Physics

JEE Advanced Revision Booklet

A Comprehensive Revision Program

Contents

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IIT JEE | MEDICAL | FOUNDATION

JEE Advanced Revision Booklet	Units Dimensions and Vectors

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A small steel ball of radius r is allowed to fall under gravity through a column of a viscous liquid of coefficient of viscosity η. After some time the velocity of the ball attains a constant value known as terminal velocity v_T. The terminal velocity depends on (i) the mass of the ball m, (ii) η, (iii) r and (iv) acceleration due to gravity g, Which of the following relations is dimensionally correct?

(A) $v_T \propto \frac{mg}{\eta r}$ **(B)** $v_T \propto \frac{\eta r}{mg}$ **(C)** $v_T \propto \eta rmg$ **(D)** $v_T \propto \frac{mgr}{\eta}$

2. If P represents radiation pressure, c represents speed of light and Q represents radiation energy striking a unit area per second, then non-zero integers x, y and z such that $P^x Q^y C^z$ is dimensionless are

(A) $x = 1, y = 1, z = -1$ **(B)** $x = 1, y = -1, z = 1$
(C) $x = -1, y = 1, z = 1$ **(D)** $x = 1, y = 1, z = 1$

3. The mass and volume of body are 4.237 g and $2.5\ cm^3$, respectively. The density of material of the body in correct significant figures is

(A) $1.6048\ g\ cm^{-3}$ **(B)** $1.69\ g\ cm^{-3}$ **(C)** $1.7\ g\ cm^{-3}$ **(D)** $1.695\ g\ cm^{-3}$

4. The numbers 2.745 and 2.735 on rounding off to 3 significant figures will give

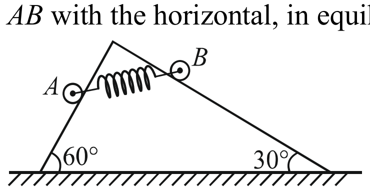
(A) 2.75 and 2.74 **(B)** 2.74 and 2.73 **(C)** 2.75 and 2.73 **(D)** 2.74 and 2.74

5. In the context of accuracy of measurement and significant figures in expressing results of experiment, which of the following is/are correct?

(1) Out of the two measurements 50.14 cm and 0.00025 ampere, the first one has greater accuracy
(2) If one travels 478 km by rail and 397 m by road, the total distance travelled is 478 km.

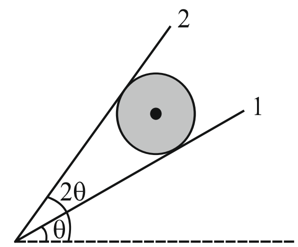
(A) Only (1) is correct **(B)** Only (2) is correct
(C) Both are correct **(D)** None of them is correct

6. Two uniform solid cylinders A and B each of mass $1\ kg$ are connected by a spring of constant $200\ N\ m^{-1}$ at their axels and are placed on a fixed wedge as shown in the figure. There is no friction between cylinders and wedge. The angle made by the line AB with the horizontal, in equilibrium, is



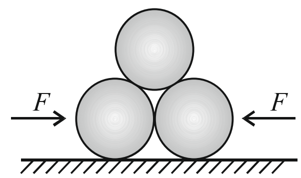
(A) 0° **(B)** 15° **(C)** 30° **(D)** None of these

7. A sphere of mass m is kept between two inclined walls, as shown in the figure. If the coefficient of friction between each wall and the sphere is zero, then the ratio of normal reaction (N_1 / N_2) offered by the walls 1 and 2 on the sphere will be



(A) $\tan\theta$ **(B)** $\tan 2\theta$ **(C)** $2\cos\theta$ **(D)** $\cos 2\theta$

8. Two smooth cylindrical bars weighing $W\ N$ each lied next to each other in contact. A similar third bar is placed over the two bars as shown in figure. Neglecting friction, the minimum horizontal force on each lower bar necessary to keep them together is:



(A) $\frac{W}{2}$ **(B)** EW **(C)** $\frac{W}{\sqrt{3}}$ **(D)** $\frac{W}{2\sqrt{3}}$

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

9. If $I = a\left(1 - e^{-\frac{t}{\lambda}}\right)$, then (where I is electric current and t is time)

(A) the SI unit of a is ampere **(B)** the SI unit of λ is second

(C) $e^{-\frac{t}{\lambda}}$ is unitless **(D)** the SI unit of $a\ e^{-\frac{t}{\lambda}}$ is ampere

10. Choose correct statement(s).

(A) Any physical quantity may have than one unit

(B) Any physical quantity can have more than one dimension formula

(C) More than one physical quantities may have same dimension

(D) We can add and subtract only those expression having same dimension

11. In a system of units, the unit of velocity be $5ms^{-1}$, the unit of acceleration be $20ms^{-2}$ and the unit of force be 10 N then select the correct alternative (s).

(A) The unit of mass is $\frac{1}{2}kg$ **(B)** The unit of length is $\frac{5}{4}m$

(C) The unit of time is $\frac{1}{4}s$ **(D)** The unit of pressure is $\frac{32}{5}Pa$

12. In a new system of units, the unit of mass is 1000 *kg* (1 metric ton), unit of length is 1000 *m* (1 *km*) and unit of time is 3600 *s* (1 hr). Select correct statement(s).

(A) The numerical value of 500 *m* in the new system is 0.5

(B) The numerical value of 7200 *s* in this new system

(C) The numerical value of 1/36 J in this new system is 3.6×10^{-4}

(D) The numerical value of 1/36 N in this new system is 0.36

13. Use dimensional analysis to see which of the following expression is/are NOT allowed if p is a pressure, t is a time, m is a mass, r is a distance, v is a velocity and T is a temperature?

(A) $\log\left(\frac{pt}{mr}\right)$ **(B)** $\log\left(\frac{prt^2}{m}\right)$ **(C)** $\log\left(\frac{pr^2}{mt^2}\right)$ **(D)** $\log\left(\frac{pr}{mtT}\right)$

14. In damped simple harmonic motion, displacement $x = a_0 e^{-\frac{bt}{2m}} \sin(\omega t + \alpha)$, where t is in second. Choose the correct option(s).

(A) Dimensions of $\frac{m}{b}$ are same as t **(B)** Dimensions of $a_0\omega$ are $[LT^{-1}]$

(C) b is dimensionless constant **(D)** α is dimensionless and unitless

15. A wave is propagating along x-axis in a medium, so that displacement y of particle at any position x, at any time t is given by

$$y = \frac{a}{t^2} e^{-\left[\frac{t}{b} - \frac{x}{c}\right]}$$

Where a, b and c are constants. Choose the correct option(s).

(A) dimension of b is $[T]$ **(B)** dimension of a is $[LT^2]$

(C) dimension of c is $[L]$ **(D)** $e^{-\left(\frac{t}{b} - \frac{x}{c}\right)}$ is dimensionless

16. In the following table some unknown physical quantities and their dimensions are given:

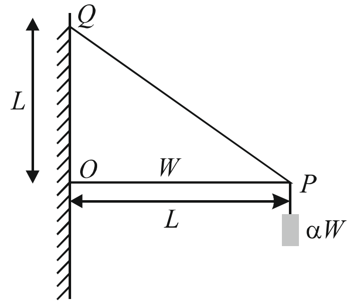
Physical quantity	Dimensional formula
X	$M^0L^0T^1$
Y	$M^0L^1T^{-1}$
Z	$M^1L^2T^{-1}$
W	$M^1L^1T^{-2}$

Tick the correct possible relation(s).

(A) $X = 2\pi\sqrt{\frac{Z}{WY}}$ **(B)** $\tan\left(\frac{X'YW}{Z}\right) = \frac{20}{3}\pi$

(C) $\exp\left(-\frac{Z}{YWX^2}\right) = \pi^2$ **(D)** $X = \sqrt{\frac{Z}{WY}}$

17. One end of a horizontal uniform beam of weight W and length L is hinged on a vertical wall at point O and its other end is supported by a light inextensible rope. The other end of the rope is fixed at point Q, at a height L above the hinge at point O. A block of weight αW is attached at the point P of the beam, as shown in the figure $(2\sqrt{2})W$. Which of the following statement(s) is(are) correct?



(A) The vertical component of reaction force at O does not depend on α

(B) The horizontal component of reaction force at O is equal to W for $\alpha = 0.5$

(C) The tension in the rope is $2W$ for $\alpha = 0.5$

(D) The rope breaks if $\alpha > 1.5$.

Paragraph for Questions 18 – 19

According to Newton's law of gravitation, force between two particles of masses m_1 and m_2 separated by distance r is given by $F = \frac{Gm_1m_2}{r^2}$, here G is universal gravitation constant.

Now suppose we take density (ρ), distance (L) and universal gravitation constant (G) as fundamental physical quantities then

18. Dimensional formula of pressure is

(A) ρ^2L^2G **(B)** ρL^2G **(C)** ρLG **(D)** cannot be determined

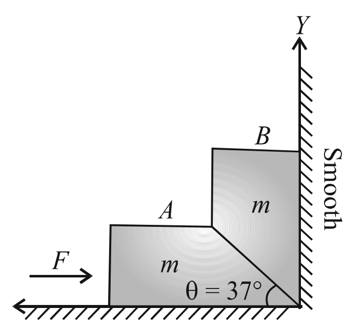
19. Dimensional formula of velocity is

(A) $L\sqrt{\frac{G}{\rho}}$ **(B)** $L\sqrt{G\rho}$ **(C)** $L\sqrt{\frac{\rho}{G}}$ **(D)** $\sqrt{\frac{LG}{\rho}}$

Paragraph for Questions 20 – 21

Two smooth blocks are placed at a smooth corner as shown in figure. Both the blocks are having mass m. We apply a force F on the small block m. Block A presses block B in the normal direction, due to which pressing force on vertical wall will increase, and pressing force on the horizontal wall decreases, as we increases $F(\theta = 37°$ with horizontal).

As soon as the pressing force on the horizontal wall by lock B becomes zero, it will lose contact with ground. If the value of F further increases, block B will accelerate in the upward direction and simultaneously block A will move towards right



20. What is the minimum value of F to lift block B form ground?

(A) $\frac{25}{12}mg$ **(B)** $\frac{5}{3}mg$ **(C)** $\frac{3}{4}mg$ **(D)** $\frac{4}{3}mg$

21. If both the blocks are stationary, the force exerted by ground on block A is

(A) $mg+\frac{3F}{4}$ **(B)** $mg-\frac{3F}{4}$ **(C)** $mg+\frac{4F}{3}$ **(D)** $mg-\frac{4F}{3}$

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

22. In a new system reter, recond, rilogram and roule are units of length, time, mass and energy respectively. In this system velocity of light $(3\times10^{8}\,ms^{-1})$, acceleration due to gravity $(10\,ms^{-2})$ and standard atmospheric pressure $(10^{5}\,Nm^{-2})$ are fundamental units.

Column I (Physical quantity in MKS system)		Column II (Numerical value in new system)	
(A)	1800 m	**(P)**	10^{-4}
(B)	3000 s	**(Q)**	10^{-32}
(C)	8100 kg	**(R)**	10^{-13}
(D)	7290 joule	**(S)**	2×10^{-13}
		(T)	10^{-50}

23. Match the following columns and mark the correct options from the codes given below.

Column I (Physical quantity in MKS system)		Column II (Numerical value in new system)	
a	$\frac{1}{3}$	**p.**	1
b	$\frac{1.00}{3.0}$	**q.**	0.3
c	2 – 0.3	**r.**	0.33
d	2 – 0.3	**s.**	2

Codes:

	a	b	c	d		a	b	c	d
(A)	q	r	s	p	**(B)**	q, r	q,r	p,s	p,s
(C)	p	q	r	s	**(D)**	r	p	s	p

SUBJECTIVE INTEGER TYPE

24. Length of a year on planet is the duration in which it completes one revolution around the sun. Assume path of the planet known as orbit to be circular with sun at the centre. The length T of a year of a planet orbiting around the sun in circular orbit depends on universal gravitational constant G, mass m_s of the sun and radius r of the orbit. If $T\propto G^{a}m_{s}^{b}r^{c}$, find value of $a+b+c+2\,c$.

25. In a new system of units, net force applied on a block of mass 10 kg moving with acceleration $10\,\text{m/s}^2$ is given as 100 unit of force. When the same block is moving at a speed of 20 m/s its kinetic energy is 20 unit of energy. A liquid has a surface tension of 10 SI units. Its surface tension in new system is 10^{n}. Find the value of n. (Dimensional formula of surface tension is $ML^{0}T^{-2}$).

26. To find the distance d over which a signal can be seen clearly in foggy condition, a railway engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer finds that d is proportional to $S^{1/n}$. Find the value of n.

27. In relativistic energy-momentum relation, $E^n = p^2c^2 + m_0^2c^4$. Find the value of n. (here E = energy, p = momentum, c = speed of light m_0 = rest mass of particle.)

28. In a new system of unts a tower of height 76 m is represented by number 7.6, sugar sack of mass 100 kg is represented by number 10 and 1 hour time is represented by number 360. If a force is measured to be 4 N, then find the number representing force in this new system.

29. A student of TK_3 batch forget Newton's formula for speed of sound but he remembers that there were speed (v), pressure (p) and density (d) in the formula. He then started using dimensional analysis to find the actual relation by assuming $v \propto p^x d^y$. Find the value of $x - y$.

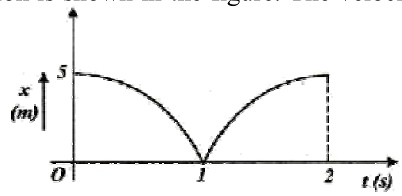
30. The distance moved by a particle in time (t) from centre of ring under the influence of a force is given by $x = a \sin \omega t$ where a and ω are constant. If ω is found to depend on the radius of the ring (r), its mass (m) and universal gravitation constant (G), by using dimensional analysis to write an expression for ω in terms of r, m and G and if $\omega = G^a m^b r^c$ then write the value of $\dfrac{1}{|a+b+c|}$.

