
$y=(1.0\ \mathrm{mm})\cos\left[\left(1.57\ \mathrm{cm^{-1}}\right)x\right]\ \sin\left[\left(78.5\ \mathrm{s^{-1}}\right)\mathrm{t}\right]$. The node closest to the origin in the region $x>0$ will be at $x=\ldots\ldots$ (in cm).

Q208. Waves and Sound, 2021 (20 Jul Shift 1)

The amplitude of wave disturbance propagating in the positive x-direction is given by $y=\frac{1}{(1+x)^2}$ at time $t=0$ and $y=\frac{1}{1+(x-2)^2}$ at $t=1\ s$, where x and y are in metres. The shape of wave does not change during the propagation. The velocity of the wave will be $\mathrm{m\ s^{-1}}$.

Q209. Waves and Sound, 2020 (05 Sep Shift 1)

In a resonance tube experiment when the tube is filled with water up to a height of $17.0\ \mathrm{cm}$, from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of $24.5\ \mathrm{cm}$. If the velocity of sound in air is $330\ \mathrm{m\ s^{-1}}$, the tuning fork frequency is :
(1) $2200\ \mathrm{Hz}$ (2) $550\ \mathrm{Hz}$
(3) $1100\ \mathrm{Hz}$ (4) $3300\ \mathrm{Hz}$

Chapter: Thermal Properties of Matter

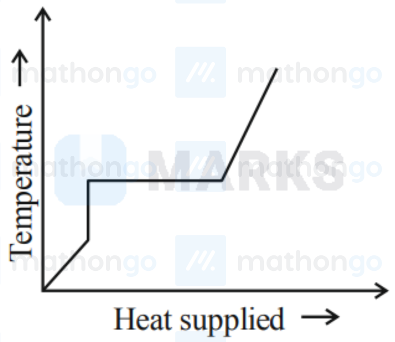
Q210. Thermal Properties of Matter, 2024 (31 Jan Shift 1)

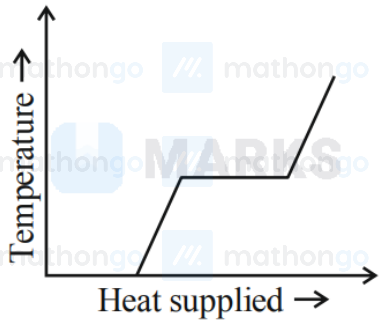
Two conductors have the same resistances at $0\ ^\circ\mathrm{C}$ but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients for their series and parallel combinations are :

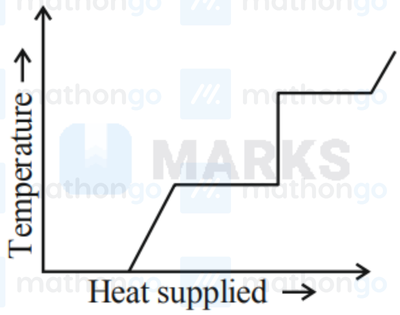
(1) $\alpha_1+\alpha_2,\ \frac{\alpha_1+\alpha_2}{2}$
(2) $\frac{\alpha_1+\alpha_2}{2},\ \frac{\alpha_1+\alpha_2}{2}$
(3) $\alpha_1+\alpha_2,\ \frac{\alpha_1\,\alpha_2}{\alpha_1+\alpha_2}$
(4) $\frac{\alpha_1+\alpha_2}{2},\ \alpha_1+\alpha_2$

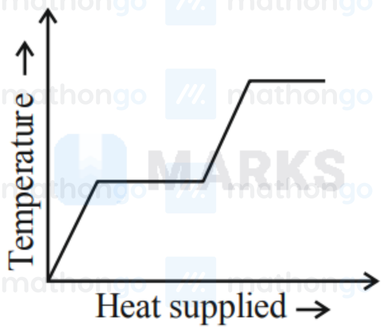
Q211. Thermal Properties of Matter, 2024 (30 Jan Shift 2)

A block of ice at $-10\ ^\circ\mathrm{C}$ is slowly heated and converted to steam at $100\ ^\circ\mathrm{C}$. Which of the following curves represent the phenomenon qualitatively:

(1)


(2)


(3)


(4)


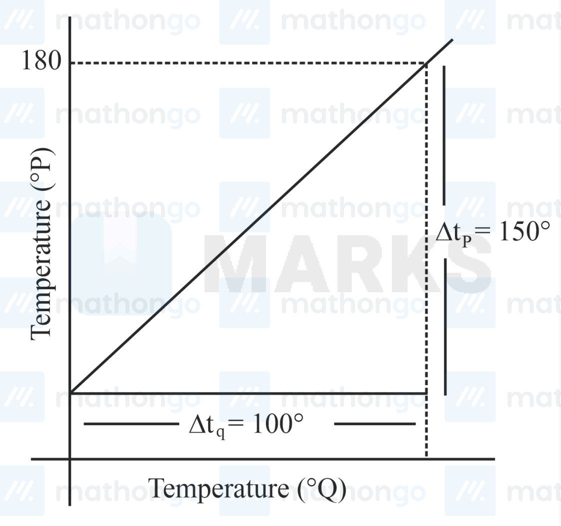
Q212. Thermal Properties of Matter, 2023 (11 Apr Shift 1)

$1\ \mathrm{kg}$ of water at $100^\circ\mathrm{C}$ is converted into steam at $100^\circ\mathrm{C}$ by boiling at atmospheric pressure. The volume of water changes from $1.00\times10^{-3}\ \mathrm{m}^3$ as a liquid to $1.671\ \mathrm{m}^3$ as steam. The change in internal energy of the system during the process will be (Given latent heat of vaporisation $=2257\ \mathrm{kJ/kg}$, Atmospheric pressure $=1\times10^5\ \mathrm{Pa}$)

(1) $-2426\ \mathrm{kJ}$
(2) $+2090\ \mathrm{kJ}$
(3) $-2090\ \mathrm{kJ}$
(4) $+2476\ \mathrm{kJ}$

Q213. Thermal Properties of Matter, 2023 (25 Jan Shift 2)

The graph between two temperature scales P and Q is shown in the figure. Between upper fixed point and lower fixed point there are 150 equal divisions of scale P and 100 divisions on scale Q. The relationship for conversion between the two scales is given by :



(1) $\frac{t_Q}{150} = \frac{t_P-180}{100}$
(2) $\frac{t_Q}{100} = \frac{t_P-30}{150}$
(3) $\frac{t_P}{180} = \frac{t_Q-40}{100}$
(4) $\frac{t_Q}{100} = \frac{t_P-180}{150}$

Q214. Thermal Properties of Matter, 2022 (25 Jul Shift 1)

A unit scale is to be prepared whose length does not change with temperature and remains 20 cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their lengths remains constant. If length of brass is 40 cm and length of iron will be _____ cm.
$\left(\alpha_{\text{iron}} = 1.2 \times 10^{-5} \text{ K}^{-1}\right.$ and $\left.\alpha_{\text{brass}} = 1.8 \times 10^{-5} \text{ K}^{-1}\right)$.

Q215. Thermal Properties of Matter, 2022 (29 Jun Shift 1)

A cylinder of fixed capacity of 44.8 litres contains helium gas at standard temperature and pressure. The amount of heat needed to raise the temperature of gas in the cylinder by 20.0°C will be (Given gas constant $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$)

(1) 249 J
(2) 415 J
(3) 498 J
(4) 830 J

Q216. Thermal Properties of Matter, 2022 (29 Jun Shift 2)

At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm? Both the diameters have been measured at room temperature (27°C).
(Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5} \text{ K}^{-1}$)

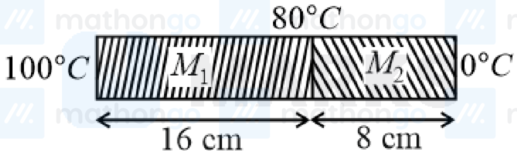
(1) 125.7°C
(2) 91.7°C
(3) 425.7°C
(4) 152.7°C

Q217. Thermal Properties of Matter, 2022 (25 Jun Shift 1)

A steam engine intakes 50 g of steam at 100°C per minute and cools it down to 20°C. If latent heat of vaporization of steam is 540 cal g^{-1}, then the heat rejected by the steam engine per minute is _____ $\times 10^3$ cal
(Given : specific heat capacity of water : $1 \text{ cal g}^{-1}{}^{\circ}\text{C}^{-1}$)

Q218. Thermal Properties of Matter, 2022 (24 Jun Shift 1)

Two metallic blocks M_1 and M_2 of same area of cross-section are connected to each other (as shown in figure). If the thermal conductivity of M_2 is K then the thermal conductivity of M_1 will be : [Assume steady state heat conduction]



(1) $10K$
(2) $8K$
(3) $12.5K$
(4) $2K$

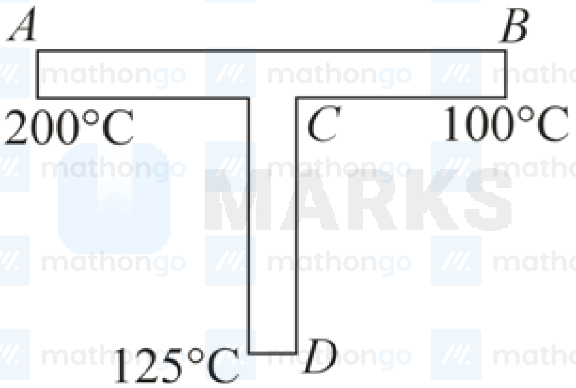
Q219. Thermal Properties of Matter, 2021 (31 Aug Shift 2)

Two thin metallic spherical shells of radii r_1 and $r_2 (r_1 < r_2)$ are placed with their centres coinciding. A material of thermal conductivity K is filled in the space between the shells. The inner shell is maintained at temperature θ_1 and the outer shell at temperature $\theta_2 (\theta_1 < \theta_2)$. The rate at which heat flows radially through the material is :

(1) $\frac{K(\theta_2-\theta_1)}{r_2-r_1}$
(2) $\frac{K(\theta_2-\theta_1)(r_2-r_1)}{4\pi r_1 r_2}$
(3) $\frac{\pi K r_1 r_2(\theta_2-\theta_1)}{r_2-r_1}$
(4) $\frac{4\pi K r_1 r_2(\theta_2-\theta_1)}{r_2-r_1}$

Q220. Thermal Properties of Matter, 2021 (27 Aug Shift 1)

A rod CD of thermal resistance $10.0\,\mathrm{KW}^{-1}$ is joined at the middle of an identical rod AB as shown in figure. The ends A, B and D are maintained at $200^\circ\mathrm{C}$, $100^\circ\mathrm{C}$ and $125^\circ\mathrm{C}$ respectively. The heat current in CD is P W. The value of P is



Q221. Thermal Properties of Matter, 2020 (03 Sep Shift 2)

A calorimeter of water equivalent 20 g contains 180 g of water at $25^\circ\mathrm{C}$. 'm' grams of steam at $100^\circ\mathrm{C}$ is mixed in it till the temperature of the mixture is $31^\circ\mathrm{C}$. The value of 'm' is close to (Latent heat of water $= 540\ \mathrm{cal\ g}^{-1}$, specific heat of water $= 1\ \mathrm{cal\ g}^{-1}{}^\circ\mathrm{C}^{-1}$)

(1) 2
(2) 4
(3) 3.2
(4) 2.6

Chapter: Thermodynamics

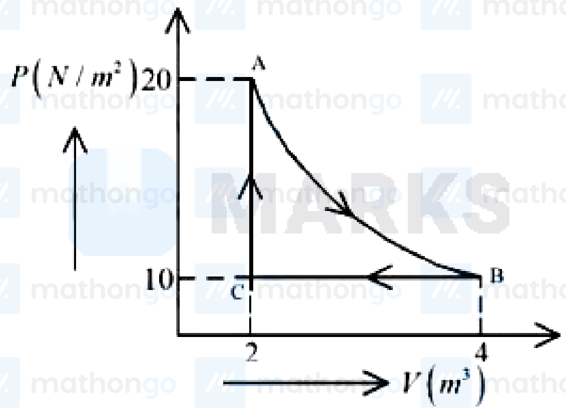
Q222. Thermodynamics, 2024 (09 Apr Shift 1)

A sample of 1 mole gas at temperature T is adiabatically expanded to double its volume. If adiabatic constant for the gas is $\gamma = \frac{3}{2}$, then the work done by the gas in the process is:

(1) $\frac{R}{T}[2-\sqrt{2}]$
(2) $\frac{T}{R}[2+\sqrt{2}]$
(3) $\mathrm{RT}[2-\sqrt{2}]$
(4) $\mathrm{RT}[2+\sqrt{2}]$

Q223. Thermodynamics, 2024 (09 Apr Shift 2)

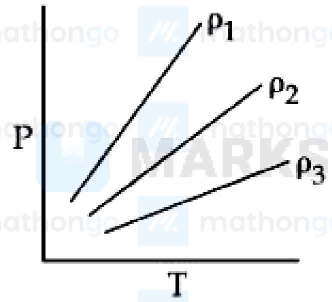
A real gas within a closed chamber at $27^\circ\mathrm{C}$ undergoes the cyclic process as shown in figure. The gas obeys $PV^3 = RT$ equation for the path A to B. The net work done in the complete cycle is (assuming $R = 8\ \mathrm{J/molK}$):



(1) 20 J
(2) 205 J
(3) −20 J
(4) 225 J

Q224. Thermodynamics, 2024 (04 Apr Shift 1)

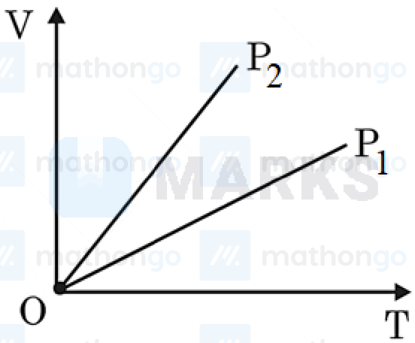
P-T diagram of an ideal gas having three different densities ρ_1, ρ_2, ρ_3 (in three different cases) is shown in the figure. Which of the following is correct :



(1) $\rho_1 > \rho_2$
(2) $\rho_2 < \rho_3$
(3) $\rho_1 = \rho_2 = \rho_3$
(4) $\rho_1 < \rho_2$

Q225. Thermodynamics, 2024 (31 Jan Shift 1)

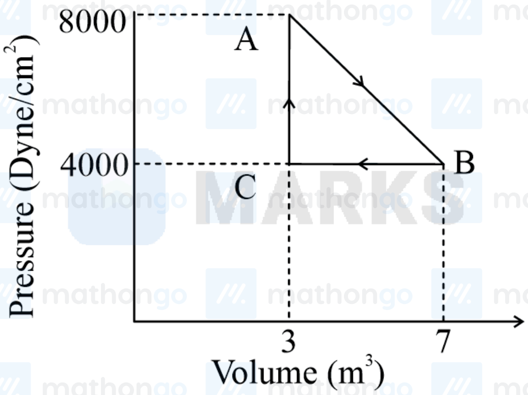
The given figure represents two isobaric processes for the same mass of an ideal gas, then



(1) $P_2 \geq P_1$
(2) $P_2 > P_1$
(3) $P_1 = P_2$
(4) $P_1 > P_2$

Q226. Thermodynamics, 2024 (29 Jan Shift 1)

A thermodynamic system is taken from an original state A to an intermediate state B by a linear process as shown in the figure. Its volume is then reduced to the original value from B to C by an isobaric process. The total work done by the gas from A to B and B to C would be :



(1) 33800 J
(2) 2200 J
(3) 600 J
(4) 800 J

Q227. Thermodynamics, 2024 (27 Jan Shift 2)

During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio of $\frac{C_p}{C_v}$ for the gas is :

(1) $\frac{5}{3}$
(2) $\frac{3}{2}$
(3) $\frac{7}{5}$
(4) $\frac{9}{7}$

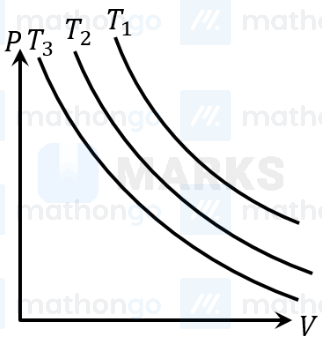
Q228. Thermodynamics, 2023 (31 Jan Shift 2)

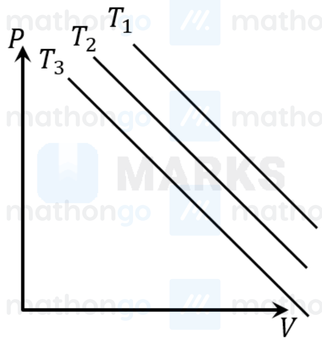
A hypothetical gas expands adiabatically such that its volume changes from 08 litres to 27 litres. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then the ratio of $\frac{C_p}{C_v}$ will be.

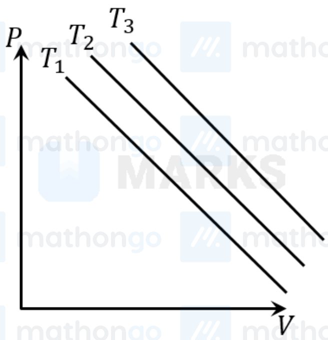
(1) $\frac{4}{3}$
(2) $\frac{3}{1}$
(3) $\frac{1}{2}$
(4) $\frac{3}{2}$

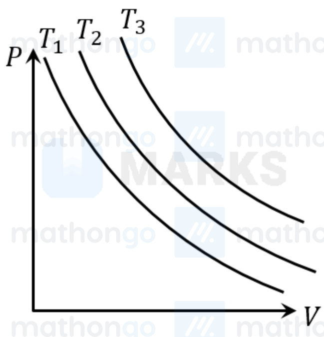
Q229. Thermodynamics, 2023 (24 Jan Shift 2)

In an Isothermal change, the change in pressure and volume of a gas can be represented for three different temperature; $T_3 > T_2 > T_1$ as:

(1)


(2)


(3)


(4)


Q230. Thermodynamics, 2023 (24 Jan Shift 2)

Let γ_1 be the ratio of molar specific heat at constant pressure and molar specific heat at constant volume of a monoatomic gas and γ_2 be the similar ratio of diatomic gas. Considering the diatomic gas molecule as a rigid rotator, the ratio $\frac{\gamma_1}{\gamma_2}$ is:

(1) $\frac{27}{35}$
(2) $\frac{35}{27}$
(3) $\frac{25}{21}$
(4) $\frac{21}{25}$

Q231. Thermodynamics, 2022 (28 Jul Shift 2)

At a certain temperature, the degrees of freedom per molecule for gas is 8. The gas performs 150 J of work when it expands under constant pressure. The amount of heat absorbed by the gas will be _____ J.

Q232. Thermodynamics, 2022 (25 Jul Shift 1)

A certain amount of gas of volume V at 27°C temperature and pressure $2 \times 10^7 \mathrm{N\ m^{-2}}$ expands isothermally until its volume gets doubled. Later it expands adiabatically until its volume gets redoubled. The final pressure of the gas will be (Use $\gamma = 1.5$)

(1) $3.536 \times 10^5\ \mathrm{Pa}$
(2) $3.536 \times 10^6\ \mathrm{Pa}$
(3) $1.25 \times 10^6\ \mathrm{Pa}$
(4) $1.25 \times 10^5\ \mathrm{Pa}$

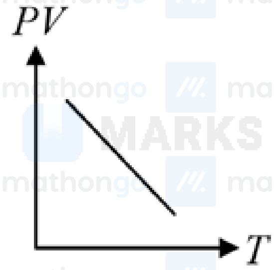
Q233. Thermodynamics, 2021 (27 Jul Shift 2)

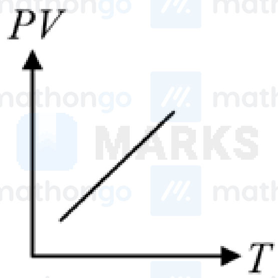
One mole of an ideal gas is taken through an adiabatic process where the temperature rises from 27°C to 37°C. If the ideal gas is composed of polyatomic molecule that has 4 vibrational modes, which of the following is true? $\left[\mathrm{R} = 8.314\ \mathrm{J\ mol^{-1} k^{-1}}\right]$

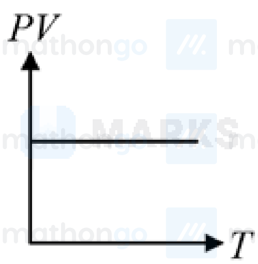
(1) work done by the gas is close to 332 J
(2) work done on the gas is close to 582 J
(3) work done by the gas is close to 582 J
(4) work done on the gas is close to 332 J

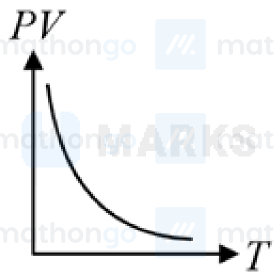
Q234. Thermodynamics, 2021 (20 Jul Shift 2)

Which of the following graphs represent the behaviour of an ideal gas? Symbols have their usual meaning.

(1)


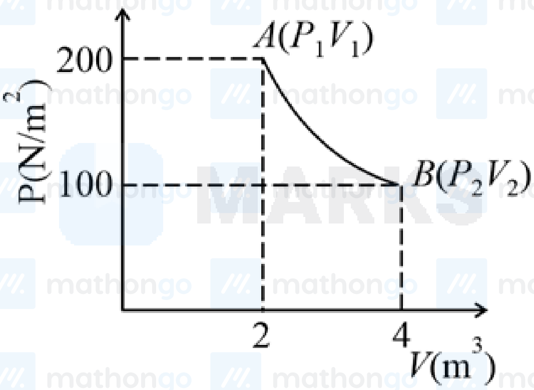
(2)


(3)


(4)


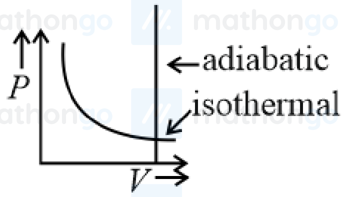
Q235. Thermodynamics, 2021 (20 Jul Shift 2)

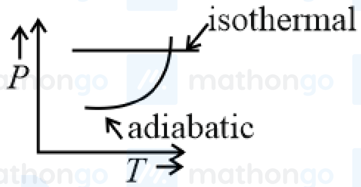
One mole of an ideal gas at 27 $^{\circ}$C is taken from A to B as shown in the given PV indicator diagram. The work done by the system will be _______ $\times 10^{-1}$ J. [Given, $R = 8.3\ \mathrm{J\ mole^{-1}\ K}$, $\ln 2 = 0.6931$] (Round off to the nearest integer)
(Round off to the nearest integer)

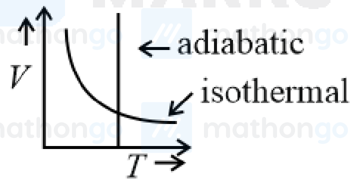


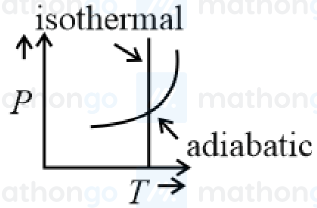
Q236. Thermodynamics, 2021 (17 Mar Shift 2)

Which one is the correct option for the two different thermodynamic processes ?

(a)


(b)


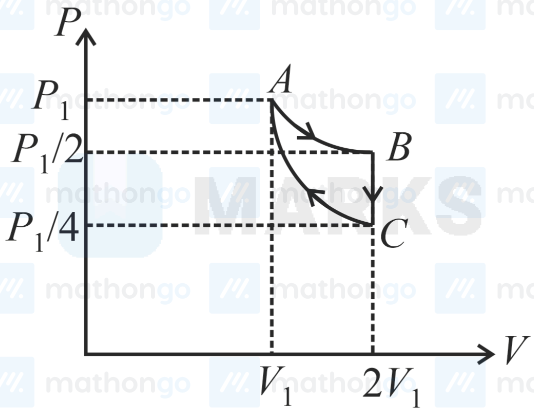
(c)


(d)


(1) (c) and (a)
(2) (c) and (d)
(3) (a) only
(4) (b) and (c)

Q237. Thermodynamics, 2021 (24 Feb Shift 2)

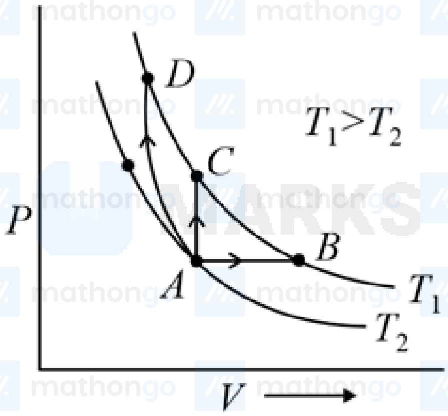
If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value ($B \rightarrow C$). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net workdone by the gas is equal to:



(1) 0
(2) $RT \ln(2)$
(3) $-\frac{RT}{2(\gamma-1)}$
(4) $RT\left[\ln(2)-\frac{1}{2(\gamma-1)}\right]$

Q238. Thermodynamics, 2020 (05 Sep Shift 1)

Three different processes that can occur in an ideal monoatomic gas are shown in the P vs V diagram. The paths are labelled as $A \rightarrow B, A \rightarrow C$ and $A \rightarrow D$. The change in internal energies during these process are taken as E_{AB}, E_{AC} and E_{AD} and the work done as W_{AB}, W_{AC} and W_{AD}. The correct relation between these parameters are:



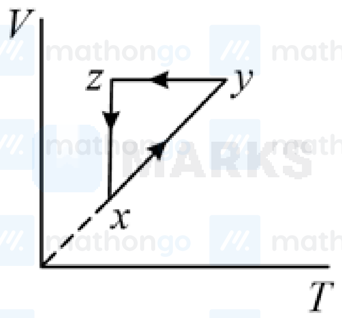
(1) $E_{AB}=E_{AC}<E_{AD}, W_{AB}>0, W_{AC}=0, W_{AD}<0$
(2) $E_{AB}=E_{AC}=E_{AD}, W_{AB}>0, W_{AC}=0, W_{AD}<0$
(3) $E_{AB}<E_{AC}<E_{AD}, W_{AB}>0, W_{AC}>W_{AD}$
(4) $E_{AB}>E_{AC}>E_{AD}, W_{AB}<W_{AC}<W_{AD}$

Q239. Thermodynamics, 2020 (09 Jan Shift 2)

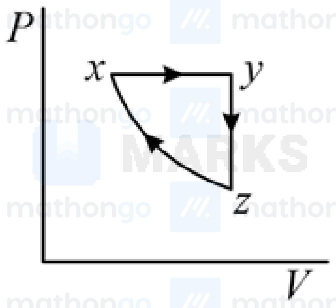
Starting at temperature $300K$, one mole of an ideal diatomic gas $(\gamma=1.4)$ is first compressed adiabatically from volume V_1 to $V_2=\frac{V_1}{16}$. It is then allowed to expand isobarically to volume $2V_2$. If all the processes are the quasi-static then the final temperature of the gas (in ^oK) is (to the nearest integer) ___________.

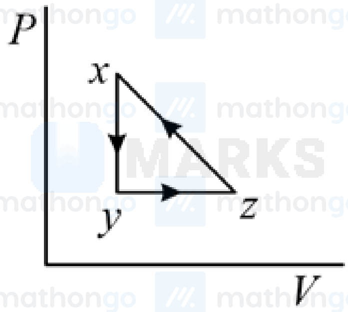
Q240. Thermodynamics, 2020 (08 Jan Shift 1)

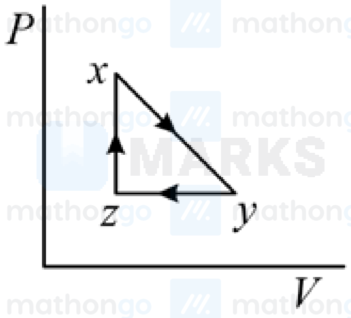
A thermodynamic cycle $xyzx$ is shown on a V - T diagram.

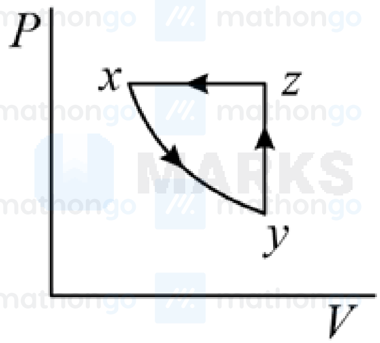


The P - V diagram that best describes this cycle is: (Diagrams are schematic and not to scale)

(1)


(2)


(3)


(4)


Chapter: Kinetic Theory of Gases

Q241. Kinetic Theory of Gases, 2024 (08 Apr Shift 2)

Given below are two statements : Statement (I) : The mean free path of gas molecules is inversely proportional to square of molecular diameter. Statement (II) : Average kinetic energy of gas molecules is directly proportional to absolute temperature of gas. 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) Both Statement I and Statement II are false
(3) Both Statement I and Statement II are true
(4) Statement I is false but Statement II is true

Q242. Kinetic Theory of Gases, 2024 (06 Apr Shift 1)

The specific heat at constant pressure of a real gas obeying $PV^2 = RT$ equation is:

(1) $\frac{R}{3} + C_V$
(2) $C_V + R$
(3) $C_V + \frac{R}{2V}$
(4) R

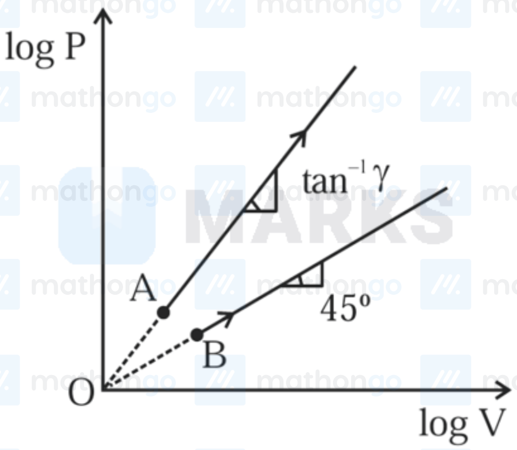
Q243. Kinetic Theory of Gases, 2024 (05 Apr Shift 2)

If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by :

(1) $\sqrt{2} n \pi d^2$
(2) $\frac{1}{\sqrt{2 n \pi d^2}}$
(3) $\frac{1}{\sqrt{2} n \pi d^2}$
(4) $\frac{1}{\sqrt{2} n^2 \pi^2 d^2}$

Q244. Kinetic Theory of Gases, 2024 (30 Jan Shift 1)

Two thermodynamical process are shown in the figure. The molar heat capacity for process A and B are C_A and C_B. The molar heat capacity at constant pressure and constant volume are represented by C_P and C_V, respectively. Choose the correct statement.



(1) $C_P > C_B > C_V$
(2) $C_A = 0$ and $C_B = \infty$
(3) $C_P > C_V > C_A = C_B$
(4) $C_A > C_P > C_V$

Q245. Kinetic Theory of Gases, 2024 (29 Jan Shift 2)

The temperature of a gas having 2.0×10^{25} molecules per cubic meter at 1.38 atm (Given, $k = 1.38 \times 10^{-23} \mathrm{J\ K^{-1}}$) is :

(1) 500 K
(2) 200 K
(3) 100 K
(4) 300 K

Q246. Kinetic Theory of Gases, 2023 (13 Apr Shift 1)

The rms speed of oxygen molecule in a vessel at particular temperature is $\left(1 + \frac{5}{x}\right)^{\frac{1}{2}} v$, when v is the average speed of the molecule. The value of x will be:
(take $\pi = \frac{22}{7}$)

(1) 27
(2) 8
(3) 28
(4) 4

Q247. Kinetic Theory of Gases, 2023 (13 Apr Shift 2)

The mean free path of molecules of a certain gas at STP is $1500d$, where d is the diameter of the gas molecules. While maintaining the standard pressure, the mean free path of the molecules at $373\ K$ is approximately:

(1) $750d$
(2) $1098d$
(3) $2049d$
(4) $1500d$

Q248. Kinetic Theory of Gases, 2023 (06 Apr Shift 1)

The number of air molecules per cm^3 is increased from 3×10^{19} to 12×10^{19}. The ratio of collision frequency of air molecules before and after the increase in number respectively is :

(1) 0.75
(2) 1.25
(3) 0.50
(4) 0.25

Q249. Kinetic Theory of Gases, 2022 (27 Jul Shift 1)

Same gas is filled in two vessels of the same volume at the same temperature. If the ratio of the number of molecules is 1 : 4, then

A. The r.m.s. velocity of gas molecules in two vessels will be the same.
B. The ratio of pressure in these vessels will be 1 : 4.
C. The ratio of pressure will be 1 : 1.
D. The r.m.s. velocity of gas molecules in two vessels will be in the ratio of 1 : 4.

(1) A and C only
(2) B and D only
(3) A and B only
(4) C and D only

Q250. Kinetic Theory of Gases, 2022 (27 Jul Shift 2)

Which statements are correct about degrees of freedom?

A. A molecule with n degrees of freedom has n^2 different ways of storing energy.
B. Each degree of freedom is associated with $\frac{1}{2}RT$ average energy per mole.
C. A monoatomic gas molecule has 1 rotational degree of freedom where as diatomic molecule has 2 rotational degrees of freedom
D. CH_4 has a total to 6 degrees of freedom.

Choose the correct answer from the option given below:

(1) B and C only
(2) B and D only
(3) A and B only
(4) C and D only

Q251. Kinetic Theory of Gases, 2022 (26 Jul Shift 2)

A gas has n degrees of freedom. The ratio of specific heat of gas at constant volume to the specific heat of gas at constant pressure will be

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

Q252. Kinetic Theory of Gases, 2022 (27 Jun Shift 1)

A mixture of hydrogen and oxygen has volume $2000\ \text{cm}^3$, temperature 300 K, pressure $100\,\text{kPa}$ and mass 0.76 g. The ratio of number of moles of hydrogen to number of moles of oxygen in the mixture will be

[Take gas constant $R = 8.3\ \text{J K}^{-1}\ \text{mol}^{-1}$]

(1) $\frac{1}{3}$
(2) $\frac{3}{1}$
(3) $\frac{1}{16}$
(4) $\frac{16}{1}$

Q253. Kinetic Theory of Gases, 2021 (20 Jul Shift 1)

Consider a mixture of gas molecule of types A, B and C having masses $m_A < m_B < m_C$. The ratio of their root mean square speeds at normal temperature and pressure is:

(1) $v_A = v_B = v_C = 0$
(2) $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$
(3) $v_A = v_B \neq v_C$
(4) $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$

Q254. Kinetic Theory of Gases, 2021 (17 Mar Shift 1)

Two ideal polyatomic gases at temperatures T_1 and T_2 are mixed so that there is no loss of energy. If F_1 and F_2, m_1 and m_2, n_1 and n_2 be the degrees of freedom, masses, number of molecules of the first and second gas respectively, the temperature of mixture of these two gases is:

(1) $\frac{n_1 T_1+n_2 T_2}{n_1+n_2}$
(2) $\frac{n_1 F_1 T_1+n_2 F_2 T_2}{n_1 F_1+n_2 F_2}$
(3) $\frac{n_1 F_1 T_1+n_2 F_2 T_2}{F_1+F_2}$
(4) $\frac{n_1 F_1 T_1+n_2 F_2 T_2}{n_1+n_2}$

Q255. Kinetic Theory of Gases, 2021 (17 Mar Shift 2)

If one mole of the polyatomic gas is having two vibrational modes and β is the ratio of molar specific heats for polyatomic gas $\left(\beta=\frac{C_P}{C_V}\right)$ then the value of β is :

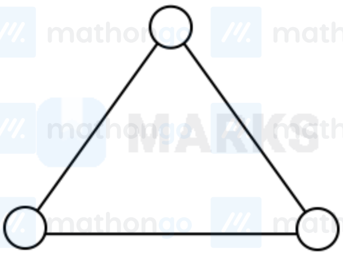
(1) 1.02
(2) 1.2
(3) 1.25
(4) 1.35

Q256. Kinetic Theory of Gases, 2020 (06 Sep Shift 2)

In a dilute gas at pressure P and temperature 't', the time between successive collision of a molecule varies with T as :

(1) T
(2) $\frac{1}{\sqrt{T}}$
(3) $\frac{1}{T}$
(4) $\sqrt{T}$

Q257. Kinetic Theory of Gases, 2020 (03 Sep Shift 1)



Consider a gas of triatomic molecules. The molecules are assumed to be triangular and made of massless rigid rods whose vertices are occupied by atoms. The internal energy of a mole of the gas at temperature T is:

(1) $\frac{5}{2} R T$
(2) $\frac{3}{2} R T$
(3) $\frac{9}{2} R T$
(4) $3 R T$

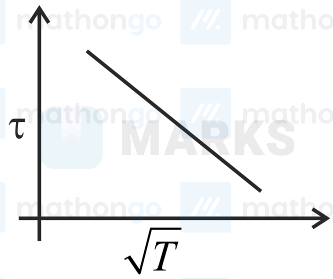
Q258. Kinetic Theory of Gases, 2020 (02 Sep Shift 1)

A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Assuming the gases to be ideal and the oxygen bond to be rigid, the total internal energy (in units of $R T$) of the mixutre is :

(1) 15
(2) 13
(3) 20
(4) 11

Q259. Kinetic Theory of Gases, 2020 (08 Jan Shift 1)

The plot that depicts the behavior of the mean free time τ (time between two successive collisions) for the molecules of an ideal gas, as a function of temperature (T), qualitatively, is: (Graphs are schematic and not drawn to scale)

(1)


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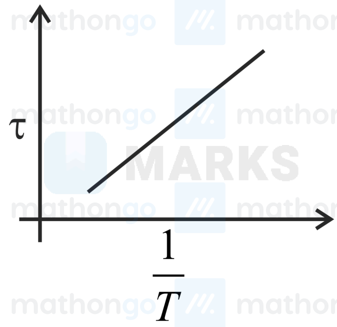

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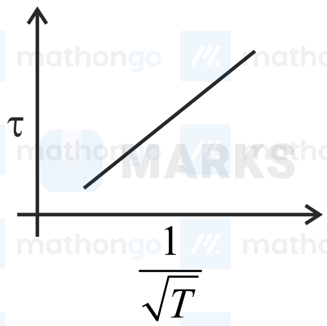
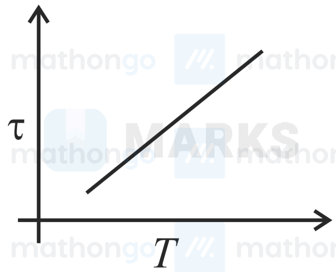


(4)


Chapter: Electrostatics

Q260. Electrostatics, 2024 (06 Apr Shift 2)

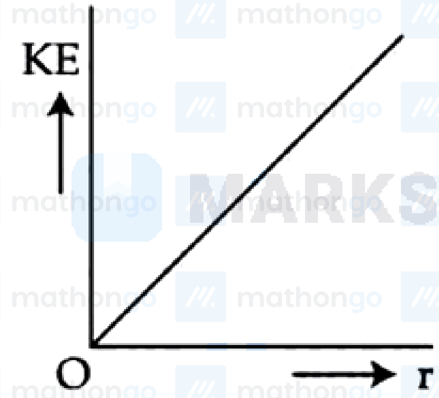
Two identical conducting spheres P and S with charge Q on each, repel each other with a force 16 N. A third identical uncharged conducting sphere R is successively brought in contact with the two spheres. The new force of repulsion between P and S is :

(1) 1 N
(2) 6 N
(3) 12 N
(4) 4 N

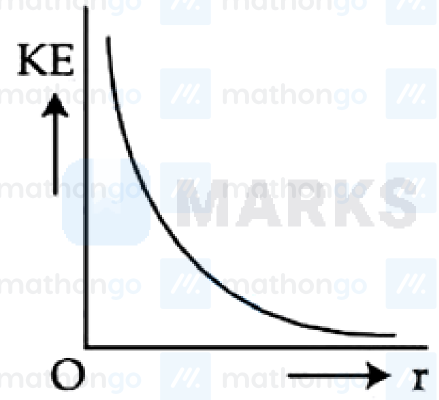
Q261. Electrostatics, 2024 (04 Apr Shift 1)

An infinitely long positively charged straight thread has a linear charge density $\lambda \mathrm{Cm}^{-1}$. An electron revolves along a circular path having axis along the length of the wire. The graph that correctly represents the variation of the kinetic energy of electron as a function of radius of circular path from the wire is :

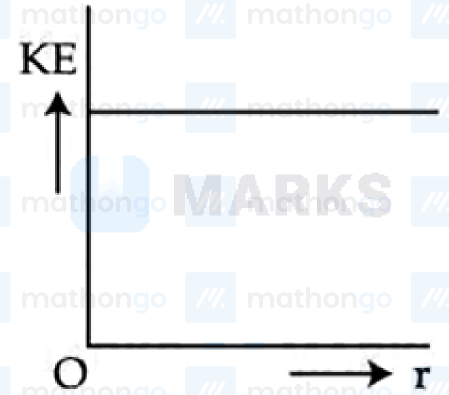
(1)



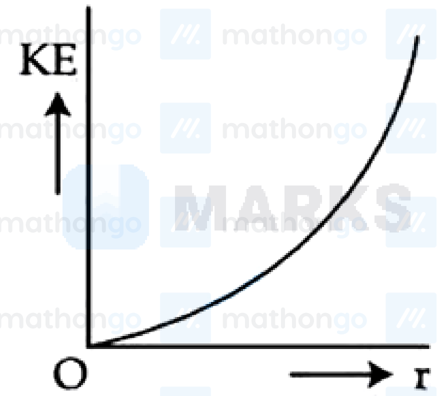
(2)



(3)



(4)



Q262. Electrostatics, 2024 (04 Apr Shift 1)

An infinite plane sheet of charge having uniform surface charge density $+\sigma_s \mathrm{C/m^2}$ is placed on $x-y$ plane. Another infinitely long line charge having uniform linear charge density $+\lambda_e \mathrm{C/m}$ is placed at $z=4$ m plane and parallel to y-axis. If the magnitude values $|\sigma_s| = 2|\lambda_e|$ then at point $(0,0,2)$, the ratio of magnitudes of electric field values due to sheet charge to that of line charge is $\pi\sqrt{n} : 1$. The value of n is_______.

Q263. Electrostatics, 2024 (30 Jan Shift 2)

Two identical charged spheres are suspended by strings of equal lengths. The string make an angle of 37° with each other. When suspended in a liquid of density $0.7 \mathrm{~g~cm^{-3}}$, the angle remains same. If density of material of the sphere is $1.4 \mathrm{~g~cm^{-3}}$, the dielectric constant of the liquid is _____ $\left(\tan 37^\circ = \frac{3}{4}\right)$

Q264. Electrostatics, 2024 (29 Jan Shift 1)

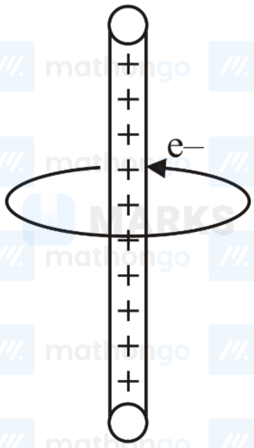
An electron is moving under the influence of the electric field of a uniformly charged infinite plane sheet S having surface charge density $+\sigma$. The electron at $t=0$ is at a distance of 1 m from S and has a speed of $1 \mathrm{~m~s^{-1}}$. The maximum value of σ, if the electron strikes S at $t=1$ s is $\alpha\left[\frac{m\epsilon_0}{e}\right] \frac{\mathrm{C}}{\mathrm{m}^2}$. The value of α is _____.

Q265. Electrostatics, 2024 (27 Jan Shift 1)

A thin metallic wire having cross sectional area of $10^{-4} \mathrm{~m^2}$ is used to make a ring of radius $30 \mathrm{~cm}$. A positive charge of 2π C is uniformly distributed over the ring, while another positive charge of $30 \mathrm{~pC}$ is kept at the centre of the ring. The tension in the ring is _______ N; provided that the ring does not get deformed (neglect the influence of gravity).
(Given, $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ SI units)

Q266. Electrostatics, 2023 (10 Apr Shift 2)

An electron revolves around an infinite cylindrical wire having uniform linear charge density $2 \times 10^{-8}\ \mathrm{C\ m^{-1}}$ in circular path under the influence of attractive electrostatic field as shown in the figure. The velocity of electron with which it is revolving is ________ $\times 10^{6}\ \mathrm{m\ s^{-1}}$. Given mass of electron $= 9 \times 10^{-31}\ \mathrm{kg}$



Q267. Electrostatics, 2023 (06 Apr Shift 2)

A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass m of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance l . If the dipole is placed in a uniform electric field $\vec{E}$; in such a way that dipole axis makes a very small angle with the electric field, $\vec{E}$. The angular frequency of the oscillations of the dipole when released is given by:

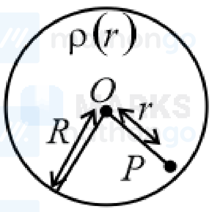
(1) $\sqrt{\frac{3qE}{2ml}}$
(2) $\sqrt{\frac{8qE}{ml}}$
(3) $\sqrt{\frac{4qE}{ml}}$
(4) $\sqrt{\frac{8qE}{3ml}}$

Q268. Electrostatics, 2022 (29 Jul Shift 1)

A spherically symmetric charge distribution is considered with charge density varying as

$$\rho(r)=\begin{cases}\rho_0\left(\frac{3}{4}-\frac{r}{R}\right) & \text{for } r \leq R\\ \text{Zero} & \text{for } r>R\end{cases}$$

Where, $r(r<R)$ is the distance from the centre O (as shown in figure). The electric field at point P will be :



(1) $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{3}{4}-\frac{r}{R}\right)$
(2) $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{3}{4}-\frac{r}{R}\right)$
(3) $\frac{\rho_0 r}{4\varepsilon_0}\left(1-\frac{r}{R}\right)$
(4) $\frac{\rho_0 r}{5\varepsilon_0}\left(1-\frac{r}{R}\right)$

Q269. Electrostatics, 2022 (29 Jul Shift 2)

Two identical metallic spheres A and B when placed at certain distance in air repel each other with a force of F. Another identical uncharged sphere C is first placed in contact with A and then in contact with B and finally placed at midpoint between spheres $A$and B. The force experienced by sphere C will be :

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

Q270. Electrostatics, 2022 (27 Jul Shift 1)

Two identical positive charges Q each are fixed at a distance of $2a$ apart from each other. Another point charge q_0 with mass m is placed at midpoint between two fixed charges. For a small displacement along the line joining the fixed charges, the charge q_0 executes SHM. The time period of oscillation of charge q_0 will be

(1) $\sqrt{\frac{4\pi^3\varepsilon_0 ma^3}{q_0Q}}$
(2) $\sqrt{\frac{q_0Q}{4\pi^3\varepsilon_0 ma^3}}$
(3) $\sqrt{\frac{2\pi^2\varepsilon_0 ma^3}{q_0Q}}$
(4) $\sqrt{\frac{8\pi^3\varepsilon_0 ma^3}{q_0Q}}$

Q271. Electrostatics, 2022 (27 Jul Shift 1)

A $1\ \mathrm{m}$ long copper wire carries a current of $1\ \mathrm{A}$. If the cross section of the wire is $2.0\ \mathrm{mm}^2$ and the resistivity of copper is $1.7\times10^{-8}\ \Omega\ \mathrm{m}$. The force experienced by moving electron in the wire is _____ $\times10^{-23}$ N
(Charge of electron$=1.6\times10^{-19}$C)

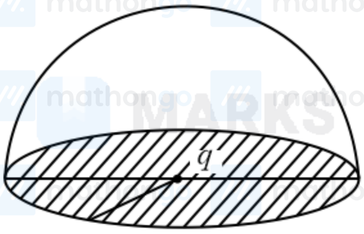
Q272. Electrostatics, 2022 (29 Jun Shift 2)

If the electric potential at any point $(x,\ y,\ z)$ m in space is given by $V=3x^2$ volt. The electric field at the point $(1,\ 0,\ 3)$ m will be :

(1) $3\ \mathrm{Vm}^{-1}$, directed along positive x-axis.
(2) $3\ \mathrm{Vm}^{-1}$, directed along negative x-axis.
(3) $6\ \mathrm{Vm}^{-1}$, directed along negative x-axis.
(4) $6\ \mathrm{Vm}^{-1}$, directed along positive x-axis.

Q273. Electrostatics, 2022 (27 Jun Shift 2)

If a charge q is placed at the centre of a closed hemispherical non-conducting surface, the total flux passing through the flat surface would be



(1) $\frac{q}{\varepsilon_0}$
(2) $\frac{q}{2\varepsilon_0}$
(3) $\frac{q}{4\varepsilon_0}$
(4) $\frac{q}{2\pi\varepsilon_0}$

Q274. Electrostatics, 2022 (26 Jun Shift 2)

Sixty four conducting drops each of radius $0.02\ \mathrm{m}$ and each carrying a charge of $5\ \mu\mathrm{C}$ are combined to form a bigger drop. The ratio of surface density of bigger drop to the smaller drop will be

(1) 1 : 4
(2) 4 : 1
(3) 1 : 8
(4) 8 : 1

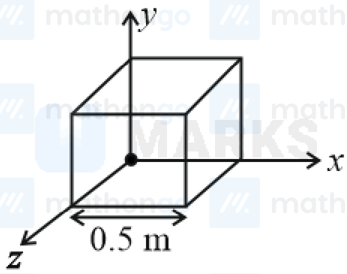
Q275. Electrostatics, 2022 (24 Jun Shift 2)

A long cylindrical volume contains a uniformly distributed charge of density ρ. The radius of cylindrical volume is R. A charge particle (q) revolves around the cylinder in a circular path. The kinetic energy of the particle is :

(1) $\frac{\rho qR^2}{4\varepsilon_o}$
(2) $\frac{\rho qR^2}{2\varepsilon_o}$
(3) $\frac{q\rho}{4\varepsilon_0 R^2}$
(4) $\frac{4\varepsilon_0 R^2}{q\rho}$

Q276. Electrostatics, 2021 (01 Sep Shift 2)

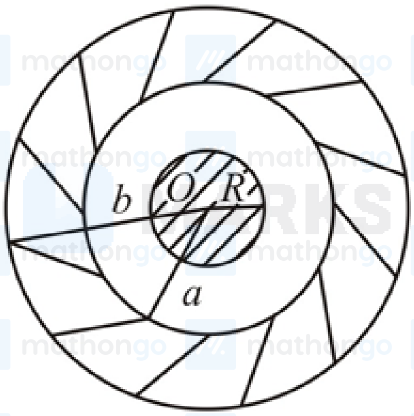
A cube is placed inside an electric field, $\overrightarrow{E}=150y^2\hat{\mathrm{j}}$ The side of the cube is $0.5\ \mathrm{m}$ and is placed in the field as shown in the given figure. The charge inside the cube is:

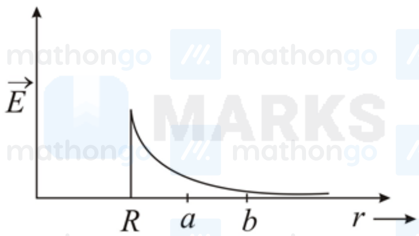


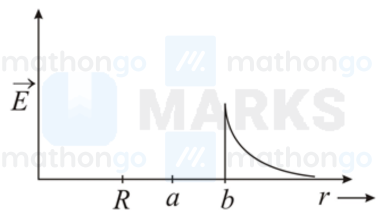
(1) $8.3 \times 10^{-11} \mathrm{C}$
(2) $3.8 \times 10^{-11} \mathrm{C}$
(3) $3.8 \times 10^{-12} \mathrm{C}$
(4) $8.3 \times 10^{-12} \mathrm{C}$

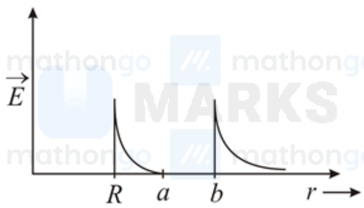
Q277. Electrostatics, 2021 (26 Aug Shift 1)

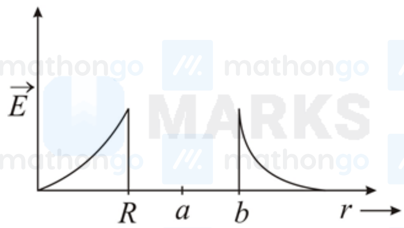
A solid metal sphere of radius R having charge q is enclosed inside the concentric spherical shell of inner radius a and outer radius b as shown in the figure. The approximate variation electric field $\vec{E}$, as a function of distance r, from centre O, is given by:



(1)


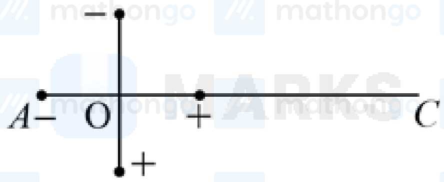
(2)


(3)


(4)


Q278. Electrostatics, 2021 (25 Jul Shift 2)

Two ideal electric dipoles A and B, having their dipole moment p_1 and p_2 respectively are placed on a plane with their centres at O as shown in the figure. At point C on the axis of dipole A, the resultant electric field is making an angle of 37° with the axis. The ratio of the dipole moment of A and B, $\frac{p_1}{p_2}$ is: (take $\sin 37^{\circ}=\frac{3}{5}$)



(1) $\frac{3}{8}$
(2) $\frac{3}{2}$
(3) $\frac{2}{3}$
(4) $\frac{4}{3}$

Q279. Electrostatics, 2021 (25 Feb Shift 1)

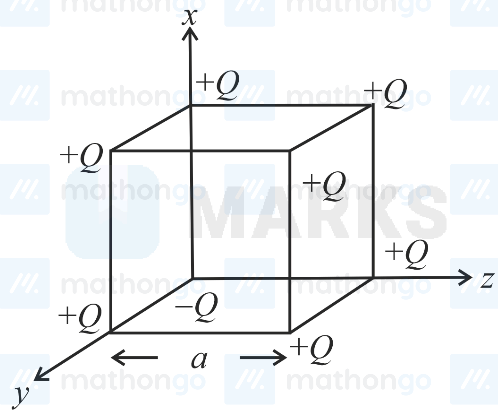
The electric field in a region is given by $\overrightarrow{E}=\left(\frac{3}{5}E_0\hat{\mathrm{i}}+\frac{4}{5}E_0\hat{\mathrm{j}}\right)$ N C^{-1}. The ratio of flux of reported field through the rectangular surface of area $0.2\ \mathrm{m}^2$ (parallel to $y-z$ plane) to that of the surface of area $0.3\ \mathrm{m}^2$ (parallel to $x-z$ plane) is $a:b=a:2$, where $a=$? [Here $\hat{\mathrm{i}}$, $\hat{\mathrm{j}}$ and $\widehat{\mathrm{k}}$ are unit vectors along x, y and z -axes respectively]

Q280. Electrostatics, 2021 (25 Feb Shift 2)

Two identical conducting spheres with negligible volume have $2.1\ \mathrm{nC}$ and $-0.1\ \mathrm{nC}$ charges, respectively. They are brought into contact and then separated by a distance of $0.5\ \mathrm{m}$. The electrostatic force acting between the spheres is ___$\times 10^{-9}$ N. [Given : $4\pi\varepsilon_0=\frac{1}{9\times10^9}$ SI unit]

Q281. Electrostatics, 2021 (24 Feb Shift 1)

A cube of side a has point charges $+\mathrm{Q}$ located at each of its vertices except at the origin where the charge is $-\mathrm{Q}$. The electric field at the centre of cube is:



(1) $\frac{-Q}{3\sqrt{3}\pi\varepsilon_0a^2}(\widehat{x}+\hat{y}+\hat{z})$
(2) $\frac{Q}{3\sqrt{3}\pi\varepsilon_0a^2}(\widehat{x}+\hat{y}+\hat{z})$
(3) $\frac{-2Q}{3\sqrt{3}\pi\varepsilon_0a^2}(\widehat{x}+\hat{y}+\hat{z})$
(4) $\frac{2Q}{3\sqrt{3}\pi\varepsilon_0a^2}(\widehat{x}+\hat{y}+\hat{z})$

Q282. Electrostatics, 2020 (06 Sep Shift 2)

Consider the force F on a charge 'q' due to a uniformly charged spherical shell of radius R carrying charge Q distributed uniformly over it. Which one of the following statements is true for F, if 'q' is placed at distance r from the centre of the shell?

(1) $\mathrm{F}=\frac{1}{4\pi\epsilon_0}\frac{\mathrm{Qq}}{\mathrm{R}^2}$ for $\mathrm{r}<\mathrm{R}$
(2) $\frac{1}{4\pi\epsilon_0}\frac{\mathrm{qQ}}{\mathrm{R}^2}>\mathrm{F}>0$ for $\mathrm{r}<\mathrm{R}$
(3) $\mathrm{F}=\frac{1}{4\pi\epsilon_0}\frac{\mathrm{Qq}}{\mathrm{r}^2}$ for $\mathrm{r}>\mathrm{R}$
(4) $\mathrm{F}=\frac{1}{4\pi\epsilon_0}\frac{\mathrm{Qq}}{\mathrm{r}^2}$ for all r

Q283. Electrostatics, 2020 (08 Jan Shift 1)

In finding the electric field using Gauss law the formula $\left|\overrightarrow{E}\right|=\frac{q_{\text{enc}}}{\varepsilon_0|A|}$ is applicable. In the formula ε_0 is permittivity of free space, A is the area of Gaussian surface and q_{enc} is charge enclosed by the Gaussian surface. This equation can be used in which of the following situation?

(1) Only when the Gaussian surface is an equipotential surface

(2) Only when the Gaussian surface is an equipotential surface and $|\vec{E}|$ is constant on the surface.

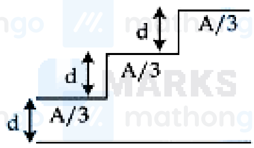
(3) Only when $|\vec{E}| =$ constant on the surface.

(4) For any choice of Gaussian surface.

Chapter: Capacitance

Q284. Capacitance, 2024 (09 Apr Shift 1)

A capacitor is made of a flat plate of area A and a second plate having a stair-like structure as shown in figure. If the area of each stair is $\frac{A}{3}$ and the height is d, the capacitance of the arrangement is :



(1) $\frac{13\epsilon_o A}{17d}$

(2) $\frac{11\epsilon_o \mathrm{A}}{18\ \mathrm{d}}$

(3) $\frac{18\epsilon_o \mathrm{A}}{11\ \mathrm{d}}$

(4) $\frac{11\epsilon_o \mathrm{A}}{20\ \mathrm{d}}$

Q285. Capacitance, 2024 (05 Apr Shift 1)

Three capacitors of capacitances $25\mu\mathrm{F}, 30\mu\mathrm{F}$ and $45\mu\mathrm{F}$ are connected in parallel to a supply of 100 V. Energy stored in the above combination is E. When these capacitors are connected in series to the same supply, the stored energy is $\frac{9}{x}$E. The value of x is _____.

Q286. Capacitance, 2024 (05 Apr Shift 1)

The electric field between the two parallel plates of a capacitor of $1.5\mu\mathrm{F}$ capacitance drops to one third of its initial value in $6.6\mu\mathrm{s}$ when the plates are connected by a thin wire. The resistance of this wire is _____ Ω. (Given, $\log 3 = 1.1$)

Q287. Capacitance, 2024 (04 Apr Shift 2)

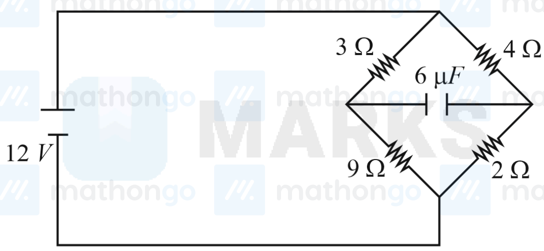
A parallel plate capacitor of capacitance 12.5pF is charged by a battery connected between its plates to potential difference of 12.0 V. The battery is now disconnected and a dielectric slab $(\epsilon_r = 6)$ is inserted between the plates. The change in its potential energy after inserting the dielectric slab is _____ 10^{-12} J.

Q288. Capacitance, 2024 (29 Jan Shift 1)

A 16 Ω wire is bend to form a square loop. A 9 V battery with internal resistance 1 Ω is connected across one of its sides. If a 4 μF capacitor is connected across one of its diagonals, the energy stored by the capacitor will be $\frac{x}{2}$ μJ, where $x =$______.

Q289. Capacitance, 2023 (13 Apr Shift 2)

In the circuit shown, the energy stored in the capacitor is n μJ. The value of n is _____.



Q290. Capacitance, 2022 (28 Jul Shift 1)

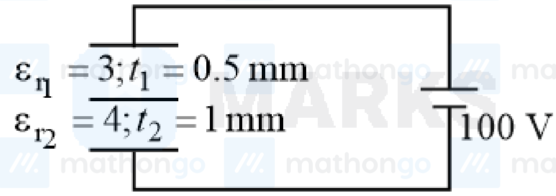
Two capacitors, each having capacitance $40\mu\mathrm{F}$ are connected in series. The space between one of the capacitors is filled with dielectric material of dielectric constant K such that the equivalence capacitance of the system became $24\mu\mathrm{F}$. The value of K

will be :

(1) 1.5
(2) 2.5
(3) 1.2
(4) 3

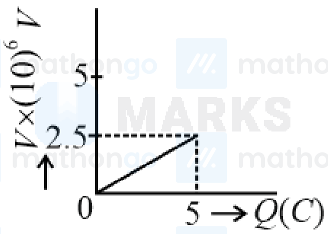
Q291. Capacitance, 2022 (26 Jul Shift 1)

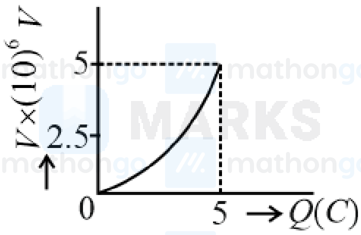
A composite parallel plate capacitor is made up of two different dielectric materials with different thickness (t_1 and t_2) as shown in figure. The two different dielectric material are separated by a conducting foil F. The voltage of the conducting foil is _____ V.

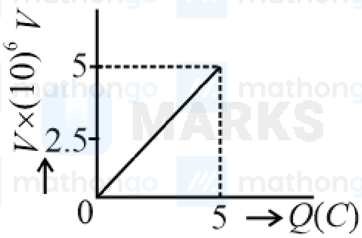


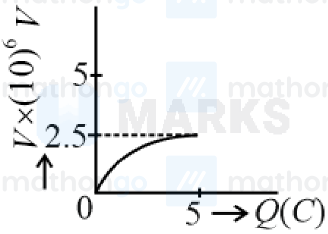
Q292. Capacitance, 2022 (25 Jul Shift 1)

A condenser of 2 μF capacitance is charged steadily from 0 to 5 C. Which of the following graph represents correctly the variation of potential difference(V) across its plates with respect to the charge (Q) on the condenser?

(1)


(2)


(3)


(4)


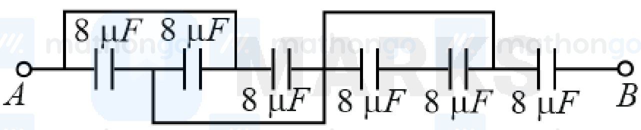
Q293. Capacitance, 2022 (27 Jun Shift 1)

A force of 10 N acts on a charged particle placed between two plates of a charged capacitor. If one plate of capacitor is removed, then the force acting on that particle will be.

(1) 5 N
(2) 10 N
(3) 20 N
(4) Zero

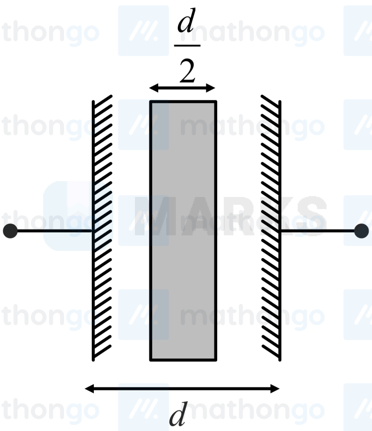
Q294. Capacitance, 2022 (25 Jun Shift 1)

The equivalent capacitance between points A and B in below shown figure will be _____ μF.



Q295. Capacitance, 2022 (25 Jun Shift 2)

Two metallic plates form a parallel plate capacitor. The distance between the plate is 'd'. A metal sheet of thickness $\frac{d}{2}$ and of area equal to area of each plate is introduced between the plates. What will be the ratio of the new capacitance to the original capacitance of the capacitor?



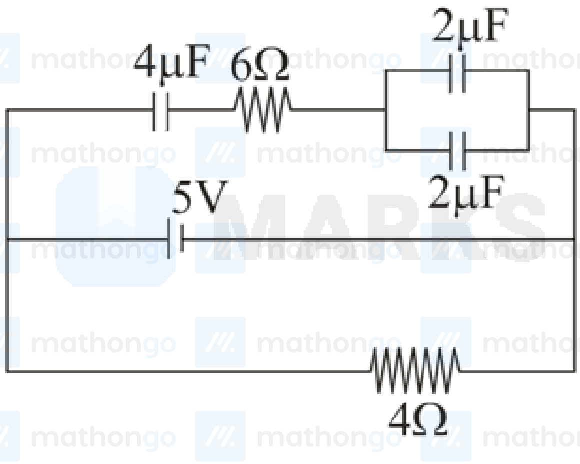
(1) 1 : 2
(2) 2 : 1
(3) 1 : 4
(4) 4 : 1

Q296. Capacitance, 2021 (01 Sep Shift 2)

A capacitor is connected to a 20 V battery through a resistance of 10Ω. It is found that the potential difference across the capacitor rises to 2 V in 1 μs. The capacitance of the capacitor is ________μF.
Given In $\left(\frac{10}{9}\right) = 0.105$
(1) 0.95
(2) 9.52
(3) 1.85
(4) 0.105

Q297. Capacitance, 2021 (27 Aug Shift 1)

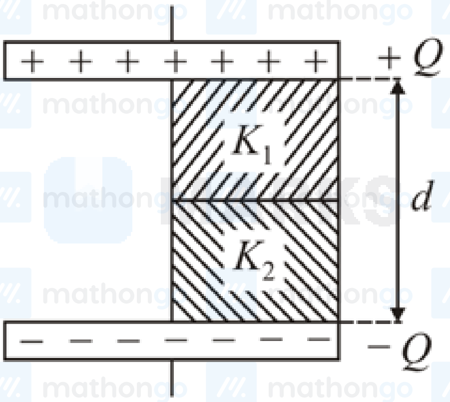
Calculate the amount of charge on capacitor of 4 μF. The internal resistance of battery is 1Ω :



(1) 4 μC
(2) 8 μC
(3) 16 μC
(4) zero

Q298. Capacitance, 2021 (26 Aug Shift 2)

A parallel-plate capacitor with plate area A has separation d between the plates. Two dielectric slabs of dielectric constant K_1 and K_2 of same area $\frac{A}{2}$ and thickness $\frac{d}{2}$ are inserted in the space between the plates. The capacitance of the capacitor will be given by :



(1) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1 K_2}{K_1+K_2}\right)$
(2) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{2(K_1+K_2)}{K_1 K_2}\right)$
(3) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1+K_2}{K_1 K_2}\right)$
(4) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1 K_2}{2(K_1+K_2)}\right)$

Q299. Capacitance, 2021 (25 Jul Shift 1)

A parallel plate capacitor with plate area 'A' and distance of separation 'd' is filled with a dielectric. What is the capacity of the capacitor when permittivity of the dielectric varies as:

$\varepsilon(x)=\varepsilon_0+kx$, for $\left(0<x\leq\frac{d}{2}\right)$

$\varepsilon(x)=\varepsilon_0+k(d-x)$, for $\left(\frac{d}{2}\leq x\leq d\right)$

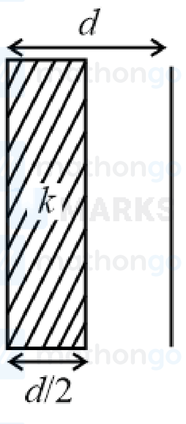
(1) $\left(\varepsilon_0+\frac{kd}{2}\right)^{2/kA}$
(2) $\frac{kA}{2ln\left(\frac{2\varepsilon_0+kd}{2\varepsilon_0}\right)}$
(3) 0
(4) $\frac{kA}{2}\ln\left(\frac{2\varepsilon_0}{2\varepsilon_0-kd}\right)$

Q300. Capacitance, 2021 (16 Mar Shift 2)

In a parallel plate capacitor set up, the plate area of capacitor is $2\ \mathrm{m}^2$ and the plates are separated by $1\ \mathrm{m}$. If the space between the plates are filled with a dielectric material of thickness $0.5\ \mathrm{m}$ and are $2\ \mathrm{m}^2$ (see figure) the capacitance of the set-up will be ε_0 ________.

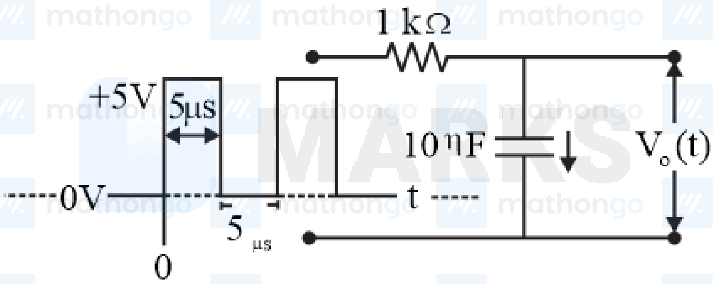
(Dielectric constant of the material $=3.2$)

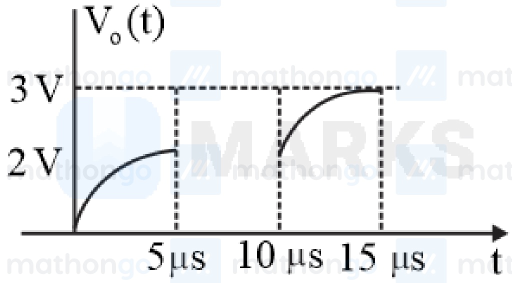
(Round off to the Nearest Integer)

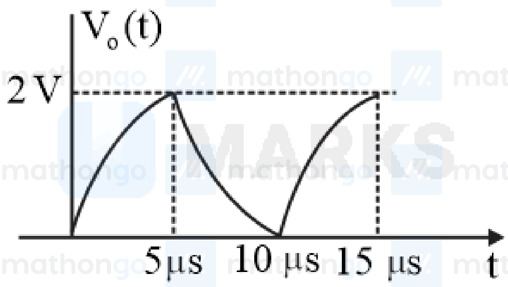


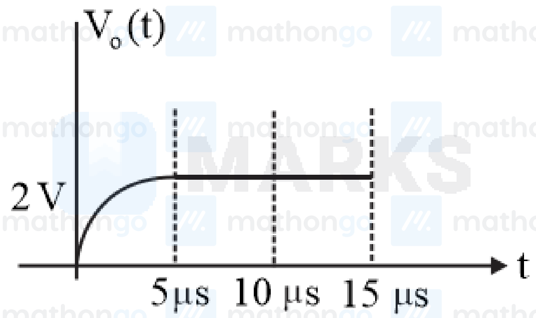
Q301. Capacitance, 2020 (06 Sep Shift 1)

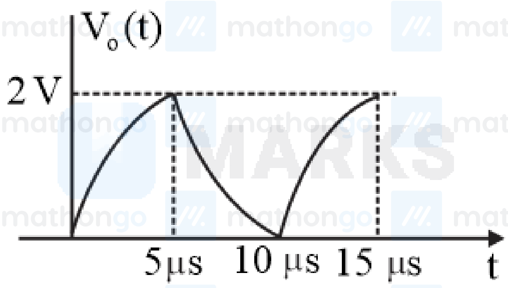
For the given input voltage waveform $\mathrm{V_{in}}(\mathrm{t})$, the output voltage waveform $\mathrm{V_0}(\mathrm{t})$, across the capacitor is correctly depicted by :



(1)


(2)


(3)


(4)


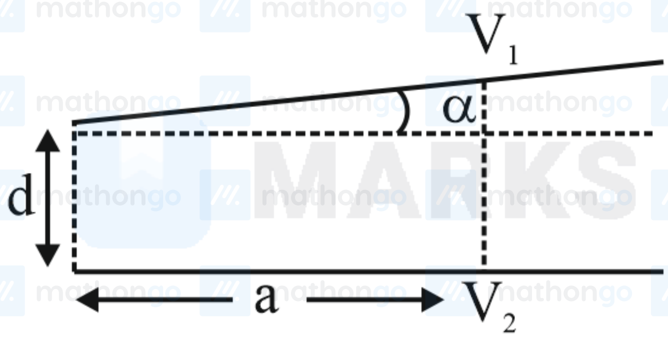
Q302. Capacitance, 2020 (05 Sep Shift 2)

A parallel plate capacitor has plate of length l, width w and separation of plates is d. It is connected to a battery of emf V. A dielectric slab of the same thickness d and of dielectric constant $K=4$ is being inserted between the plates of the capacitor. At what length of the slab inside plates, will the energy stored in the capacitor be two times the initial energy stored?

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

Q303. Capacitance, 2020 (08 Jan Shift 2)

A capacitor is made of two square plates each of side ' a ' making a very small angle α between them, as shown in figure. The capacitance will be close to:



(1) $\frac{\epsilon_0 a^2}{d}\left(1-\frac{\alpha a}{2d}\right)$
(2) $\frac{\epsilon_0 a^2}{d}\left(1-\frac{\alpha a}{4d}\right)$
(3) $\frac{\epsilon_0 a^2}{d}\left(1+\frac{\alpha a}{d}\right)$
(4) $\frac{\epsilon_0 a^2}{d}\left(1-\frac{3\alpha a}{2d}\right)$

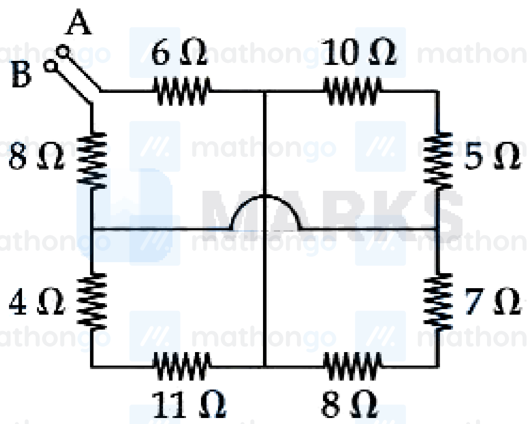
Chapter: Current Electricity

Q304. Current Electricity, 2024 (09 Apr Shift 1)

A galvanmeter has a coil of resistance 200Ω with a full scale deflection at 20μA. The value of resistance to be added to use it as an ammeter of range $(0-20)$mA is ;

(1) 0.40Ω
(2) 0.20Ω
(3) 0.50Ω
(4) 0.10Ω

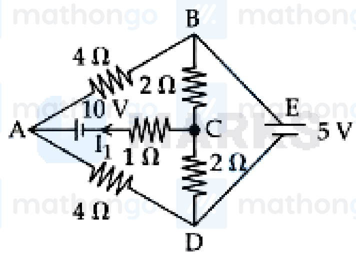
Q305. Current Electricity, 2024 (09 Apr Shift 1)



The equivalent resistance between A and B is :

(1) 18Ω
(2) 19Ω
(3) 25Ω
(4) 27Ω

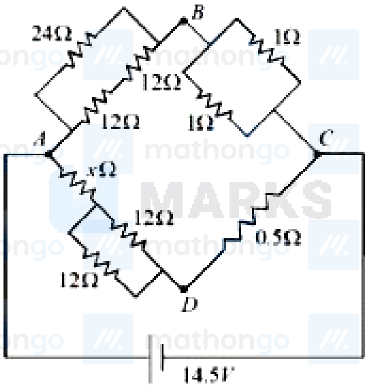
Q306. Current Electricity, 2024 (09 Apr Shift 1)



The current flowing through the 1Ω resistor is $\frac{n}{10}$ A. The value of n is __________

Q307. Current Electricity, 2024 (06 Apr Shift 1)

The value of unknown resistance (x) for which the potential difference between B and D will be zero in the arrangement

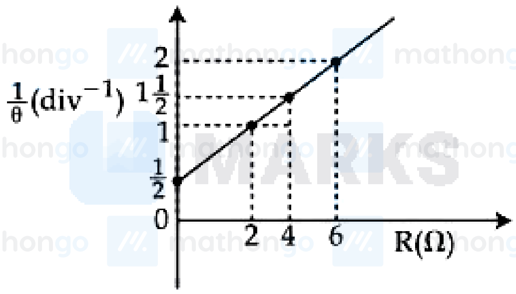


shown, is :

(1) 3Ω
(2) 42Ω
(3) 9Ω
(4) 6Ω

Q308. Current Electricity, 2024 (05 Apr Shift 1)

In the experiment to determine the galvanometer resistance by half-deflection method, the plot of $1/\theta$ vs the resistance (R) of the resistance box is shown in the figure. The figure of merit of the galvanometer is _____ $\times 10^{-1}$ A/ division. [The source has



emf 2V]

Q309. Current Electricity, 2024 (05 Apr Shift 2)

A galvanometer of resistance 100Ω when connected in series with 400Ω measures a voltage of upto 10 V. The value of resistance required to convert the galvanometer into ammeter to read upto 10 A is $x \times 10^{-2}\Omega$. The value of x is :

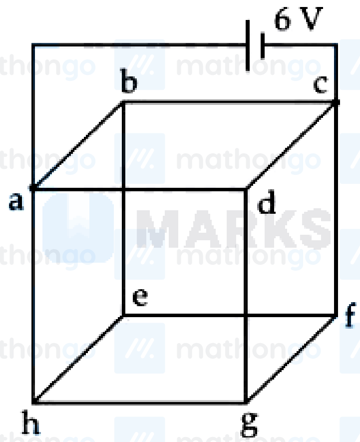
(1) 2
(2) 800
(3) 20
(4) 200

Q310. Current Electricity, 2024 (05 Apr Shift 2)

A wire of resistance 20Ω is divided into 10 equal parts, resulting pairs. A combination of two parts are connected in parallel and so on. Now resulting pairs of parallel combination are connected in series. The equivalent resistance of final combination is _____ Ω.