JEE Advanced Revision Booklet	Kinematics of a Particle & Motion in Two Dimension

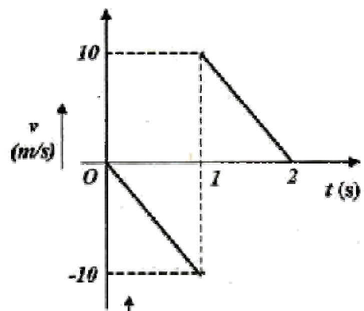
SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

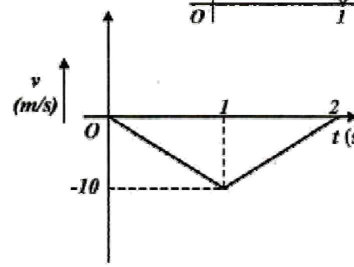
1. The displacement-time graph of a moving particle with constant acceleration is shown in the figure. The velocity-time graph is given by



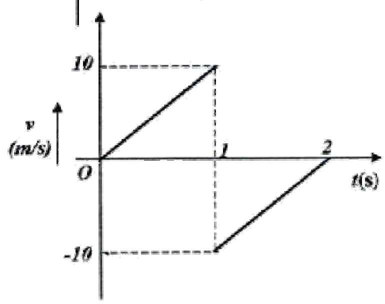
(A)



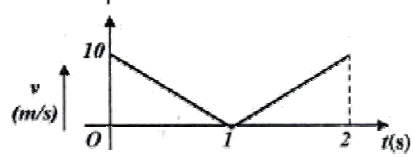
(B)



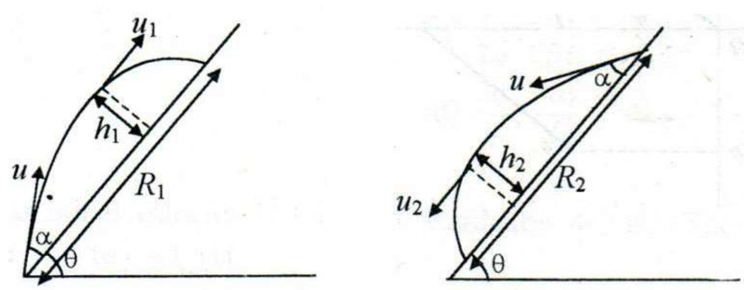
(C)



(D)



2. Two balls are thrown from an inclined plane at angle of projection α with the plane, one up the plane while other down the inclined plane (as shown in figure). In the figure u_1 and u_2 are the speeds when the line of motion of the particle is parallel to the inclined plane and h_1 and h_2 are maximum displacements perpendicular to inclined plane respectively.



(i) $h_1 = h_2 = \dfrac{u^2 \sin^2 \alpha}{2g\cos\theta}$ **(ii)** $T_1 = T_2 = \dfrac{2u\sin\alpha}{g\cos\theta} = T$

(iii) $R_1 = R_2 = g\sin\theta . T^2$ **(iv)** $u_1 = u_2$

The correct choice is :

(A) All are true **(B)** Statements (i) and (ii) are true

(C) Statements (i), (ii) and (iii) are true **(D)** Statements (i), (ii) and (iv) are true

3. A particle is thrown with an initial velocity v_0 at an angle α to the horizontal. The ratio of radius of curvature at the highest point of its path to the maximum height is :

(A) $\frac{1}{2}\cot\alpha$ **(B)** $2\cot^2\alpha$ **(C)** $2\cot\alpha$ **(D)** $\frac{1}{2}\cot^2\alpha$

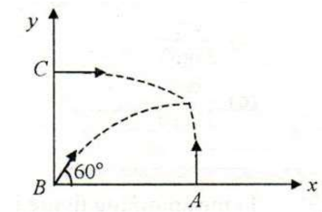
4. The distance between two moving cars A and B at a particular time is *d*. Their relative velocity is V with the component along AB being u and perpendicular to AB being *v*. The time that elapses before they arrive at their nearest distance is :

(A) $\frac{du}{V^2}$ **(B)** $\frac{dv}{V^2}$ **(C)** $\frac{d(u+v)}{V^2}$ **(D)** $\frac{dV}{(u+v)^2}$

5. Two particles positioned at A(5, 3) and B(7, 3) are moving with constant velocity $2\hat{i}+3\hat{j}$ and $x\hat{i}+y\hat{j}$ respectively. After 2*s* they collide, then the values of *x* and *y* are respectively

(A) 2, 2 **(B)** 1, 3 **(C)** 3, 2 **(D)** 1, 1

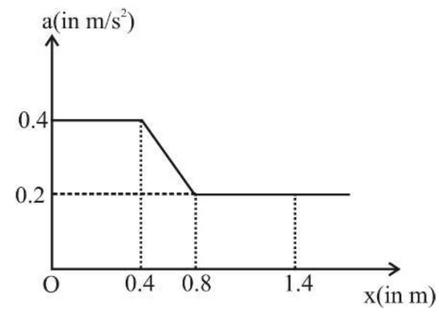
6. Three particles A, B and C are projected with initial velocities v_A, v_B and v_C (in vertical plane) as shown in figure. The particles collide at highest point of A. Then $v_A : v_B : v_C$ is :



(A) $1:2:\sqrt{3}$ **(B)** $\sqrt{3}:2:1$

(C) $\sqrt{3}:1:2$ **(D)** Data insufficient

7. The acceleration of a particle which moves along the positive *x*-axis varies with its position as shown. If the velocity of the particle is 0.8 m/s at *x* = 0, the velocity of the particle at *x* = 1.4 is : (in m/s)



(A) 1.6

(B) 1.2

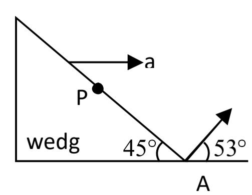
(C) 1.4

(D) None of these

8. A ball is thrown from a point on ground at some angle of projection. At the same time a bird starts from a point directly above this point of projection at a height h horizontally with speed u. Given that in its flight ball just touches the bird at one point. Find the distance on ground where ball strikes

(A) $2u\sqrt{\frac{h}{g}}$ **(B)** $u\sqrt{\frac{2h}{g}}$ **(C)** $2u\sqrt{\frac{2h}{g}}$ **(D)** $u\sqrt{\frac{h}{g}}$

9. A particle is projected from point A at an angle of $53°$ with horizontal. At the same time wedge starts from rest and moves with constant acceleration a as shown. The value of a for which the particle strikes the plane perpendicular to it at point P is : $\left(tan\,53° = \frac{4}{3}\right)\left(g = 10\ m/s^2\right)$



(A) 10 m/s^2 **(B)** 100 m/s^2

(C) 26/3 m/s^2 **(D)** 140 m/s^2

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

10. A ball of mass m is projected from the ground with an initial velocity u making an angle θ with the horizontal. Then choose the correct statement(s).

(A) the change in velocity between the point of projection and the highest point is u sin $\theta\hat{j}$ (downward)

(B) the average velocity averaged over the time of flight is $u\cos\theta\hat{i}$ (horizontal)

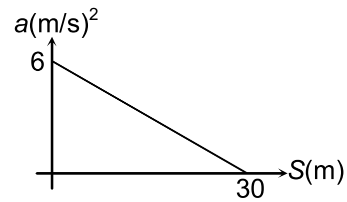
(C) the change in velocity in the complete projectile motion is $-2u\sin\theta\hat{j}$

(D) the rate at which momentum of the ball is changing is constant

11. A particle has initial velocity 10 m/s. It moves due to constant retarding force along the line of velocity which produces a retardation of 5 m/s^2. Then

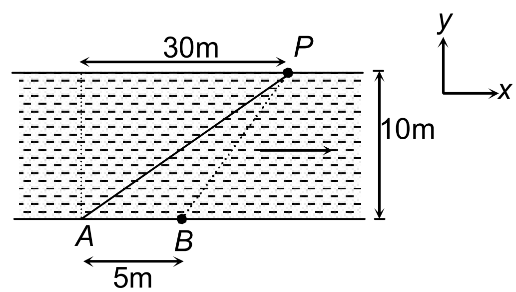
(A) the maximum displacement in the direction of initial velocity is 10 m
(B) the distance travelled in first 3 seconds is 7.5 m
(C) the distance travelled in first 3 seconds is 12.5 m
(D) the distance travelled in first 3 seconds is 17.5 m

12. A train starts from rest at $S = 0$ and is subjected to acceleration as shown :



(A) Change in velocity at the end of 10 m displacement is 50 m/s.
(B) Velocity of the train for $S = 10$ m is 10 m/s.
(C) The maximum velocity attained by train is not greater than 14 m/s
(D) The maximum velocity of the train is between 15 m/s and 16 m/s.

13. Two swimmers A and B start swimming from different positions on the same bank as shown in figure. The swimmer A swims at angle 90^0 with respect to the river to reach point P. He takes 120 seconds to cross the river of width 10m. The swimmer B also takes the same time to reach the point P

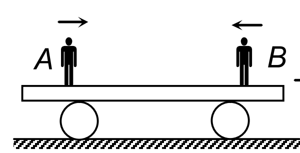


(A) Velocity of A with respect to river is 1/6 m/s
(B) River flow velocity is 1/4 m/s
(C) Velocity of B along y-axis with respect to earth is 1/3 m/s
(D) Velocity of B along x-axis with respect to earth is 5/24 m/s

14. A rocket is fired vertically up from the ground with a resultant acceleration of 10 m/s^2 upward. The fuel is finished in 1 minute and it continuous to move up ($g = 10$ m/s^2)

(A) The maximum height reached by rocket from ground is 18 km.
(B) The maximum height reached by rocket from ground is 36 km.
(C) The time from initial in which rocket again at ground is 240 s.
(D) The time from initial in which rocket again at ground is $(120+60\sqrt{2})$s.

15. In a situation, a board is moving with a velocity v with respect to earth, while a man A is running with a velocity $2v$ with respect to earth and the man B is running with a velocity $-2v$ with respect to earth. If both men are running from the opposite ends of the board at the same time, as shown. Length of the board is L. If they meet after time T, then :



(A) Value of T is $L/4v$ **(B)** Value of T is $L/2v$
(C) Displacement of man B with respect to board in time T is $3L/4$
(D) Displacement of man A with respect to board in time T is $L/4$

16. A jeep runs around a curve of radius 0.3 km at a constant speed of 60 ms^{-1}. The jeep covers a curve of 60^0 arc.

(A) Resultant change in velocity of jeep is 60 ms^{-1}
(B) Instantaneous acceleration of jeep is 12 ms^{-1}
(C) Average acceleration of jeep is 11.5 ms^{-1}
(D) Instantaneous and average acceleration are same in this case

17. Take the z-axis as vertical and xy plane as horizontal. A particle A is projected with speed of $4\sqrt{2}$ m/s at an angle 45^0 to the horizontal in the xz. Particle B is also projected at same instant but with speed 5 m/s at an angle $\tan^{-1}(4/3)$ with horizontal in yz plane, then which of the following statement/s is/are correct? ($g = 10$ m/s^2)

(A) Magnitude of relative velocity of A with respect to B is 5 m/s during motion
(B) Particle A and B again hit the ground at the same instant
(C) The separation between A and B when they hit the ground is 4 m
(D) The path of A with respect to B is straight line

18. Two particles A and B are projected from the same point with the same velocity of projection but at different angles α and β of projection respectively, such that the maximum height of A is two-third of the horizontal range of B. Then which of the following relations is(are) incorrect?

(A) $3(1-\cos 2\alpha) = 8\sin 2\beta$ **(B)** Range of A = maximum height of B

(C) Maximum value of β is $\frac{1}{2}\sin^{-1}\frac{3}{4}$ **(D)** Maximum horizontal range of $A = \frac{u^2}{g}$

19. In a projectile motion let v_x and v_y are the horizontal and vertical components of velocity at any time *t* and *x* and *y* are displacements along horizontal and vertical from the point of projection at any time *t*. Then

(A) $v_y - t$ graph is a straight line with negative slope and positive intercept

(B) $x - t$ graph is a straight line passing through origin

(C) $y - t$ graph is a straight line passing through origin

(D) $v_x - t$ graph is a straight line

20. Two particle *P* and *Q* move in a straight line *AB* towards each other. *P* starts from *A* with velocity u_1 and an acceleration a_1. *Q* starts from *B* with velocity u_2 and acceleration a_2. They pass each other at the midpoint of *AB* and arrive at the other ends of *AB* with equal velocities.

(A) They meet at midpoint at time $t = \frac{2(u_2 - u_1)}{(a_1 - a_2)}$

(B) The length of path specified *i.e.*, *AB* is $1 = \frac{4(u_2 - u_1)(a_1u_2 - a_2u_1)}{(a_1 - a_2)^2}$

(C) They reach the other ends of *AB* with equal velocities if $(u_2 + u_1)(a_1 - a_2) = 8(a_1u_2 - a_2u_2)$

(D) They reach the other ends of *AB* with equal velocities if $(u_2 - u_1)(a_1 + a_2) = 8(a_2u_1 - a_1u_2)$

21. Three particles *A*, *B* and *C* and situated at the vertices of an equilateral triangle *ABC* of side of length *l* at time *t* = 0. Each of the particles moves with constant speed *u*. A always has its velocity along *AB*, *B* along *BC* and *C* along *CA*.

(A) The time after which they meet is $\frac{2l}{3u}$

(B) Total distance travelled by each particle before they meet is $\frac{2l}{3}$

(C) Average velocity during the motion is $\frac{\sqrt{3}u}{2}$

(D) Relative velocity of approach between any two particles is $\frac{3u}{2}$

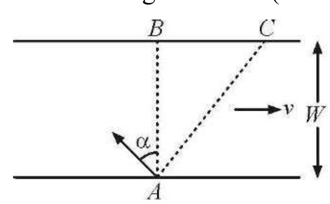
22. A motor boat is to reach at a point 30° upstream on other side of a river flowing with velocity 5 *m/s*. Velocity of motor boat with respect to water is $5\sqrt{3}$ *m*/sec. The driver should steer the boat at an angle of

(A) 30° up w.r.t. the line of destination from the starting point

(B) 60° up w.r.t. normal to the bank **(C)** 150° w.r.t. stream direction

(D) None of these

23. A man in a boat crosses a river from point *A*. If he rows perpendicular to the bank her reaches point *C*(*BC* = 120 *cm*) in 10 minutes. If the man heads at a certain angle α to the straight line *AB* (*AB* is perpendicular to the banks) against the current he reaches point *B* in 12.5 minutes.



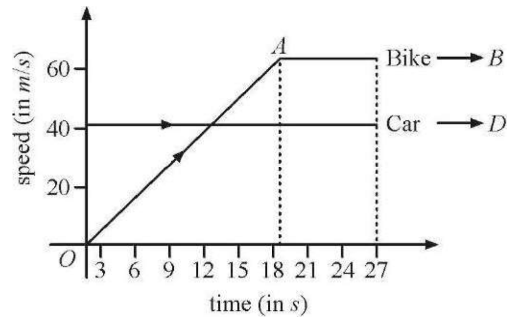
(A) The width of the river is 300 *m*

(B) The width of the river is 200 *m*

(C) The rowing velocity is 20 *m*/min

(D) The rowing velocity is 30 *m*/min

24. At the instant a motor bike starts from rest in a given direction, a car overtakes the motor bike, both moving in the same direction. The speed time graphs for motor bike and car are represented by *OAB* and *CD* respectively. Then



(A) At $t = 18\ s$ the motor bike and car are 180 m apart
(B) At $t = 18\ s$ the motor bike and car are 720 m apart
(C) The relative distance between motor bike and car reduce to zero at $t = 27\ s$ and both are 1080 m far from origin
(D) The relative distance between motor bike and car always remains same

25. A particle moves with an initial velocity v_0 and retardation αv, where v is velocity at any time t.

(A) The particle will cover a total distance $\frac{v_0}{\alpha}$
(B) The particle will come to rest after time $\frac{1}{\alpha}$
(C) The velocity will continue to move for a long time
(D) The velocity of particle will become $\frac{v_0}{e}$ after time $\frac{1}{\alpha}$

26. The velocity of a particle along a straight line increases according to the linear law $v = v_0 + kx$, where k is a constant. Then

(A) The acceleration of the particle is $k(v_0 + kx)$
(B) The particle takes a time $\frac{1}{k}\log_e\left(\frac{v_1}{v_0}\right)$ to attain a velocity v_1
(C) Velocity varies linearly with displacement with slope of velocity displacement curve equal to k
(D) Data is insufficient to arrive at a conclusion

27. A particle is fired from a point on the ground with speed u making an angle θ with the horizontal. Then

(A) The radius of curvature of the projectile at the highest point is $\frac{u^2\cos^2\theta}{g}$
(B) The radius of curvature of the projectile at the highest point is $\frac{u^2\sin^2\theta}{g}$
(C) At the point of projection magnitude of tangential acceleration is $g\sin\theta$
(D) At the point of projection magnitude of tangential acceleration is $g\cos\theta$

Paragraph for Questions 28 - 29

Raindrops are falling with a velocity $10\sqrt{2}\ m/s$ making an angle of 45° with the vertical . The drops appear to be falling vertically to a man running with constant velocity. The velocity of rain drops change such that the rain drops now appear to be falling vertically with $\sqrt{3}$ times the velocity it appeared earlier to the same person running with same velocity.

28. The magnitude of velocity of man with respect to ground is :

(A) $10\sqrt{2}\ m/s$ **(B)** $10\sqrt{3}\ m/s$ **(C)** $10\ m/s$ **(D)** $20\ m/s$

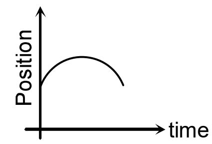
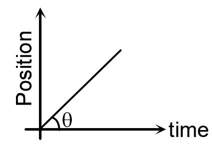
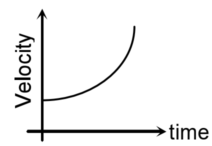
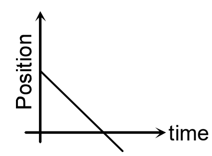
29. After the velocity of rain drops change, the magnitude of velocity of raindrops with respect to ground is :

(A) $20\sqrt{3}\ m/s$ **(B)** $10\ m/s$ **(C)** $10\sqrt{3}\ m/s$ **(D)** $20\ m/s$

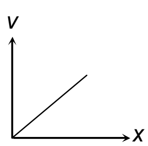
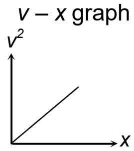
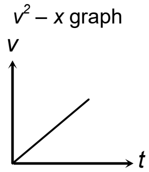
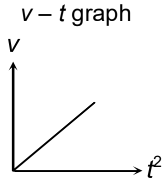
MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

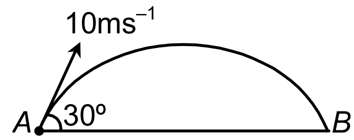
30. **MATCH THE FOLLOWING :**

Column 1		Column 2	
(A)	Particle moving with constant speed	**(p)**	
(B)	Particle moving with increasing acceleration	**(q)**	
(C)	Particle moving with constant negative acceleration	**(r)**	
(D)	Particle moving with zero acceleration	**(s)**	

31. Column-1 gives some graphs for a particle moving along x-axis in positive x-direction. The variables v, x and t represent speed of particle, x-coordinate of particle and time respectively. Column-2 gives certain resulting interpretation. Match the graphs in Column-1 with the statements in Column-2.

Column 1		Column 2	
(A)	 $v - x$ graph	**(p)**	Acceleration of particle is uniform
(B)	 $v^2 - x$ graph	**(q)**	Acceleration of particle is non-uniform
(C)	 $v - t$ graph	**(r)**	Acceleration of particle is directly proportion to 't'
(D)	 $v - t^2$ graph	**(s)**	Acceleration of particle is directly proportional to 'x'

32. As shown in the figure there is a particle of mass $\sqrt{3}$ kg, is projected with speed 10 m/s at an angle 30º with horizontal (Take g = 10 m/s^2) then match the following :



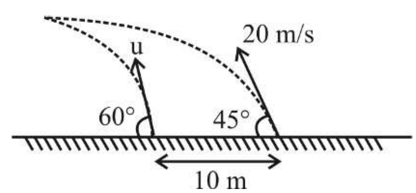
	Column 1		**Column 2**
(A)	Average velocity (in m/s) during half of the time of flight is	**(p)**	$\frac{1}{2}$
(B)	The time (in sec) after which the angle between velocity vector and acceleration vector becomes $\pi/2$	**(q)**	$\frac{5}{2}\sqrt{13}$
(C)	Horizontal range (m)	**(r)**	$5\sqrt{3}$
(D)	Change in linear momentum (N-s) when particle is at highest point	**(s)**	At an angle of $\tan^{-1}\left(\frac{1}{2\sqrt{3}}\right)$ from horizontal

33. A particle is moving along a circle of a fixed radius and gaining speed in a uniform manner. Match Columns I and II.

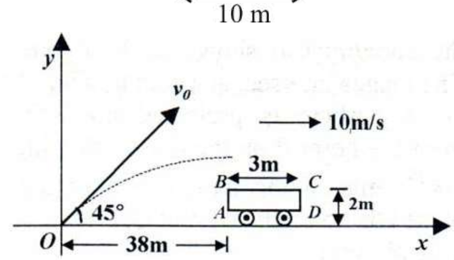
	Column 1		**Column 2**
(A)	Tangential acceleration is	**(p)**	zero
(B)	Radial acceleration is	**(q)**	A non – zero constant value
(C)	Angular acceleration is	**(r)**	Variable
(D)	Angular momentum is	**(s)**	g(10 m/s^2)

SUBJECTIVE INTEGER TYPE

34. In the figure shown, the two projectiles are fired simultaneously. What should be the value of 'n' if initial speed of the left side projectile is $n\sqrt{\frac{2}{3}}$ m/s for the two projectile to hit in mid-air ?

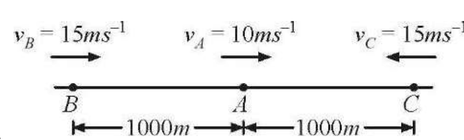


35. A ball is thrown from the origin in the x-y plane with velocity 28.28 m/s at an angle 45° to the x-axis. At the same instant a trolley also s2tarts moving with uniform velocity of l0 m/s along the positive x- axis. Initially, the trolley is located at 38m from the origin. Determine position with respect to end of B trolley at which the ball hits the trolley.



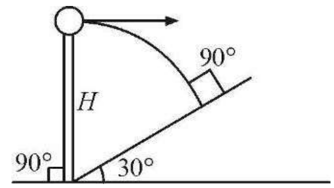
36. The accelerator of a train can produce a uniform acceleration of $0.25\ ms^{-2}$ and its brake can produce a retardation of $0.5\ ms^{-2}$. The shortest time in which the train can travel between two stations 8 km apart is x minutes and 10 s, if it stops at both stations. The value of x is.

37. On a two-lane road, car A is travelling with a speed of $36\ kmh^{-1}$. Two cars B and C approach car A. In opposite directions with a speed of $54\ kmh^{-1}$. each. At a certain instant, when the distance AB is equal to AC, both being 1 km, B decides to overtake A before C does. What minimum acceleration of car B (in m/s^2) is required to avoid an accident?



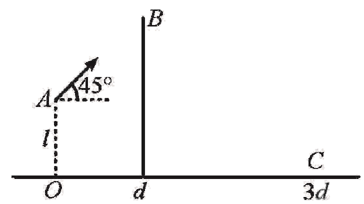
38. A stone is dropped from a height h. Simultaneously another stone is thrown up from the ground with such a velocity so that it can reach a height of $4h$. The time when two stone cross each other is $\sqrt{\left(\frac{h}{kg}\right)}$ where $k =$

39. In the given figure, the angle of inclination of the inclined plane is 30°. A particle is projected with horizontal velocity v_0 from height H. Find the horizontal velocity v_0 (in m/s) so that the particle hits the inclined plane perpendicularly. Given, $H = 4m,\ g = 10\ m/s^2$



40. The slopes of wind screen of two cars are $\alpha_1 = 30°$ and $\alpha_2 = 15°$ respectively. At what ratio of $\frac{V_1}{V_2}$ of the velocities of the cars will their drivers see the hail stones bounced back by the wind screen on their cars in vertical direction assume hail stones fall vertically downwards and collisions to be elastic

41. A projectile is launched at time $t = 0$ from point A which is at height $l\ m$ above the floor with speed $v\ m/sec$ and at an angle $\theta = 45°$ with the floor. It passes through a hoop at B which is $1m$ above A and B is the highest point of the trajectory. The horizontal distance between A and B is d metres. The projectile then falls into a basket, hitting the floor at C a horizontal distance $3d$ metres from A. Find l (in m)



42. A body is projected up from the bottom an inclined plane with a velocity $3\sqrt{3}\ m/\text{sec}$ which makes an angle 60° if the horizontal. The angle of projection is 30° with the plane then the time of flight when it strikes the same plane is $0.1x$. Then the value of x is.

43. A student is standing on a train travelling along a straight horizontal track at a speed of 10 m/s. The student throws a ball into the air along a path, that makes an initial angle of 60° with the horizontal along the track as observed by the student. The professor standing on the ground observes the ball to rise vertically. What will be the maximum height (in m) reached by the ball.

44. A balloon moves up vertically such that if a stone is thrown from it with a horizontal velocity v_0 relative to it the stone always hits the ground at a fixed point $2v_0^2/g$ horizontally away from it. If the height y of balloon as function of time is $y = \frac{kv_0^2}{g}(1 - e^{-gt/2v_0})$. Then find k?

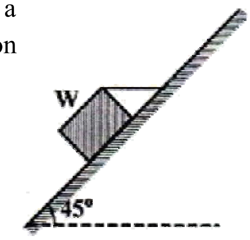
45. A cat, on seeing a rat a distance $d = 5m$, starts with velocity $u = 5\ ms^{-1}$ and moves with acceleration $\alpha = 2.5\ ms^{-2}$ in order to catch it, while the rat with acceleration β starts from rest. For what value of β will the cat overtake the rat? (in ms^{-2})

JEE Advanced Revision Booklet	Dynamics of a Particle

SINGLE CORRECT ANSWER TYPE

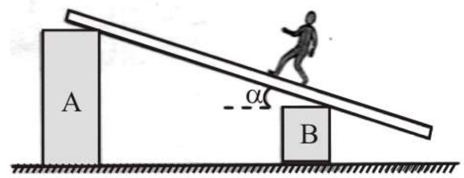
Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A rectangular block weighing 150 N, is lying on a rough inclined plane with inclination angle 45º as shown in the figure. The block is tied up by a horizontal string which has a tension of 50 N to keep the block just in equilibrium, then the coefficient of friction between the block and the inclined surface is :



(A) Zero
(B) 0.33
(C) 0.5
(D) 0.7

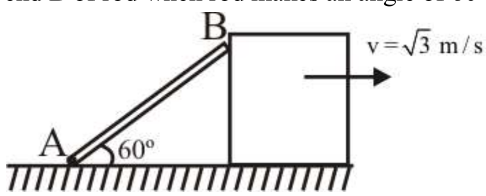
2. A plank is held at an angle α to the horizontal (figure) on two fixed supports A and B. The plank can slide against the supports (without friction) because of its weight Mg. With what acceleration and in what direction, a man of mass *m* should move so that the plank does not move.



(A) $g\sin\alpha\left(1+\frac{m}{M}\right)$ *down the incline* **(B)** $g\sin\alpha\left(1+\frac{M}{m}\right)$ *down the incline*

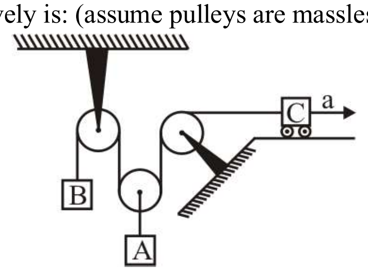
(C) $g\sin\alpha\left(1+\frac{m}{M}\right)$ *up the incline* **(D)** $g\sin\alpha\left(1+\frac{M}{m}\right)$ *up the incline*

3. A rod AB is shown in figure. End A of the rod is hinged on the ground. Block is moving with velocity $\sqrt{3}$ m/s towards right. The velocity of end B of rod when rod makes an angle of 60º with the ground is:



(A) $\sqrt{3}$ m/s **(B)** 2 m/s **(C)** $2\sqrt{3}$ m/s **(D)** 3 m/

4. A trolley *C* shown in the figure is driven with an acceleration a = 3 m/s^2. The ratio of acceleration of the bodies *A* and *B* of masses 10 kg and 5 kg respectively is: (assume pulleys are massless and friction is absent everywhere)

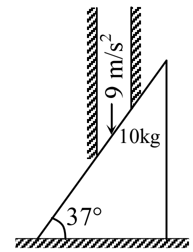


(A) 2 : 1 **(B)** 1 : 3 **(C)** 1 : 1 **(D)** 2 : 3

5. In the system shown in figure, all the surfaces are smooth. Rod is moved by external agent with acceleration 9 m/s^2 vertically downwards. Force exerted on the rod by the wedge will be :

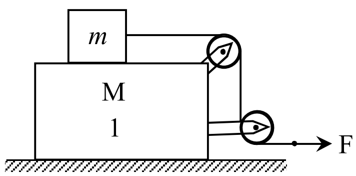
(A) 120 N **(B)** 200 N

(C) 135/2 N **(D)** 225/2 N



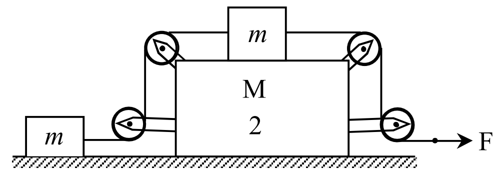
6. In the situation shown in figure all the string are light and inextensible and pullies are light. There is no friction at any surface and all blocks are of cubodial shape. A horizontal force of magnitude F is applied to right most free end of string in both cases of figure 1 and 2 as shown. At the instant shown, the tension in all strings are non zero. Let the magnitude of acceleration of large blocks (of mass M) in figure 1 and figure 2 are a_1 and a_2 respectively. Then:

Figure : 1



Smooth horizontal surface

Figure : 2



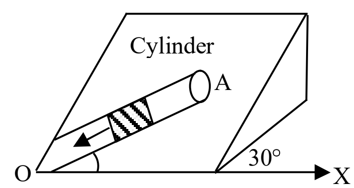
Smooth horizontal surface

(A) $a_1 = a_2 \neq 0$ **(B)** $a_1 = a_2 = 0$ **(C)** $a_1 > a_2$ **(D)** $a_1 < a_2$

7. An inclined plane makes an angle 30° with the horizontal. A groove (OA) of length 5 m cut, in the plane makes an angle 30° with OX. A short smooth cylinder is free to slide down the influence of gravity. The Time taken by the cylinder to reach from A to O is : ($g = 10\ m/s^2$)

(A) 4 s **(B)** 2 s

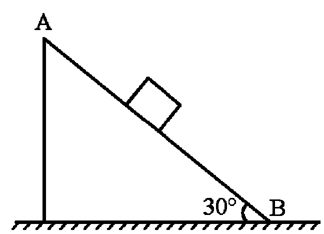
(C) 2 s **(D)** 1 s



8. A particle of mass m = 0.1 kg is released from rest from a point A of a wedge of mass M = 2.4 kg free to slide on a frictionless horizontal plane. The particle slides down the smooth face AB of the wedge. When the velocity of the wedge is 0.2 m/s the velocity of the particle in m/s relative to the wedge is :

(A) 4.8 **(B)** 5.77

(C) 7.5 **(D)** 10



MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

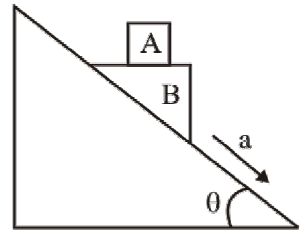
9. In the given figure, a block A rests on a smooth triangular block B and the block B is given an acceleration of $a = 2$ m/s^2 along the plane.