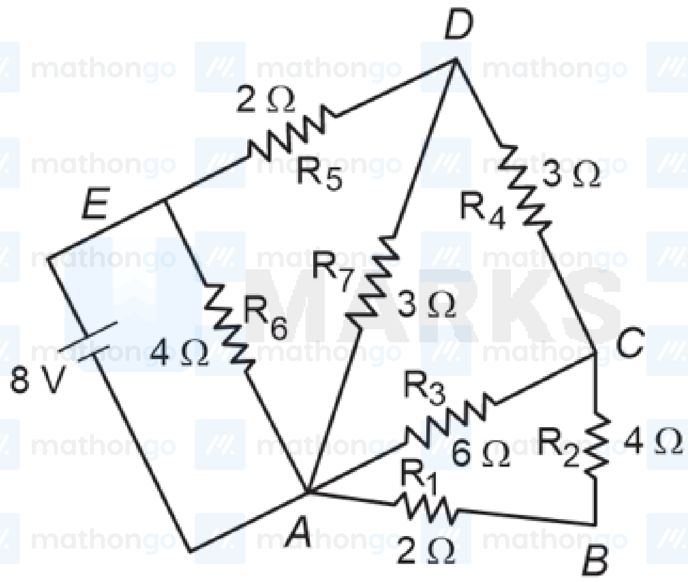
Q311. Current Electricity, 2024 (04 Apr Shift 1)

Twelve wires each having resistance 2Ω are joined to form a cube. A battery of 6 V emf is joined across point a and c. The



voltage difference between e and f is _______V.

Q312. Current Electricity, 2023 (11 Apr Shift 2)



The current flowing through R_2 is :

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

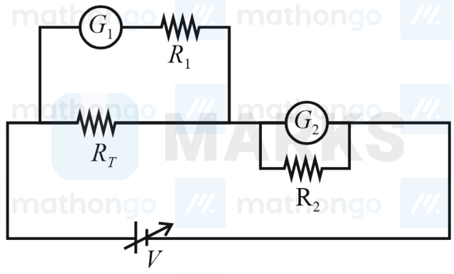
(2) $\frac{1}{2}$ A

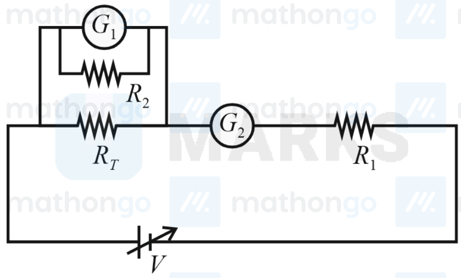
(3) $\frac{1}{3}$ A

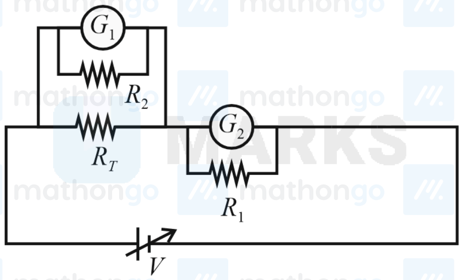
(4) $\frac{1}{4}$ A

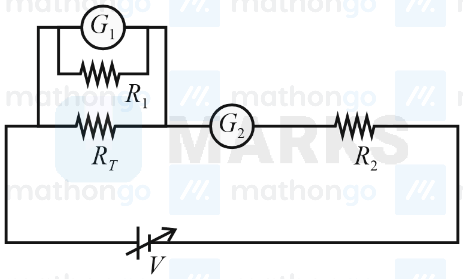
Q313. Current Electricity, 2023 (06 Apr Shift 2)

A student is provided with a variable voltage source V, a test resistor $R_T = 10\Omega$, two identical galvanometers G_1 and G_2 and two additional resistors, $R_1 = 10M\Omega$ and $R_2 = 0.001\Omega$. For conducting an experiment to verify ohm's law, the most suitable circuit is:

(1) 

(2) 

(3) 

(4) 

Q314. Current Electricity, 2022 (28 Jul Shift 2)

Given below are two statements :

Statement I : A uniform wire of resistance 80 Ω is cut into four equal parts. These parts are now connected in parallel. The equivalent resistance of the combination will be 5 Ω.

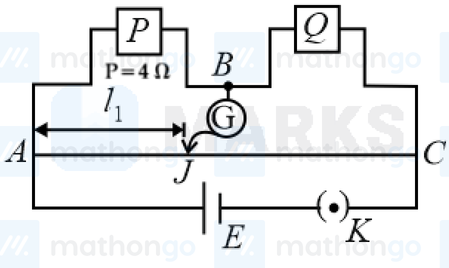
Statement II : Two resistance $2R$ and $3R$ are connected in parallel in an electric circuit. The value of thermal energy developed in $3R$ and $2R$ will be in the ratio 3 : 2.

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

(1) Both statement I and statement II are correct
(2) Both statement I and statement II are incorrect
(3) Statement I is correct but statement II is incorrect
(4) Statement I is incorrect but statement II is correct.

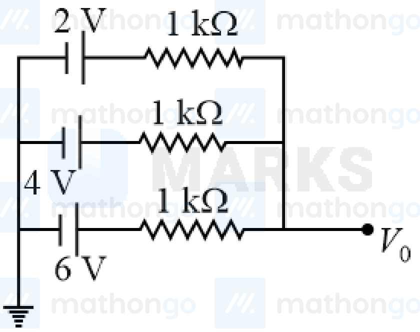
Q315. Current Electricity, 2022 (26 Jul Shift 1)

Resistance are connected in a meter bridge circuit as shown in the figure. The balancing length l_1 is 40 cm. Now an unknown resistance x is connected in series with P and new balancing length is found to be 80 cm measured from the same end. Then the value of x will be _____ Ω.



Q316. Current Electricity, 2022 (25 Jul Shift 1)

In the given figure, the value of V_0 will be _____ V.



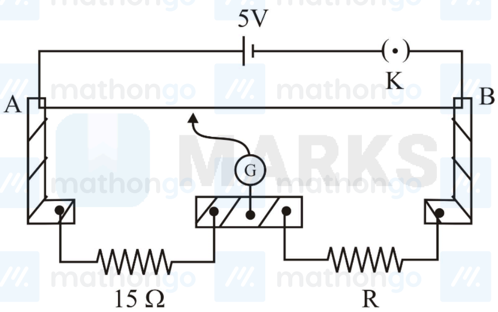
Q317. Current Electricity, 2022 (29 Jun Shift 2)

The combination of two identical cells, whether connected in series or parallel combination provides the same current through an external resistance of $2\ \Omega$. The value of internal resistance of each cell is

(1) $2\ \Omega$
(2) $4\ \Omega$
(3) $6\ \Omega$
(4) $8\ \Omega$

Q318. Current Electricity, 2022 (28 Jun Shift 1)

A meter bridge setup is shown in the figure. It is used to determine an unknown resistance R using a given resistor of $15\ \Omega$. The galvanometer (G) shows null defection when tapping key is at $43\ \mathrm{cm}$ mark from end A. If the end correction for end A is $2\ \mathrm{cm}$, then the determined value of R will be Ω.



Q319. Current Electricity, 2022 (27 Jun Shift 1)

The current density in a cylindrical wire of radius $4\ \mathrm{mm}$ is $4 \times 10^6\ \mathrm{A\ m^{-2}}$. The current through the outer portion of the wire between radial distances $\frac{R}{2}$ and R is _____ π A.

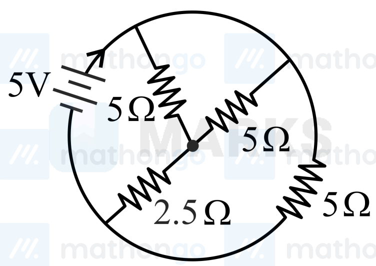
Q320. Current Electricity, 2022 (26 Jun Shift 1)

An aluminium wire is stretched to make its length, 0.4% larger. The percentage change in resistance is

(1) 0.4%
(2) 0.2%
(3) 0.8%
(4) 0.6%

Q321. Current Electricity, 2022 (25 Jun Shift 1)

The total current supplied to the circuit as shown in figure by the 5 V battery is _____ A.

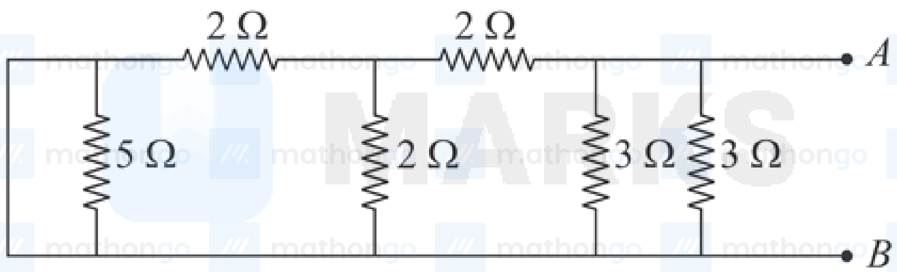


Q322. Current Electricity, 2021 (31 Aug Shift 1)

A square-shaped wire with a resistance of each side $3\ \Omega$ is bent to form a complete circle. The resistance between two diametrically opposite points of the circle in a unit of Ω will is, ______.

Q323. Current Electricity, 2021 (31 Aug Shift 2)

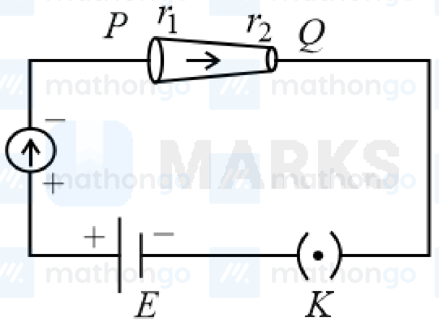
The equivalent resistance of the given circuit between the terminals A and B is :



(1) $0\ \Omega$
(2) $\frac{9}{2}\ \Omega$
(3) $3\ \Omega$
(4) $1\ \Omega$

Q324. Current Electricity, 2021 (27 Jul Shift 1)

In the given figure, a battery of emf E is connected across a conductor PQ of length l and different area of cross-sections having radii r_1 and $r_2 (r_2 < r_1)$.

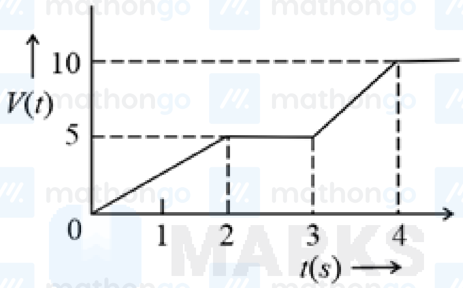


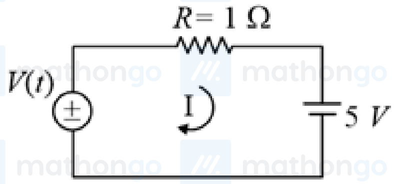
Choose the correct option as one moves from P to Q.

(1) Drift velocity of electron increases.
(2) Electric field decreases.
(3) Electron current decreases.
(4) All of these

Q325. Current Electricity, 2021 (27 Jul Shift 2)

For the circuit shown, the value of current at time $t = 3.2$ s will be ______ A.



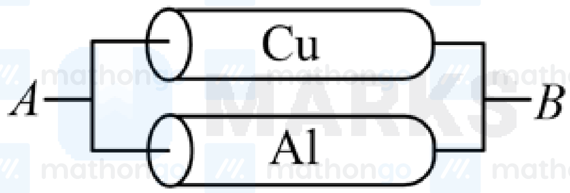


[Voltage distribution $\mathrm{V(t)}$ is shown by Fig. (1) and the circuit is shown in Fig. (2)]

Q326. Current Electricity, 2021 (22 Jul Shift 1)

A Copper (Cu) rod of length $25\ \mathrm{cm}$ and cross-sectional area $3\ \mathrm{mm}^2$ is joined with a similar Aluminium (Al) rod as shown in figure. Find the resistance of the combination between the ends A and B.

(Take resistivity of Copper $= 1.7 \times 10^{-8}\ \Omega\mathrm{m}$, Resistivity of aluminium $= 2.6 \times 10^{-8}\ \Omega\mathrm{m}$)



(1) $2.170\ \mathrm{m}\Omega$
(2) $1.420\ \mathrm{m}\Omega$
(3) $0.0858\ \mathrm{m}\Omega$
(4) $0.858\ \mathrm{m}\Omega$

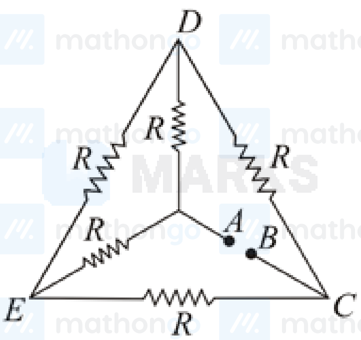
Q327. Current Electricity, 2021 (18 Mar Shift 1)

In the experiment of Ohm's law, a potential difference of $5.0\ \mathrm{V}$ is applied across the end of a conductor of length $10.0\ \mathrm{cm}$ and diameter of $5.00\ \mathrm{mm}$. The measured current in the conductor is $2.00\ \mathrm{A}$. The maximum permissible percentage error in the resistivity of the conductor is :-

(1) 3.9
(2) 8.4
(3) 7.5
(4) 3.0

Q328. Current Electricity, 2021 (26 Feb Shift 1)

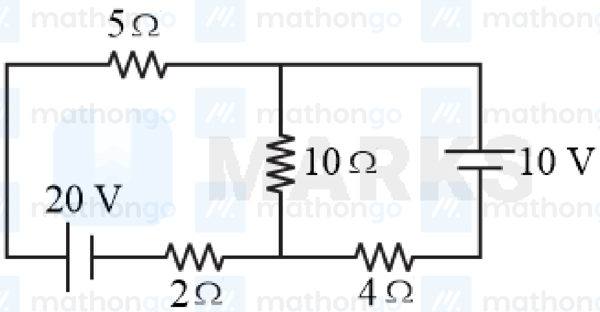
Five equal resistances are connected in a network as shown in figure. The net resistance between the points A and B is :



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

Q329. Current Electricity, 2020 (06 Sep Shift 2)

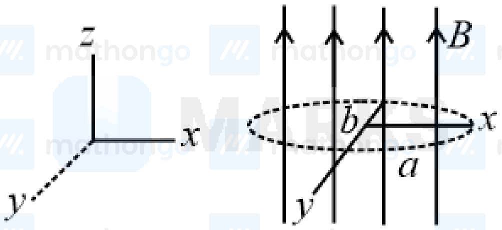
In the figure shown, the current in the 10 V battery is close to :



(1) 0.71 A from positive to negative terminal
(2) 0.42 A from positive to negative terminal
(3) 0.21 A from positive to negative terminal
(4) 0.36 A from negative to postive terminal

Q330. Current Electricity, 2020 (03 Sep Shift 1)

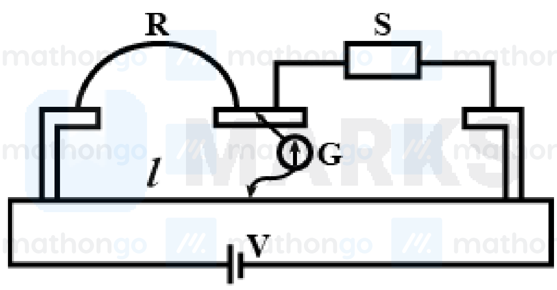
An elliptical loop having resistance R, of semi major axis a , and semi minor axis b is placed in a magnetic field as shown in the figure. If the loop is rotated about the x-axis with angular frequency ω, the average power loss in the loop due to Joule heating is :



(1) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$
(2) zero
(3) $\frac{\pi \mathrm{bB} \omega}{\mathrm{R}}$
(4) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{R}$

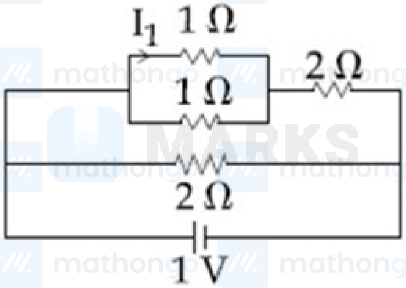
Q331. Current Electricity, 2020 (09 Jan Shift 2)

In a meter bridge experiment S is a standard resistance. R is a resistance wire. It is found that balancing length is $l = 25$cm. If R is replaced by a wire of hall length and half diameter that of R of same material, then the balancing distance l' (in cm) will now be ______________.



Q332. Current Electricity, 2020 (07 Jan Shift 1)

The current I_1 (in A) flowing through 1Ω resistor in the following circuit is:



(1) 0.4
(2) 0.5
(3) 0.2
(4) 0.25

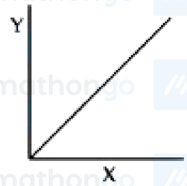
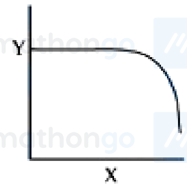
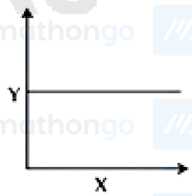
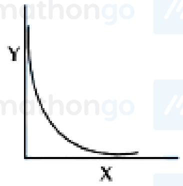
Chapter: Magnetic Properties of Matter

Q333. Magnetic Properties of Matter, 2024 (08 Apr Shift 2)

The coercivity of a magnet is $5 \times 10^3\ \mathrm{A/m}$. The amount of current required to be passed in a solenoid of length 30 cm and the number of turns 150 , so that the magnet gets demagnetised when inside the solenoid is _____A.

Q334. Magnetic Properties of Matter, 2024 (06 Apr Shift 2)

Match List-I with List-II :

List-I Y vs X		List-II Shape of Graph
(A) Y = magnetic susceptibility X = magnetising field	(I)	
(B) Y = magnetic field X = distance from centre of a current carrying wire for $x < a$ (where a = radius of wire)	(II)	
(C) Y = magnetic field X = distance from centre of a current carrying wire for $x > a$ (where a = radius of wire)	(III)	
(D) Y = magnetic field inside solenoid X = distance from centre	(IV)	

Choose the correct answer from the options given below :

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

Q335. Magnetic Properties of Matter, 2023 (10 Apr Shift 1)

The current required to be passed through a solenoid of 15 cm length and 60 turns in order to demagnetise a bar magnet of magnetic intensity 2.4×10^3 A m^{-1} is ________ A.

Q336. Magnetic Properties of Matter, 2023 (10 Apr Shift 2)

Given below are two statements:

Statement I: For diamagnetic substance $-1 \leq x < 0$, where x is the magnetic susceptibility.

Statement II: Diamagnetic substance when placed in an external magnetic field, tend to move from stronger to weaker part of the field. In the light of the above statements, choose the correct answer from the options give below.

(1) Both **Statement I** and **Statement II** are False
(2) **Statement I** is correct but **Statement II** is false
(3) **Statement I** is incorrect but **Statement II** is true
(4) Both **Statement I** and **Statement II** are true

Q337. Magnetic Properties of Matter, 2022 (25 Jul Shift 2)

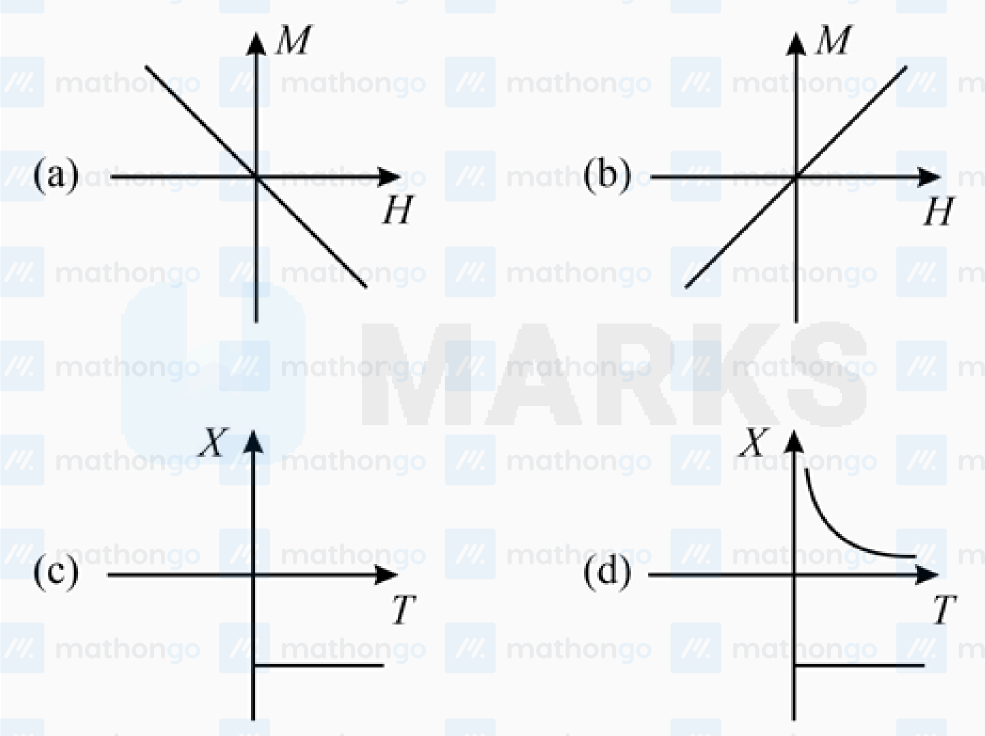
An electron with energy $0.1\,\text{keV}$ moves at right angle to the earth's magnetic field of $1 \times 10^{-4}\,\text{Wbm}^{-2}$. The frequency of revolution of the electron will be

(Take mass of electron $= 9.0 \times 10^{-31}$ kg)

(1) 1.6×10^5 Hz
(2) 5.6×10^5 Hz
(3) 2.8×10^6 Hz
(4) 1.8×10^6 Hz

Q338. Magnetic Properties of Matter, 2021 (01 Sep Shift 2)

Following plots show Magnetization (M) vs Magnetising field (H) and Magnetic susceptibility (χ) vs Temperature (T) graph :



Which of the following combination will be represented by a diamagnetic material?

(1) (b), (c)
(2) (b), (d)
(3) (a), (d)
(4) (a), (c)

Q339. Magnetic Properties of Matter, 2021 (18 Mar Shift 2)

Which of the following statements are correct?

(A) Electric monopoles do not exist whereas magnetic monopoles exist.

(B) Magnetic field lines due to a solenoid at its ends and outside cannot be completely straight and confined.

(C) Magnetic field lines are completely confined within a toroid.

(D) Magnetic field lines inside a bar magnet are not parallel.

(E) $\chi = -1$ is the condition for a perfect diamagnetic material, where χ is its magnetic susceptibility.

Choose the correct answer from the options given below :

(1) (C) and (E) only
(2) (B) and (D) only
(3) (A) and (B) only
(4) (B) and (C) only

Q340. Magnetic Properties of Matter, 2020 (03 Sep Shift 2)

A perfectly diamagnetic sphere has a small spherical cavity at its centre, which is filled with a paramagnetic substance. The whole system is placed in a uniform magnetic field $\overrightarrow{\mathrm{B}}$. Then the field inside the paramagnetic substance is:

(1) $\overrightarrow{\mathrm{B}}$
(2) Zero
(3) much large than $|\overrightarrow{\mathrm{B}}|$ and parallel to $\overrightarrow{\mathrm{B}}$
(4) much large than $|\overrightarrow{\mathrm{B}}|$ but opposite to $\overrightarrow{\mathrm{B}}$

Chapter: Magnetic Effects of Current

Q341. Magnetic Effects of Current, 2024 (09 Apr Shift 2)

A straight magnetic strip has a magnetic moment of $44 \mathrm{Am}^2$. If the strip is bent in a semicircular shape, its magnetic moment will be ______ Am^2. (given $\pi = \frac{22}{7}$)

Q342. Magnetic Effects of Current, 2024 (06 Apr Shift 1)

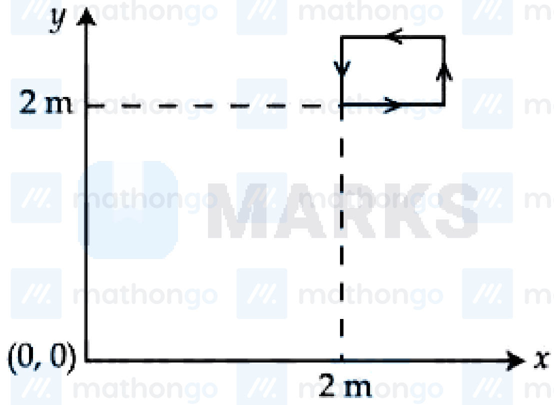
A circular coil having 200 turns, $2.5 \times 10^{-4}\ \mathrm{m}^2$ area and carrying $100 \mu\mathrm{A}$ current is placed in a uniform magnetic field of $1\mathrm{T}$. Initially the magnetic dipole moment $(\vec{M})$ was directed along $\vec{B}$. Amount of work, required to rotate the coil through 90° from its initial orientation such that $\vec{M}$ becomes perpendicular to $\vec{B}$, is ______ $\mu\mathrm{J}$.

Q343. Magnetic Effects of Current, 2024 (05 Apr Shift 2)

A solenoid of length 0.5 m has a radius of 1 cm and is made up of ' m ' number of turns. It carries a current of 5 A. If the magnitude of the magnetic field inside the solenoid is 6.28×10^{-3} T then the value of m is _____.

Q344. Magnetic Effects of Current, 2024 (04 Apr Shift 1)

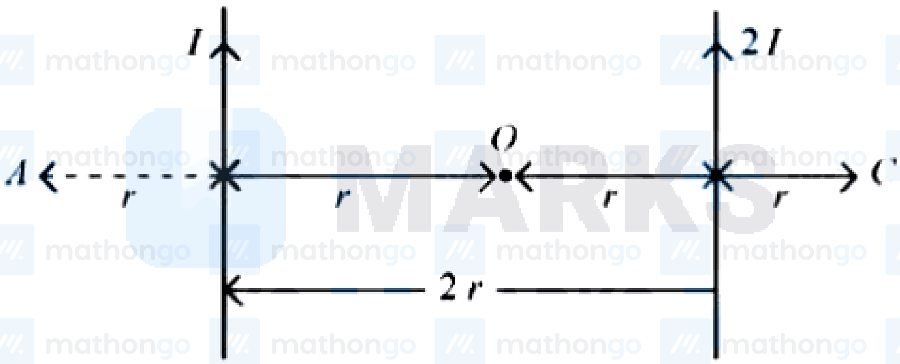
The magnetic field existing in a region is given by $\vec{B} = 0.2(1 + 2x)\hat{k}$ T. A square loop of edge 50 cm carrying 0.5 A current is placed in $x - y$ plane with its edges parallel to the $x - y$ axes, as shown in figure. The magnitude of the net magnetic force



experienced by the loop is_____ mN.

Q345. Magnetic Effects of Current, 2024 (04 Apr Shift 2)

Two parallel long current carrying wire separated by a distance $2r$ are shown in the figure. The ratio of magnetic field at A to the magnetic field produced at C is $\frac{x}{7}$. The value of x is_____

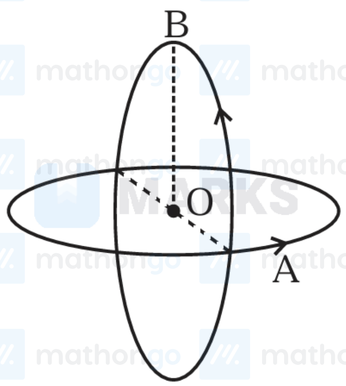


Q346. Magnetic Effects of Current, 2024 (01 Feb Shift 1)

A regular polygon of 6 sides is formed by bending a wire of length 4 π meter. If an electric current of $4\pi\sqrt{3}$ A is flowing through the sides of the polygon, the magnetic field at the centre of the polygon would be $x \times 10^{-7}$ T. The value of x is ______.

Q347. Magnetic Effects of Current, 2024 (30 Jan Shift 1)

Two insulated circular loop A and B radius a carrying a current of I in the anti clockwise direction as shown in figure. The magnitude of the magnetic induction at the centre will be:



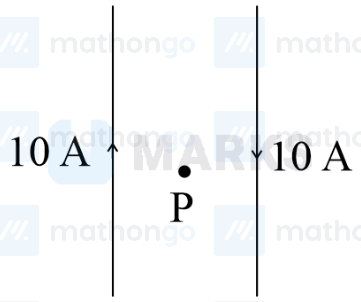
(1) $\frac{\sqrt{2}\mu_0 I}{a}$
(2) $\frac{\mu_0 I}{2a}$
(3) $\frac{\mu_0 I}{\sqrt{2}a}$
(4) $\frac{2\mu_0 I}{a}$

Q348. Magnetic Effects of Current, 2024 (29 Jan Shift 1)

The magnetic potential due to a magnetic dipole at a point on its axis situated at a distance of 20 cm from its center is 1.5×10^{-5} T m. The magnetic moment of the dipole is ________ A m^2. (Given : $\frac{\mu_0}{4\pi} = 10^{-7}$ T m A^{-1})

Q349. Magnetic Effects of Current, 2024 (27 Jan Shift 1)

Two long, straight wires carry equal currents in opposite directions as shown in figure. The separation between the wires is 5.0 cm. The magnitude of the magnetic field at a point P midway between the wires is _____ μT. (Given: $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1})



Q350. Magnetic Effects of Current, 2024 (27 Jan Shift 1)

A proton moving with a constant velocity passes through a region of space without any change in its velocity. If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic fields respectively, then the region of space may have :

(A) $E = 0, B = 0$; (B) $E = 0, B \neq 0$; (C) $E \neq 0, B = 0$; (D) $E \neq 0, B \neq 0$

Choose the most appropriate answer from the options given below :

(1) (A), (B) and (C) only
(2) (A), (C) and (D) only
(3) (A), (B) and (D) only
(4) (B), (C) and (D) only

Q351. Magnetic Effects of Current, 2023 (06 Apr Shift 1)

A long straight wire of circular cross-section (radius a) is carrying steady current I. The current I is uniformly distributed across this cross-section. The magnetic field is

(1) inversely proportional to r in the region $r < a$ and uniform throughout in the region $r > a$
(2) directly proportional to r in the region $r < a$ and inversely proportional to r in the region $r > a$
(3) Zero in the region $r < a$ and inversely proportional to r in the region $r > a$
(4) uniform in the region $r < a$ and inversely proportional to distance r from the axis, in the region $r > a$

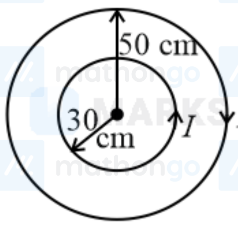
Q352. Magnetic Effects of Current, 2023 (25 Jan Shift 2)

For a moving coil galvanometer, the deflection in the coil is 0.05 rad when a current of 10 mA is passed through it. If the torsional constant of suspension wire is 4.0×10^{-5} N m rad^{-1}, the magnetic field is 0.01 T and the number of turns in the coil is 200, the area of each turn (in cm^2) is :

(1) 2.0
(2) 1.0
(3) 1.5
(4) 0.5

Q353. Magnetic Effects of Current, 2022 (26 Jul Shift 2)

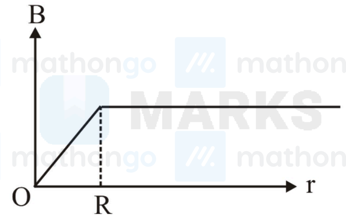
Two concentric circular loops of radii $r_1 = 30$ cm and $r_2 = 50$ cm are placed in $X - Y$ plane as shown in the figure. A current $I = 7$ A is flowing through them in the direction as shown in figure. The net magnetic moment of this system of two circular loops is approximately

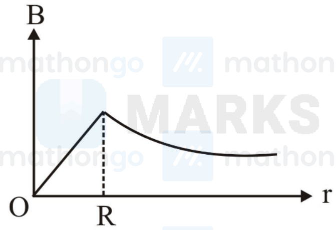


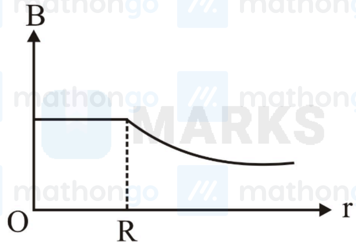
(1) $\frac{7}{2}\widehat{k}$ A m^2
(2) $-\frac{7}{2}\widehat{k}$ A m^2
(3) $7\widehat{k}$ A m^2
(4) $-7\widehat{k}$ A m^2

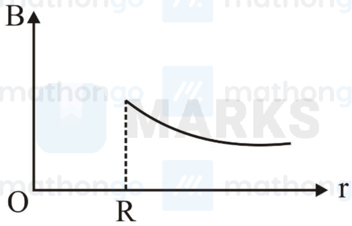
Q354. Magnetic Effects of Current, 2022 (28 Jun Shift 1)

An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface.
Choose the correct representation of magnetic field (B)as a function of radial distance (r) from the axis of cylinder.

(1)


(2)


(3)


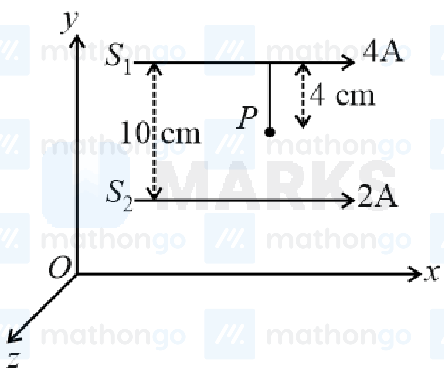
(4)


Q355. Magnetic Effects of Current, 2022 (27 Jun Shift 2)

Two long parallel conductors S_1 and S_2 are separated by a distance 10 cm and carrying currents of 4 A and 2 A respectively. The conductors are placed along x-axis in $X-Y$ plane. There is a point P located between the conductors (as shown in figure).

A charge particle of 3π coulomb is passing through the point P with velocity $\vec{v}=\left(2\hat{i}+3\hat{j}\right)$ m s^{-1}; where $\hat{i}$ & $\hat{j}$ represents unit vector along x & $y$axis respectively.

The force acting on the charge particle is $4\pi\times10^{-5}\left(-x\hat{i}+2\hat{j}\right)$ N. The value of x is



(1) 2
(2) 1
(3) 3
(4) -3

Q356. Magnetic Effects of Current, 2022 (27 Jun Shift 2)

A deuteron and a proton moving with equal kinetic energy enter into to a uniform magnetic field at right angle to the field. If r_d and r_p are the radii of their circular paths respectively, then the ratio $\frac{r_d}{r_p}$ will be $\sqrt{x}:1$ where x is ______ .

Q357. Magnetic Effects of Current, 2022 (26 Jun Shift 1)

A proton and an alpha particle of the same velocity enter in a uniform magnetic field which is acting perpendicular to their direction of motion. The ratio of the radii of the circular paths described by the alpha particle and proton is

(1) 4 : 1
(2) 2 : 1
(3) 1 : 2
(4) 1 : 4

Q358. Magnetic Effects of Current, 2021 (31 Aug Shift 1)

A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. Find the magnetic field at centre, when a current I passes through coil :

(1) $\frac{\mu_0 I}{8}\left[\frac{a+b}{a-b}\right]$
(2) $\frac{\mu_0 \mathrm{I}}{4(\mathrm{a}-\mathrm{b})}\left[\frac{1}{\mathrm{a}}-\frac{1}{\mathrm{b}}\right]$
(3) $\frac{\mu_0 I}{8}\left(\frac{a-b}{a+b}\right)$
(4) $\frac{\mu_0 I N}{2(b-a)}\log_e\left(\frac{b}{a}\right)$

Q359. Magnetic Effects of Current, 2021 (31 Aug Shift 2)

A long solenoid with $1000 \text{ turns } \mathrm{m}^{-1}$ has a core material with relative permeability 500 and volume 10^3 cm^3. If the core material is replaced by another material having relative permeability of 750 with same volume maintaining same current of 0.75 A in the solenoid, the fractional change in the magnetic moment of the core would be approximately $\left(\frac{x}{499}\right)$. Find the value of x.

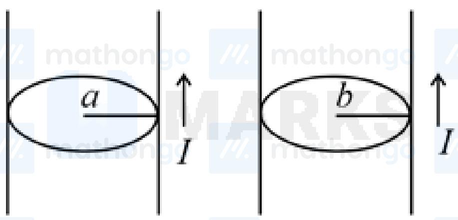
Q360. Magnetic Effects of Current, 2021 (26 Aug Shift 1)

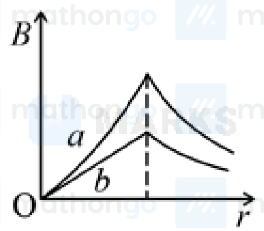
The fractional change in the magnetic field intensity at a distance r from centre on the axis of current carrying coil of radius a to the magnetic field intensity at the centre of the same coil is: (Take $\mathrm{r}<\mathrm{a}$)

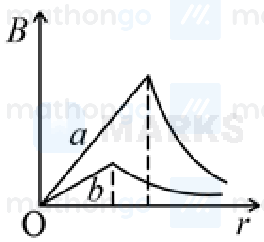
(1) $\frac{2}{3}\frac{a^2}{r^2}$
(2) $\frac{3}{2}\frac{a^2}{r^2}$
(3) $\frac{3}{2}\frac{r^2}{a^2}$
(4) $\frac{2}{3}\frac{r^2}{a^2}$

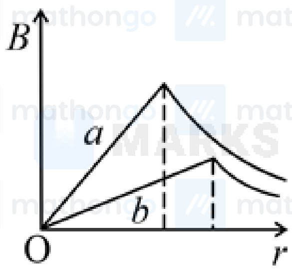
Q361. Magnetic Effects of Current, 2021 (27 Jul Shift 2)

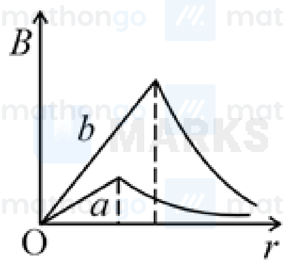
Figure A and B shown two long straight wires of circular cross-section (a and b with $a<b$), carrying current I which is uniformly distributed across the cross-section. The magnitude of magnetic field B varies with radius r and can be represented as:



(1)


(2)


(3)


(4)


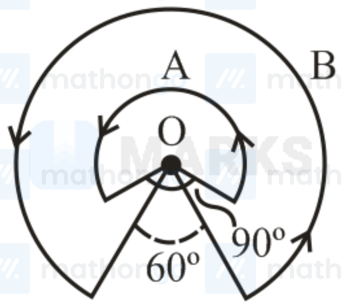
Q362. Magnetic Effects of Current, 2020 (05 Sep Shift 1)

A square loop of side $2a$, and carrying current I is kept in XZ plane with its centre at origin. A long wire carrying the same current I is placed parallel to the z-axis and passing through the point $(0,\ b,\ 0),(b>>\ a)$. The magnitude of the torque on the loop about z-axis is given by.

(1) $\frac{\mu_0 I^2 a^2}{2\pi b}$
(2) $\frac{\mu_0 I^2 a^3}{2\pi b^2}$
(3) $\frac{2\mu_0 I^2 a^2}{\pi b}$
(4) $\frac{2\mu_0 I^2 a^3}{\pi b^2}$

Q363. Magnetic Effects of Current, 2020 (04 Sep Shift 1)

A wire A, bent in the shape of an arc of a circle, carrying a current of 2 A and having radius 2 cm and another wire B, also bent in the shape of an arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is:



(1) 4 : 6
(2) 6 : 4
(3) 2 : 5
(4) 6 : 5

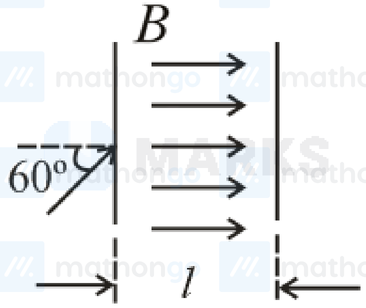
Q364. Magnetic Effects of Current, 2020 (02 Sep Shift 1)

A beam of protons with speed $4\times10^5\ \mathrm{m\ s^{-1}}$ enters a uniform magnetic field of $0.3\ \mathrm{T}$ at an angle 60° to the magnetic field, the pitch of the resulting helical path of protons is close to : (Mass of the proton$=1.67\times10^{-27}\ \mathrm{kg}$, charge of the proton $=1.69\times10^{-19}\mathrm{C}$)

(1) 2 cm
(2) 5 cm
(3) 12 cm
(4) 4 cm

Q365. Magnetic Effects of Current, 2020 (02 Sep Shift 2)

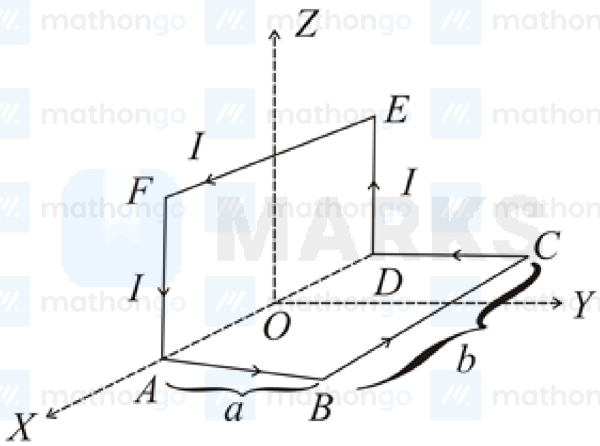
The figure shows a region of length 'ℓ' with a uniform magnetic field of $0.3\ \mathrm{T}$ in it and a proton entering the region with velocity $4 \times 10^5\ \mathrm{m\,s^{-1}}$ making an angle 60° with the field. If the proton completes 10 revolution by the time it cross the region shown, 'ℓ' is close to (mass of proton $= 1.67 \times 10^{-27}$ kg, charge of the proton$= 1.6 \times 10^{-19}$ C)



(1) $0.11\ \mathrm{m}$
(2) $0.88\ \mathrm{m}$
(3) $0.44\ \mathrm{m}$
(4) $0.22\ \mathrm{m}$

Q366. Magnetic Effects of Current, 2020 (02 Sep Shift 2)

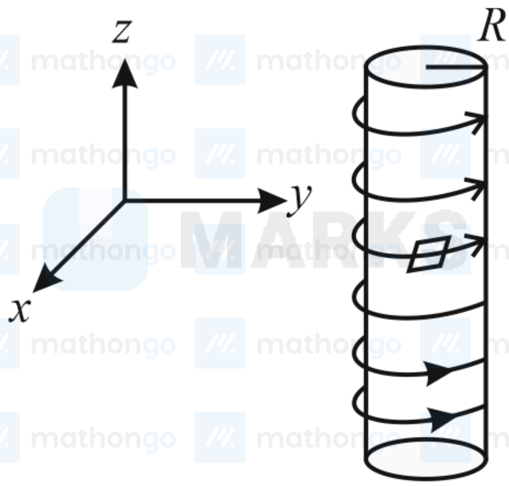
A wire carrying current I is bent in the shapeABCDEFA as shown, where rectangle ABCDA and ADEFA are perpendicular to each other. If the sides of the rectangles are of lengths a and b, then the magnitude and direction of magnetic moment of the loop ABCDEFA is :



(1) $\sqrt{2}abI$ along $\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$
(2) abI along $\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$
(3) $\sqrt{2}abI$ along $\left(\frac{\hat{j}}{\sqrt{5}} + \frac{2\hat{k}}{\sqrt{5}}\right)$
(4) abI along $\left(\frac{\hat{j}}{\sqrt{5}} + \frac{\hat{k}}{\sqrt{5}}\right)$

Q367. Magnetic Effects of Current, 2020 (09 Jan Shift 2)

An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current I. The electron gun shoots an electron along the radius of the solenoid with speed v. If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning):



(1) $\frac{e\mu_0 nIR}{m}$
(2) $\frac{e\mu_0 nIR}{2m}$
(3) $\frac{e\mu_0 nIR}{4m}$
(4) $\frac{2e\mu_0 nIR}{m}$

Q368. Magnetic Effects of Current, 2020 (07 Jan Shift 1)

A long solenoid of radius R carries a time (t) dependent current $I(t) = I_0 t(1-t)$. A ring of radius $2R$ is placed coaxially near its middle. During the time interval $0 \leq t \leq 1$, the induced current (I_R) and the induced $EMF(V_R)$ in the ring change as:

(1) Direction of I_R remains unchanged and V_R is maximum at $t = 0.5$
(2) At $t = 0.25$ direction of I_R reverses and V_R is maximum
(3) Direction of I_R remains unchanged and V_R is zero at $t = 0.25$
(4) At $t = 0.5$ direction of I_R reverses and V_R is zero

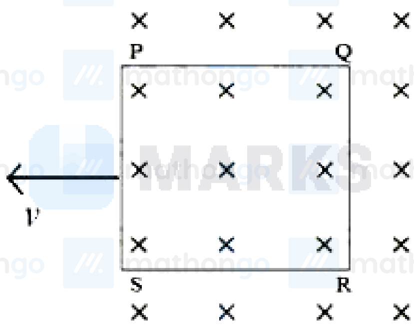
Chapter: Electromagnetic Induction

Q369. Electromagnetic Induction, 2024 (09 Apr Shift 1)

When a coil is connected across a 20 V dc supply, it draws a current of 5 A. When it is connected across 20 V, 50 Hz ac supply, it draws a current of 4 A. The self inductance of the coil is ______ mH. (Take $\pi = 3$)

Q370. Electromagnetic Induction, 2024 (08 Apr Shift 1)

A square loop PQRS having 10 turns, area 3.6×10^{-3} m^2 and resistance 100Ω is slowly and uniformly being pulled out of a uniform magnetic field of magnitude B $= 0.5$ T as shown. Work done in pulling the loop out of the field in 1.0 s is ______



$\times 10^{-6}$ J.

Q371. Electromagnetic Induction, 2024 (04 Apr Shift 2)

A rod of length 60 cm rotates with a uniform angular velocity $20 \mathrm{rads}^{-1}$ about its perpendicular bisector, in a uniform magnetic filed $0.5 T$. The direction of magnetic field is parallel to the axis of rotation. The potential difference between the two ends of the rod is _____ V.

Q372. Electromagnetic Induction, 2024 (01 Feb Shift 1)

A rectangular loop of sides $12\ \mathrm{cm}$ and $5\ \mathrm{cm}$, with its sides parallel to the x-axis and y-axis respectively moves with a velocity of $5\ \mathrm{cm}\ \mathrm{s}^{-1}$ in the positive x axis direction, in a space containing a variable magnetic field in the positive z direction. The field has a gradient of $10^{-3}\ \mathrm{T}\ \mathrm{cm}^{-1}$ along the negative x direction and it is decreasing with time at the rate of $10^{-3}\ \mathrm{T}\ \mathrm{s}^{-1}$. If the resistance of the loop is $6\ \mathrm{m}\Omega$, the power dissipated by the loop as heat is ______ $\times 10^{-9}$ W.

Q373. Electromagnetic Induction, 2024 (31 Jan Shift 1)

A small square loop of wire of side l is placed inside a large square loop of wire of side $L\left(L=l^2\right)$. The loops are coplanar and their centers coincide. The value of the mutual inductance of the system is $\sqrt{x} \times 10^{-7}$ H, where $x=$______.

Q374. Electromagnetic Induction, 2024 (29 Jan Shift 1)

A square loop of side $10\ \mathrm{cm}$ and resistance $0.7\ \Omega$ is placed vertically in the east-west plane. A uniform magnetic field of $0.20\ \mathrm{T}$ is set up across the plane in the north-east direction. The magnetic field is decreased to zero in 1 s at a steady rate. Then, the magnitude of induced emf is $\sqrt{x} \times 10^{-3}$ V. The value of x is _______.

Q375. Electromagnetic Induction, 2024 (27 Jan Shift 1)

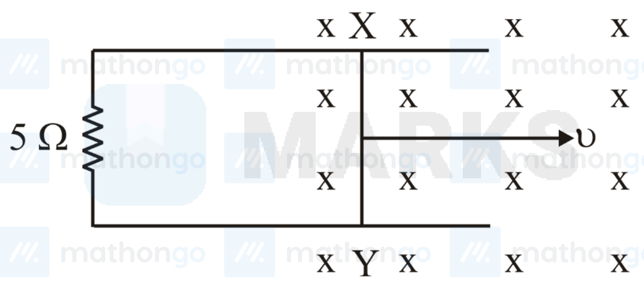
Two coils have mutual inductance 0.002 H. The current changes in the first coil according to the relation $i=i_0 sin\omega t$, where $i_0=5$ A and $\omega=50\pi$ rad s^{-1}. The maximum value of emf in the second coil is $\frac{\pi}{\alpha}$ V. The value of α is

Q376. Electromagnetic Induction, 2023 (13 Apr Shift 2)

An insulated copper wire of 100 turns is wrapped around a wooden cylindrical core of the cross-sectional area $24\ \mathrm{cm}^2$. The two ends of the wire are connected to a resistor. The total resistance in the circuit is $12\ \Omega$. If an externally applied uniform magnetic field in the core along its axis changes from 1.5 T in one direction to 1.5 T in the opposite direction, the charge flowing through a point in the circuit during the change of magnetic field will be _____ mC.

Q377. Electromagnetic Induction, 2023 (10 Apr Shift 1)

A 1 m long metal rod XY completes the circuit as shown in figure. The plane of the circuit is perpendicular to the magnetic field of flux density 0.15 T. If the resistance of the circuit is $5\ \Omega$, the force needed to move the rod in direction, as indicated, with a constant speed of $4\ \mathrm{m}\ \mathrm{s}^{-1}$ will be _______ 10^{-3} N.



Q378. Electromagnetic Induction, 2023 (06 Apr Shift 1)

The induced emf can be produced in a coil by

A. moving the coil with uniform speed inside uniform magnetic field

B. moving the coil with non uniform speed inside uniform magnetic field

C. rotating the coil inside the uniform magnetic field

D. changing the area of the coil inside the uniform magnetic field

Choose the correct answer from the options given below:

(1) B and C only
(2) A and C only
(3) C and D only
(4) B and D only

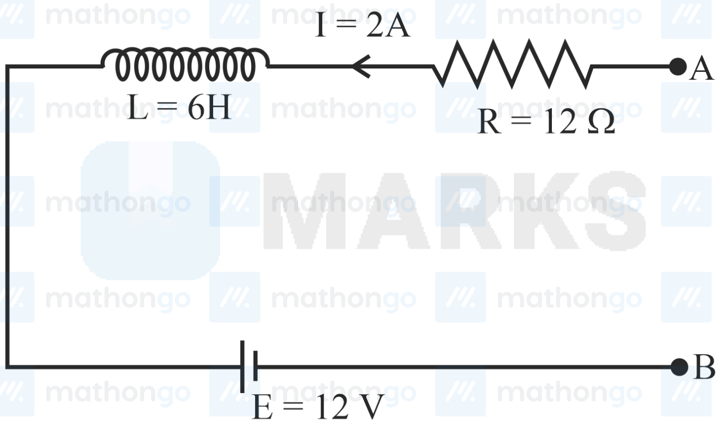
Q379. Electromagnetic Induction, 2023 (06 Apr Shift 1)

For the plane electromagnetic wave given by $E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$, the ratio of average electric energy density to average magnetic energy density is

(1) $\frac{1}{2}$
(2) 2
(3) 4
(4) 1

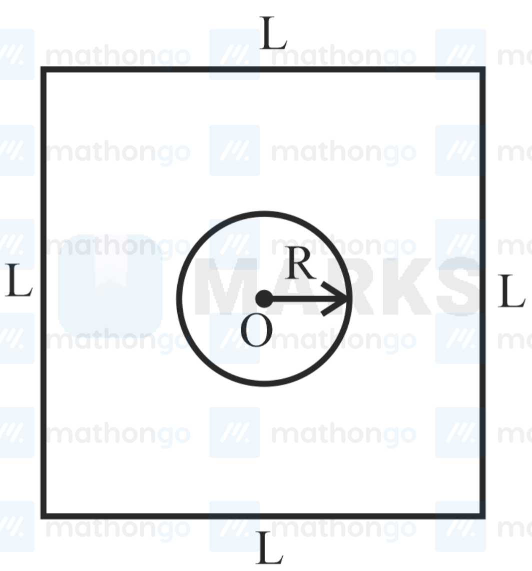
Q380. Electromagnetic Induction, 2023 (30 Jan Shift 1)

As per the given figure, if $\frac{dI}{dt} = -1 \text{ A s}^{-1}$, then the value of V_{AB} at this instant will be ______ V.



Q381. Electromagnetic Induction, 2023 (29 Jan Shift 1)

Find the mutual inductance in the arrangement, when a small circular loop of wire of radius R is placed inside a large square loop of wire of side $L (L \gg R)$. The loops are coplanar and their centres coincide :



(1) $M = \frac{\sqrt{2}\mu_0 R^2}{L}$
(2) $M = \frac{2\sqrt{2}\mu_0 R}{L^2}$
(3) $M = \frac{2\sqrt{2}\mu_0 R^2}{L}$
(4) $M = \frac{\sqrt{2}\mu_0 R}{L^2}$

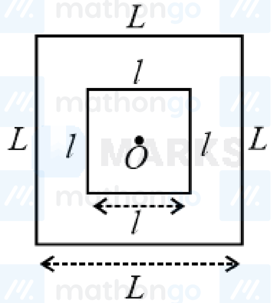
Q382. Electromagnetic Induction, 2022 (26 Jul Shift 1)

In a series LR circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. The ratio $\frac{P_1}{P_2}$ is

(1) $\frac{1}{2}$
(2) $\frac{1}{\sqrt{2}}$
(3) $\frac{\sqrt{3}}{\sqrt{2}}$
(4) 2 : 1

Q383. Electromagnetic Induction, 2022 (25 Jul Shift 1)

A small square loop of wire of side l is placed inside a large square loop of wire $L (L \gg l)$. Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is



(1) $\frac{2\sqrt{2}\mu_0 L^2}{\pi l}$
(2) $\frac{\mu_0 l^2}{2\sqrt{2}\pi L}$
(3) $\frac{\mu_0 L^2}{2\sqrt{2}\pi l}$
(4) $\frac{2\sqrt{2}\mu_0 l^2}{\pi L}$

Q384. Electromagnetic Induction, 2022 (26 Jun Shift 2)

Two coils of self inductance L_1 and L_2 are connected in series combination having mutual inductance of the coils as M. The equivalent self inductance of the combination will be

(1) $\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{M}$
(2) $L_1 + L_2 - 2M$
(3) $L_1 + L_2 + M$
(4) $L_1 + L_2 + 2M$

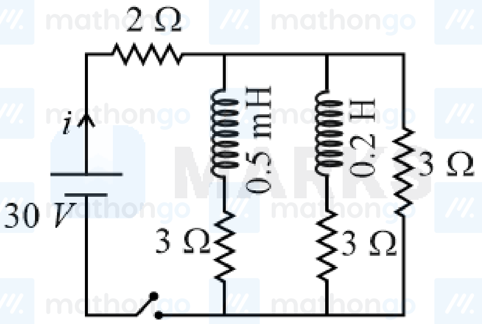
Q385. Electromagnetic Induction, 2022 (26 Jun Shift 2)

A metallic conductor of length $1 \mathrm{~m}$ rotates in a vertical plane parallel to east-west direction about one of its end with angular velocity $5 \mathrm{~rad~s}^{-1}$. If the horizontal component of earth's magnetic field is 0.2×10^{-4} T, then emf induced between the two ends of the conductor is

(1) $5 \mu V$
(2) $50 \mu \mathrm{V}$
(3) $5 \mathrm{~m} V$
(4) $50 \mathrm{~m} V$

Q386. Electromagnetic Induction, 2021 (01 Sep Shift 2)

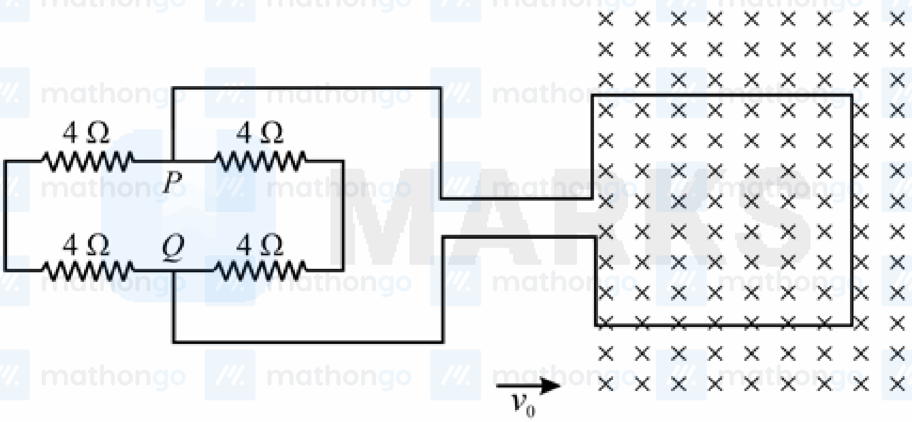
For the given circuit the current i through the battery when the key in closed and the steady state has been reached is



(1) 10 A
(2) 6 A
(3) 25 A
(4) 0 A

Q387. Electromagnetic Induction, 2021 (01 Sep Shift 2)

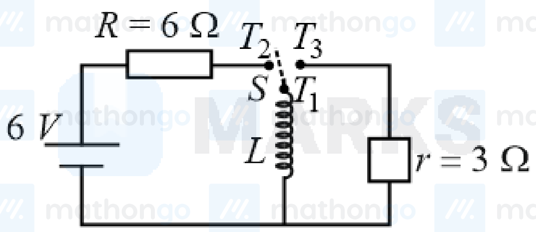
A square loop of side 20 cm and resistance $1\ \Omega$ is moved towards right with a constant speed v_0. The right arm of the loop is in a uniform magnetic field of $5\ \mathrm{T}$. The field is perpendicular to the plane of the loop and is going into it. The loop is connected to a network of resistors each of value 4Ω. What should be the value of v_0 so that a steady current of $2\ \mathrm{mA}$ flows in the loop ?



(1) $10^{-2}\ \mathrm{cm\ s^{-1}}$
(2) $1\ \mathrm{m\ s^{-1}}$
(3) $1\ \mathrm{cm\ s^{-1}}$
(4) $10^2\ \mathrm{m\ s^{-1}}$

Q388. Electromagnetic Induction, 2021 (27 Jul Shift 1)

Consider an electrical circuit containing a two way switch S. Initially S is open and then T_1 is connected to T_2. As the current in $R = 6\ \Omega$ attains a maximum value of steady-state level, T_1 is disconnected from T_2 and immediately connected to T_3. Potential drop across $r = 3\ \Omega$ resistor immediately after T_1 is connected to T_3 is ______V. (Round off to the Nearest Integer)



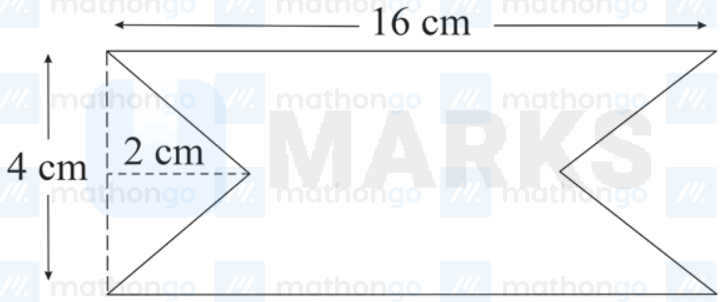
Q389. Electromagnetic Induction, 2020 (05 Sep Shift 1)

Two concentric circular coils, C_1 and C_2, are placed in the XY plane. C_1 has 500turns, and a radius of 1 cm. C_2 has 200 turns and radius of 20 cm . C_2 carries a time dependent current $I(t) = (5t^2 - 2t + 3)$ A where t is in s. The emf induced in

C_1(in mV) at the instant $t = 1$s is $\frac{4}{x}$. The value of x is ....

Q390. Electromagnetic Induction, 2020 (08 Jan Shift 1)

At time $t = 0$ magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5s, then induced EMF in the loop is:



(1) 56μV
(2) 28μV
(3) 48μV
(4) 36μV

Q391. Electromagnetic Induction, 2020 (07 Jan Shift 1)

A loop ABCDEFA of straight edges has six corner points $A(0,0,0), B(5,0,0), C(5,5,0), D(0,5,0), E(0,5,5)$ and $F(0,0,5)$. The magnetic field in this region is $\vec{B} = \left(3\hat{i} + 4\hat{k}\right)T$. The quantity of flux through the loop ABCDEFA (in Wb) is ____________

Q392. Electromagnetic Induction, 2020 (07 Jan Shift 2)

A planar loop of wire rotates in a uniform magnetic field. Initially, at $t = 0$, the plane of the loop is perpendicular to the magnetic field. If it rotates with a period of 10s about an axis in its plane then the magnitude of induced emf will be maximum and minimum, respectively at:

(1) 2.5 s and 7.5 s
(2) 2.5 s and 5.0 s
(3) 5.0 s and 7.5 s
(4) 5.0 s and 10. 0 s

Chapter: Alternating Current

Q393. Alternating Current, 2024 (09 Apr Shift 2)

A capacitor of reactance $4\sqrt{3}\Omega$ and a resistor of resistance 4Ω are connected in series with an ac source of peak value $8\sqrt{2}$ V. The power dissipation in the circuit is ________ W.

Q394. Alternating Current, 2024 (08 Apr Shift 2)

A coil of negligible resistance is connected in series with 90Ω resistor across 120 V, 60 Hz supply. A voltmeter reads 36 V across resistance. Inductance of the coil is :

(1) 0.286H
(2) 0.76H
(3) 2.86H
(4) 0.91H

Q395. Alternating Current, 2024 (08 Apr Shift 2)

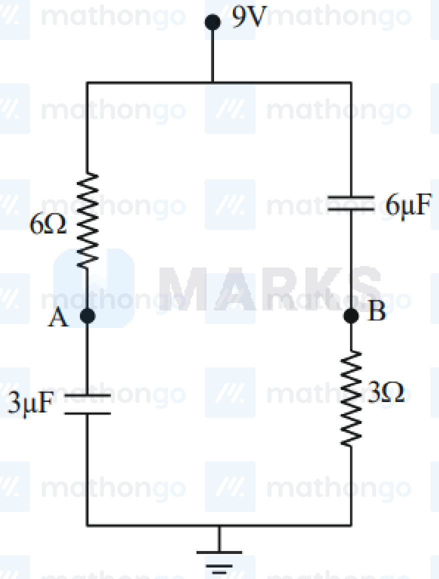
An alternating emf $\mathrm{E} = 110\sqrt{2}\sin 100\mathrm{t}$ volt is applied to a capacitor of $2\mu\mathrm{F}$, the rms value of current in the circuit is _____ mA,

Q396. Alternating Current, 2024 (06 Apr Shift 1)

When a dc voltage of 100 V is applied to an inductor, a dc current of 5 A flows through it. When an ac voltage of 200 V peak value is connected to inductor, its inductive reactance is found to be $20\sqrt{3}\Omega$. The power dissipated in the circuit is _______ W.

Q397. Alternating Current, 2024 (29 Jan Shift 2)

In the given figure, the charge stored in $6 \mu \mathrm{F}$ capacitor, when points A and B are joined by a connecting wire is ________ $\mu \mathrm{C}$.



Q398. Alternating Current, 2024 (27 Jan Shift 2)

The primary side of a transformer is connected to $230 \mathrm{~V}, 50 \mathrm{~Hz}$ supply. The turn ratio of primary to secondary winding is $10 : 1$. Load resistance connected to the secondary side is 46Ω. The power consumed in it is:

(1) $12.5 \mathrm{~W}$
(2) $10.0 \mathrm{~W}$
(3) $11.5 \mathrm{~W}$
(4) $12.0 \mathrm{~W}$

Q399. Alternating Current, 2023 (01 Feb Shift 1)

A series LCR circuit is connected to an ac source of $220 \mathrm{~V}, 50 \mathrm{~Hz}$. The circuit contain a resistance $R=100 \Omega$ and an inductor of inductive reactance $X_L=79.6 \Omega$. The capacitance of the capacitor needed to maximize the average rate at which energy is supplied will be ______ μF.

Q400. Alternating Current, 2023 (30 Jan Shift 1)

In a series LR circuit with $X_L=R$, power factor is P_1. If a capacitor of capacitance C with $X_C=X_L$ is added to the circuit the power factor becomes P_2. The ratio of P_1 to P_2 will be :

(1) 1 : 3
(2) $1 : \sqrt{2}$
(3) 1 : 1
(4) 1 : 2

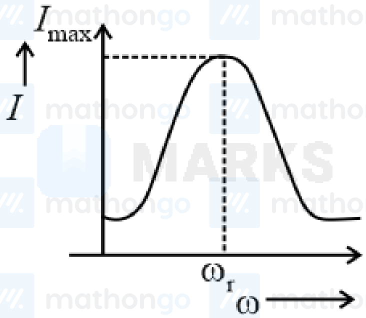
Q401. Alternating Current, 2022 (27 Jul Shift 2)

A series LCR circuit has $L=0.01 \mathrm{H}, R=10 \Omega$ and $C=1 \mu \mathrm{F}$ and it is connected to ac voltage of amplitude (V_m) 50 V. At frequency 60% lower than resonant frequency, the amplitude of current will be approximately

(1) $466 \mathrm{~mA}$
(2) $312 \mathrm{~mA}$
(3) $238 \mathrm{~mA}$
(4) $196 \mathrm{~mA}$

Q402. Alternating Current, 2022 (29 Jun Shift 1)

For a series LCR circuit, I vs ω curve is shown



(a) To the left of ω_r, the circuit is mainly capacitive.
(b) To the left of ω_r, the circuit is mainly inductive.
(c) At ω_r, impedance of the circuit is equal to the resistance of the circuit.
(d) At ω_r, impedance of the circuit is 0.
Choose the most appropriate answer from the options given below.
(1) (a) and (d) only
(2) (b) and (d) only
(3) (a) and (c) only
(4) (b) and (c) only

Q403. Alternating Current, 2022 (28 Jun Shift 1)

A telegraph line of length $100\ \text{km}$ has a capacity of $0.01\ \mu\text{F}\ \text{km}^{-1}$ and it carries an alternating current at 0.5 kilo cycle per second. If minimum impedance is required, then the value of the inductance that needs to be introduced in series is _____ mH. (If $\pi = \sqrt{10}$)

Q404. Alternating Current, 2022 (25 Jun Shift 1)

Match List - I with List - II.

List-I	List-II
(A) AC generator	(I) Detects the presence of current in the circuit
(B) Galvanometer	(II) Converts mechanical energy into electrical energy
(C) Transformer	(III) Works on the principle of resonance in AC circuit
(D) Metal detector	(IV) Changes an alternating voltage for smaller or greater value

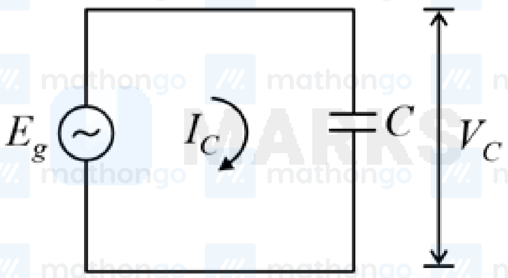
(1) $(\mathrm{A})-(\mathrm{II}),(\mathrm{B})-(\mathrm{I}),(\mathrm{C})-(\mathrm{IV}),(\mathrm{D})-(\mathrm{III})$
(2) $(\mathrm{A})-(\mathrm{II}),(\mathrm{B})-(\mathrm{I}),(\mathrm{C})-(\mathrm{III}),(\mathrm{D})-(\mathrm{IV})$
(3) $(\mathrm{A})-(\mathrm{III}),(\mathrm{B})-(\mathrm{IV}),(\mathrm{C})-(\mathrm{II}),(\mathrm{D})-(\mathrm{I})$
(4) $(\mathrm{A})-(\mathrm{III}),(\mathrm{B})-(\mathrm{I}),(\mathrm{C})-(\mathrm{II}),(\mathrm{D})-(\mathrm{IV})$

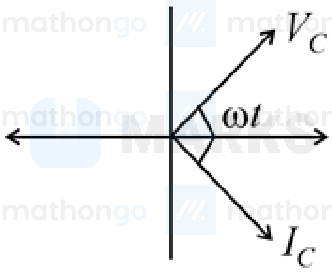
Q405. Alternating Current, 2021 (26 Aug Shift 1)

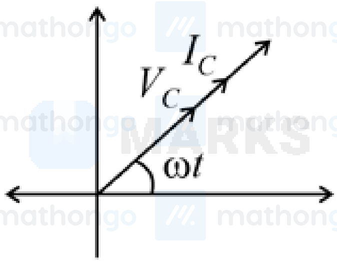
A series LCR circuit driven by 300 V at a frequency of $50\ \text{Hz}$ contains a resistance $\mathrm{R} = 3\ \mathrm{k\Omega}$, an inductor of inductive reactance $\mathrm{X_L} = 250\pi\ \Omega$ and an unknown capacitor. The value of capacitance to maximise the average power should be: $\left(\text{take } \pi^2 = 10\right)$
(1) $400\ \mu\text{F}$
(2) $4\ \mu\text{F}$
(3) $40\ \mu\text{F}$
(4) $25\ \mu\text{F}$

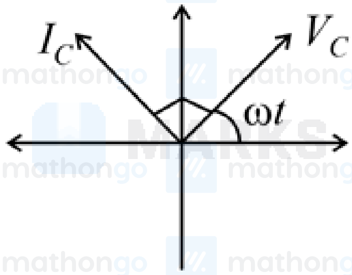
Q406. Alternating Current, 2021 (22 Jul Shift 1)

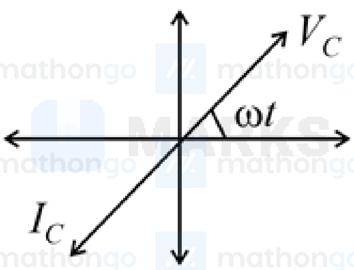
In a circuit consisting of a capacitance and a generator with alternating emf, $E_g = E_{go} sin\omega t$, V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is



(1)


(2)


(3)


(4)


Q407. Alternating Current, 2021 (22 Jul Shift 1)

Match List-I with List-II.

List - I		List - II
(a) $\omega L > \frac{1}{\omega C}$	(i)	Current is in phase with emf
(b) $\omega \mathrm{L} = \frac{1}{\omega \mathrm{C}}$	(ii)	Current lags behind the applied emf
(c) $\omega \mathrm{L} < \frac{1}{\omega \mathrm{C}}$	(iii)	Maximum current occurs
(d) Resonant frequency	(iv)	Current leads the emf

Choose the correct answer from the options given below.

(1) (a) - (ii) ; (b) - (i) ; (c) - (iv) ; (d) - (iii)
(2) (a) - (ii) ; (b) - (i) ; (c) - (iii) ; (d) - (iv)
(3) (a) - (iii) ; (b) - (i) ; (c) - (iv); (d) - (ii)
(4) (a) - (iv) ; (b) - (iii) ; (c) - (ii); (d) - (i)

Q408. Alternating Current, 2020 (07 Jan Shift 1)

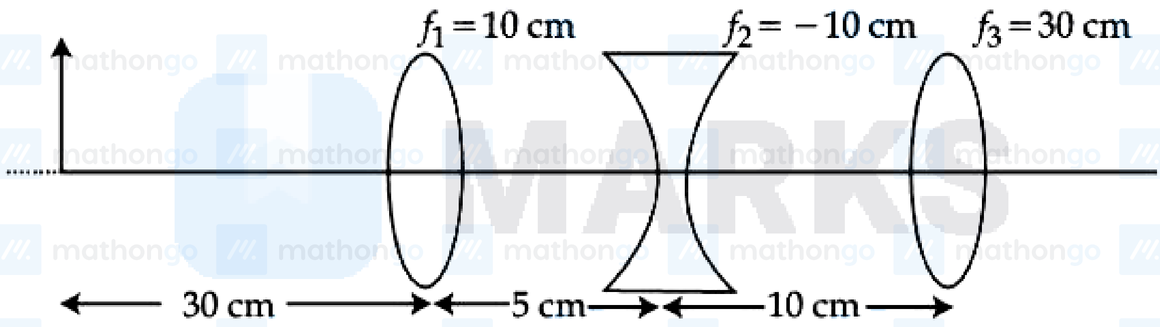
A LCR circuit behaves like a clamped harmonic oscillator. Comparing it with a physical spring-mass damped oscillator having damping constant $'b'$, the correct equivalence would be:

(1) $L \leftrightarrow m, C \leftrightarrow k, R \leftrightarrow b$
(2) $L \leftrightarrow \frac{1}{b}, C \leftrightarrow \frac{1}{m}, R \leftrightarrow \frac{1}{k}$
(3) $L \leftrightarrow k, C \leftrightarrow b, R \leftrightarrow m$
(4) $L \leftrightarrow m, C \leftrightarrow \frac{1}{k}, R \leftrightarrow b$

Chapter: Ray Optics

Q409. Ray Optics, 2024 (08 Apr Shift 2)

The position of the image formed by the combination of lenses is :



(1) 15 cm (right of second lens)
(2) 30 cm (left of third lens)
(3) 15 cm (left of second lens)
(4) 30 cm (right of third lens)

Q410. Ray Optics, 2024 (06 Apr Shift 1)

The refractive index of prism is $\mu = \sqrt{3}$ and the ratio of the angle of minimum deviation to the angle of prism is one. The value of angle of prism is _______.

Q411. Ray Optics, 2024 (06 Apr Shift 2)

In finding out refractive index of glass slab the following observations were made through travelling microscope 50 vernier scale division $= 49$MSD; 20 divisions on main scale in each cm For mark on paper MSR $= 8.45$ cm, VC $= 26$ For mark on paper seen through slab MSR $= 7.12$ cm, $VC = 41$ For powder particle on the top surface of the glass slab MSR $= 4.05$ cm, VC $= 1$ (MSR $=$ Main Scale Reading, VC $=$ Vernier Coincidence) Refractive index of the glass slab is :

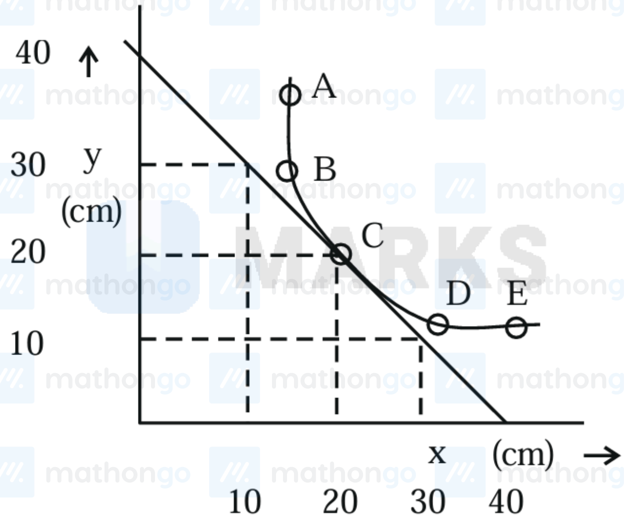
(1) 1.52
(2) 1.35
(3) 1.42
(4) 1.24

Q412. Ray Optics, 2024 (04 Apr Shift 2)

A light ray is incident on a glass slab of thickness $4\sqrt{3}$ cm and refractive index $\sqrt{2}$. The angle of incidence is equal to the critical angle for the glass slab with air. The lateral displacement of ray after passing through glass slab is _____ cm. (Given $\sin 15^\circ = 0.25$)

Q413. Ray Optics, 2024 (30 Jan Shift 2)

In an experiment to measure the focal length (f) of a convex lens, the magnitude of object distance(x) and the image distance (y) are measured with reference to the focal point of the lens. The $y - x$ plot is shown in figure. The focal length of the lens is _____ cm.