(A) normal force on block A due to block B is m(g – a)

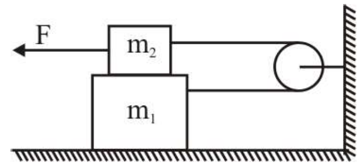
(B) acceleration of block A relative to block B is a cos θ

(C) If friction is present between block and A and B, the coefficient of friction should be greater than $\frac{a}{g}\cos\theta$, for no relative motion between A and B

(D) If friction is present between block and A and B, the coefficient of friction should be greater than $\frac{a\cos\theta}{g - a\sin\theta}$, for no relative motion between A and B



10. Two blocks each of mass 1 kg are placed as shown. They are connected by a string which passes over a smooth (massless) pulley. There is no friction between m_1 and the ground and the coefficient of friction between m_1 and m_2 is 0.2. A force F is applied to m_2. Which of the following statements is/are correct.



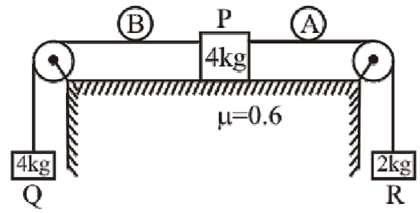
(A) The system will be in equilibrium if $F < 4\,N$.

(B) If $F > 4\,N$ the tension in the string will be 4N.

(C) If $F > 4\,N$ the frictional force between the block will be 2N.

(D) If F = 6N the tension in the string will be 3N.

11. A block P of mass 4 kg is placed on horizontal rough surface with coefficient of friction $\mu = 0.6$. And two blocks R and Q of masses 2 kg and 4 kg connected with the help of massless strings A and B respectively passing over frictionless pulleys as shown, then ($g = 10 m/s^2$)



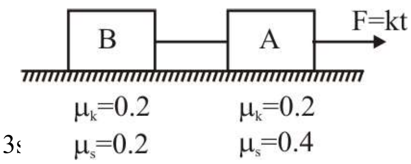
(A) acceleration of block P is zero.

(B) tension in string A is 20 N.

(C) tension in string B is 40 N.

(D) contact force on block P is $20\sqrt{5}$ N.

12. Two blocks A and B each of mass 1/2 kg is connected by a massless inextensible string and kept on horizontal surface. Coefficient of friction between block and surface is shown in figure. A force F = kt (where k = 1 N/s and t is time in second) applied on A. Then (g = 10 m/s^2)



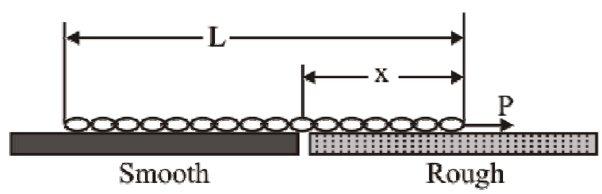
(A) work done by friction force on block B is zero in time interval t = 0 to t = 3s

(B) work done by friction force on block A is zero in time interval t = 0 to t = 3s.

(C) work done by tension on B is also zero in time interval t = 0 to t = 3s.

(D) speed of blocks at t = 10s is 27.5 m/s.

13. A chain of length L is placed on a horizontal surface as shown in figure. At any instant x is the length of chain on rough surface and the remaining portion lies on smooth surface. Initially x = 0. A horizontal force P is applied to the chain (as shown in figure.) In the duration x changes from x = 0 to x = L, for chain to move with constant speed. Choose the incorrect option(s):



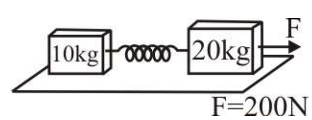
(A) the magnitude of P should increase with time

(B) the magnitude of P should decrease with time

(C) the magnitude of P should increase first and then decrease with time

(D) the magnitude of P should decrease first and then increase with time

14. Two blocks of masses 10 kg and 20 kg are connected by a light spring as shown. A force of 200 N acts on the 20 kg mass as shown. At a certain instant the acceleration of 10 kg mass is 12 ms^{-2} towards right direction.



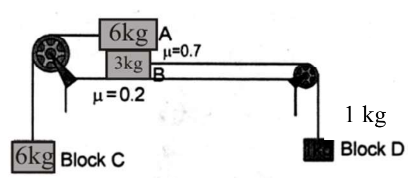
(A) At that instant the 20 kg mass has an acceleration of 12 ms^{-2}.

(B) At that instant the 20 kg mass has an acceleration of 4 ms^{-2}.

(C) The stretching force in the spring is 120 N.

(D) The collective system moves with a common acceleration of 30 ms^{-2} when extension in the connecting spring is the maximum.

15. An arrangement of the masses and pulleys is shown in the figure. Strings connecting masses A and B with pulleys are horizontal and all pulleys and strings are light. Friction coefficient between the surface and the block B is 0.2 and between blocks A and B is 0.7. The system is released from rest. (Use g = 10 m/s^2)



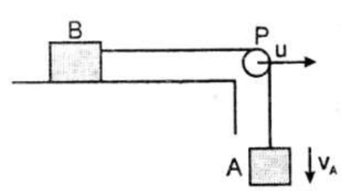
(A) The magnitude of acceleration of the system is 2 m/s^2 and there is no slipping between block A and block B.

(B) The magnitude of friction force between block A and block B is 42 N.

(C) Acceleration of block C is 1 m/s^2 downwards.

(D) Tension in the string connecting block B and block D is 12 N.

16. In the figure, the pulley P moves to the right with a constant speed u. The downward speed of A is v_A and the speed of B to the right is v_B.

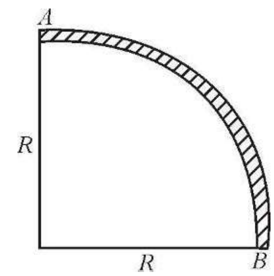


(A) $v_B = v_A$ **(B)** $v_B = u + v_A$

(C) $v_B + u = v_A$

(D) the two blocks have accelerations of the same magnitude

17. A rope AB of linear mass density λ is placed on a quarter vertical fixed disc of radius R as shown in the figure. The surface between the disc and rope is rough such that the rope is just in equilibrium. Gravitational acceleration is g. Choose the correct option(s).



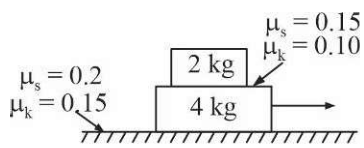
(A) Coefficient of static friction between rope and disc is $\mu = 1$

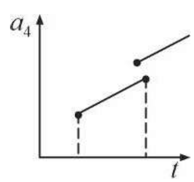
(B) Coefficient of static friction between rope and disc is $\mu = \frac{1}{\sqrt{2}}$

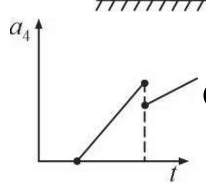
(C) Maximum tension in the rope is at the top most point A of the rope

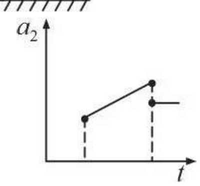
(D) Maximum tension in the rope is $\lambda Rg(\sqrt{2}-1)$

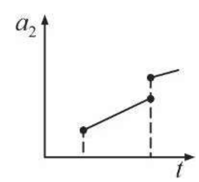
18. Two blocks of masses 2 kg and 4 kg are placed over each other as shown in the adjoining figure. The coefficient of kinetic and static friction are as shown in the figure. A variable force $F = 4t$ starts acting on the 4 kg block as shown. Choose the correct option from the following. (a_4 and a_2 represent the accelerations of 4 kg and 2 kg blocks, respectively.)



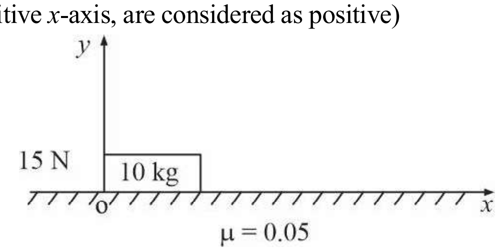
(A) 

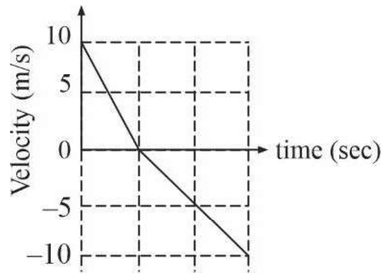
(B) 

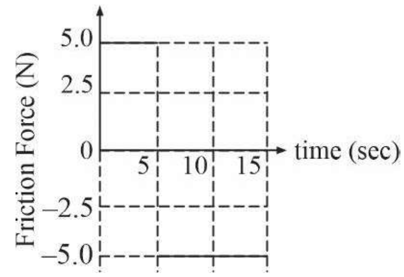
(C) 

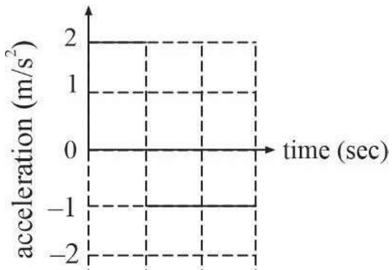
(D) 

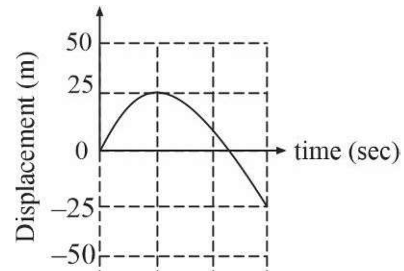
19. A body of mass 10 kg is kept at horizontal rough surface as shown in the figure. The coefficient of friction between body and the surface is 0.05. At $t = 0$, body is given velocity 10 m/s along positive x-axis, simultaneously, a force of 15 N starts acting along negative x-axis continuously through the motion of body. Choose the correct graph(s). (Physical quantities along positive x-axis, are considered as positive)



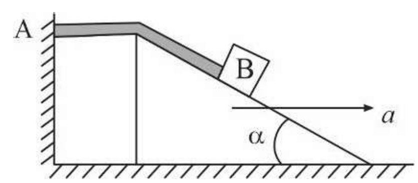
(A) 

(B) 

(C) 

(D) 

20. A massless inextensible string rests on a stationary wedge forming an angle α with the horizontal as shown in the figure. One end of the string is fixed to the wall at point A. A small block of mass m is attached to the string at point B. The wedge starts moving to the right with a constant acceleration a due to an external force (not shown in the figure). Then choose the correct result(s) (Assume all contact surface to be smooth)



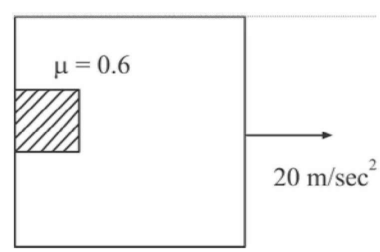
(A) Acceleration of block B is $2a\cos\alpha/2$ with respect to ground

(B) Acceleration of block B is $2a\sin\alpha/2$ with respect to ground

(C) Normal reaction applied by the wedge on the block B is $N = mg\cos\alpha + ma\sin\alpha$

(D) Normal reaction applied by the wedge on the block B is $N = mg\cos\alpha + \dfrac{ma(1-\cos\alpha)}{\sin\alpha}$

21. A block of mass s10 kg placed in contact with the vertical wall of a box which is acceleration in horizontal direction with acceleration $20\ \text{m/sec}^2$. Friction coefficient is $\mu = 0.6$ (Take $g = 10\ \text{m/sec}^2$)



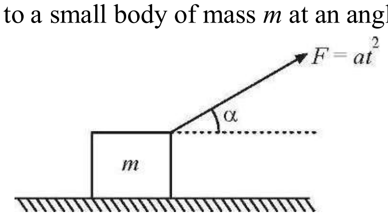
(A) Acceleration of block is $20\ \text{m/sec}^2$ as ween by observer on ground

(B) Friction force on the block is 100 N

(C) Contact force between wall and block is $100\sqrt{5}$(N)

(D) Contact force between vertical wall and block is only electromagnetic in nature

22. At $t = 0$, a force $F = at^2$ is applied to a small body of mass m at an angle α resting on a smooth horizontal plane.



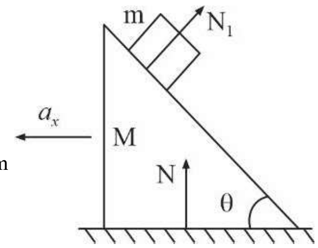
(A) Velocity of the body at the moment it breaks off the plane is $\sqrt{\dfrac{mg^3}{9a\tan^2\alpha\sin\alpha}}$

(B) The distance travelled by the before breaking off the plane is $\dfrac{mg^2}{12a\sin\alpha\tan\alpha}$

(C) Its acceleration at the time of breaking off the plane is $g\cot\alpha$.

(D) Time at which it breaks off the plane is $\sqrt{\dfrac{mg}{a\sin\alpha}}$

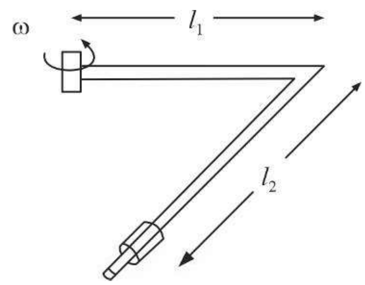
23. A block of mass m is released from rest on a wedge of mass M as shown in the figure, a_x is the horizontal acceleration of wedge and N is the ground reaction, N_1 is normal reaction between block and wedge Mark the correct statements.



(A) $N = (M+m)g$ **(B)** $g - \frac{N}{(M+m)} = a_{cm}$

(C) $\frac{N_1 \sin\theta}{M} = a_x$ **(D)** $N_1 = mg\cos\theta$

24. A rough L-shaped rod is located in a horizontal plane and a sleeve of mass m is inserted in the rod. The rod is rotated with a constant angular velocity ω in the horizontal plane. The lengths l_1 and l_2 are shown in the figure. The normal reaction and frictional force acting on the sleeve when it just starts slipping are ($\mu =$ coefficient of static friction between the rod and the sleeve)

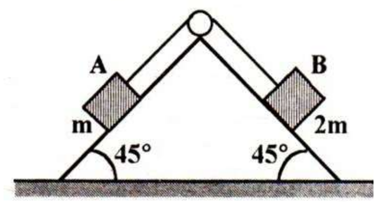


(A) $N = m\omega^2 l_1$ **(B)** $f = m\omega^2 l_2$

(C) $N = m\sqrt{g^2 + \omega^2 l_1^2}$ **(D)** $f = \mu N$

Paragraph for Questions 25 - 27

Block A of mass m and block B of mass 2m are placed on a fixed triangular wedge by means of a massless, inextensible string and a frictionless pulley as shown in figure. The wedge is inclined at 45° to the horizontal on both sides. The coefficient of friction between block A and the wedge is 2/3 and that between block B and the wedge is 1/3. If the system of A and B is released from rest, find



25. The acceleration of A :

(A) 2 m/s^2 **(B)** 3 m/s^2 **(C)** 5 m/s^2 **(D)** Zero

26. Tension in the string,

(A) $\frac{\sqrt{2}}{3}$mg **(B)** $\frac{2\sqrt{2}}{3}$mg **(C)** $\sqrt{2}$mg **(D)** mg$/\sqrt{2}$

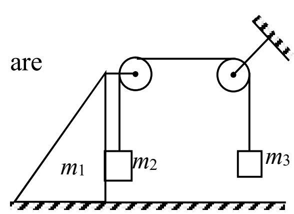
27. The magnitude and direction of the force of friction acting on A.

(A) $\frac{mg}{\sqrt{2}}$, downward **(B)** $\frac{mg}{3\sqrt{2}}$, downward **(C)** $\frac{mg}{\sqrt{2}}$, upward **(D)** $\frac{mg}{3\sqrt{2}}$, upward

Paragraph for Q.28 - 30

In the following figure both the pulleys and the string are massless and all the surfaces are frictionless.

Given : $m_1 = 1kg,\ m_2 = 2kg,\ m_3 = 3kg$.



28. The tension in the string is :

(A) $\frac{120}{7}N$ **(B)** $\frac{240}{7}N$ **(C)** $\frac{130}{7}N$ **(D)** None of these

29. The acceleration of m_1 is :

(A) $\frac{40}{7}m/s^2$ **(B)** $\frac{30}{7}m/s^2$ **(C)** $\frac{20}{7}m/s^2$ **(D)** None of these

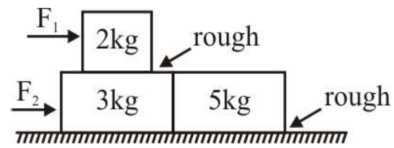
30. The acceleration of m_3 is :

(A) $\frac{40}{7}m/s^2$ **(B)** $\frac{30}{7}m/s^2$ **(C)** $\frac{20}{7}m/s^2$ **(D)** None of these

MATRIX MATCH TYPE

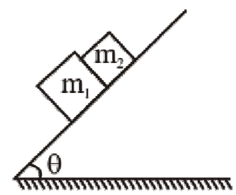
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

31. In the given figure, coefficient of friction between the 2kg and 3kg blocks are $\mu_S = 0.3$ and $\mu_K = 0.2$, between the 5kg and surface are $\mu_S = \mu_K = 0.1$ and between 3 kg and surface is $\mu_S = \mu_K = 0$, ($g = 10$ m/s^2) .



	Column 1		Column 2
(A)	For $F_1 = 0, F_2 = 15$ N	**(p)**	acceleration of all blocks will be same
(B)	For $F_1 = 25/4$N, $F_2 = 0$	**(q)**	acceleration of any two blocks will be different
(C)	For $F_1 = 8$ N, $F_2 = 10$ N	**(r)**	frictional force between 2kg and 3kg block is less than maximum static friction
(D)	For $F_1 = 16$ N, $F_2 = 9$ N	**(s)**	contact force between 3kg and 5kg block is less than 10 N.

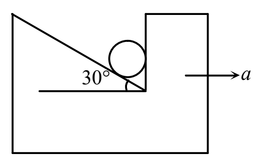
32. Two blocks of mass m_1 and m_2 ($m_2 > m_1$) are placed in contact with each other on an inclined plane as shown in figure. The co-efficient of friction between m_1 and surface is μ_1 and between m_2 and surface is μ_2.



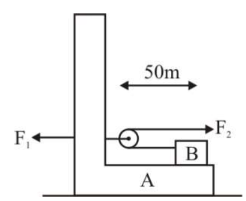
	Column 1		Column 2
(A)	$\mu_1 = 0.3, \mu_2 = 0.2$	**(p)**	Acceleration of both blocks is different.
(B)	$\mu_1 = 0.2, \mu_2 = 0.3$	**(q)**	Acceleration of both blocks is same.
(C)	$\mu_1 = 0.3, \mu_2 = 0.3$	**(r)**	Normal reaction between both the blocks is zero.
(D)	$\mu_1 = 0.3, \mu_2 = 0.2$ and the inclined plane starts moving up with acceleration $g/2$.	**(s)**	Normal reaction between both the blocks is non-zero.

SUBJECTIVE INTEGER TYPE

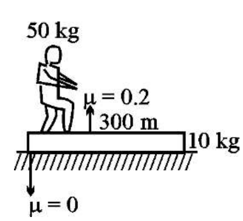
33. A heavy spherical ball is constrained in a frame as shown in figure. The inclined surface is smooth. The maximum acceleration with which the frame can move without causing the ball to leave the frame is $\frac{n}{\sqrt{3}}$. Find value of n.



34. A 1 kg block B rests on a bracket A of same mass as shown in figure. Constant forces F_1 = 20N and F_2 = 8N start acting at time t = 0. The distance of block B from pulley is 50 m at t = 0. Determine the time (in s) when block B reaches the pulley.

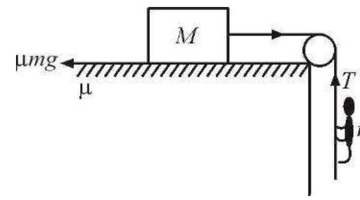


35. A man of mass 50 kg is standing on one end of a stationary wooden plank resting on a frictionless surface. The mass of the plank is 10 kg, its length is 300 m and the coefficient of friction between the man and the plank is 0.2. Find k if shortest time (in s) in which the man can reach the other end of the plank starting from rest and stopping at the other end is 10 k.



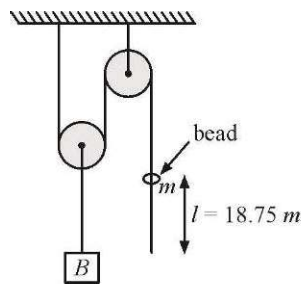
36. A particle of mass 2.5 kg is moving in gravity free space with velocity of $3\hat{i}$ m/s. At $t = 0$, a force of magnitude 67.5 N starts acting on the particle such that it is always perpendicular to its instantaneous velocity. Find x if minimum time (in ms) after which the particle has the same velocity as the initial is $\frac{2\pi}{x}$ seconds.

37. A monkey of mass 'm' climbs up to a rope hung over a fixed pulley with an acceleration $g/4$. The opposite end of the rope is tied to a block of mass M lying on a rough horizontal plane. The coefficient of friction between the block and horizontal plane is μ. Find the tension in the rope and if $T = \frac{M(5m - 4\mu M)}{k(M+m)} + \mu Mg$. Find value of k?



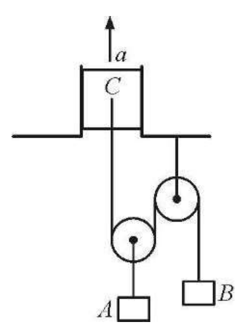
38. Find the minimum force required to keep a block of mas m in equilibrium on a rough inclined plane with inclination α and coefficient of friction $\mu(< \tan\alpha)$ and if $F_{\min} = \frac{mg(\sin\alpha - \mu\cos\alpha)\sqrt{1+k\mu^2}}{1+\mu}$. Find k?

39. In the system shown in the figure, a bead of mass m can slide on the string. There is friction between the bead and the string. Block B has mass equal to twice that of the bead. The system is released from rest with length l = 18.75 m of the string hanging below the bead. Assuming the pulley and string to be massless. Find the distance (in meter) moved by the block B before the bead slips out of the thread.

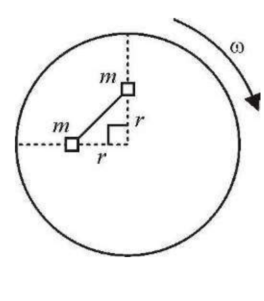


40. A cyclist rides along the circumference of a circular horizontal track of radius r. The coefficient of friction $\mu = \mu_0\left(1 - \frac{r}{R}\right)$ where $\mu_0 = 0.8$ is a constant, $R = 2$ and r is the distance from the centre of the circle. Calculate the maximum velocity of the cyclist.

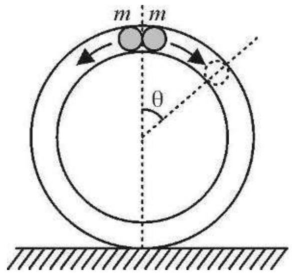
41. The block C shown in the figure is ascending with an acceleration a = 3 m/s^2 by means of some motor not shown here. Find the acceleration of the bodies A and B of masses 10 kg and 5 kg respectively in m/s^2, assuming pulleys are massless and friction is absent everywhere. If $|a_A| = a$ and $|a_B| = b$ then find $a + b$?



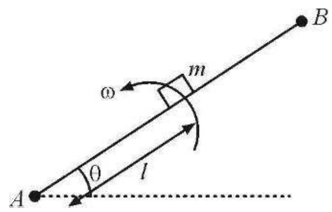
42. Two particles of mass m each are kept on a horizontal circular platform on two mutually perpendicular radii at equal distance r from the centre of the table. The particles are connected with a string, which is just taught when the platform is not rotating. The coefficient of static friction between the platform and block is μ (now if angular speed of platform m is slowly increased). Find the maximum angular speed (ω) of platform about its centre so that the blocks remain stationary relative to platform. (If $\mu = \frac{1}{\sqrt{2}}$, $r = 2.5$ m and $g = 10\ m/s^2$)



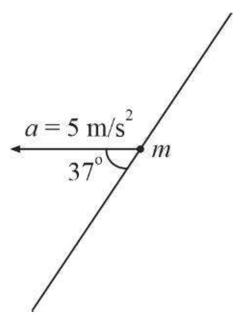
43. A circular tube of mass M is placed vertically on a horizontal surface as shown in the figure. Two small spheres, each of mass m just fit in the tube are released from the top, as shown in the figure. If θ gives the angle between radius vector of either ball with the vertical, obtain the value of the ratio m/M for which the tube breaks its contact with ground when $\theta = 60°$ (Ignore any friction).



44. A plank is rotating in a vertical plane about one of its ends with a constant angular velocity $\omega = \sqrt{2}$ rad/s. A block of mass $m = 2$ *kg* is placed at a distance $l = 1$ *m* from its end A (see figure) which is hinged. The block starts sliding down when the plank makes an angle $\theta = 30°$ with the horizontal. If coefficient of friction between the plank and the block is μ and given that $\mu^2 = k/25$. Find the value of k.



45. A bead of mass m is fitted onto a rough rod of length of 30.6 m and can move along it only. At the initial moment the bead is in the middle of the rod. The rod moves with the constant acceleration $a = 5\,m/s^2$ as shown in the figure. Find the time when the bead will leave the rod if the coefficient of friction between bead and rod is $\mu = 0.2$ (Neglect gravity)

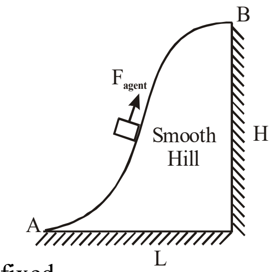


JEE Advanced Revision Booklet	Energy & Momentum

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

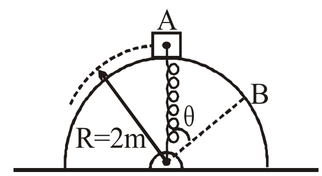
1. An external agent moves the block m slowly from A to B, along a smooth hill such that every time he applies the force tangentially. Find the work done by the agent in this interval.



(A) $\dfrac{m^2g^2H^2}{L}$ **(B)** $\dfrac{mgH^2}{L}$

(C) mg (H + L) **(D)** mgH

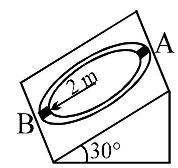
2. A 2 kg block is gently pushed from rest at A and it slides down along the fixed smooth circular surface. If the attached spring has a force constant k = 20 N/m. What is unstretched length of spring so that it does not allow the block to leave the surface until angle with the vertical is θ = 60°.



(A) 1 m **(B)** 1.5 m

(C) 0.5 m **(D)** 0.8 m

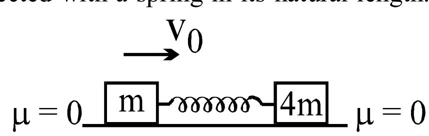
3. A small block of mass m is released from A inside the frictionless circular groove of radius 2 m on an inclined plane as shown in figure. The contact force between the block and inclined plane at point B is



(A) $\sqrt{28}$ mg **(B)** 2.5 mg

(C) $\dfrac{\sqrt{28}}{2}$ mg **(D)** 18.5 mg

4. Two blocks of masses m and 4m lies on a smooth horizontal surface connected with a spring in its natural length. Mass m is given velocity v0 through an impulse as shown in the diagram.
Which of the following is **not true** about subsequent motion



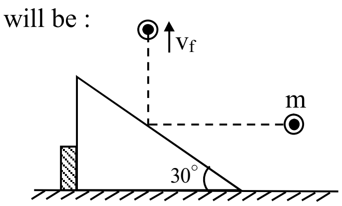
(A) Kinetic energy is maximum in ground frame and centre of mass (COM) frame simultaneously

(B) Value of maximum kinetic energy & minimum kinetic energy is same in COM frame & ground frame

(C) Minimum kinetic energy is zero in COM frame but non zero in ground frame

(D) Maximum and minimum kinetic energies of m in ground frame is respectively $\frac{1}{2}mv_0^2$ and zero

5. DAs shown in the figure a body mass *m* moving horizontal with speed $\sqrt{3}m/s$ hits a fixed smooth wedge and goes up with a velocity v_f in the vertical direction. If $\angle$ of wedge is $30°$, the velocity v_f will be :



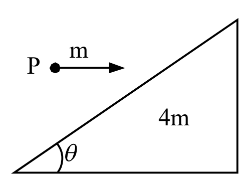
(A) $\sqrt{3}\ m/s$

(B) 3 *m/s*

(C) $\dfrac{1}{\sqrt{3}} m/s$

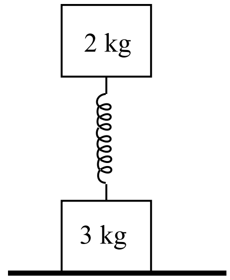
(D) this is not possible

6. In the figure shown, a particle P of mass *m* strikes the inclined smooth plane of wedge of mass 4*m* horizontally and rebounds vertically. The wedge is on a smooth horizontal plane. Assume no toppling of the wedge. If the angle θ is $60°$, then the co-efficient of restitution is:



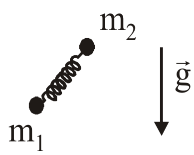
(A) $\dfrac{7}{12}$ **(B)** $\dfrac{1}{\sqrt{3}}$ **(C)** $\dfrac{7}{4\sqrt{3}}$ **(D)** $\dfrac{1}{3}$

7. The ends of a spring are attached to blocks of masses 3 kg and 2 kg. The 3kg block rests on a horizontal surface and the 2 kg block which is vertically above it is in equilibrium producing a compression of 1 cm of the spring. How much more must the 2 kg mass be compressed so that when it is released, the 3 kg block may be lifted off the ground ?