Q414. Ray Optics, 2024 (29 Jan Shift 1)

A convex mirror of radius of curvature 30 cm forms an image that is half the size of the object. The object distance is :

(1) -45 cm
(2) 45 cm
(3) -15 cm
(4) 15 cm

Q415. Ray Optics, 2024 (29 Jan Shift 1)

A biconvex lens of refractive index 1.5 has a focal length of 20 cm in air. Its focal length when immersed in a liquid of refractive index 1.6 will be:

(1) -16 cm
(2) -160 cm
(3) $+160$ cm
(4) $+16$ cm

Q416. Ray Optics, 2024 (27 Jan Shift 1)

If the refractive index of the material of a prism is $\cot\left(\frac{A}{2}\right)$, where A is the angle of prism then the angle of minimum deviation will be

(1) $\pi - 2$ A
(2) $\frac{\pi}{2} - 2$ A
(3) $\pi -$ A
(4) $\frac{\pi}{2} -$ A

Q417. Ray Optics, 2023 (12 Apr Shift 1)

An ice cube has a bubble inside. When viewed from one side the apparent distance of the bubble is 12 cm. When viewed from the opposite side, the apparent distance of the bubble is observed as 4 cm. If the side of the ice cube is 24 cm, the refractive index of the ice cube is

(1) $\frac{3}{2}$
(2) $\frac{2}{3}$
(3) $\frac{6}{5}$
(4) $\frac{4}{3}$

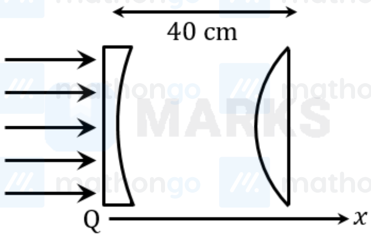
Q418. Ray Optics, 2023 (06 Apr Shift 2)

A 2 meter long scale with least count of 0.2 cm is used to measure the locations of objects on an optical bench. While measuring the focal length of a convex lens, the object pin and the convex lens are placed at 80 cm mark and 1 m mark, respectively. The image of the object pin on the other side of lens coincides with image pin that is kept at 180 cm mark. The $\%$ error in the estimation of focal length is:

(1) 0.85
(2) 1.70
(3) 1.02
(4) 0.51

Q419. Ray Optics, 2023 (24 Jan Shift 1)

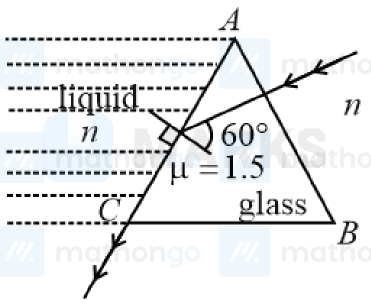
As shown in the figure, a combination of a thin plano-concave lens and a thin plano-convex lens is used to image an object placed at infinity. The radius of curvature of both the lenses is 30 cm and refraction index of the material for both the lenses is 1.75. Both the lenses are placed at distance of 40 cm from each other. Due to the combination, the image of the object is formed at distance x = ______ cm, from concave lens.



Q420. Ray Optics, 2022 (26 Jul Shift 2)

In the given figure, the face AC of the equilateral prism is immersed in a liquid of refractive index n. For incident angle 60° at the side AC, the refracted light beam just grazes along face AC. The refractive index of the liquid $n = \frac{\sqrt{x}}{4}$. The value of x is ______ .

(Given refractive index of glass $= 1.5$)



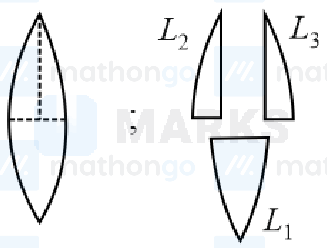
Q421. Ray Optics, 2022 (25 Jul Shift 1)

Time taken by light to travel in two different materials A and B of refractive indices μ_A and μ_B of same thickness is t_1 and t_2 respectively. If $t_2 - t_1 = 5 \times 10^{-10}$s and the ratio of μ_A to μ_B is 1 : 2. Then the thickness of material, in meter is: (Given v_A and v_B are velocities of light in A and B materials respectively).

(1) $5 \times 10^{-10} v_A$ m
(2) 5×10^{-10} m
(3) 1.5×10^{10} m
(4) $5 \times 10^{-10} v_B$ m

Q422. Ray Optics, 2022 (27 Jun Shift 2)

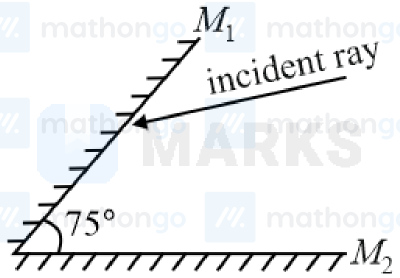
A convex lens has power P. It is cut into two halves along its principal axis. Further one piece (out of the two halves) is cut into two halves perpendicular to the principal axis (as shown in figures). Choose the incorrect option for the reported pieces.



(1) Power of $L_1 = \frac{P}{2}$
(2) Power of $L_2 = \frac{P}{2}$
(3) Power of $L_3 = \frac{P}{2}$
(4) Power of $L_1 = P$

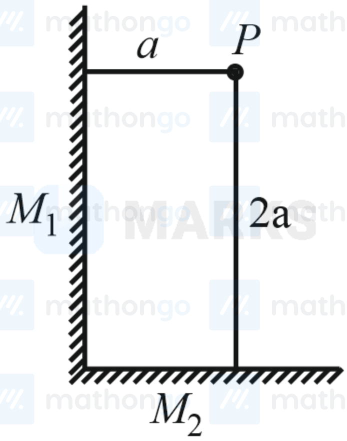
Q423. Ray Optics, 2022 (26 Jun Shift 1)

A light ray is incident, at an incident angle θ_1, on the system of two plane mirrors M_1 and M_2 having an inclination angle 75° between them (as shown in figure). After reflecting from mirror M_1 it gets reflected back by the mirror M_2 with an angle of reflection 30°. The total deviation of the ray will be _____ degree.



Q424. Ray Optics, 2021 (31 Aug Shift 1)

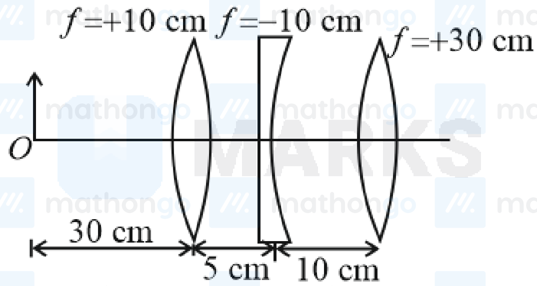
Two plane mirrors M_1 and M_2 are at right angle to each other shown. A point source P is placed at a and $2a$ meter away from M_1 and M_2 respectively. The shortest distance between the images thus formed is : (Take $\sqrt{5}=2.3$)



(1) $2.3\ a$
(2) $2\sqrt{10}a$
(3) $4.6a$
(4) $3a$

Q425. Ray Optics, 2021 (27 Aug Shift 1)

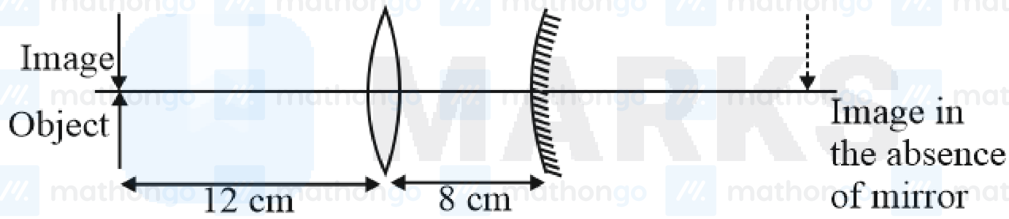
Find the distance of the image from object O, formed by the combination of lenses in the figure:



(1) $75\ \text{cm}$
(2) $10\ \text{cm}$
(3) infinity
(4) $20\ \text{cm}$

Q426. Ray Optics, 2021 (26 Aug Shift 2)

An object is placed at a distance of 12 cm from a convex lens. A convex mirror of focal length 15 cm is placed on another side of the lens at 8 cm as shown in the figure. The image of the object coincides with the object.



When the convex mirror is removed, a real and inverted image is formed at a position. The distance of the image from the object will be ___ cm

Q427. Ray Optics, 2021 (18 Mar Shift 1)

Your friend is having eye sight problem. She is not able to see clearly a distant uniform window mesh and it appears to her as nonuniform and distorted. The doctor diagnosed the problem as :

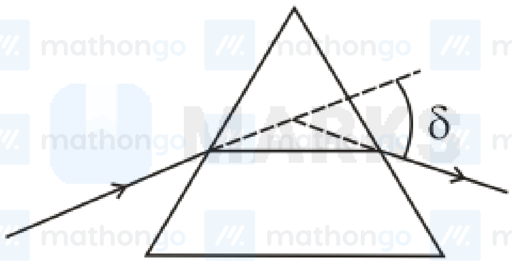
(1) Astigmatism
(2) Myopia with Astigmatism
(3) Presbyopia with Astigmatism
(4) Myopia and hypermetropia

Q428. Ray Optics, 2021 (17 Mar Shift 2)

The image of an object placed in air formed by a convex refracting surface is at a distance of 10 m behind the surface. The image is real and is at $\frac{2^{rd}}{3}$ of the distance of the object from the surface. The wavelength of light inside the surface is $\frac{2}{3}$ times the wavelength in air. The radius of the curved surface is $\frac{x}{13}$ m, the value of x is ______.

Q429. Ray Optics, 2021 (16 Mar Shift 1)

The angle of deviation through a prism is minimum when



(A) Incident ray and emergent ray are symmetric to the prism
(B) The refracted ray inside the prism becomes parallel to its base
(C) Angle of incidence is equal to that of the angle of emergence
(D) When angle of emergence is double the angle of incidence

Choose the correct answer from the options given below :

(1) Statements (A),(B) and (C) are true
(2) Only statement (D) is true
(3) Only statements (A) and (B) are true
(4) Statements (B) and (C) are true

Q430. Ray Optics, 2021 (26 Feb Shift 2)

The incident ray, reflected ray and the outward drawn normal are denoted by the unitvectors $\vec{a}, \vec{b}$ and $\vec{c}$ respectively. Then choose the correct relation for these vectors.

(1) $\overrightarrow{b}=\overrightarrow{a}+2\overrightarrow{c}$

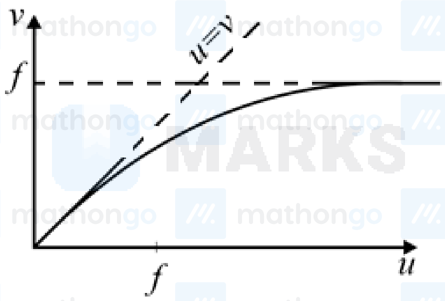
(2) $\overrightarrow{b}=2\overrightarrow{a}+\overrightarrow{c}$

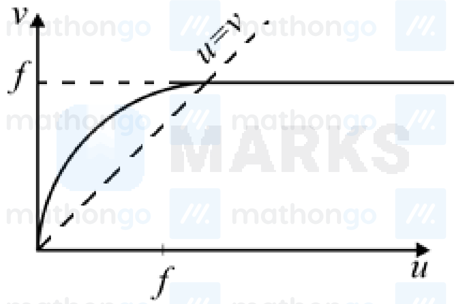
(3) $\overrightarrow{b}=\overrightarrow{a}-2\left(\overrightarrow{a}\cdot\overrightarrow{c}\right)\overrightarrow{c}$

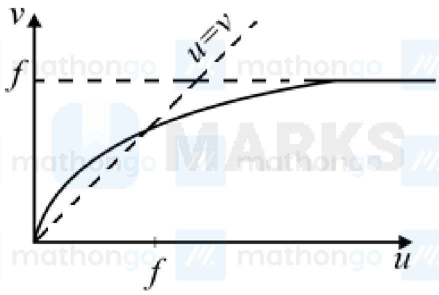
(4) $\overrightarrow{b}=\overrightarrow{a}-\overrightarrow{c}$

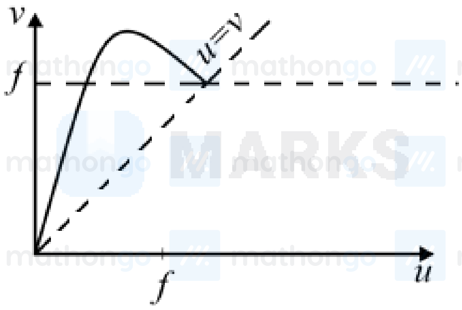
Q431. Ray Optics, 2020 (05 Sep Shift 1)

For a concave lens of focal length f, the relation between object and image distance u and v, respectively, from its pole can best be represented by ($u=v$ is the reference line):

(1)


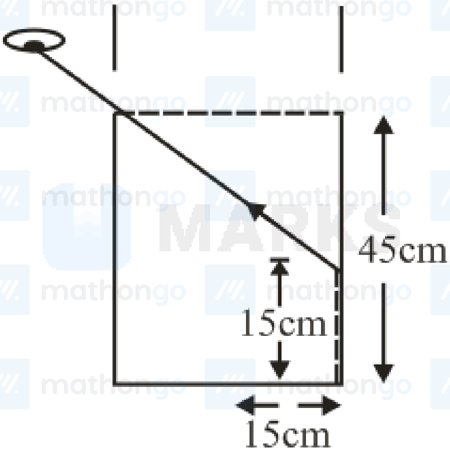
(2)


(3)


(4)


Q432. Ray Optics, 2020 (03 Sep Shift 1)

An observer can see through a small hole on the side of a jar (radius $15\ \mathrm{cm}$) at a point at height of $15\ \mathrm{cm}$ from the bottom (see figure). The hole is at a height of $45\ \mathrm{cm}$. When the jar is filled with a liquid up to a height of $30\ \mathrm{cm}$ the same observer can see the edge at the bottom of the jar. If the refractive index of the liquid is $\frac{\mathrm{N}}{100}$, where N is an integer, the value of N is



Q433. Ray Optics, 2020 (09 Jan Shift 1)

A vessel of depth 2h is half filled with a liquid of refractive index $2\sqrt{2}$ and the upper half with another liquid of refractive index $\sqrt{2}$. The liquids are immiscible. The apparent depth of the inner surface of the bottom of the vessel will be

(1) $\frac{h}{\sqrt{2}}$
(2) $\frac{h}{2(\sqrt{2}+1)}$
(3) $\frac{h}{3\sqrt{2}}$
(4) $\frac{3\sqrt{2}h}{4}$

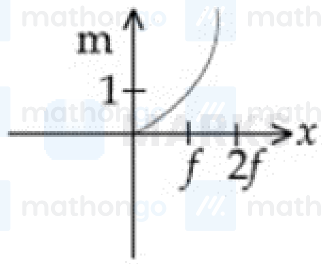
Q434. Ray Optics, 2020 (09 Jan Shift 2)

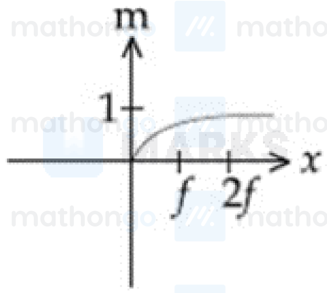
There is a small source of light at some depth below the surface of water (refractive index $=\frac{4}{3}$) in a tank of large cross sectional surface area. Neglecting any reflection from the bottom and absorption by water, percentage of light that emerges out of surface is (nearly):
[Use the fact that surface area of a spherical cap of height h and radius of curvature r is $2\pi rh$]

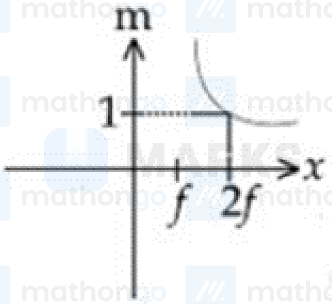
(1) 21%
(2) 34%
(3) 17%
(4) 50%

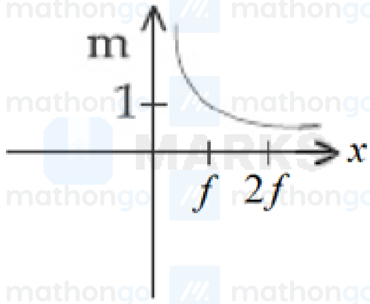
Q435. Ray Optics, 2020 (08 Jan Shift 2)

An object is gradually moving away from the focal point of a concave mirror along the axis of the mirror. The graphical representation of the magnitude of linear magnification (m) versus distance of the object from the mirror (x) is correctly given by
(Graphs are drawn schematically and are not to scale)

(1)


(2)


(3)


(4)


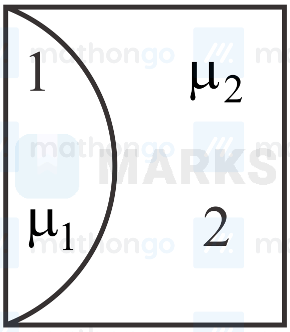
Q436. Ray Optics, 2020 (07 Jan Shift 2)

A thin lens made of glass (refractive index $=1.5$) of focal length $f=16\mathrm{cm}$ is immersed in a liquid of refractive index 1.42 . If its focal length in liquid is f_l , then the ratio f_l/f is closest to the integer:

(1) 1
(2) 9
(3) 5
(4) 17

Q437. Ray Optics, 2019 (10 Apr Shift 1)

One plano-convex and one plano-concave lens of the same radius of curvature R but of different materials are joined side by side as shown in the figure. If the refractive index of the material of 1 is μ_1 and that of 2 is μ_2, then the focal length of the combination is:



(1) $\frac{R}{2-(\mu_1-\mu_2)}$
(2) $\frac{R}{2(\mu_1-\mu_2)}$
(3) $\frac{2R}{\mu_1-\mu_2}$
(4) $\frac{R}{\mu_1-\mu_2}$

Chapter: Wave Optics

Q438. Wave Optics, 2024 (09 Apr Shift 2)

Monochromatic light of wavelength 500 nm is used in Young's double slit experiment. An interference pattern is obtained on a screen. When one of the slits is covered with a very thin glass plate (refractive index $= 1.5$), the central maximum is shifted to a position previously occupied by the 4^{th} bright fringe. The thickness of the glass-plate is ______ μm.

Q439. Wave Optics, 2024 (31 Jan Shift 1)

Two waves of intensity ratio $1 : 9$ cross each other at a point. The resultant intensities at the point, when (a) Waves are incoherent is I_1 (b) Waves are coherent is I_2 and differ in phase by 60°. If $\frac{I_1}{I_2} = \frac{10}{x}$, then $x =$ _________.

Q440. Wave Optics, 2023 (06 Apr Shift 2)

A beam of light consisting of two wavelengths $7000\ \mathring{A}$ and $5500\ \mathring{A}$ is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the plane of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is $n \times 10^{-5}$ m. The value of n is _____.

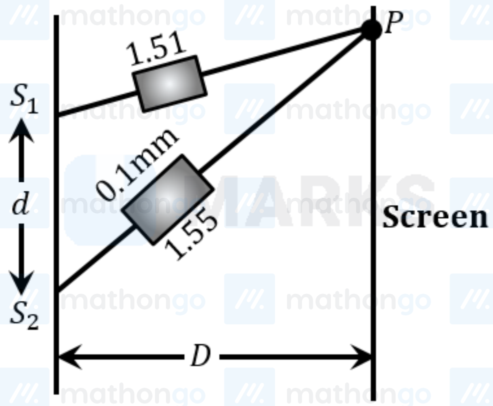
Q441. Wave Optics, 2023 (01 Feb Shift 1)

'n' polarizing sheets are arranged such that each makes an angle 45° with the proceeding sheet. An unpolarized light of intensity I is incident into this arrangement. The output intensity is found to be $\frac{I}{64}$. The value of n will be:

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

Q442. Wave Optics, 2023 (30 Jan Shift 1)

In Young's double slit experiment, two slits S_1 and S_2 are d distance apart and the separation from slits to screen is D (as shown in figure). Now if two transparent slabs of equal thickness 0.1 mm but refractive index 1.51 and 1.55 are introduced in the path of beam ($\lambda = 4000\ \text{Å}$) from S_1 and S_2 respectively. The central bright fringe spot will shift by ________ number of fringes.



Q443. Wave Optics, 2023 (24 Jan Shift 1)

Given below are two statements :

Statement I : If the Brewster's angle for the light propagating from air to glass is θ_B, then Brewster's angle for the light propagating from glass to air is $\frac{\pi}{2}-\theta_B$.

Statement II : The Brewster's angle for the light propagating from glass to air is $\tan^{-1}(\mu_g)$, where μ_g is the refractive index of glass.

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

(1) Both Statements I and Statement II are true.
(2) Statement I is true but Statement II is false.
(3) Both Statement I and Statement II are false.
(4) Statement I is false but Statement II is true.

Q444. Wave Optics, 2022 (27 Jul Shift 2)

Two coherent sources of light interfere. The intensity ratio of two sources is 1 : 4. For this interference pattern if the value of $\frac{I_{\max}+I_{\min}}{I_{\max}-I_{\min}}$ is equal to $\frac{2\alpha+1}{\beta+3}$, then $\frac{\alpha}{\beta}$ will be

(1) 1.5
(2) 2
(3) 0.5
(4) 1

Q445. Wave Optics, 2022 (25 Jun Shift 2)

A light whose electric field vectors are completely removed by using a good polaroid, allowed to incident on the surface of the prism at Brewster's angle. Choose the most suitable option for the phenomenon related to the prism.

(1) Reflected and refracted rays will be perpendicular to each other.
(2) Wave will propagate along the surface of prism.
(3) No refraction, and there will be total reflection of light.
(4) No reflection. and there will be total transmission of light.

Q446. Wave Optics, 2022 (24 Jun Shift 1)

Sodium light of wavelengths 650 nm and 655 nm is used to study diffraction at a single slit of aperture 0.5 mm. The distance between the slit and the screen is 2.0 m. The separation between the positions of the first maxima of diffraction pattern obtained in the two cases is _____ $\times 10^{-5}$ m

Q447. Wave Optics, 2021 (25 Jul Shift 1)

In the Young's double slit experiment, the distance between the slits varies in time as $d(t)=d_0+a_0\ \sin\omega t$; where $d_0,\ \omega$ and a_0 are constants. The difference between the largest fringe width and the smallest fringe width obtained over time is given as:

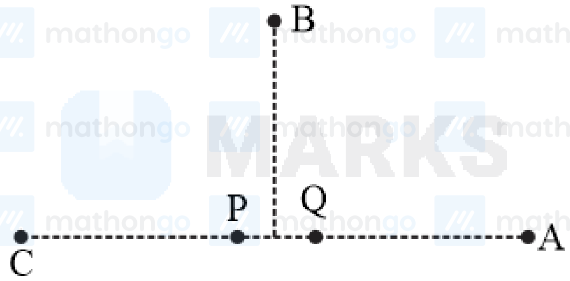
(1) $\frac{2\lambda D(d_0)}{(d_0^2-a_0^2)}$
(2) $\frac{2\lambda D a_0}{(d_0^2-a_0^2)}$
(3) $\frac{\lambda D}{d_0^2}a_0$
(4) $\frac{\lambda D}{d_0+a_0}$

Q448. Wave Optics, 2021 (24 Feb Shift 1)

An unpolarized light beam is incident on the polarizer of a polarization experiment and the intensity of light beam emerging from the analyzer is measured as 100 Lumens. Now, if the analyzer is rotated around the horizontal axis (direction of light) by 30° in clockwise direction, the intensity of emerging light will be _______Lumens.

Q449. Wave Optics, 2020 (06 Sep Shift 1)

In the figure below, P and Q are two equally intense coherent sources emitting radiation of wavelength 20m. The separation between P and Q is 5m and the phase of P is ahead of that of Q by 90°. A, B and C are three distinct point of observation, each equidistant from the midpoint of PQ. The intensities of radiation at A, B, C will be in the ratio :



(1) 0 : 1 : 4
(2) 2 : 1 : 0
(3) 0 : 1 : 2
(4) 4 : 1 : 0

Q450. Wave Optics, 2020 (04 Sep Shift 1)

A beam of plane polarized light of large cross-sectional area and uniform intensity of $3.3 \mathrm{~W~m}^{-2}$ falls normally on a polarizer (cross-sectional area $3 \times 10^{-4} \mathrm{~m}^2$), which rotates about its axis with an angular speed of $31.4 \mathrm{~rad~s}^{-1}$. The energy of light passing through the polarizer per revolution, is close to:

(1) 1.0×10^{-5} J
(2) 1.0×10^{-4} J
(3) 1.5×10^{-4} J
(4) 5.0×10^{-4} J

Q451. Wave Optics, 2020 (04 Sep Shift 1)

A beam of plane polarized light of large cross-sectional area and uniform intensity of $3.3 \mathrm{~W~m}^{-2}$ falls normally on a polarizer (cross-sectional area $3 \times 10^{-4} \mathrm{~m}^2$), which rotates about its axis with an angular speed of $31.4 \mathrm{~rad~s}^{-1}$. The energy of light passing through the polarizer per revolution, is close to:

(1) 1.0×10^{-5} J
(2) 1.0×10^{-4} J
(3) 1.5×10^{-4} J
(4) 5.0×10^{-4} J

Q452. Wave Optics, 2020 (02 Sep Shift 2)

In a Young's double slit experiment,16 fringes are observed in a certain segment of the screen when light of wavelength $700 \mathrm{~nm}$ is used. If the wavelength of light is changed to $400 \mathrm{~nm}$, the number of fringes observed in the same segment of the screen would be :

(1) 24
(2) 30
(3) 18
(4) 28

Q453. Wave Optics, 2020 (09 Jan Shift 1)

The aperture diameter of a telescope is 5m . The separation between the moon and the earth is 4×10^5km . With light of wavelength of 5500Å , the minimum separation between objects on the surface of moon, so that they are just resolved, is close to:

(1) 60m
(2) 20m
(3) 200m
(4) 600m

Q454. Wave Optics, 2020 (09 Jan Shift 2)

In a Young's double slit experiment 15 fringes are observed on a small portion of the screen when light of wavelength 500 nm is used. Ten fringes are observed on the same section of the screen when another light source of wavelength λ is used. Then the value of λ is (in nm) __________.

Chapter: Dual Nature of Matter

Q455. Dual Nature of Matter, 2024 (08 Apr Shift 1)

Average force exerted on a non-reflecting surface at normal incidence is 2.4×10^{-4} N. If 360 $\mathrm{W/cm^2}$ is the light energy flux during span of 1 hour 30 minutes, Then the area of the surface is:

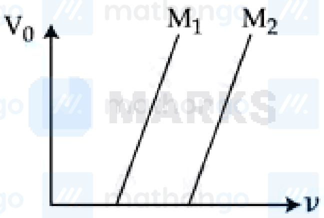
(1) $0.2\ \mathrm{m^2}$
(2) $20\ \mathrm{m^2}$
(3) $0.1\ \mathrm{m^2}$
(4) $0.02\ \mathrm{m^2}$

Q456. Dual Nature of Matter, 2024 (06 Apr Shift 1)

Which of the following phenomena does not explain by wave nature of light. A. reflection B. diffraction C. photoelectric effect D. interference E. polarization Choose the most appropriate answer from the options given below:

(1) E only
(2) B, D only
(3) C only
(4) A, C only

Q457. Dual Nature of Matter, 2024 (05 Apr Shift 1)



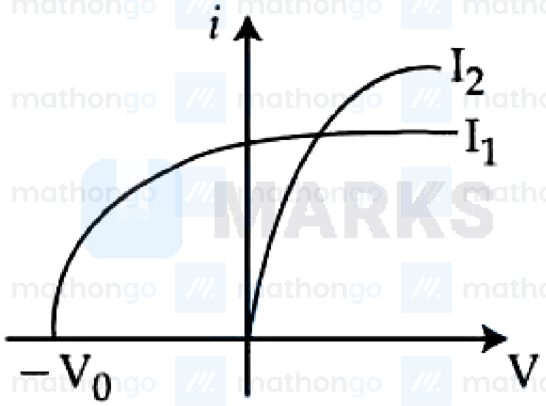
Given below are two statements : Statement I : Figure shows the variation of stopping potential with frequency (ν) for the two photosensitive materials M_1 and M_2. The slope gives value of $\frac{h}{e}$, where h is Planck's constant, e is the charge of electron. Statement II : M_2 will emit photoelectrons of greater kinetic energy for the incident radiation having same frequency. In the light of the above statements, choose the most appropriate answer from the options given below.

(1) Both Statement I and Statement II are correct
(2) Statement I is incorrect but Statement II is correct
(3) Both Statement I and Statement II are incorrect
(4) Statement I is correct and Statement II is incorrect

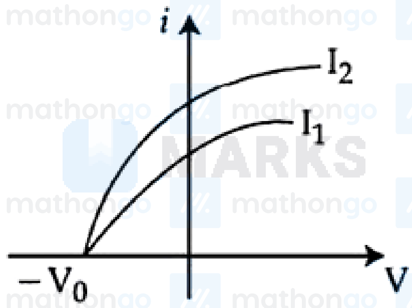
Q458. Dual Nature of Matter, 2024 (04 Apr Shift 1)

Which figure shows the correct variation of applied potential difference (V) with photoelectric current (I) at two different intensities of light $(I_1 < I_2)$ of same wavelengths :

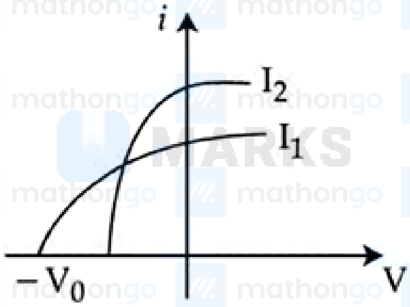
(1)



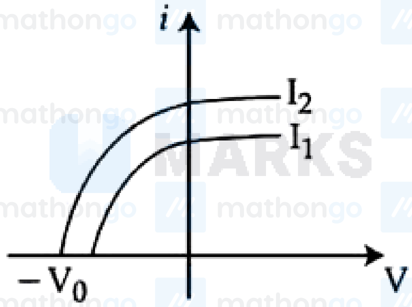
(2)



(3)



(4)



Q459. Dual Nature of Matter, 2024 (31 Jan Shift 1)

When a metal surface is illuminated by light of wavelength λ, the stopping potential is 8 V. When the same surface is illuminated by light of wavelength 3λ, stopping potential is 2 V. The threshold wavelength for this surface is :

(1) 5λ
(2) 3λ
(3) 9λ
(4) 4.5λ

Q460. Dual Nature of Matter, 2024 (31 Jan Shift 2)

In a photoelectric effect experiment a light of frequency 1.5 times the threshold frequency is made to fall on the surface of photosensitive material. Now if the frequency is halved and intensity is doubled, the number of photo electrons emitted will be:

(1) Doubled
(2) Quadrupled
(3) Zero
(4) Halved

Q461. Dual Nature of Matter, 2024 (29 Jan Shift 1)

The de-Broglie wavelength of an electron is the same as that of a photon. If velocity of electron is 25% of the velocity of light, then the ratio of K.E. of electron and K.E. of photon will be:

(1) $\frac{1}{1}$
(2) $\frac{1}{8}$
(3) $\frac{8}{1}$
(4) $\frac{1}{4}$

Q462. Dual Nature of Matter, 2023 (08 Apr Shift 2)

In photoelectric effect

A. The photocurrent is proportional to the intensity of the incident radiation.

B. Maximum kinetic energy with which photoelectrons are emitted depends on the intensity of incident light.

C. Max K.E. with which photoelectrons are emitted depends on the frequency of incident light.

D. The emission of photoelectrons require a minimum threshold intensity of incident radiation.

E. Max K.E. of the photoelectrons is independent of the frequency of the incident light.

Choose the correct answer from the options given below:

(1) A and B only
(2) A and E only
(3) A and C only
(4) B and C only

Q463. Dual Nature of Matter, 2022 (29 Jul Shift 2)

An α particle and a proton are accelerated from rest through the same potential difference. The ratio of linear momenta acquired by above two particals will be :

(1) $\sqrt{2}:1$
(2) $2\sqrt{2}:1$
(3) $4\sqrt{2}:1$
(4) $8:1$

Q464. Dual Nature of Matter, 2022 (27 Jul Shift 1)

An electron (mass m) with an initial velocity $\vec{v}=v_0\hat{i}(v_0>0)$ is moving in an electric field $\vec{E}=-E_0\hat{i}(E_0>0)$ where E_0 is constant. If at $t=0$, de-Broglie wavelength is $\lambda_0=\frac{h}{mv_0}$, then its de-Broglie wavelength after time t is given by

(1) λ_0
(2) $\lambda_0\left(1+\frac{eE_0t}{mv_0}\right)$
(3) $\lambda_0 t$
(4) $\frac{\lambda_0}{\left(1+\frac{eE_0t}{mv_0}\right)}$

Q465. Dual Nature of Matter, 2022 (26 Jul Shift 1)

A parallel beam of light of wavelength $900\ \mathrm{nm}$ and intensity $100\,\mathrm{Wm}^{-2}$ is incident on a surface perpendicular to the beam. The number of photons crossing $1\ \mathrm{cm}^2$ area perpendicular to the beam in one second is

(1) 3×10^{16}
(2) 4.5×10^{16}
(3) 4.5×10^{17}
(4) 4.5×10^{20}

Q466. Dual Nature of Matter, 2022 (25 Jul Shift 1)

A metal exposed to light of wavelength $800\ \mathrm{nm}$ and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength $500\ \mathrm{nm}$ is used. The work function of the metal is
(Take $hc=1230\ \mathrm{eV}-\mathrm{nm}$).

(1) $1.537\,\mathrm{eV}$
(2) $2.46\,\mathrm{eV}$
(3) $0.615\,\mathrm{eV}$
(4) $1.23\,\mathrm{eV}$

Q467. Dual Nature of Matter, 2022 (29 Jun Shift 2)

The electric field at a point associated with a light wave is given by
$E=200\left[\sin\left(6\times10^{15}\right)t+\sin\left(9\times10^{15}\right)t\right]\ \mathrm{Vm}^{-1}$
Given: $h=4.14\times10^{-15}\ \mathrm{eVs}$

If this light falls on a metal surface having a work function of $2.50\ \mathrm{eV}$, the maximum kinetic energy of the photoelectrons will be

(1) $1.90\ \mathrm{eV}$
(2) $3.27\ \mathrm{eV}$
(3) $3.60\ \mathrm{eV}$
(4) $3.42\ \mathrm{eV}$

Q468. Dual Nature of Matter, 2021 (20 Jul Shift 2)

An electron having de-Broglie wavelength λ is incident on a target in a X-ray tube. Cut-off wavelength of emitted X-ray is:

(1) 0
(2) $\frac{2\,m^2c^2\lambda^2}{h^2}$
(3) $\frac{2mc\lambda^2}{h}$
(4) $\frac{hc}{mc}$

Q469. Dual Nature of Matter, 2021 (20 Jul Shift 2)

A certain metallic surface is illuminated by monochromatic radiation of wavelength λ. The stopping potential for photoelectric current for this radiation is $3\,V_0$. If the same surface is illuminated with a radiation of wavelength 2λ, the stopping potential is V_0. The threshold wavelength of this surface for photoelectric effect is________ λ.

Q470. Dual Nature of Matter, 2021 (17 Mar Shift 2)

Two identical photocathodes receive the light of frequencies f_1 and f_2 respectively. If the velocities of the photo-electrons coming out are v_1 and v_2 respectively, then

(1) $v_1^2 - v_2^2 = \frac{2h}{m}[f_1 - f_2]$
(2) $v_1^2 + v_2^2 = \frac{2h}{m}[f_1 + f_2]$
(3) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{\frac{1}{2}}$
(4) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{\frac{1}{2}}$

Q471. Dual Nature of Matter, 2020 (09 Jan Shift 2)

An electron of mass m and magnitude of charge e at rest, gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of this electron at a time t is (ignore relativistic effects)

(1) $\frac{d\lambda}{dt} = -\frac{h}{eEt}$
(2) $\frac{d\lambda}{dt} = -\frac{2h}{eEt}$
(3) $\frac{d\lambda}{dt} = -\frac{2h}{eEt^2}$
(4) $\frac{d\lambda}{dt} = -\frac{h}{eEt^2}$

Q472. Dual Nature of Matter, 2020 (08 Jan Shift 2)

An electron (mass m) with initial velocity $\vec{v} = v_0\hat{i} + v_0\hat{j}$ is in an electric filed $\vec{E} = -E_0\hat{k}$. If λ_0 is initial de-Broglie wavelength of electron, its de-Broglie wave length at time t is given by:

(1) $\frac{\lambda_0\sqrt{2}}{\sqrt{1+\frac{e^2E^2t^2}{m^2v_0^2}}}$
(2) $\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{m^2v_0^2}}}$
(3) $\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{2m^2v_0^2}}}$
(4) $\frac{\lambda_0}{\sqrt{2+\frac{e^2E^2t^2}{m^2v_0^2}}}$

Chapter: Atomic Physics

Q473. Atomic Physics, 2024 (08 Apr Shift 1)

In an alpha particle scattering experiment distance of closest approach for the α particle is 4.5×10^{-14} m. If target nucleus has atomic number 80 , then maximum velocity of α - particle is _______ $\times 10^5$ m/s approximately. $\left(\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\right.$ SI unit, mass of α particle $= 6.72 \times 10^{-27}$ kg$\left.\right)$

Q474. Atomic Physics, 2024 (06 Apr Shift 1)

The ratio of the shortest wavelength of Balmer series to the shortest wavelength of Lyman series for hydrogen atom is :

(1) 4 : 1
(2) 1 : 4
(3) 2 : 1
(4) 1 : 2

Q475. Atomic Physics, 2024 (04 Apr Shift 1)

A hydrogen atom changes its state from $n = 3$ to $n = 2$. Due to recoil, the percentage change in the wave length of emitted light is approximately 1×10^{-n}. The value of n is_____. [Given $\mathrm{Rhc} = 13.6\mathrm{eV}, \mathrm{hc} = 1242\mathrm{eVnm}, \mathrm{h} = 6.6 \times 10^{-34}$ J s mass of the hydrogenatom $= 1.6 \times 10^{-27}$ kg]

Q476. Atomic Physics, 2024 (01 Feb Shift 2)

A particular hydrogen - like ion emits the radiation of frequency 3×10^{15} Hz when it makes transition from $n = 2$ to $n = 1$. The frequency of radiation emitted in transition from $n = 3$ to $n = 1$ is $\frac{x}{9} \times 10^{15}$ Hz, when $x =$ _____.

Q477. Atomic Physics, 2024 (29 Jan Shift 2)

Hydrogen atom is bombarded with electrons accelerated through a potential different of V, which causes excitation of hydrogen atoms. If the experiment is being formed at $T = 0$ K. The minimum potential difference needed to observe any Balmer series lines in the emission spectra will be $\frac{\alpha}{10}$ V, where $\alpha =$________.(Write the value to the nearest integer)

Q478. Atomic Physics, 2023 (01 Feb Shift 1)

A light of energy 12.75 eV is incident on a hydrogen atom in its ground state. The atom absorbs the radiation and reaches to one of its excited states. The angular momentum of the atom in the excited state is $\frac{x}{\pi} \times 10^{-17}$ eVs. The value of x is ______ (use $h = 4.14 \times 10^{-15}$ eVs, $c = 3 \times 10^{8}$ m s^{-1})

Q479. Atomic Physics, 2022 (29 Jul Shift 1)

Find the ratio of energies of photons produced due to transition of an election of hydrogen atom from its(i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level.

(1) 3 : 4
(2) 4 : 3
(3) 1 : 4
(4) 4 : 1

Q480. Atomic Physics, 2022 (25 Jul Shift 2)

$\frac{x}{x+4}$ is the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its
(i) third permitted energy level to the second level and
(ii) the highest permitted energy level to the second permitted level.
The value of x will be

Q481. Atomic Physics, 2022 (27 Jun Shift 2)

Given below are two statements

Statement I: In hydrogen atom, the frequency of radiation emitted when an electron jumps from lower energy orbit (E_1) to higher energy orbit (E_2), is given as $hf = \mathrm{E}_1 - \mathrm{E}_2$

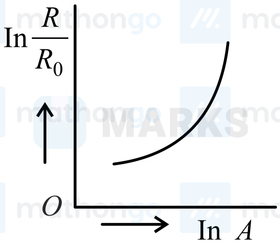
Statement II: The jumping of electron from higher energy orbit (E_2) to lower energy orbit (E_1) is associated with frequency of radiation given as $f = \frac{(\mathrm{E}_2 - \mathrm{E}_1)}{h}$. This condition is Bohr's frequency condition.

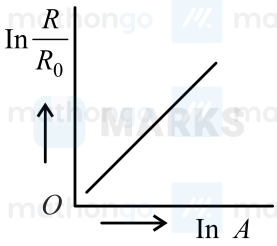
In the light of the above statements, choose the correct answer from the options given below:

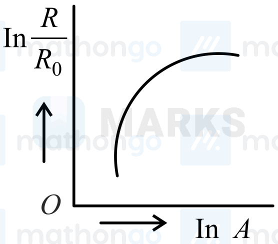
(1) Both statement I and statement II are true.
(2) Both statement I and statement II are false.
(3) Statement I is correct but statement II is false.
(4) Statement I is incorrect but statement II is true.

Q482. Atomic Physics, 2022 (25 Jun Shift 2)

Which of the following figure represents the variation of $\ln\left(\frac{R}{R_0}\right)$ with $\ln A$ (if $R =$ radius of a nucleus and $A =$ its mass number)

(1)


(2)


(3)


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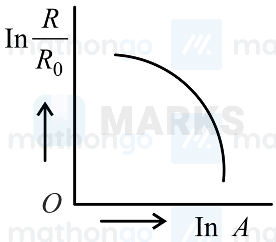


Q483. Atomic Physics, 2022 (24 Jun Shift 2)

In Bohr's atomic model of hydrogen, let K, P and E are the kinetic energy, potential energy and total energy of the electron respectively. Choose the correct option when the electron undergoes transitions to a higher level :

(1) All K, P and E increase.
(2) K decreases, P and E increase.
(3) P decreases, K and E increase.
(4) K increases, P and E decrease

Q484. Atomic Physics, 2021 (27 Jul Shift 1)

In Bohr's atomic model, the electron is assumed to revolve in a circular orbit of radius 0.5 Å. If the speed of electron is $2.2 \times 10^6 \mathrm{~m~s}^{-1}$. Then the current associated with the electron will be__________ $\times 10^{-2}$ mA. [Take π as $\frac{22}{7}$]

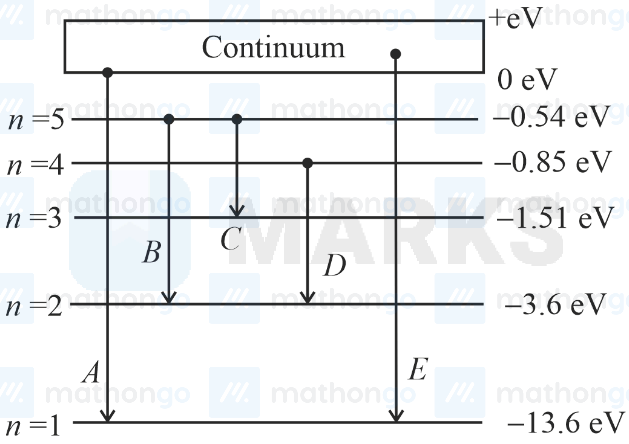
Q485. Atomic Physics, 2021 (16 Mar Shift 1)

The first three spectral lines of H-atom in the Balmer series are given $\lambda_1, \lambda_2, \lambda_3$ considering the Bohr atomic model, the wave lengths of first and third spectral lines $\left(\frac{\lambda_1}{\lambda_3}\right)$ are related by a factor of approximately $x \times 10^{-1}$. The value of x, to the nearest integer, is ________.

Q486. Atomic Physics, 2021 (24 Feb Shift 1)

In the given figure, the energy levels of hydrogen atom have been shown along with some transitions marked A, B, C, D and E.

The transitions A, B and C respectively represent



(1) The ionization potential of hydrogen, second member of Balmer series and third member of Paschen series.

(2) The series limit of Lyman series, second member of Balmer series and second member of Paschen series.

(3) The series limit of Lyman series, third member of Balmer series and second member of Paschen series.

(4) The first member of the Lyman series, third member of Balmer series and second member of Paschen series.

Q487. Atomic Physics, 2020 (08 Jan Shift 1)

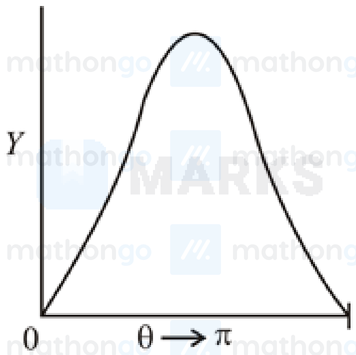
The graph which depicts the results of Rutherford gold foil experiment with α -particles is:

θ : Scattering angle

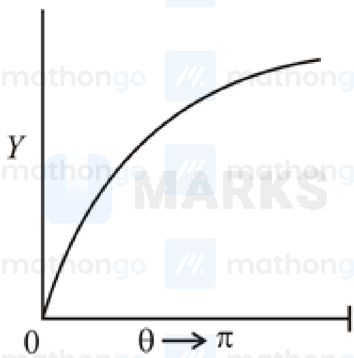
Y : Number of scattered α -particles detected

(Plots are schematic and not to scale)

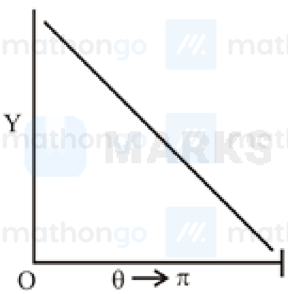
(1)



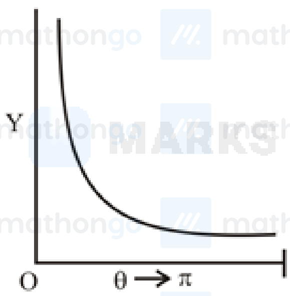
(2)



(3)



(4)



Q488. Atomic Physics, 2020 (08 Jan Shift 2)

The first member of the Balmer series of hydrogen atom has a wavelength of 6561 Å. The wavelength of the second member of the Balmer series (in nm) is______________

Chapter: Nuclear Physics

Q489. Nuclear Physics, 2024 (09 Apr Shift 1)

A star has 100% helium composition. It starts to convert three ^{4}He into one ^{12}C via triple alpha process as $^4\mathrm{He} + {}^4\mathrm{He} + {}^4\mathrm{He} \rightarrow {}^{12}\mathrm{C} + \mathrm{Q}$. The mass of the star is 2.0×10^{32} kg and it generates energy at the rate of 5.808×10^{30} W. The rate of converting these ^{4}He to ^{12}C is $\mathrm{n} \times 10^{42}\ \mathrm{s}^{-1}$, where n is _________ [Take, mass of $^4\mathrm{He} = 4.0026\mathrm{u}$, mass of $^{12}\mathrm{C} = 12\mathrm{u}$]

Q490. Nuclear Physics, 2024 (09 Apr Shift 2)

The energy released in the fusion of 2 kg of hydrogen deep in the sun is E_H and the energy released in the fission of 2 kg of ^{235}U is E_U. The ratio $\frac{E_H}{E_U}$ is approximately: (Consider the fusion reaction as $4 \mid H + 2\mathrm{e}^- \rightarrow {}^4_2\mathrm{He} + 2v + 6\gamma + 26.7\mathrm{MeV}$, energy released in the fission reaction of ^{235}U is 200MeV per fission nucleus and $\mathrm{N_A} = 6.023 \times 10^{23}$)

(1) 7.62
(2) 25.6
(3) 15.04
(4) 9.13

Q491. Nuclear Physics, 2024 (01 Feb Shift 2)

From the statements given below :

(A) The angular momentum of an electron in n^{th} orbit is an integral multiple of h.
(B) Nuclear forces do not obey inverse square law.
(C) Nuclear forces are spin dependent.
(D) Nuclear forces are central and charge independent.
(E) Stability of nucleus is inversely proportional to the value of packing fraction.

Choose the correct answer from the options given below :

(1) (A), (B), (C), (D) only
(2) (A), (C), (D), (E) only
(3) (A), (B), (C), (E) only
(4) (B), (C), (D), (E) only

Q492. Nuclear Physics, 2024 (29 Jan Shift 1)

The explosive in a Hydrogen bomb is a mixture of $_1\mathrm{H}^2$, $_1\mathrm{H}^3$ and $_3\mathrm{Li}^6$ in some condensed form. The chain reaction is given by $_3\mathrm{Li}^6 + {}_0\mathrm{n}^1 \rightarrow {}_2\mathrm{He}^4 + {}_1\mathrm{H}^3$; $_1\mathrm{H}^2 + {}_1\mathrm{H}^3 \rightarrow {}_2\mathrm{He}^4 + {}_0\mathrm{n}^1$
During the explosion the energy released is approximately [Given : $M(\mathrm{Li}) = 6.01690$ amu, $M({}_1\mathrm{H}^2) = 2.01471$ amu, $M({}_2\mathrm{He}^4) = 4.00388$ amu and 1 amu $= 931.5$ MeV]

(1) $28.12\,\mathrm{MeV}$
(2) $12.64\,\mathrm{MeV}$
(3) $16.48\,\mathrm{MeV}$
(4) $22.22\,\mathrm{MeV}$

Q493. Nuclear Physics, 2023 (12 Apr Shift 1)

A common example of alpha decay is

$^{238}{}_{92}\mathrm{U} \rightarrow {}^{234}{}_{90}\ \mathrm{Th} + {}_2\ \mathrm{He}^4 + Q$

Given:

$^{238}{}_{92}\mathrm{U} = 238.05060$ u

$^{234}{}_{90}\mathrm{Th} = 234.04360$ u

$^4{}_2\mathrm{He} = 4.00260$ u and $1\mathrm{u} = 931.5 \frac{\mathrm{MeV}}{c^2}$

The energy released (Q) during the alpha decay of $^{238}{}_{92}$U is _____ MeV.

Q494. Nuclear Physics, 2022 (26 Jul Shift 2)

Two lighter nuclei combine to form a comparatively heavier nucleus by the relation given below:

${}^2_1X + {}^2_1X = {}^4_2Y$

The binding energies per nucleon ${}^2_1X$ and ${}^4_2Y$ are $1.1\,\mathrm{MeV}$ and $7.6\,\mathrm{MeV}$ respectively. The energy released in this process is_____ MeV.

Q495. Nuclear Physics, 2022 (28 Jun Shift 1)

The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as

(1) $Q=K_p$
(2) $(K_p+Q)<0$
(3) $Q<K_p$
(4) $(K_p+Q)>0$

Q496. Nuclear Physics, 2022 (24 Jun Shift 1)

Nucleus A is having mass number 220 and its binding energy per nucleon is 5.6 MeV. It splits in two fragments B and C of mass numbers 105 and 115. The binding energy of nucleons in B and C is 6.4 MeV per nucleon. The energy Q released per fission will be:

(1) 0.8 MeV
(2) 275 MeV
(3) 220 MeV
(4) 176 MeV

Q497. Nuclear Physics, 2021 (25 Jul Shift 2)

From the given data, the amount of energy required to break the nucleus of aluminium $_{13}^{27}\mathrm{Al}$ is __________ $x \times 10^{-3}$ J

Mass of neutron $=1.00866$ u

Mass of proton $=1.00726$ u

Mass of Aluminium nucleus $=27.18846$ u

(Assume 1 u corresponds to x J of energy)

(Round off to the nearest integer)

Q498. Nuclear Physics, 2020 (03 Sep Shift 2)

The radius R of a nucleus of mass number A can be estimated by the formula $\mathrm{R}=\left(1.3\times10^{-15}\right)\mathrm{A}^{1/3}\mathrm{m}$. It follows that the mass density of n nucleus is of the order of: $\left(M_{prot}\cong M_{\text{neut}}\simeq 1.67\times10^{-27}\ \mathrm{kg}\right)$

(1) $10^3\ \mathrm{kg\ m^{-3}}$
(2) $10^{10}\ \mathrm{kg\ m^{-3}}$
(3) $10^{24}\ \mathrm{kg\ m^{-3}}$
(4) $10^{17}\ \mathrm{kg\ m^{-3}}$

Chapter: Electromagnetic Waves

Q499. Electromagnetic Waves, 2024 (09 Apr Shift 1)

A plane EM wave is propagating along x direction. It has a wavelength of 4 mm. If electric field is in y direction with the maximum magnitude of $60\mathrm{Vm}^{-1}$, the equation for magnetic field is :

(1) $\mathrm{B}_z=2\times10^{-7}\sin\left[\frac{\pi}{2}\times10^3\left(x-3\times10^8\mathrm{t}\right)\right]\hat{\mathrm{k}}\mathrm{T}$
(2) $\mathrm{B}_z=60\sin\left[\frac{\pi}{2}\left(x-3\times10^8\mathrm{t}\right)\right]\hat{\mathrm{k}}\mathrm{T}$
(3) $\mathrm{B}_x=60\sin\left[\frac{\pi}{2}\left(x-3\times10^8\mathrm{t}\right)\right]\mathrm{i}\,\hat{T}$
(4) $\mathrm{B}_z=2\times10^{-7}\sin\left[\frac{\pi}{2}\left(x-3\times10^8\mathrm{t}\right)\right]\hat{\mathrm{k}}\mathrm{T}$

Q500. Electromagnetic Waves, 2024 (06 Apr Shift 1)

Electromagnetic waves travel in a medium with speed of $1.5\times10^8\ \mathrm{m\ s^{-1}}$. The relative permeability of the medium is 2.0 . The relative permittivity will be:

(1) 2
(2) 4
(3) 5
(4) 1

Q501. Electromagnetic Waves, 2024 (27 Jan Shift 2)

An object is placed in a medium of refractive index 3. An electromagnetic wave of intensity $6\times10^8\ \mathrm{W\ m^{-2}}$ falls normally on the object and it is absorbed completely. The radiation pressure on the object would be (speed of light in free space $=3\times10^8\ \mathrm{m\ s^{-1}}$):

(1) $36\ \mathrm{N\ m^{-2}}$
(2) $18\ \mathrm{N\ m^{-2}}$
(3) $6\ \mathrm{N\ m^{-2}}$
(4) $2\ \mathrm{N\ m^{-2}}$

Q502. Electromagnetic Waves, 2023 (15 Apr Shift 1)

Match List-I with List II of Electromagnetic waves with corresponding wavelength range:

	List I		List II
(A)	Microwave	(I)	$400\ \text{nm}$ to $1\ \text{nm}$
(B)	Ultraviolet	(II)	$1\ \text{nm}$ to $10^{-3}\ \text{nm}$
(C)	X-Ray	(III)	$1\ \text{mm}$ to $700\ \text{nm}$
(D)	Infra-red	(IV)	$0.1\ \text{m}$ to $1\ \text{mm}$

Choose the correct answer from the options given below:

(1) (A) – (IV), (B) – (I), (C) – (II), (D) – (III)
(2) (A) – (IV), (B) – (I), (C) – (III), (D) – (II)
(3) (A) – (IV), (B) – (II), (C) – (I), (D) – (III)
(4) (A) – (I), (B) – (IV), (C) – (II), (D) – (III)

Q503. Electromagnetic Waves, 2023 (13 Apr Shift 1)

Which of the following Maxwell's equation is valid for time varying conditions but not valid for static conditions:

(1) $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$
(2) $\oint \vec{E} \cdot \vec{dl} = 0$
(3) $\oint \vec{D} \cdot \vec{dA} = Q$
(4) $\oint \vec{E} \cdot \vec{dl} = -\frac{\partial \phi_B}{\partial t}$

Q504. Electromagnetic Waves, 2023 (13 Apr Shift 2)

Given below are two statements:

Statement I : Out of microwaves, infrared rays and ultraviolet rays, ultraviolet rays are the most effective for the emission of electrons from a metallic surface

Statement II : Above the threshold frequency, the maximum kinetic energy of photoelectrons is inversely proportional to the frequency of the incident light

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

(1) Statement I is false but Statement II is true
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are true
(4) Both Statement I and Statement II are false

Q505. Electromagnetic Waves, 2023 (24 Jan Shift 1)

If $\vec{E}$ and $\vec{K}$ represent electric field and propagation vectors of the EM waves in vacuum, then magnetic field vector is given by: ($\omega-$ angular frequency)

(1) $\frac{1}{\omega}\left(\vec{K} \times \vec{E}\right)$
(2) $\omega\left(\vec{E} \times \vec{K}\right)$
(3) $\omega\left(\vec{K} \times \vec{E}\right)$
(4) $\vec{K} \times \vec{E}$

Q506. Electromagnetic Waves, 2022 (26 Jun Shift 1)

If Electric field intensity of a uniform plane electro magnetic wave is given as

$E = -301.6 \sin(kz - \omega t)\widehat{a}_x + 452.4 \sin(kz - \omega t)\widehat{a}_y\ \text{V m}^{-1}$. Then, magnetic intensity H of this wave in A m^{-1} will be

[Given : Speed of light in vacuum $c = 3 \times 10^8\ \text{m s}^{-1}$, Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}\ \text{N A}^{-2}$]

(1) $+0.8 \sin(kz - \omega t)\widehat{a}_y + 0.8 \sin(kz - \omega t)\widehat{a}_x$
(2) $+1.0 \times 10^{-6} \sin(kz - \omega t)\widehat{a}_y + 1.5 \times 10^{-6}(kz - \omega t)\widehat{a}_x$
(3) $-0.8 \sin(kz - \omega t)\widehat{a}_y - 1.2 \sin(kz - \omega t)\widehat{a}_x$
(4) $-1.0 \times 10^{-6} \sin(kz - \omega t)\widehat{a}_y - 1.5 \times 10^{-6} \sin(kz - \omega t)\widehat{a}_x$

Q507. Electromagnetic Waves, 2022 (25 Jun Shift 1)

The electric field in an electromagnetic wave is given by $E = 56.5 \sin \omega\left(\frac{t-x}{c}\right)\ \text{NC}^{-1}$. Find the intensity of the wave if it is propagating along x-axis in the free space. (Given $\epsilon_0 = 8.85 \times 10^{-12}\text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$)

(1) $5.65\ \text{Wm}^{-2}$
(2) $1.9 \times 10^{-7}\ \text{Wm}^{-2}$
(3) $4.24\ \ \text{Wm}^{-2}$
(4) $56.5\ \text{Wm}^{-2}$

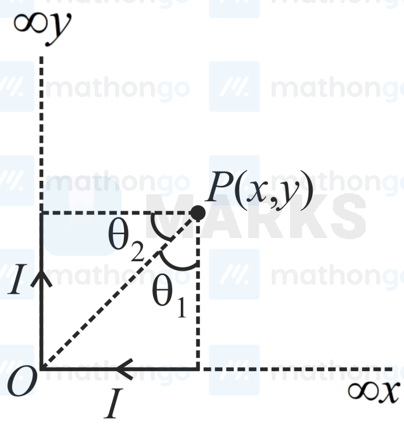
Q508. Electromagnetic Waves, 2022 (25 Jun Shift 2)

The electromagnetic waves travel in a medium at a speed of $2.0 \times 10^8\ \mathrm{m\,s^{-1}}$. The relative permeability of the medium is 1.0. The relative permittivity of the medium will be

(1) 2.25
(2) 4.25
(3) 6.25
(4) 8.25

Q509. Electromagnetic Waves, 2021 (01 Sep Shift 2)

There are two infinitely long straight current-carrying conductors and they are held at right angles to each other so that their common ends meet at the origin as shown in the figure given below. The ratio of current in both conductors is $1:1$. The magnetic field at point P is_________.



(1) $\frac{\mu_0 \mathrm{I}}{4\pi \mathrm{xy}}\left[\sqrt{x^2+y^2}-\left(x+y\right)\right]$
(2) $\frac{\mu_0 \mathrm{I} xy}{4\pi}\left[\sqrt{x^2+y^2}-\left(x+y\right)\right]$
(3) $\frac{\mu_0 \mathrm{I}}{4\pi \mathrm{xy}}\left[\sqrt{x^2+y^2}+\left(x+y\right)\right]$
(4) $\frac{\mu_0 \mathrm{I} xy}{4\pi}\left[\sqrt{x^2+y^2}+\left(x+y\right)\right]$

Q510. Electromagnetic Waves, 2021 (31 Aug Shift 1)

The electric field in an electromagnetic wave is given by
$E=\left(50\ \mathrm{N\,C^{-1}}\right)\sin\omega\left(t-\frac{x}{c}\right)$
The energy contained in a cylinder of volume V is 5.5×10^{-12} J. The value of V is _______ cm^3.
(given $\epsilon_0 = 8.8 \times 10^{-12}\mathrm{C^2\,N^{-1}\,m^{-2}}$)

Q511. Electromagnetic Waves, 2021 (25 Jul Shift 1)

A linearly polarised electromagnetic wave in vacuum is $E=3.1\cos\left[(1.8)z-\left(5.4\times10^6\right)t\right]\hat{\mathrm{i}}\ \mathrm{N\,C^{-1}}$ is incident normally on a perfectly reflecting wall at $z=a$. Choose the correct option.

(1) The wavelength is 5.4 m.
(2) The frequency of electromagnetic wave is 54×10^4 Hz.
(3) The transmitted wave will be $3.1\cos\left[(1.8)z-\left(5.4\times10^6\right)t\right]\hat{\mathrm{i}}\ \mathrm{N/C}$.
(4) The reflected wave will be $3.1\cos\left[(1.8)\mathrm{z}+\left(5.4\times10^6\right)t\right]\hat{\mathrm{i}}\ \mathrm{N\,C^{-1}}$.

Q512. Electromagnetic Waves, 2021 (24 Feb Shift 2)

Match List - I with List - II.

List-I	List-II
(a) Source of microwave frequency	(i) Radioactive decay of nucleus
(b) Source of infrared frequency	(ii) Magnetron
(c) Source of Gamma Rays	(iii) Inner shell electrons
(d) Source of X-rays	(iv) Vibration of atoms and molecules
	(v) LASER

(vi) RC circuit

Choose the correct answer from the options given below:

(1) (a)-(ii), (b)-(iv), (c)-(vi), (d)-(iii)
(2) (a)-(vi), (b)-(iv), (c)-(i), (d)-(v)
(3) (a)-(vi), (b)-(v), (c)-(i), (d)-(iv)
(4) (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

Q513. Electromagnetic Waves, 2020 (05 Sep Shift 2)

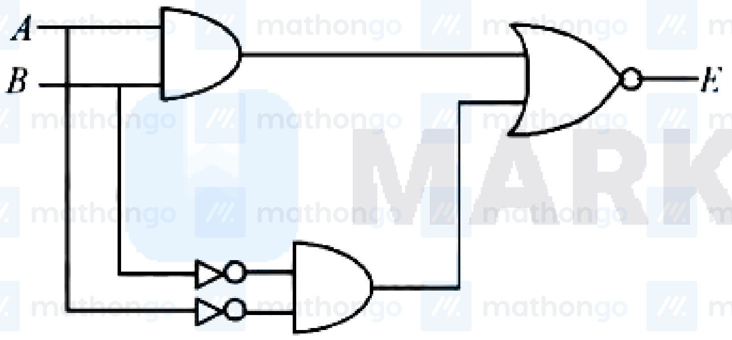
The correct match between the entries in column I and column II are :

	I		II
	Radiation		**Wavelength**
a	Microwave	i	100 m
b	Gamma rays	ii	10^{-15}m
c	A.M. radio	iii	10^{-10}m
d	X–rays	iv	10^{-3}m

(1) (a)–(ii), (b) – (i), (c) – (iv), (d) – (iii)
(2) (a)–(i), (b) – (iii), (c) – (iv), (d) – (ii)
(3) (a)–(iii), (b) – (ii), (c) – (i), (d) – (iv)
(4) (a)–(iv), (b) – (ii), (c) – (i), (d) – (iii)

Chapter: Semiconductors

Q514. Semiconductors, 2024 (09 Apr Shift 2)



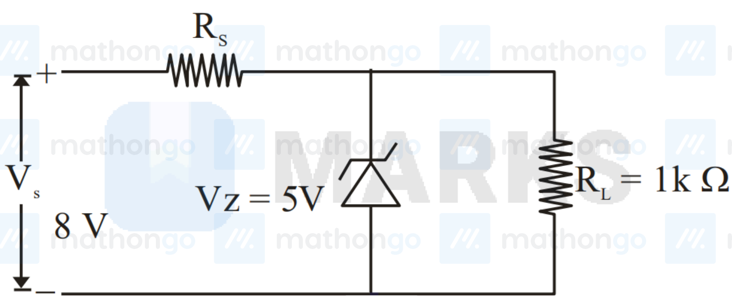
A	B	E
0	0	0
0	1	X
1	0	Y
1	1	0

In the truth table of the above circuit the value of X and Y are :

(1) 0,0
(2) 1,1
(3) 1,0
(4) 0,1

Q515. Semiconductors, 2024 (01 Feb Shift 1)

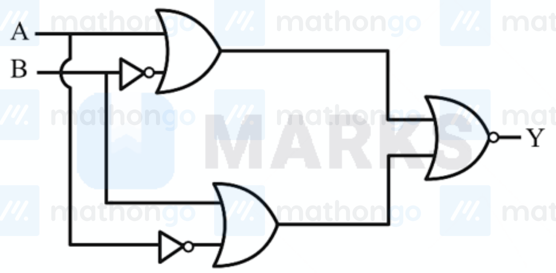
In the given circuit if the power rating of Zener diode is 10 mW, the value of series resistance R_s to regulate the input unregulated supply is:



(1) $\frac{3}{7}\ k\Omega$
(2) 10 Ω
(3) 1 $k\Omega$
(4) 10 $k\Omega$

Q516. Semiconductors, 2024 (31 Jan Shift 2)

The output of the given circuit diagram is



(1)

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

(2)

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

(3)

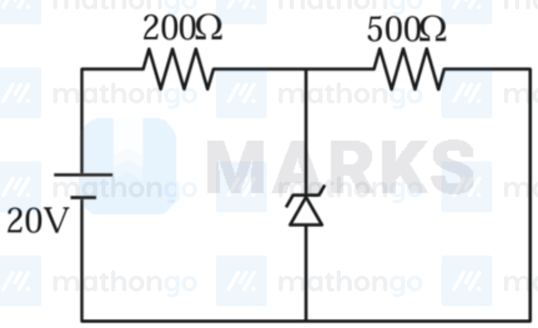
A	B	Y
0	0	0
1	0	0
0	1	0
1	1	0

(4)

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

Q517. Semiconductors, 2024 (30 Jan Shift 1)

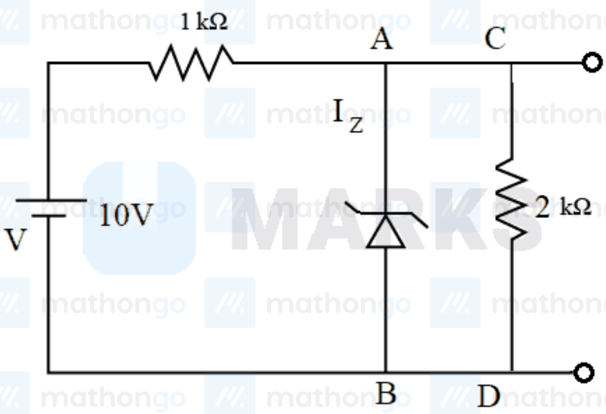
A Zener diode of breakdown voltage 10 V is used as a voltage regulator as shown in the figure. The current through the Zener diode is



(1) 50 mA
(2) 0
(3) 30 mA
(4) 20 mA

Q518. Semiconductors, 2024 (29 Jan Shift 1)

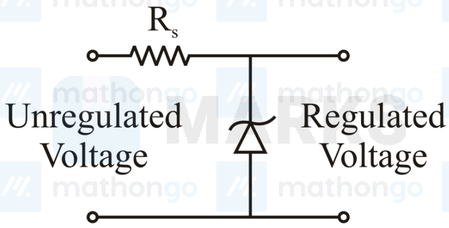
In the given circuit, the breakdown voltage of the Zener diode is 3.0 V. What is the value of I_z ?



(1) $3.3 \mathrm{~mA}$
(2) $5.5 \mathrm{~mA}$
(3) $10 \mathrm{~mA}$
(4) $7 \mathrm{~mA}$

Q519. Semiconductors, 2023 (10 Apr Shift 1)

A zener diode of power rating 1.6 W is to be used as voltage regulator. If the zener diode has a breakdown of 8 V and it has to regulate voltage fluctuating between 3 V and 10 V The value of resistance R_s for safe operation of diode will be



(1) 10 Ω
(2) 12 Ω
(3) 13.3 Ω
(4) 13 Ω

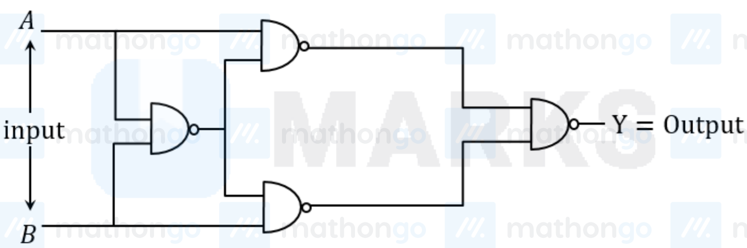
Q520. Semiconductors, 2023 (01 Feb Shift 2)

Choose the correct statement about Zener diode:

(1) It works as a voltage regulator in reverse bias and behaves like simple p-n junction diode in forward bias
(2) It works as a voltage regulator in both forward and reverse bias
(3) It works a voltage regulator only in forward bias
(4) It works as a voltage regulator in forward bias and behaves like simple p-n junction diode in reverse bias

Q521. Semiconductors, 2023 (30 Jan Shift 2)

The output Y for the inputs A and B of circuit is given by



Truth table of the shown circuit is :

(1) $\begin{bmatrix} A & B & Y \\ 0 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$

(2) $\begin{bmatrix} A & B & Y \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$

(3) $\begin{bmatrix} A & B & Y \\ 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

(4) $\begin{bmatrix} A & B & Y \\ 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$

Q522. Semiconductors, 2023 (25 Jan Shift 1)

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: Photodiodes are used in forward bias usually for measuring the light intensity.

Reason R: For a $p-n$ junction diode, at applied voltage V the current in the forward bias is more than the current in the reverse bias for $|V_z| > \pm V \geq |V_0|$ where V_0 is the threshold voltage and V_z is the breakdown voltage.

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 correct explanation A

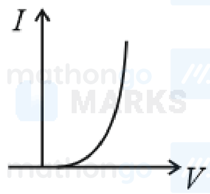
(2) Both A and R are true but R is NOT the correct explanation A

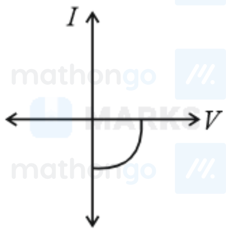
(3) A is false but R is true

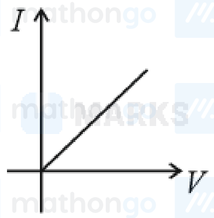
(4) A is true but R is false

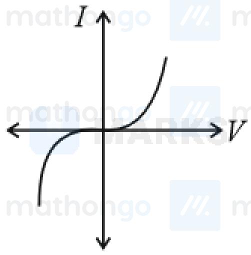
Q523. Semiconductors, 2022 (28 Jul Shift 1)

Identify the solar cell characteristics from the following options :

(1)


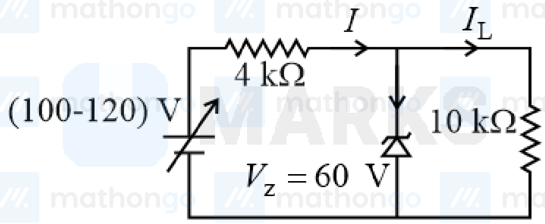
(2)


(3)


(4)


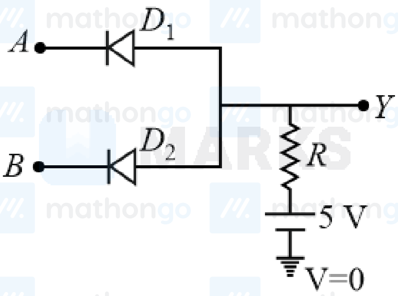
Q524. Semiconductors, 2022 (26 Jul Shift 1)

In the circuit shown below, maximum Zener diode current will be _____ mA.



Q525. Semiconductors, 2022 (25 Jul Shift 1)

In the circuit, the logical value of $A=1$ or $B=1$ when potential at A or B is 5 V and the logical value of $A=0$ or $B=0$ when potential at A or B is 0V.



The truth table of the given circuit will be :

(1)

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

(2)

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

(3)

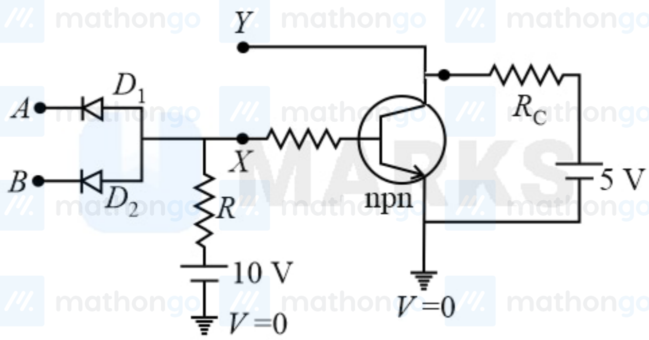
A	B	Y
0	0	0
1	0	0
0	1	0
1	1	0

(4)

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

Q526. Semiconductors, 2022 (28 Jun Shift 1)

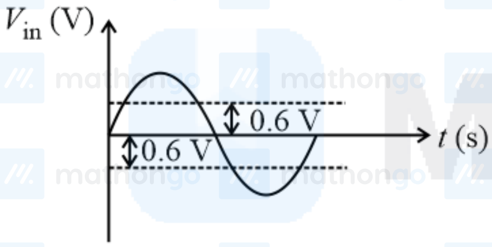
In the following circuit, the correct relation between output (Y) and inputs A and B will be

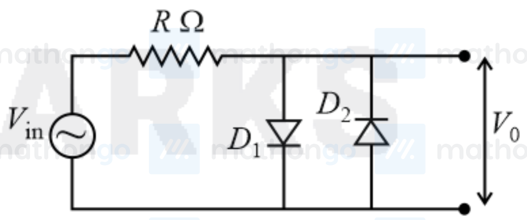


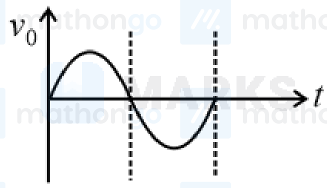
(1) $Y=A\cdot B$
(2) $Y=A+B$
(3) $Y=\overline{A\cdot B}$
(4) $Y=\overline{A+B}$

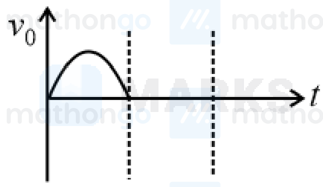
Q527. Semiconductors, 2022 (28 Jun Shift 2)

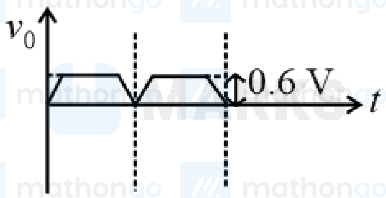
In the given circuit the input voltage V_{in} is shown in figure. The cut-in voltage of $p-n$ junction diode (D_1 or D_2) is 0.6 V. Which of the following output voltage (V_0) waveform across the diode is correct?