(A) 1.5 cm **(B)** 1 cm **(C)** 2.5 cm **(D)** 3 cm

8. Two particles are inter connected by an ideal spring (see figure). The spring is compressed and system is projected in air under gravity. If the acceleration of m_1 is $\vec{a}$ find acceleration of m_2.



(A) $\vec{g}$ **(B)** $\vec{g}+\vec{a}$ **(C)** $\dfrac{m_1\vec{g}-m_1\vec{a}}{m_2}$ **(D)** $\dfrac{m_1\vec{g}+m_2\vec{g}-m_1\vec{a}}{m_2}$

9. A particle of mass 15 kg has an initial velocity $\vec{v}_i=\hat{i}-2\hat{j}$ m/s. It collides with another body and the impact time is 0.1s, resulting in a velocity $\vec{v}_f=6\hat{i}+4\hat{j}+5\hat{k}$ m/s after impact. The average force of impact on the particle is

(A) $150(5\hat{i}+6\hat{j}+5\hat{k})$ **(B)** $15(5\hat{i}+6\hat{j}+5\hat{k})$

(C) $150(5\hat{i}-6\hat{j}+5\hat{k})$ **(D)** $15(5\hat{i}+6\hat{j}+5\hat{k})$

10. When you pull a tablecloth out from under a set of dishes, it's important to pull the cloth as fast as possible because

(A) the work done on the dishes by the cloth is proportional to the time during which the cloth pulls on them.

(B) the weight of the dishes on the cloth is proportional to the time during which the cloth is moving.

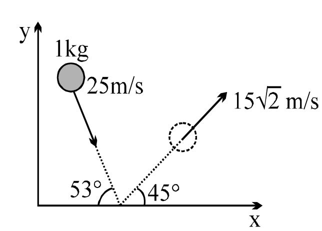
(C) the force of sliding friction that the cloth exerts on the dishes is proportional to the time during which the cloth is moving.

(D) the momentum transferred to the dishes is proportional to the time during which the cloth pulls on them.

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

11. A ball of mass 1 kg bounces against the smooth ground as shown in the figure. The velocity just before collision is 25 m/s and the velocity after just after hitting the ground is $15\sqrt{2}$ m/s. Select the correct alternative(s)



(A) Magnitude of Impulse = 5 Ns

(B) Magnitude of Impulse = 35 Ns

(C) Coefficient of restitution, e = 0.75

(D) Coefficient of restitution, e = 0.25

12. A particle of mass m makes a head-on elastic collision with another particle of mass 2m initially at rest. The velocity of the first particle before and after collision is given to be u_1 and v_1 and the velocity of second particle after the collision is v_2. Which of the following statements is true in respect of this collision?

(A) For all values of u_1, v_1 will always be less than u_1 in magnitude.

(B) The fractional loss in kinetic energy of the first particle is $\frac{8}{9}$

(C) The gain in kinetic energy of the second particle is $\left(\frac{8}{9}\right)^{th}$ of the initial kinetic energy the first particle.

(D) There is a net loss in the kinetic energy of the two particle system in the collision.

13. A tennis racket (held firmly in the hand) moving at a speed u_1 hits a small ball moving towards it at a speed u_0.

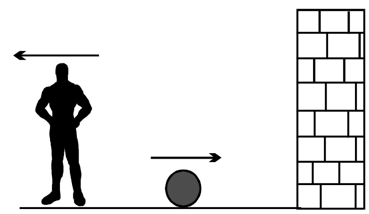
(A) The maximum possible speed of the ball after it is hit is $u_0 + 2u_1$.

(B) Magnitude of impulse on ball due to tennis racket is $2mu_1$.

(C) Work done by tennis racket on ball is $2mu_1 (u_0 + u_1)$

(D) Work done by tennis racket on ball is zero.

14. A man of mass M is carrying a ball of the mass M/2. The man is initially in the state of rest at a distance D from fixed vertical wall. He throws the ball towards the wall with a velocity V horizontally with respect to earth at t = 0. As a result of throwing, the man also starts moving backwards. The ball rebounds elastically from the wall. The man finally collects the ball. Assuming friction to be absent.



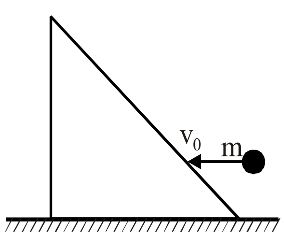
(A) the velocity of the man + ball system after the man has collected the ball is $\frac{2V}{3}$

(B) Impulse by ball on man is $\frac{MV}{3}$

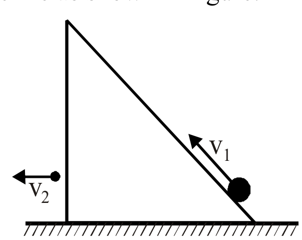
(C) Impulse by ball on man is $\frac{MV}{6}$

(D) He catches the ball again at t = $\frac{4D}{V}$

15. Consider a situation in which a ball collides horizontally with a wedge as shown in figure. All surfaces are smooth. It is observed that after collision ball starts moving on the incline as shown in figure.



Before collision



After collision

Which of the following statement(s) is(are) **NOT** correct for this situation.

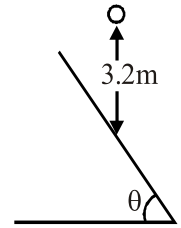
(A) Collision between ball and wedge is perfectly inelastic (e = 0)

(B) Momentum of the ball can be conserved only along incline just before and after collision.

(C) Momentum of system (ball + wedge) can be conserved along any direction just before and after collision.

(D) Momentum of system (ball + wedge) can be conserved only along initial direction of motion of the ball.

16. A ball of mass 1kg is dropped from a height of 3.2m on smooth inclined plane. The coefficient of restitution for the collision is $e = \frac{1}{2}$. The ball's velocity become horizontal after the collision.



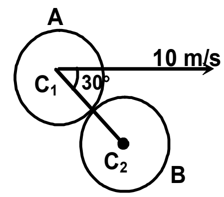
(A) The angle $\theta = \tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$

(B) The speed of the ball after the collision = $4\sqrt{2}$ m/s

(C) The total loss in kinetic energy during the collision is 8J

(D) The ball hits the inclined plane again while travelling vertically downward.

17. A ball collides elastically with an another identical ball B with velocity 10 m/s at an angle of 30° from the line joining their centers C_1 and C_2, then



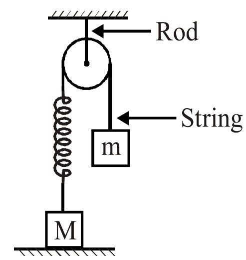
(A) velocity of ball A after collision is 5 m/s

(B) velocity of ball B after collision is $5\sqrt{3}$ m/s

(C) both the balls moves at right angles after collision

(D) KE will not be conserved here, because collision is not head on.

18. In figure, a block of mass m is released from rest when spring was in its natural length. The pulley also has mass m but it is frictionless. Suppose the value of m is such that finally it is just able to lift the block M up after releasing it.



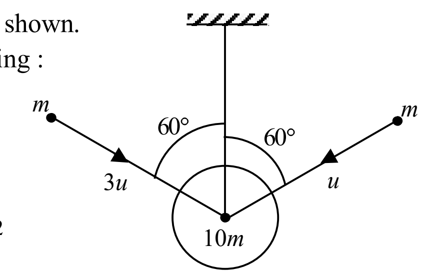
(A) The weight of m required to just lift M is $\frac{M}{2}g$

(B) The tension in the rod, when m is in has zero acceleration $\frac{M}{2}g$

(C) The normal force acting on M when m has zero acceleration $\frac{M}{2}g$

(D) The tension in the string when displacement of m is maximum possible is Mg

19. A bob of mass $10m$ is suspended through an inextensible string of length ℓ. When the bob is at rest is equilibrium position, two particles each of mass m strike it as shown. The particles, stick after collision. Choose the correct statement from the following :

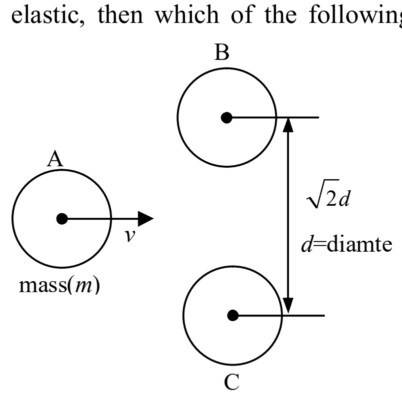


(A) Impulse in the string due to tension is $2mu$

(B) Velocity of the system just after collision is $v = \frac{u\sqrt{3}}{14}$

(C) Loss of energy is $\frac{137}{28}mu^2$ **(D)** Loss of energy is $\frac{137}{56}mu^2$

20. Three identical discs A, B and C rest on a smooth horizontal plane, the disc A set in motion with velocity v along perpendicular bisector of line BC joining centre of disc. Distance between the centers of disk B and C is $\sqrt{2}$ times of the diameter of each disc. A stops after collision and all collisions are elastic, then which of the following statements is(are) correct :



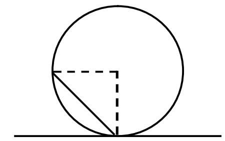
(A) Net impulse on A is $\sqrt{2}\ (mv)$

(B) Net impulse on A is mv

(C) Impulse on B due to A of same magnitude as impulse on C due to A

(D) Total kinetic energy of system (A + B+ C) before collision is equal to total kinetic energy of system(A + B + C) after collision

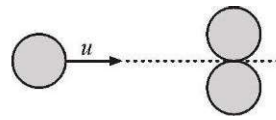
21. Inside a hollow sphere of mass M, a rod of length $R\sqrt{2}$ is released from the state of rest. The mass of the rod is same as that of the sphere. If the inner radius of the hollow sphere is R then find out its horizontal displacement with respect to ground in time in which the rod becomes horizontal.



Assume friction to completely absent.

(A) $\frac{R}{2}$ **(B)** $\frac{R}{4}$ **(C)** $\frac{R}{2\sqrt{2}}$ **(D)** R

22. Two equal spheres of mass m are in contact on a smooth horizontal table. A third identical sphere impinges symmetrically on them and reduces to rest, then:



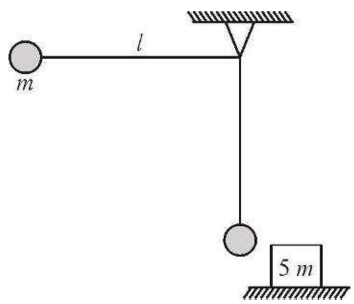
(A) Coefficient of restitution is $e = \frac{2}{3}$

(B) Loss of kinetic energy $\frac{1}{6}mu^2$ where u is velocity before impact

(C) After the collision, velocity of equal mass sphere is $\frac{u}{\sqrt{3}}$

(D) Loss of kinetic energy $\frac{1}{3}mu^2$

23. A pendulum bob of mass m connected to the end of an ideal string of length l is released from rest from horizontal position as shown in figure. At the lowest point, the bob makes an elastic collision with a stationary block of mass $5m$, which is kept on a frictionless surface. Mark out the correct statement(s) for the instant just after the impact.



(A) Tension in the string at lowest point just after collision is (17/9) mg

(B) Tension in the string at lowest point just before collision is 3 mg

(C) The velocity of the block is $\sqrt{2gl}/3$

(D) The maximum height attained by the pendulum bob after impact is (measured from the lowest position $4l/9$

24. A body of mass m moving with a velocity v in the x direction collides with another body of mass M moving in y direction with a velocity V. They coalesce into one body during collision.

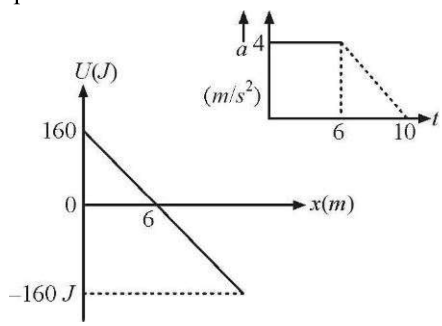
(A) The magnitude of momentum of the composite body $[(mv)^2 + (MV)^2]^{1/2}$

(B) The fraction of initial $K.E.$ transformed into heat is $= \left(\frac{mM}{m+M}\right)\left(\frac{v^2+V^2}{mv^2+MV^2}\right)$

(C) Decrease in kinetic energy is $\frac{mM}{2(m+M)}(v^2+V^2)$

(D) None of these

25. A particle of mass 1 *kg* is moving along *X*-axis. Its velocity is 6 *m/s* at $x = 0$. Acceleration time curve and potential energy-displacement curve of the particle are shown.



(A) The work done by all the forces is 704 *J*
(B) The work done by external forces is 350 *J*
(C) The work done by external forces is 384 *J*
(D) The work done by conservation forces is 300 *J*

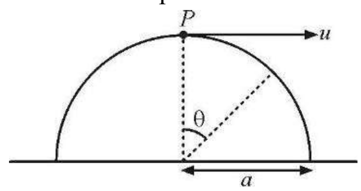
26. A block of mass 1 *kg* moves towards a spring of force constant 10 *N/m*. The spring is massless and unstretched. The coefficient of friction between block and surface is 0.30. After compressing the spring, block does not return back: (g = 10 *m/s*)
(A) The maximum value of speed of block for which it is possible is 3.8 *m/s*
(B) The maximum value of speed of block for which it is possible is 4.2 *m/s*
(C) If E_i and E_f are initial and final mechanical energy, which is sum of kinetic energy and potential energy, the work done by friction on a system is $(E_i - E_f)$
(D) Statement in option (C) is wrong

27. The alternative that gives the conservative force of the following is.
(A) $\vec{F}_1 = 2xy\hat{i} + x^2\hat{j}$ **(B)** $\vec{F}_2 = y^3\hat{i} + xy^2\hat{i}$
(C) $\vec{F}_3 = y\hat{i} + x\hat{j}$ **(D)** $\vec{F}_4 = xy^2\hat{i} + x^2\hat{i}$

28. A man is standing on a plank which is placed on smooth horizontal surface. There is sufficient friction between feet of man and plank. Now man starts running over plank, correct statement is/are:
(A) Work done by friction on man with respect to ground is negative
(B) Work done by friction on man with respect to ground is positive
(C) Work done by friction on plank with respect to ground is positive
(D) Work done by friction on man with respect to plank is zero

29. A small sphere of mass *m* suspended by a thread is first taken a side so that thread forms the right angle with the vertical and then released, then
(A) Total acceleration of sphere as a function of θ measured from the vertical is $g\sqrt{1+3\cos^2\theta}$
(B) Thread tension as a function of θ measured from the vertical is $T = 3mg\cos\theta$
(C) The angle θ between the thread and the vertical at the moment when the total acceleration over of the sphere is directed horizontally is $\cos^{-1}1/\sqrt{3}$
(D) The thread tension at the moment when the vertical component of the sphere's velocity is maximum will be *mg*

30. A particle P is initially at rest on the top *pf* a smooth hemispherical surface which is fixed on a horizontal plane. The particle is given a velocity u horizontal. Radius of spherical surface is a.