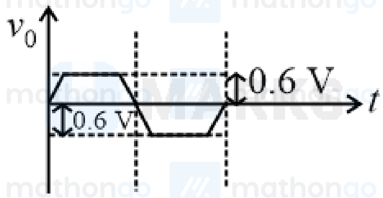




(1) 

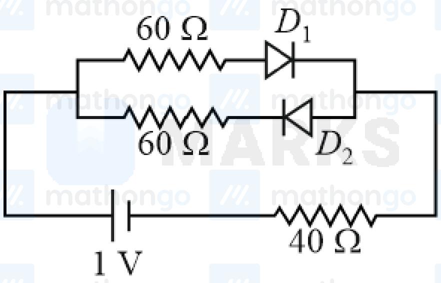
(2) 

(3) 

(4) 

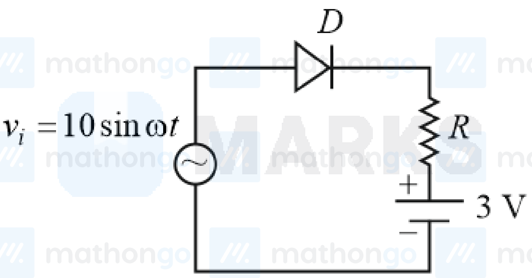
Q528. Semiconductors, 2022 (27 Jun Shift 2)

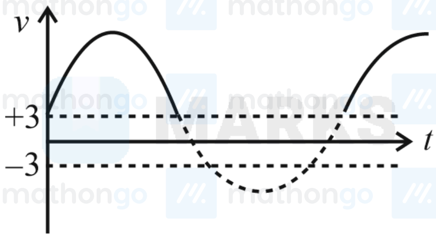
The cut-off voltage of the diodes (shown in figure) in forward bias is 0.6 V. The current through the resister of 40Ω is _____ mA.

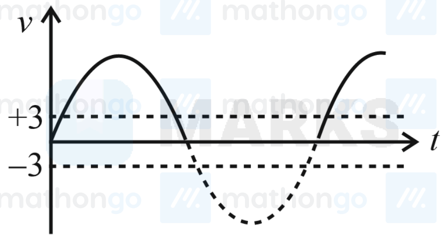


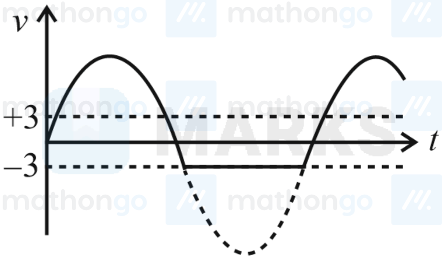
Q529. Semiconductors, 2021 (31 Aug Shift 1)

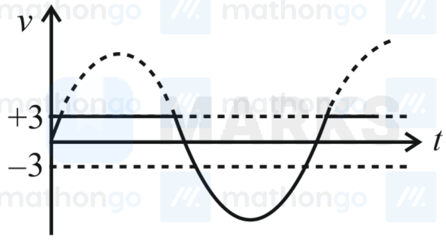
Choose the correct waveform that can represent the voltage across R of the following circuit, assuming the diode is ideal one:



(1)


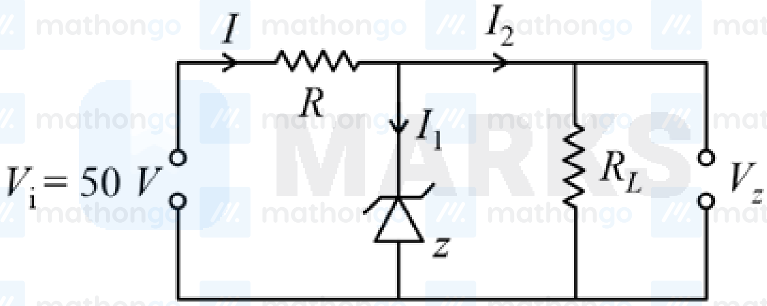
(2)


(3)


(4)


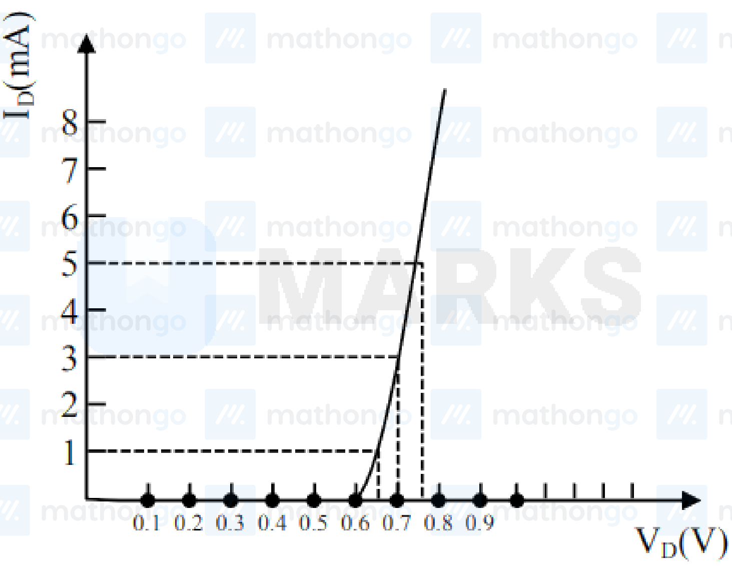
Q530. Semiconductors, 2021 (22 Jul Shift 1)

In a given circuit diagram, a 5 V zener diode along with a series resistance is connected across a 50 V power supply. The minimum value of the resistance required, if the maximum zener current is 90 mA will be ____ Ω.



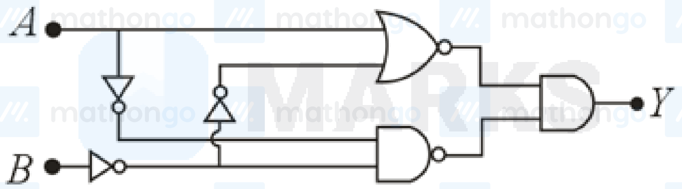
Q531. Semiconductors, 2021 (20 Jul Shift 2)

For the forward biased diode characteristics shown in the figure, the dynamic resistance at $I_D = 3 \text{ mA}$ will be ________Ω.



Q532. Semiconductors, 2021 (16 Mar Shift 1)

In the logic circuit shown in the figure, if input A and B are 0 to 1 respectively, the output at Y would be x. The value of x is ________.



Q533. Semiconductors, 2021 (25 Feb Shift 2)

For extrinsic semiconductors; when doping level is increased;

(1) Fermi-level of p and n- type semiconductors will not be affected.

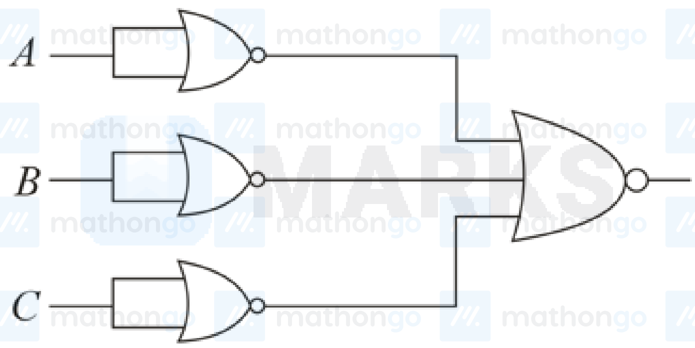
(2) Fermi-level of p-type semiconductor will go upward and Fermi-level of n-type semiconductors will go downward.

(3) Fermi-level of both p-type and n-type semiconductors will go upward for $T > T_F$ K and downward for $T < T_F$ K, where T_F is Fermi temperature.

(4) Fermi-level of p- type semiconductors will go downward and Fermi-level of n- type semiconductor will go upward.

Q534. Semiconductors, 2020 (04 Sep Shift 2)

Identify the operation performed by the circuit given below :



(1) NAND

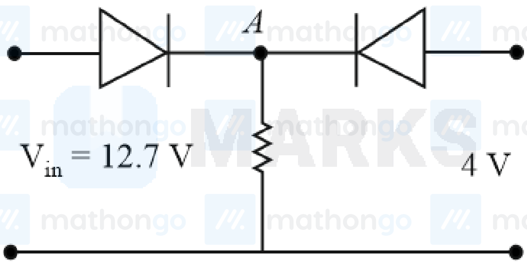
(2) OR

(3) AND

(4) NOT

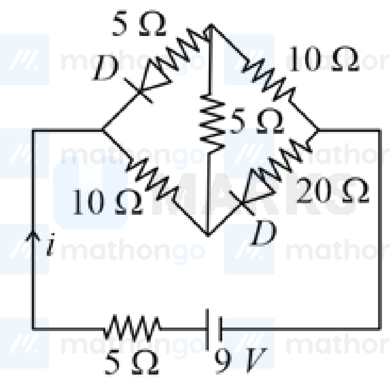
Q535. Semiconductors, 2020 (09 Jan Shift 1)

Both the diodes used in the circuit shown are assumed to be ideal and have negligible resistance when these are forward biased. Built in potential in each diode is $0.7V$. For the input voltages shown in the figure, the voltage (in Volts) at point A is ________



Q536. Semiconductors, 2020 (09 Jan Shift 2)

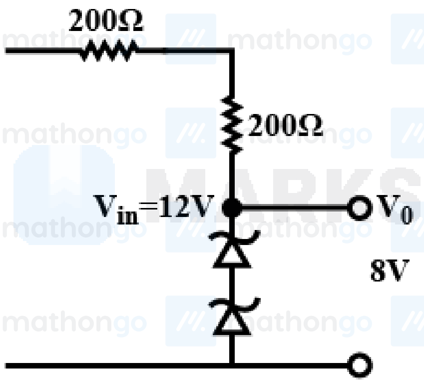
The current i in the network is



(1) 0.2 A
(2) 0.6 A
(3) 0.3 A
(4) 0 A

Q537. Semiconductors, 2020 (09 Jan Shift 2)

In the circuit shown below, is working as a 8 V dc regulated voltage source. When 12 V is used as an input, the power dissipated (in mW) in each diode is (Considering both zener diodes are identical)



Chapter: Experimental Physics

Q538. Experimental Physics, 2024 (08 Apr Shift 1)

The diameter of a sphere is measured using a vernier caliper whose 9 divisions of main scale are equal to 10 divisions of vernier scale. The shortest division on the main scale is equal to 1 mm. The main scale reading is 2 cm and second division of vernier scale coincides with a division on main scale. If mass of the sphere is 8.635 g, the density of the sphere is:

(1) $2.0 \mathrm{~g/cm}^3$
(2) $1.7 \mathrm{~g/cm}^3$
(3) $2.2 \mathrm{~g/cm}^3$
(4) $2.5 \mathrm{~g/cm}^3$

Q539. Experimental Physics, 2024 (08 Apr Shift 2)

There are 100 divisions on the circular scale of a screw gauge of pitch 1 mm. With no measuring quantity in between the jaws, the zero of the circular scale lies 5 divisions below the reference line. The diameter of a wire is then measured using this screw gauge. It is found that 4 linear scale divisions are clearly visible while 60 divisions on circular scale coincide with the reference line. The diameter of the wire is :

(1) 3.35 mm
(2) 4.65 mm
(3) 4.55 mm
(4) 4.60 mm

Q540. Experimental Physics, 2024 (31 Jan Shift 2)

The measured value of the length of a simple pendulum is $20\ \mathrm{cm}$ with $2\ \mathrm{mm}$ accuracy. The time for 50 oscillations was measured to be 40 seconds with 1 second resolution. From these measurements, the accuracy in the measurement of acceleration due to gravity is $N\%$. The value of N is:

(1) 4
(2) 8
(3) 6
(4) 5

Q541. Experimental Physics, 2024 (27 Jan Shift 2)

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

Assertion (A) : In Vernier calliper if positive zero error exists, then while taking measurements, the reading taken will be more than the actual reading.

Reason (R) : The zero error in Vernier Calliper might have happened due to manufacturing defect or due to rough handling.

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

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

Q542. Experimental Physics, 2023 (10 Apr Shift 2)

In an experiment with vernier callipers of least count $0.1\ \mathrm{mm}$, when two jaws are joined together the zero of vernier scale lies right to the zero of the main scale and 6^{th} division of vernier scale coincides with the main scale division. While measuring the diameter of a spherical bob, the zero of vernier scale lies in between $3.2\ \mathrm{cm}$ and $3.3\ \mathrm{cm}$ marks and 4^{th} division of vernier scale coincides with the main scale division. The diameter of bob is measured as

(1) $3.22\ \mathrm{cm}$
(2) $3.18\ \mathrm{cm}$
(3) $3.26\ \mathrm{cm}$
(4) $3.25\ \mathrm{cm}$

Q543. Experimental Physics, 2023 (30 Jan Shift 1)

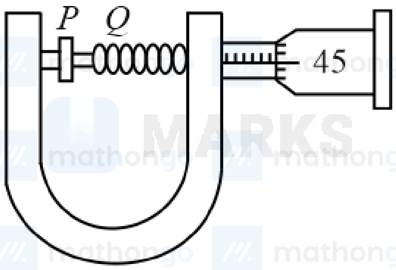
In a screw gauge, there are 100 divisions on the circular scale and the main scale moves by $0.5\ \mathrm{mm}$ on a complete rotation of the circular scale. The zero of circular scale lies 6 divisions below the line of graduation when two studs are brought in contact with each other. When a wire is placed between the studs, 4 linear scale divisions are clearly visible while 46^{th} division the circular scale coincide with the reference line. The diameter of the wire is ______ $\times 10^{-2}\ \mathrm{mm}$.

Q544. Experimental Physics, 2023 (29 Jan Shift 1)

In a metre bridge experiment the balance point is obtained if the gaps are closed by $2\ \Omega$ and $3\ \Omega$. A shunt of $X\ \Omega$ is added to $3\ \Omega$ resistor to shift the balancing point by $22.5\ \mathrm{cm}$. The value of X is ______.

Q545. Experimental Physics, 2022 (29 Jul Shift 1)

In an experiment to find out the diameter of wire using screw gauge, the following observation were noted:



(a) Screw moves $0.5\ \mathrm{mm}$ on main scale in one complete rotation

(b) Total divisions on circular scale $= 50$

(c) Main scale reading is 2.5 mm
(d) 45^{th}msup division of circular scale is in the pitch line
(e) Instrument has 0.03 mm negative error Then the diameter of wire is :

(1) 2.92 mm
(2) 2.54 mm
(3) 2.98 mm
(4) 3.45 mm

Q546. Experimental Physics, 2022 (26 Jul Shift 1)

A screw gauge of pitch 0.5 mm is used to measure the diameter of uniform wire of length 6.8 cm, the main scale reading is 1.5 mm and circular scale reading is 7. The calculated curved surface area of wire to appropriate significant figures is
[Screw gauge has 50 divisions on the circular scale]

(1) $6.8\ \text{cm}^2$
(2) $3.4\ \text{cm}^2$
(3) $3.9\ \text{cm}^2$
(4) $2.4\ \text{cm}^2$

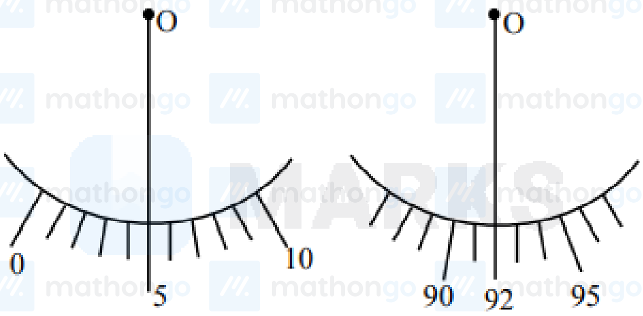
Q547. Experimental Physics, 2022 (26 Jul Shift 2)

In a Vernier Caliper 10 divisions of Vernier scale is equal to the 9 divisions of main scale. When both jaws of Vernier calipers touch each other, the zero of the Vernier scale is shifted to the left of zero of the main scale and 4^{th} Vernier scale division exactly coincides with the main scale reading. One main scale division is equal to 1 mm. While measuring diameter of a spherical body, the body is held between two jaws. It is now observed that zero of the Vernier scale lies between 30 and 31 divisions of main scale reading and 6^{th} Vernier scale division exactly. coincides with the main scale reading. The diameter of the spherical body will be:

(1) 3.02 cm
(2) 3.06 cm
(3) 3.10 cm
(4) 3.20 cm

Q548. Experimental Physics, 2021 (25 Jul Shift 1)

Student A and student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the radius of the wire is 0.322 cm. The absolute value of the difference between the final circular scale readings observed by the students A and B is ______.
[Figure shows position of reference O when jaws of screw gauge are closed]
Given pitch $= 0.1$ cm.



Screw gauge (A) Screw gauge (B)

Q549. Experimental Physics, 2020 (06 Sep Shift 1)

A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved and the lest count of the screw gauge, are respectively:

(1) Negative, 2μm
(2) Positive 10μm
(3) Positive $0.1mm$
(4) Positive, $0.1\mu m$

Q550. Experimental Physics, 2020 (06 Sep Shift 2)

A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings 5.50 mm, 5.55 mm, 5.34 mm, 5.65 mm. The average of these four reading is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should therefore be recorded as :

(1) (5.5375 ± 0.0739) mm
(2) (5.5375 ± 0.0740) mm
(3) (5.538 ± 0.074) mm
(4) (5.54 ± 0.07) mm

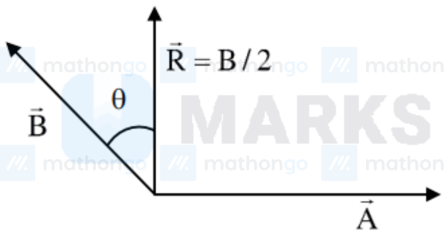
ANSWER KEYS

1. (150)	**2.** (1)	**3.** (2)	**4.** (3)	**5.** (25)	**6.** (4)	**7.** (3)	**8.** (1)
9. (2)	**10.** (1)	**11.** (4)	**12.** (1)	**13.** (3)	**14.** (1)	**15.** (4)	**16.** (1)
17. (2)	**18.** (1)	**19.** (3)	**20.** (2)	**21.** (2)	**22.** (1)	**23.** (1)	**24.** (2)
25. (673)	**26.** (1)	**27.** (4)	**28.** (2)	**29.** (200)	**30.** (4)	**31.** (1)	**32.** (3)
33. (1)	**34.** (3)	**35.** (1)	**36.** (1)	**37.** (3)	**38.** (1)	**39.** (580)	**40.** (2)
41. (3)	**42.** (15)	**43.** (5)	**44.** (2)	**45.** (3)	**46.** (30)	**47.** (2)	**48.** (120)
49. (2)	**50.** (3)	**51.** (2)	**52.** (240)	**53.** (4)	**54.** (2)	**55.** (2)	**56.** (2)
57. (2)	**58.** (2)	**59.** (3)	**60.** (3)	**61.** (4)	**62.** (1)	**63.** (4)	**64.** (3)
65. (1)	**66.** (3)	**67.** (3)	**68.** (1)	**69.** (1)	**70.** (36)	**71.** (2)	**72.** (21)
73. (2)	**74.** (2)	**75.** (2)	**76.** (1)	**77.** (4)	**78.** (4)	**79.** (2)	**80.** (2)
81. (24)	**82.** (2)	**83.** (1)	**84.** (1)	**85.** (120)	**86.** (3)	**87.** (16)	**88.** (2)
89. (10)	**90.** (1)	**91.** (15)	**92.** (4)	**93.** (4)	**94.** (2)	**95.** (2)	**96.** (3)
97. (4)	**98.** (20)	**99.** (1)	**100.** (2)	**101.** (1)	**102.** (3)	**103.** (4)	**104.** (13)
105. (4)	**106.** (4)	**107.** (250)	**108.** (10)	**109.** (16)	**110.** (2)	**111.** (3)	**112.** (10)
113. (5)	**114.** (3)	**115.** (52)	**116.** (3)	**117.** (3)	**118.** (1)	**119.** (3)	**120.** (195)
121. (3)	**122.** (15)	**123.** (1)	**124.** (4)	**125.** (2)	**126.** (1)	**127.** (2)	**128.** (2)
129. (2)	**130.** (4)	**131.** (2)	**132.** (1)	**133.** (2)	**134.** (1)	**135.** (1)	**136.** (1)
137. (3)	**138.** (2)	**139.** (4)	**140.** (1)	**141.** (1)	**142.** (1)	**143.** (4)	**144.** (2)
145. (2)	**146.** (2)	**147.** (12)	**148.** (2)	**149.** (16)	**150.** (2)	**151.** (1)	**152.** (20)
153. (48)	**154.** (4)	**155.** (2)	**156.** (1)	**157.** (3)	**158.** (25)	**159.** (1)	**160.** (4)
161. (3)	**162.** (3)	**163.** (1)	**164.** (3)	**165.** (3)	**166.** (3)	**167.** (4)	**168.** (4)
169. (3)	**170.** (3)	**171.** (2)	**172.** (2)	**173.** (363)	**174.** (3)	**175.** (3)	**176.** (1)
177. (3)	**178.** (25600)	**179.** (4)	**180.** (101)	**181.** (2)	**182.** (4)	**183.** (4)	**184.** (17)
185. (7)	**186.** (8)	**187.** (2)	**188.** (20)	**189.** (4)	**190.** (2)	**191.** (1)	**192.** (4)
193. (1)	**194.** (4)	**195.** (2)	**196.** (2)	**197.** (4)	**198.** (2)	**199.** (1)	**200.** (1)
201. (104)	**202.** (4)	**203.** (152)	**204.** (80)	**205.** (5)	**206.** (10)	**207.** (1)	**208.** (2)
209. (1)	**210.** (2)	**211.** (4)	**212.** (2)	**213.** (2)	**214.** (60)	**215.** (3)	**216.** (4)
217. (31)	**218.** (2)	**219.** (4)	**220.** (2)	**221.** (1)	**222.** (3)	**223.** (2)	**224.** (1)
225. (4)	**226.** (4)	**227.** (2)	**228.** (1)	**229.** (4)	**230.** (3)	**231.** (750)	**232.** (2)
233. (2)	**234.** (2)	**235.** (17258)	**236.** (2)	**237.** (4)	**238.** (2)	**239.** (1819)	**240.** (1)
241. (3)	**242.** (3)	**243.** (3)	**244.** (1)	**245.** (1)	**246.** (3)	**247.** (3)	**248.** (4)

249. (3)	**250.** (2)	**251.** (1)	**252.** (2)	**253.** (4)	**254.** (2)	**255.** (2)	**256.** (2)
257. (4)	**258.** (1)	**259.** (3)	**260.** (2)	**261.** (3)	**262.** (16)	**263.** (2)	**264.** (8)
265. (3)	**266.** (8)	**267.** (1)	**268.** (3)	**269.** (2)	**270.** (1)	**271.** (136)	**272.** (3)
273. (2)	**274.** (2)	**275.** (1)	**276.** (1)	**277.** (3)	**278.** (3)	**279.** (1)	**280.** (36)
281. (3)	**282.** (3)	**283.** (2)	**284.** (2)	**285.** (86)	**286.** (4)	**287.** (750)	**288.** (81)
289. (75)	**290.** (1)	**291.** (60)	**292.** (1)	**293.** (1)	**294.** (6)	**295.** (2)	**296.** (1)
297. (2)	**298.** (1)	**299.** (2)	**300.** (3)	**301.** (1)	**302.** (2)	**303.** (1)	**304.** (2)
305. (2)	**306.** (25)	**307.** (4)	**308.** (5)	**309.** (3)	**310.** (5)	**311.** (1)	**312.** (3)
313. (1)	**314.** (3)	**315.** (20)	**316.** (4)	**317.** (1)	**318.** (19)	**319.** (48)	**320.** (3)
321. (2)	**322.** (3)	**323.** (4)	**324.** (1)	**325.** (1)	**326.** (4)	**327.** (1)	**328.** (1)
329. (3)	**330.** (1)	**331.** (40)	**332.** (3)	**333.** (10)	**334.** (4)	**335.** (6)	**336.** (4)
337. (3)	**338.** (4)	**339.** (1)	**340.** (2)	**341.** (28)	**342.** (5)	**343.** (500)	**344.** (50)
345. (5)	**346.** (72)	**347.** (3)	**348.** (6)	**349.** (160)	**350.** (3)	**351.** (2)	**352.** (2)
353. (2)	**354.** (4)	**355.** (3)	**356.** (2)	**357.** (2)	**358.** (4)	**359.** (250)	**360.** (3)
361. (3)	**362.** (3)	**363.** (4)	**364.** (4)	**365.** (3)	**366.** (1)	**367.** (1)	**368.** (4)
369. (10)	**370.** (3)	**371.** (0)	**372.** (216)	**373.** (128)	**374.** (2)	**375.** (2)	**376.** (60)
377. (18)	**378.** (3)	**379.** (4)	**380.** (30)	**381.** (3)	**382.** (2)	**383.** (4)	**384.** (2)
385. (2)	**386.** (1)	**387.** (3)	**388.** (3)	**389.** (5)	**390.** (1)	**391.** (175)	**392.** (2)
393. (4)	**394.** (2)	**395.** (22)	**396.** (250)	**397.** (36)	**398.** (3)	**399.** (40)	**400.** (2)
401. (3)	**402.** (3)	**403.** (100)	**404.** (1)	**405.** (2)	**406.** (3)	**407.** (1)	**408.** (4)
409. (4)	**410.** (60)	**411.** (3)	**412.** (2)	**413.** (20)	**414.** (3)	**415.** (2)	**416.** (1)
417. (1)	**418.** (2)	**419.** (120)	**420.** (27)	**421.** (1)	**422.** (1)	**423.** (210)	**424.** (3)
425. (1)	**426.** (50)	**427.** (2)	**428.** (30)	**429.** (1)	**430.** (3)	**431.** (1)	**432.** (158)
433. (4)	**434.** (3)	**435.** (3)	**436.** (2)	**437.** (4)	**438.** (4)	**439.** (13)	**440.** (462)
441. (2)	**442.** (10)	**443.** (2)	**444.** (2)	**445.** (4)	**446.** (3)	**447.** (2)	**448.** (75)
449. (2)	**450.** (2)	**451.** (2)	**452.** (4)	**453.** (1)	**454.** (750)	**455.** (4)	**456.** (3)
457. (4)	**458.** (2)	**459.** (3)	**460.** (3)	**461.** (2)	**462.** (3)	**463.** (2)	**464.** (4)
465. (2)	**466.** (3)	**467.** (4)	**468.** (3)	**469.** (4)	**470.** (1)	**471.** (4)	**472.** (3)
473. (156)	**474.** (1)	**475.** (7)	**476.** (32)	**477.** (121)	**478.** (828)	**479.** (1)	**480.** (5)
481. (4)	**482.** (2)	**483.** (2)	**484.** (112)	**485.** (15)	**486.** (3)	**487.** (4)	**488.** (486)
489. (15)	**490.** (1)	**491.** (3)	**492.** (4)	**493.** (4)	**494.** (26)	**495.** (4)	**496.** (4)
497. (27)	**498.** (4)	**499.** (1)	**500.** (1)	**501.** (3)	**502.** (1)	**503.** (4)	**504.** (2)
505. (1)	**506.** (3)	**507.** (3)	**508.** (1)	**509.** (3)	**510.** (500)	**511.** (4)	**512.** (4)

513. (4)	**514.** (2)	**515.** (1)	**516.** (3)	**517.** (3)	**518.** (2)	**519.** (1)	**520.** (1)
521. (4)	**522.** (3)	**523.** (2)	**524.** (9)	**525.** (1)	**526.** (3)	**527.** (4)	**528.** (4)
529. (1)	**530.** (500)	**531.** (25)	**532.** (0)	**533.** (4)	**534.** (3)	**535.** (12)	**536.** (3)
537. (40)	**538.** (1)	**539.** (3)	**540.** (3)	**541.** (2)	**542.** (2)	**543.** (220)	**544.** (2)
545. (3)	**546.** (2)	**547.** (3)	**548.** (13)	**549.** (2)	**550.** (4)		

1.



(150)

$B\cos\theta = \frac{B}{2}$

$\Rightarrow \theta = 60^\circ$

So, angle between $\vec{A}$&$\vec{B}$ is $90^\circ + 60^\circ = 150^\circ$

2.

$T = 2\pi\sqrt{\frac{m}{k}}$

$T^2 \propto \frac{m}{k}$

(1) $\frac{2\Delta T}{T}\% = \frac{\Delta m}{m}\% - \frac{\Delta k}{k}\%$

$\frac{\Delta k}{k}\% = \frac{\Delta m}{m}\% - \frac{2\Delta T}{T}\%$

$\frac{\Delta k}{k}\% = (-1)\% - 2(2)\% = |-5\%| = 5\%$

3.

(2)

$\vec{R} = (2\vec{Q} + 2\vec{P}) + (2\vec{Q} - 2\vec{P})$

$\vec{R} = 4\vec{Q}$

Angle between $\vec{Q}$ and $\vec{R}$ is zero.

4. **(3)**

Rules for significant figures:

1. All non-zero numbers are significant
2. Zeros between two non-zero digits are significant
3. Leading zeros are not significant
4. Trailing zeros to the right of the decimal are significant
5. Trailing zeros in a whole number with the decimal shown are significant
6. Trailing zeros in a whole number with no decimal shown are not significant

From above rule, we get

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

5. **(25)**

The given data is

$l' = 1.2l A' = 0.96A$

$l' = 1.2l$

$A' = 0.96A$

Using the formula $R = \frac{\rho l}{A}$, the new resistance is

$R' = \frac{1.2\rho l}{0.96A}$

$\Rightarrow R' = 1.25R$

$\Rightarrow \Delta R = 1.25R - R = 0.25R$

Hence, the percentage increase is

$= \frac{\Delta R}{R} \times 100 = \frac{0.25R}{R} \times 100 = 25\%$

$= \frac{\Delta R}{R} \times 100$

$= \frac{0.25R}{R} \times 100 = 25\%$

6. **(4)**

Heat generated through resistance is given by, $H = i^2Rt$

Therefore, the percentage error in the calculation can be found by,

$\Rightarrow \frac{\Delta H}{H} \times 100 = 2 \times \frac{\Delta i}{i} \times 100 + \frac{\Delta R}{R} \times 100 + \frac{\Delta t}{t} \times 100$

$\Rightarrow \frac{\Delta H}{H} \times 100 = 4\% + 1\% + 3\%$

$\Rightarrow \frac{\Delta H}{H} \times 100 = 8\%$

7. **(3)**

Volume of the wire is $V = \pi r^2 l$.

Density of the wire is $\rho = \frac{m}{\pi r^2 l}$

Relative error in measurement of density

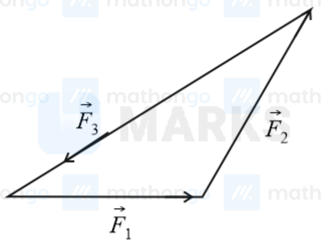
$\Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2 \times \frac{\Delta r}{r} + \frac{\Delta l}{l}$

$= \frac{0.006}{0.6} + 2 \times \frac{0.005}{0.5} + \frac{0.04}{4}$

$= 0.01 + 0.02 + 0.01 = 0.04$

$\therefore$ Percentage error in $\rho = 0.04 \times 100 = 4\%$

8. **(1)** Use triangle law of vector addition,



here, $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$, since net force is zero it means the body is in equilibrium so both the statements are correct.

9. **(2)** $\vec{F}_1$ and $\vec{F}_2$ at θ_1

$F_{net\ 1} = \sqrt{P^2 + Q^2 + P^2 + Q^2 + 2\left(P^2 + Q^2\right)\cos\theta_1}$

$F_{net\ 2} = \sqrt{P^2 + Q^2 + P^2 + Q^2 + 2\left(P^2 + Q^2\right)\cos\theta_2}$

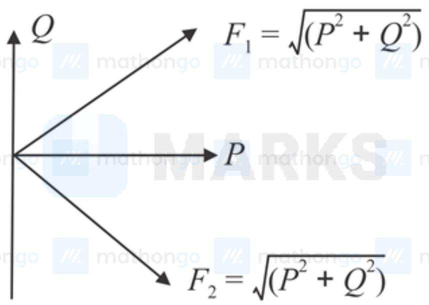
If $F_{net\ 1} = \sqrt{3\left(P^2 + Q^2\right)} = \sqrt{2\left(P^2 + Q^2\right) + 2\left(P^2 + Q^2\right)\cos\theta_1}$

$\Rightarrow \cos\theta_1 = \frac{P^2 + Q^2}{2\left(P^2 + Q^2\right)}$

$\Rightarrow \theta_1 = 60°$

$F_{net\ 2} = \sqrt{2\left(P^2 + Q^2\right)} = \sqrt{2\left(P^2 + Q^2\right) + 2\left(P^2 + Q^2\right)\cos\theta_2}$

$\Rightarrow \cos\theta_2 = 0 \Rightarrow \theta_2 = 90°$



10. **(1)**

$T = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow g = \frac{4\pi^2\ell}{T^2}$

$\frac{\Delta g}{g} = \frac{\Delta\ell}{\ell} + \frac{2\Delta T}{T}$

$\Delta T = \frac{\text{least count of time } (\Delta T_0)}{\text{number of oscillations } (n)}$

$\frac{\Delta g}{g} = \frac{\Delta\ell}{\ell} + \frac{2\Delta T_0}{nT}$

As $\Delta\ell$ and ΔT_0 are same for all observations so

$\frac{\Delta g}{g}$ is minimum for highest value of ℓ, n and T

$\Rightarrow$ Minimum percentage error in g is for student number 1.

11. $[\mathrm{uG}]=\left[\left(\mathrm{M}^1 \mathrm{~L}^{-1} \mathrm{~T}^{-2}\right)\left(\mathrm{M}^{-1} \mathrm{~L}^3 \mathrm{~T}^{-2}\right)\right]$

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

$[\sqrt{\mathrm{uG}}]=\left[\mathrm{L}^1 \mathrm{~T}^{-2}\right]$

12. **(1)** Comparing the given equation with standard equation of standing $\frac{2\pi n}{\lambda}=\omega \& \frac{2\pi}{\lambda}=k$

$\left[\frac{\mathrm{n}}{\lambda}\right]=[\omega]=\mathrm{T}^{-1}$

$[\mathrm{nt}]=[\lambda]=\mathrm{L}$

$[\mathrm{n}]=[\lambda\omega]=\mathrm{LT}^{-1}$

$[\mathrm{x}]=[\lambda]=\mathrm{L}$

13. **(3)**

Viscous force is given by, $F=\eta A \frac{dv}{dy}$.

Hence, $\left[\mathrm{MLT}^{-2}\right]=\eta\left[\mathrm{L}^2\right]\left[\mathrm{T}^{-1}\right]$

$\Rightarrow \eta=\left[\mathrm{ML}^{-1} \mathrm{T}^{-1}\right]$

Surface tension is given by, $ST=\frac{F}{\ell}$.

Hence, dimension will be $=\frac{\left[\mathrm{MLT}^{-2}\right]}{[\mathrm{L}]}=\left[\mathrm{ML}^0 \mathrm{T}^{-2}\right]$

Angular momentum, $L=mvr=\left[\mathrm{ML}^2 \mathrm{T}^{-1}\right]$

Rotational kinetic energy, $K.E=\frac{1}{2} I\omega^2=\left[\mathrm{ML}^2 \mathrm{T}^{-2}\right]$

14. **(1)**

The dimensions of the required quantities can be written as

$E=h\nu \Rightarrow [h]=\frac{[E]}{[\nu]} \Rightarrow \left[h\right]=\frac{\left[\mathrm{ML}^2 \mathrm{T}^{-2}\right]}{\left[\mathrm{T}^{-1}\right]}=\left[\mathrm{ML}^2 \mathrm{T}^{-1}\right]$

$E=h\nu$

$\Rightarrow [h]=\frac{[E]}{[\nu]}$

$\Rightarrow \left[h\right]=\frac{\left[\mathrm{ML}^2 \mathrm{T}^{-2}\right]}{\left[\mathrm{T}^{-1}\right]}$

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

$[L]=[mvr]$

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

$=\left[\mathrm{ML}^2 \mathrm{~T}^{-1}\right]$

$[p]=[mv]$

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

$=\left[\mathrm{ML}^1 \mathrm{~T}^{-1}\right]$

$[\tau]=[Fr]$

$=\left[\mathrm{MLT}^{-2}\right][\mathrm{L}]$

$=\left[\mathrm{ML}^2 \mathrm{~T}^{-2}\right]$

where, h is Planck's constant, L is angular momentum, p is linear momentum and τ is moment of force.

From the above analysis, it can be concluded that Statement I is true, but statement II is false.

15. **(4)**

Given that energy density $U=\frac{\alpha}{\beta} \sin \frac{\alpha x}{kt}$

As $\frac{\alpha x}{kt}$ should be dimensionless, the dimensions of αx and kt should be same.

$\Rightarrow [\alpha][x]=[k][t] \Rightarrow [\alpha]=\frac{[k][t]}{[x]}$

Now,

$[U]=\frac{[\alpha]}{[\beta]}$

$$\Rightarrow [\beta] = \frac{[\alpha]}{[U]} = \frac{[k][t]}{[x]\left[\frac{E}{V}\right]} = \frac{\left[\frac{E}{t}\right][t]}{[x]\left[\frac{E}{V}\right]}$$

$$\Rightarrow [\beta] = \frac{\left[L^3\right]}{[L]} = \left[M^0L^2T^0\right]$$

16. (1)

We know, Viscosity = Pascal- second

Let $[\eta] = P^xA^yT^z = \left[M^1L^{-1}T^{-1}\right]$

$\Rightarrow \left[M^1L^{+1}T^{-1}\right]^x\left[L^2\right]^y\left[T^1\right]^z = M^1L^{-1}T^{-1}$

$\Rightarrow M^xL^{+x+2y}T^{-x+z} = M^1L^{-1}T^{-1}$

From above, we have

$x = 1 \quad x + 2y = -1 \quad -x + z = -1$

$x = 1$
$x + 2y = -1$
$-x + z = -1$

Solving above three equations, we get

$y = -1$ and $z = 0$

So, Viscosity $= \left[P^1A^{-1}T^0\right]$

17. (2)

The dimension of magnetic induction is, $MT^{-2}A^{-1}$, the dimension of magnetic flux is, $\phi = \vec{B}\cdot\vec{A} \Rightarrow [\phi] = ML^2T^{-2}A^{-1}$, the dimension of magnetic permeability, $MLT^{-2}A^{-2}$ and, the dimension of magnetization, $M^0L^{-1}A$.

18. (1)

q = CV

$\left[C\right] = \left[\frac{q}{V}\right] = \frac{(A\times T)^2}{ML^2T^{-2}}$

$= M^{-1}L^{-2}T^4A^2$

$\left[E\right] = \left[\frac{F}{q}\right] = \frac{MLT^{-2}}{AT}$

$= MLT^{-3}A^{-1}$

$F = \frac{q_1q_2}{4\pi\epsilon_0r^2}$

$\left[\epsilon_o\right] = M^{-1}L^{-3}T^4A^2$

Speed of light $c = \frac{1}{\sqrt{\mu_0\epsilon_o}}$

$\mu_0 = \frac{1}{\epsilon_0c^2}$

$\left[\mu_0\right] = \frac{1}{\left[M^{-1}L^{-3}T^4A^2\right]\left[LT^{-1}\right]^2}$

$= \left[M^1L^1T^{-2}A^{-2}\right]$

19. (3) $\frac{IFv^2}{WL^4} = \frac{\left(M^1L^2\right)\left(M^{+}L^1T^{-2}\right)\left(L^1T^{-2}\right)^2}{\left(M^1L^2T^{-2}\right)\left(L^4\right)} = \frac{M^1L^{-2}T^{-2}}{L^3} = M^4L^{-1}T^{-2} =$ Energy density

20. (2)

$[hc] = \left[MLT^{-2}3\right]$

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

$[G] = \left[M^{-1}L^3T^{-2}\right]$

Substituting the dimensional formulas in the given formula,

$[f] = \left[ML^2T^{-2}\right]$

21. (2) $V = K(h)^a(I)^b(G)^c(C)^d$ (V is voltage)

We know $\left[h\right] = ML^2T^{-1}$

$[I] = A$

$\left[G\right] = M^{-1}L^3T^{-2}$

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

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

$ML^2T^{-3}A^{-1} = \left(ML^2T^{-1}\right)^a(A)^b\left(M^{-1}L^3T^{-2}\right)^c\left(LT^{-1}\right)^d$

$ML^2T^{-3}A^{-1} = M^{a-c}L^{2a+3c+d}T^{-a-2c-d}A^b$

$a - c = 1$ .....(1)

$2a + 3c + d = 2$ .....(2)

$-a - 2c - d = -3$ .....(3)

$b = -1$ ...(4)

On solving

$c = -1$

$a = 0$

$d = 5,\ b = -1$

$V = K(h)^0(A)^{-1}(G)^{-1}(C)^5$

22.

$$t_1 = \frac{u + \sqrt{u^2 + 2gh}}{g}$$

$$t_2 = \frac{-u + \sqrt{u^2 + 2gh}}{g}$$

(1) $t = \frac{\sqrt{2gh}}{g}$

$$t_1t_2 = \frac{\left(u^2 + 2gh\right) - u^2}{g^2} = \frac{2gh}{g^2} = t^2$$

$\Rightarrow t = \sqrt{t_1t_2}$

23. **(1)**

Given: $t = \alpha x^2 + \beta x$

Differentiating w.r.t time, we get

$\frac{dt}{dx} = 2\alpha x + \beta$

$\Rightarrow \frac{1}{v} = 2\alpha x + \beta$

Differentiating w.r.t time again, we get

$\Rightarrow -\frac{1}{v^2}\frac{dv}{dt} = 2\alpha\frac{dx}{dt}$

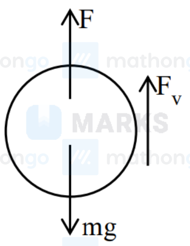
$\Rightarrow \frac{dv}{dt} = -2\alpha v^3\left[\text{as } v = \frac{dx}{dt}\right] \Rightarrow a = \frac{dv}{dt} = -2\alpha v^3$

$\Rightarrow \frac{dv}{dt} = -2\alpha v^3\left[\text{as } v = \frac{dx}{dt}\right]$

$\Rightarrow a = \frac{dv}{dt} = -2\alpha v^3$

24. **(2)**

Consider a small steel ball as shown below:



As shown in diagram, buoyancy force $F_B = F$.

Applying Newton's second law, we get

$mg - F_B - F_v = ma$

$\Rightarrow \left(\rho\frac{4}{3}\pi r^3\right)g - \left(\rho_L\frac{4}{3}\pi r^3\right)g - 6\pi\eta rv = m\frac{dv}{dt}$

Let $\frac{4}{3m}\pi R^3g\left(\rho - \rho_L\right) = K_1$ and $\frac{6\pi\eta r}{m} = K_2$, then we get

$\Rightarrow \frac{dv}{dt} = K_1 - K_2 v$

Integrating both sides, we get

$\Rightarrow \int_0^v \frac{dv}{K_1 - K_2 v} = \int_0^t dt$

$\Rightarrow -\frac{1}{K_2} \ln\left[K_1 - K_2 v\right]_0^v = t$

$\Rightarrow \ln\left(\frac{K_1 - K_2 v}{K_1}\right) = -K_2 t$

$\Rightarrow K_1 - K_2 v = K_1 e^{-K_2 t}$

$\Rightarrow v = \frac{K_1}{K_2}\left[1 - e^{-K_2 t}\right]$

Clearly, option B matches with the given variation of velocity with time.

25. **(673)**

Given, $u_x = 5 \text{ m s}^{-1}$, $a_x = 3 \text{ m s}^{-2}$, $x = 84 \text{ m}$

The formula to calculate the velocity of the particle along x-axis is given by

$v_x^2 = u_x^2 + 2ax \quad \ldots(1)$

From equation (1), it follows that

$v_x^2 = 25 + 2(3)(84) \Rightarrow v_x = 23 \text{ m s}^{-1}$

$v_x^2 = 25 + 2(3)(84)$

$\Rightarrow v_x = 23 \text{ m s}^{-1}$

Also, the velocity of the particle along x-axis can be written as

$v_x = u_x + a_x t \quad \ldots(2)$

From equation (2), it follows that

$t = \frac{23-5}{3}$

$= 6 \text{ s}$

Similarly, for the y - component of the velocity, it follows that

$v_y = 0 + a_y t$

$= 0 + 2 \times (6)$

$= 12 \text{ m s}^{-1}$

Hence, the magnitude of the velocity is given by

$v^2 = v_x^2 + v_y^2 = 23^2 + 12^2 = 673 v = \sqrt{673} \text{ m s}^{-1}$

$v^2 = v_x^2 + v_y^2$

$= 23^2 + 12^2$

$= 673$

$v = \sqrt{673} \text{ m s}^{-1}$

Therefore, $\alpha = 673$.

26. **(1)**

When the bullet just enters the target, its equation of motion is given by

$v^2 - u^2 = 2aS \quad \ldots(1)$

Equation (1) implies that

$\left(\frac{2u}{3}\right)^2 = u^2 + 2(-a)\left(4 \times 10^{-2}\right) \Rightarrow \frac{4u^2}{9} = u^2 - 2a\left(4 \times 10^{-2}\right) \Rightarrow \frac{5u^2}{9} = 2a\left(4 \times 10^{-2}\right) \quad \ldots(2)$

$\left(\frac{2u}{3}\right)^2 = u^2 + 2(-a)\left(4 \times 10^{-2}\right)$

$\Rightarrow \frac{4u^2}{9} = u^2 - 2a\left(4 \times 10^{-2}\right)$

$\Rightarrow \frac{5u^2}{9} = 2a\left(4 \times 10^{-2}\right) \quad \ldots(2)$

When the bullet stops inside the target, its equation of motion can be written as

$0 = \left(\frac{2u}{3}\right)^2 + 2(-a)(x) \quad \ldots(3)$

Equation (3) implies that

$\frac{4u^2}{9} = 2ax \quad \ldots(4)$

Dividing equation (2) by equation (4), we have

$\frac{5}{4} = \frac{4 \times 10^{-2}}{x} \Rightarrow x = \frac{16}{5} \times 10^{-2} \Rightarrow x = 3.2 \times 10^{-2} \text{ m} = 32 \times 10^{-3} \text{ m}$

$\frac{5}{4} = \frac{4\times10^{-2}}{x}$
$\Rightarrow x = \frac{16}{5} \times 10^{-2}$
$\Rightarrow x = 3.2 \times 10^{-2}$ m
$= 32 \times 10^{-3}$ m
Hence, $D = 32$.

27. (4)

From the position time graph the velocity is found out by the slope of the line. The slope is given by $\frac{x_2 - x_1}{t_2 - t_1}$.

The slope of B is greater than A. Hence, the velocity of B is greater than A. As can be seen from the graph $X_A < X_B$. So A lives closer to the school and $V_B > V_A$. Hence, this is the correct option.

28. (2)

Acceleration can be written as, $a = v\frac{dv}{dx}$.
Given: $a = -2x$(-ve sign is due to retardation)
Therefore,
$v\frac{dv}{dx} = -2x \Rightarrow vdv = (-2x)dx$
$v\frac{dv}{dx} = -2x$
$\Rightarrow vdv = (-2x)dx$
Integrating both sides, we get

$\frac{1}{2}\left(v_f^2 - v_i^2\right) = -2\left(\frac{x^2}{2}\right) = x^2 \Rightarrow \left|\frac{1}{2}m\left(v_f^2 - v_i^2\right)\right| = mx^2$

$\frac{1}{2}\left(v_f^2 - v_i^2\right) = -2\left(\frac{x^2}{2}\right) = x^2$
$\Rightarrow \left|\frac{1}{2}m\left(v_f^2 - v_i^2\right)\right| = mx^2$

$\Rightarrow \left|\Delta KE\right| = 0.01x^2 = \left(\frac{10}{x}\right)^{-2}$

Hence, $n = 2$.

29. (200)
Given that, the initial velocity $u = 20$ m/s, the distance of the station $S_1 = 500$ m, and the final velocity $v = 0$.
The relation between the distance travelled (S) by the train with its initial velocity (u) and its final velocity (v) is given by
$v^2 = u^2 - 2aS.......................\left(1\right)$
where, a indicates the retardation of the train.
Substitute the values corresponding to the initial condition into equation (1) and solve to calculate the retardation of the train.
$0 = \left(20\right)^2 - 2 \times a \times 500$
$a = 0.4 \text{ m/s}^2$
For the second scenario, the initial velocity $u = 20$ m/s and the distance travelled by the train $S_2 = 250$ m.
Use these values along with the value of the retardation into equation (1) and solve to calculate the final velocity of the train.
$v^2 = \left(20\right)^2 - 2 \times 0.4 \times 250$
$= 200$
$v = \sqrt{200}.........................\left(2\right)$
Comparing the value of the final velocity obtained in equation (2) with the given expression, we get $x = 200$.

30. (4)

As the juggler is throwing n balls each second and 2nd when the first is at its highest point, so the time taken by one ball to reach the highest point, $t = \frac{1}{n}$ s.
And as at highest point $v = 0$.
So, from first equation of motion,

$v = u + at \Rightarrow 0 = u - g\left(\frac{1}{n}\right) \Rightarrow u = \frac{g}{n}$
$v = u + at$
$\Rightarrow 0 = u - g\left(\frac{1}{n}\right)$
$\Rightarrow u = \frac{g}{n}$

Now in order to calculate height, using second equation of motion, we have:

$S = ut + \frac{1}{2}at^2$ ...(i)

$\Rightarrow h = \frac{1}{n} \times \frac{g}{n} - \frac{1}{2}g \times \left(\frac{1}{n}\right)^2$

$\Rightarrow h = \frac{g}{2n^2}$

So, the balls rise up to a height of $h = \frac{g}{2n^2}$ m.

31. **(1)**

As the upward direction is taken as positive, the velocity at $t = 0$ is $u = -100$ m s^{-1}.

As it is falling under gravity, its acceleration is constant and $a = -10$ m s^{-2}.

Applying equation of motion for constant acceleration during the time of fall i.e., for 0 to 10 s,

$v = u + at \Rightarrow v = -100 - 10 \times 10 \Rightarrow v = -200$ m s^{-1}

$v = u + at$

$\Rightarrow v = -100 - 10 \times 10$

$\Rightarrow v = -200 \text{ m s}^{-1}$

After 10 s it hits the ground and remains at rest.

Therefore, option A is the correct representation.

32. **(3)**

When it is thrown upward, $-h = v \times 6 - \frac{1}{2}g(6)^2$

When it is thrown downward, $-h = -v \times 1.5 - \frac{1}{2}g(1.5)^2$

Therefore, $5h = 5[36 + 9]$ $h = 45$ m

When the ball is dropped, $h = \frac{1}{2}gt^2 \Rightarrow 45 = \frac{1}{2} \times 10 \times t^2 \Rightarrow t = 3$ s

Alternate method, $t = \sqrt{t_1t_2} = \sqrt{6 \times 1.5} = 3$ s

33. **(1)** The equation of the straight line, $y = mx + c$, from the above graph we get the equation, $v^2 = 2x + 20$, now differentiate it with respect to x,

$\Rightarrow 2v\frac{dv}{dx} = 2 \Rightarrow a = \frac{2}{2} = 1$ m s^{-2}.

34. **(3)**

$u = \sqrt{2gh}$

Now,

$S = \frac{h}{3}, \ a = -g$

$S = ut + \frac{1}{2}at^2$

$\frac{h}{3} = \sqrt{2gh}t + \frac{1}{2}(-g)t^2$

$t^2\left(\frac{g}{2}\right) - \sqrt{2gh}t + \frac{h}{3} = 0$

From quadratic equation

$t_1, \ t_2 = \frac{\sqrt{2gh} \pm \sqrt{2gh - \frac{4}{2}\frac{g\,h}{3}}}{g}$

$\frac{t_1}{t_2} = \frac{\sqrt{2gh} - \sqrt{\frac{4gh}{3}}}{\sqrt{2gh} + \sqrt{\frac{4gh}{3}}}$

$= \frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$

35. **(1)**

$t = mx^2 + nx$

$\frac{1}{v} = \frac{dt}{dx} = 2mx + n$

$V = \frac{1}{2mx + n}$

$\frac{dv}{dt} = -\frac{2m}{(2mx+n)^2}\left(\frac{dx}{dt}\right)$

$a = -(2m)v^3$

36. **(1)**

Total distance covered by the body is equal to the modulus of area under graph velocity-time graph

$\Rightarrow d = \left(\frac{1}{2} \times 4 \times 2\right) + (4 \times 1) + \left(\frac{1}{2} \times 4 \times \frac{4}{3}\right) + \left(\frac{1}{2} \times 2 \times \frac{5}{3}\right)$

$\Rightarrow d = 4 + 4 + \frac{8}{3} + \frac{5}{3}$

$\Rightarrow d = \frac{37}{3} \mathrm{m}$

37. (3)

38. (1)

$V_{MA} = -1.8 \mathrm{km\ hr}^{-1} = -0.5 \mathrm{~m\ s}^{-1}$

$V_{\mathrm{man}, B} = V_{\mathrm{man}, A} + V_{A, B}$

$= V_{\mathrm{man}, A} + V_A - V_B$

$= -0.5 + 10 - (-20)$

$= -0.5 + 30$

$= 29.5 \mathrm{~m\ s}^{-1}$

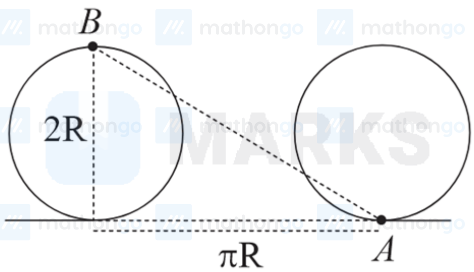
39. (580)

$\vec{v}_1 = (8 - 6t)\hat{i}$

$\vec{v}_2 = \left(-24t^2\right)\hat{j}$

$\left|\vec{v}_{21}\right| = \sqrt{580}$

40. (2)



The displacement is the hypotenuse of the diameter and the distance travelled for half the rotation πR.
By using Pythagoras theorem,

Displacement of $A = \sqrt{(2R)^2 + (\pi R)^2}$

$= R\sqrt{\pi^2 + 4}$

41. (3)

The trajectory of a projectile is parabolic in nature. At maximum height, it can be written that

$\frac{dy}{dx} = 0 \quad \ldots (1)$

Substitute the expression for trajectory into equation (1) and solve to calculate the horizontal distance, for which the projectile attains the maximum height.

$\frac{d}{dx}\left[x - \frac{x^2}{20}\right] = 0$

$\Rightarrow 1 - \frac{x}{10} = 0$

$\Rightarrow x = 10 \mathrm{~m}$

Substitute the value of x in the given expression for the trajectory to obtain the maximum height.

$y = \left(10 - \frac{10^2}{20}\right) \mathrm{m}$

$= 5 \mathrm{~m}$

42. (15)

The maximum range is given by, $R_{\max} = \frac{u^2 \sin 2(45°)}{g} = \frac{u^2}{g}$.
For the range to be half of the maximum range,

$\frac{R_{max}}{2} = \frac{u^2}{2\,g} = \frac{u^2 \sin 2\theta}{g}$

$\Rightarrow \sin 2\theta = \frac{1}{2}$

$\Rightarrow 2\theta = 30°$ or $2\theta = 150°$

$\Rightarrow \theta = 15°, 75°$

Therefore, answer is 15 or 75

43. **(5)**

Given here, initial velocity, $u_x = 1$

Equation of trajectory, $y = 5\,x(1 - x) = 5x - 5x^2$

Now, differentiating the above equation,

$\frac{dy}{dt} = 5\frac{dx}{dt} - 10x\frac{dx}{dt}$

For initial y-component of velocity

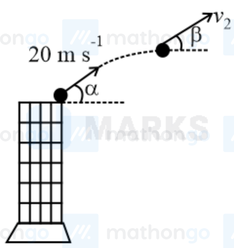
$u_y = \left(\frac{dy}{dt}\right)_{x=0} \Rightarrow 5(1) = 5$

$u_y = \left(\frac{dy}{dt}\right)_{x=0}$

$\Rightarrow 5(1) = 5$

$\vec{u}_y = 5\hat{j}$

44. **(2)**



Component of velocity in horizontal direction,

$v_x = 20\cos\alpha = v_2\cos\beta$

Component of velocity in vertical direction,

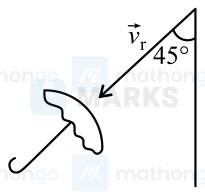
$v_y = 20\sin\alpha - g \times 10 = v_2\sin\beta$

$\Rightarrow \tan\beta = \frac{20\sin\alpha - 100}{20\cos\alpha}$

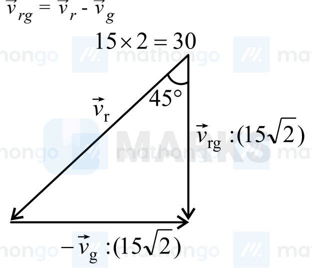
$\Rightarrow \tan\beta = \tan\alpha - \frac{5}{\cos\alpha}$

$\Rightarrow \tan\beta = \tan\alpha - 5\sec\alpha$

45. **(3)**



$\vec{v}_{rg} = \vec{v}_r - \vec{v}_g$



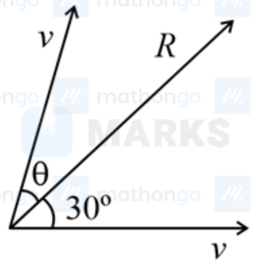
From the above diagram, velocity of the raindrop wrt ground will be,

$\left|\vec{v}_r\right| = \sqrt{\left(15\sqrt{2}\right)^2 + \left(15\sqrt{2}\right)^2} = 30\ \text{km h}^{-1}$

And velocity of the raindrop wrt the moving girl will be,

$\left|\vec{v}_{rg}\right| = 15\sqrt{2} = \frac{30}{\sqrt{2}}\ \text{km h}^{-1}$

46. **(30)**



Both velocity vectors are of same magnitude therefore resultant would pass exactly midway through them $\theta = 30°$

47. (2)

$\mu_s N = \frac{mv^2}{R}$

$N = \frac{mv^2}{\mu_s R} = mg + F_L$

$F_L = \frac{mv^2}{\mu_s R} - mg$

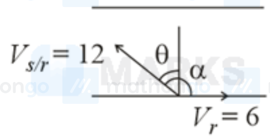
48. (120)

$12\sin\theta = v_r$

$\sin\theta = \frac{1}{2}$

$\theta = 30°$

$\therefore\ \alpha = 120°$



49. (2)

$F = -\alpha x^2$

$ma = -\alpha x^2$

$a = \frac{-\alpha x^2}{m}$

$\frac{vdv}{dx} = -\frac{\alpha}{m}x^2$

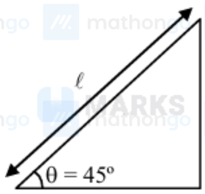
$\int_{v_0}^{0} vdv = \int_0^x -\frac{\alpha}{m}x^2 dx$

$\left(\frac{v^2}{2}\right)_{v_0}^{0} = -\frac{\alpha}{m}\left(\frac{x^3}{3}\right)_0^x$

$\frac{-v_0^2}{2} = -\frac{\alpha}{m}\frac{x^3}{3}$

$x = \left(\frac{3mv_0^2}{2\alpha}\right)^{\frac{1}{3}}$

50.



(3)

Case-1 : No friction

$a = g\sin\theta$

$\ell = \frac{1}{2}(g\sin\theta)t_1^2$

$t_1 = \sqrt{\frac{2\ell}{g\sin\theta}}$

Case-2 : With friction

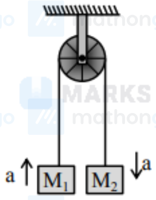
$a = g\sin\theta - \mu g\cos\theta$

$\ell = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)t_2^2$

$\sqrt{\frac{2\ell}{g\sin\theta - \mu g\cos\theta}} = n\sqrt{\frac{2\ell}{g\sin\theta}}$

$\mu = 1 - \frac{1}{n^2}$

51.



(2)

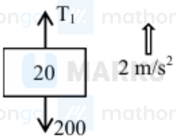
$a = \left(\frac{M_2 - M_1}{M_1 + M_2}\right)g$

$\frac{g}{\sqrt{2}} = \left(\frac{M_2 - M_1}{M_1 + M_2}\right)g$

$\left(M_1 + M_2\right) = \sqrt{2}M_2 - \sqrt{2}M_1$

$\frac{M_1}{M_2} = \left(\frac{\sqrt{2} - 1}{\sqrt{2} + 1}\right)$

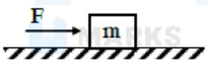
52. **(240)** FBD of M_1 :



$T_1 - 200 = (4 + 6 + 10) \times 2$

$\therefore T_1 = 240$

53.

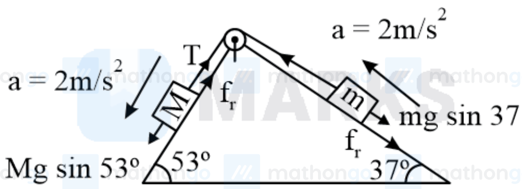


(4)

$F = ma \Rightarrow a = \frac{F}{m} = \frac{kt}{m}$

a vs t will be straight line passing through origin.

54. **(2)**



For M block:

$10g\sin 53° - \mu(10g)\cos 53° - T = 10 \times 2$

$\Rightarrow T = 80 - 15 - 20$

$\Rightarrow T = 45$ N

For m block:

$T - mg\sin 37° - \mu\, mg\cos 37° = m \times 2$

$\Rightarrow 45 = 10\, m$

$\Rightarrow m = 4.5$ kg

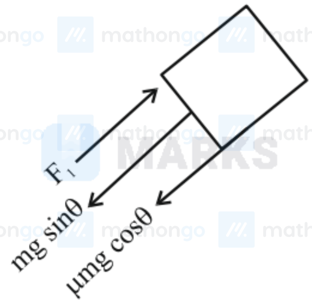
55. **(2)**

Limiting friction force is, $f_{max} = \mu(mg\cos\theta)$

$= 0.1 \times \frac{50 \times \sqrt{3}}{2}$

$= 2.5\sqrt{3}$ N

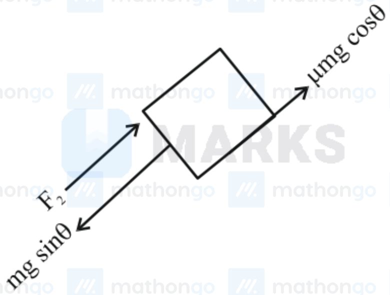
For first case:



We can write, $F_1 = mg\sin\theta + f_{max}$

$= 25 + 2.5\sqrt{3}$

For second case:



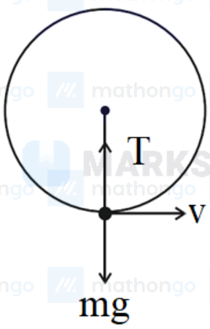
$F_2 = mg\sin\theta - f_{max}$

$= 25 - 2.5\sqrt{3}$

$\therefore F_1 - F_2 = 5\sqrt{3}$ N

56. (2)

Given that



Given the mass $m = 900\text{ g} = \frac{900}{1000}\text{ kg} = \frac{9}{10}\text{ kg}$,

The radius of the circular path $r = 1$ m

And, the angular velocity

$\omega = \frac{2\pi N}{60} = \frac{2\pi(10)}{60} = \frac{\pi}{3}\text{ rad s}^{-1}$

With reference to the above diagram, the formula to calculate the tension at the lowermost point can be written as

$T - mg = mr\omega^2 \Rightarrow T = mg + mr\omega^2 \quad \ldots(1)$

$T - mg = mr\omega^2$

$\Rightarrow T = mg + mr\omega^2 \quad \ldots(1)$

From equation (1), it follows that

$T = \frac{9}{10} \times 9.8 + \frac{9}{10} \times 1\left(\frac{\pi}{3}\right)^2$

$= 8.82 + \frac{9}{10} \times \frac{\pi^2}{9}$

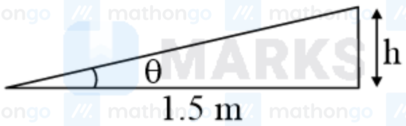
$= 8.82 + 0.98$

$= 9.8$ N

57. (2)

For the train, moving along the curved rails, it can be written, with reference to the figure below, that

$\tan\theta = \frac{v^2}{Rg}$ ...(1)



Also, from the above figure, it follows that

$\tan\theta = \frac{h}{1.5}$ ...(2)

Equations (1) and (2) imply that

$\frac{h}{1.5} = \frac{v^2}{Rg} \Rightarrow h = 1.5 \times \frac{v^2}{Rg} = 1.5 \times \frac{(12\ \text{m s}^{-1})^2}{400\ \text{m} \times 10\ \text{m s}^{-2}} = 0.054\ \text{m} = 5.4\ \text{cm}$

$\frac{h}{1.5} = \frac{v^2}{Rg}$

$\Rightarrow h = 1.5 \times \frac{v^2}{Rg}$

$= 1.5 \times \frac{(12\ \text{m s}^{-1})^2}{400\ \text{m} \times 10\ \text{m s}^{-2}}$

$= 0.054\ \text{m}$

$= 5.4\ \text{cm}$

58. (2)

The coin will slip when

$\mu mg = m\omega^2 r$

$\Rightarrow \mu g = \omega^2 \times 1\ \text{cm}$ ...(i)

Now, $\omega' = \frac{\omega}{2}$

$\mu g = \left(\frac{\omega}{2}\right)^2 R$ ...(ii)

Hence we can write from (i) and (ii)

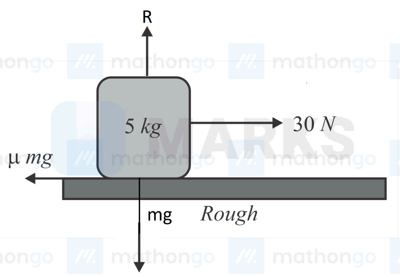
$\omega^2 \times 1\ \text{cm} = \frac{\omega^2}{4} R \Rightarrow R = 4\ \text{cm}$

$\omega^2 \times 1\ \text{cm} = \frac{\omega^2}{4} R$

$\Rightarrow R = 4\ \text{cm}$

59. (3)

Forces acting on block is shown below



From the second equation of motion,

$s = \frac{1}{2}at^2 \Rightarrow 50 = \frac{1}{2}a \times 10^2 \Rightarrow a = 1\ \text{m s}^{-2}$

$s = \frac{1}{2}at^2$

$\Rightarrow 50 = \frac{1}{2}a \times 10^2$

$\Rightarrow a = 1\ \text{m s}^{-2}$

Applying Newton's second law in vertical direction,

$R - mg = 0 \Rightarrow R = mg$

$R - mg = 0$

$\Rightarrow R = mg$

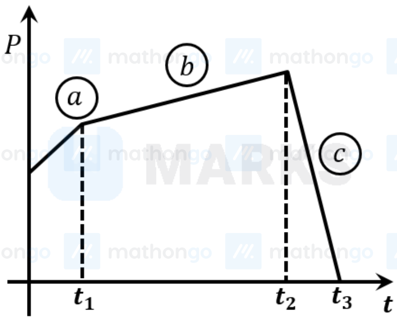
(where R is the magnitude of normal reaction on the block due to the surface)

If μ is the coefficient of kinetic friction between the block and the surface, applying Newton's second law in horizontal direction,

$30 - \mu R = ma \Rightarrow 30 - \mu mg = ma \Rightarrow 30 - 50\mu = 5 \Rightarrow \mu = \frac{1}{2} = 0.5$

$30 - \mu R = ma$
$\Rightarrow 30 - \mu mg = ma$
$\Rightarrow 30 - 50\mu = 5$
$\Rightarrow \mu = \frac{1}{2} = 0.5$

60. (3)



From Newton's second,

$|F| = \left|\frac{dp}{dt}\right| = |\text{slope of p - t curve}|$

From the given graph, we can see that slope of region c is maximum and slope of region b is minimum.

Thus, $|F_c| > |F_a| > |F_b|$.

61. (4)

Let angle of inclination is $\theta = 45°$.

Then, acceleration along the incline in case of smooth incline will be, $a_1 = g\sin\theta = \frac{g}{\sqrt{2}}$.

In case of rough incline, kinetic friction will act against the direction of motion. Normal force acting on the object will be $mg\cos\theta$. Therefore, acceleration along the inc in case of rough incline will be,

$a_2 = g\sin\theta - \mu g\cos\theta = \frac{g}{\sqrt{2}} - \frac{\mu g}{\sqrt{2}}$.

Now as per question,

$t_2 = nt_1$

and as the displacement covered is the same in both case, $0 + \frac{1}{2}a_1t_1^2 = 0 + \frac{1}{2}a_2t_2^2$

$\Rightarrow \frac{g}{\sqrt{2}}t_1^2 = \left(\frac{g}{\sqrt{2}} - \frac{\mu g}{\sqrt{2}}\right)n^2t_1^2$

$\Rightarrow \mu = 1 - \frac{1}{n^2}$

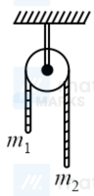
62. (1)

The required centripetal force will be provided by the normal reaction

$\Rightarrow N = \frac{mv^2}{r}$

This equation is similar to $y = kx^2$ which is a parabola.

63. (4)



According to the information given in the question, the part of the chain that envelopes the pulley is very small. Therefore, the acceleration of the chain can be written as,

$a = \frac{(m_2 - m_1)}{(m_2 + m_1)}g$

Since $a = \frac{g}{2}$

$\frac{g}{2} = \frac{(m_2 - m_1)}{(m_2 + m_1)}g \Rightarrow \frac{g}{2} = \frac{(L - l) - l}{L}g \Rightarrow l = \frac{L}{4} = \frac{L}{x}$

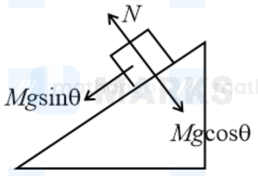
$\frac{g}{2} = \frac{(m_2 - m_1)}{(m_2 + m_1)} g$

$\Rightarrow \frac{g}{2} = \frac{(L-l)-l}{L} g$

$\Rightarrow l = \frac{L}{4} = \frac{L}{x}$

$\Rightarrow x = 4$

64. (3)



As per the information given in the question the lift is moving upward with uniform velocity. Therefore, the frame of reference attached to the lift is an inertial frame of reference. The acceleration of the block down the incline will be,

$a = g\sin\theta$

Using equation of motion for constant acceleration,

$s = ut + \frac{1}{2}at^2$

$\Rightarrow l = \frac{1}{2}g\sin 30°(2)^2 \quad \ldots (1)$

When the inclination is changed to 45°,

$l = \frac{1}{2}g\sin 45° t^2 \quad \ldots (2)$

Equating the above equations,

$\frac{1}{2}g\sin 30°(2)^2 = \frac{1}{2}g\sin 45°(t)^2$

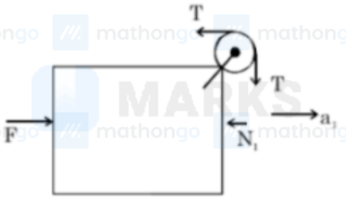
$\Rightarrow \left(\frac{1}{2}\right)(4) = \frac{1}{\sqrt{2}}t^2 \Rightarrow t = \sqrt{2\sqrt{2}} = 1.68$ s

$\Rightarrow \left(\frac{1}{2}\right)(4) = \frac{1}{\sqrt{2}}t^2$

$\Rightarrow t = \sqrt{2\sqrt{2}} = 1.68$ s

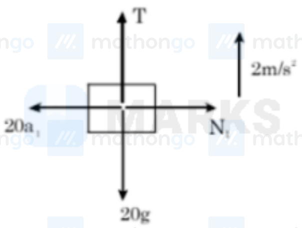
65. (1) Let acceleration of 100 kg block $= a_1$

FBD of 100 kg block w.r.t ground



$F - T - N_1 = 100a_1$ ... (i)

FBD of 20 block wrt 100 kg



$T - 20\,g = 20(2)$

$T = 240$ ... (ii)

$N_1 = 20a_1$ ... (iii)

FBD of 10 kg block wrt 100 kg

$10a_1 - 240 = 10(2)$

$a_1 = 26\ m/s^2$

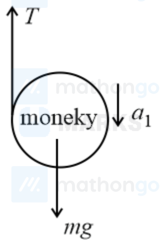
$F - 240 - 20(26) = 100 \times 26$

$\Rightarrow F = 3360$ N

66. (3)

Let a_1 be the acceleration of monkey while moving down.

F.B.D of monkey while moving downward



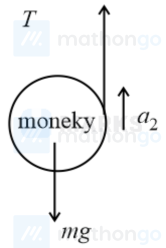
Using Newton's second law of motion,

$mg - T = ma_1$

$\therefore\ 500 - T = 50 \times 4 \Rightarrow T = 300$ N

Let a_2 be the acceleration of monkey while moving up.

F.B.D of monkey while moving up



Using Newton's second law of motion

$T - mg = ma_2$

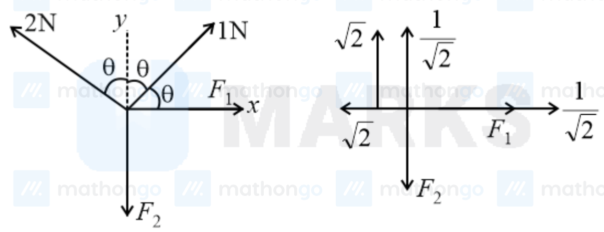
$\Rightarrow\ T - 500 = 50 \times 5$

$\Rightarrow T = 750$ N

Breaking strength of rope $= 750 - 300 = 350$ N

$\therefore$ Rope will break while monkey is moving upward.

67. (3)



Here, $\theta = 45°$

Applying equilibrium conditions,

Taking components along x & y

Considering right side positive, $\sum F_x = 0$

$F_1 + 1\sin45° - 2\sin45° = 0F_1 = 2\sin45° - 1\sin45°$

$F_1 + 1\sin 45^\circ - 2\sin 45^\circ = 0$

$F_1 = 2\sin 45^\circ - 1\sin 45^\circ$

$F_1 = \sqrt{2} - \frac{1}{\sqrt{2}} = \frac{2-1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

Taking upward positive, $\sum F_y = 0$

$1\cos45° + 2\cos45° - F_2 = 0F_2 = 1\cos45° + 2\cos45°$

$1\cos 45^\circ + 2\cos 45^\circ - F_2 = 0$

$F_2 = 1\cos 45^\circ + 2\cos 45^\circ$

$F_2 = \sqrt{2} + \frac{1}{\sqrt{2}} = \frac{2+1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$

$F_1 : F_2 = 1 : 3$

$x = 3$

68. (1)

Let additional force required be $\vec{F}$.

Vector sum of the four forces and additional force.

$\vec{F} + 5\hat{i} - 6\hat{i} + 7\hat{j} - 8\hat{j} = 0$

Force required to make net acceleration zero

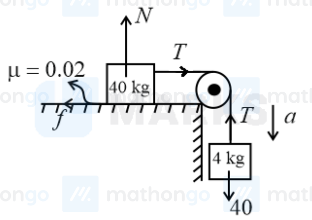
$\vec{F} = \hat{i} + \hat{j}$

Therefore, the required force is $|\vec{F}| = \sqrt{1^2 + 1^2} = \sqrt{2}$ N

Angle with x-axis: $\tan\theta = \frac{y \text{ component}}{x \text{ component}} = \frac{1}{1}$

Thus, $\theta = 45°$

69. (1)



For hanging block,

$40 - T = 4a \quad \cdots(1)$

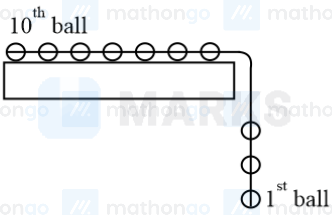
Now, maximum value of friction force will be,

$f_{max} = \mu N = 0.02 \times 40 \times 10 = 8$ N

For block on table, $T - 8 = 40a \quad \cdots(2)$

From equation(1) and equation (2), we get$32 = 44a \Rightarrow a = \frac{32}{44} = \frac{8}{11}$ m s^{-2}

70. (36)



Acceleration,$a = \frac{\text{Net pulling force}}{\text{Total mass}}$

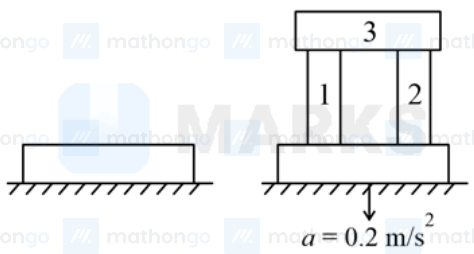
$a = \frac{6mg}{10m} = \frac{6g}{10} = 6$ m s^{-2}

Considering ball 8, 9 & 10 as system, tension between ball 7 & 8 can be written as,

$T_{7,8} = (3m) \times a$

$= 3 \times 2 \times 6 = 36$ N

71. (2)



Writing force equation in vertical direction,

$Mg - N = Ma$

$\Rightarrow 70\,g - N = 70 \times 0.2$

$\Rightarrow N = 70[g - 0.2] = 70 \times 9.8$

$\therefore N = 686$ newton

Note: Since there is no compressive normal from the sides, hence friction will not act.

Hence option 2.

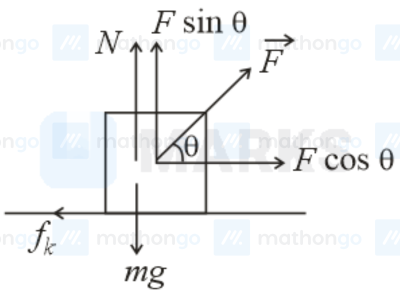
72. (21)

$a_{\max} = \mu g = \frac{3}{7} \times 9.8$

$F = (M + m)a_{\max} = 5a_{\max}$

$= 21$ N

73. (2)



$N = mg - f\sin\theta$

$F\cos\theta - \mu_k N = ma$

$F\cos\theta - \mu_k(mg - F\sin\theta) = ma$

$a = \frac{F}{m}\cos\theta - \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

74. $a_c = \omega^2 x$

$\frac{vdv}{dx} = \omega^2 x$

$\int_0^v vdv = \int_1^3 \omega^2 x dx$

(2) $\frac{v^2}{2} = \omega^2\left[\frac{x^2}{2}\right]$

$\frac{v^2}{2} = \frac{\omega^2}{2}\left[3^2 - 1^2\right]$

$v = 2\sqrt{2}\omega$

$x = 2$

75. P = constant $\Rightarrow$ FV = constant

$\Rightarrow \mathrm{m}\frac{\mathrm{dV}}{\mathrm{dt}}\mathrm{V}$ = constant

$\int_0^{\mathrm{V}} \mathrm{VdV} = (\mathrm{C})\int_0^{\mathrm{t}} \mathrm{dt}$

$\left(\frac{\mathrm{V}^2}{2}\right) = \mathrm{Ct}$

(2) $\mathrm{V} \propto \mathrm{t}^{1/2}$

$\frac{\mathrm{ds}}{\mathrm{dt}} \propto \mathrm{t}^{1/2}$

$\int_0^{\mathrm{S}} \mathrm{ds} = \mathrm{K}\int_0^{\mathrm{t}} \mathrm{t}^{1/2}\mathrm{dt}$

$\mathrm{S} = \mathrm{K} \times \frac{2}{3}\mathrm{t}^{3/2}$

$\mathrm{S} \propto \mathrm{t}^{3/2}$

$\therefore$ displacement is proportional to $(\mathrm{t})^{3/2}$

76. Velocity just before collision $=\sqrt{2gh}$

Velocity just after collision $=\sqrt{2\,g\left(\frac{h}{2}\right)}$

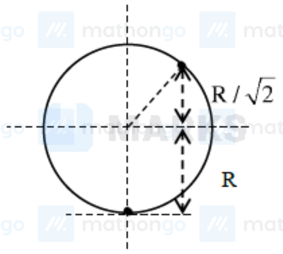
$\therefore \Delta KE=\frac{1}{2}m(2gh)-\frac{1}{2}mgh$

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

$\therefore$ % loss in energy

$=\frac{\Delta KE}{KE_i}\times 100=\frac{\frac{1}{2}mgh}{\frac{1}{2}mg2\,h}\times 100=50\%$

77.



(4)

Apply W.E.T. from A to B

$\Rightarrow W_{mg}=K_B-K_A$

$\Rightarrow mg\times\left(\frac{R}{\sqrt{2}}+R\right)=\frac{1}{2}mv_B^2-0\left\{v_A=0\text{ rest}\right\}$

$\Rightarrow mgR\frac{(\sqrt{2}+1)}{\sqrt{2}}=\frac{1}{2}mv_B^2$

$\Rightarrow\sqrt{gR\frac{2(\sqrt{2}+1)}{\sqrt{2}}}=v_B$

$\Rightarrow\sqrt{\frac{10\times 14\times 2(2.4)}{1.4}}=v_B$

$\Rightarrow 21.9=v_B$

78. (4)

Given: $\vec{F}=\left(6t\,\hat{i}+6t^2\,\hat{j}\right)$ N

Now, $\vec{F}=m\vec{a}=\left(6t\,\hat{i}+6t^2\,\hat{j}\right)$

$\Rightarrow\vec{a}=\frac{\vec{F}}{m}=\left(3t\,\hat{i}+3t^2\,\hat{j}\right)$

Hence, velocity $\vec{v}=\int_0^t\vec{a}\,dt=\frac{3t^2}{2}\hat{i}+t^3\hat{j}$

Required power, $P=\vec{F}.\vec{v}=\left(9t^3+6t^5\right)$ W

79. (2)

The velocity given is minimum, just enough to complete verticle circle. At the top most point, tension of the string will be zero and gravitational force will provide the required centripetal force.

Therefore,

$mg=\frac{m\left(V_H\right)^2}{L}\Rightarrow\frac{1}{2}m\left(V_H\right)^2=\frac{1}{2}gL$

$mg=\frac{m\left(V_H\right)^2}{L}$

$\Rightarrow\frac{1}{2}m(V_H)^2=\frac{1}{2}gL$

Apply energy conservation between point A and B, we get

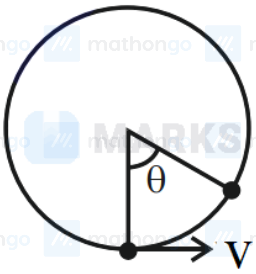
$\frac{1}{2}mV_L^2=\frac{1}{2}mV_H^2+mg\left(2\,L\right)$

$\Rightarrow V_L=\sqrt{5gL}$

Also, $V_H=\sqrt{gL}$

Required ratio, $\frac{(K.E)_A}{(K.E)_B}=\frac{\frac{1}{2}m\left(\sqrt{5gL}\right)^2}{\frac{1}{2}m\left(\sqrt{gL}\right)^2}=\frac{5}{1}$

80. (2)



At the lowermost point, there is no tangential force on the ball. Thus, there exists no tangential acceleration at the bottommost point, only the centripetal acceleration survives.

On the other hand, in the extreme position of the ball, there is no centripetal acceleration as the ball becomes momentarily at rest at that position. Here, only tangential acceleration survives.

Thus, with respect to the figure above, equating the kinetic energy at the bottommost point to the potential energy at the extreme point, we have

$\frac{1}{2}mv^2=mgl\left(1-\cos\theta\right)\Rightarrow\frac{v^2}{l}=2g\left(1-\cos\theta\right)\quad...(1)$

$\frac{1}{2}mv^2=mg\,l\left(1-\cos\theta\right)$

$\Rightarrow\frac{v^2}{l}=2g\left(1-\cos\theta\right)\quad...(1)$

Now, the net acceleration $\left(a_t\right)$ at the extreme point can be written as

$a_t=g\sin\theta\quad...(2)$

According to the given problem, it follows that for the two positions of the ball,

$a_t=\frac{v^2}{l}\quad...(3)$

Equations (1), (2) and (3) imply that

$g\sin\theta=2g\left(1-\cos\theta\right)\Rightarrow2\sin\frac{\theta}{2}\cos\frac{\theta}{2}=4\sin^2\frac{\theta}{2}\Rightarrow\tan\frac{\theta}{2}=\frac{1}{2}\Rightarrow\theta=2\tan^{-1}\left(\frac{1}{2}\right)$

$g\sin\theta=2g\left(1-\cos\theta\right)$

$\Rightarrow2\sin\frac{\theta}{2}\cos\frac{\theta}{2}=4\sin^2\frac{\theta}{2}$

$\Rightarrow\tan\frac{\theta}{2}=\frac{1}{2}$

$\Rightarrow\theta=2\tan^{-1}\left(\frac{1}{2}\right)$

81. (24)

Using work - energy theorem

$W_{net}=\Delta KE$

$W_{net}=\left(K_f-K_i\right)$

$\Rightarrow-\frac{1}{2}Kx^2=\frac{1}{2}m\left(\frac{v}{2}\right)^2-\frac{1}{2}mv^2\Rightarrow-\frac{1}{2}Kx^2=\frac{E}{4}-E$

$\Rightarrow-\frac{1}{2}Kx^2=\frac{1}{2}m\left(\frac{v}{2}\right)^2-\frac{1}{2}mv^2$

$\Rightarrow-\frac{1}{2}Kx^2=\frac{E}{4}-E$

$\Rightarrow\frac{1}{2}Kx^2=\frac{3E}{4}\Rightarrow K=\frac{3E}{2x^2}$

$\Rightarrow\frac{1}{2}Kx^2=\frac{3E}{4}$

$\Rightarrow K=\frac{3E}{2x^2}$

$\Rightarrow K=\frac{3E}{2\times\left(\frac{1}{4}\right)^2}=24E\text{ N m}^{-1}$

Thus, the value of $n=24$.

82. (2)

Given: $v=3x^2+4$

Initial and final velocities are $v_i = 3(0)^2 + 4 = 4 \text{ m s}^{-1}$

and $v_f = 3(2)^2 + 4 = 16 \text{ m s}^{-1}$

From work-energy theorem,

$\Rightarrow \Delta KE = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$

$\Rightarrow \Delta KE = \frac{1}{2} \times \frac{1}{2}\left(16^2 - 4^2\right)$

$\Rightarrow \Delta KE = W = 60 \text{ J}$

83. (1)

Here, gain in kinetic energy = loss in potential energy

Now loss in potential energy of particle in falling from height y to y_0 is $mg\left(y - y_0\right)$.

So, $\Delta KE = K - 0 = -\left[mg\left(y - y_0\right) - mgy\right]$

Thus, kinetic energy at point B is $K = mgy_0$

84. (1)

As seen from figure, work done in first graph, $W_a = 0$.

Now, work done in figure b, $W_b = +\text{ve}$, and that in figure c, $W_c = +\text{ve}, > W_b$.

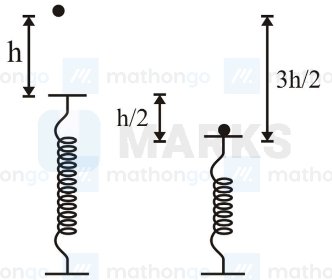
In last graph, work done is $W_d = -ve$.

So, the descending order of total work done is

$\Rightarrow W_c > W_b > W_a > W_d$

$\Rightarrow W_3 > W_2 > W_1 > W_4$

85. (120)



Loss in the gravitational potential energy of the ball= gain in the potential energy by the spring

$-\Delta PE_{\text{gravitational}} = \Delta PE_{\text{spring}}$

$mg\left(h + \frac{h}{2}\right) = \frac{1}{2}k\left(\frac{h}{2}\right)^2 \Rightarrow mg\frac{3h}{2} = \frac{kh^2}{8}$

$\Rightarrow k = \frac{12mg}{h} = \frac{12 \times 0.1 \times 10}{0.1} = 120 \text{ N m}^{-1}$

86. (3)

Given $U = \frac{A}{r^{10}} - \frac{B}{r^5}$.

Now, for equilibrium, $\frac{dU}{dr} = 0$.

So, differentiating the given equation,

$\frac{-10A}{r^{11}} + \frac{5B}{r^6} = 0$

$\Rightarrow \frac{10A}{r^{11}} = \frac{5B}{r^6} \Rightarrow r^5 = \frac{2A}{B} \Rightarrow r = \left(\frac{2A}{B}\right)^{\frac{1}{5}}$

$\Rightarrow \frac{10A}{r^{11}} = \frac{5B}{r^6}$

$\Rightarrow r^5 = \frac{2A}{B}$

$\Rightarrow r = \left(\frac{2A}{B}\right)^{\frac{1}{5}}$

87. (16)

Work $= \Delta$K. E.

$W_{\text{triction}} + W_{\text{spring}} = 0 - \frac{1}{2}mv^2$

$-\frac{90}{100}\left(\frac{1}{2}mv^2\right) + W_{\text{spring}} = -\frac{1}{2}mv^2$

$w_{\text{spring}} = -\frac{10}{100} \times \frac{1}{2}mv^2$

$-\frac{1}{2}kx^2 = -\frac{1}{20}mv^2 \Rightarrow k = \frac{40000 \times (20)^2}{10 \times (1)^2} = 16 \times 10^5$

88. **(2)**

(A) at $x > x_4$, $U =$ constant $= 6$ J

$K = E_{mech.} - U = 2$ J $=$ constant

(B) at $x < x_1$, $U =$ constant $= 8$ J

$K = E_{mech.} - U = 8 - 8 = 0$ J

Particle is at rest.

(C) At $x = x_2$, $U = 0 \Rightarrow E_{mech.} = K = 8$ J

KE is greatest, and particle is moving at fastest speed.

(D) At $x = x_3$, $U = 4$ J

$U + K = 8$ J

$K = 4$ J

89. **(10)** Using work-energy theorem, $W_g = \Delta K.E.$

$(10)(g)(5) = \frac{1}{2}(10)v^2 - 0$

$v = 10 \text{ m s}^{-1}$.

90. **(1)**

For equilibrium

$\frac{dU}{dr} = 0$

$\frac{-10\alpha}{r^{11}} + \frac{5\beta}{r^6} = 0$

$\frac{5\beta}{r^6} = \frac{10\alpha}{r^{11}}$

$r^5 = \frac{2\alpha}{\beta}$

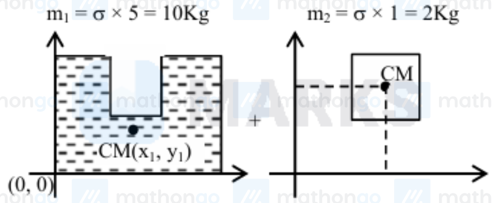
$r^5 = \frac{2\alpha}{\beta}$

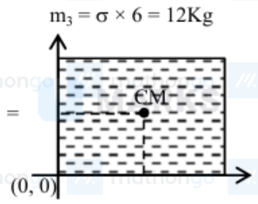
$r = \left(\frac{2\alpha}{\beta}\right)^{\frac{1}{5}} a = 1$

$r = \left(\frac{2\alpha}{\beta}\right)^{\frac{1}{5}}$

$a = 1$

91. **(15)** $m_1 = \sigma \times 5 = 10$Kg





$\Rightarrow m_1x_1 + m_2x_2 = m_3x_3$

$10x_1 + 2(1.5) = 12(1.5) \Rightarrow x_1 = 1.5$ cm

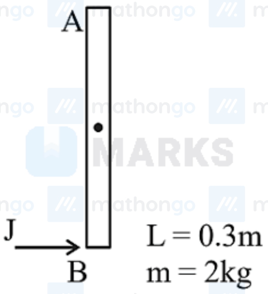
$\Rightarrow m_1y_1 + m_2y_2 = m_3y_3$

$10y_1 + 2(1.5) = 12 \times 1 \Rightarrow y_1 = 0.9$ cm

$\frac{x_1}{y_1} = \frac{1.5}{0.9} = \frac{15}{9}$

$n = 15$

92. **(4)**



Impulse $J = 0.2$ N s

$\Rightarrow$ J $= \int Fdt = 0.2$ N s

Now, angular impulse $\left(\vec{M}\right)$ will be

$M_c = \int \tau dt$

$= \int F\frac{L}{2}dt$

$= \frac{L}{2}\int Fdt = \frac{L}{2} \times$ J

$= \frac{0.3}{2} \times 0.2$

$= 0.03$

Moment of inertia of the rod about the centre of mass, $I_{\text{cm}} = \frac{ML^2}{12} = \frac{2 \times (0.3)^2}{12} = \frac{0.09}{6}$

Angular impulse will be equal to the change in angular momentum.

$M = I_{\text{cm}}\left(\omega_f - \omega_i\right)$

$\Rightarrow 0.03 = \frac{0.09}{6}\left(\omega_f\right)$

$\Rightarrow \omega_f = 2 \text{ rad s}^{-1}$

For angular displacement, we can write $\theta = \omega t$

$\Rightarrow t = \frac{\theta}{\omega} = \frac{\pi}{2 \times 2} = \frac{\pi}{4}$ s.

Therefore, $x = 4$.

93. (4)

Using equation of motion with constant acceleration, we can write:

$v_1 = \sqrt{2gh_1}$ and $v_2 = \sqrt{2gh_2}$

Now, required impulse

$\vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$

Given, $M = 0.1$ kg

Therefore,

$I = \Delta p = 0.1\left(\sqrt{2 \times 9.8 \times 5} - \left(-\sqrt{2 \times 9.8 \times 10}\right)\right)$

$= 0.1\left(7\sqrt{2} + 14\right) \approx 2.39 \text{ kg m s}^{-1}$

94. (2)

The kinetic energy and the momentum of a moving object are related by

$K = \frac{p^2}{2m} \quad ...(1)$

Hence, the ratio of the kinetic energies of two objects having masses m and m' can be calculated as follows:

$\frac{K}{K'} = \frac{\frac{p^2}{2m}}{\frac{p^2}{2m'}}$

$= \frac{m'}{m} \quad ...(2)$

Substitute the ratio of the kinetic energies into equation (2) and simplify to obtain the ratio of their masses.

$\Rightarrow \frac{16}{9} = \frac{m'}{m}$

$\Rightarrow m : m' = 9 : 16$

95. (2)

Using the law of Momentum conservation

$m_1v_1 + m_2\left(-v_2\right) = 0$

$\Rightarrow m_1v_1 = m_2v_2$

$$\Rightarrow \left(\frac{m_1}{m_2}\right) = \left(\frac{v_2}{v_1}\right) \Rightarrow \frac{\frac{4\pi\rho r^3{}_1}{3}}{\frac{4\pi\rho r^3{}_2}{3}} = \left(\frac{v_2}{v_1}\right)$$

$$\Rightarrow \left(\frac{m_1}{m_2}\right) = \left(\frac{v_2}{v_1}\right)$$

$$\Rightarrow \frac{\frac{4\pi\rho r^3{}_1}{3}}{\frac{4\pi\rho r^3{}_2}{3}} = \left(\frac{v_2}{v_1}\right)$$

It is given

$$\frac{r_1}{r_2} = \frac{1}{2^{\frac{1}{3}}}$$

and $\left(\frac{r_1}{r_2}\right)^3 = \left(\frac{v_2}{v_1}\right)$ Therefore, $\left(\frac{1}{2}\right) = \left(\frac{v_2}{v_1}\right)$

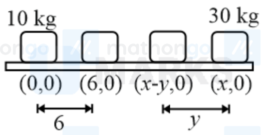
and $\left(\frac{r_1}{r_2}\right)^3 = \left(\frac{v_2}{v_1}\right)$

Therefore,

$$\left(\frac{1}{2}\right) = \left(\frac{v_2}{v_1}\right)$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{2}{1}$$

96. (3)



Initial position of centre of mass: $x_{CM} = \frac{10(0) + 30 \times x}{40} = \frac{3x}{4}$

Final position of the centre of mass: $x'_{CM} = \frac{10(6) + 30 \times (x-y)}{40} = \frac{6 + 3(x-y)}{4}$

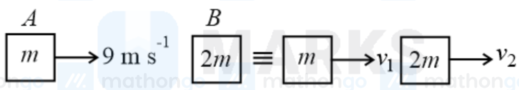
As position of centre of mass remains same,

$x_{CM} = x'_{CM} \Rightarrow \frac{3x}{4} = \frac{6+3(x-y)}{4} \Rightarrow 3x = 6 + 3x - 3y \Rightarrow y = 2$ cm

Alternate method, $\Delta x_{\text{COM}} = \frac{m_1 \Delta x_1 + m_2 \Delta x_2}{(m_1 + m_2)} \Rightarrow 0 = 10 \times 6 + 30y \Rightarrow y = -2$ cm

97. (4)

Collision between A and B

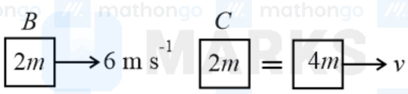


$m \times 9 = mv_1 + 2\,mv_2$ (from momentum conservation)

$e = 1 = \frac{v_2 - v_1}{9}$

$\Rightarrow v_2 = 6 \text{ m sec}^{-1},\ v_1 = -3 \text{ m sec}^{-1}$

Collision between B and C



$2\,m \times 6 = 4mv$ (from momentum conservation)

$v = 3 \text{ m s}^{-1}$

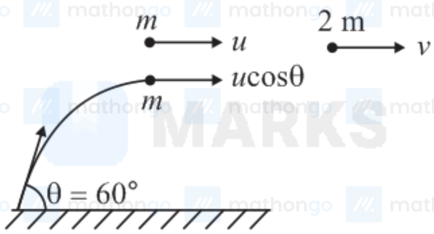
98. (20) Let the velocity of 2nd fragment is $\vec{v}$ then by conservation of linear momentum

$$10\left(10\sqrt{3}\right)\hat{i} = (10)\left(10\hat{j}\right) + 10\vec{v}$$

$$\Rightarrow \vec{v} = 10\sqrt{3}\hat{i} - 10\hat{j}$$

$$\left|\vec{v}\right| = \sqrt{300 + 100} = \sqrt{400} = 20 \text{ m s}^{-1}.$$

99.



(1)

$p_i = p_f$

$mu + mu\cos\theta = 2mv$

$\Rightarrow v = \frac{u\left(1+\cos 60^0\right)}{2} = \frac{3}{4}u$

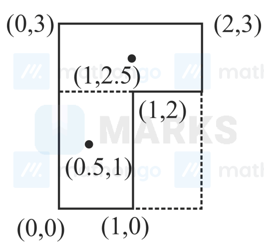
So horizontal range after collision $= vt$

$= v\sqrt{\frac{2H_{max}}{g}}$

$= \frac{3}{4}u\sqrt{\frac{2u^2\sin^2\left(60^0\right)}{2g^2}}$

$= \frac{3}{4}u^2\frac{\sqrt{\frac{3}{4}}}{g} = \frac{3\sqrt{3}u^2}{8g}$

100. (2)



$\vec{r}_{cm} = \frac{2\times\left(\frac{\hat{i}}{2}+\hat{j}\right)+2\times\left(\hat{i}+\frac{5\hat{j}}{2}\right)}{4}$

$\vec{r}_{cm} = \frac{3}{4}\hat{i} + \frac{7}{4}\hat{j}$

101. (1)

$M_1 = \frac{4}{3}\pi R^3\rho$

$M_2 = \frac{4}{3}\pi(1)^3(-\rho)$

$X_{com} = \frac{M_1X_1+M_2X_2}{M_1+M_2}$

$\Rightarrow \frac{\left[\frac{4}{3}\pi R^3\rho\right]0+\left[\frac{4}{3}\pi(1)^3(-\rho)\right][R-1]}{\frac{4}{3}\pi R^3\rho+\frac{4}{3}\pi(1)^3(-\rho)} - (2 - R)$

$\Rightarrow \frac{(R-1)}{\left(R^3-1\right)} = (2 - R)(R \neq 1)$

$\frac{(R-1)}{(R-1)\left(R^2+R+1\right)} = 2 - 1$

$\left(R^2 + R + 1\right)(2 - R) = 1$

Alternative:

$M_{remaining}(2 - R) = M_{cavity}(1 - R)$

$\Rightarrow \left(R^3 - 1^3\right)(2 - R) = 1^3[R - 1]$

$\Rightarrow \left(R^2 + R + 1\right)(2 - R) = 1$

102. (3) For slipping

$a = g\sin\theta$

$\ell = \frac{1}{2}at^2 \Rightarrow t = \sqrt{\frac{2\ell}{g\sin\theta}}$

For rolling

$a' = \frac{g\sin\theta}{1+\frac{k^2}{R^2}}\left[k = \frac{R}{\sqrt{2}}\right]$

$\Rightarrow a' = \frac{2\,g\sin\theta}{3}$

$\ell = \frac{1}{2}a'\left(t'\right)^2$

$\Rightarrow t' = \sqrt{\frac{6\ell}{2\,g\sin\theta}} = \sqrt{\frac{\alpha}{2}}\sqrt{\frac{2\ell}{g\sin\theta}}$

$\Rightarrow \alpha = 3$

103. (4)

$w_g + w_{Fr} + w_s = \Delta KE$

$5 \times 10 \times 5 - 0.5 \times 5 \times 10 \times x - \frac{1}{2}Kx^2 = 0 - 0$

$250 = 25x + 50x^2$

$2x^2 + x - 10 = 0$

$x = 2$

104. (13) By conservation of angular momentum

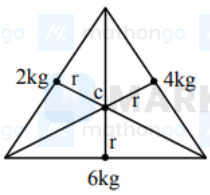
$I_1\omega_1 = I_2\omega_2$

$\left(\frac{2}{5}MR^2\right)\frac{2\pi}{T_1} = \frac{2}{5}M\left(\frac{3}{4}R\right)^2\frac{2\pi}{T_2}$

$\frac{1}{T_1} = \frac{9}{16\,T_2}$

$\frac{1}{T_2} = \frac{9}{16} \times T_1 = \frac{9}{16} \times 24\text{hr} = \frac{27}{2}\text{hr} = 13\text{hr}30\text{mins}.$

105. (4)



$r = \frac{1}{\sqrt{3}}$

Moment of inertia about C and perpendicular to the plane is :

$I = r^2[2 + 4 + 6]$

$= \frac{1}{3} \times 12$

$I = 4\text{ kg} - \text{m}^2$

106. (4)

$I_{sphere} = \frac{2}{3}MR^2 = Mk_1^2$

$I_{cylinder} = \frac{1}{12}M\left(4R^2\right) + \frac{1}{4}MR^2 + M(2R)^2$

$= \frac{67}{12}MR^2 = Mk_2^2$

$\frac{k_1}{k_2} = \sqrt{\frac{2}{3} \cdot \frac{12}{67}} = \sqrt{\frac{8}{67}}$

107. (250)

Initial angular momentum, $L_i = I\omega_i = \frac{MR^2}{2} \cdot \omega = 100\text{ kg m}^2\text{ s}^{-1}$

Initial kinetic energy, $E_i = \frac{1}{2} \cdot \frac{MR^2}{2} \cdot \omega^2 = 500\text{ J}$

From conservation of angular momentum, we can write

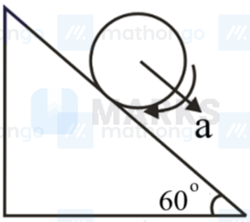
$\vec{L}_i = \vec{L}_f \Rightarrow 100 = 2I\omega_f$

$\Rightarrow \omega_f = 5\text{ rad s}^{-1}$

$E_f = 2 \times \frac{1}{2} \cdot \frac{5\left(2\right)^2}{2} \cdot (5)^2 = 250\text{ J}$

Therefore, required energy loss $\Delta E = 250$ J

108. (10)



For rolling motion, the acceleration of the cylinder along the inclined plane can be expressed as

$a = \frac{g\sin\theta}{1+\frac{I_{cm}}{MR^2}}$ . . . (1)

The moment of inertia of the cylinder can be written as

$I_{cm} = \frac{1}{2}MR^2$ . . . (2)

From equations (1) and (2), it follows that

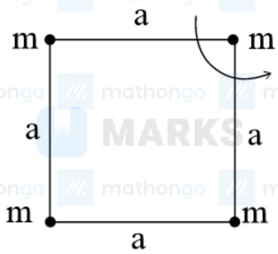
$a = \frac{g\sin\theta}{1+\frac{1}{2}}$

$= \frac{2\times10\times\frac{\sqrt{3}}{2}}{3}$

$= \frac{10}{\sqrt{3}}$ m s^{-2}

Therefore, $x = 10$.

109. (16)



The formula to calculate the moment of inertia of a system of particles about a point can be written as

$I = \sum_{i=1}^{n} m_i r_i^2$ . . . (1)

where, m_i is the mass of the i^{th} particle situated at a distance r_i from the point.

With reference to the above diagram, it can be written that the net moment of inertia of the system of particles is

$I = ma^2 + ma^2 + m\left(\sqrt{2}a\right)^2$

$= 4ma^2$

$= 4 \times 1$ kg $\times (2$ m$)^2$

$= 16$ kg m^2

110. (2)

Let speed of cylinder upon reaching the bottom of the inclined plane be v.

Here, gain in kinetic energy = loss in potential energy

So, $\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = mgl\sin\theta$

$\Rightarrow \frac{1}{2}\left(\frac{mr^2}{2}\right)\omega^2 + \frac{1}{2}mv^2 = mgl\sin30°$

For pure rolling, $v = r\omega$

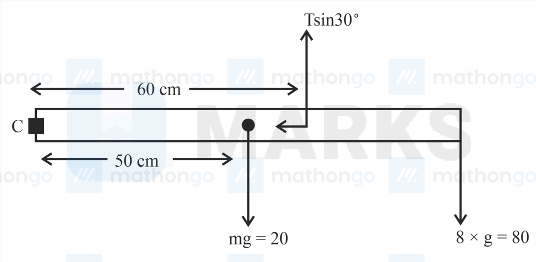
$\Rightarrow \frac{1}{2}\left(\frac{mr^2}{2}\right)\left(\frac{v}{r}\right)^2 + \frac{1}{2}mv^2 = mgl\sin30°$

$\Rightarrow \frac{1}{4}mv^2 + \frac{1}{2}mv^2 = mgl\sin30° \Rightarrow \frac{3}{4}mv^2 = \frac{mgl}{2} \Rightarrow v = \sqrt{\frac{4gl}{6}}$

Putting the values, we have

$\Rightarrow v = \sqrt{\frac{4\times10\times0.6}{6}} = 2$ m s^{-1}

111. (3)



Let T be the tension in cable.

Since the system is at equilibrium, the net torque, about an axis perpendicular to the plane and passing through the point of contact of the rod and the wall, is zero.

Therefore, torque about point C

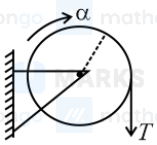
$T\sin 30^\circ \times 60 = mg \times 50 + 8g \times 100$

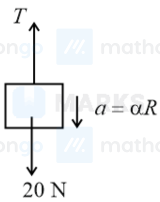
$\frac{T}{2} \times 60 = 20 \times 50 + 80 \times 100$

$\Rightarrow 3T = 100 + 800$

$\Rightarrow 300$ N.

112. (10)





Let a be the acceleration of block and α be the angular acceleration of disc.

Now, for unwrapping without slipping, $R\alpha = a$.

Forces acting on block are shown in FDB.

Using Newton's second law

$mg - T = ma \quad \ldots(1)$

Torque about centre of disc is $\tau = I\alpha$

$TR = \frac{MR^2}{2}\alpha = \frac{4R^2}{2}\alpha = \Rightarrow T = 2R\alpha \quad \ldots(2)$

Putting the value of tension in equation (1), we get

$mg - 2R\alpha = ma \Rightarrow mg - 2R\frac{a}{R} = ma \Rightarrow mg - 2a = ma \Rightarrow ma + 2a = mg \Rightarrow a = \frac{mg}{m+2} = \frac{2 \times 10}{2+2} = 5 \text{ m s}^{-2}$

Now, $\alpha = \frac{5}{0.1} = 50 \text{ rad s}^{-2}$

Tension in the cord is $T = 2 \times 0.1 \times 50 = 10$ N.

113. (5)

$\because\ 2\left(I_2 + I_3\right) + I_4 = xI_1$

Now

For solid sphere about its diameter $I_1 = \frac{2}{5}MR^2$,

For solid cylinder about its axis $I_2 = \frac{1}{2}MR^2$,

For circular disc about its diameter $I_3 = \frac{1}{4}MR^2$

And for circular ring about its diameter $I_4 = \frac{1}{2}MR^2$

$\Rightarrow 2\left(\frac{MR^2}{2} + \frac{MR^2}{4}\right) + \frac{MR^2}{2} = x \times \frac{2}{5}MR^2$

$\Rightarrow 2\left(\frac{3}{4}\right) + \frac{1}{2} = x \times \frac{2}{5}$

$\Rightarrow 2 = x \times \frac{2}{5}$

$\Rightarrow x = 5$

114. (3)

Angular momentum conservation

$I_1\omega_1 + I_2\omega_2 = \left(I_1 + I_2\right)\omega$

$\omega = \frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}$

Loss $= \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2 - \frac{1}{2}\left(I_1 + I_2\right)\omega^2$

$= \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2 - \frac{1}{2}\left(I_1 + I_2\right)\left(\frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}\right)^2$

$= \frac{1}{2}\frac{I_1 I_2}{\left(I_1 + I_2\right)}\left(\omega_1 - \omega_2\right)^2$

$E_i - E_f = \frac{I_1 I_2\left(\omega_1 - \omega_2\right)^2}{2\left(I_1 + I_2\right)}$

115. (52)

$I_A = \left[\frac{Mr^2}{2} + M\left(7r - \frac{r}{2}\right)^2\right] + \left[\frac{M\left(6r\right)^2}{12} + \left(M\left(3r - \frac{r}{2}\right)^2\right)\right]$

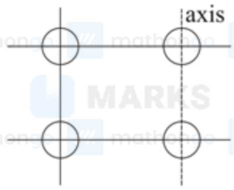
$= \left\{\frac{Mr^2}{2} + M\frac{\left(169\right)r^2}{4}\right\} + \left\{3Mr^2 + \frac{25Mr^2}{4}\right\} = \frac{171Mr^2}{4} + \frac{37Mr^2}{4} = \frac{208}{4}Mr^2 = 52Mr^2$

116. (3)

$a = \frac{g\sin\theta}{1 + \frac{I}{mR^2}} = \frac{5}{7} \times \frac{10}{2} = \frac{25}{7}$

$t = \frac{2v_0}{a} = \frac{2 \times 1 \times 7}{25} = 0.56.$

117. (3)

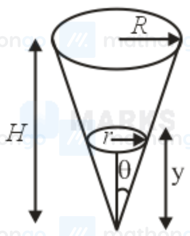


$I = 2 \times \left(\frac{2}{5}ma^2\right) + 2 \times \left(\frac{2}{5}ma^2 + mb^2\right)$

$I = \frac{8}{5}ma^2 + 2mb^2$

118. (1)

It can be assumed as several parts of discs having different radius, so



$I = \int dI = \int dm\left(r^2\right)$

From diagram

$\frac{r}{y} = \tan\theta = \frac{R}{H}$

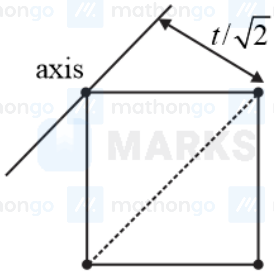
$r = \frac{R}{H} \cdot y$

$dm = \rho\left(\pi r^2\right)dy$

From equation (i), (ii) and (iii)

$I = \frac{MR^2}{2}$

119. (3)



$1 = M\left(\frac{1}{\sqrt{2}}\right)^2 + m\left(\sqrt{1}e\right)^2$

$3m\ell^2\omega$

120. (195)

$\vec{r} = (4 - 1)\hat{i} + (3 - 2)\hat{j} + (-1 - 1)\hat{k}$

$= 3\hat{i} + \hat{j} - 2\hat{k}$

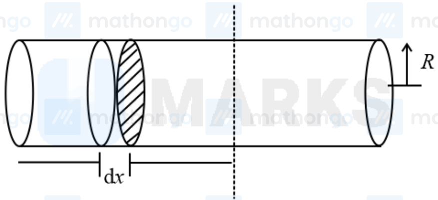
$$\tau = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 1 & -2 \\ 1 & 2 & 3 \end{vmatrix}$$

$= \hat{i}(7) - \hat{j}(11) + \hat{k}(5) = 7\hat{i} - 11\hat{j} + 5\hat{k}$

$= \sqrt{49 + 121 + 25} = \sqrt{195}$

121. (3)

Let a cylinder of mass m_1, length L and radius R then take elementary disc of radius R and trickiness dx at distance of x from axis OO' then moment of inertia about O this element



$dI = \frac{dmR^2}{4} + dmx^2$

$I = \int dI = \int \frac{dmR^2}{4} + \int_{n=-L/2}^{n=L/2} \frac{M}{L} dx \times x^2$

$\Rightarrow I = \frac{MR^2}{4} + \frac{ML^2}{12}$

$\Rightarrow I = \frac{M}{4} \times \frac{V}{\pi L} + \frac{ML^2}{12}$

$\frac{dI}{dL} = -\frac{mV}{4\pi L^2} + \frac{M \times 2L}{12} = 0$

$\Rightarrow \quad V = \frac{2}{3}\pi L^3 \quad \Rightarrow \quad \pi R^2 L = \frac{2}{3}\pi L^3 \quad \Rightarrow \quad \frac{L}{R} = \sqrt{\frac{3}{2}}\left(I = \frac{MV}{4\pi L} + \frac{ML^2}{12}\right)$

122. (15)

according to energy conservation

$mg\frac{1}{2}\sin 30° = \frac{1}{2}\frac{ml^2}{3}\omega^2$

Solving

$\omega^2 = 15$

$\omega = \sqrt{15}$

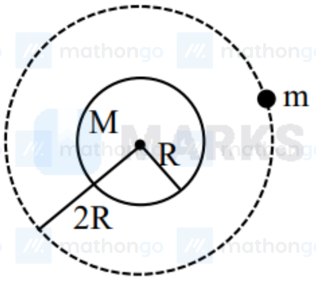
123. (1) $TE_i \;= TE_f K_i + U_i = K_{linear} + K_{rotational} + U_{final}$

$0 + 0 = \frac{1}{2}m_2v^2 + \frac{1}{2}m_1v^2 + \frac{1}{2}I\omega^2 - m_1gh + m_2gh$

$$\sqrt{\frac{2\left(m_1-m_2\right)gh}{\left(m_1+m_2+\frac{I}{R^2}\right)R^2}}=\omega$$

$$\frac{1}{R}\sqrt{\frac{2\left(m_1-m_2\right)gh}{\left(m_1+m_2+\frac{I}{R^2}\right)}}$$

124.



(4)

Total energy $=\frac{-GMm}{2(2R)}$

if energy $=\frac{10^4R}{6}$ is added then

$$\frac{-GMm}{4R}+\frac{10^4R}{6}=\frac{-GMm}{2r}$$

where r is new radius of revolving and $g=\frac{GM}{R^2}$

$$-\frac{mgR}{4}+\frac{10^4R}{6}=-\frac{mgR^2}{2r}\left(m=10^3\text{ kg}\right)$$

$$-\frac{10^3\times10\times R}{4}+\frac{10^4R}{6}=-\frac{10^3\times10\times R^2}{2r}$$

$$-\frac{1}{4}+\frac{1}{6}=-\frac{R}{2r}$$

$r=6R$

125.

$$\frac{\pi r_1^2}{T_A}=\frac{L}{2\,m_1}\ldots\ldots(1)$$

$$\frac{\pi r_2^2}{T_B}=\frac{3\,L}{2\,m_2}\ldots\ldots(2)$$

(2) $\Rightarrow\frac{T_A}{T_B}=3\cdot\frac{m_1}{m_2}\cdot\left(\frac{r_1}{r_2}\right)^2$

$$\left(\frac{T_A}{T_B}\right)^2=\left(\frac{r_1}{r_2}\right)^3\Rightarrow\left(\frac{r_1}{r_2}\right)^2=\left(\frac{T_A}{T_B}\right)^{\frac{4}{3}}$$

$$\Rightarrow\frac{1}{27}\cdot\left(\frac{m_2}{m_1}\right)^3=\left(\frac{T_A}{T_B}\right)$$

126.

$$F_e=\frac{kQ_1Q_2}{r^2}=\frac{9\times10^9\times1.6\times10^{-19}\times1.6\times10^{-19}}{r^2}$$

(1) $F_g=\frac{Gm_1\,m_2}{r^2}=\frac{6.67\times10^{-11}\times9.1\times10^{-31}\times1.6\times10^{-27}}{r^2}$

$$\frac{F_e}{F_g}\cong0.23\times10^{40}\cong2.3\times10^{39}$$

Option (1)

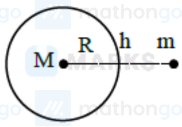
127.

$KE=\frac{1}{2}mv^2=\frac{GMm}{2a}$

(2) $PE=-2KE$

$TE=-KE$

128.



(2)

$\Rightarrow \frac{GMm}{(R+h)^2} = \frac{mv^2}{(R+h)}$

$\Rightarrow \frac{GM}{(R+h)} = v^2$ ....(1)

$\Rightarrow v = (R+h)\omega$

$\Rightarrow v = (R+h)\frac{2\pi}{T}$ ....(2)

$\Rightarrow \frac{GM}{R^2} = g$

$\Rightarrow GM = gR^2$ ....(3)

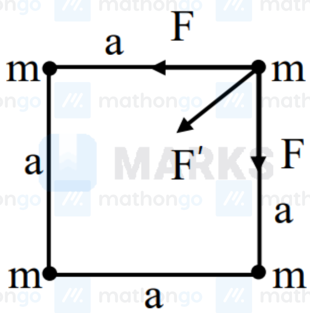
Put value from (2) \& (3) in eq. (1)

$\Rightarrow \frac{gR^2}{(R+h)} = (R+h)^2\left(\frac{2\pi}{T}\right)^2$

$\Rightarrow \frac{T^2R^2 g}{(2\pi)^2} = (R+h)^3$

$\Rightarrow \left[\frac{T^2R^2 g}{(2\pi)^2}\right]^{1/3} - R = h$

129. (2)



Resultant force, $F_{net} = \sqrt{2}F + F'$, where

$F = \frac{Gm^2}{a^2}$ and $F' = \frac{Gm^2}{(\sqrt{2}a)^2}$

Therefore, $F_{net} = \sqrt{2}\frac{Gm^2}{a^2} + \frac{Gm^2}{2a^2}$

Comparing with the expression given in the question, we get

$\left(\frac{2\sqrt{2}+1}{32}\right)\frac{Gm^2}{L^2} = \frac{Gm^2}{a^2}\left(\frac{2\sqrt{2}+1}{2}\right)$

$\Rightarrow a = 4L$

130. (4)

The acceleration due to gravity at a height h above the surface of the Earth is given by

$g_p = \frac{gR^2}{(R+h)^2}$ . . . (1)

The acceleration due to gravity at a depth h below the surface of the Earth is given by

$g_q = g\left(1 - \frac{h}{R}\right)$ . . . (2)

According to the given problem,

$g_p = g_q$ . . . (3)

Equations (1), (2) and (3) imply that

$\frac{g}{\left(1+\frac{h}{R}\right)^2} = g\left(1 - \frac{h}{R}\right) \Rightarrow \left(1 - \frac{h^2}{R^2}\right)\left(1 + \frac{h}{R}\right) = 1$ . . . (4)

Take $\frac{h}{R} = x$

So, from equation (4), it follows that

$x^3 - x + x^2 = 0 \Rightarrow x^2 + x - 1 = 0 \Rightarrow x = \frac{\sqrt{5}-1}{2} \Rightarrow h = \frac{R}{2}\left(\sqrt{5} - 1\right)$

131. (2)

It is known that

$\omega = \frac{2\pi}{T} \Rightarrow \omega \propto \frac{1}{T}$

As,

$T_{\text{moon}} \approx 27$ days

$T_{\text{earth}} \approx 365$ days

$\Rightarrow \omega_{\text{moon}} > \omega_{\text{earth}}$

Hence, Both the assertion and the reason are correct and the reason is the correct explanation for the assertion.

132. (1)

The formula to calculate the escape velocity$\left(v_e\right)$ for the Earth is given by

$v_e = \sqrt{\frac{2GM_e}{R_e}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \left(1\right)$

where, G is the Universal Gravitational constant, M_e is the mass and R_e is the radius of Earth.

The formula for the escape velocity $\left(v_{\text{esc}}\right)$ of any planet is given by

$v_{\text{esc}} = \sqrt{\frac{2GM}{R}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \left(2\right)$

where, M is the mass and R is the radius of the planet.

Given that the mass of the planet is 9 times the mass of the Earth and the radius of the planet is 2 times the radius of the Earth.

Substitute $\frac{M_e}{9}$ for M and $\frac{R_e}{2}$ for R into equation (2) and simplify to obtain the escape velocity for the planet in terms of that in Earth.

$v_{\text{esc}} = \sqrt{\frac{2G\frac{M_e}{9}}{\frac{R_e}{2}}}$

$= \sqrt{\frac{2}{9}\frac{2GM_e}{R_e}}$

$= \frac{\sqrt{2}}{3}v_e \ldots\ldots\ldots\ldots\ldots\ldots \left(3\right)$

Comparing equation (3) with the given expression, it can be written that

$x = 2$.

133. (2)

Given, $E = -\frac{K}{r^2}$

Gravitational field and gravitational potential is related as $E = -\frac{\mathrm{d}V}{\mathrm{d}r}$

So, $-\frac{\mathrm{d}V}{\mathrm{d}r} = \frac{-K}{r^2}$

Integrating the above relation,

$\int_{10}^{V} \mathrm{d}V = \int_2^3 \frac{K}{r^2}\,\mathrm{d}r$

$\Rightarrow V - 10 = K\left[\frac{1}{2} - \frac{1}{3}\right]$

$\Rightarrow V - 10 = \frac{K}{6} \Rightarrow V = \frac{6}{6} + 10 \Rightarrow V = 11\ \mathrm{J\ kg^{-1}}$

134. (1)

Gravitational potential energy on the earth surface $U_i = \frac{-GMm}{R}$

Gravitational potential energy at a height h above the earth's surface $U_f = -\frac{GMm}{R+h} = -\frac{GMm}{R+3R} = -\frac{GMm}{4R}$

Gain in gravitational potential energy

$\Delta U = U_f - U_i = -\frac{GMm}{4R} + \frac{GMm}{R} = \frac{GMm+4GMm}{4R} = \frac{3GMm}{4R}$

Gravitational potential energy in terms of acceleration due to gravity is $\Delta U = \frac{3}{4}mgR$

$= \frac{3}{4} \times 1 \times 10 \times 64 \times 10^5$

$= 48$ MJ

135. (1)

We know that escape velocity is given by,

$$v = \sqrt{\frac{2GM}{R}} \Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{M_A}{M_B} \times \frac{R_B}{R_A}} = \sqrt{\frac{\rho_A R_A{}^3}{\rho_B R_B{}^3} \times \frac{R_B}{R_A}} = \sqrt{\frac{\rho_A R_A{}^2}{\rho_B R_B{}^2}} = \sqrt{\frac{1}{4} \times \frac{4}{1}} \Rightarrow v_B = v_A = 12 \text{ km s}^{-1}$$

136. (1)

We know that the gravitational field strength varies according to the variation of the distance of an object from the centre of the earth.

So, gravitational field strength inside the earth varies as,

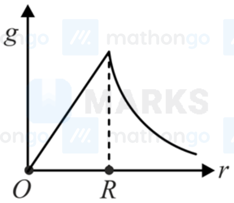
$g = \frac{GMr}{R^3}$ if $0 \le r \le R$.

So, $g \propto r$.

At the surface, it is maximum, $g = \frac{GM}{R^2}$.

Outside the earth, it varies as, $g \propto \frac{1}{r^2}$ for $(r \ge R)$.

So, this is the possible graph,



137. (3)

Energy given $= U_f - U_i$

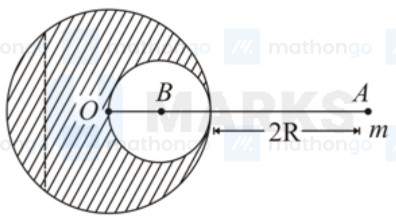
$= 0 - \left(-\frac{3}{5}\frac{GM^2}{R}\right)$

$= \frac{3}{5}\frac{GM^2}{R}$

$x = 3$

138. (2)

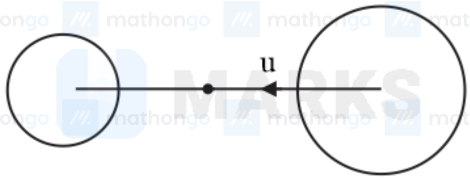
Let the initial mass of the sphere is m'. Hence, mass of a removed portion will be $m'/8, F_1 = m.E. = \frac{m.Gm'}{9R^2}$



$$F_2 = m\left[\frac{G \cdot m'}{(3R)^2} - \frac{G \cdot m'/8}{(5R/2)^2}\right] = \frac{Gm'}{9R^2} - \frac{Gm' \times 4}{8 \times 25} = \left(\frac{1}{9} - \frac{1}{50}\right)\frac{Gm'}{R^2}$$

$$F_2 = \frac{41}{50 \times 9} \cdot \frac{Gm'}{R^2} \Rightarrow \frac{F_1}{F_2} = \frac{1}{9} \times \frac{50 \times 9}{41} = \frac{50}{41}$$

139. (4)



$$\frac{1}{2}mu^2 + \left[\frac{-G \times 10Mm}{2a} - \frac{GMm}{8a}\right] = 0 - \frac{G \times 16Mm}{8a} - \frac{GM \times m}{2a}$$

$$\Rightarrow u = \sqrt{\frac{45GM}{4a}}$$

$u = \frac{3}{2}\sqrt{\frac{5GM}{a}}$

140. (1)

Acceleration due to gravity at height h above the pole is given by

$g_h = g\left(1 - \frac{2h}{R}\right) \ldots (1)$

Acceleration due to gravity at the equator due to rotation of the earth is given by

$g' = g - \omega^2 R \cos^2\lambda \ldots (2)$

At the equator, $\lambda = 0$

$\Rightarrow g' = g - \omega^2 R \ldots (3)$

As both weights are equal, i.e.; $g_h = g'$

From equation (1) and (2), we get,

$\Rightarrow \omega^2 R = \frac{2g}{R}h$

$\therefore h = \frac{R^2\omega^2}{2g}$

141. (1)

$V_x = -\int_\infty^x \frac{Ax}{\left(A^2+x^2\right)^{3/2}}(-dx)$

$V_x = -\frac{A}{\sqrt{A^2+x^2}}$

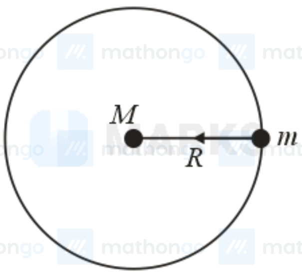
142. (1)

$M = \int \rho dV$

$M = \int_0^R \frac{k}{r} 4\pi r^2 dr$

$M = 4\pi k \int_0^R r dr$

$M = \frac{4\pi k R^2}{2} = 2\pi k R^2$



$F_G = \frac{GMm}{R^2} = m\omega_0^2 R$

$\Rightarrow \frac{G\frac{4\pi k R^2}{2}}{R^2} = \omega_0^2 R \Rightarrow \omega_0 = \sqrt{\frac{2\pi k G}{R}}$

$\because T = \frac{2\pi}{\omega_0} = \frac{2\pi\sqrt{R}}{\sqrt{2\pi k G}} = \sqrt{\frac{2\pi R}{kG}}$

$\Rightarrow T^2 \propto R$

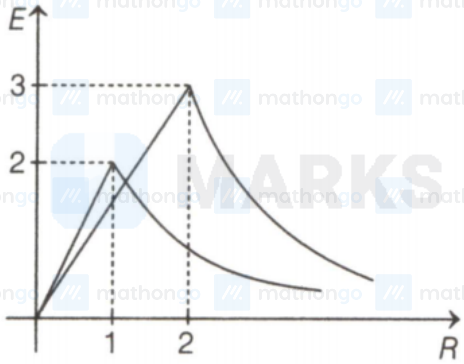
143. (4) Conserving momentum

$\frac{m}{2}\frac{v}{2} + mv = \left(m + \frac{m}{2}\right)v_f$

$v_f = \frac{2mV}{4 \times \frac{3m}{2}} = \frac{5V}{6}$

$v_f < v_{orb} (= v)$ thus the combined mass will go on to an elliptical path

144. (2)



$3=\frac{GM_2}{2^2}$

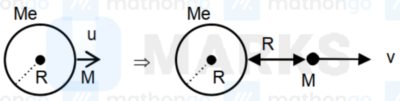
$2=\frac{GM_1}{1^2}$

$\therefore \frac{3}{2}=\frac{1}{4}\frac{M_2}{M_1}$

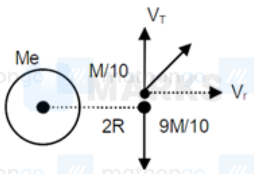
$\frac{M_1}{M_2}=\frac{1}{6}$

145. (2)

$\frac{-GM_eM}{R}+\frac{1}{2}Mu^2=\frac{-GM_eM}{2R}+\frac{1}{2}Mv^2$



$v=\sqrt{u^2-\frac{GM_e}{R}}$



$V_\tau \rightarrow$ Transverse velocity of rocket

$V_R \rightarrow$ Radial velocity of rocket

$V=\sqrt{\frac{GM_e}{2R}}$

$\frac{M}{10}V_T=\frac{9M}{10}\sqrt{\frac{GM_e}{2R}}$

$\frac{M}{10}V_r=M\sqrt{u^2-\frac{GM_e}{R}}$

Kinetic energy $=\frac{1}{2}\frac{M}{10}\left(V_T^2+V_r^2\right)=\frac{M}{20}\left(81\frac{GM_e}{2R}+100u^2-100\frac{GM_e}{R}\right)$

$=\frac{M}{20}\left(100u^2-\frac{119GM_e}{2R}\right)$

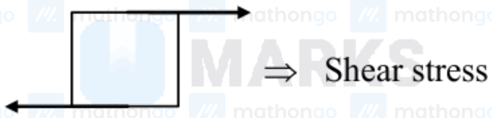
$=5M\left(u^2-\frac{119GM_e}{200R}\right)$

146. **(2)** (1) stress $=\frac{F_{\text{restoring}}}{A}$

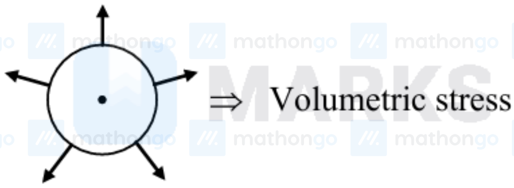
If A = 1

Stress $=F_{\text{restoring}}$

(A)-(III)



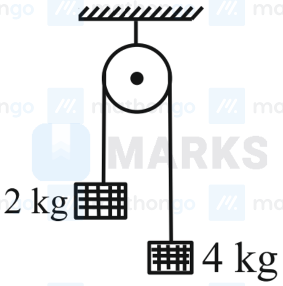
(2)
(B)-(IV)



(3)
(C)-(I)

(4)
(D)-(II)

147. (12)



For the given system, $T = \left(\frac{2m_1m_2}{m_1+m_2}\right)g = \frac{80}{3}$ N

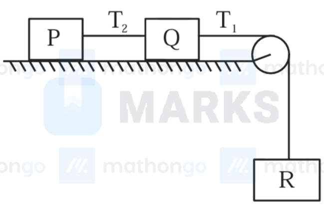
Area of the wire, $A = \pi r^2 = 16\pi \times 10^{-10}$ m^2

Strain $= \frac{\Delta l}{l} = \frac{F}{AY} = \frac{T}{AY}$

$= \frac{\frac{80}{3}}{16\pi \times 10^{-10} \times 2 \times 10^{11}} = \frac{1}{12\pi}$

$\Rightarrow \alpha = 12$

148. (2)



Acceleration of the system, $a = \frac{3g}{9} = \frac{10}{3}$ m s^{-2}

Now, for R we can write

$30 - T_1 = 3 \times a$

$\Rightarrow T_1 = 20$ N

Therefore, strain developed in wire B,

strain $= \frac{\text{stress}}{Y} = \frac{\frac{T_1}{A}}{Y} = \frac{\frac{20}{0.005 \times 10^{-4}}}{2 \times 10^{11}}$

$= 2 \times 10^{-4}$

149. (16)

The formula for Young's modulus is given by

$$Y = \frac{\frac{F}{A}}{\frac{\Delta l}{l}}$$

$$= \frac{Fl}{A\Delta l}$$

From above equation, it follows that

$$\Delta l = \frac{Fl}{AY} \quad ...(1)$$

Again, volume of the wire is given by

$$V = Al \Rightarrow l = \frac{V}{A}$$

Hence, from equation (1),

$$\Delta l = \frac{FV}{A^2Y} \quad ...(2)$$

As, Y and V is the same for both the wires,

$$\Delta l \propto \frac{F}{A^2}$$

Hence, for two wires, it can be written that

$$\frac{\Delta l_1}{\Delta l_2} = \frac{F_1}{A_1^2} \times \frac{A_2^2}{F_2} \quad ...(3)$$

As $\Delta l_1 = \Delta l_2$, from equation (3), it follows that

$$F_1 A_2^2 = F_2 A_1^2 \Rightarrow \frac{F_1}{F_2} = \frac{A_1^2}{A_2^2} = \left(\frac{4}{1}\right)^2 = 16$$

150. (2)

The formula to calculate the Bulk modulus is given by

$$B = -\frac{\Delta P}{\left(\frac{\Delta V}{V}\right)} \quad ...(1)$$

From equation (1), the fractional compression in volume may be obtained as follows:

$$-\left(\frac{\Delta V}{V}\right) = \frac{\Delta P}{B}$$

$$= \frac{\rho g \Delta h}{B} \quad ...(2)$$

From equation (2) it follows that

$$\left|-\left(\frac{\Delta V}{V}\right)\right| = \frac{1000 \times 10 \times 4000}{2 \times 10^9}$$

$$\Rightarrow \left(\frac{\Delta V}{V}\right) = 2 \times 10^{-2}$$

Hence, $\alpha = 2$.

151. (1)

The data given is

$P = aV^{-3}$

Bulk modulus is given by,

$$B = -\frac{dP}{\frac{dV}{V}} = -V\frac{dP}{dV}$$

$$= -V\frac{d}{dV}\left\{\frac{a}{V^3}\right\}$$

$$= -V\left[\frac{-3a}{V^4}\right]$$

$$= \frac{3a}{V^3} = 3P$$

152. (20)

The force acting on steel wire F is $(2 + 1.14)\,g = 3.14g$

From the relation of Young's modulus, it can be written

$$\frac{F}{A} = Y\left(\frac{\Delta L}{L}\right)$$

$$\Rightarrow \Delta L = \left(\frac{FL}{AY}\right) = \frac{3.14 \times g \times 1.6}{\pi \times (0.2)^2 \times 2 \times 10^{11} \times 10^{-4}}$$

$\Rightarrow \Delta L = 2 \times 10^{-5}$

$\Rightarrow \Delta L = 20 \times 10^{-6}$ m

153. (48)

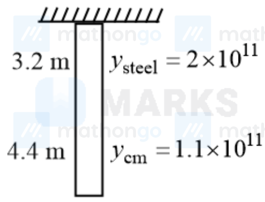
Shearing stress is given by $\frac{F}{A} = \eta \frac{x}{l}$

Thus, displacement is $x = \frac{Fl}{A\eta}$

$\Rightarrow x = \frac{18 \times 10^{4} \times 60 \times 10^{-2}}{60 \times 10^{-2} \times 15 \times 10^{-2} \times 25 \times 10^{9}}$

$= 48 \times 10^{-6}$ m $= 48\ \mu$m

154. (4)



When two wires are connected end to end, the tension in them will be same.

Change in length using Hooke's law can be found as,

$Y = \frac{Fl}{A\Delta l} \Rightarrow \Delta l = \frac{Fl}{AY}$

Total change in length can be written as,

$\Delta l = \Delta l_1 + \Delta l_2$

$\Rightarrow \Delta l = \frac{Fl_1}{A_1 Y_1} + \frac{Fl_2}{A_2 Y_2}$

$\Rightarrow F = \frac{\Delta l}{\frac{l_1}{A_1 Y_1} + \frac{l_2}{A_2 Y_2}} = \frac{1.4 \times 10^{-3}}{\frac{3.2}{\pi\left(1.4 \times 10^{-3}\right)^2 \times 2.0 \times 10^{11}} + \frac{4.4}{\pi\left(1.4 \times 10^{-3}\right)^2 \times 1.1 \times 10^{11}}} \Rightarrow F = 1.54 \times 10^{2} = 154$ N

155. (2)

We know that, Young's modulus is $Y = \frac{FL}{A\Delta L}$, where, F is force or load acting on wire, A is cross-section area, L is length and ΔL is extension in length.

Now, from given graph, the slope of the line is $= \frac{\frac{\Delta L}{W}}{L} = \frac{\frac{\Delta L}{L}}{W} = \frac{1}{YA}$

$\Rightarrow Y = \frac{1}{(\text{slope})A}$

Thus, Young's modulus of the steel wires is $Y = \frac{1}{2 \times 10^{-6}\left(0.25 \times 10^{-5}\right)}$

$\Rightarrow Y = 2 \times 10^{11}$ N m^{-2}.

Therefore, $x = 2$.

156. (1)

Since breaking stress (Maximum lifting capacity) is the property of material, so it will remain same.

Now, breaking stress $= \frac{\text{Maximum lifting capacity}}{\text{Area of cross section of rope}}$

$\Rightarrow \frac{10}{2.5 \times 10^{-4}} = \frac{25}{A}$

$A = 625 \times 10^{-6}$

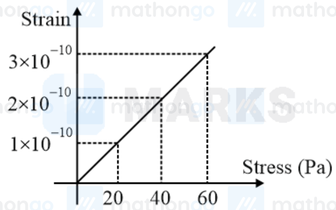
$= 6.25 \times 10^{-4}$ m^2

157. (3)

From Hooke's law, $\Delta L = \frac{FL}{AY} \Rightarrow \Delta L \propto F$. Therefore,

$\frac{L_2 - L}{L_1 - L} = \frac{m_2 g}{m_1 g} = \frac{2}{1} \Rightarrow L = 2L_1 - L_2$

158. (25)



From the above graph, we can find that when the strain is 5×10^{-4} the stress is 100 MPa. We know that energy density is

$U = \frac{1}{2} \times$ stress $\times$ strain $\Rightarrow U = \frac{1}{2} \times 100 \times 10^6 \times 5 \times 10^{-4}$

$\Rightarrow U = 2.5 \times 10^4 \text{ J m}^{-3} = 25 \text{ kJ m}^{-3}$

159. **(1)** $v = \sqrt{\frac{T}{\mu}}$

$\Rightarrow T = \mu v^2$

$\Rightarrow \frac{\mu v^2}{A} = Y\frac{\Delta l}{l}$

$\Rightarrow \Delta l = \frac{\mu v^2 l}{AY}$

After substituting value of μ, v, l, A and Y we get

$\Delta l = 0.3\text{mm}$

160. **(4)** There are two liquid-air surfaces in bubble so

$\Delta P = 2\left(\frac{2S}{R}\right) = \frac{4S}{R}$

161. **(3)** Capillary rise

$h = \frac{2T\cos\theta}{\rho g r}$;

If $\theta = 0^\circ$ then rise is non-zero

$\therefore$ Statement-1 is incorrect.

162. **(3)**

For water, the surface tension decreases as the temperature increases. At higher temperatures, the water molecules have more kinetic energy and are better able to overc the cohesive forces at the surface, resulting in a decrease in surface tension.

So, the height of capillary rise will be smaller in hot water and larger in cold water.

Hence, statement I is true, but statement II is false.

163. **(1)**

Let radius of the newly formed drops be r.

As total volume will remain constant, therefore

$\frac{4}{3}\pi R^3 = 27 \times \left(\frac{4}{3} \times \pi r^3\right)$

$\Rightarrow R^3 = 27r^3$

$\Rightarrow R = 3r$

$\Rightarrow r = \frac{R}{3}$

$\Rightarrow r^2 = \frac{R^2}{9}$

Now, work done $= T \times \Delta A$

$= T\left[27\left(4\pi r^2\right)\right] - T\left[4\pi R^2\right] = T\left[27\left(4\pi\frac{R^2}{9}\right)\right] - T\left[4\pi R^2\right] = T\pi R^2(12 - 4)$

$= 8\pi R^2 T$

164. **(3)**

Using Bernoulli's theorem,

$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2 \quad \ldots (i)$

Using equation of continuity,

$A_A V_A = A_B V_B$

So, $1.5 \times 10^{-4} \times V_A = 25 \times 10^{-6} \times V_B$

$V_A = \frac{25 \times 10^{-6}}{1.5 \times 10^{-4}} \times 0.6$

$= \frac{1}{10} \text{ m s}^{-1}$

Substituting in equation (i)

$\Rightarrow P_A - P_B = \frac{1000}{2}\left[0.6^2 - 0.1^2\right] = \frac{1000}{2} \times 0.7 \times 0.5$

$= 175\ Pa$

165. (3)

The terminal velocity is

$V_T = \frac{2}{9}r^2 g\frac{\left(\rho - \rho'\right)}{\eta} \Rightarrow V_T \propto r^2$

Differentiating and dividing by V_T,

$\Rightarrow \frac{dV_T}{V_T} = 2\frac{dr}{r} = 2 \times \frac{0.1}{5}$

So, the percentage error is

$\frac{dV_T}{V_T} \times 100 = \frac{0.2}{5} \times 100 = 4\%$

As can be seen the terminal velocity is directly proportional to the square of the radius. Hence A is true but R is false.

166. (3)

The buoyant force is given by

$B = V\rho_0 g$

where V is the volume of the ball. The weight of the ball

$W = Mg = V\rho g$, is acting in the opposite direction of the buoyant force . Hence, at terminal velocity

$Mg - B = F_v$

$\Rightarrow B + F_v = Mg$

$\Rightarrow F_v = V\rho g - V\rho_0 g \Rightarrow F_v = \rho V g\left(1 - \frac{\rho_0}{\rho}\right) \Rightarrow F_v = Mg\left(1 - \frac{\rho_0}{\rho}\right)$

167. (4)

Pascal's law states that the pressure in a closed incompressible fluid is transmitted equally in all directions.

The formula for pressure is given by

$P = \frac{F}{A}$

When a toothpaste is squeezed let the pressure transmitted by P. At the mouth of the toothpaste the pressure will also be equal to P due to Pascal's law. The pressure applied to the tube is transmitted equally throughout the toothpaste. When the pressure reaches the open end, it forces toothpaste out through the opening. Hence, both $A\&R$ is correct and R is correct explanation for A.

168. (4)

Volume of water coming out of the pipe per sec $= Av = 10 \times 10^{-4} \times 20 = 0.02\ \mathrm{m^3\ s^{-1}}$

Mass of water hitting the wall per second $m = 0.02 \times 10^3 = 20\ \mathrm{kg\ s^{-1}}$

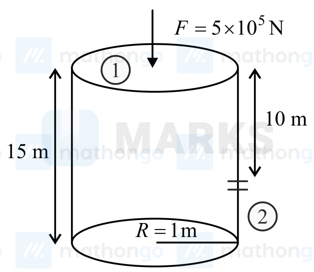
As the water hits the wall normal to the wall and stops, the change of momentum of water hitting the wall is $= m(0 - (-v)) = mv$

$= 20 \times 20 = 400\ \mathrm{kg\ m\ s^{-2}}$

Since, the change of momentum obtained is per unit time, it is same as the force.

Thus, the force acting on the wall by water = force experienced by water jet = 400 N.

169. (3)



Assuming there is no atmospheric pressure on piston, $P_1 = \frac{F}{\pi R^2}$ and $P_2 = P_0$.

Applying Bernoulli's equation at point 1 and 2,

$p_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = p_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$

$$\Rightarrow \left(\frac{F}{\pi R^2}\right) + \rho g\left(h_1 - h_2\right) = P_0 + \frac{1}{2}\rho v_2^2$$

$$\Rightarrow v_2 = \sqrt{\frac{2F}{\pi R^2 \rho} - \frac{2P_0}{\rho} + 2g\left(h_1 - h_2\right)}$$

$$v_2 = \sqrt{\frac{2\times\left(5\times10^5\right)}{3.14\times1^2\times1000} - \frac{2\times1.01\times10^5}{1000} + 2\times10\times10}$$

$\approx 17.8\ \mathrm{m\ s^{-1}}$

170. (3)

The volume of the bigger drop will be, $V = \frac{4}{3}\pi R^3$. If the radius of smaller drops is r, using the conservation of volume,

$n\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow 729 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow r = \frac{R}{9}$

The initial surface energy will be,

$E_i = \left(4\pi R^2\right)T$

And final surface energy will be,

$E_f = n\left(4\pi r^2\right)T = 729 \times 4\pi\left(\frac{R}{9}\right)^2 T = 36\pi R^2 T$

Therefore, the change in the surface energy will be,

$\Rightarrow \Delta E = E_f - E_i = 32\pi R^2 T = 32 \times 3.14 \times \left(1 \times 10^{-2}\right)^2 \times 75 \times 10^{-3} \Rightarrow \Delta E = 7.5 \times 10^{-4}\ \mathrm{J}$

171. (2)

Terminal velocity is given by $v_T = \frac{2r^2(\rho-\sigma)g}{9\eta}$, where, r is radius of falling body, ρ is density of falling body and σ is density of fluid.

$\Rightarrow v_T = \frac{2\times10^{-12}\times10^6\times10^{-3}\times10}{9\times1.8\times10^{-5}}$

$\Rightarrow v_T = 123.4 \times 10^{-6}\ \mathrm{m\ s^{-1}}$

172. (2)

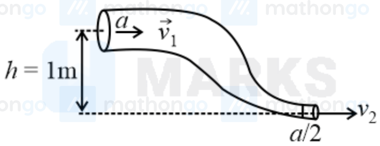
At the time of terminal velocity ball is in equilibrium i.e. $F_g = F_b + F_v$

$\Rightarrow F_v = F_g - F_b$

$\Rightarrow F_v = mg - d_2\frac{m}{d_1}g$

$\Rightarrow mg\left(1 - \frac{d_2}{d_1}\right)$

173. (363)



From equation of continuity,

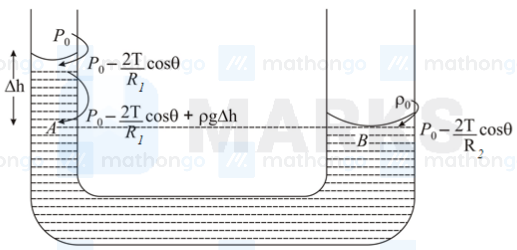
$av_1 = \frac{a}{2}v_2 \Rightarrow v_2 = 2v_1$

From Bernoulli's theorem,

$P_1 + \frac{1}{2}\rho {v_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g h_2 \Rightarrow P_1 - P_2 = \rho\left[g\left(h_2 - h_1\right) + \frac{1}{2}\left({v_2}^2 - {v_1}^2\right)\right] \Rightarrow 4100 = 800\left[10(-1) + \frac{1}{2}3{v_1}^2\right] \Rightarrow \frac{4100}{800} + 10 = \frac{3}{2}{v_1}^2 \Rightarrow v_1 = \sqrt{\frac{121}{4\times3}} = \frac{\sqrt{363}}{6}$ m

Therefore, $x = 363$.

174. (3)



$P_0 - \frac{2T}{R_1} + h_1\rho g = P_0 - \frac{2T}{R_2} + h_2\rho g$

$\left(h_1 - h_2\right)\rho g = 2T\left[\frac{1}{2.5\times10^{-3}} - \frac{1}{4\times10^{-3}}\right] \Rightarrow h_1 - h_2 = 2.19$ mm

175. (3)

For no sliding

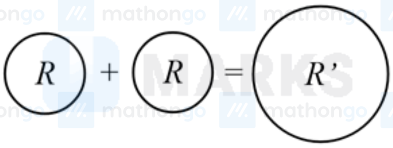
$f \geq \rho a v^2$

$\mu m g \geq \rho a v^2$

$\mu \rho A h g \geq \rho a 2 \mathrm{gh}$

$\mu \geq \frac{2a}{A}$

176. (1)



$\frac{4}{3}\pi R^3 + \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R'^3$

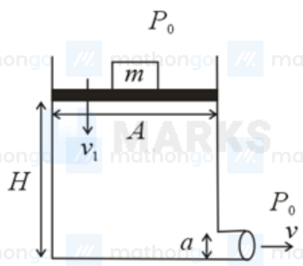
$R' = 2^{\frac{1}{3}}R$ ...(i)

$A_i = 2\left[4\pi R^2\right]$

$A_f = 4\pi R'^2$

$\frac{U_i}{U_f} = \frac{A_i}{A_f} = \frac{2R^2}{2^{\frac{2}{3}}R^2} = 2^{\frac{1}{3}}$

177. (3)



$m = 24$ kg

$A = 0.4\ \mathrm{m}^2$

$a = 1\ \mathrm{cm}^2$

$H = 40$ cm

Using Bernoulli's equation,

$\Rightarrow \left(P_0 + \frac{mg}{A}\right) + \rho g H + \frac{1}{2}P v_1^2$

$= P_0 + 0 + \frac{1}{2}\rho v^2 \quad \ldots(1)$

$\Rightarrow$ Neglecting v_1

$\Rightarrow v = \sqrt{2gH + \frac{2mg}{A\rho}}$

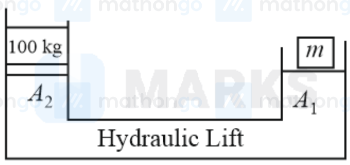
$\Rightarrow v = \sqrt{8 + 1.2}$

$\Rightarrow v = 3.033\ \mathrm{m\ s^{-1}}$

$\Rightarrow v \simeq 3\ \mathrm{m\ s^{-1}}$

178. (25600)

Using Pascals law,



$\frac{100\times g}{A_2} = \frac{mg}{A_1} \quad \ldots(1)$

Let m mass can lift M_0 in second case then

$$\frac{M_0 g}{16A_2} = \frac{mg}{A_1/16} \quad ...(2)$$

$$\left\{\text{Since } A = \frac{\pi d^2}{4}\right\}$$

From equation (1) and (2) we get

$$\frac{M_0}{16.100} = 16$$

$$\Rightarrow M_0 = 25600 \text{ kg}$$

179. (4)

$$P + \frac{1}{2}\rho v^2 = \frac{P}{2} + \frac{1}{2}\rho V^2$$

$$\frac{P}{2} + \frac{1}{2}\rho v^2 = \frac{1}{2}\rho V^2;$$

$$V = \sqrt{v^2 + \frac{P}{\rho}}$$

180. (101)

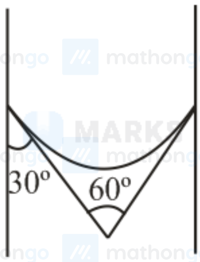
Using the concept of rise due to surface tension,

$$\frac{2T}{r} = h\rho g$$

$$T = \frac{rh\rho g}{2} = \frac{15\times10^{-5}\times15\times10^{-2}\times900\times10}{2} = 101 \text{ milliNewton m}^{-1}$$

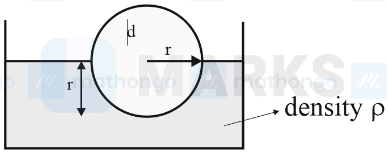
181. (2)

$h = \frac{2T\cos\theta}{\rho gr}$ $\theta = 30°$ $P = 667 \text{ kg m}^{-3}$; $T = 1/20 \text{ N m}^{-1}$; $r = 0.15\times10^{-3}$



$$= \frac{2\times\frac{1}{20}\times\frac{\sqrt{3}}{2}}{667\times10\times0.15\times10^{-3}} = 0.087\text{m}$$

182.