(A) If the particle leaves the sphere, when it has fallen vertically by a distance of $\frac{a}{4}, u = \frac{\sqrt{ga}}{2}$

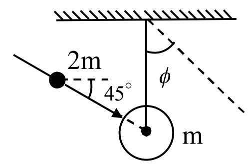
(B) If the particle leaves the sphere at angle θ (fig) where $\cos\theta = \frac{\sqrt{3}}{2}$, then $u = \frac{\sqrt{ag}}{3}$

(C) If $u = 0$ and the particle just slides down the hemispherical surface, it will leave the surface when $\cos\theta = \frac{2}{3}$

(D) The minimum value of u, for the object to leave the sphere without sliding over the surface is $\sqrt{ag}$

Paragraph for Q.31 - 33

A ball of mass 'm' is suspended by massless string of length 'ℓ' from fixed point. A particle of mass $2m$ strikes in the direction $\theta = 45°$ from horizontal and sticks to it ($\ell \gg$ radius of ball) :



31. What should be minimum initial velocity of $2m$ mass, so that the system can complete vertical circle.

(A) $3\sqrt{2g\ell}$ **(B)** $3\sqrt{\frac{5g\ell}{2}}$ **(C)** $3\sqrt{5g\ell}$ **(D)** $\sqrt{5g\ell}$

32. If $\phi = 60°$, the string is cut, what will be the velocity of combined mass at highest point of trajectory :

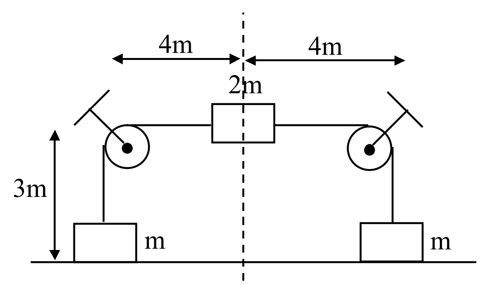
(A) $\sqrt{\frac{g\ell}{2}}$ **(B)** $\sqrt{g\ell}$ **(C)** $2\sqrt{g\ell}$ **(D)** $\frac{1}{2}\sqrt{5g\ell}$

33. In the previous question, what will be maximum height achieved by the combined mass from the initial position of ball $'m'$.

(A) $\frac{\ell}{2}$ **(B)** $\frac{3\ell}{2}$ **(C)** ℓ **(D)** 2ℓ

Paragraph for Q.34 - 35

Three masses m, m and $2m$ are held stationary as shown in the figure with all the strings taut. Now, the mass $2m$ is released and it starts falling vertically downward.



34 Velocity of masses m at the instant $2m$ touches the ground is :

(A) $10\sqrt{\frac{5}{13}}\ m/s$ **(B)** $15\sqrt{\frac{5}{17}}\ m/s$

(C) $10\sqrt{\frac{5}{17}}\ m/s$ **(D)** $6\sqrt{\frac{5}{17}}\ m/s$

35. The maximum height reached by masses m (in metre is)

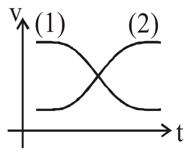
(A) 0.78 **(B)** 1.53 **(C)** 2.16 **(D)** None of these

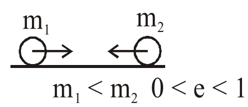
MATRIX MATCH TYPE

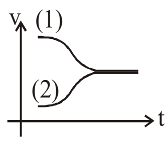
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column I are labelled as (A), (B), (C) & (D) whereas statements in Column II are labeled as p, q, r, s & t. More than one choice from Column II can be matched with Column I.

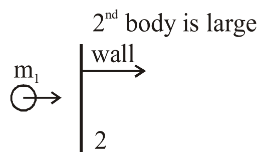
36. Assume that 2 bodies collide head on. The graph of their velocities with time are shown in column-1 match them with appropriate situation in column-2

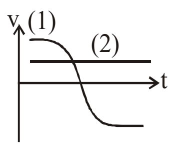
Column 1 | **Column 2**

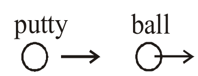
(A) 

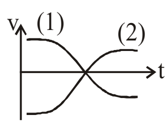
(p) 

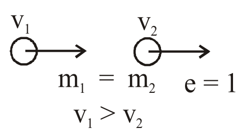
(B) 

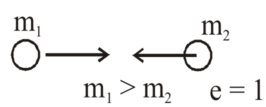
(q) 

(C) 

(r) 

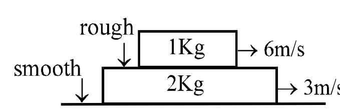
(D) 

(s) 

(t) 

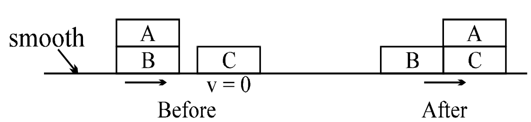
37. In the figure shown, upper block is given a velocity 6m/s & lower block a velocity 3m/s. When relative motion between them stops. (Here block 2 Kg is very long)

	Column 1		**Column 2**
(A)	Work done by friction on 1 kg block	**(p)**	3 Joule
(B)	Work done by friction on 2 kg block	**(q)**	negative
(C)	Net work done by friction	**(r)**	positive
(D)	Loss in K.E. of system (2kg + 1kg block)	**(s)**	7 Joule

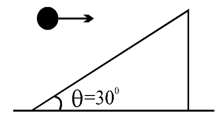


SUBJECTIVE INTEGER TYPE

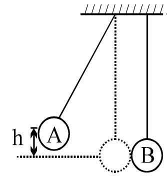
38. Board A is placed on board B as shown. Both boards slide, without moving with respect to each other, along a frictionless horizontal surface at a speed 6 m/s. Board B hits a resulting board C "head-on". After the collision, boards B and C stick together and board A slides on top of board C and stops its motion relative to C in the position shown on the diagram. What is the length (in m) of each board? All three boards have the same mass, size and shape. The coefficient of kinetic friction between boards A and C and between boards A & B is 0.3. (Take $g = 10\ m/s^2$)



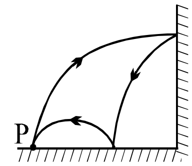
39. An inclined plane is placed on a horizontal smooth surface. The plane is struck by an small elastic ball whose velocity is horizontal just before the impact. The ball bounces off the inclined plane and then lands on it again at the point of first impact. Find the ratio of the masses of the ball and the inclined plane. (Angle $\theta = 30°$)



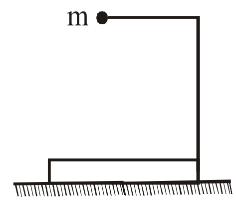
40. Two massless strings of same length hang from the ceiling very near to each other as shown in the figure. Two balls A and B of masses 0.25 kg and 0.5 kg are attached to the string. The ball A is released from rest at a height as shown in the figure, so that its velocity is 3 m/s before collision. The collision between two balls is completely elastic. Find the speed (in m/s) of ball A just after the collision.



41. A small ball is projected from point P on floor towards a wall as shown.
It hits the wall when its velocity is horizontal. Ball reaches point P after one bounce on the floor. If the coefficient of restitution is the same for the two collisions, find the value of its reciprocal. [All surfaces are smooth]

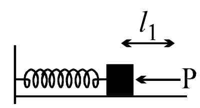


42. A small ball of mass 2g is attached to a string of length ℓ whose other end is fastened to an upright vertical rod fixed on a wooden board resting on a horizontal table. The combined mass of the board and rod is 1kg. The friction coefficient between the board and the table is μ. The ball is released from rest with the string in a horizontal position. While the ball swings, the board does not move.

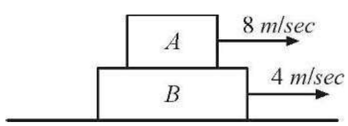


What is minimum value that μ must have to prevent the board from moving to the left while the ball swings down ? Using necessary approximation, express your answer as $x \times 10^{-3}$ and find x.

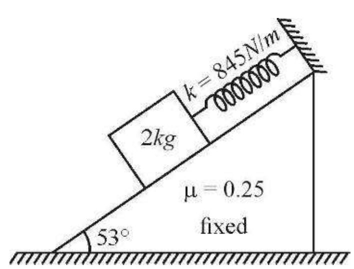
43. A block of mass m placed on a smooth horizontal surface is attached to a spring and is held at rest by a force P as shown. Suddenly the force P changes its direction opposite to the previous one. Find the ratio l_2/l_1, where l_2 is the maximum extension in the spring and l_1 is the initial compression.



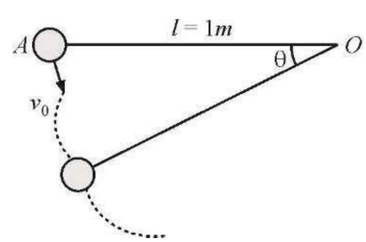
44. Block A of mass $1kg$ is placed on the rough surface of block B of mass $3kg$. Block B is placed on smooth horizontal surface. Blocks are given the velocities as shown. Find net work done by the frictional force. [in (–) ve J]



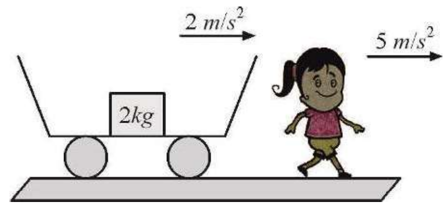
45. A Block of mass $2kg$ is placed on an inclined plane of angle 53°, attached with a spring as shown. Friction coefficient between block and the incline is 0.25. The block is released from the rest and when spring is in natural length. Find maximum speed of the block it acquires after the release in cm/s is found to be nearly $5n$. Find 'n' (Take $g = 10\ m/s^2$)



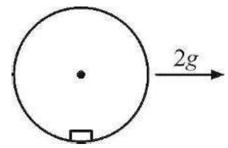
46. The sphere at P is given a down ward velocity v_0 and swings in a vertical plane at the end of a rope of $l = 1m$ attached to a support at O. The rope breaks at angle 30° from horizontal, knowing that it can withstand a maximum tension equal to four times the weight of the sphere. Then the value of v_0 will be $(g = 10\ m/s^2)$



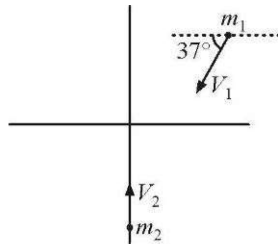
47. An observer and a vehicle, both starts moving together from rest with accelerations $5\ m/s^2$ and $2\ m/s^2$, respectively. There is a 2 *kg* block on the floor of the vehicle, and $\mu = 0.3$ between their surfaces. Find the work done by frictional force on the 2 *kg* block as observed by the running observer, during first 2 seconds of the motion.



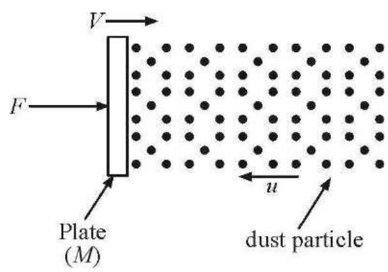
48. A block of mass *m* is placed inside a smooth hollow cylinder of radius *R* kept horizontally. Initially system was at rest. Now cylinder is given constant acceleration 2*g* in the horizontal direction by external agent. Find the maximum angular displacement of the block with the vertical.



49. Two balls with masses $m_1 = 3\ kg$ and $m_2 = 5\ kg$ have identical velocity $V = 5\ m/s$ in the direction shown in figure. They collide at origin. Find the distance of position of C.M. from the origin 2 sec after the collision.

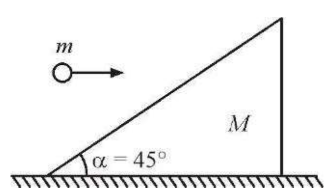


50. A plate of mass *M* is moved with constant velocity '*v*' against dust particles moving with velocity '*u*' in opposite direction as shown. The density of the dust is ρ and plate area is *A*. Find the force *F* required to keep the plate moving uniformly is $A\rho(u+v)^N$, then *N* is

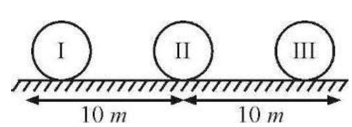


51. A simple pendulum is suspended from a peg on a vertical wall. The pendulum is pulled away from the wall to a horizontal position and released. The ball hits the wall, the coefficient of restitution, being $(2/\sqrt{5})$. What is the minimum number of collisions after which the amplitude of oscillation becomes less than 60°?

52. A small particle of mass $m = 2\ kg$ moving with constant horizontal velocity $u = 10\ m/s$ strikes a wedge shaped block of mass $M = 4\ kg$ placed on smooth horizontal surface on its inclined surface as shown in figure. After collision particle starts moving up the inclined plane. Calculate the velocity of wedge immediately after collision.

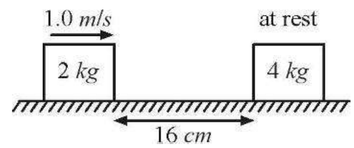


53. Three identical balls, ball I, and II and ball III are placed on a smooth floor on a straight line at the separation of $10\ m$ between balls as shown in figure. Initially balls are stationary. Ball I is given velocity of 10 *m/s* towards ball II. Collision between ball I and II is inelastic with coefficient of restitution 0.5 but collision between ball II and III is perfectly elastic. What is the time interval between two consecutive collisions between ball I and II?

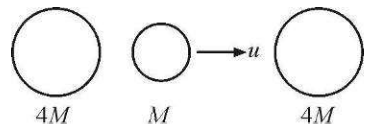


54. Three objects A, B and C are kept in a straight line on a frictionless horizontal surfaces. These have masses m, $2m$ and m respectively. The object A moves towards B with a speed 9 m/s and makes an elastic collision with it. Thereafter, B makes completely inelastic collision 'C'. All motions occur on the same straight line. Find the final speed in m/s of the object 'C'.

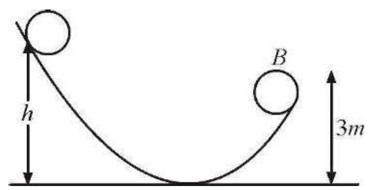
55. The friction coefficient between the horizontal surface and each of the blocks shown in the figure is 0.2. The collision between the blocks is perfectly elastic. Find the separation between them (in cm) when they come to rest. (Take $g = 10\ m/s^2$)



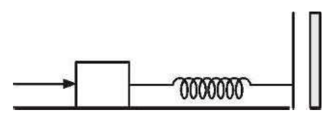
56. Two particle of equal masses 4 M are initially at rest. A particle of mass M moving at speed u collide elastically with one of the larger balls. How many collisions occur?



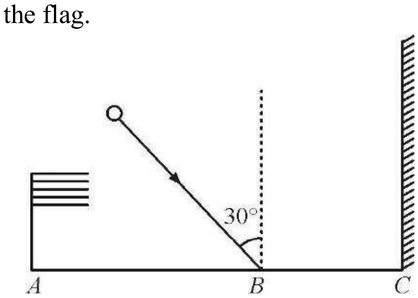
57. A ball leaves the track at B which is at $3m$ height from bottom most point of the track. The ball further rises upto $4m$ height from the bottom most point before falling down. Find h (in m), if the track at B makes an angle 30° with horizontal.