(4)

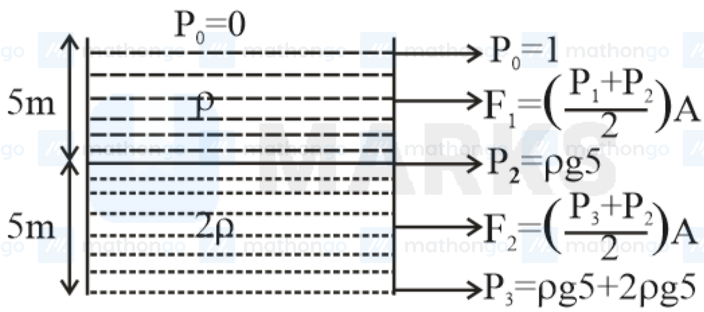
$$dVg = p\left(\frac{V}{2}\right)g + T(2\pi r)$$

$$\Rightarrow d.\frac{4}{3}\pi r^3 g = p.\frac{2}{3}\pi r^3 g + 2\pi rT$$

$$\Rightarrow \frac{2}{3}r^2 g(2d-p) = 2T$$

$$\Rightarrow r = \sqrt{\frac{3T}{(2d-p)g}}$$

183.



(4)

$$\frac{F_1}{F_2} = \frac{1}{4}$$

184. $x = 4$ m, $V = 2$ m/s, a = 16 m/s^2

$|a| = \omega^2 x$

$\Rightarrow 16 = \omega^2(4)$

$\omega = 2$rad/s

(17) $v = \omega\sqrt{A^2 - x^2}$

$A = \sqrt{\frac{v^2}{\omega^2} + x^2} \Rightarrow A = \sqrt{\frac{4}{4} + 16}$

$A = \sqrt{17}$ m

185. (7)

Speed in SHM in terms of displacement is given by, $v = \omega\sqrt{A^2 - x^2}$.

at $x = \frac{2A}{3}$, we get

$v = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2} = \frac{\sqrt{5}A\omega}{3}$

Let the new amplitude be = A'

Then,

$v' = 3v \Rightarrow \omega\sqrt{(A')^2 - \left(\frac{2A}{3}\right)^2} = \sqrt{5}A\omega$

$\Rightarrow A' = \frac{7}{3}A$

Therefore, $n = 7$.

186. (8)

Acceleration due to gravity at surface of earth, $g = \frac{GM}{R^2}$.

Now, at distance R from the surface of the earth, $g' = \frac{GM}{(R+R)^2} = \frac{g}{4}$

Therefore,

$T = 2\pi\sqrt{\frac{l}{\frac{g}{4}}}$

$\Rightarrow T = 2\pi\sqrt{\frac{4\times 4}{g}}$

$\Rightarrow T = 2\pi\frac{4}{\pi} = 8$ s

187. (2)

As can be seen from the diagram, the initial phase of the particle is given by

$\varphi = 30°$

$= \frac{\pi}{6}$

The equation of motion of the particle at its initial position at time $t = 0$ can be written as

$x(t) = r\cos\theta \quad \ldots(1)$

where, θ is the angular displacement of the particle at time $t = t$.

Since, the position of the particle at a later instant of time always lags behind its initial position at time $t = 0$, the equation of motion of the particle at any instant of time is given by

$x(t) = r\cos(\theta + \varphi) \quad \ldots(2)$

Substitute the values of the known parameters into equation (2) to obtain the required expression

$x\left(t\right) = r\cos\left(\omega t + \frac{\pi}{6}\right)$

188. (20)

Both the springs are connected in parallel, therefore

$K_{eq} = K + K = 2K$

Now, time period of spring-block system is given by,

$T = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{2K}}$

Given here, $m = 490$ gm $= 0.49$ kg and $K = 2$ N m^{-1}

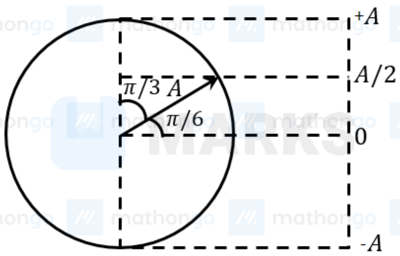
So, $T = 2\pi\sqrt{\frac{0.49}{2\times2}}$

$= 2\pi\sqrt{\frac{49}{400}} = 2\pi\frac{7}{20} = \frac{7\pi}{10}$

Now, number of oscillation in 14π is

$N = \frac{\text{time}}{T} = \frac{14\pi}{\frac{7\pi}{10}} = 20$

189. (4)



The position of a particle performing an SHM is given by:

$x = A\sin(\omega t + \phi)$

Since at $t = 0$ s, the particle is at $x = 0$, therefore the initial phase $\phi = 0$.

At time $t = 2$ s, the particle is at $x = \frac{A}{2}$.

$\therefore\ \frac{A}{2} = A\sin(2\omega) \Rightarrow \omega = \frac{\pi}{12}$ s^{-1}

Therefore, time period

$T = \frac{2\pi}{\omega} = 24$ s

The total time taken from $x = 0$ to $x = A$ is $\frac{T}{4} = 6$ s.

Since the time taken from $x = 0$ to $x = \frac{A}{2}$ is 2 s, therefore the time taken from $x = \frac{A}{2}$ to $x = A$ is 4 s.

190. (2)

Given here, potential energy, $U = 4(1 - \cos 4x)$ J

Using the relation between conservative force and potential energy, $F = -\frac{dU}{dx}$.

We have, $F = -4(+\sin 4x)4 = -16\sin(4x)$

For small θ, $\sin\theta \approx \theta$.

Acceleration of particle is $a = -\frac{64x}{m} = \frac{-64x}{4} = -16x$

As the oscillations are simple harmonic in nature, so $a = -\omega^2 x \Rightarrow \omega^2 = 16 \Rightarrow \omega = 4$ rad s^{-1}

Now, time period of oscillation is $T = \frac{2\pi}{\omega} = \frac{\pi}{2}$.

Thus, the value of $K = 2$.

191. (1)

From the figure, $A = 2$ m

$\frac{1}{2}m\omega^2A^2 = 10$

$\frac{1}{2}m\omega^2(2)^2 = 10$

$m\omega^2 = 5$

$5(\omega^2) = 5$

$\omega^2 = 1$

$\omega = 1$

$T = \frac{2\pi}{\omega} = 2\pi$

$2\pi\sqrt{\frac{\ell}{g_p}} = 2\pi$

$2\pi\sqrt{\frac{4}{g_p}} = 2\pi$

$g_p = 4\text{m/s}^2$

192. (4)

Considering $\rightarrow$ Spring - mass system

$x = x_0\sin\omega t$

$P.E. = \frac{1}{2}kx^2 = \frac{1}{2}kxo^2\sin^2\omega t = c\sin^2\omega t$

$\Rightarrow PE = \left(\frac{1-\cos2\omega t}{2}\right)$

193. (1)

$y_1 = 10\sin\left(3\pi t + \frac{\pi}{3}\right)$

$y_2 = 5\left[\sin3\pi t + \sqrt{3}\cos\pi t\right]$

$y_2 = 10\sin\left(3\pi t + \frac{\pi}{3}\right) \Rightarrow \frac{A_2}{A_1} = \frac{10}{10} = 1$

194. (4)

$v^2 = \omega^2\left(A^2 - x^2\right)$

$A^2 = x_1^2 + \frac{v_1^2}{\omega^2} = x_2^2 + \frac{v_2^2}{\omega^2}$

$\omega^2 = \frac{v_2^2 - v_1^2}{x_1^2 - x_2^2}$

$T = 2\pi\sqrt{\frac{x_1^2 - x_2^2}{v_2^2 - v_1^2}}$

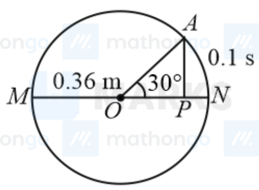
195. (2)

$T_a = 2\pi\sqrt{\frac{M}{K}}$

$T_b = 2\pi\sqrt{\frac{M}{K/2}}$

$\frac{T_b}{T_a} = \sqrt{2} = \sqrt{x}$

196. (2)



The point A covers 30° in 0. 1 s.

Then, we have $\frac{\pi}{6}$ rad $\longrightarrow$ 0. 1 s.

Or 1 rad $\longrightarrow \frac{0.1}{\frac{\pi}{6}}$ s

Or 2π in $\rightarrow \frac{0.1 \times 6}{\pi} \times 2\pi$

Thus, time taken is T = 1. 2 sec.

We know that $\omega = \frac{2\pi}{T}$

Then, $\omega = \frac{2\pi}{1.2}$

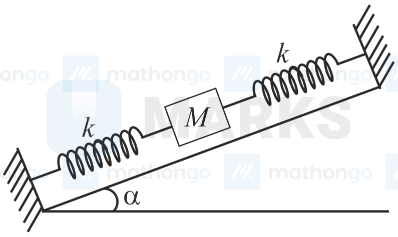
Restoration force $\left(\text{F}\right) = \text{m}\omega^2\text{A}$.

Then Restoration force per unit mass $\left(\frac{\text{F}}{\text{m}}\right) = \omega^2$ A

$\left(\frac{\text{F}}{\text{m}}\right) = \left(\frac{2\pi}{1.2}\right)^2 \times 0.36$

$\cong 9.87$ N

197. (4)



$K_{eq} = K_1 + K_2 = K + K = 2K$

$T = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{2\ K}}$

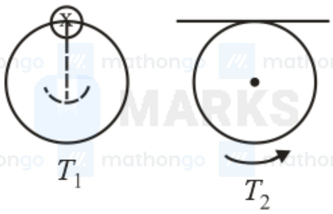
$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{2K}{m}}$

198. (2)

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\left(\sqrt{\frac{YA}{mL}}\right)$

$f = \frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$

199. (1)



The time period of oscillation of physical pendulum is given by

$T = 2\pi\sqrt{\frac{I}{Mgl}}\ \ldots (1)$

Where, I is the moment of inertia of ring about given axis and l is the distance of centre of mass of ring from the axis of rotation.

Moment of inertia of ring in its plane is given by

$I_1 = I_c + Md^2 = MR^2 + MR^2 = 2MR^2$

Moment of inertia of ring perpendicular to its plane is given by

$I_2 = I_c + Md^2 = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$

Now the ratio of time period is given by

$\frac{T_1}{T_2} = \sqrt{\frac{I_1}{I_2}}$

$\Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{2MR^2}{\frac{3}{2}MR^2}}$

$\Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{4}{3}} = \frac{2}{\sqrt{3}}$

200. (1)

The given equation is $y = 2\sin(\omega t - kx)$

The maximum particle velocity $= A\omega$

And the wave velocity $= \frac{\omega}{k}$

For wave velocity to be equal to maximum particle velocity

$\frac{\omega}{k} = A\omega$

$\Rightarrow k = \frac{1}{A}$

Since, $k = \frac{2\pi}{\lambda}$

$\lambda = 2\pi A = 4\pi$ cm.

201. (104)

Wavelength of wave $\Rightarrow \lambda = \frac{v}{f} = \frac{336}{400} = 84$ cm

At first resonance

$\frac{\lambda}{4} = l + e \Rightarrow \frac{84}{4} = 20 + e$, where, e is end correction.

$\Rightarrow e = 1$

So third resonance length

$5\frac{\lambda}{4} = l_2 + e$

$5(21) = l_2 + 1$

$l_2 = 104$ cm

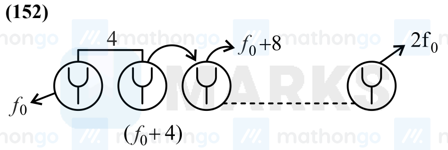
202. (4)

If the velocity of the sound in the medium is v then, $f_1 = \frac{v}{4.08}$ and $f_2 = \frac{v}{4.16}$

Now beat frequency,

$f_b = \Delta f = \left|f_1 - f_2\right| = \frac{40}{12} = \frac{10}{3}$ Hz $\Rightarrow v\left[\frac{1}{4.08} - \frac{1}{4.16}\right] = \frac{10}{3}$ Hz $\Rightarrow 707.2$ m s^{-1}

203. (152)



Each fork produces 4 beats per second with the previous means each fork has frequency 4 Hz more than the previous.

Using relation, $f_{\text{last}} = f_{\text{first}} + (N - 1)x$, here, N is the number of tuning fork in series and x is beat frequency between two successive forks.

$2f_0 = f_0 + (20 - 1)4$

$\Rightarrow 2f_0 = f_0 + 76 \Rightarrow f_0 = 76$ Hz

Frequency of last tuning fork is 152 Hz.

204. (80)

The fundamental frequency of the closed organ pipe is given by, $f_0 = \frac{v}{4l_c}$.

The frequency of the first overtone of a open organ pipe is given by, $f_1 = 2 \times \frac{v}{2l_o}$.

Since,

$f_0 = f_1 \Rightarrow \frac{v}{4l_c} = \frac{v}{l_o} \Rightarrow l_o = 4 \times 20 = 80$ cm.

205. (5)

Amplitude is the maximum displacement from the mean position, for that

$\sin\left(\frac{2\pi t}{T}\right) = 1$

Therefore, $A = \left|10\cos\left(\frac{4}{3}\pi\right)\right| = 10 \times \frac{1}{2} = 5$ cm

206. (10) $f_n = \frac{nv}{2\ell} = 500$

$f_{n+1} = \frac{(n+1)v}{2\ell} = 550$

$\frac{n+1}{n} = \frac{11}{10}$

Thus, $n = 10$

Thus, $\ell = \frac{\mathrm{nv}}{2\mathrm{f_n}}\left(\mathrm{v} = \sqrt{\frac{\mathrm{T}}{\mu}}\right)$

$= \frac{10}{2 \times 500} \times \sqrt{\frac{900}{9 \times 10^{-4}}} = 10$ m

207. (1)

At Node,

$y = 0$

$\Rightarrow \cos(1.57x)\sin(78.5t) = 0$

$\Rightarrow \cos(1.57x) = 0$

$\Rightarrow 1.57x = \frac{\pi}{2}$

$\Rightarrow x = 1$ cm

208. **(2)** At $t=0, y=\frac{1}{1+x^2}$

At time $t=t, y=\frac{1}{1+(x-vt)^2}$

At $t=1, y=\frac{1}{1+(x-v)^2} \ldots$(i)

At $t=1, y=\frac{1}{1+(x-2)^2} \ldots$(ii)

Comparing (i) and (ii)

$v=2 \mathrm{~m} \mathrm{~s}^{-1}$

209. **(1)**

$\frac{\lambda}{2}=24.5-17=7.5 \mathrm{~cm}$

$f=\frac{V}{\lambda}$

$=\frac{330 \times 100}{15}=2200 \mathrm{~Hz}$

210. **(2)**

Change in resistance due to temperature is given by, $R'=R(1+\alpha \Delta T)$

For Series Combination:

$R_{eq}=R_1+R_2$

$\Rightarrow 2R\left(1+\alpha_{eq} \Delta T\right)=R\left(1+\alpha_1 \Delta T\right)+R\left(1+\alpha_2 \Delta T\right)$

$\Rightarrow 2R\left(1+\alpha_{eq} \Delta T\right)=2R+\left(\alpha_1+\alpha_2\right) R \Delta T$

$\Rightarrow \alpha_{eq}=\frac{\alpha_1+\alpha_2}{2}$

For Parallel Combination:

$\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}$

$\Rightarrow \frac{1}{\frac{R}{2}\left(1+\alpha_{eq} \Delta T\right)}=\frac{1}{R\left(1+\alpha_1 \Delta T\right)}+\frac{1}{R\left(1+\alpha_2 \Delta T\right)}$

$\Rightarrow \frac{2}{1+\alpha_{eq} \Delta T}=\frac{1}{1+\alpha_1 \Delta T}+\frac{1}{1+\alpha_2 \Delta T}$

$\Rightarrow \frac{2}{1+\alpha_{eq} \Delta T}=\frac{1+\alpha_2 \Delta T+1+\alpha_1 \Delta T}{\left(1+\alpha_1 \Delta T\right)\left(1+\alpha_2 \Delta T\right)}$

$\Rightarrow 2\left[\left(1+\alpha_1 \Delta T\right)\left(1+\alpha_2 \Delta T\right)\right]=\left[2+\left(\alpha_1+\alpha_2\right) \Delta T\right]\left[1+\alpha_{eq} \Delta T\right]$

$\Rightarrow 2\left[1+\alpha_1 \Delta T+\alpha_2 \Delta T+\alpha_1 \alpha_2 \Delta T\right]=2+2 \alpha_{eq} \Delta T+\left(\alpha_1+\alpha_2\right) \Delta T+\alpha_{eq}\left(\alpha_1+\alpha_2\right) \Delta T^2$

Neglecting small terms

$2+2\left(\alpha_1+\alpha_2\right) \Delta T=2+2 \alpha_{eq} \Delta T+\left(\alpha_1+\alpha_2\right) \Delta T$

$\Rightarrow\left(\alpha_1+\alpha_2\right) \Delta T=2 \alpha_{eq} \Delta T$

$\Rightarrow \alpha_{eq}=\frac{\alpha_1+\alpha_2}{2}$

211. **(4)**

When the state of the substance is not changing, temperature of the substance increases when heat is supplied to it. But when the substance changes the state, the heat supplied to it used as latent heat and the temperature remains constant until all the substance converts to other state.

Therefore, temperature of ice first increases from -10 °C to 0 °C. Then, remains constant at 0°C till whole ice is melted. Then, it increases from 0 °C to 100 °C. Again it remains constant at 100 °C till whole water converts into steam.

212. **(2)**

The work to be done in the process is given by

$dW=PdV$

$=1 \times 10^5 \mathrm{~Pa} \times(1.671-0.001) \mathrm{~m}^3$

$=1.670 \times 10^5 \mathrm{~J}$

The change in heat energy during the vaporisation process can be calculated as follows-

$\Delta Q_{\text{supplied}}=2257 \times 1 \times 10^3 \mathrm{~J}$

$=22.57 \times 10^5 \mathrm{~J}$

Hence, the change in internal energy in the process is given by

$\Delta U = \Delta Q_{supplied} - \Delta W$

$= \left(22.57 - 1.67\right) \times 10^5$ J

$= 20.9 \times 10^5$ J

$= 2090$ kJ

213. (2)

From the graph

For scale P,

Lower fixed point = 180 - 150 = 30°P

Upper fixed point = 180°P

For scale Q,

Lower fixed point = 0°Q

Upper fixed point = 100°Q

Thus, the relationship between the two scales P and Q is given by

$\frac{t_P - 30}{180 - 30} = \frac{t_Q - 0}{100 - 0}$

$\Rightarrow \frac{t_P - 30}{150} = \frac{t_Q}{100}$

214. (60)

Linear expansion of solid with temperature is given by $L_f = L_0(1 + \alpha \Delta T)$

Here, $l_B\left(1 + \alpha_B \Delta T\right) - l_i\left(1 + \alpha_i \Delta T\right) = l_B - l_i$

$\Rightarrow \alpha_B l_B = l_i \alpha_i$

$\Rightarrow 1.8 \times 10^{-5} \times 40 = l_i \times 1.2 \times 10^{-5}$

$\Rightarrow l_i = \frac{1.8 \times 10^{-5} \times 40}{1.2 \times 10^{-5}} = \frac{3 \times 40}{2} = 60$

$\Rightarrow l_i = 60$ cm

215. (3)

At STP volume occupied by one mole of a gas is 22.4 L. Therefore, number of moles are, $n = \frac{44.8}{22.4} = 2$ mol.

The process is isochoric process as the volume of the cylinder remains fixed and helium is a monatomic gas. Therefore, amount of heat needed will be,

$Q = n \text{ Cv } \Delta T = (2)\left(\frac{3}{2}R\right)(20) = 3 \times 8.3 \times 20 = 498$ J

216. (4)

To fit gold ring of diameter 5.230 cm over wooden bangle of diameter 6.241 cm, gold ring expansion is required.

So, $l = l_0[1 + \alpha \Delta T]$

$\Rightarrow 6.241 = 6.230\left[1 + 1.4 \times 10^{-5}(T - 27)\right]$

$\Rightarrow \frac{6.241}{6.230} - 1 = 1.4 \times 10^{-5}(T - 27)$

$\Rightarrow T = 152.7°C$

217. (31)

Heat rejected by the steam engine per minute will be equal to latent heat per minute plus heat rejected by the water to cool down.

$\frac{\Delta H}{\Delta t} = \frac{\Delta m}{\Delta t}L + \frac{\Delta m}{\Delta t}s\,\Delta T \Rightarrow \frac{\Delta H}{\Delta t} = 50 \times 540 + 50 \times 1 \times 80 = 31000 \text{ cal min}^{-1} = 31 \times 10^3 \text{ cal min}^{-1}$

218. (2)

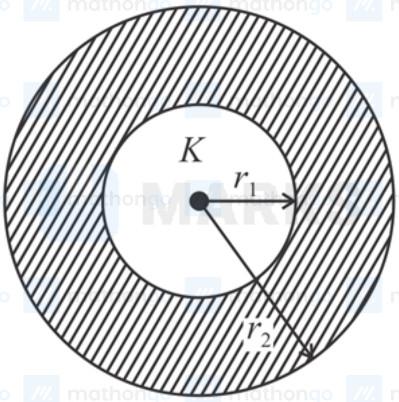
Let thermal conductivity of M_1 be K'.

Using heat current relation for steady state conduction,

$\frac{K'A(100 - 80)}{16} = \frac{KA(80 - 0)}{8}$

$\Rightarrow \frac{K' \times 20}{16} = \frac{K \times 80}{8} \Rightarrow K' = 8K$

219.



(4)

Equivalent resistance $(R) = \frac{r_2 - r_1}{K4\pi r_2 r_1}$

Thus, Heat flow $= \frac{4\pi K(r_1 r_2)(\theta_2 - \theta_1)}{(r_2 - r_1)}$

220. (2)

$Q_{AC} + Q_{DC} = Q_{CB}$

$\frac{KA(200-t)}{\frac{\ell}{2}} + \frac{KA(125-t)}{\ell} = \frac{(t-100)KA}{\frac{\ell}{2}}$

$400 - 2t + 125 - t = 2t - 200$

$725 = 5t$

$t = 145°C$

$Q_{CD} = \frac{KA(145-125)}{\ell} = \frac{20}{\frac{\ell}{KA}} = 2$ W

221. (1)

$(200)(31 - 25) = m \times 540 + m(1)(69)$

$1200 = m(609)$

$m \approx 2$

222. $TV^{\gamma-1} =$ constant

$\Rightarrow T(V)^{\frac{3}{2}-1} = T_f(2V)^{\frac{3}{2}-1}$

$\Rightarrow TV^{\frac{1}{2}} = T_f(2)^{\frac{1}{2}}(V)^{\frac{1}{2}}$

$\Rightarrow T_f = \left(\frac{T}{\sqrt{2}}\right)$

(3)

Now, W.D. $= \frac{nR\Delta T}{1-\gamma} = \frac{1 \cdot R\left[\frac{T}{\sqrt{2}} - T\right]}{1 - \frac{3}{2}}$

$\Rightarrow$ W.D. $= 2RT\left[1 - \frac{1}{\sqrt{2}}\right]$

$\Rightarrow$ W.D. $= RT[2 - \sqrt{2}]$

223. (2) $W_{AB} = \int PdV$ (Assuming T to be constant)

$= \int \frac{RTdV}{V^3}$

$= RT\int_2^4 V^{-3}dV$

$= 8 \times 300 \times \left(-\frac{1}{2}\left[\frac{1}{4^2} - \frac{1}{2^2}\right]\right)$

$= 225$ J

$W_{BC} = P\int_4^2 dV = 10(2-4) = -20$ J

$W_{CA} = 0$

$\therefore W_{cycle} = 205$ J

224. (1) For ideal gas

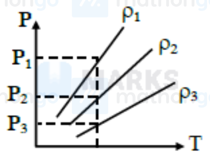
$PV = nRT$

$PV = \frac{m}{M}RT$

$P = \left(\frac{M}{V}\right)\frac{RT}{M}$

$P = \frac{\rho RT}{M}$

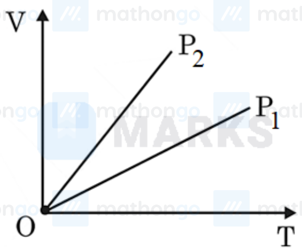
(Where m is mass of gas and M is molecular mass of gas)



for same temperature $P_1 > P_2 > P_3$

So $\rho_1 > \rho_2 > \rho_3$

225. (4)



As we know, $PV = nRT$

$\Rightarrow V = \left(\frac{nR}{P}\right)T$

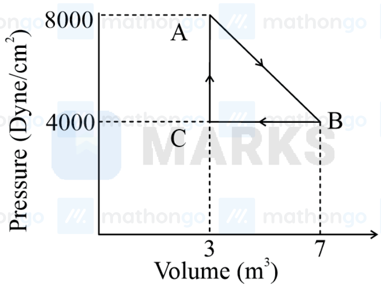
Therefore, slope $= \frac{nR}{P}$

Or slope $\propto \frac{1}{P}$

As $(\text{Slope})_2 > (\text{Slope})_1$

$\Rightarrow P_2 < P_1$

226. (4)



Work done during the path A → B can be written as $W_{AB} = \frac{1}{2}\left(8000 + 4000\right)\text{ dyne cm}^{-2} \times \frac{1\ \text{N}}{10^5\ \text{dyne}} \times \frac{1\ \text{cm}^2}{10^{-4}\ \text{m}^2} \times (7 - 3)\text{ m}^3$

$= 2400$ J

The work done during the process B → C is given by

$$W_{BC} = \left(4000\text{ dyne cm}^{-2} \times \frac{1\ \text{N}}{10^5\ \text{dyne}} \times \frac{1\ \text{cm}^2}{10^{-4}\ \text{m}^2}\right) \times (3 - 7)\text{ m}^3$$

$= -1600$ J

Hence, the total work done is given by

$W = W_{AB} + W_{BC}$
$= 2400\text{ J} - 1600\text{ J}$
$= 800\text{ J}$

227. (2)

It is given that

$P \propto T^3 \Rightarrow PT^{-3} = \text{constant} \quad ...(1)$

For an adiabatic process,

$PV^{\gamma} = \text{constant} \quad ...(2)$

Assuming the gas to be a perfect gas, it can be written from equation (2) that

$P\left(\frac{nRT}{P}\right)^{\gamma} = \text{constant} \Rightarrow P^{1-\gamma}T^{\gamma} = \text{constant} \Rightarrow PT^{\frac{\gamma}{1-\gamma}} = \text{constant}$

By comparing with equation(1), we get

$\Rightarrow \frac{\gamma}{1-\gamma} = -3 \Rightarrow \gamma = -3 + 3\gamma \Rightarrow 3 = 2\gamma \Rightarrow \gamma = \frac{3}{2}$

228. (1)

Let γ be the ratio of $\frac{C_p}{C_v}$.

Then for adiabatic process PV^{γ} = Constant

$\Rightarrow \frac{P_i}{P_f} = \left(\frac{V_f}{V_i}\right)^{\gamma}$

$\Rightarrow \left(\frac{81}{16}\right) = \left(\frac{27}{8}\right)^{\gamma} \Rightarrow \left[\left(\frac{3}{2}\right)^3\right]^{\frac{4}{3}} = \left(\frac{27}{8}\right)^{\gamma}$

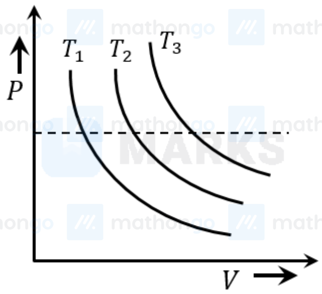
$\Rightarrow \gamma = \frac{4}{3}$

229. (4)

In case of isothermal process, pressure vs volume graph is a rectangular hyperbola.

The graph of the isothermal process shifts away from the origin as the temperature of the process is increased. Thus, the curve away from the origin T_3 have the highest temperature whereas the curve closer to the origin T_1 have the lowest temperature.

Here, the dotted line shows the isobaric line that implies $T_3 > T_2 > T_1$ as $T = \frac{PV}{nR}$.



230. (3)

As we know, $C_v = f\frac{R}{2}$

and $C_p = C_v + R = f\frac{R}{2} + R$

Therefore, $\gamma = \frac{C_p}{C_v} = 1 + \frac{2}{f}$

For monatomic gas, $f = 3$ and hence $\gamma_1 = \frac{5}{3}$

For diatomic gas, $f = 5$ and hence $\gamma_2 = \frac{7}{5}$

Required ratio, $\frac{\gamma_1}{\gamma_2} = \frac{25}{21}$

231. (750)

For constant pressure process,

Work done is given by $W = nR\Delta T = 150$ J, here, R is gas constant.

Now, for above process, $f = 8$.

So, specific heat at constant pressure is $C_P = \left(1 + \frac{f}{2}\right)R$.

Amount of heat adsorbed by the gas is

$Q = nC_P R\Delta T = \left(\frac{f}{2}+1\right)nR\Delta T = \left(\frac{8}{2}+1\right)150 = 750 \text{ J}$

232. (2)

Given here, $P_1 = 2 \times 10^7 \text{ N m}^{-2} = 2 \times 10^7 \text{ Pa}$

Using Boyle's law,

$P_1V_1 = P_2V_2$

Since $V_2 = 2V_1$.

Hence, $P_2 = \frac{P_1}{2}$ (isothermal expansion)

$P_2 = 1 \times 10^7 \text{ Pa}$

Now, during adiabatic expansion,

$P_2\left(V_2\right)^\gamma = P_3\left(2V_2\right)^\gamma$

$P_3 = \frac{1 \times 10^7}{2^{1.5}} = 3.536 \times 10^6 \text{ Pa}$

233. (2)

Since, each vibrational mode, corresponds to two degrees of freedom, hence, f =3 (trans .) +3(rot .)+8(vib .)=14

& $\gamma = 1 + \frac{2}{\mathrm{f}}$

$\gamma = 1 + \frac{2}{14} = \frac{8}{7}$

$\mathrm{W} = \frac{\mathrm{nR}\Delta\mathrm{T}}{\gamma - 1} = -582$

As W < 0. work is done on the gas.

234. (2)

$PV = nRT$

$PV \propto T$

Straight line with positive slope (nR).

235. (17258)

Process of isothermal

$W = nRT\ell n\left(\frac{V_2}{V_1}\right)$

$= 1 \times 8.3 \times 300 \times \ln 2$

$= 17258 \times 10^{-1} \text{ J}$

236. (2)

Option (a) is wrong; since in adiabatic process V $\neq$ constant.

Option (b) is wrong, since in the isothermal process

T= constant

Option (c) & (d) matches isotherms & adiabatic formula :

$TV^{\gamma-1} =$ constant & $\frac{T^\gamma}{P^{\gamma-1}} =$ constant

237. (4)

$A - B =$ isothermal process

$W_{AB} = P_1V_1 \ln\left[\frac{2V_1}{V_1}\right] = P_1V_1\ln(2)$

$B - C \rightarrow$ Isochoric process

$W_{BC} = 0$

$C - A \rightarrow$ Adiabatic process

$W_{CA} = \frac{P_1V_1 - \frac{P_1}{4} \times 2V_1}{1-\gamma} = \frac{P_1V_1\left[1-\frac{1}{2}\right]}{1-\gamma} = \frac{P_1V_1}{2(1-\gamma)}$

$W_{\text{net}} = W_{AB} + W_{BC} + W_{CA} \quad \left\{P_1V_1 = RT\right\}$

$= P_1V_1 \ln(2) + 0 + \frac{P_1V_1}{2(1-\gamma)}$

$W_{\text{net}} = RT\left[\ln(2) - \frac{1}{2(\gamma-1)}\right]$

238. (2)

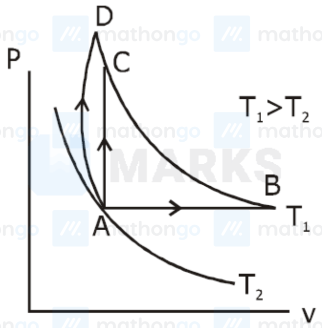
$E_{AB} = E_{AC} = E_{AD}$

$dU = \frac{nfR}{2}\left(T_f - T_i\right)$

$W_{AB} > 0\left(+\right)$ as $V \uparrow$

$W_{AC} = 0$ as $V =$ constant

$W_{AD} < 0\left(-\right)$ as $V \downarrow$



ΔT is same for $E_{AB} = E_{AC} = E_{AD}$

239. (1819) $PV^{\gamma} =$ constant

$TV^{\gamma-1} =$ constant

$300\left(V_1\right)^{1.4-1} = T_B\left(\frac{V_1}{16}\right)^{2/5}$

$T_B = 300 \times 2^{8/5}$

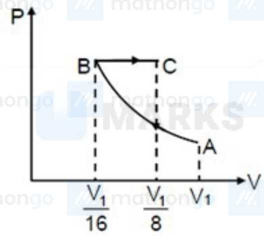
Now for BC process

$\frac{V_B}{T_B} = \frac{V_c}{T_c}$

$T_c = \frac{V_c T_B}{v_B} = 2 \times 300 \times 2^{8/5}$

$T_c = 1818.859$

$T_c = 1819K$



240. (1)

According to the ideal equation,

$PV = nRT$

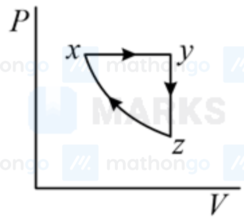
In the given V- T diagram,

In process $x \rightarrow y$, $V \propto T$. So, the process is isobaric process.

In process $y \rightarrow z$, $V =$ constant. So, the process is an isochoric process.

In process $z \rightarrow x$, $T =$ constant. So, the process is an isothermal process.

Analyzing using the ideal gas equation in each process, the P- V graph can be drawn as shown below,



241. $\lambda = \frac{RT}{\sqrt{2}\pi d^2 N_A P}$

(3)

$KE = \frac{f}{2}nRT$

242. $dQ = du + dW$

$CdT = C_V dT + PdV$

$\therefore PV^2 = RT$

(3) $P =$ constant

$P(2VdV) = RdT$

$PdV = \frac{RdT}{2V}$

Put in equation (1)

$C = C_V + \frac{R}{2V}$

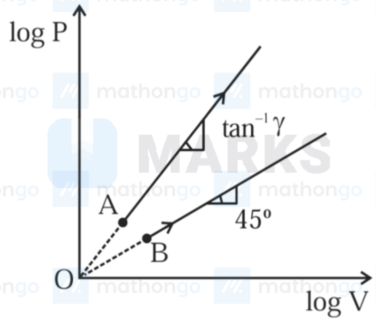
243. (3) $n =$ number of molecule per unit volume

$d =$ diameter of the molecule

$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$

(By Theory)

244. (1)



For process A:

$\log P = \gamma \log V \Rightarrow P = V^{\gamma}, \left(\gamma > 1\right)$

$PV^{-\gamma} =$ Constant

$C_A = C_V + \frac{R}{1+\gamma}$ ...(i)

Likewise, for process $B \rightarrow PV^{-1} =$ Constant

$C_B = C_v + \frac{R}{1+1}$

$C_B = C_v + \frac{R}{2}$ ...(ii)

Also, $C_P = C_v + R$ ...(iii)

By (ii) and (iii), we get

$C_P > C_B > C_v$

245. (1)

From ideal gas equation, $PV = nRT$

$\Rightarrow PV = \frac{N}{N_A}RT$, where $N =$ total number of molecules

$\Rightarrow P = \frac{N}{V}\left(\frac{R}{N_A}\right)T \Rightarrow P = \frac{N}{V}kT$

$\Rightarrow 1.38 \times \left(1.01 \times 10^5\right) = \left(2 \times 10^{25}\right) \times \left(1.38 \times 10^{-23}\right) \times T$

$\Rightarrow 1.01 \times 10^5 = 2 \times 10^2 \times T$

$T = \frac{1.01 \times 10^3}{2} \approx 500$ K

246. (3)

The RMS speed is given by

$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

The average speed is given by

$v_{\text{avg}} = \sqrt{\frac{8RT}{\pi M}}$

The ratio is

$$\Rightarrow \frac{v_{\text{rms}}}{v_{\text{avg}}}=\sqrt{\frac{\frac{3RT}{M}}{\frac{8RT}{\pi M}}}=\sqrt{\frac{3\pi}{8}}=\sqrt{\frac{3}{8}\times\frac{22}{7}}\Rightarrow\frac{v_{\text{rms}}}{v_{\text{avg}}}=\sqrt{\frac{33}{28}}$$

Comparing it with the given value $\left(1+\frac{5}{x}\right)^{\frac{1}{2}}$,

$\frac{v_{\text{rms}}}{v_{\text{avg}}}=\sqrt{1+\frac{5}{28}}\Rightarrow x=28$

247. (3)

The mean free path is given by the relation,

$\lambda=\frac{RT}{\sqrt{2}\pi d^2N_AP}$

So, $\lambda\propto T$

Let λ' be the new mean free path.

Hence,

$\frac{1500d}{\lambda'}=\frac{273}{373}$

$\Rightarrow\lambda'=2049.45d\approx2049d$

248. (4)

The given data is

$n_1=3\times10^{19}n_2=12\times10^{19}$

The mean time between two collision has the meaning of a period τ, since it indicates the repetitive time intervals in which on average collisions take place. The reciprocal of the time τ can be understood as the collision frequency f, which indicates the number of collisions per unit time.The collision frequency is also directly proportional to the number molecules per unit volume.

$f\propto\frac{1}{\tau}$

$\Rightarrow f\propto n$

$\Rightarrow\frac{f_1}{f_2}=\frac{n_1}{n_2}=\frac{3\times10^{19}}{12\times10^{19}}=0.25$

249. (3)

The rms velocity of a gas is given by $V_{\text{rms}}=\sqrt{\frac{3RT}{M}}$. Therefore,$V_{\text{rms}}$ is independent of number of moles, Hence, statement A is correct and D is incorrect.

According to the ideal gas equation $PV=nRT\Rightarrow P\propto n$

$\Rightarrow\frac{P_1}{P_2}=\frac{n_1}{n_2}=\frac{1}{4}$

Hence, statement B is correct and C is incorrect.

Ans [A & B only are correct]

250. (2)

According to the equipartition of energy, each degree of freedom carries $\frac{1}{2}RT$ energy per mole and total energy per mole of a gas having n degrees of freedom is $\frac{1}{2}nRT$. Therefore, statement A is wrong and statement B is correct.

A monoatomic molecule only has translational degrees of freedom and does not have rotational degree of freedom. For a polyatomic model there are three rotational degrees of freedom and three translational degrees of freedom. Therefore, statement C is incorrect and statement D is correct.

251. (1)

For a gas having degrees of freedom n,

$C_V=\frac{nR}{2}$ and using Mayer's relation $C_P=C_V+R$. Therefore,

$\frac{C_V}{C_P}=\frac{n}{n+2}$.

252. (2)

From the ideal gas equation, total number of moles in the mixture are,

$n=\frac{PV}{RT}=\frac{2\times10^{-3}\times100\times10^3\times3}{25\times300}\Rightarrow n=\frac{2}{25}=0.08$

If number of moles of oxygen are n_1 and of hydrogen are n_2

$n_1+n_2=n=0.08\ldots(1)$

And total mass of the mixture

$n_1(32) + n_2(2) = 0.76 \ldots(2)$

Solving the above equations,

$n_1 = 0.02$ and $n_2 = 0.06$

$\frac{n_2}{n_1} = 3$

253. **(4)** $V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$m_A < m_B < m_C$

$\Rightarrow V_A > V_B > V_C$

$\Rightarrow \frac{1}{V_A} < \frac{1}{V_B} < \frac{1}{V_C}$

254. **(2)**

Let the final temperature of the mixture be T.

Since, there is no loss in energy.

$\Delta U = 0$

$\Rightarrow \frac{F_1}{2} n_1 R \Delta T + \frac{F_2}{2} n_2 R \Delta T = 0$

$\Rightarrow \frac{F_1}{2} n_1 R\left(T_1 - T\right) + \frac{F_2}{2} n_2 R\left(T_2 - T\right) = 0$

$\Rightarrow T = \frac{F_1 n_1 R T_1 + F_2 n_2 R T_2}{F_1 n_1 R + F_2 n_2 R} = \frac{F_1 n_1 \ T_1 + F_2 n_2 \ T_2}{F_1 n_1 + F_2 n_2}$

255. **(2)**

$f = 4 + 3 + 3 = 10$, assuming non-linear,

$\beta = \frac{C_p}{C_v} = 1 + \frac{2}{f} = \frac{12}{10} = 1.2$

256. **(2)** $T_{\text{mean}} \ \alpha \frac{1}{\sqrt{T}}$

$\therefore$ time $= \frac{V}{4\pi\sqrt{2}} r^2 VN$

$V = \sqrt{\frac{2RT}{\pi M}}$

257. **(4)**

The formula of internal energy of a gas is given by

$U = \frac{f}{2} RT$

Here R is the gas constant and T is temperature.

$\left(R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}\right)$

For the given configuration of triatomic molecules, the degree of freedom $f = 6$

$\Rightarrow U = \frac{6}{2} RT = 3RT$

258. **(1)**

$\frac{f_1 n_1 RT_1}{2} + \frac{f_2 n_2 RT_2}{2}$

$= 3 \times \frac{5}{2} RT + \frac{5}{2} \times 3RT = 15$

259. **(3)**

The average time taken by a moving particle between successive collisions or impacts is referred to as the mean free time (τ).

The average distance a moving particle travels between successive collisions or impacts is referred to as the mean free path (λ).

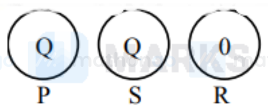
$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P}$

and $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

So, the mean free time $\tau = \frac{\lambda}{v_{\text{rms}}}$

Therefore, $\tau \propto \frac{1}{\sqrt{T}}$

260.

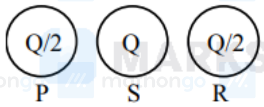


(2)

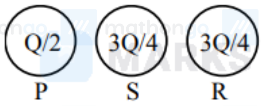
$F_{PS} \propto Q^2$

$F_{PS} = 16 \text{ N}$

Now If P & R are brought in contact then



Now If $S \& R$ are brought in contact then

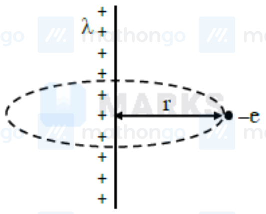


New force between P & S is :

$F_{PS} \propto \frac{Q}{2} \times \frac{3Q}{4}$

$F_{PS} \propto \frac{3Q^2}{8} = \frac{3}{8} \times 16 = 6 \text{ N}$

261.



(3)

Electric field E at a distance r due to infinite long wire is $E = \frac{2k\lambda}{r}$

Force of electron $\Rightarrow F = eE$

$F = e\left(\frac{2k\lambda}{r}\right)$

$F = \frac{2k\lambda e}{r}$

This force will provide required centripetal force

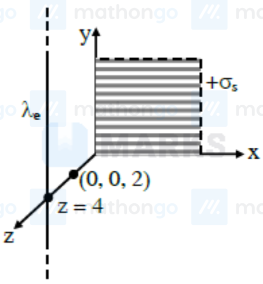
$F = \frac{m^2}{r} = \frac{2k\lambda e}{r}$

$v = \sqrt{\frac{2k\lambda e}{m}}$

$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{2k\lambda e}{m}\right)$

$= k\lambda e$

262.



(16)

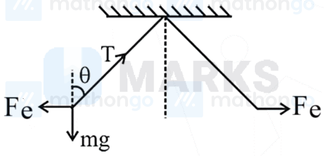
$\frac{E_S}{E_\ell} = \frac{\sigma}{2\epsilon_0} \times \frac{2\pi\epsilon_0 r}{\lambda}$

$= \frac{\pi \times \sigma r}{\lambda}$

$= \frac{\pi \times 2\lambda \times 2}{\lambda} = \frac{4\pi}{1}$

$\therefore n = 16$

263. (2)



For first case:

$Tcos\theta = mg$ and

$Tsin\theta = F_e$

Therefore, $tan\theta = \frac{F_e}{mg}$

$tan\theta = \frac{F_e}{\rho_B Vg} \ldots \left(\text{i}\right)$

For second case:

$tan\theta = \frac{\frac{F_e}{k}}{\rho_B Vg - \rho_L Vg} \ldots\ldots \left(\text{ii}\right)$

From Eq. (i) & (ii), we get

$\rho_B Vg = \left(\rho_B - \rho_L\right) kVg$

$\Rightarrow 1.4 = 0.7k$

$\Rightarrow k = 2$

264. (8)

The value of the electric field due to the uniformly charged plane sheet is given by

$E = \frac{\sigma}{2\varepsilon_0} \quad \ldots (1)$

Thus, the force on the electron is given by

$F = -eE$

$= -\frac{\sigma e}{2\varepsilon_0} \quad \ldots (2)$

So, the acceleration of the electron is given by

$a = -\frac{\sigma e}{2\varepsilon_0 m}$

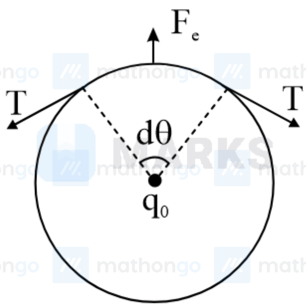
Given, $u = 1\ \text{m s}^{-1}$, $t = 1$ s and $S = -1$ m

Using the equation of motion, it can be written that

$-1 = 1 \times 1 - \frac{1}{2} \times \frac{\sigma e}{2\varepsilon_0 m} \times \left(1\right)^2 \Rightarrow \sigma = 8\frac{\varepsilon_0 m}{e}\ \text{C m}^{-2}$

$\therefore \alpha = 8.$

265. (3)



The linear charge density of the ring is given by

$\lambda = \frac{Q}{2\pi R} \quad \ldots (1)$

With reference to the above diagram, for the equilibrium condition of the ring, it can be written that

$2\ Tsin\left(\frac{d\theta}{2}\right) = \frac{1}{4\pi\varepsilon_0}\frac{q_0}{R^2} \cdot [\lambda(Rd\theta)]$

$\Rightarrow T = \frac{1}{4\pi\varepsilon_0}\frac{q_0 Q}{\left(R^2\right) \times 2\pi}$ [As for very small angles $\sin\left(\frac{d\theta}{2}\right) = \frac{d\theta}{2}$]

$$= \frac{\left(9\times10^{9}\right)\left(2\pi\times30\times10^{-12}\right)}{\left(0.30\right)^{2}\times2\pi}$$

$$= \frac{9\times10^{-3}\times30}{9\times10^{-2}} = 3\text{ N}$$

266. (8)

The electric field is given by

$$E = \left(\frac{2k\lambda}{r}\right)$$

The required centripetal force is

$$F = \left(\frac{mv^{2}}{r}\right)$$

The force due to the field is equal to the required centripetal force,

$$\Rightarrow \left(\frac{2k\lambda}{r}\right)e = \frac{mv^{2}}{r}$$

$$\Rightarrow v = \sqrt{\frac{2k\lambda e}{m}} = \sqrt{\frac{2\times9\times10^{9}\times2\times10^{-8}\times1.6\times10^{-19}}{9\times10^{-31}}}$$

$$= \sqrt{1.6\times4\times10^{13}} = 4\times2\times10^{6}\text{ m s}^{-1}$$

$$= 8\times10^{6}\text{ m s}^{-1}$$

267. (1)

The data given is

l = distance between the charges

q = charge

m = mass of the positive charge

$2m$ = mass of negative charge

The moment of inertia of the system is

$$I = \left(\frac{m\times2m}{m+2m}\right)(l)^{2} = \frac{2ml^{2}}{3}$$

The angular frequency can be written as

$$\omega = \sqrt{\frac{pE}{I}}\ \ldots(i)$$

Substituting the value of moment of inertia in the equation (i) we get

$$\omega = \sqrt{\frac{pE}{\frac{2ml^{2}}{3}}} = \sqrt{\frac{3pE}{2ml^{2}}}$$

The value of the dipole moment is

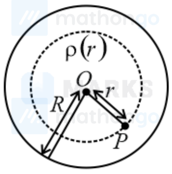
$p = ql$

Hence, the angular frequency becomes

$$\omega = \sqrt{\frac{3qE}{2ml}}$$

This question was given bonus by NTA as none of the options matched in the original paper.

268. (3)



According to Gauss's law, the electric flux through a closed surface area is equal to the charge inside the surface divided by ε_0.

$$\Rightarrow \oint \vec{E}\cdot d\vec{s} = \frac{Q_{in}}{\varepsilon_0}$$

$$\Rightarrow E4\pi r^2 = \frac{\int_0^r \rho_0\left(\frac{3}{4} - \frac{r}{R}\right)4\pi r^2 dr}{\varepsilon_0}$$

$$\Rightarrow E4\pi r^2 = \frac{\rho_o 4\pi}{\varepsilon_o}\left(\frac{3}{4}\frac{r^3}{3} - \frac{r^4}{4R}\right)$$

$$\Rightarrow E = \frac{\rho_o r}{4\varepsilon_o}\left(1 - \frac{r}{R}\right)$$

269. (2)

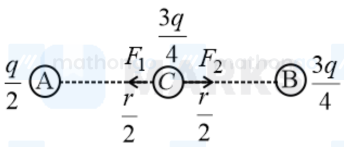
Let charge on A and B be $q_A = q_B = q$.

Then force acting between them is $F = \frac{Kq^2}{r^2}$.

When C is placed in contact with A, charge on A and C will be $= \frac{q}{2}$

Now C is placed in contact with B, charge on B and C will be $= \frac{q + \frac{q}{2}}{2} = \frac{3q}{4}$

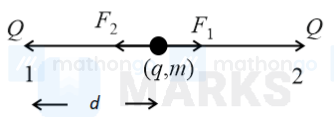
Now, force experienced by sphere C is



$$F' = F_2 - F_1 = \frac{K9q^2}{16 \times \frac{r^2}{4}} - \frac{K3q^2}{8 \times \frac{r^2}{4}} = \frac{\left(K\frac{3q}{4} - K\frac{q}{2}\right)}{\frac{r^2}{4}} \times \frac{3q}{4}$$

$$= \frac{3Kq^2}{4r^2} = \frac{3}{4}F$$

270. (1)



Let the charged particle be displaced slightly towards right by distance $x(x \ll d)$.

$(Q\ at\ A,\ q): F_1 = \frac{1}{4\pi\epsilon_0}\frac{Qq}{(d+x)^2}$, towards right

$(Q$ at $B,\ q)$: $F_2 = \frac{1}{4\pi\epsilon_0}\frac{Qq}{(d-x)^2}$, towards left

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$, will bring it towards $O.\vec{F}_{net} = \frac{1}{4\pi\epsilon_0}\left[\frac{1}{(d+x)^2} - \frac{1}{(d-x)^2}\right]\hat{i}$

$$= \frac{-Qq}{4\pi\epsilon_0}\left[\frac{4xd}{\left(d^2 - x^2\right)^2}\right]\hat{i}$$

Since $x \ll d,\ x^2$ is negligible.

$$\vec{F}_{net} = -\left(\frac{Qq}{\pi\epsilon_0 d^3}\right) \times x\hat{i}$$

Clearly, the direction of the force is opposite to the displacement & $F \propto x$, hence it is an SHM.

Acceraleration of charged particle is given as,

$a = \frac{F}{m} = -\frac{Qq}{\pi\epsilon_0 m d^3}x \quad \ldots.(1)$

And we know that for SHM,

$a = -\omega^2 x \quad \ldots.(2)$

Comparing (1) and (2), we get

$\omega = \sqrt{\frac{Qq}{\pi\epsilon_0 md^3}}$

Hence, the time period, $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\pi\epsilon_0 md^3}{Qq}}$

Therefore, $T = \sqrt{\frac{4\pi^3\varepsilon_0 ma^3}{q_0 Q}}$

271. (136)

Given here, length $l = 1$ m, current $i = 1$ A, area $A = 2 \times 10^{-6}$ m and resistivity $\rho = 1.7 \times 10^{-8}\ \Omega$ m.

Resistance of wire is $R = \frac{\rho l}{A} = \frac{1.7 \times 10^{-8} \times 1}{2 \times 10^{-5}} = \frac{1.7}{2} \times 10^{-2}\ \Omega$

Now, electric field in the wire is $E = \rho J$, where, $J = \frac{i}{A}$ is current density.

Thus, $E = \frac{i\rho}{A} = iR = 1 \times \frac{1.7}{2} \times 10^{-2}$ V m^{-1}

Electric force in terms of electric field is given by $F = qE$

Therefore, force experienced by moving electron is $F = 1.6 \times 10^{-19} \times \frac{1.7}{2} \times 10^{-2}$

$= 1.36 \times 10^{-21} = 136 \times 10^{-23}$ N

272. (3)

Electric potential $V = 3x^2$

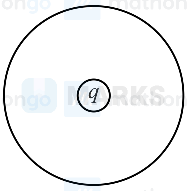
Electric potential and electric field are related as $E = -\frac{dV}{dx} = -6x$.

At the point (1, 0, 3) m,

$\Rightarrow E = -6 \times 1 = -6$ V m^{-1}

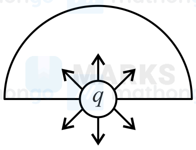
Thus, electric field is 6 V m^{-1} along negative x- axis.

273. (2)



Assume a complete sphere, then flux due to a charge placed at the center of sphere is $\phi = \frac{q}{\varepsilon_0}$

Flux through hemisphere surface is equal to flux passing through flat surface $\phi = \frac{1}{2} \times \frac{q}{\varepsilon_0} = \frac{q}{2\varepsilon_0}$

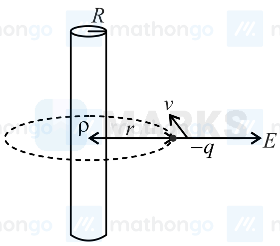


274. (2)

Total volume will be constant. Therefore, $n\left(\frac{4\pi}{3}r^3\right) = \frac{4\pi}{3}R^3 \Rightarrow 64^{\frac{1}{3}}r = R \Rightarrow R = 4r$

Final surface charge density $\sigma' = \frac{n\sigma_0 4\pi r^2}{4\pi R^2} = \frac{64 \times \sigma_0 r^2}{16r^2} \Rightarrow \frac{\sigma'}{\sigma_0} = \frac{4}{1}$

275. (1)



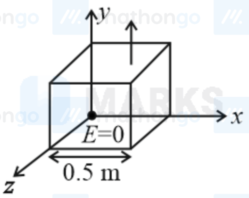
Electric field due to a long cylinder is,

$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{\rho A}{2\pi\varepsilon_0 r}$

If a charge q is rotating in a circle of radius r

$\frac{mv^2}{r} = qE \Rightarrow \frac{mv^2}{r} = q\frac{\rho A}{2\pi\varepsilon_0 r} \Rightarrow \frac{1}{2}mv^2 = \frac{q\rho\pi R^2}{4\pi\varepsilon_0} = \frac{q\rho R^2}{4\varepsilon_0}$

276. (1)



By gauss law $\oint \vec{E} \cdot \overrightarrow{ds} = \frac{q_{in}}{\varepsilon_0}$

$\varepsilon_0(150)(0.5)^2 \times (0.5)^2 = q_{in}$

$q_{in} = \frac{8.85 \times 10^{-12} \times 150}{16} = 8.3 \times 10^{-11}\text{C}$

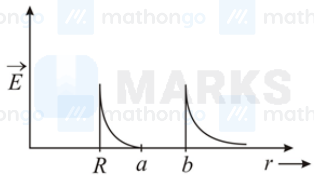
277. (3)

In the above question, the variation of the electric field with r, is,

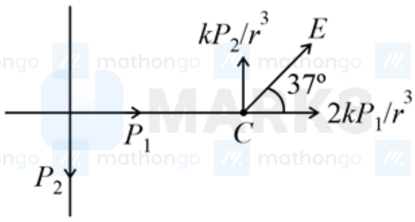
For $0 < r < R \quad E = 0$,

for $R \le r \le a \quad E = \frac{kQ}{r^2}$,

for $a < r \le b \quad E = 0$ & $r > b \quad E = \frac{kQ}{r^2}$, so the correct graph is,



278. (3)



$\tan 37° = \frac{3}{4} = \frac{\frac{kP_2}{r^3}}{\frac{2kP_1}{r^3}} = \frac{P_2}{2P_1} = \frac{3}{4}$

$\frac{P_2}{P_1} = \frac{3}{2}$

$\frac{P_1}{P_2} = \frac{2}{3}$

279. (1)

$\vec{E} = \left(\frac{3E_0}{5}\hat{i} + \frac{4E_0}{5}\hat{j}\right) \text{N C}^{-1}$

$A_1 = 0.2 \text{ m}^2$ [parallel to y - z plane]

$= \vec{A}_1 = 0.2 \text{ m}^2\hat{i}$

$A_2 = 0.3 \text{ m}^2$ [parallel to x - z plane]

$\vec{A}_2 = 0.3 \text{ m}^2\hat{j}$

Now, $\phi_a = \left[\frac{3E_0}{5}\hat{i} + \frac{4E_0}{5}\hat{j}\right] \cdot \left[0.2\hat{i}\right] = \frac{3 \times 0.2}{5}E_0$

& $\phi_b = \left[\frac{3E_0}{5}\hat{i} + \frac{4E_0}{5}\hat{j}\right] \cdot \left[0.3\hat{j}\right] = \frac{4 \times 0.3}{5}E_0$

Now, $\frac{\phi_a}{\phi_b} = \frac{0.6}{1.2} = \frac{1}{2} = \frac{a}{b}$

$\Rightarrow a : b = 1 : 2$

$\Rightarrow a = 1$

280. (36)

$q = \frac{(2.1-0.1)}{2}$ nC = 1 nC

$f = \frac{9\times10^{9}\times10^{-18}}{(0.5)^2} = 36\times10^{-9}$

281. (3)

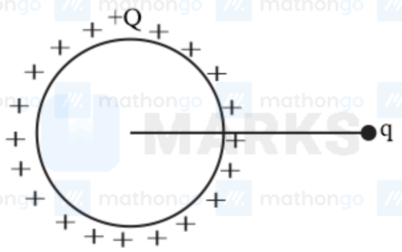
We can replace $-Q$ charge at origin by $+Q$ and $-2Q$.

Now due to $+Q$ charge at every corner of cube. Electric field at center of cube is zero so now net electric field at center is only due to -2Q charge at origin.

$\vec{E} = \frac{kq\vec{r}}{r^3} = \frac{1(-2Q)\frac{a}{2}(\hat{x}+\hat{y}+\hat{z})}{4\pi\varepsilon_0\left(\frac{a}{2}\sqrt{3}\right)^3}$

$\vec{E} = \frac{-2Q(\hat{x}+\hat{y}+\hat{z})}{3\sqrt{3}\pi a^2\varepsilon_0}$

282. (3)



E = O, r < R

$= \frac{qQ}{r^2}$, r ≥ R

Inside F = 0 and outside sphere

$F = \frac{2Qq}{4\pi\epsilon_0 r^2}$

283. (2)

According to Gauss law of electrostatics, the electric flux through an enclosed surface is given by $\phi_E = \frac{q_{\text{enc}}}{\varepsilon_0}$

From the formula of electric flux, $\phi = \vec{E}\cdot\ d\vec{s}$

Also, the relation between electric field and electric potential is given by $V = \vec{E}\cdot\ d\vec{r}$

So, the formula $\left|\vec{E}\right| = \frac{q_{\text{enc}}}{\varepsilon_0|A|}$ is only applicable when the Gaussian surface is an equipotential surface and $\left|\vec{E}\right|$ is constant on the surface.

284. (2) All capacitor are in parallel combination.

Also effective area is common area only

$\Rightarrow C_{\text{eq}} = C_1 + C_2 + C_3$

$\Rightarrow C_{\text{eq}} = \frac{A\varepsilon_0}{3d} + \frac{A\varepsilon_0}{3(2d)} + \frac{A\varepsilon_0}{3(3d)}$

$\Rightarrow C_{\text{eq}} = \frac{A\varepsilon_0}{3}\left(\frac{11}{6d}\right)$

$\Rightarrow C_{\text{eq}} = \frac{11A\varepsilon_0}{18d}$

285. (86) In parallel combination : Potential difference is same across all

Energy $= \frac{1}{2}\left(C_1 + C_2 + C_3\right)V^2$

$= \frac{1}{2}(25+30+45)\times(100)^2\times10^{-6} = 0.5 = E$

In series combination: Charge is same on all.

$$\frac{1}{C_{equ}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{25} + \frac{1}{30} + \frac{1}{45}$$

$$\frac{1}{C_{equ}} = \frac{(18+15+10)}{450} = \frac{43}{450} \Rightarrow C_{equ} = \frac{450}{43}$$

$$\text{Energy} = \frac{Q^2}{2C_1} + \frac{Q^2}{2C_2} + \frac{Q^2}{2C_3}$$

$$= \frac{Q^2}{2}\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$$

$$\frac{\left(V \times C_{equ}\right)^2}{2} \times \frac{1}{C_{equ}} = \frac{V^2 C_{equ}}{2}$$

$$\frac{(100)^2}{2} \times \frac{450}{43} \times 10^{-6}$$

$$\Rightarrow \frac{4.5}{86} = \frac{9}{x}E = \frac{9}{x} \times 0.5 \Rightarrow x = 86$$

286.

$$E = \frac{E_0}{3} \Rightarrow V = \frac{V_0}{3}$$

$$\frac{V_0}{3} = V_0 e^{-\frac{t}{\tau}}$$

(4) $t = \tau \ell n 3$

$$6.6 \times 10^{-6} = R\left(1.5 \times 10^{-6}\right)(1.1)$$

$$R = \frac{6}{1.5} = 4\Omega$$

287. (750) Before inserting dielectric capacitance is given $C_0 = 12.5\text{pF}$ and charge on the capacitor $Q = C_0 V$ After inserting dielectric capacitance will become $\epsilon_r C_0$.

Change in potential energy of the capacitor

$$= E_i - E_f$$

$$= \frac{Q^2}{2C_i} - \frac{Q^2}{2C_f} = \frac{Q^2}{2C_0}\left[1 - \frac{1}{\epsilon_r}\right]$$

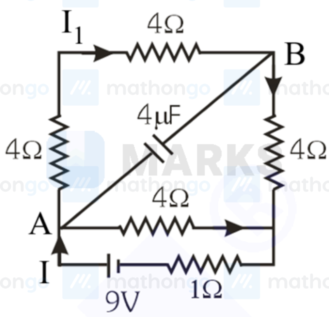
$$= \frac{\left(C_0 V\right)^2}{2C_0}\left[1 - \frac{1}{\epsilon_r}\right] = \frac{1}{2} C_0 V^2 \left[1 - \frac{1}{\epsilon_r}\right]$$

Using $C_0 = 12.5\text{pF}$, $V = 12$ V, $\epsilon_r = 6$

$$= \frac{1}{2}(12.5) \times 12^2 \left[1 - \frac{1}{6}\right] = \frac{1}{2}(12.5) \times 12^2 \times \frac{5}{6}$$

$$= 750\text{pJ} = 750 \times 10^{-12}\text{ J}$$

288. (81)



Under the balanced state, there is no flow of charge through the capacitor. So, the path connecting the capacitor behaves as an open path.

The equivalent resistance of the entire circuit, under equilibrium condition, can be calculated as follows:

$$R_{eq} = 1 + \frac{1}{\frac{1}{4+4+4} + \frac{1}{4}}\ \Omega$$

$$= (1+3)\ \Omega$$

$$= 4\ \Omega$$

Hence, the current through the entire circuit is given by

$I = \frac{V}{R_{eq}}$

$= \frac{9}{4}$ A

So, the current $\left(I_1\right)$ can be written as

$I_1 = \frac{9}{4} \times \frac{4}{16}$ A

$= \frac{9}{16}$ A

The potential difference between the points A and B is,

$V_A - V_B = I_1 \times 8$

$= \frac{9}{16} \times 8$

$= \frac{9}{2}$ V

Hence, the energy stored in the capacitor is given by

$U = \frac{1}{2}C\left(V_A - V_B\right)^2$

$= \frac{1}{2} \times 4 \times \frac{81}{4}$ μJ

$= \frac{81}{2}$ μJ

$\therefore x = 81$

289. (75)

The capacitor works as an open circuit in the given configuration.

The potential difference between the two plates of the capacitor will be the difference across the resistors having resistances 3 Ω and 4 Ω.

Hence, the potential difference (ΔV) across the capacitor can be calculated as follows:

$\Delta V = \left(\frac{4}{6} \times 12 - \frac{3}{12} \times 12\right)$ V

$= 5$ V

The formula to calculate the energy stored in the capacitor is given by

$U = \frac{1}{2}C\left(\Delta V\right)^2 \quad \ldots(1)$

Substitute the values of the known parameters into equation (1) to calculate the required energy stored.

$U = \frac{1}{2} \times 6\ \mu\text{F} \times (5\ \text{V})^2$

$= 75$ μJ

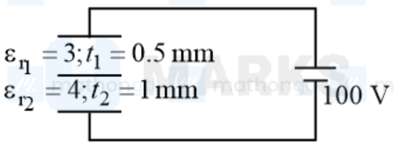
290. (1)

When a dielectric is inserted between the sheets of a capacitor, its capacitance becomes KC.

Now the equivalent capacitance in series combination will be,

$C_{eq} = \frac{C \times KC}{C(1+K)} \Rightarrow 24 = \frac{40K}{1+K} \Rightarrow K = 1.5$

291. (60)



Capacitance of each capacitor

$C_1 = \frac{A3\varepsilon_0}{\frac{1}{2}} = 6A\epsilon_0$ and $C_2 = \frac{A4\epsilon_0}{1} = 4A\varepsilon_0$

Here, A is area of plate.

Equivalent capacitance is

$C_{eq} = \frac{C_1C_2}{C_1+C_2} = \frac{6A\varepsilon_0 \times 4A\varepsilon_0}{6A\varepsilon_0 + 4A\varepsilon_0} = \frac{24}{10}A\epsilon_0$

Now, net charge stored is $q_{net} = C_{eq}(\Delta V) = \frac{24}{10}A\varepsilon_0(100) = 240A\varepsilon_0$

Potential drop across C_2 is $\Delta V_2 = \frac{240A\varepsilon_0}{4A\varepsilon_0} = 60$ V

Thus, voltage of the conducting foil is $V_{\text{foil}} = 60$ V

292. (1)

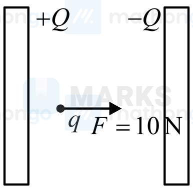
The charge on a condenser is given by $Q = CV$.

$\Rightarrow V = \frac{1}{C}Q$

Since the capacitance depends on the construction of the condenser, it is constant. Therefore, the graph will be straight line with slope $= \frac{1}{C}$.

Slope $= \frac{1}{C} = \frac{1}{2\times10^{-6}} = 5\times10^5$

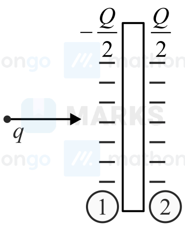
293. (1)



Electric field due to each plate, $E_1 = E_2 = \frac{\sigma}{2\varepsilon_0} = \frac{Q}{2A\varepsilon_0}$

Net electric field between the plates, $E_{\text{net}} = E_1 + E_2 = \frac{Q}{A\varepsilon_0}$

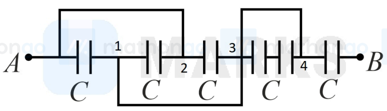
Force on charged particle between the plates, $F_1 = qE_{net} = \frac{qQ}{A\varepsilon_0} = 10$ N



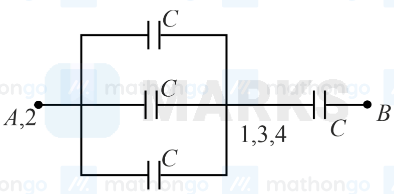
Now, in second case, the net electric field, $E = \frac{\sigma}{2\varepsilon_0} = \frac{Q}{2A\varepsilon_0} = 5$ N

Force on charged particle, $F_2 = qE = \frac{qQ}{2A\varepsilon_0} = 5$ N

294. (6)



Point 3 and 4 are at same potential, hence we can replace the capacitor with a wire.



Capacitors between points A and 3 are in parallel combination as shown above and their combined capacitance value will be $3C$.

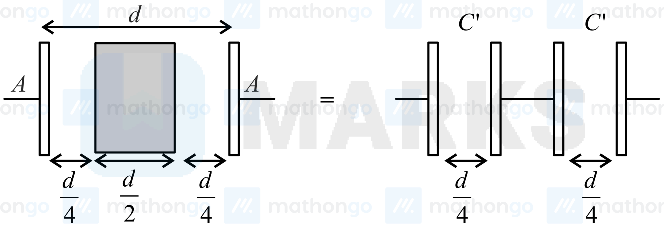
This $3C$ capacitance is in series with C.

The equivalent capacitance of the system between points A and B is,

$C_{\text{AB}} = \frac{3C\times C}{3C+C} = \frac{3C}{4}$

$\Rightarrow C_{\text{AB}} = \frac{3}{4}\times 8\ \mu\text{F} = 6\ \mu\text{F}$

295. (2)



Before the metal sheet is inserted, capacitance is given by $C = \frac{\varepsilon_0 A}{d}$.

After the sheet is inserted, the system is equivalent to two capacitors in series, each of capacitance $C' = \frac{\varepsilon_0 A}{\left(\frac{d}{4}\right)} = 4C$.

The equivalent capacity is now $\frac{1}{C'} = \frac{1}{4C} + \frac{1}{4C} \Rightarrow C' = 2C$.

The ratio is $\frac{C}{C'} = \frac{1}{2} = 1:2$

296. (1)

$V = V_0\left(1 - e^{-t/RC}\right)$

$2 = 20\left(1 - e^{-\frac{1\mu s}{10C}}\right)$

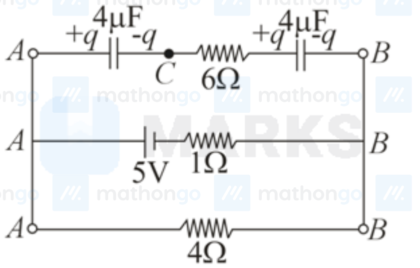
$\frac{1}{10} = \left(1 - e^{-\frac{1 \times 10^{-6}}{10C}}\right)$

$e^{-\frac{1 \times 10^{-6}}{10C}} = \frac{9}{10}$

$\frac{1 \times 10^{-6}}{10C} = \ln\left(\frac{10}{9}\right)$

$C = \frac{1 \times 10^{-6}}{10 \times \ln\left(\frac{10}{9}\right)} = \frac{10^{-7}}{1.05} = \frac{1}{1.05}\mu F = \frac{100}{105}\mu F = 0.95\mu F$

297. (2)

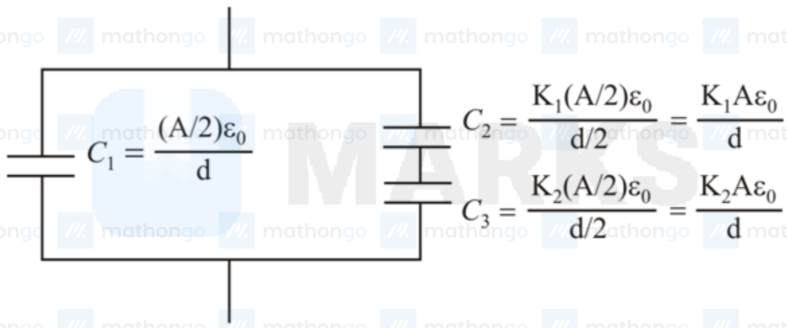


Using $i = \frac{5}{4+1} = 1\ A$

$\therefore V_{AB} = i \times 4 = 4\ V \ \therefore V_{AC} = V_{CB} = 2$ Volt

$\therefore q$ on $4\mu F = CV_{AC} = 8\mu C$

298. (1)

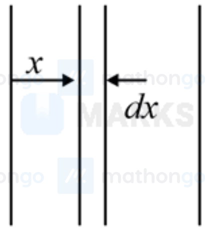


$C_{eq} = C_1 + \frac{C_2C_3}{C_2+C_3}$

$$C_{eq}=\frac{A\varepsilon_0}{2\ d}+\frac{\frac{K_1\ A\varepsilon_0}{d}\times\frac{K_2\ A\varepsilon_0}{d}}{\frac{K_1\ A\varepsilon_0}{d}+\frac{K_2\ A\varepsilon_0}{d}}$$

$$C_{eq}=\frac{A\varepsilon_0}{2\ d}+\frac{A\varepsilon_0}{d}\left(\frac{K_1\ K_2}{K_1+K_2}\right)=\frac{A\varepsilon_0}{d}\left(\frac{1}{2}+\frac{K_1\ K_2}{K_1+K_2}\right)$$

299. (2)



Taking an element of width dx at a distance $x(x<d/2)$ from left plate

$$dc=\frac{(\varepsilon_0+kx)A}{dx}$$

Capacitance of half of the capacitor

$$\frac{1}{C}=\int_0^{d/2}\frac{1}{dc}=\frac{1}{A}\int_0^{d/2}\frac{dx}{\varepsilon_0+kx}$$

$$\frac{1}{C}=\frac{1}{kA}ln\left(\frac{\varepsilon_0+kd/2}{\varepsilon_0}\right)$$

Capacitance of second half will be same

$$C_{eq}=\frac{C}{2}=\frac{kA}{2ln\left(\frac{2\varepsilon_0+kd}{2\varepsilon_0}\right)}$$

300. (3)

The given system can be considered as a series combination of two capacitors. The equivalent capacitance can be given as,

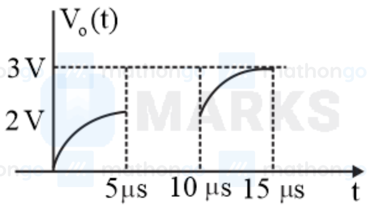
$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}\Rightarrow\frac{1}{C}=\frac{\frac{d}{2}}{K\varepsilon_0A}+\frac{\frac{d}{2}}{\varepsilon_0A}$$

$$\Rightarrow C=\frac{\varepsilon_0A}{\frac{d}{2K}+\frac{d}{2}}=\frac{2\varepsilon_0A}{\frac{d}{K}+d}$$

$$=\frac{2\times2\varepsilon_0}{\frac{1}{3.2}+1}=\frac{4\times3.2}{4.2}\varepsilon_0$$

$$=3.04\varepsilon_0$$

301. (1)

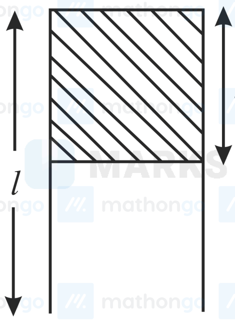


When first pulse is applied the potential across capacitor is given by $V=V_0\left(1-e^{-\frac{t}{RC}}\right)$

When no pulse is applied, capacitor will discharge like $V=V_0^{'}e^{t/RC}$ when again, second pulse is applied $V=V_0\left(1-e^{-\frac{t}{RC}}\right)$

Using all three equations the correct graph is :

302. (2)



Given,

Length of plate of parallel plate capacitor is l

Width of plate is w

Separation of plates is d.

Emf of battery is V

Thickness of dielectric slab is d

Dielectric constant of slab is $K = 4$

Capacitance of capacitor before the insertion of dielectric slab is

$C_0 = \frac{A\varepsilon_0}{d} = \frac{wl\varepsilon_0}{d} \ \ldots (1)$

Energy stored in the capacitor before the insertion of dielectrics is given by,

$U_0 = \frac{1}{2}C_0V^2 = \frac{1}{2}\left(\frac{wl\varepsilon_0}{d}\right)V^2 \ \ldots (2)$

Suppose that, the slab is inside the plate at y distance, therefore, it becomes the combination of two capacitors one with air with length $(l - y)$ and another with dielectric with length y as shown in diagram.

Now the capacitance of capacitor in parallel combination is given by,

$C = C_1 + C_2 \ \ldots (3)$

Where,

$C_1 = \frac{w(l-y)\varepsilon_0}{d} \ \ldots (4)$

$C_1 = \frac{wyK\varepsilon_0}{d} \ \ldots (5)$

Now energy stored in this combination of capacitor is given by

$U = \frac{1}{2}(C_1 + C_2)V^2 \ \ldots (6)$

Now according to the given condition,

$2U_0 = U$

$\Rightarrow 2\left(\frac{1}{2}C_0V^2\right) = \frac{1}{2}(C_1 + C_2)V^2$

$\Rightarrow 2C_0 = C_1 + C_2$

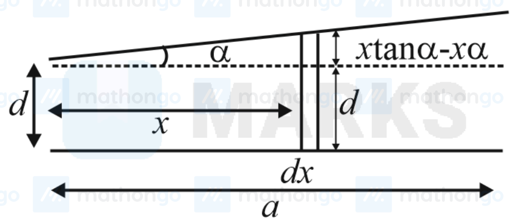
$\Rightarrow 2\left(\frac{\epsilon_0 wl}{d}\right) = \frac{\epsilon_0 Kwy}{d} + \frac{\epsilon_0 w(l-y)}{d}$

$\Rightarrow 2l = Ky + l - y$

$\Rightarrow l = 4y - y = 3y$

$\Rightarrow y = \frac{l}{3}$

303.



(1)

$dc = \frac{\epsilon_0 a dx}{d + \alpha x}$

$\Rightarrow c = \frac{\epsilon_0 a}{\alpha}[In(d + \alpha x)]_0^a$

$= \frac{\epsilon_0 a}{\alpha} In\left(1 + \frac{\alpha a}{d}\right) \approx \frac{\epsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{2b}\right)$

304. G = 200Ω

$i_g = 20\mu A$

$i = i_g\left(\frac{G}{S} + 1\right)$

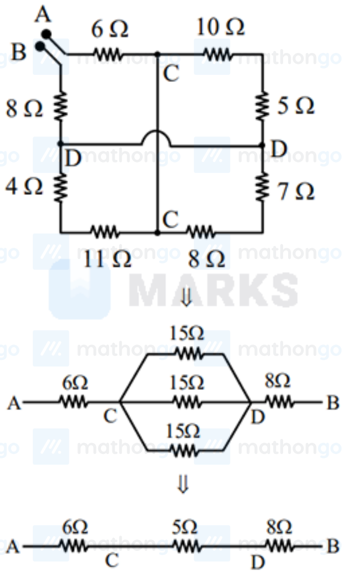
(2)

$\Rightarrow 20 \times 10^{-3} = 20 \times 10^{-6}\left(\frac{200}{S} + 1\right)$

$\Rightarrow \frac{200}{S} = 999$

$\Rightarrow S \approx 0.2\Omega$

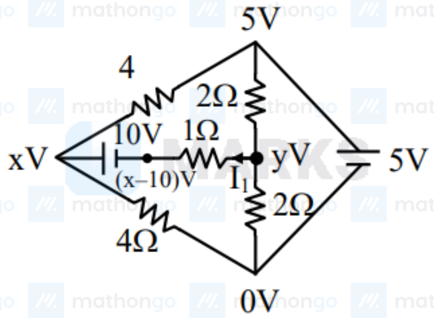
305.



(2)

$\Rightarrow R_{eq} = 6\Omega + 5\Omega + 8\Omega = 19\Omega$

306.



(25)

$$\frac{y-5}{2}+\frac{y-0}{2}+\frac{y-x+10}{1}=0$$

$y-5+y+2y-2x+20=0$

$4y-2x+15=0 \quad \ldots.(\text{i})$

$$\frac{x-5}{4}+\frac{x-0}{4}+\frac{x-10-y}{1}=0$$

$x-5+x+4x-40-4y=0$

$6x-4y-45=0 \quad ..(i)$

$$\begin{array}{l} -2x+4y+15=0..(ii) \\ \hline \quad 4x-30=0 \end{array}$$

$x=\frac{15}{2}\&4y-15+15=0$

$y=0$

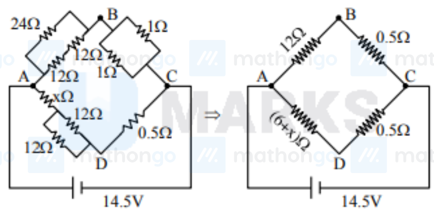
$$i=\frac{y-x+10}{1}$$

$$i=\frac{0-7.5+10}{1}$$

$i=2.5A=\frac{n}{10}A$

$n=25$

307.



(4)

In case of balanced Wheatstone Bridge

$$\frac{V_{AB}}{V_{AD}}=\frac{V_{BC}}{V_{CD}} \Rightarrow \frac{12}{6+x}=\frac{0.5}{0.5}$$

$x=6\Omega$

308. $i=K\theta$

$$\frac{2}{G+R}=K\theta$$

(5) $\Rightarrow \frac{1}{\theta}=\frac{(G+R)K}{2}=R\left(\frac{K}{2}\right)+\frac{KG}{2}$

Slope $=\frac{K}{2}=\frac{1}{4} \Rightarrow K=0.5=5\times10^{-1}A$

309. **(3)** $i_g=\frac{10}{400+100}=20\times10^{-3}$ A

For ammeter

Let shunt resistance $=$ S

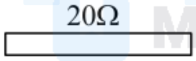
$i_gR=\left(i-i_g\right)S$

$20\times10^{-3}\times100=10\text{ S}$

$\text{S}=20\times10^{-2}\Omega$

310.

20Ω



$\Rightarrow$ 10 equal part

(5)

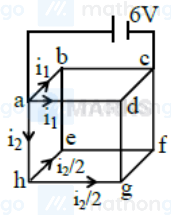
Each part has resistance $=2\Omega$

2 parts are connected in parallel so, R = 1Ω

Now, there will be 5 parts each of resistance 1Ω, they are connected in series.

$R_{eq} = 5R$, $R_{eq} = 5\Omega$

311.



(1)

From symmetry, current through e-b & g-d =0

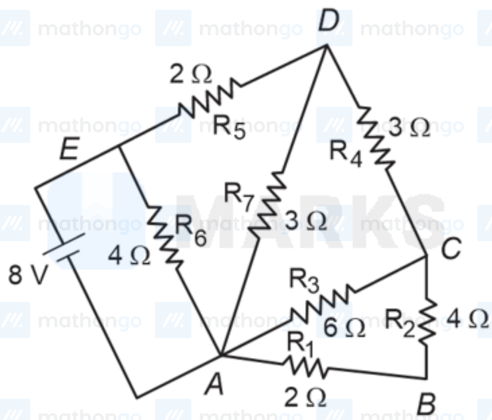
$\therefore R_{eq} = \frac{3}{4} \times R = \frac{3}{2}\Omega$

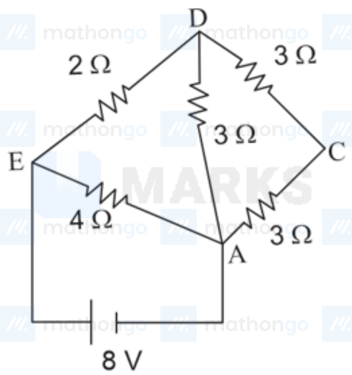
$\therefore$ Current through battery $= \frac{6 \times 2}{3} = 4$ A

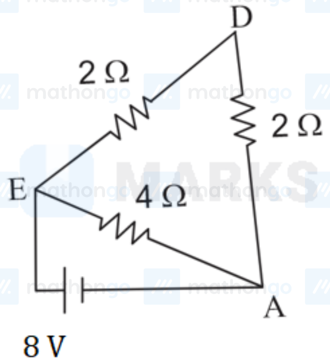
$i_2 = \frac{4}{8} \times 2 = 1$ A

$\therefore \Delta V$ across e-f $= \frac{i_2}{2} \times R = \frac{1}{2} \times 2 = 1$ V

312. (3)







As can be seen from the first circuit above, CB & AB are in series which is in parallel with CA. So, the net resistance is

$R' = \frac{6}{2}\ \Omega = 3\ \ \Omega$ as shown in the second diagram.

From the second diagram, DC & CA is in series which is parallel to DA. Hence the resistance is

$R'' = \left(\frac{6\times3}{(6+3)}\right)\Omega = 2\ \Omega$ as shown in third diagram.

From third diagram, both ED & DA are in series which is parallel to EA.

The equivalent resistance as can be seen from the above simplified circuit is $R_{eq} = 2\ \Omega$.

The current I through battery, $I = \frac{8}{2} = 4$ A.

From the second diagram, the part $EDACD$ has a resistance of 4 Ω, the total current will divide equally between $EDACD$ & EA. So consider $I_1 = 2$ A flowing through ED. Note that I_1 will be the same current flowing in the first diagram through ED.

From first diagram, when the resistances are in parallel the current is divided in the inverse ratio. Thus,

I' through $CD = \frac{3}{9} \times 2 = \frac{2}{3}$ A

I'' through $R_2 = \frac{1}{2}\left(\frac{2}{3}\right) = \frac{1}{3}$ A

313. (1)

A galvanometer is a tool used to either detect or quantify an electric current. The movement of a magnetic needle or a coil in a magnetic field, which is an essential component of a galvanometer, typically indicates the current and its strength.

Depending up on the resistance and the connectivity in the circuit, galvanometer can be used either as voltmeter or as an ammeter.

Voltmeter should have very high resistance, while ammeter should be having very less resistance.

Hence, the high resistor R_1 should be connected in series with the galvanometer in order to measure the potential difference across the test resistor. Also, the low resistor R_2 should be connected in parallel with the galvanometer in order to measure the current across the test resistor.

Thus, this combination will work properly.

314. (3)

Statement 1 - $R = 80\ \Omega$

When it is cut into 4 equal parts, the resistance of each part will be,

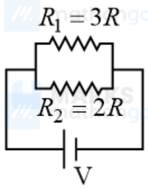
$R_1 = R_2 = R_3 = R_4 = 20\ \Omega$

When these resistances are connected in parallel,

$R_{eq} = \frac{20}{4} = 5\ \Omega$

Hence, the statement I is correct.

Statement 2 -



When the resistances are connected in parallel, the potential difference between them is same. Therefore, the power consumed can be written as,

$P = \frac{V^2}{R}$

$\Rightarrow \frac{P_1}{P_2} = \left(\frac{R_2}{R_1}\right) = \frac{2}{3}$

Hence, statement II is incorrect.

315. (20)

Applying balanced condition for meter bridge

Initially, $\frac{P}{Q} = \frac{40\ \text{cm}}{60\ \text{cm}} = \frac{2}{3}$ ...(1)

Finally, $\frac{P+x}{Q} = \frac{80\ \text{cm}}{20\ \text{cm}} = \frac{4}{1}$ ...(2)

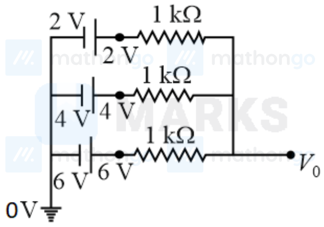
Dividing equation (2) by ((1),

$\frac{P+x}{P} = 4 \times \frac{3}{2} = 6$

$\Rightarrow 1 + \frac{x}{P} = 6 \Rightarrow \frac{x}{P} = 5$

$\therefore\ x = 5P = 5 \times 4 = 20\ \Omega$

316. (4)



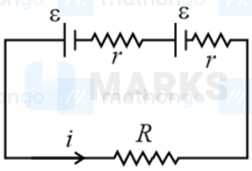
Using Kirchhoff's junction rule,

$\frac{V_0 - 2}{1\ \text{k}\Omega} + \frac{V_0 - 4}{1\ \text{k}\Omega} + \frac{V_0 - 6}{1\ \text{k}\Omega} = 0$

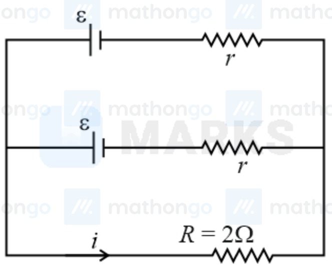
$3V_0 - 12 = 0$

$V_0 = 4$ V

317. (1)



When the cells are connected in series $i_s = \frac{2\varepsilon}{2r+R} = \frac{2\varepsilon}{2r+2}$



When they are connected in parallel, the emf is $\varepsilon_p = \frac{\frac{\varepsilon}{r}+\frac{\varepsilon}{r}}{\frac{1}{r}+\frac{1}{r}} = \varepsilon$ and the effective internal resistance will be $r_p = \frac{r \times r}{r+r} = \frac{r}{2}$. Therefore, the current will be,

$i_p = \frac{\varepsilon}{R+\frac{r}{2}} = \frac{\varepsilon}{2+\frac{r}{2}} = \frac{2\varepsilon}{4+r}$

Since, $i_s = i_p \Rightarrow \frac{2\varepsilon}{2r+2} = \frac{2\varepsilon}{4+r} \Rightarrow r = 2\ \Omega$

318. (19)

Using the conditions of a balanced wheatstone bridge and adding the end correction.

$\frac{15}{R} = \frac{l+e}{(L+e)-(l+e)} \Rightarrow \frac{15}{(43+2)} = \frac{R}{(102-45)} \Rightarrow R = \frac{57}{45} \times 15$

$\Rightarrow R = 19\ \Omega$

319. (48)

Current density is defined as current per unit cross-section area. Therefore,

$i = JA = J \times \pi\left(R^2 - \frac{R^2}{4}\right)$

$\Rightarrow i = 4 \times 10^6 \times \pi \times 16 \times 10^{-6} \times \frac{3}{4}$

$\Rightarrow i = 48\pi\ \text{A}$

320. (3)

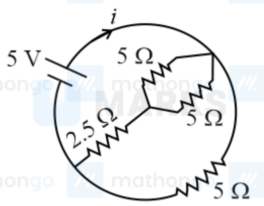
Volume of wire having cross-sectional area A and length l is, $V = Al$

Resistance of a wire is given by, $R = \frac{\rho l}{A} = \frac{\rho l}{\frac{V}{l}} = \frac{\rho l^2}{V}$

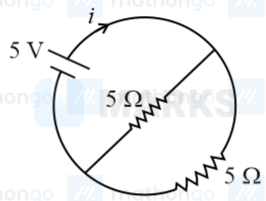
As change in length is small,

$\frac{\Delta R}{R} \times 100\% = \frac{2\Delta l}{l} \times 100\% = 2 \times 0.4\% = 0.8\%$

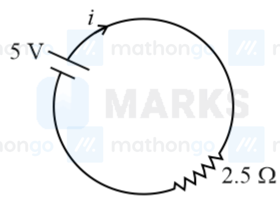
321. (2)



As in this case, $5\ \Omega$ & $5\ \Omega$ are in parallel hence, their combined resistance value will be $2.5\ \Omega$. Now, this $2.5\ \Omega$ with existing $2.5\ \Omega$ are in series and hence can be combined to write $5\ \Omega$.

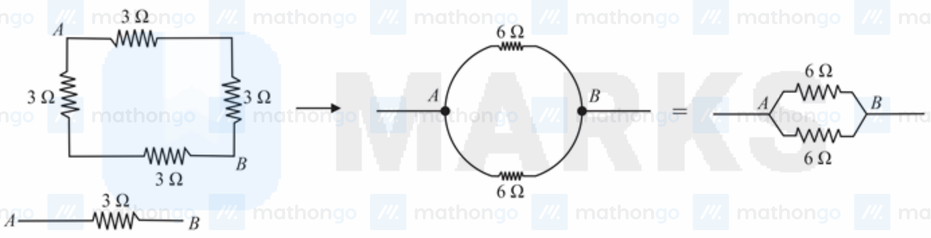


In the final diagram, we can write equivalent resistance across the battery as $2.5\ \Omega$.



Hence, current through the battery is, $i = \frac{5\ \text{V}}{2.5\ \Omega} = 2\ \text{A}$

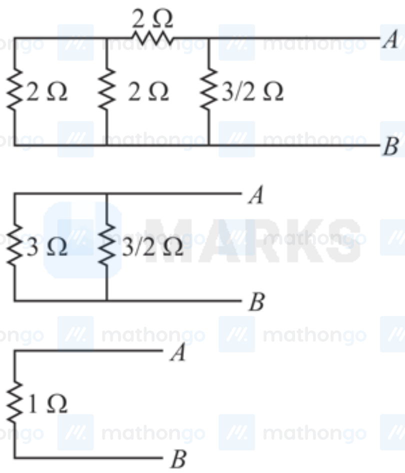
322. **(3)** We know that in a parallel combination of resistors the net resistance, $\frac{1}{R_P}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\ldots$ and when they are connected in series then net resistance is, $R=R_1+R_2+R_3+\ldots\ldots+R_n$. A square-shaped wire with a resistance of each side is, 3 Ω, then the circuit is,



then the net resistance is 3 Ω.

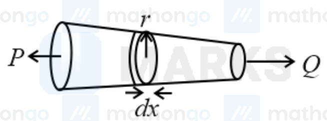
323. **(4)**

In the question circuit the resistance of 5 Ω, is short-circuited, it means the new equivalent circuit will be,



$\Rightarrow R_{AB}=\frac{3\times\frac{3}{2}}{3+\frac{3}{2}}=1\ \Omega.$

324. **(1)**



Current is constant in conductor

i = constant

Resistance of element $dR=\frac{\rho dx}{\pi r^2}$

$dV=idR=\frac{\text{ipdx}}{\pi r^2}$

$E=\frac{dV}{dx}=\frac{i\rho}{\pi r^2}$

and $V_d=\frac{eE\tau}{m}$

$\therefore\ V_d\times E$

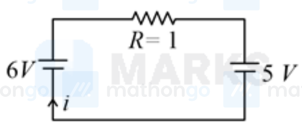
$\rightarrow E\propto\frac{1}{\mathrm{r}^2}$

If r decreases, E will increase.

$\therefore\ V_d$ will increase.

325. **(1)**

From graph voltage at $t=3.2$ sec is 6 volt.



$i=\frac{6-5}{1}$

$i=1$ A

326. **(4)** $R = \frac{R_1 R_2}{R_1 + R_2} = \frac{\ell}{A} \cdot \frac{\rho_1 \rho_2}{\rho_1 + \rho_2}$

$R = \frac{25 \times 10^{-2}}{3 \times 10^{-6}} \times \frac{1.7 \times 2.6 \times 10^{-16}}{4.3 \times 10^{-8}}$

$R = 0.858\ \text{m}\Omega$

327. **(1)** $R = \frac{\rho \ell}{A} = \frac{V}{I}$

$\rho = \frac{AV}{I\ell} = \frac{\pi d^2\ V}{4I\ell}\ \left(A = \frac{\pi d^2}{4}\right)$

$\therefore\ \frac{\Delta\rho}{\rho} = \frac{2\Delta d}{d} + \frac{\Delta V}{V} + \frac{\Delta I}{I} + \frac{\Delta \ell}{\ell}$

$\frac{\Delta\rho}{\rho} = 2\left(\frac{0.01}{5.00}\right) + \frac{0.1}{5.0} + \frac{0.01}{2.00} + \frac{0.1}{10.0}$

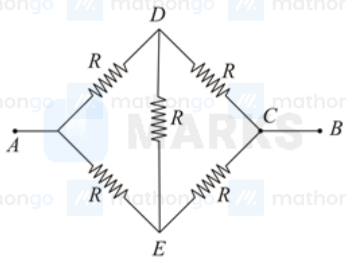
$\frac{\Delta\rho}{\rho} = 0.004 + 0.02 + 0.005 + 0.01$

$\frac{\Delta\rho}{\rho} = 0.039$

$\%\ \text{error} = \frac{\Delta\rho}{\rho} \times 100 = 0.039 \times 100 = 3.90\,\%$.

328. **(1)**

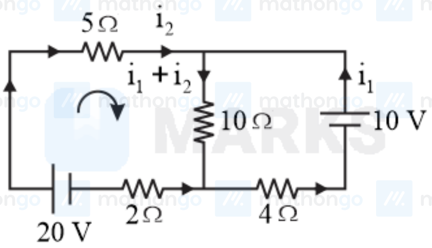
This diagram can be drawn like



It is a wheat stone bridge

$\therefore\ R_{eq} = \frac{2R \times 2R}{2R + 2R} \Rightarrow R$

329. **(3)**



$-5i_2 - 10\left(i_1 + i_2\right) - 2i_2 + 20 = 0$

$-10i_1 - 17i_2 + 20 = 0$

$-10 + 4i_1 + 10\left(i_1 + i_2\right) = 0$

$14i_1 + 10i_2 + 10 = 0$

$10i_1 + 17i_2 = 20 \rightarrow\ \times 10$

$14i_1 + 10i_2 = 10 \rightarrow 17$

$-138i_1 = 30$

$i_1 = -\frac{30}{138} = -0.217$

i_1 is negative it means current flows from positive to negative terminal

330. **(1)**

The expression for induced EMF in the rotating loop in uniform magnetic field is given by

$\varepsilon = \text{NAB}\omega \cos\omega t$

The average power loss

$<\text{P}> = <\frac{\varepsilon^2}{\text{R}}> = <\frac{\text{A}^2\text{B}^2\omega^2\cos^2\omega t}{\text{R}}>$

$<\cos^2\theta> = \frac{1}{2}$

$$< P > = \frac{A^2B^2\omega^2}{R}\left(\frac{1}{2}\right)$$

$$\Rightarrow \quad < P > = \frac{\pi^2a^2b^2B^2}{2R}\left(\omega^2\right)$$

331. **(40)** $\frac{X}{R} = \frac{75}{25} = 3$

$R = \frac{pl}{A} = \frac{4pl}{\pi d^2}$

$$R' = \frac{4p\left(\frac{l}{2}\right)}{\pi\left(\frac{d}{2}\right)^2} = 2R$$

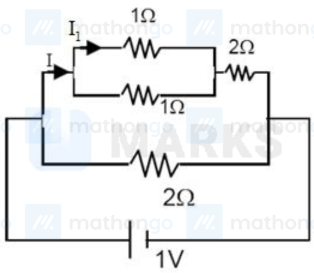
$\pi\left(\frac{d}{2}\right)^2$

then $\frac{X}{R'} = \left(\frac{100 - l}{l}\right)$

$\frac{100 - l}{l} = \frac{X}{2R} = \frac{3}{2}$

$l = 40.00\ cm$

332.

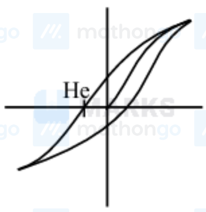


(3)

$I = \frac{1}{2.5} = 0.4A$

$I_1 = \frac{I}{2} = 0.2A$

333.



(10)

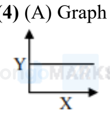
$$H_c = \frac{\mu_o ni}{\mu_o}$$

$$5 \times 10^3 = \frac{150}{30} \times 100 \times i$$

$$\frac{50}{5} = i$$

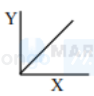
$I = 10$

334. **(4)** (A) Graph between Magnetic susceptibility and magnetising field is :



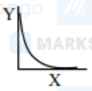
(B) magnetic field due to a current carrying wire for x < a :

$B = \frac{\mu_0 ir}{2\pi a^2}$

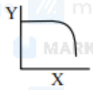


(C) magnetic field due to a current carrying wire for $x > a$:

$B = \frac{\mu_0 i}{2\pi a}$



(D) magnetic field inside solenoid varies as:



335. (6)

The magnetic intensity is

$H = \frac{B}{\mu_0} - M$

For $M = 0$, it can be written

$H = \left(\frac{B}{\mu_0}\right) = ni$

The data given is

$H = 2.4 \times 10^3$ A m^{-1} $l = 15 \times 10^{-2}$ m $N = 60$

Using the relation, $n = \frac{N}{l}$ and $H = ni$, the value of the current is,

$i = \frac{H}{n} = \frac{2.4 \times 10^3 \times 15 \times 10^{-2}}{60} = 6$ A

336. (4)

There are no atomic dipoles in diamagnetic materials because the resultant magnetic moment of each atom is zero due to paired electrons. Diamagnetic materials are repelled by a magnet. These substances are weakly repelled by the field, so in a nonuniform field, these substances have a tendency to move from a strong to a weak part of the external magnetic field.

For diamagnetic substance ($-1 < x < 0$) and a diamagnetic substance is repelled by the magnetic field.

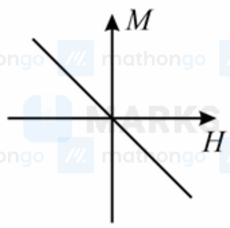
337. (3)

The frequency of revolution of the electron is $f = \frac{eB}{2\pi m}$, here, e is charge of electron, B is magnetic field and m is mass of electron.

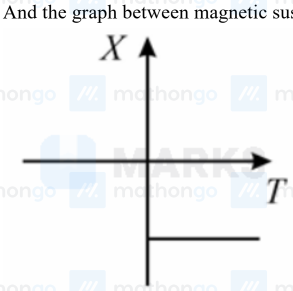
So, $f = \frac{1.6 \times 10^{-19} \times 10^{-4}}{2\pi \times 9 \times 10^{-31}} = 2.8 \times 10^6$ Hz

338. (4)

A magnetic field is a vector field that describes the magnetic influence on moving electric charges, electric currents, and magnetic materials. A moving charge in a mag field experiences a force perpendicular to its own velocity and to the magnetic field. So the graph between magnetizing field, and magnetizing field,



And the graph between magnetic susceptibility and temperature,



339. (1)

Statement (C) is correct because, the magnetic field outside the toroid is zero and they form closed loops inside the toroid itself.

Statement (E) is correct because we know that super conductors are materials inside which the net magnetic field is always zero and they are perfect diamagnetic.

$\mu_r = 1 + \chi$

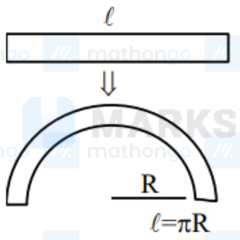
$\chi = -1$

$\mu_r = 0$

For superconductors.

340. (2) When magnetic field is applied diamagnetic substance produces magnetic field in opposite direction so net magnetic field will be zero.

341. (28) Magnetic moment of straight wire $= m x \ell = 44$



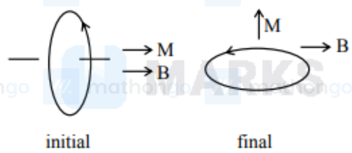
Magnetic moment of arc

$= m \times 2r$

$= m \times \frac{2\ell}{\pi}$

$= \frac{44 \times 2}{\pi} = \frac{88}{\pi} = 28$

342.



(5)

We know

$W_{ext} = \Delta U + \Delta KE \quad (\text{P.E.} = -\vec{M} \cdot \vec{B})$

$= -\vec{M} \cdot \vec{B}_f + \vec{M} \cdot \vec{B}_i + 0$

$= -MB\cos 90 + MB\cos 0$

$= MB$

$= NIAB$

$= 200 \times 100 \times 10^{-6} \times \frac{5}{2} \times 10^{-4} \times 1 = 5\mu J$

343. (500) $\mu_0 ni = B \quad n =$ number of turns per unit length

$\mu_0\left(\frac{m}{\ell}\right)i = B$

$m = \frac{B.\ell}{\mu_0 i} = \frac{6.28 \times 10^{-3} \times 0.5}{12.56 \times 10^{-7} \times 5}$

$m = 500$

344. (50) Force on segment parallel to x-axis will cancel each other. Hence F_{net} will be due to portion parallel to y-axis.

$F = 0.5 \times 0.5 \times 6 \times 0.2 - 0.5 \times 0.5 \times 0.2 \times 5$

$= 0.5 \times 0.5 \times 0.2$

$= 0.25 \times 0.2$

$= 50 \times 10^{-3}$ N

$= 50$mN

345.

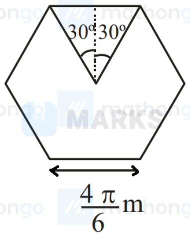
$B_A = \frac{\mu_0 i}{2\pi r} + \frac{\mu_0 (2i)}{2\pi(3r)} = \frac{5\mu_0 i}{6\pi r}$

(5) $B_C = \frac{\mu_0 (2i)}{2\pi r} + \frac{\mu_0 i}{2\pi(3r)} = \frac{7\mu_0 i}{6\pi r}$

$\therefore \frac{B_A}{B_C} = \frac{5}{7}$

$\therefore x = 5$

346. (72)



Direction of magnetic field due to all six sides will be in the same direction, therefore we can write

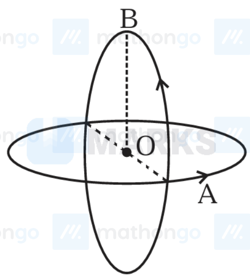
$B = 6\left(\frac{\mu_0 I}{4\pi r}\right)(\sin 30° + \sin 30°)$, where r = distance of the sides from the centre.

$= 6\frac{10^{-7} \times 4\pi\sqrt{3}}{\left(\frac{\pi}{3} \times \sqrt{3}\right)}$

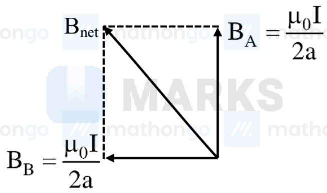
$= 72 \times 10^{-7}$ T

Hence, $x = 72$.

347. (3)



Right hand thumb rule states that, "If you imagine holding a current carrying wire in your right-hand with your thumb pointing towards the direction of electric current then the direction in which your fingers curl, gives the direction of lines of force of the magnetic field". In this case, direciton of magnetic field at the centre for both w is as shown below.



Magnetic field due to a circular wire is given by, $B_A = B_B = \frac{\mu_0 I}{2a}$

As both magnetic field lines at centre are perpendicular, therefore

$\because B_{net} = \sqrt{(B_A)^2 + (B_B)^2} = \frac{\sqrt{2}\mu_0 I}{2a} = \frac{\mu_0 I}{\sqrt{2}a}$

348. (6)

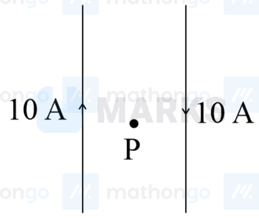
The formula to calculate the magnetic potential due to a magnetic dipole can be written as

$V = \frac{\mu_0}{4\pi}\frac{M}{r^2}$ . . . (1)

Substitute the values of the known parameters into equation (1) and solve to calculate the required magnetic moment of the dipole.

$1.5 \times 10^{-5} = 10^{-7} \times \frac{M}{\left(20 \times 10^{-2}\right)^2} \Rightarrow M = \frac{1.5 \times 10^{-5} \times 20 \times 20 \times 10^{-4}}{10^{-7}} \Rightarrow M = 1.5 \times 4 = 6 \text{ A m}^2$

349. (160)



The direction of the magnetic field at the observation point due to the current carrying conductor is determined by the right-hand cork screw rule.

From the given diagram, it is clear that as the conductors carry current in the mutually opposite direction, the direction of the magnetic fields produced by them at point will be the same.

Hence, the required magnetic field at P due to the conductors can be calculated as follows:

$$B = 2 \times \left(\frac{\mu_0 i}{2\pi a}\right)$$

$$= 2 \times \frac{4\pi \times 10^{-7} \times 10}{2\pi \times \left(\frac{5}{2} \times 10^{-2}\right)} \text{ T}$$

$$= 160 \times 10^{-6} \text{ T}$$

$$= 160 \ \mu\text{T}$$

350. (3)

Net force on proton inside an electric and a magnetic field is given by

$$\vec{F}_e + \vec{F}_m = q\vec{E} + q\left(\vec{v} \times \vec{B}\right) \quad \ldots(1)$$

If both $\vec{E}$ and $\vec{B}$ are zero, then $\vec{F}_e$ and $\vec{F}_m$ both are zero. Hence, velocity may remain constant. Therefore, option (A) is correct.

If $E = 0,\ B \neq 0$, but velocity is parallel or antiparallel to the magnetic field, then also $\vec{F}_e$ and $\vec{F}_m$ both are zero. Hence, option (B) is also correct.

If $E \neq 0,\ B \neq 0$, but $\vec{F}_e + \vec{F}_m = 0$, then also velocity may remain constant. Thus, option (D) is also correct.

351. (2)

The formula to calculate the magnetic field inside the conducting wire is given by

$$B_{\text{in}} = \frac{\mu_0 J r}{2} \quad \ldots(1)$$

The formula to calculate the magnetic field outside the conducting wire is given by

$$B_{\text{out}} = \frac{\mu_0 J a^2}{2r} \quad \ldots(2)$$

From equation (1), it can be concluded that the magnetic field is directly proportional to the radial distance inside the wire, whereas from equation (2), it can be concluded that the magnetic field is inversely proportional to the radial distance outside the wire.

352. (2)

Given: $\theta = 0.05$ rad, $I = 10$ mA, $K = 4 \times 10^{-5}$ N m rad^{-1}, $B = 0.01$ T, $N = 200$

The torsional constant of a wire used in a moving coil galvanometer is given by

$K = \frac{NIAB}{\theta}$, where, A is area of each turn

So, $A = \frac{K\theta}{NIB} = \frac{4 \times 10^{-5} \times 0.05}{200 \times 10 \times 10^{-3} \times 0.01}$

Thus, $A = 10^{-4}\ \text{m}^2 = 1\ \text{cm}^2$

353. (2)

Net magnetic moment of the system is

$\vec{M} = -IA_1\hat{k} + IA_2\hat{k}$ (Here currents in both circular loops are in opposite direction)

$$\vec{M} = -I\pi(0.5)^2\hat{k} + I\pi(0.3)^2\hat{k}$$

$$\vec{M} = -7 \times \frac{22}{7}\left(\frac{25}{100} - \frac{9}{100}\right)\hat{k} = -22\left(\frac{16}{100}\right)\hat{k}$$

$$\vec{M} = -3.52\hat{k} \text{ A m}^2$$

$$= -\frac{7}{2}\hat{k} \text{ A m}^2$$

354. (4)

According to Ampere's law,

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 i$$

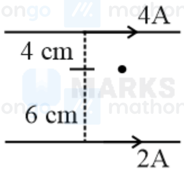
Inside the hollow cylinder, current will be zero. Therefore, magnetic field will also be zero.

Outside the cylinder,

$$B 2\pi r = \mu_0 i \Rightarrow B = \frac{\mu_0 i}{2\pi r} \Rightarrow B \propto \frac{1}{r}$$

Hence, the correct answer is D.

355. (3)



Net magnetic field at P is $B_{\text{Net}} = \left(\frac{\mu_0 \times i_1}{2\pi r_1} - \frac{\mu_0 i_2}{2\pi r_2}\right)(-\hat{k})$

$B_{\text{Net}} = \frac{\mu_0 4}{2\pi \times \frac{4}{100}} - \frac{\mu_0 2}{2\pi \times \frac{6}{100}}$

$= \frac{\mu_0}{\pi} \times 100\left[\frac{1}{2} - \frac{1}{6}\right]$

$= \frac{\mu_0}{\pi} \times 100\left[\frac{4}{2 \times 6}\right]$

$= \frac{\mu_0 \times 100}{3\pi}(-\hat{k})$

So, force acting on charge particle is $\vec{F} = q(\vec{v} \times \vec{B}) = 3\pi[2\hat{i} + 3\hat{j}]\frac{\mu_0 \times 100}{3\pi}(-\hat{k})$

$= 4\pi \times 10^{-7}[2\hat{i} + 3\hat{j}] \times 100(-\hat{k})$

$= 4\pi \times 10^{-5}[2\hat{j} - 3\hat{i}]$

$\therefore \; x = 3$

356. (2)

As we know, radius of circular path followed by charged particle under perpendicular magnetic field is given by,

$R = \frac{mv}{qB}$ and $KE = \frac{1}{2}mv^2$

Therefore,

$\Rightarrow R = \frac{\sqrt{2m(KE)}}{qB}$ Then, $R \propto \frac{\sqrt{m}}{q}$

$\Rightarrow \frac{R_d}{R_p} = \sqrt{\frac{m_d}{m_p}} \times \frac{q_p}{q_d} = \sqrt{\frac{2}{1}} \times \frac{1}{1} = \sqrt{2} : 1$

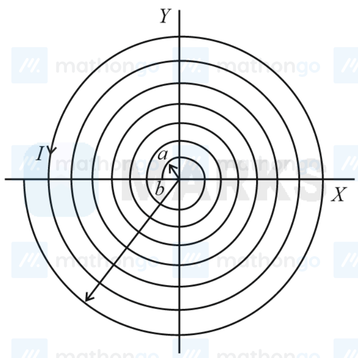
Thus, $x = 2$.

357. (2)

Radius of circular path of charged particle (q) of mass (m) moving with velocity (v) in magnetic field (B) is given by $r = \frac{mv}{qB}$

$\frac{r_\alpha}{r_p} = \frac{\frac{(4m)v}{(2e)B}}{\frac{mv}{eB}} = 2 : 1$

358.



(4)

Recall the formula of the magnitude of the magnetic field in terms of current and permeability in free space, $B = \int_a^b \frac{\mu_0 dNi}{2x} = \int_a^b \frac{\mu_0\left(\frac{N}{b-a}dx\right)i}{2x} = \frac{\mu_0 Ni}{2(b-a)} ln\left(\frac{b}{a}\right)$.

359.

(250) $\vec{M} = \frac{\text{magnetic moment } (\vec{m})}{V}$

$\Rightarrow \chi\vec{H} = \frac{\vec{m}}{V}$

$\Rightarrow \vec{m} = (\mu_r - 1)NiV$

$\therefore \frac{\Delta m}{m} = \frac{[(750-1)-(500-1)]NiV}{(500-1)NiV} = 250$

360. (3)

As we know,

$$B_{axis}=\frac{\mu_0 iR^2}{2\left(R^2+x^2\right)^{3/2}} \text{ where, } R=a$$

$$B_{centre}=\frac{\mu_0 i}{2a}$$

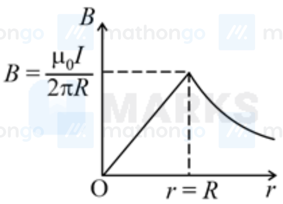
$$\therefore B_{axis}=\frac{\mu_0 ia^2}{2\left(a^2+r^2\right)^{3/2}}$$

$$\therefore \text{ fractional change in magnetic field }=\frac{\frac{\mu_0 i}{2a}-\frac{\mu_0 ia^2}{2\left(a^2+r^2\right)^{3/2}}}{\frac{\mu_0 i}{2a}}=1-\frac{1}{\left[1+\left(\frac{r^2}{a^2}\right)\right]^{3/2}}$$

$$\approx 1-\left[1-\frac{3}{2}\frac{r^2}{a^2}\right]=\frac{3}{2}\frac{r^2}{a^2}$$

361. (3)

Graph for wire of radius R:



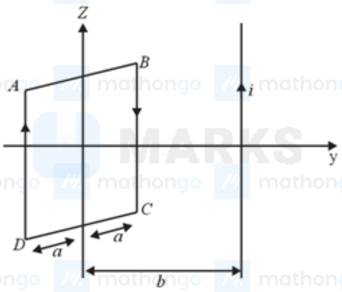
As $b>a$

$B_a>B_b$

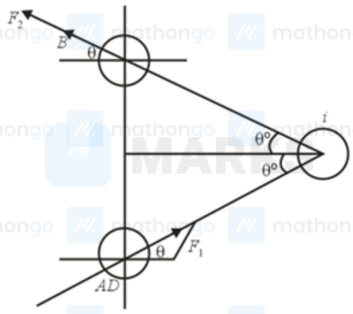
$B_a=\frac{\mu_0 i}{2\pi a}$

$B_b=\frac{\mu_0 i}{2\pi b}$

362. (3)



Net force acting on wire AB & CD are zero



$$F_1=ILB=I\times(2a)\times\left(\frac{\mu_0 I}{2\pi\sqrt{a^2+b^2}}\right)=\frac{\mu_0 I^2 a}{\pi\sqrt{a^2+b^2}}$$

$$\tau=F_1\cos\theta\times 2a=\frac{\mu_0 I^2 a}{\pi\sqrt{a^2+b^2}}\times\frac{b}{\sqrt{a^2+b^2}}\times 2a$$

$\tau = \frac{2\mu_0 I^2 a^2 b}{\pi\left(a^2+b^2\right)} \approx \frac{2\mu_0 I^2 a^2}{\pi b}, \ (a \ll b)$

363. (4)

Given,

Current in the arc A is $i_1 = 2$ A

Current in the arc B is $i_2 = 3$ A

Radius of arc A is $R_1 = 2$ cm

Radius of arc B is $R_2 = 4$ cm

Magnetic field at the centre of circular current carrying arc is given by

$B_C = \frac{\mu_0 i}{4\pi R}(\theta) \ \ldots \left(1\right)$

Where, θ is the angle subtended at centre.

Magnetic field at the centre due to arc A and B is given by

$B_A = \frac{\mu_0 i_1}{4\pi R_1}\left(2\pi - \frac{\pi}{2}\right) \ldots (2)$

$B_B = \frac{\mu_0 i_2}{4\pi R_2}\left(2\pi - \frac{\pi}{3}\right) \ldots (3)$

Dividing equation (2) by (1), we get

$\Rightarrow \frac{B_A}{B_B} = \frac{i_1}{i_2} \times \frac{R_2\left(2\pi - \frac{\pi}{2}\right)}{R_1\left(2\pi - \frac{\pi}{3}\right)}$

$\Rightarrow \frac{B_A}{B_B} = \frac{2}{3} \times \frac{4}{2} \times \frac{3\pi}{2} \times \frac{3}{5\pi}$

$\Rightarrow \frac{B_A}{B_B} = \frac{6}{5}$

364. (4)

Pitch

$= (V\cos\theta)T$

$= \left(V\cos\theta\right)\frac{2\pi m}{eB}$

$= \left(4 \times 10^5 \cos 60°\right)\frac{2\pi}{0.3 \times 10}\left(\frac{1.67 \times 10^{-27}}{1.69 \times 10^{19}}\right)$

4 cm

365. (3)

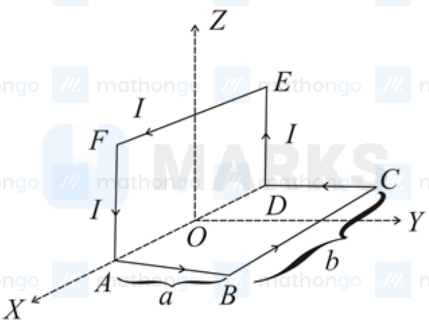
$\ell = 10 \times$ pitch

$= 10 \times v\cos 60° \times \frac{2\pi m}{qB}$

$\ell = \frac{10\pi mv}{qB}$

Put in the value of given data we find $\ell = 0.44$ m

366. (1)



Loop ABCD

$\vec{M}_1 = \left(abI\right)\left(\hat{k}\right)$

For Loop DEFA $\vec{M}_2 = \left(abI\right)\left(\hat{j}\right)$

$\vec{M} = \vec{M}_1 + \vec{M}_2; \vec{M} = (abI)(\hat{j} + \hat{k})$

$\sqrt{2}abI$ along $\left(\frac{\hat{j}}{\sqrt{2}} + \frac{\hat{k}}{\sqrt{2}}\right)$.

367. (1)

Magnetic Field Inside Solenoid is $B = \mu_0 nI$

Velocity v has given to the electron

So, Magnetic Force

$F = qvB$

as v and B are perpendicular.

In a magnetic field, charge will move on a circular path. Here, If radius is just less than or equal to radius of solenoid then the electron does not hit the surface.

$F = qvB = \frac{mv^2}{R} \Rightarrow mv = qBR as\ q = ev = \frac{eBR}{m} So,\ V = \frac{e\mu_0 nIR}{m}$

368. (4) $I = I_0 t - I_0 t^2$

$\phi = BA$

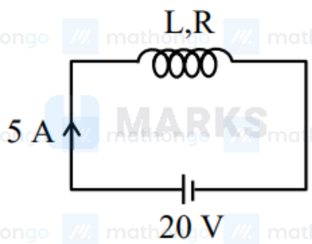
$\phi = \mu_0 nIA$

$V_R = -\frac{d\phi}{dt} = -\mu_0 nAI_0(1 - 2t)$

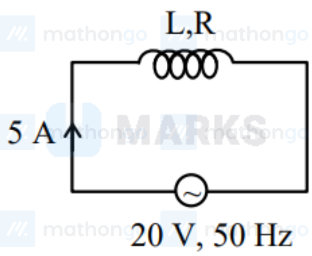
$V_R = 0$ at $t = \frac{1}{2}$

And $I_R = \frac{V_R}{\text{Resistance of loop}} = 0$

369. (10) Case-I:



$i = \frac{20}{R} \Rightarrow R = 4\Omega$



Case-II:

$i = \frac{20}{Z}$

$4 = \frac{20}{\sqrt{R^2 + X_L^2}} \Rightarrow \sqrt{R^2 + X_L^2} = 5$

$R^2 + X_L^2 = 25 \Rightarrow X_L = 3\Omega$

$L = \frac{3}{2\pi f} = \frac{1}{2 \times 50} = \frac{1000}{100}\text{mH}$

$L = 10\text{mH}$

370. $\epsilon = NB\ell v$

(3) $i = \frac{\epsilon}{R} = \frac{NB\ell v}{R}$

$F = N(i\ell B) = \frac{N^2B^2\ell^2 v}{R}$

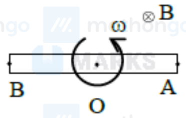
$W = F \times \ell = \frac{N^2 B^2 \ell^3}{R}\left(\frac{\ell}{t}\right)$

$A = \ell^2$

$W = \frac{(10 \times 10)(0.5)^2 \times \left(3.6 \times 10^{-3}\right)^2}{100 \times 1}$

$W = 3.24 \times 10^{-6}$ J

371.



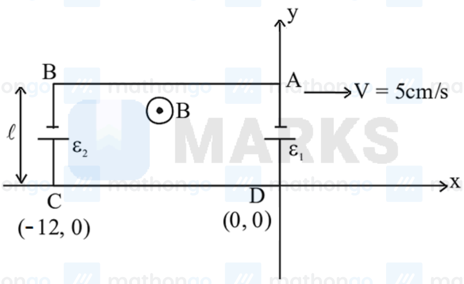
(0)

$\because V_0 - V_A = \frac{B\omega\ell^2}{2}$

$V_0 - V_B = \frac{B\omega\ell^2}{2}$

$\therefore V_A = V_B \therefore V_A - V_B = 0$

372. (216)



Let B_0 is the magnetic field at origin. Then,

$\frac{dB}{dx} = -\frac{10^{-3}}{10^{-2}}$

$\Rightarrow \int_{B_0}^{B} dB = -\int_0^x 10^{-1} dx$

$\Rightarrow B - B_0 = -10^{-1}x$

$\Rightarrow B = \left(B_0 - \frac{x}{10}\right)$

Motional emf in $AB = 0$

Motional emf in $CD = 0$

Motional emf in $AD = \varepsilon_1 = B_0\ell v$

Magnetic field on rod BC

$= \left(B_0 - \frac{\left(-12 \times 10^{-2}\right)}{10}\right)$

Motional emf in $BC = \varepsilon_2 = \left(B_0 + \frac{12 \times 10^{-2}}{10}\right)\ell \times v$

Net equivalent emf $\varepsilon_{eq} = \varepsilon_2 - \varepsilon_1 = 300 \times 10^{-7}$ V

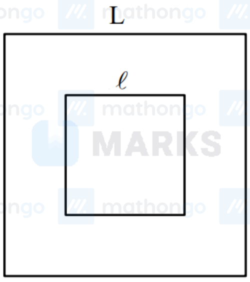
For time variation

$\left(\varepsilon_{eq}\right)' = A\frac{dB}{dt} = 60 \times 10^{-7}\ V$

$\left(\varepsilon_{eq}\right)_{net} = \varepsilon_{eq} + \left(\varepsilon_{eq}\right)' = 360 \times 10^{-7}$ V

Power $r = \frac{\left(\varepsilon_{eq}\right)^2_{net}}{R} = 216 \times 10^{-9}$ W

373. (128)



Flux linkage for inner loop

$\phi = B_{\text{center}} \times l^2$

$= 4 \times \frac{\mu_0 i}{4\pi \frac{L}{2}}(\sin 45° + \sin 45°) l^2$

$\Rightarrow \phi = 2\sqrt{2}\frac{\mu_0 i}{\pi L} l^2$

Therefore, mutual inductance will be

$M = \frac{\phi}{i} = \frac{2\sqrt{2}\mu_0 l^2}{\pi L} = 2\sqrt{2}\frac{\mu_0}{\pi}$

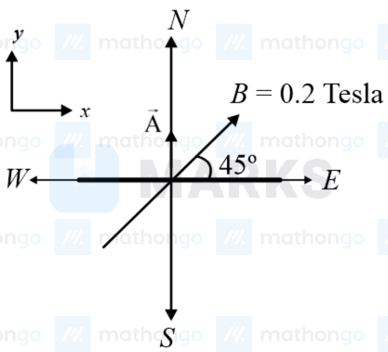
$= 2\sqrt{2}\frac{4\pi}{\pi} \times 10^{-7}$

$= 8\sqrt{2} \times 10^{-7}$

$= \sqrt{128} \times 10^{-7}$ H

Hence, $x = 128$.

374. (2)



The area vector for the square loop is given by

$\vec{A} = \left(0.1\right)^2 \hat{j}\ m^2$

According to the above diagram, the magnetic field is given by

$\vec{B} = \frac{0.2}{\sqrt{2}}\hat{i} + \frac{0.2}{\sqrt{2}}\hat{j}$

Hence, the magnitude of induced emf can be calculated as follows

$e = \frac{\Delta\phi}{\Delta t}$

$= \frac{\vec{B}\cdot\vec{A} - 0}{1}$

$= \frac{\left(\frac{0.2}{\sqrt{2}}\hat{i} + \frac{0.2}{\sqrt{2}}\hat{j}\right)\cdot\left(\left(0.1\right)^2\ \hat{j}\ \right) - 0}{1}$ V

$= \sqrt{2} \times 10^{-3}$ V

Hence, $x = 2$.

375. (2)

The amount of flux induced in the second coil due to the first one is given by

$\phi_2 = Mi$

$= Mi_0 sin\omega t \quad \ldots(1)$

where, M is the mutual inductance of the coils.

The formula to calculate the emf induced can be written as

$\varepsilon = -\frac{d\phi_2}{dt} \quad \ldots(2)$

From equation (2), it follows that,

$\varepsilon_{max} = Mi_0\omega$

$= 0.002 \times 5 \times 50\pi$ V

$= \frac{\pi}{2}$ V

Hence, $\alpha = 2$.

376. (60)

The induced emf (ε) in the turns of the coil can be written as

$\varepsilon = -\frac{d\varphi}{dt}$

$= iR \quad \ldots(1)$

Simplify equation (1) to obtain the required charge through a point in the circuit.

$-\frac{d\varphi}{dt} = iR$

$\Rightarrow -\frac{1}{R}\int_{\varphi_1}^{\varphi_2} d\varphi = \int idt$

$\Rightarrow q = \frac{\varphi_1 - \varphi_2}{R} \quad \ldots(2)$

Where, φ_1, φ_2 are the magnetic flux associated with the coil from two ends.

As, $\varphi = NBA$, from equation (2), it can be written that

$q = \frac{NA}{R}\left(B_1 - B_2\right) \quad \ldots(3)$

where, N, A are the number of turns and the cross-sectional area of the core respectively.

Substitute the values of the known parameters into equation (3) to calculate the required charge.

$q = \frac{100 \times 24 \times 10^{-4}\ \text{m}^2 \times (1.5\ \text{T} - (-1.5\ \text{T}))}{12\ \Omega}$

$= 0.06\ \text{C} \times \frac{1000\ \text{mC}}{1\ \text{C}}$

$= 60$ mC

377. (18)

The force on the rod is given by

$F = ilB$

$\Rightarrow F = \frac{Bvl}{R} \times lB$

$\Rightarrow F = \frac{B^2 l^2 v}{R} \quad \ldots\left(i\right)$

The data given is

$R = 5\ \Omega l = 1\ \text{m} v = 4\ \text{m s}^{-1}\text{B} = 0.15$ T

Substituting the values in equation (i)

$F = \frac{(0.15)^2 \times (1)^2 \times 4}{5}$

$= 18 \times 10^{-3}$ N

378. (3)

Induced emf is given by Faraday's law

$|\varepsilon| = \frac{d\phi}{dt}$

where ϕ is the magnetic flux.

The rate of change of flux through a circuit is defined as emf. The formula for flux is $\phi = \vec{B} \cdot \vec{A}$. In the statements $A\&B$ given in the question, the magnetic flux in the coil in uniform magnetic field does not change. So, no emf is induced.

But in statement C, the angle between the area vector and the magnetic field continuously changes hence, an emf is generated. In statement D, the area is changing in unit time so magnetic flux will change and an emf is generated.

379. (4)

The formula to calculate the average electric energy density is given by

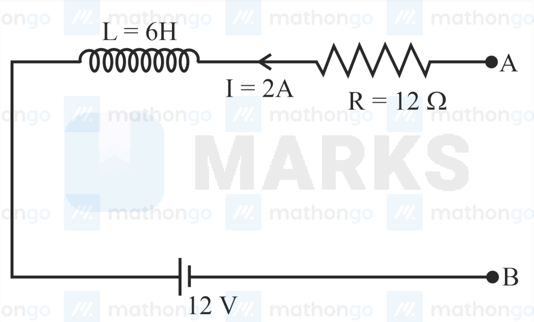
$U_E = \frac{1}{2}\varepsilon_0 E^2 \quad \ldots\left(1\right)$

and, the formula to calculate average magnetic energy density is given by

$U_B = \frac{1}{2\mu_0}B^2 \quad \ldots (2)$

For any particular electromagnetic wave, both magnetic and electric field are equally involved in contributing to energy density. Hence, the ratio of average electric energy density to magnetic energy density is 1.

380. (30)



Given here, $\frac{dI}{dt} = -1 \text{ A s}^{-1}$

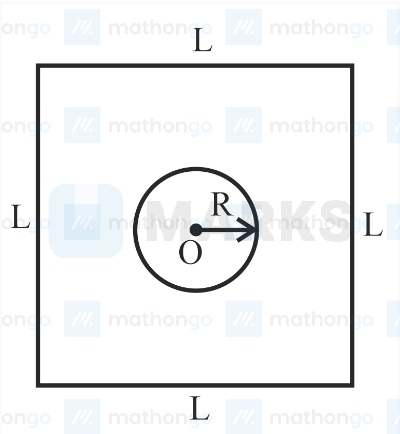
Applying Kirchhoff's voltage law to the circuit,

$V_A - IR - L\frac{dI}{dt} - 12 = V_B$

$\Rightarrow V_A - 2 \times 12 - 6(-1) - 12 = V_B$

$\Rightarrow V_{AB} = V_A - V_B = 36 - 6 = 30 \text{ V}$

381. (3)



The magnetic field due to the rectangular loop at its centre is:

$B = 4 \times \frac{\mu_0 i}{4\pi\left(\frac{L}{2}\right)}\left[\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right] = \frac{2\sqrt{2}\mu_0 i}{\pi L}$

Therefore, the flux through the circular loop $\phi = \pi R^2 \times B = \frac{2\sqrt{2}\mu_0 R^2 i}{L}$

If M is the mutual inductance, then

$M\frac{di}{dt} = \frac{d\phi}{dt} = \frac{2\sqrt{2}\mu_0 R^2}{L}\frac{di}{dt}$

$\Rightarrow M = \frac{2\sqrt{2}\mu_0 R^2}{L}$

382. (2)

In case of L - R circuit

$Z = \sqrt{X_L^2 + R^2}$ Therefore, power factor

$P_1 = \cos\phi = \frac{R}{Z}$

As $X_L = R \Rightarrow Z = \sqrt{2}R$

$\Rightarrow P_1 = \frac{R}{\sqrt{2}R} \Rightarrow P_1 = \frac{1}{\sqrt{2}}$

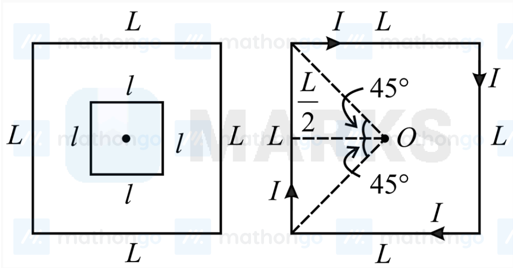
In case of L - C - R circuit

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

According to the question $X_L = X_C \Rightarrow Z = R \Rightarrow P_2 = \cos\phi = \frac{R}{R} = 1$

$\Rightarrow \frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$

383. (4)



Let a current, I pass through the square loop of side, L. The magnetic field at the centre O,

$B = 4 \times$ Magnetic field due to each side

$\Rightarrow B = 4 \times \frac{\mu_0}{4\pi} \cdot \frac{I}{L/2}\left(\sin 45^\circ + \sin 45^\circ\right)$

$\Rightarrow B = \frac{2\mu_0 I}{\pi L}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) = \frac{2\sqrt{2}\mu_0 I}{\pi L}$

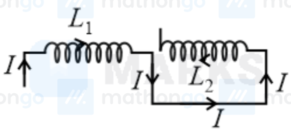
Magnetic flux linked with the small square loop,

$\phi = BA = Bl^2 = \frac{2\sqrt{2}\mu_0 I l^2}{\pi L}$

Mutual inductance of the coil,

$M = \frac{\phi}{I} = \frac{2\sqrt{2}\mu_0 l^2}{\pi L}$.

384. (2)



Here self inductances are in series but their mutual inductances are linked oppositely.

As the inductors connected are in series opposition, hence magnetic flux will be opposing each other. Therefore,

$L_{eq} = L_1 + L_2 - 2M$

385. (2)

Given here, $B_H = 0.2 \times 10^{-4}$ T, $\omega = 5$ rad s^{-1} and $l = 1$ m.

Emf induced in a rotating conducting rod is given by,

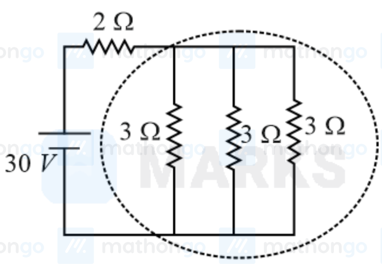
$\varepsilon = \frac{1}{2}B\omega l^2$

Substituting the given values, we obtain

$\varepsilon = \frac{1}{2} \times 0.2 \times 10^{-4} \times 5 \times (1)^2 = 0.5 \times 10^{-4}$ V $= 50$ μV

386. (1)

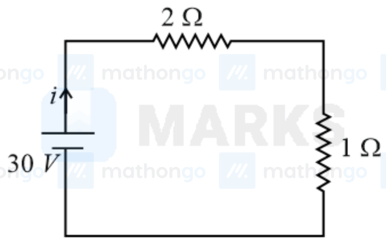
In a steady state, the inductor behaves as a conducting wire. So, the equivalent circuit becomes,



Parallel (R_{eq})

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1 \Rightarrow R_{eq} = 1\ \Omega$

so, the circuit becomes,



$\Rightarrow I = \frac{30}{3} = 10$ A

387. (3)

The EMF is induced in the coil when it is moving in a uniform magnetic field,

$e = Bvl$ and the current, $i = \frac{e}{R} \Rightarrow \frac{Blv}{R} = 0.002$ A

$\Rightarrow v = \frac{0.002 \times R}{Bl} = \frac{0.002 \times (4+1)}{5 \times 0.2} = 0.01 \text{ m s}^{-1} = 1 \text{ cm s}^{-1}$.

388. (3)

When T_1 and T_2 are connected, then the steady state current in the inductor $I = \frac{6}{6} = 1$ A

When T_1 and T_3 are connected then current through inductor remains same. So potential difference across 3 Ω

$V = Ir = 1 \times 3 = 3$ V

389. (5)

$I = \left(5t^2 + 2t + C\right)$

$\frac{di}{dt} = \left(10t + 2\right)$

$\phi_{\text{small}} = BA = \left(\frac{\mu_0 I N_2}{2R}\right)\left(\pi r^2\right)$

induced emf in small coil

$e = \frac{d\phi}{dt} = \left(\frac{\mu_0 N_2}{2r}\right)\pi r^2 N_1 \frac{di}{dt} = \left(\frac{\mu_0 N_1 N_2 \pi r^2}{2R}\right)\left(10t - 2\right)$

at $t = 1$

$e = \left(\frac{\mu_0 N_1 N_2 \pi r^2}{2R}\right)8 = 4\frac{\mu_0 N_1 N_2 \pi r^2}{R} = \frac{4\left(4\pi\right)10^{-7} \times 200}{20} \times 500 \times \frac{10^{-4}}{10^{-2}}\pi$

$= 80 \times \pi^2 \times 10^{-7} \times 10 \times 10^2 \times 10^{-2} = 8 \times 10^{-4} \text{ volt} = 0.8 \text{ mV} = \frac{4}{x}$

$x = 5$

390.

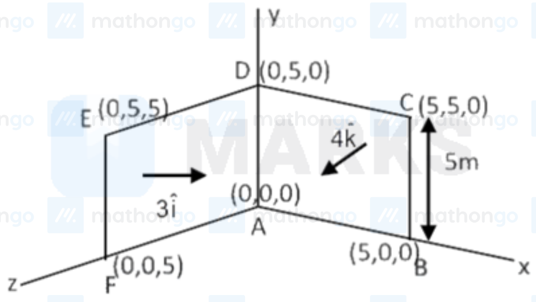
(1) $\varepsilon = \left|-\frac{d\phi}{dt}\right| = \left|-\frac{AdB}{dt}\right|$

$\varepsilon = \left|-\frac{\Delta\phi}{\Delta t}\right| = \left|\frac{A\Delta B}{\Delta t}\right|$

$= (16 \times 4 - 4 \times 2)\frac{(1000 - 500)}{5} \times 10^{-4} \times 10^{-4}$

$= 56 \times \frac{500}{5} \times 10^{-8} = 56 \times 10^{-6} V$

391. **(175)** $\phi = \vec{B}.\vec{A} = \left(3\hat{i} + 4\hat{k}\right).\left(25\hat{i} + 25\hat{k}\right)$



$\phi = (2 \times 25) + (4 \times 25) = 175$weber

392. (2)

$\Phi = \vec{B} \cdot \vec{A} = BA\cos\theta = BA\cos(\omega t)$

$e = \left|\frac{d\phi}{dt}\right| = BA\omega\sin(\omega t)$

When $\omega t = \frac{\pi}{2}$

$\because$ ϕ will be minimum.

$\therefore$ e will be maximum

$t = \frac{\frac{\pi}{2}}{\frac{\pi}{5}} = 2.5$ s

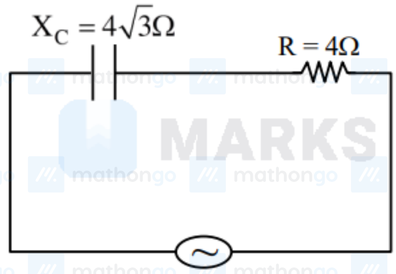
When $\omega t = \pi$

$\because$ ϕ will be maximum.

$\therefore$ e will be minimum

$t = \frac{\pi}{\pi/5} = 5$ s

393.



(4)

$Z = \sqrt{R^2 + X^2 L}$

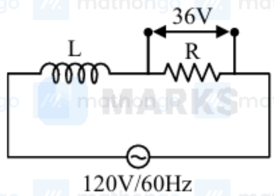
$Z = \sqrt{4^2 + (4\sqrt{3})^2} = 8\Omega$

$V_{rms} = \frac{V}{\sqrt{2}} = \frac{8\sqrt{2}}{\sqrt{2}} = (8\text{ V})$

$I_{rms} = \frac{V_{rms}}{Z} = \frac{8}{8} = 1\text{ A}$

Power dissipated $= I_{rms}^2 \times R = 1 \times 4 = (4\text{ W})$

394.



(2)

$36 = I_{rms}R$

$36 = \frac{120}{\sqrt{X_L^2 + R^2}} \times R$

$R = 90\Omega \Rightarrow 36 = \frac{120 \times 90}{\sqrt{X_L^2 + 90^2}}$

$\sqrt{X_L^2 + 90^2} = 300$

$X_L^2 = 81900$

$X_L = 286.18$

$\omega L = 286.18$

$L = \frac{286.18}{376.8}$

$L = 0.76\text{H}$

395. $C = 2\mu f;\quad E = 110\sqrt{2}\sin(100t)$

$$X_C = \frac{1}{\omega c} = \frac{1}{100 \times 2 \times 10^{-6}}$$

$$= \frac{10000}{2} = 5000\Omega$$

(22) $i_o = \dfrac{110\sqrt{2}}{5000}$

$$i_{rms} = \frac{110\sqrt{2}}{5000\sqrt{2}}$$

$$= \frac{110}{5}\text{ mA}$$

$$= 22\text{ mA}$$

396. (250) For DC voltage

$R = \frac{V}{I} = \frac{100}{5} = 20\Omega$

for AC voltage

$X_L = 20\sqrt{3}\Omega$

$R = 20\Omega$

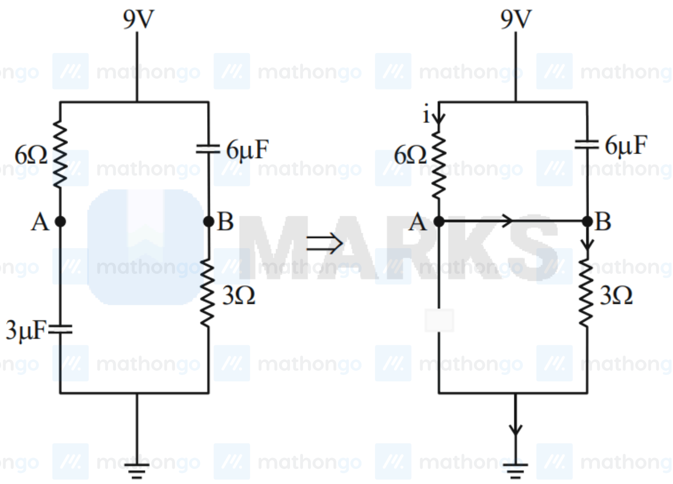
$Z = \sqrt{X_L^2 + R^2} = \sqrt{3 \times 400 + 400} = 40\Omega$

$$\text{Power } = i_{rms}^2 R$$

$$= \left(\frac{V_{rms}}{Z}\right)^2 \times R = \left(\frac{\frac{200}{\sqrt{2}}}{40}\right)^2 \times 20 = 250\text{ W}$$

397. (36)

At steady state, capacitor behaves as an open circuit and current flows in circuit as shown in the diagram.



$R_{eq} = 9\ \Omega$

$i = \frac{9\text{ V}}{9\Omega} = 1\text{ A}$

$\Delta V_{6\Omega} = 1 \times 6 = 6\text{ V}$

$V_A = 3\text{ V}$

So, potential difference across 6μF is 6 V.

Hence, $Q = C\Delta V$

$= 6 \times 6 \times 10^{-6}\text{ C}$

$= 36\ \mu\text{C}$

398. (3)

The voltages associated with the primary and the secondary side of the transformer are related to the turn ratio as follows:

$\frac{V_1}{V_2} = \frac{N_1}{N_2}\quad \ldots(1)$

From equation (1), it follows that

$\frac{230}{V_2} = \frac{10}{1}$

$V_2 = 23$ V

Hence, the power consumed can be calculated as follows

$P = \frac{V_2^2}{R}$

$= \frac{23 \times 23}{46}$

$= 11.5$ W

399. (40)

The average rate at which energy supplied i.e. power delivered is maximum in case of the resonance, therefore

$X_C = X_L$

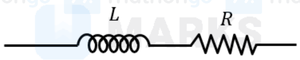
$\Rightarrow \frac{1}{\omega C} = 79.6\ \Omega$

$\Rightarrow \quad C = \frac{1}{\omega \times 79.6} = \frac{1}{2\pi f \times 79.6} = \frac{1}{100\pi \times 79.6} = 40\ \mu\text{F}$

Hence, $C = 40\ \mu$F.

400. (2)

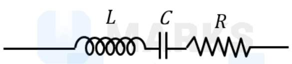
In case of LR circuit:



Given: $X_L = R$

$P_1 = \cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \left(X_L\right)^2}} = \frac{1}{\sqrt{2}}$

In case of LCR circuit:



$P_2 = \cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \left(X_L - X_C\right)^2}} = 1$

Therefore,

$\frac{P_1}{P_2} = 1 : \sqrt{2}$

401. (3)

For an LCR circuit. the resonant angular frequency is given by, $\omega_0 = \frac{1}{\sqrt{LC}} = 10^4$ rad s^{-1}

The given frequency is 60 % lower than resonant frequency. Therefore,

$\omega' = 0.4 \times 10^4 = 4000$ rad s^{-1}

Reactance of the capacitor at given frequency,

$X_C = \left(\omega' C\right)^{-1} = 250\ \Omega.$

Reactance of the inductor at given frequency,

$X_L = \left(\omega' L\right) = 40\ \Omega$

Now the amplitude of the current in the given circuit will be,

$i_0 = \frac{V_0}{\sqrt{R^2 + \left(X_C' - X_L'\right)^2}} = \frac{50}{\sqrt{10^2 + (250 - 40)^2}} = 238$ mA

402. (3)

The impedance of an AC circuit is given by, $Z = \sqrt{R^2 + \left(X_C - X_L\right)^2}$.

For current to be maximum Z should be minimum. The value of Z will be minimum when $X_C - X_L = 0$. Therefore, the value of $Z = R$. Hence, statement C is correct and statement D is wrong.

To the left of ω_r i.e. when $\omega < \omega_r$, $X_C > X_L$. Therefore, the circuit is mainly capacitive. Hence, statement A is correct and statement B is wrong.

403. (100)

The frequency given is 0.5 kilo cycle per second $\Rightarrow f = 500$ Hz $\Rightarrow \omega = 2\pi f = 1000\pi$ rad s^{-1}.

Total capacitance of the wire is $C = 0.01 \times 10^{-6} \times 100$ F.

Impedance is minimum at resonance. Therefore, for minimum impedance

$X_L = X_C$

$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow L = \frac{1}{\omega^2 C} = \frac{1}{1000^2 \times \pi^2 \times 0.01 \times 10^{-6} \times 100} = 10^{-1}$ H $= 100$ mH

404. (1)

AC generator-- Converts mechanical energy into electrical energy. $A \rightarrow II$.

Galvanometer-- Detects the presence of current in the circuit B - I.

Transformer-- Changes an alternating voltage for smaller or greater value C - IV.

Metal detector-- Works on the principle of resonance in AC circuit D - III.

405. (2)

Angular frequency, $\omega = 2\pi f = 2\pi \times 50 = 100\pi$ rad s^{-1}

At resonance,

$X_C = X_L \Rightarrow \frac{1}{\omega C} = \omega L \Rightarrow \frac{1}{\omega C} = 250\pi \Rightarrow C = \frac{1}{100\pi \times 250\pi}$ F $= 4\ \mu$F

406. (3) In capacitor, current lead voltage by $\frac{\pi}{2}$.

407. (1)

(a) For $x_L > x_C$, voltage leads the current

(ii)

(b) For $x_L = x_C$, voltage & current are in same phase

(i)

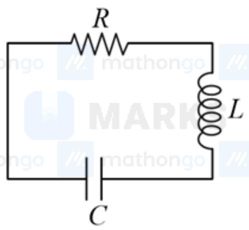
(c) For $x_L < x_C$, current leads the voltage

(iv)

(d) For resonant frequency $x_L = x_C$, current is maximum

(iii)

408. (4) In damped oscillation $ma + bv + kx = 0$



$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0 \ldots.$ (i)

In the circuit

$-iR - L\frac{di}{dt} - \frac{q}{c} = 0$

$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{1}{c}.q = 0.$. (ii)

Comparing equation (i) and (ii)

$m = L, b = R, k = \frac{1}{c}$

409. (4) For lens 1 : $f_1 = 10, u = -30, v = ?$

$v = \frac{uf}{u+f} = \frac{-30 \times 10}{-30+10} = 15$

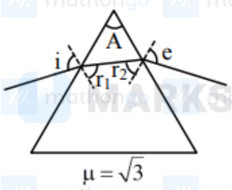
For lens 2: $f_1 = -10, u = 10, v = ?$

$v = \frac{uf}{u+f} = \frac{10 \times -10}{10-10} = \infty$

For lens 3 : $f = 30, u = -\infty, v = ?$

So v will be 30 .

410.



(60)

For $\delta_{\min}$

$i = e$

$r_1 = r_2 = \frac{A}{2}$

$\frac{\delta_{\min}}{A} = 1$

$\frac{2i - A}{A} = 1$

$2i = 2A$

$i = A$

Snell's law

$1 \times \sin i = \mu \sin r$

$\sin i = \mu \sin\left(\frac{A}{2}\right)$

$\sin A = \mu \sin\left(\frac{A}{2}\right)$

$2\sin\frac{A}{2}\cos\frac{A}{2} = \sqrt{3}\sin\left(\frac{A}{2}\right)$

$\cos\left(\frac{A}{2}\right) = \frac{\sqrt{3}}{2}$

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

$\therefore A = 60^\circ$

411. $1\text{MSD} = \frac{1\text{ cm}}{20} = 0.05\text{ cm}$

(3) $1\text{VSD} = \frac{49}{50}\text{MSD} = \frac{49}{50} \times 0.05\text{ cm} = 0.049\text{ cm}$

$\text{LC} = 1\text{MSD} - 1\text{VSD} = 0.001\text{ cm}$

For mark on paper, $L_1 = 8.45\text{ cm} + 26 \times 0.001\text{ cm} = 84.76\text{ mm}$

For mark on paper through slab, $L2 = 7.12\text{ cm} + 41 \times 0.001\text{ cm} = 71.61\text{ mm}$

For powder particle on top surface, $ZE = 4.05\text{ cm} + 1 \times 0.001\text{ cm} = 40.51\text{ mm}$

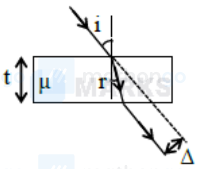
$\therefore$ actual $L_1 = 84.76 - 40.51 = 44.25\text{ mm}$

actual $L_2 = 71.61 - 40.51 = 31.10\text{ mm}$

$L_2 = \frac{L_1}{\mu}$

$\Rightarrow \mu = \frac{L_1}{L_2} = \frac{44.25}{31.10} = 1.42$

412.



(2)

$i = \theta_c$

$\Rightarrow i = \sin^{-1}\left(\frac{1}{\mu}\right)$

$\Rightarrow i = 45^\circ$

and according to snell's law

$1\sin 45^\circ = \sqrt{2}\sin r$

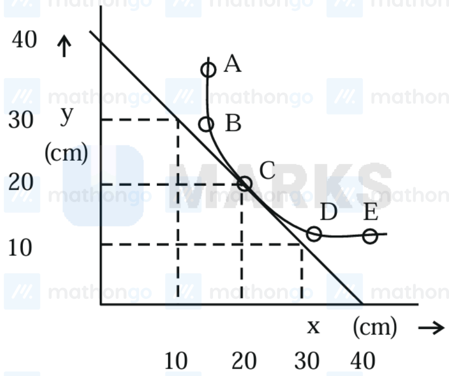
$\Rightarrow r = 30^\circ$

Lateral displacement $\Delta = \frac{t\sin(i-r)}{\cos r}$

$\Rightarrow \Delta = \frac{4\sqrt{3} \times \sin 15^\circ}{\cos 30^\circ}$

$\Rightarrow \Delta = 2\text{ cm}$

413. (20)



From Newton's formula for lens, we can write

$x_1x_2 = f^2 \Rightarrow 20 \times 20 = f^2$

Therefore, $f = 20$ cm

414. (3)

Given $R = 30$ cm

So, $f = \frac{R}{2} = +15$ cm

For convex mirror, virtual image is formed for real object. Thus, magnification $(m) = \frac{1}{2}$

The magnification can be written as

$m = -\frac{v}{u}$ . . . (1)

Equation (1) implies that

$\frac{1}{2} = -\frac{v}{u} \Rightarrow v = -\frac{u}{2}$

The relation between the object distance, image distance and the focal length of the mirror is given by

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ . . . (2)

Equation (2) implies that

$\frac{1}{15} = \frac{1}{-\frac{u}{2}} + \frac{1}{u} = -\frac{1}{u} \Rightarrow u = -15$ cm

415. (2)

Given, the refractive index of the material of the lens is $\mu_1 = 1.5$, the refractive index of the medium is $\mu_m = 1.6$ and the focal length of the lens in air is $f_a = 20$ cm.

In air:

$\frac{1}{f_a} = \left(\mu_1 - 1\right)\left[\frac{2}{R}\right]$

In liquid:

$\frac{1}{f_m} = \left(\frac{\mu_1}{\mu_m} - 1\right)\left[\frac{2}{R}\right]$

The focal length as measured in air and that as measured inside the liquid medium are related by,

$\frac{f_m}{f_a} = \frac{\left(\mu_1 - 1\right)\mu_m}{\left(\mu_1 - \mu_m\right)}$ . . . (1)

Equation (1) implies that

$\frac{f_m}{20} = \frac{(1.5-1)1.6}{(1.5-1.6)} \Rightarrow f_m = -160$ cm

416. (1)

The formula to calculate the refractive index (μ) of the material of the prism is given by

$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$ . . . (1)

From equation (1), it follows that

$\cot\frac{A}{2} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$

$\Rightarrow \cos\frac{A}{2} = \sin\left(\frac{A+\delta_m}{2}\right) \Rightarrow \sin\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\left(\frac{A+\delta_m}{2}\right)$

$\Rightarrow \frac{A+\delta_m}{2} = \frac{\pi}{2} - \frac{A}{2}$

$\Rightarrow \delta_m = \pi - 2A$

417. (1)

Let's assume that the original position of the bubble is x from one side of the ice cube of side a.

When the bubble is seen from one side, it can be written that

$\frac{x}{\mu} = 12 \quad \ldots(1)$

For the view from the other side, it can be written that

$\frac{a-x}{\mu} = 4 \quad \ldots(2)$

From equations (1) and (2), it is given that

$24 - 12\mu = 4\mu$

$\Rightarrow \mu = \frac{24}{16}$

$= 1.5$

418. (2)

The formula for a lens is given by $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \ldots(i)$

$u = (100 \pm 0.2)$ cm - (80 ± 0.2) cm = (20 ± 0.4) cm

$v = (180 \pm 0.2)$ cm - (100 ± 0.2) cm = (80 ± 0.4) cm

Substituting the values in the equation of focal length,

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{80} - \left(-\frac{1}{20}\right) = \frac{5}{80}$

$\Rightarrow f = 16$ cm

Differentiating the equation (i)

$\frac{df}{f^2} = \frac{dv}{v^2} + \frac{du}{u^2}$(Only positive sign is considered for error calculation)

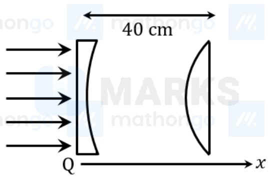
$= \frac{0.4}{6400} + \frac{0.4}{400} = 0.4 \times \frac{17}{6400}$

$\Rightarrow df = 0.4 \times \frac{17}{6400} \times 16^2 = 0.272$

The percentage error is

$\frac{df}{f} \times 100 = \frac{0.272}{16} \times 100 = 1.70\,\%$

419. (120)



Using Lens Makers formula for the plano-concave part, we can write

$\frac{1}{f_1} = \left(1.75 - 1\right)\left(-\frac{1}{30}\right)$

$\Rightarrow f_1 = -40$ cm

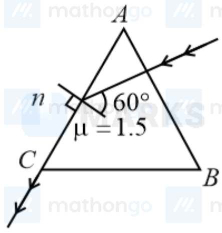
Using Lens Makers formula for the plano-convex part, we can write

$\frac{1}{f_2} = (1.75 - 1)\left(\frac{1}{30}\right) \Rightarrow f_2 = 40$ cm

Image from first lens will be virtual and on the left of first lens at focal length 40 cm. So the object for second lens will be 80 cm from second lens which is $2f_2$. Final image is formed at 80 cm from second lens on the right.

So, $x = 120$.

420. (27)



When the refracted light just grazes the boundary the incident angle is called a critical angle.

Using snell's law at face AC.

$1.5\sin 60° = n \times \sin 90°$

$\Rightarrow 1.5 \times \frac{\sqrt{3}}{2} = n = \frac{\sqrt{x}}{4}$

$\Rightarrow 3\sqrt{3} = \sqrt{x}$

$\Rightarrow x = 27$

421. (1)

The speed of light in a medium is inversely proportional to the refractive index of the material. Therefore,

$\frac{\mu_A}{\mu_B} = \frac{v_B}{v_A} = \frac{1}{2}$

Let the thickness is d

$\Rightarrow t_2 - t_1 = \frac{d}{v_B} - \frac{d}{v_A} = 5 \times 10^{-10}$ s

As $v_A = 2v_B \Rightarrow d = 5 \times 10^{-10} \times 2v_B$

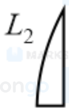
$\Rightarrow d = 5 \times 10^{-10} \times v_A$ m.

422. (1)

Using Lens maker's formula, power is given by

$P = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

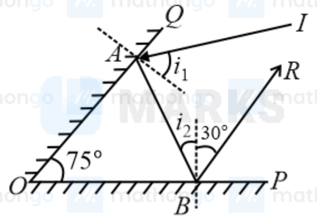
When convex lens is cut into two parts, $P_1 = \frac{1}{f} = (\mu - 1)\left(\frac{2}{R}\right) = P$



When half convex lens is cut into two parts,$P_2 = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R}\right) = \frac{P}{2}$

Power of lens, $P_3 = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R}\right) = \frac{P}{2}$

423. (210)



From the above figure, $i_2 = 30°$,

Now,

$\angle OBA + \angle ABR + \angle RBP = 180° \Rightarrow 2\angle OBA + 60° = 180° \Rightarrow \angle OBA = 60°$

In triangle OAB,

$\angle OBA + \angle AOB + \angle OAB = 180° \Rightarrow 60° + 75° + \angle OAB = 180° \Rightarrow \angle OAB = 45°$

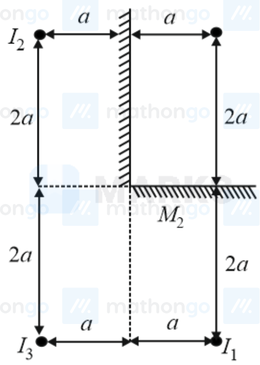
And,

$\angle OAB + \angle BAI + \angle IAQ = 180° \Rightarrow 2\angle OAB + 2i_1 = 180° \Rightarrow i_1 = 45°$

Now the total deviation of the ray will be,

$\delta = 360° - 2\left(i_1 + i_2\right) \Rightarrow \delta = 360° - 2(30° + 45°)\delta = 210°$

424. (3)



We know that the formula of the distance between two points is, $d = \sqrt{\left(x_2 - x_1\right)^2 + \left(y_2 - y_1\right)^2}$, now put the values from the above the diagram in the above formula, th

the distance between I_1 and I_2, $d = \sqrt{(4a)^2 + (2a)^2} \approx 4.6a$

425. (1)

(1) Lens formula

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$,

$\frac{1}{v} - \frac{1}{-30} = \frac{1}{10}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{30}$; $\frac{1}{v} = \frac{3-1}{30}$; $v = 15$ cm

(2) $u = +10$

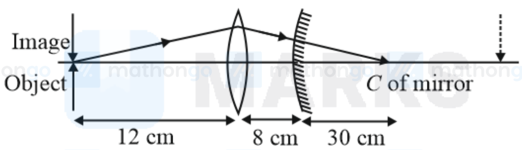
$\frac{1}{v} - \frac{1}{10} = \frac{1}{-10}$

$\frac{1}{v} = \frac{-1}{10} + \frac{1}{10}$ $v = \infty$

(3) Ray will converge at focus of 30 cm right of third lens.

it.$v = +30$ cm (from third lens)

426. (50)



For the object to coincide with the image, the light must fall perpendicularly to the mirror. This means that the light will have to converge at C of the mirror. Without th

mirror also, the light would coverage at C. So the distance is: $= 12 + 8 + 30 = 50$ cm.

427. (2) If distant objects are blurry then the problem is Myopia. If objects are distorted then the problem is Astigmatism

428. (30)

$\lambda_m = \frac{\lambda_a}{\mu} \Rightarrow \mu = \frac{3}{2}$

$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu - 1}{R}$

$\Rightarrow \frac{3}{2 \times 10} + \frac{1}{15} = \frac{\frac{3}{2} - 1}{R}$

$\Rightarrow R = \frac{30}{13}$ m

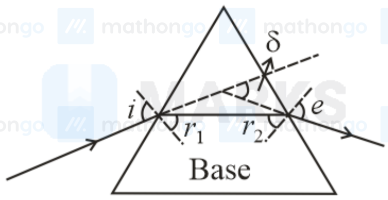
$= 30$

429. (1)

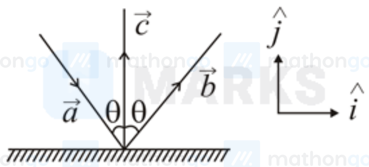
As per the figure given in question, we are considering it an Isosceles Prism.

Deviation is minimum in a prism when :

$i = e, r_1 = r_2$ and ray (2) is parallel to base of prism.



430. (3)



$\vec{a} = \sin\theta\hat{i} - \cos\theta\hat{j}$

$\vec{b} = \sin\theta\hat{i} + \cos\theta\hat{j}$

$\vec{c} = \hat{j}$

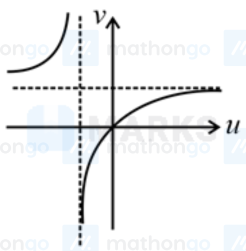
$\vec{a} - 2\left(\vec{a} \cdot \vec{c}\right)\vec{c} = \sin\theta\hat{i} + \cos\theta\hat{j}$

431. (1)

From the lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow v = f - \frac{f^2}{u+f}$

now, if we plot a graph between u and v



When $u \to \infty;\ v = f - \frac{f^2}{\infty} = f$

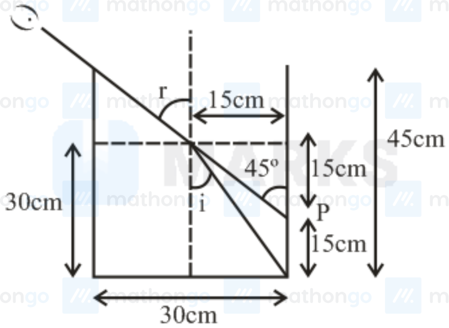
and for $u \to 0;\ v = 0$

Given that $u = v$ is a reference line, therefore, $\frac{dv}{du} = 0 + \frac{f^2}{(u+f)^2}$

$\frac{dv}{du}_{u=0} = 0 + \frac{f^2}{(0+f)^2} = 1$

The equation of tangent of the curve at the origin, $v - 0 = 1(u - 0) \Rightarrow v = u$

432. (158)



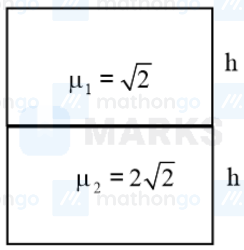
From Shell's Law

$\mu \times \sin i = 1 \times \sin r$

$\mu \times \frac{\sqrt{15}}{\sqrt{15^{2}+30^{2}}} = 1 \times \sin 45°$

$\mu = \sqrt{\frac{5}{2}} = 158 \times 10^{-2}$

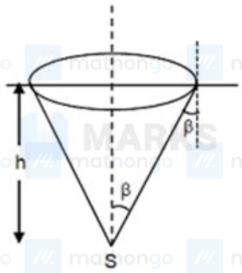
433. (4)



$d = \frac{h}{\sqrt{2}} + \frac{h}{2\sqrt{2}}$

$\Rightarrow d = \frac{h}{\sqrt{2}} \times \frac{3}{2} = \frac{3\sqrt{2}h}{4}$

434.



(3)

$sin\beta = \frac{3}{4}, \cos\beta = \frac{\sqrt{7}}{4}$

Solid angle $d\Omega = 2\pi R^2(1 - \cos\beta)$

Percentage of light $= \frac{2\pi R^2(1-\cos\beta)}{4\pi R^2} \times 100$

$= \frac{1-cos\beta}{2} \times 100 = \left(\frac{4-\sqrt{7}}{8}\right) \times 100 \approx 17\%$

435. (3) At focus, magnification is ∞ .

436.

(2) $\frac{1}{f_a} = \left(\frac{\mu_g}{\mu_a} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\Rightarrow \frac{f_a}{f_m} = \frac{\left(\frac{\mu_g}{\mu_m} - 1\right)}{\left(\frac{\mu_g}{\mu_a} - 1\right)} = \frac{\left(\frac{1.50}{1.42} - 1\right)}{\left[\frac{1.50}{1} - 1\right]} = \frac{0.08}{(1.92)(0.5)}$$

$$\frac{f_a}{f_m} = \frac{(1.42)(0.05)}{0.08} = 8.875 \approx 9$$

437. (4) From lens maker's formula,

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_1} = \left(\mu_1 - 1\right)\left(\frac{1}{\infty} - \frac{1}{(-R)}\right) = \frac{\mu_1 - 1}{R}$$

$$\frac{1}{f_2} = \left(\mu_2 - 1\right)\left(\frac{1}{(-R)} - \frac{1}{\infty}\right) = -\frac{\left(\mu_2 - 1\right)}{R}$$

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{\mu_1 - 1}{R} - \frac{\mu_2 - 1}{R}$$

$$= \frac{\mu_1 - \mu_2}{R}$$

$$f_{eq} = \frac{R}{\mu_1 - \mu_2}$$

438. (4)

$(\mu - 1)t = n\lambda$

$(1.5 - 1)t = 4 \times 500 \times 10^{-9}$ m

$t = 4000 \times 10^{-9}$ m

$t = 4\mu m$

439. (13)

For incoherent wave, $I_1 = I_A + I_B \Rightarrow I_1 = I_0 + 9I_0$

$\Rightarrow I_1 = 10I_0$

For coherent wave $I_2 = I_A + I_B + 2\sqrt{I_A I_B}\cos 60^o$

$\Rightarrow I_2 = I_0 + 9I_0 + 2\sqrt{9I_0^2} \times \frac{1}{2} = 13I_0$

$\Rightarrow \frac{I_1}{I_2} = \frac{10}{13}$

Therefore, $x = 13$.

440. (462)

The given data is

$\lambda_1 = 7000\ \overset{o}{A}$

$\lambda_2 = 5500\ \overset{o}{A}$

$d = 2.5 \times 10^{-3}$ m

$D = 1.5$ m

The path difference is given by

$n\lambda_1 = m\lambda_2$

$7n = 5.5$ m

$\Rightarrow 14n = 11$ m $\Rightarrow n = 11$ and $m = 14$

The formula for the distance of a bright fringe is

$y = \frac{n\lambda_1 D}{d}$

$\Rightarrow y = \frac{11 \times 7 \times 10^{-7} \times 1.5}{2.5 \times 10^{-3}}$

$= 46.2 \times 10^{-4} = 462 \times 10^{-5}$

It is given that

$n \times 10^{-5} = 462 \times 10^{-5} \Rightarrow n = 462$

441. (2)

When an unpolarized light passes through a polariser, the intensity of the emergent light from the polariser depends on the square of the cosine of the angle between the plane of the polariser and the direction of the incident light.

The formula to calculate the intensity $\left(I_1\right)$ of the emergent light from a polariser which makes an angle θ with the direction of the incident light is given by

$I_1 = I\cos^2\theta.................\left(1\right)$

where, I is the intensity of the incident light.

Substitute 45° for θ into equation (1) to obtain the intensity of the first emergent light.

$I_1 = I\cos^2 45°$

$= \frac{I}{2}$

In a similar manner, the intensity (I_2) of the second emergent light can be written as

$I_2 = I_1\cos^2 45°$

$= \frac{I_1}{2}$

$= \frac{I}{4}$

$= \frac{I}{2^2}$

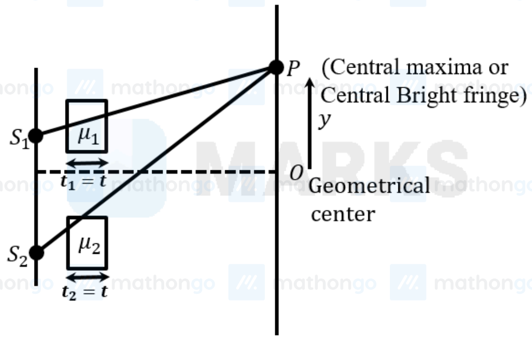
Thus, for n number of such polarisers, the net intensity (I_n) of the emergent light can be written as

$I_n = \frac{I}{2^n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$

Comparing equation (1) with the given expression for the intensity, it can be concluded that

$n = 6$

442. (10)



The change in path difference due to the two slabs at P is $\Delta x = (\mu_2 - \mu_1)t$

$= (1.55 - 1.51) \times 0.1 = 0.04 \times 10^{-4}$

$\Rightarrow \Delta x = 4 \times 10^{-6} = 4\ \mu m$

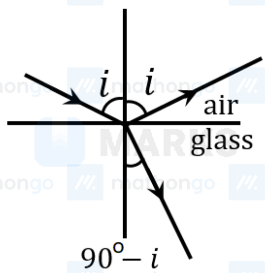
Now, the distance of central maxima from geometrical center is $y = \frac{\Delta x D}{d} = 4 \times 10^{-6}\frac{D}{d}$

Now, fringe width, $n\beta = 4 \times 10^{-6}\frac{D}{d}$

Or, $\frac{n\lambda D}{d} = 4 \times 10^{-6}\frac{D}{d}$

Number of shift, $n = \frac{4 \times 10^{-6}}{4 \times 10^{-7}} = 10.$

443. (2)



Applying Snell's law, we get

$\mu_a \sin i = \mu_g \sin(90° - i)$

$\tan i = \frac{\mu_g}{\mu_a}$

When going from glass to air

$\tan i' = \frac{\mu_a}{\mu_g} = \cot i$

Clearly, $i' = \left(\frac{\pi}{2} - i\right)$ & hence Statement I is true but Statement II is false.

444. (2)

Given here, $\frac{I_1}{I_2} = \frac{1}{4}$ or $I_2 = 4I_1$

Maximum intensity is $I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = I_1 + 4I_1 + 2\sqrt{I_1 4I_1} = 9I_1$

Minimum intensity is $I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = I_1 + 4I_1 - 2\sqrt{I_1 4I_1} = I_1$

The ratio of $\frac{I_{\max} + I_{\min}}{I_{\max} - I_{\min}}$ is

$\frac{9I_1 + I_1}{9I_1 - I_1} = \frac{10}{8} = \frac{5}{4} = \frac{2\alpha + 1}{\beta + 3}$

$\alpha = 2 \;\; \beta = 1$

$\therefore \frac{\alpha}{\beta} = \frac{2}{1} = 2$

445. (4) A light whose electric field vectors are completely removed by using a good Polaroid, allowed to incident on the surface of the prism at Brewster's angle. Then, no reflection of light but there will be total transmission of light.

446. (3)

The condition for maxima in diffraction is,

$b\sin\theta = (2n + 1)\frac{\lambda}{2}$.

For the first maxima $n = 1$. Therefore,

$b\sin\theta = \frac{3\lambda}{2} \Rightarrow \sin\theta = \frac{3\lambda}{2b} = \frac{y}{D}y = \frac{3\lambda D}{2b}$

Now the difference between the positions of the maxima will be,

$y_1 - y_2 = \frac{3D}{2b}\left(\lambda_1 - \lambda_2\right) \Rightarrow y_1 - y_2 = \frac{3 \times 2}{2 \times 5 \times 10^{-4}} \times (655 - 650) \times 10^{-9} = 3 \times 10^{-5}$ m

447. (2)

Fringe width,

$\beta = \frac{\lambda D}{d}$

$\beta_{\max} \Rightarrow d_{\min}$ and $\beta_{\min} \Rightarrow d_{\max}$

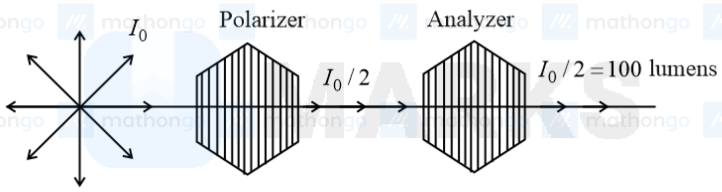
$d = d_0 + a_0\sin\omega t$

$d_{\max} = d_0 + a_0$ and $d_{\min} = d_0 - a_0$

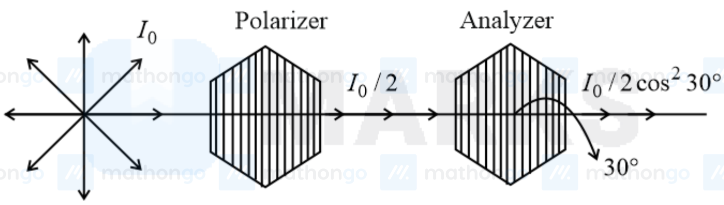
$\therefore \;\beta_{\min} = \frac{\lambda D}{d_0 + a_0}$ and $\therefore \;\beta_{\max} = \frac{\lambda D}{d_0 - a_0}$

$\beta_{\max} - \beta_{\min} = \frac{\lambda D}{d_0 - a_0} - \frac{\lambda D}{d_0 + a_0} = \frac{2\lambda D a_0}{d_0^2 - a_0^2}$

448. (75)



Assuming initially axis of Polarizer and Analyzer are parallel



Now emerging intensity $= \frac{I_0}{2}\cos^2 30°$

$= 100\left(\frac{\sqrt{3}}{2}\right)^2 = 100 \times \frac{3}{4} = 75$

449. (2)

$\Delta P_A = \frac{\pi}{2} \times \frac{20}{2\pi} - 5 = 0$ so $\Delta\phi_A = 0$

$\Delta P_B = \frac{\pi}{2} \times \frac{20}{2\pi} = 5$ so $\Delta\phi_B = \frac{\pi}{2}$

$\Delta P_C = 5 + 5 = 10$ so $\Delta\phi c = \pi$

$I = \text{Io}\cos^2\frac{\Delta\phi}{2}$

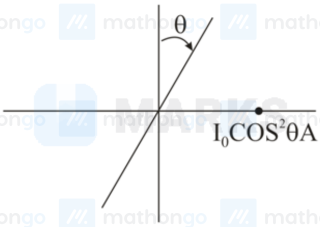
so $I_A = I_0$

$I_B = \frac{I_0}{2}$

$Ic = 0$

so $IA : I_B : I_C = 2 : 1 : 0$

450. (2)



Given,

Intensity of plane polarized light of large cross-sectional area is $I_0 = 3.3 \text{ W m}^{-2}$

Area of cross-section of polarizer is $A = 3 \times 10^{-4} \text{ m}^2$

Angular speed of rotation is $\omega = 31.4 \text{ rad s}^{-1}$

The intensity of light is the given by the definition,

$I = \frac{E}{AT} \ldots (1)$

Intensity of light passing through the polarizer as polarizer rotates is given by

$I_{avg} = I_0 \frac{1}{T} \int_0^T \cos^2(\omega t) \, d\, t$

$\Rightarrow I_{avg} = I_0 \frac{1}{T} \int_0^T \left[\frac{1 + \cos(2\omega t)}{2} \right] d\, t$

$\Rightarrow I_{avg} = I_0 \frac{1}{2T} \left[\int_0^T d\, t + \int_0^T \cos(2\omega t) \, d\, t \right]$

$\Rightarrow I_{avg} = I_0 \frac{1}{2T} [T + 0]$

$\Rightarrow I_{avg} = \frac{I_0}{2} \ldots (2)$

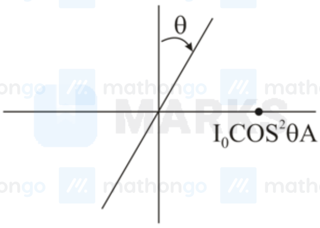
Using equation (1) and (2) we get energy per revolution is given by

$E = \frac{I_0 A}{2} T = \frac{I_0 A}{2} \frac{2\pi}{\omega}$

$E = \frac{3.3 \times 3 \times 10^{-4}}{2} \frac{3.14}{31.4}$

$E \simeq 1 \times 10^{-4} \text{ J}$

451. (2)



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$\Rightarrow I_{avg} = I_0 \frac{1}{2T} \left[\int_0^T d\, t + \int_0^T \cos(2\omega t) \, d\, t \right]$

$\Rightarrow I_{avg} = I_0 \frac{1}{2T} [T + 0]$

$\Rightarrow I_{avg} = \frac{I_0}{2} \ ...\left(2\right)$

Using equation (1) and (2) we get energy per revolution is given by

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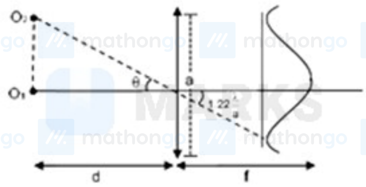
$E = \frac{3.3 \times 3 \times 10^{-4}}{2} \frac{3.14}{31.4}$

$E \simeq 1 \times 10^{-4}$ J

452. **(4)** $y = \frac{m_1 D \lambda_1}{d} = \frac{m D \lambda_2}{d}$

$\frac{m_2}{m_1} = \frac{\lambda_1}{\lambda_2} \Rightarrow m_2 = \frac{700}{400} \times 16 = 28$

453.



(1)

$\theta = 1.22 \frac{\lambda}{a}$

Distance $= O_1 O_2 = d\theta$

$= 1.22 \frac{\lambda}{a} d$

Distance $= O_1 O_2 = \frac{1.22 \times 5893 \times 10^{-10} \times 4 \times 10^8}{5} \approx 57.5 m$

$\therefore$ answer from options $= 60 m$

(minimum distance)

454. **(750)** $15 \times 500 \times \frac{D}{d} = 10 \times \lambda_2 \times \frac{D}{d}$

$\lambda_2 = 15 \times 50 \ nm$

$\lambda_2 = 750 \ nm$

455. Pressure $= \frac{I}{C} = \frac{F}{A}$

(4) $\Rightarrow \frac{360}{10^{-4} \times 3 \times 10^8} = \frac{2.4 \times 10^{-4}}{A}$

$\Rightarrow$ A $= 2 \times 10^{-2}$ m^2 $= 0.02$ m^2

456. **(3)** (Theory)

Photoelectric effect prove particle nature of light.

457. $eV_0 = h\nu - \phi$

(4) $V_0 = \frac{h}{e}\nu - \frac{\phi}{e}$

M_2 material has higher work function, so statement-(II) is incorrect.

458. **(2)** Given lights are of same wavelength.

Hence stopping potential will remain same.

Since $I_2 > I_1$, hence saturation current corresponding to I_2 will be greater than that corresponding to I_1.

459. **(3)**

From photoelectric effect equation, we can write $E = \phi + K_{max}$

and work function can be written as $\phi = \frac{hc}{\lambda_0}$.

Also, maximum kinetic energy $K_{max} = eV_0$

For first case:

$8e = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ... (i)

For second case:

$2e = \frac{hc}{3\lambda} - \frac{hc}{\lambda_0}$ ... (ii)

After using equation (ii) in (i), we get

$4\left(\frac{hc}{3\lambda} - \frac{hc}{\lambda_0}\right) = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

$\Rightarrow \lambda_0 = 9\lambda$

460. **(3)**

Given, $f_i = f_0$. Now, $f = \frac{f_i}{2} = \frac{f_0}{2}$.

Since $\frac{f_0}{2} < f_0$ i.e. the incident frequency is less than threshold frequency. Hence, there will be no emission of photoelectrons.

Therefore, current $= 0$ and no photo electrons will be emitted.

461. (2)

For photon,

$E_P = \frac{hc}{\lambda_p} \Rightarrow \lambda_p = \frac{hc}{E_P}$

For electron

$\lambda_e = \frac{h}{m_e v_e}$

$= \frac{h v_e}{2\ K_e}$

Given $v_e = 0.25c$. So,

$\lambda_e = \frac{h \times 0.25c}{2\ K_e}$

$= \frac{hc}{8\ K_e}$

Also $\lambda_p = \lambda_e$. Thus,

$\frac{hc}{E_p} = \frac{hc}{8K_e} \Rightarrow \frac{K_e}{E_p} = \frac{1}{8}$

462. (3)

With proper energetic radiation, the photoelectric current increases with an increase in accelerating potential until it reaches a point where it reaches its maximum and does not increase with an additional increase in accelerating potential.

For a given potential difference, the photocurrent is directly proportional to the intensity of the incident radiation.

The maximum kinetic energy of the emitted photoelectrons can be written as

$K_{\max} = h\nu - \varphi$

From above equation, it can be seen that the maximum kinetic energy of the photoelectron depends on the frequency of the light used.

Hence, the statements A and C are correct.

463. (2)

For α particle, $m_\alpha = 4$ a.m.u and charge $q_\alpha = 2e$.

For proton, $m_p = 1$ a.m.u and charge $q_p = e$.

As the charged particle are moving through same potential, the kinetic energy acquired by the particle will be equal to electric potential energy i.e.,

$\frac{1}{2}mv^2 = qV$, where, V is potential.

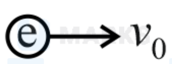
Using the relation between momentum (p) and kinetic energy, we have

$p = \sqrt{2mE} = \sqrt{2mqV}$

Then, the ratio of linear momenta of two particles is $\frac{p_\alpha}{p_p} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}} = \sqrt{\frac{4}{1} \times \frac{2}{1}}$

$= \frac{2\sqrt{2}}{1} = 2\sqrt{2} : 1$

464. (4)



Initial de-Broglie wavelength of electron,

$\lambda_0 = \frac{h}{mv_0}$ ....(i)

Force on electron in electric field,

$\mathrm{F} = -e\mathrm{E} = -e\left[-E_0\hat{\mathrm{i}}\right] = eE_0\hat{\mathrm{i}}$

Acceleration of electron, $a = \frac{\mathrm{F}}{m} = \frac{eE_0\hat{\mathrm{i}}}{m}$

Velocity of electron after time t,

$v = v_0\hat{\mathrm{i}} + \left(\frac{eE_0\hat{\mathrm{i}}}{m}\right)t = \left(v_0 + \frac{eE_0}{m}t\right)\hat{\mathrm{i}} = v_0\left(1 + \frac{eE_0}{mv_0}t\right)\hat{\mathrm{i}}$

de-Broglie wavelength associated with electron at time t is

$\lambda = \frac{h}{mv}$

$$\Rightarrow \lambda = \frac{h}{m\left[v_0\left(1+\frac{eE_0}{mv_0}t\right)\right]} = \frac{\lambda_0}{\left[1+\frac{eE_0}{mv_0}t\right]}$$

465. (2)

Wavelength of incident beam $\lambda = 900 \times 10^{-9}$ m

Energy of a single photon $E = \frac{hc}{\lambda}$.

Intensity is defined as power per unit area. Therefore,

Intensity of incident beam $I = \frac{E}{tA}$

If the number of photons crossing the given area per second is n, then

$$n = \frac{E_{\text{net}}}{E_{\text{single pholon}}} = \frac{IA\lambda}{hc}$$

$$\Rightarrow n = \frac{(100)\left(1\times10^{-4}\right)\left(900\times10^{-9}\right)}{6.62\times10^{-34}\times3\times10^{8}} = 4.5 \times 10^{16}.$$

466. (3)

According to Einstein's photoelectric equation

$$k_{max} = \frac{hc}{\lambda} - \phi$$

$$\Rightarrow k_1 = \frac{1230}{800} - \phi \quad \ldots(1)$$

And $\Rightarrow k_2 = \frac{1230}{500} - \phi$

Since, $k_2 = 2k_1$

$$\Rightarrow 2k_1 = \frac{1230}{500} - \phi \quad \ldots(2)$$

Eliminating k_1 from (1) and (2) we get

$$0 = \frac{1230}{500} - \frac{1230}{400} + \phi$$

$$\Rightarrow \phi = 0.615 \text{ eV}$$

467. (4)

Given: $E = 200\left[\sin\left(6 \times 10^{15}\right)t + \sin\left(9 \times 10^{15}\right)t\right]$ V m^{-1}

Here, angular velocity, $\omega_1 = 6 \times 10^{15}$ and $\omega_2 = 9 \times 10^{15}$

Maximum kinetic energy of the photoelectron is $\text{KE}_{\text{max.}} = E - \phi$

$$= hf - \phi = \frac{h\omega}{2\pi} - \phi$$

$$= \frac{4.14\times10^{-15}\times9\times10^{15}}{2\times3.14} - 2.5 = 5.92 - 2.50 = 3.42 \text{ eV}$$

468. (3)

$$\lambda = \frac{h}{mv}$$

Kinetic energy, $\frac{P^2}{2m} = \frac{h^2}{2m\lambda^2} = \frac{hc}{\lambda_c}$

$$\lambda_c = \frac{2m\lambda^2 c}{h}$$

469. (4)

$$\text{KE} = \frac{hc}{\lambda} - \phi hc$$

$$e\left(3V_0\right) = \frac{hc}{\lambda_0} - \phi \ \ldots(\text{i})$$

$$eV_0 = \frac{hc}{2\lambda_0} - \phi \ \ldots(\text{ii})$$

Using (i) and (ii),

$$\phi = \frac{hc}{4\lambda_0} = \frac{hc}{\lambda_t}$$

$$\lambda_t = 4\lambda_0$$

470. (1)

$$\frac{1}{2}mv_1^2 = hf_1 - \phi$$

$$\frac{1}{2}mv_2^2 = hf_2 - \phi$$

$$v_1^2 - v_2^2 = \frac{2h}{m}\left(f_1 - f_2\right)$$

471. (4)

The acceleration of the electron is

$a = \frac{eE}{m}$

The velocity of the electron as a function of time is

$v = at = \frac{eE}{m}t$

The de-Broglie wavelength is

$\lambda = \frac{h}{mv}$

$\lambda = \frac{h}{m\left(\frac{eE}{m}\right)t}$

$\lambda = \frac{h}{eEt}$

$\frac{d\lambda}{dt} = -\frac{h}{eEt^2}$

472. **(3)**

Initial velocity of electron,

$v = v_0\hat{i} + v_0\hat{j} \Rightarrow |u| = \sqrt{v_0^2 + v_0^2} = v_0\sqrt{2}$

Initial de Broglie wavelength associated with electron,

$\lambda_0 = \frac{h}{p} = \frac{h}{mv_0\sqrt{2}}$

now,

$v = u + at$

Velocity as a function of time $= v_0\hat{i} + v_0\hat{j} + \frac{eE_0}{m}t\hat{k}$

so wavelength $\lambda = \frac{h}{m\sqrt{2v_0^2 + \frac{e^2E_0^2}{m^2}t^2}}$

$\lambda = \frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2}{2m^2v_0^2}t^2}}$

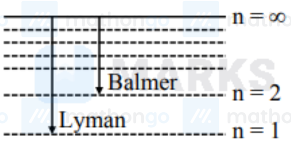
473. $v = \sqrt{\frac{4KZe^2}{mr_{min}}}$

(156) $= \sqrt{\frac{4 \times 9 \times 10^9 \times 80}{6.72 \times 10^{-27} \times 4.5 \times 10^{-14}}} \times 1.6 \times 10^{-19}$

$= 9.759 \times 10^{25} \times 1.6 \times 10^{-19}$

$= 156 \times 10^5 \text{ m/s}$

474.



(1)

$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$\frac{\frac{1}{\lambda_L} = Rz^2\left(\frac{1}{1^2}\right)}{\frac{1}{\lambda_B} = Rz^2\left(\frac{1}{2^2}\right)}$$

$\frac{\lambda_B}{\lambda_L} = 4 : 1$

475.

$$\Delta E = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 1.9\text{eV}$$

$$\Delta E = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{\Delta E}$$

$$P_i = P_t$$

(7) $$0 = -mv + \frac{h}{\lambda''}$$

$$\Rightarrow v = \frac{h}{m\lambda'}$$

$$\Delta E = \frac{1}{2}mv^2 + \frac{hc}{\lambda''}$$

$$= \frac{1}{2}m\left(\frac{h}{m\lambda}\right)^2 + \frac{hc}{\lambda'}$$

Now

$$\Delta E = \frac{h^2}{2m\lambda'^2} + \frac{hc}{\lambda'}$$

$$\lambda'^2\Delta E - hc\lambda' - \frac{h^2}{2m} = 0$$

$$\lambda' = \frac{hc \pm \sqrt{h^2c^2 + \frac{4\Delta E h^2}{2m}}}{2\Delta E}$$

$$\lambda' = \frac{hc \pm hc\sqrt{1 + \frac{2\Delta E}{mc}}}{2\Delta E}$$

$$\frac{\lambda'}{\lambda} = \frac{1 + \left(1 + \frac{2\Delta E}{mc^2}\right)^{\frac{1}{2}}}{2} = \frac{1 + 1 + \frac{\Delta E}{mc^2}}{2}$$

$$\frac{\lambda'}{\lambda} = 1 + \frac{\Delta E}{2mc^2}$$

$$\frac{\lambda' - \lambda}{\lambda} = \frac{\Delta E}{2mc^2} = \frac{1.9 \times 1.6 \times 10^{-19}}{2 \times 1.67 \times 10^{-27} \times 9 \times 10^{15}} = 10^{-9}$$

$\therefore$ % change $\approx 10^{-7}$

Correct answer 7

476. (32)

For Hydrogen like atom, energy emitted is $E = -13.6Z^2\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$

$$\Rightarrow E = C\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\Rightarrow h\nu = C\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

Therefore, the ratio $\frac{\nu_1}{\nu_2} = \frac{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{2-1}}{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{3-1}}$

$$= \frac{\left[\frac{1}{1} - \frac{1}{4}\right]}{\left[\frac{1}{1} - \frac{1}{9}\right]} = \frac{\frac{3}{4}}{\frac{8}{9}}$$

$= \frac{3}{4} \times \frac{9}{8}$

$\Rightarrow \frac{v_1}{v_2} = \frac{27}{32}$

$\Rightarrow v_2 = \frac{32}{27} v_1 = \frac{32}{27} \times 3 \times 10^{15}$ Hz $= \frac{32}{9} \times 10^{15}$ Hz

Hence, $x = 32$.

477. (121)

For minimum potential difference, electron has to make transition from $n = 3$ to $n = 2$ state but first electron has to reach to $n = 3$ state from ground state. So, energ

bombarding electron should be equal to energy difference of $n = 3$ and $n = 1$ state.

$\Delta E = 13.6\left[1 - \frac{1}{3^2}\right] e = eV$

$\Rightarrow \frac{13.6 \times 8}{9} = V$

$\Rightarrow V = 12.09$ V ≈ 12.1 V

So, $\alpha = 121$.

478. (828)

Let the electron jumped to n^{th} excited state.

In the ground state, energy $E = -13.6$ eV

So, using relation $12.75 = 13.6\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$

$\Rightarrow 0.9375 = \left[1 - \frac{1}{n^2}\right] \Rightarrow n^2 = 16$

$\Rightarrow n = \sqrt{16} = 4$

Now, angular momentum, $L = \frac{nh}{2\pi} = \frac{4h}{2\pi} = \frac{2h}{\pi}$

$= \frac{2}{\pi} \times 4.14 \times 10^{-15}$

$= \frac{828 \times 10^{-17}}{\pi}$ eVs

Hence, the value of $x = 828$.

479. (1)

Energy of an electron in the n^{th} orbit of a Hydrogen atom is given by, $E_n = \frac{-13.6}{n^2}$ eV

Therefore,

$\Rightarrow \frac{E_2 - E_1}{E_\infty - E_1} = \frac{13.6\left(1 - \frac{1}{4}\right)}{13.6} = \frac{3}{4}$

480. (5)

Energy of a photon released in transition of electron in hydrogen atom is given by,

$E = 13.6\left(\frac{1}{{n_2}^2} - \frac{1}{{n_1}^2}\right)$ eV

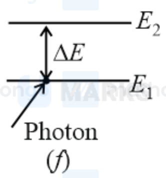
$\Rightarrow \frac{E_1}{E_2} = \frac{13.6\left(\frac{1}{4} - \frac{1}{9}\right)}{13.6\left(\frac{1}{4} - \frac{1}{\infty}\right)} = \frac{x}{x+4} \Rightarrow \frac{\frac{1}{4} - \frac{1}{9}}{\frac{1}{4}} = \frac{x}{x+4}$

$\Rightarrow \frac{5}{9} = \frac{x}{x+4}$

$\Rightarrow 5x + 20 = 9x$

$\Rightarrow x = 5$

481. (4)



According to Bohr's model, when electron makes the transition from lower orbit to higher orbit, its energy can be given as

$\Delta E = E_{final} - E_{initial} = hf$, here, h is Planck's constant.

Then, $f = \frac{E_2 - E_1}{h}$.

Bohr's frequency condition is the law that state that the frequency of the radiation emitted or absorbed during the transition of an atomic system between two stationary states equals the difference in the energies of the states divided by Planck's constant.

Hence, Statement I is incorrect but statement II is true.

482. (2)

We know the relation between radius and atomic mass number is $R = R_0 A^{\frac{1}{3}} \Rightarrow \ln R = \ln R_0 + \frac{1}{3}\ln A$

$\Rightarrow \ln\left(\frac{R}{R_0}\right) = \frac{1}{3}\ln A$

It is similar to $y = mx$ which is equation of line passing through origin.

483. (2)

Total energy of electron is stated as $E = -\frac{Z^2 me^4}{8\left(nh\varepsilon_0\right)^2}$, potential energy $P = -\frac{Z^2 me^4}{4\left(nh\varepsilon_0\right)^2}$ and kinetic energy is given by $K = \frac{Z^2 me^4}{8\left(nh\varepsilon_0\right)^2}$.

So, as electron makes transition to higher level, total energy and potential energy increases due to the negative sign while the kinetic energy of electron decreases.

484. (112)

Time taken to revolve in circular orbit is $T = \frac{2\pi}{\omega} = \frac{2\pi r}{v} = \frac{2 \times \frac{22}{7} \times 5 \times 10^{-11}}{2.2 \times 10^6} = \frac{10}{7} \times 10^{-16}$ s

Now, current associated with the electron is $I = \frac{e}{T} = \frac{1.6 \times 10^{-19}}{\frac{10}{7} \times 10^{-16}} = 1.12 \times 10^{-3}$A

$\Rightarrow I = 1.12$ mA

Hence, the current is 112×10^2 mA.

485. (15)

$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\frac{1}{\lambda_1} = Rz^2\frac{5}{36}$ ... (i)

For 3rd line

$\frac{1}{\lambda_3} = Rz^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$

$\frac{1}{\lambda_3} = Rz^2\frac{21}{100}$ ... (ii)

(ii) ÷ (i)

$\frac{\lambda_1}{\lambda_3} = \frac{21}{100} \times \frac{36}{5} = 1.512 = 15.12 \times 10^{-1}$

$x \approx 15$

486. (3)

$A \rightarrow$ Series limit of Lyman series.

$B \rightarrow$ Third member of Balmer series.

$C \rightarrow$ Second member of Paschen series.

487. (4)

Rutherford carried out an experiment in which he bombarded a thin sheet of gold foil with α-particles and then analysed the trajectory of these particles after they collic with the gold foil.

For a detector at a specific angle with respect to the incident beam, the number of particles per unit area striking the detector is given by the Rutherford formula,

$Y(\theta) = \frac{N_i n L Z^2 k^2 e^4}{4r^2 (KE)^2 \sin^4\left(\frac{\theta}{2}\right)}$

Here, $N_i =$ Number of incident alpha particles,

$n =$ Atoms per unit volume in target,

$L =$ Thickness of target,

$Z =$ Atomic number of target,

$e =$ Electron charge,

$k =$ Coulomb's constant,

$r =$ Distance between target and detector,

$KE =$ Kinetic energy of alpha particles,

$\theta =$ Scattering angle.

Therefore, $Y \propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$

488.

(486) $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\frac{1}{\lambda_1} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$

$\frac{\lambda_2}{\lambda_1} = \frac{20}{27}$

$\lambda_2 = \frac{20}{27} \times 6561 \overset{\circ}{A} = 4860 \overset{\circ}{A}$

= 486 nm

489. (15) $^4He + {}^4He + {}^4He \rightarrow {}^{12}C + Q$

power generated $= \frac{N}{t}Q$

where, N $\rightarrow$ No. of reaction / sec.

$Q = \left(3\ m_{He} - m_C\right)C^2$

$Q = (3 \times 4.0026 - 12)\left(3 \times 10^8\right)^2$

Q = 7.266MeV

$\frac{N}{t} = \frac{\text{power}}{Q} = \frac{5.808 \times 10^{30}}{7.266 \times 10^6 \times 1.6 \times 10^{-19}}$

$\frac{N}{t} = 5 \times 10^{42}$

rate of conversion of ^4He into $^{12}C = 15 \times 10^{42}$ Hence, n = 15

490. (1) In each fusion reaction, $4{}^1_1H$ nucleus are used.

Energy released per Nuclei of ${}^1_1H = \frac{26.7}{4}$MeV

$\therefore$ Energy released by 2 kg hydrogen $\left(E_H\right)$

$= \frac{2000}{1} \times N_A \times \frac{26.7}{4}$MeV

&

$\therefore$ Energy released by 2 kg Vranium $\left(E_V\right)$

$= \frac{2000}{235} \times N_A \times 200$MeV

So,

$\frac{E_H}{E_V} = 235 \times \frac{26.7}{4 \times 200} = 7.84$

$\therefore$ Approximately close to 7.62

491. (3)

(A) Electron revolves around nucleus only in those orbits for which the angular momentum is an integral multiple of $\frac{h}{2\pi}$.

(B) Nuclear force does not follow the inverse square law.

(C) Nuclear forces are spin dependent but charge independent.

(D) Nuclear force is attractive in nature. It is a non central force, meaning it does not depend upon the distance between the particles but rather upon their orientation. Nuclear force is stronger if the spin is parallel; and weak if it is anti parallel.

(E) The negative value (less quantity) of packing fraction indicates that the isotope is stable. Positive value of packing fraction implies unstable (radioactive) nucleus. A the stability of the nucleus is inversely proportional to the value of the packing fraction.

492. (4)

Combining the reactions, it can be written that

$Li6_3 + n1_0 \rightarrow He4_2 + H3_1$

$H2_1 + H3_1 \rightarrow He4_2 + n1_0$

$\overline{\hspace{6cm}} Li6_3 + H2_1 \rightarrow 2\left(He4_2\right)$

Hence, the energy released in process can be calculated as follows

$Q = \Delta mc^2$

$= \left[M\left(Li\right) + M\left(H2_1\right) - 2 \times M\left(He4_2\right)\right] \times 931.5$ MeV

$= [6.01690 + 2.01471 - 2 \times 4.00388] \times 931.5$ MeV

= 22.22 MeV

493. (4)

The formula to calculate the Q-value of the given nuclear reaction can be written as

$Q = \left(m_{\mathrm{U}} - m_{\mathrm{Th}} - m_{\mathrm{He}}\right)c^2 \quad \ldots(1)$

Substitute the values of the known parameters into equation (1) to calculate the required Q-value for the reaction.

$Q = (238.05060\ \mathrm{u} - 234.04360\ \mathrm{u} - 4.00260\ \mathrm{u})c^2$

$= 0.0044c^2 \times 931.5\ \mathrm{MeV}/c^2$

$\approx\ 4\ \mathrm{MeV}$

494. (26)

Energy released in the given process = Binding energy of product - Binding energy of reactants.

$= 7.6 \times 4 - (1.1 \times 2) \times 2$

$= 30.4 - 4.4$

$= 26\mathrm{MeV}$

495. (4)

The Q-value of the reaction is defined as the difference between the sum of the masses of the initial reactants and the sum of the masses of the final products, in energy units.

For any reaction to happen spontaneously there must be some energy released in the process. Therefore,

$\left(K_p + Q\right) > 0.$

496. (4)

The total binding energy of nucleus A is,

$E_A = 220 \times 5.6 = 1232\ \mathrm{MeV}$

The total binding energy of B and C combined is,

$E_B + E_C = 105 \times 6.4 + 115 \times 6.4 = 1408\ \mathrm{MeV}$

Therefore, the energy released per fission is,

$Q = E_B + E_C - E_A = 1408 - 1232 = 176\ \mathrm{MeV}$

497. (27)

$\Delta m = \left(Zm_P + \left(A - Z\right)m_n\right) - M_{\mathrm{Al}}$

$= (13 \times 1.00726 + 14 \times 1.00866) - 27.18846$

$= 27.21562 - 27.18846$

$= 0.02716\ \mathrm{u}$

$E = 27.16x \times 10^{-3}\ \mathrm{J}$

498. (4) $\rho_{\text{nucleus}} = \frac{\text{mass}}{\text{volume}}$

$= \frac{A}{(4/3)\pi r_0^3 A} = \frac{3}{4\pi r_0^3}$

$= 2.3 \times 10^{17}\ \mathrm{kg/m^3}$

499. (1) $\mathrm{E} = \mathrm{BC} \Rightarrow 60 = \mathrm{B} \times 3 \times 10^8$

$\Rightarrow \mathrm{B} = 2 \times 10^{-7}$

Also $\quad \mathrm{C} = \mathrm{f}\lambda$

$\Rightarrow 3 \times 10^8 = \mathrm{f} \times 4 \times 10^{-3}$

$\Rightarrow \mathrm{f} = \frac{3}{4} \times 10^{11}$

$\Rightarrow \omega = 2\pi\mathrm{f} = \frac{3}{4} \times 2\pi \times 10^{11}$

$\Rightarrow \omega = \frac{\pi}{2} \times 10^3\mathrm{C}$

$\Rightarrow$ Electric field $\Rightarrow y$ direction

Propagation $\Rightarrow$ x direction

Magnetic field $\Rightarrow$ z-direction

500.

$$\frac{\varepsilon_m \times \mu_m}{\varepsilon_0 \times \mu_0} = \frac{\frac{1}{v^2}}{\frac{1}{c^2}}$$

$$\varepsilon_r \times \mu_r = \frac{c^2}{v^2}$$

(1)

$$\varepsilon_r \times 2 = \frac{\left(3 \times 10^8\right)^2}{\left(1.5 \times 10^8\right)^2}$$

$$\varepsilon_r \times 2 = 4$$

$$\varepsilon_r = 2$$

501. (3)

The formula to calculate the radiation pressure is given by

$P = \frac{I}{v} \quad . . . (1)$

Also, the velocity of the electromagnetic wave can be expressed as

$\mu = \frac{c}{v} \quad . . . (2)$

Equations (1) and (2) imply that

$$P = \frac{I \cdot \mu}{c}$$

$$= \frac{6 \times 10^8 \times 3}{3 \times 10^8}$$

$$= 6 \text{ N m}^{-2}$$

502. (1)

The electromagnetic spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out with different energies. In the daily life, two commonly known EM waves are the light wave and the radio wave.

The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays.

The wavelengths of different parts of the electromagnetic spectrum are related by the following relation:

$\lambda_X < \lambda_{UV} < \lambda_{IR} < \lambda_{MW}$

503. (4)

Maxwell's four equations describe the electric and magnetic fields arising from distributions of electric charges and currents, and how those fields change in time.

The equations are as follows:

$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0} \quad . . . (1) \oint \vec{B} \cdot d\vec{A} = 0 \quad . . . (2) \oint \vec{E} \cdot d\vec{l} = -\frac{\partial \phi_B}{\partial t} \quad . . . (3) \oint \vec{B} \cdot d\vec{l} = \mu_0 I \quad . . . (4)$

From the above set of equations, it is clear that only the third equation is valid for time varying field.

Hence, this is the correct option.

504. (2)

Out of the three types of radiation, UV rays would be having highest frequency. The maximum kinetic energy is

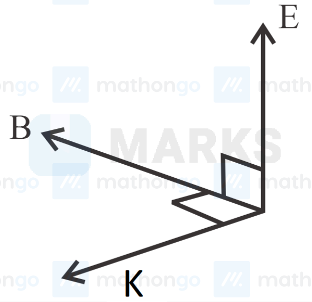
$K_{max} = hf - \phi$

Clearly, the maximum kinetic energy is dependant on the frequency of the incident radiation and the work function of the metal.

From the given spectrums UV rays have the highest energy. Hence, this option is the correct one.

505. (1)

As we know, direction of electromagnetic wave will be in the direction of the vector $\vec{E} \times \vec{B}$.



Magnitude of $B = \frac{E}{c} = \frac{K}{\omega}E$

$\Rightarrow \vec{B} = \frac{1}{\omega}\left(\vec{K} \times \vec{E}\right)$

506. (3)

The relation between magnetic field and electric field is given by,

$c = \frac{E_0}{B_0} \Rightarrow B_0 = \frac{E_0}{c}$

And magnetic intensity is given by,

$H_0 = \frac{B_0}{\mu_0} \Rightarrow H_0 = \frac{E_0}{c\mu_0}$

Also, $\vec{E}$ and $\vec{B}$ are perpendicular to each other.

Therefore,

$\left|H_{y0}\right| = \frac{301.6}{3 \times 10^8 \times 4\pi \times 10^{-7}} = 0.8 \text{ A m}^{-1} \left|H_{x0}\right| = \frac{452.4}{3 \times 10^8 \times 4\pi \times 10^{-7}} = 1.2 \text{ A m}^{-1}$

Hence, C is the answer.

507. (3)

Given, $E = 56.5 \sin\omega\left(\frac{t - x}{c}\right) \text{N C}^{-1}$

Comparing it with the general equation of electromagnetic wave,

$E = E_0 \sin(\omega t - kx)$

We have, $E_0 = 56.5 \text{ N C}^{-1}$

So, the intensity will be $I = \frac{1}{2}\varepsilon_0 E_0^2 c$

$= \frac{1}{2} \times 8.85 \times 10^{-12} \times (56.5)^2 \times 3 \times 10^8$

$= 4.24 \text{ W m}^{-2}$

508. (1) Here, $v = 2 \times 10^8 \text{ m s}^{-1}$ and $\mu_r = 1$

The speed of electromagnetic waves in a medium is given by $v = \frac{1}{\sqrt{\mu\varepsilon}}$ ...(i)

where μ and ε are absolute permeability and absolute permittivity of the medium.

Now, $\mu = \mu_0\mu_r$ and $\varepsilon = \varepsilon_0\varepsilon_r$

Then, we have,

$$v = \frac{1}{\sqrt{\mu_0\mu_r \times \varepsilon_0\varepsilon_r}} = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \times \frac{1}{\sqrt{\mu_r\varepsilon_r}} = \frac{c}{\sqrt{\mu_r\varepsilon_r}}$$

$$or\ \varepsilon_r = \frac{c^2}{v^2\mu_r} = \frac{\left(3 \times 10^8\right)^2}{\left(2 \times 10^8\right)^2} = \frac{9}{4} = 2.25$$

509. (3)

$B = \frac{\mu_0 I}{4\pi y}\left(1 + \sin\theta_1\right) + \frac{\mu_0 I}{4\pi x}\left(1 + \sin\theta_2\right)$

$$B = \frac{\mu_0 I}{4\pi y}\left(1 + \frac{x}{\sqrt{x^2+y^2}}\right) + \frac{\mu_0 I}{4\pi x}\left(1 + \frac{y}{\sqrt{x^2+y^2}}\right)$$

$$B = \frac{\mu_0 I}{4\pi x} + \frac{\mu_0 I}{4\pi y} + \frac{\mu_0 I}{4\pi}\left[\frac{x}{y\sqrt{x^2+y^2}} + \frac{y}{x\sqrt{x^2+y^2}}\right] \Rightarrow B = \frac{\mu_0 I}{4\pi}\left[\frac{1}{x} + \frac{1}{y}\right] + \frac{\mu_0 I}{4\pi}\frac{\sqrt{x^2+y^2}}{xy} = \frac{\mu_0 I}{4\pi}\left[\frac{x+y+\sqrt{x^2+y^2}}{xy}\right]$$

510. (500) Energy density $= \frac{1}{2}\varepsilon_0 E^2$

Energy $= \frac{1}{2}\varepsilon_0 E^2 \times$ volume

$5.5 \times 10^{-12} = \frac{1}{2} \times 8.8 \times 10^{-12} \times 50^2 \times \text{V}$

$V = 500 \text{ cm}^3$

511. (4) Reflected wave will have direction opposite to incident wave.

512. (4) (a) Source of microwave frequency is magnetron.

(b) Source of infrared frequency is vibration of atoms and molecules.

(c) Source of Gamma rays is radioactive decay of nucleus

(d) Source of X-rays inner shell electron transition.

513. (4)

According to the EM Wave Spectrum, wavelength range for,

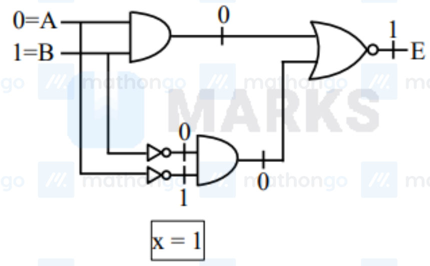
(a) Gamma-rays is fm.

(b) X-rays is A^0

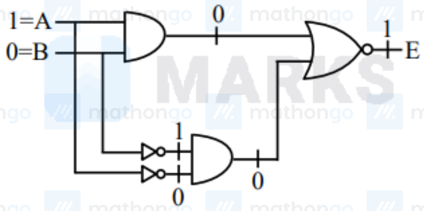
(c) Microwave is in mm

(d) A. M. radio wave is in m

514. **For x**

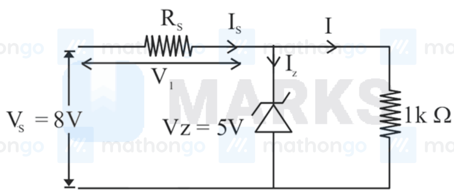


For y



(2)

515. (1)



Potential drop across R_s,

$V_1 = 8 - 5 = 3$ V

Current through the load resistor

$I = \frac{5}{1 \times 10^3} = 5$ mA

Maximum current through Zener diode

$I_{Z,\ max} = \frac{10}{5} = 2$ mA

And minimum current through Zener diode

$I_{Z,\ min} = 0$

$\therefore\ I_{S,\ max} = 5 + 2 = 7mA$

And $R_{S,\ min} = \frac{V_1}{I_{S,\ max}} = \frac{3}{7}k\Omega$

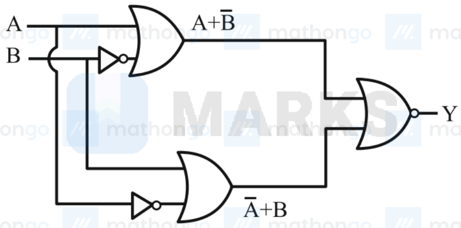
Similarly,

$I_{S,\ min} = 5$ mA

And $R_{S,\ max} = \frac{V_1}{I_{S,\ min}} = \frac{3}{5}\ k\Omega$

$\therefore\ \frac{3}{7}k\Omega < R_s < \frac{3}{5}k\Omega$

516. (3)



If $A = 0;\ \bar{A} = 1$

$A = 1;\ \bar{A} = 0$

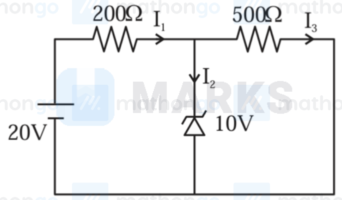
$B = 0;\ \bar{B} = 1$

$B = 1;\ \bar{B} = 0$

Using De Morgan's theorem, we can write

$$Y = \left(A+\bar{B}\right)+\left(\bar{A}+B\right) = \left(A+\bar{B}\right)\cdot\left(\bar{A}+B\right) = \left(\bar{A}\cdot B\right)\cdot\left(A\cdot\bar{B}\right) = 0$$

517. (3)



As Zener is in breakdown region, therefore potential drop across it would be 10 V. Now,

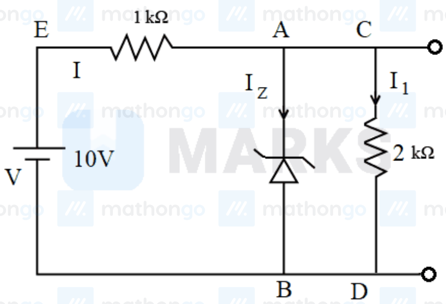
$I_3 = \frac{10}{500} = \frac{1}{50}$ A and

$I_1 = \frac{10}{200} = \frac{1}{20}$ A

Also, $I_2 = I_1 - I_3$

$\Rightarrow I_2 = \left(\frac{1}{20} - \frac{1}{50}\right) = \left(\frac{3}{100}\right)$ A = 30 mA

518. (2)



Given that, $V_z = 3$ V

Let potential at $B = 0$ V

Potential at $E\left(V_E\right) = 10$ V

Now, $V_C = V_A = 3$ V and,

$I_z + I_1 = I \quad \ldots(1)$

The current through 1 kΩ resistor is given by

$I = \frac{10-3}{1000}$ A

$= \frac{7}{1000}$ A

From the diagram, it follows that

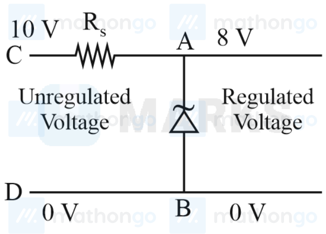
$I_1 = \frac{3}{2000}$ A

Therefore, from equation (1), it follows that

$I_z = \frac{7-1.5}{1000}$ A

$= 5.5$ mA

519. (1)



Power rating of zener diode $= 1.6$ W

From the diagram above,

$V_A - V_B = 8$ V

Power is given by

$P = Vi \Rightarrow i = \frac{1.6 \text{ W}}{8 \text{ V}} = 0.2$ A

Also, $V_C - V_A = 10 \text{ V} - 8 \text{ V} = 2$ V

Thus, using Ohm's law,

$R_s = \frac{2 \text{ V}}{0.2 \text{ A}} = 10\ \Omega$

520. (1)

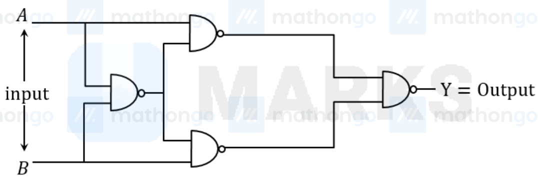
Zener diode is a special type of p-n junction diode.

In a p-n junction diode, the majority carriers in p-side are the holes and that in n-side are the electrons. When a p-n junction diode is connected in such a way that the p- is connected to the positive terminal and the n-side is connected to the negative terminal of a battery, there is a flow of current through the circuit. This condition is kno as the forward bias condition of the junction.

If the connections are made in the opposite order, there is very less current that can pass through the p-n junction diode. This is called the reverse bias condition.

A Zener diode works in a reverse bias condition. It works in breakdown region of the applied voltage as a voltage regulator. Hence, it can act as simple p-n junction in forward bias

521. (4)



Output using DeMorgan's theorem can be written as,

$Y = ((A \cdot A \cdot B) \cdot (A \cdot B \cdot B)) = (A \cdot A \cdot B) + (A \cdot B \cdot B) = (A \cdot A \cdot B) + (A \cdot B \cdot B) = (A \cdot (A + B)) + ((A + B) \cdot B) = A \cdot A + A \cdot B + A \cdot B + B \cdot B = (A + B) \cdot (A + B)$

Which represents XOR gate.

Therefore, required truth table will be

$$\begin{bmatrix} A & B & Y \\ 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

522. (3)

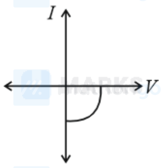
Photodiodes are operated in reverse bias condition. The change in saturation reverse current in a photodiode with reverse bias is directly proportional to the change in li intensity, thus can be precisely measured.

Current in forward bias (for applied voltage $V \geq V_0$) is always greater than current in reverse bias (for $V \leq V_z$) in a p - n junction diode.

Hence, Assertion if false but Reason is true.

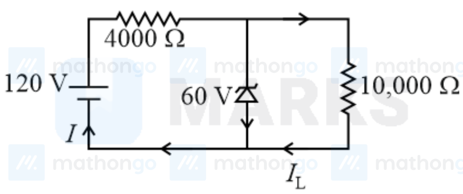
523. (2)

The I - V curve for solar cell is available in the fourth quadrant, i.e. where current is negative, which means that current I is supplied by the solar cell and not drawn by it.



In the given figure, the point where the graph touches the x - axis shows the open circuit voltage while the point where it touches the y - axis shows the short circuit current.

524. (9)



Current through load resistor is $I_L = \frac{60 \text{ V}}{10000 \ \Omega} = 0.006$ A and current through 4000 Ω resistor is $I = \frac{(120-60) \text{ V}}{4000 \ \Omega} = 0.015$ A

Thus, maximum current through Zener diode is $I_Z = I - I_L$

$= 0.015 - 0.006 = 0.009$ A = 9 mA

525. (1)

When both A and B have logical value ‘1’ both diode are reverse bias and current will flow in resistor hence output will be 5 volt i.e. logical value ‘1’.

In all other case conduction will take place, hence output will be zero volt i.e. logical value ‘0’. So truth table is

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

Thus, given circuit is equivalent to an AND gate.

526. (3)

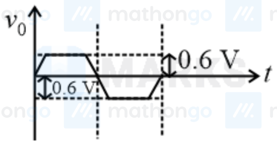
When both of the inputs are given with +10 V that is logical 1, both of the diodes are in OFF condition and hence supply voltage will appear at the base terminal of the transistor which makes it switched ON and supply voltage gets a path to the ground through this transistors. Therefore, it represents NAND gate.

Hence, $Y = A \cdot B$

527. (4)

During the positive half cycle of the input waveform, diode D_1 is forward biased and diode D_2 is reverse biased. Here 0. 6 V appears across the output as the diode is conducting. During negative half cycle the diode D_1 is reverse biased and D_2 is forward biased, so, -0. 6 V appears across the output as the diode is conducting in nega direction. This circuit can be used as a voltage limiter. This circuit will not allow any voltage above 0. 6 Vand below -0. 6 V.

Hence, the output waveform is



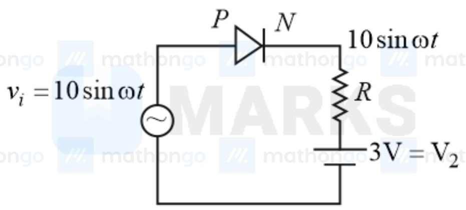
528. (4)

Here diode D_1 is forward biased and diode D_2 is reverse biased.

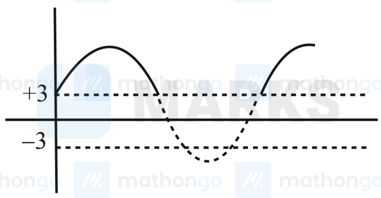
So, no current will flow through diode D_2 resistor.

Current through the resistor of 40 Ω is $i = \frac{1-0.6}{60+40} = \frac{0.4}{100} = 4$ mA

529. (1)

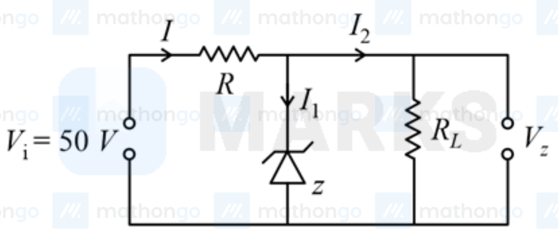


Current will flow from the diode when diode is in forward biased.



Thus $\Delta V = (10\sin\omega t - 3)V$ and ΔV will be 'zero', when diode is reverse biased.

530. (500)



Voltage across, $R_L = 5$ V

$\Rightarrow i_2 = \frac{5}{R_L}$

Also, voltage across $R = 50 - 5 = 45$ volt

$v = iR \Rightarrow R = \frac{v}{i} = \frac{45}{i_i + i_2}$

$R = \frac{45}{90mA + \frac{5}{R_L}}$

Current in zener diode is maximum when $R_L \to \infty$

$\left(i_2 \to 0 \text{ and } i_i = i\right)$

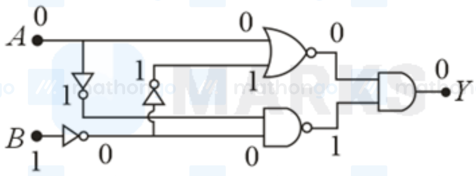
So $R = \frac{45}{90\ \text{mA}} = 500\ \Omega$

531. (25)

$R_d = \frac{dV}{di} = \frac{1}{\left(\frac{di}{dv}\right)} = \frac{1}{\left(\frac{5 \cdot 1 \times 10^{-3}}{0.75 - 0.65}\right)}$

$\frac{100}{4} = 25\ \Omega$

532.



(0)

533. (4)

In n-type semiconductor pentavalent impurity is added. Each pentavalent impurity donates a free electron. So the Fermi-level of n -type semiconductor will go upward. & In p-type semiconductor trivalent impurity is added. Each trivalent impurity creates a hole in the valence band. So the Fermi-level of p-type semiconductor wi downward.

534. (3)

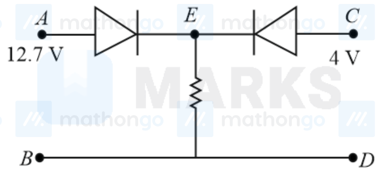
Behaves like a NOT gate so boolean equation will be

$y = \overline{\bar{A} + \bar{B} + \bar{C}}$

$y = A \cdot B \cdot C$

Whole arrangement behaves like an AND gate

535.



(12)

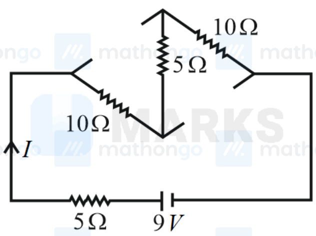
Let $V_B = 0$

Right diode is reversed baised and left diode is forward biased

$\therefore V_A = 12.7 - 0.7$

$= 12$ Volt

536. (3) Both the diodes are in reverse biased.



$I = \frac{9}{30} = \frac{3}{10}\text{A} = 0.3\ \text{A}$

537. (40) $i = \frac{(12-8)}{(200+200)}\text{A} = \frac{4}{400} = 10^{-2}\ \text{A}$

Power loss in each diode $= (4)\left(10^{-2}\right)$ W $= 40$ mW

538. (1) Given 9MSD = 10VSD

mass = 8.635 g

LC = 1MSD − 1VSD

$LC = 1MSD - \frac{9}{10}MSD$

$LC = \frac{1}{10}MSD$

LC = 0.01 cm

Reading of diameter = MSR + LC × VSR

= 2 cm + (0.01) × (2)

= 2.02 cm

Volume of sphere $= \frac{4}{3}\pi\left(\frac{d}{2}\right)^3 = \frac{4}{3}\pi\left(\frac{2.02}{2}\right)^3$

= 4.32 cm^3

Density $= \frac{\text{mass}}{\text{volume}} = \frac{8.635}{4.32} = 1.998 \sim 2.00$ g

SECTION -B

539. (3)

Least count $= \frac{1}{100}$ mm = 0.01 mm

zero error = + 0.05 mm

Reading = 4 × 1 mm + 60 × 0.01 mm − 0.05 mm

= 4.55 mm

540. (3)

Time period of a simple pendulum is given by, $T = 2\pi\left(\frac{l}{g}\right)$.

$\Rightarrow g = \frac{4\pi^2 l}{T^2}$

Therefore, fractional error will be

$\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$

$= \frac{0.2}{20} + 2\left(\frac{1}{40}\right)$

$= \frac{1.2}{20}$

Percentage change $= \frac{1.2}{20} \times 100 = 6\%$

541. (2)

If a positive zero error exists in a vernier callipers, it means that the instrument shows a reading greater than zero even when the jaws are closed and there is no object b measured. In such a case, when actual measurements are taken, the readings will be more than the actual values.

The zero error in Vernier callipers can indeed occur due to manufacturing defects or rough handling. Manufacturing defects may lead to misalignments or inaccuracies the instrument, while rough handling can result in damage that affects the calibration of the callipers.

Hence, both (A) and (R) are correct, but (R) is not the correct explanation of (A)

542. (2)

The least count is $LC = 0.1$ mm

Zero error $(ZE) = 6 \times LC = 6 \times 0.1$ mm $= 0.6$ mm

The total reading is $TR = MSR + (VSR \times LC) - ZE \Rightarrow TR = 32$ mm $+ (0.1 \times 4)$ mm $- 0.6$ mm $\Rightarrow TR = 31.8$ mm $= 3.18$ cm

543. (220)

Least count of screw gauge is $= \frac{\text{Pitch}}{\text{No. of circular divisions}}$

$= \frac{0.5 \text{ mm}}{100}$

Least count, $LC = 5 \times 10^{-3}$ mm

The zero of circular scale lies 6 divisions below the line of graduation. So, zero error is positive.

Positive zero error $= MSR + CSR(LC)$

$= 0 \text{ mm} + 6\left(5 \times 10^{-3} \text{ mm}\right)$

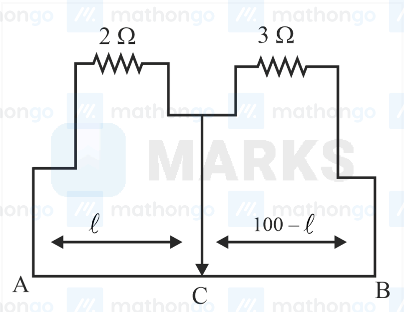
Diameter of wire, $d = MSR + CSR\ (LC)$– Positive zero error

$= 4 \times 0.5 \text{ mm} + 46\left(5 \times 10^{-3}\right) - 6\left(5 \times 10^{-3}\right)$ mm

$= 2 \text{ mm} + 40 \times 5 \times 10^{-3} \text{ mm} = 2.2$ mm

Hence, diameter of wire is 220×10^{-2} mm.

544. (2)

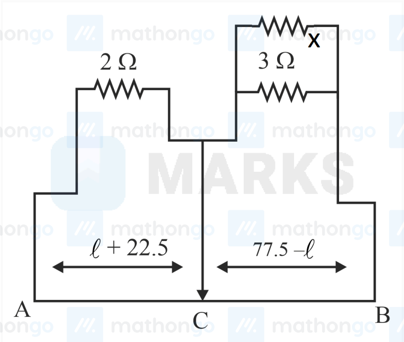


Case 1: No shunt is added

The initial balancing length l of the bridge is,

$\frac{2}{3} = \frac{l}{100 - l}$

$\Rightarrow 200 - 2l = 3l \Rightarrow l = 40$ cm



Case 2: When shunt is added

The new balancing length is, $l_1 = 22.5 + 40 = 62.5$ cm

So, $\frac{62.5}{37.5} = \frac{2}{\left(\frac{3X}{3+X}\right)}$

$\Rightarrow X = 2.$

545. (3)

From the data given in the question,

Pitch of the screw gauge $= 0.5$ mm.

Total divisions on the circular scalen $= 50$.

Therefore, the least count of the screw gauge is LC $= \frac{\text{pitch}}{\text{n}} = \frac{0.5}{50} = 0.01$ mm

Now, MSR $= 2.5$ mm, CSR $= 45$

Diameter reading $=$ MSR + LC × CSR - zero error

$\Rightarrow d = 2.5 + 0.45 - (-0.03)$

$\Rightarrow d = 2.98$ mm

546. (2)

Least Count (L.C) $= \frac{P}{N} = \frac{0.5 \text{ mm}}{50} = 0.01$ mm

Length of wire $= 6.8$ cm

Diameter of wire $= 1.5$ mm $+ 7 \times$ L.C

$= 1.5$ mm $+ 7 \times .01 = 1.57$ mm

Curved surface area $= \pi Dl$

$= 3.14 \times 6.8 \times 1.57 \times 10^{-1}$ cm^2

$= 3.352$ cm$^2 = 3.4$ cm^2

547. (3)

Given that 1 M. S. D = 1 mm

And 9 M. S. D = 10 V. S. D

$\Rightarrow$ 1 V. S. D = 0. 9M. S. D = 0. 9 mm

L.C of vernier caliper $= 1 - 0.9 = 0.1$ mm $= 0.01$ cm

Zero error $= (10 - 4) \times 0.1$ mm $= 0.6$ mm as at zero the, the zero of the vernier is shifted towards left zero error is negative. Therefore, zero error $= -0.6$ mm.

Reading $= M.S.R + V.S.R -$ Zero error
Reading $= 3 + 6 \times 0.01 - [-0.06]$
Reading $= 3 + 0.06 + 0.06$
Reading $= 3.12$ cm
The closest option is 3.10 cm

548. (13)
For A,
Reading $= MSR + CSR +$ Error
$0.322 = 0.300 + CSR + 5 \times LC$
$0.322 = 0.300 + CSR + 0.005$
$CSR = 0.017$
For B,
Reading $= MSR + CSR +$ Error
$0.322 = 0.200 + CSR + 0.092$
$CSR = 0.030$
Difference $= 0.030 - 0.017 = 0.013$ cm
Division on circular scale $= \frac{0.013}{0.001} = 13$

549. (2)

550. (4)
Significant rule says that reading should has same significant figure as that of reading given.
$5.5375 \rightarrow$ rounded to $\rightarrow 5.54$.
$0.07395 \rightarrow$ rounded to $\rightarrow 0.07$
therefore, $(5.54 \pm 0.07)\ mm$