58. A block of mass 0.18 kg is attached to a spring of force-constant 2 N/m. The coefficient of friction between the block and the floor is 0.1, initially the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06 m and comes to rest for the first time. The initial velocity of the block in m/s is $V = N/10$. Then N is.



59. A ball collides at B with velocity 10 m/s at 30° with vertical. There is a flag at A and a wall at C. Collision of ball with ground is perfectly inelastic ($e = 0$) and that with wall is elastic ($e = 1$). Given $AB = BC = 10\ m$. Find the time after which ball will collide with the flag.



60. A small ball of mass m is attached to the end of the string of length $\ell = 1$m whose other end is fixed. From its lowest position, the ball is given a kinetic energy $mg\ell/5$. The net acceleration (in m/s^2) of the ball at the instant when the string makes an angle θ of 37° with the vertical is __________.

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A thin wire is bent in form of a helix of radius R and height H. The pitch of helix is $\frac{H}{2}$ and mass per unit length of wire is λ. Moment of inertia of wire about the axis of helix is:

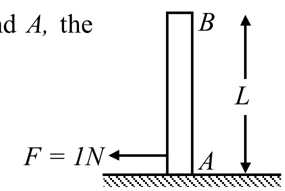
(A) λHR^2 **(B)** $2\lambda R^2\sqrt{H^2+4\pi R^2}$

(C) $\lambda R^2\sqrt{H^2+16\pi^2R^2}$ **(D)** None of these

2. Consider a uniform rectangular plate of mass M and dimensions (a × b). Its moment of inertia about one of the diagonal is:

(A) $\frac{Ma^2b^2}{6\left(a^2+b^2\right)}$ **(B)** $\frac{Ma^2b^2}{3\left(a^2+b^2\right)}$ **(C)** $\frac{Ma^2b^2}{12\left(a^2+b^2\right)}$ **(D)** None of these

3. A uniform smooth rod of mass $m = 1kg$ and length L is balanced in the vertical position as shown in the figure. When a horizontal force F is applied at end A, the acceleration of top point Bat this instant is:

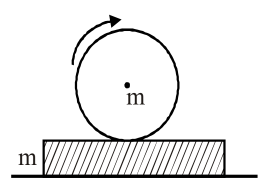


(A) $2m/s^2$to right
(B) 1 m/s^2 to left
(C) 1 m/s^2 to right
(D) None of these

4. A body is rolling without slipping on a horizontal plane. If the rotational energy of the body is 40% of the total kinetic energy, then the body might be:

(A) Cylinder **(B)** Hollow sphere **(C)** Solid cylinder **(D)** Ring

5. A sphere of mass m is given some angular velocity about a horizontal axis through its centre, and gently placed on a plank of mass m as shown in the figure. The coefficient of friction between the two is μ. The plank rests on a smooth horizontal surface. The initial acceleration of centre of mass of the sphere relative to the plank will be

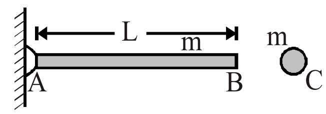


(A) zero **(B)** μg **(C)** $\frac{7}{5}\mu g$ **(D)** 2μg

6. A rod of length L is held vertically on a smooth horizontal surface. The top end of the rod is given a gentle push. At a certain instant of time, when the rod makes an angle θ with horizontal the velocity of COM of the rod is v_0. The velocity of the end of the rod in contact with the surface at that instant is :

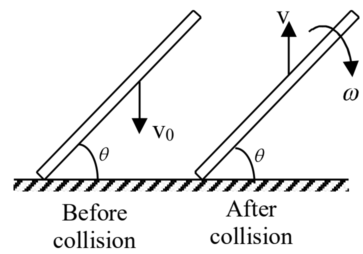
(A) $v_0 \cot\theta$ **(B)** $v_0 \cos\theta$ **(C)** $v_0 \sin\theta$ **(D)** $v_0 \tan\theta$

7. A uniform bar AB of mass m and a ball of the same mass are released from rest from the same horizontal position. The bar is hinged at end A. There is gravity downwards. What is the distance of the point from point B that has the same acceleration as the ball, immediately after release?



(A) $\frac{2L}{3}$ **(B)** $\frac{L}{3}$ **(C)** $\frac{L}{2}$ **(D)** $\frac{3L}{4}$

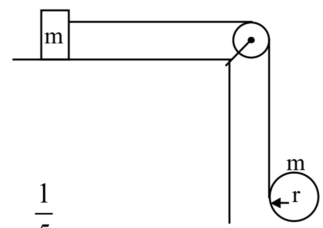
8. A uniform bar of mass M and length L collides with a horizontal surface. Before collision velocity of centre of mass was v_0 and no angular velocity. Just after collision velocity of centre of mass of bar becomes v in upward direction as shown in the figure. Angular velocity ω of the bar just after impact is :



(A) $\dfrac{6(v_0+v)\cos\theta}{L}$ **(B)** $\dfrac{6(v_0-v)\cos\theta}{L}$

(C) $\dfrac{(v_0+v)\cos\theta}{L}$ **(D)** $\dfrac{(v_0-v)\cos\theta}{6L}$

9. A light thread is wound on a disk of mass m and other end of thread is connected to a block of mass m, which is placed on a rough ground as shown in the diagram. Find the minimum value of coefficient of friction for which block remain at rest:



(A) $\frac{1}{3}$ **(B)** $\frac{1}{4}$ **(C)** $\frac{1}{2}$ **(D)** $\frac{1}{5}$

10. Two point masses of 0.3 kg and 0.7 kg are fixed at the ends of a rod of length 1.4 m and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum, is located at a distance of :

(A) 0.42 m from mass of 0.3 kg **(B)** 0.70 m from mass of 0.7 kg

(C) 0.98 m from mass of 0.3 kg **(D)** 0.98 m from mass of 0.7 kg

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

11. Which of the following statements is(are) true

(A) Work done by kinetic friction on a rigid body may be positive

(B) A uniform sphere rolls up an inclined plane without sliding. The friction force on it will be up the incline. (only contact force and gravitational force is acting)

(C) A uniform sphere rolls down an inclined plane without sliding. The friction force on it will be up the incline. (only contact force and gravitational force is acting)

(D) A uniform sphere is left from rest from the top of a rough inclined plane. It moves down the plane with slipping. The friction force on it will be up the incline always.

12. A thin bar of mass M and length L is free to rotate about a fixed horizontal axis through a point at its end. The bar is brought to a horizontal position and then released. The angular velocity when it reaches the lowest point is

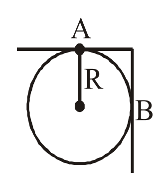
(A) Directly proportional to its length and inversely proportional to its mass

(B) Independent of mass and inversely proportional to the square root of its length

(C) Dependent only upon the acceleration due to gravity and the length of the bar

(D) Directly proportional to its length and inversely proportional to the acceleration due to gravity

13. A rod bent at right angle along its centre line, is placed on a rough horizontal fixed cylinder of radius R as shown in the figure. Mass of rod is 2 m and rod is in equilibrium. Assume that frictional force on rod at A and B are equal in magnitude.



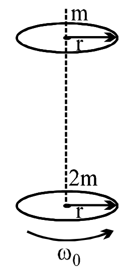
(A) Normal force applied by cylinder on rod at A is 3mg/2.

(B) Normal force applied by cylinder on rod at B must be zero.

(C) Frictional force acting on rod at B is upward.

(D) Normal force applied by cylinder on rod at A is mg.

14. A disc of mass m and radius r is gently placed on another disc of mass 2m & radius r. The disc of mass 2m is rotating with angular velocity ω_0 initially. The disc is placed such that axis of both are coincident. The coefficient of friction is μ for surfaces in contact. Assume that pressure on disc is uniformly distributed. Find the correct statement.



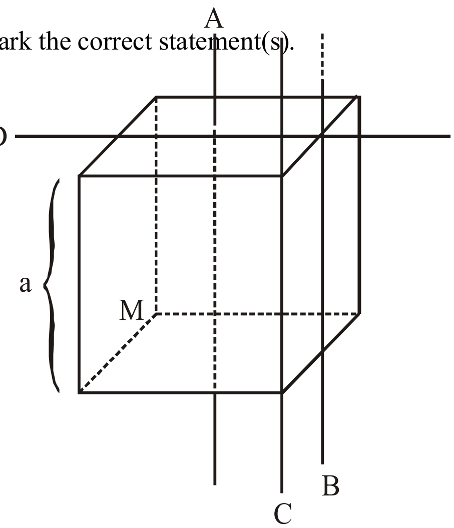
(A) Loss in kinetic energy of system $\Delta K = \dfrac{1}{3} mr^2\omega_0^2$.

(B) Loss in kinetic energy of system $\Delta K = \dfrac{1}{6} mr^2\omega_0^2$.

(C) The common angular velocity is $\dfrac{2}{3}\omega_0$.

(D) The common angular velocity is $\dfrac{4}{3}\omega_0$

15. A uniform cubical block of mass M and side 'a' is as shown in the figure Mark the correct statement(s).



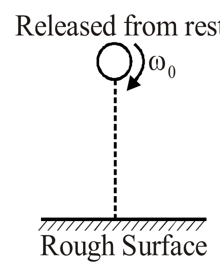
(A) The moment of inertia about axis A, passing through the centre of mass is $I_A = \dfrac{1}{6} Ma^2$

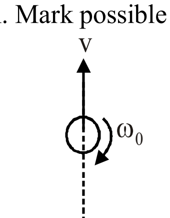
(B) The moment of inertia about axis B, which bisects one of the cube faces is $I_B = \dfrac{5}{12} Ma^2$

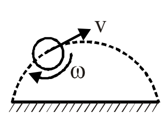
(C) The moment of inertia about axis C, along one of the cube edges is $I_C = \dfrac{2}{3} Ma^2$

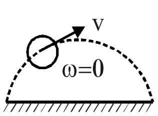
(D) The moment of inertia about axis D, which bisects one of the horizontal cube faces is $\dfrac{7}{12} Ma^2$

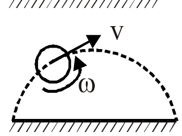
16. A disc is given an angular speed ω_0 and released from a certain height (as shown in the figure). Motion of disc is observed after collision with the rough surface. Velocity of centre of mass of ball and direction of ω is shown in the figure after the collision. Mark possible path(s) of disc can follow after the collision.



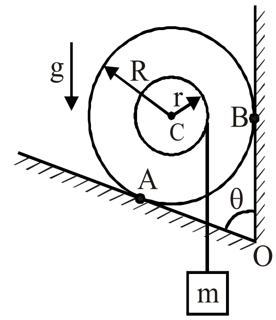
(A)


(B)


(C)


(D)


17. A massless spool of inner radius r, outer radius R is placed against vertical wall and tilted split floor as shown in the figure. A light inextensible thread is tightly wound around the spool through which a mass m is hanging. There exists no friction at point A, while the coefficient of friction between spool and point B is μ. The angle between two surfaces is θ.



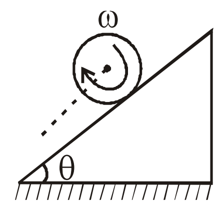
(A) the magnitude of force on the spool at B in order to maintain equilibrium is $Mg\sqrt{\left(\frac{r}{R}\right)^2+\left(1-\frac{r}{R}\right)^2\frac{1}{\tan^2\theta}}$

(B) the magnitude of force on the spool at B in order to maintain equilibrium is $mg\left(1-\frac{r}{R}\right)\frac{1}{\tan\theta}$

(C) the minimum value of μ for the system to remain in equilibrium is $\frac{\cot\theta}{(R/r)-1}$

(D) the minimum value of μ for the sysem to remain in equilibrium is $\frac{\tan\theta}{(R/r)-1}$

18. A solid sphere is given a angular velocity ω and kept on a rough fixed incline plane as shown in the figure. Then choose the correct statement.



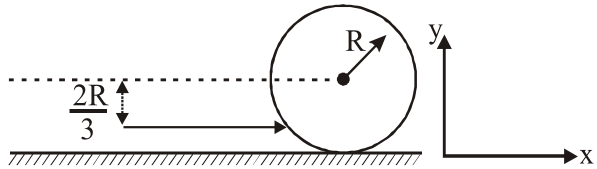
(A) If μ = tan θ then sphere will be in linear equilibrium for some time and after that pure rolling down the plane will start.

(B) If μ = tan θ then sphere will move up the plane and frictional force acting all the time will be 2 mg sinθ.

(C) If $\mu = \frac{\tan\theta}{2}$ there will never be pure rolling (consider inclined plane to be long enough.)

(D) If incline plane is not fixed and it is on smooth horizontal surface then linear momentum of the system (wedge and sphere) can be conserved in horizontal direction.

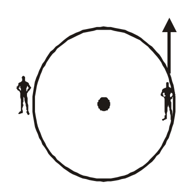
19. A billiard ball initially at rest is given a sharp blow by a cue stick. The force is horizontal and is applied at a distance 2R/3 below the centre line, as shown in the figure. The initial speed of the ball is v_0, and the coefficient of kinetic friction is μ_k. (μ_k is small) :



(A) Initially kinetic friction acts in $-\hat{i}$ direction **(B)** Initially kinetic friction in $\hat{i}$ direction.

(C) Ball instantaneously starts pure rolling. **(D)** Initial angular velocity of ball is $\frac{5v_0}{3R}$

20. A student Amir of mass m is standing on the edge of an horizontal disc of radius R. The disc is free to rotate about a frictionless vertical axis passing through its centre. Initially the student and disc are at rest. At t = 0 the student starts to run at his maximum velocity v relative to disc. He runs along the circumference of the disc towards his friend Salman in anticlockwise sense. Salman is stationary on ground. Moment of inertia of disc is I.



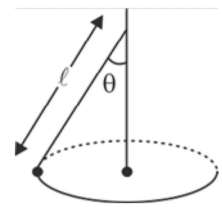
(A) Time taken to reach Salman is $\frac{\pi R}{v}\left(1+\frac{I}{mR^2}\right)$.

(B) If disc were considered massless time taken to reach Salman is $\frac{\pi R}{v}$.

(C) If disc were considered massless Amir can never reach Salman.

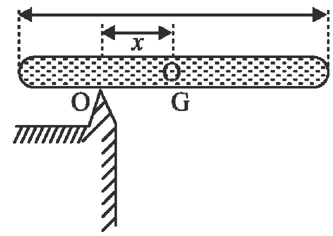
(D) Time taken will be minimum if Amir instead of running along circumference runs along diameter towards Salman.

21. A particle is rotating in a conical pendulum with help of a string of length ℓ as shown in the figure. The speed of the particle is constant and angle θ is also constant with time. It can be said that



(A) Angular momentum of the particle about the point of suspension is not constant.
(B) Only the direction of angular momentum of the particle about the point of suspenstion is constant.
(C) Only the magnitude of angular momentum about the point of suspension is constant.
(D) Net torque on the particle about the point of suspension is zero.

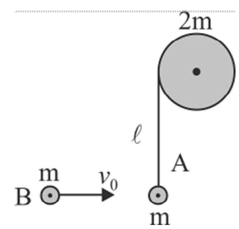
22. In the adjacent figure a uniform rod of length ℓ and mass m is kept at rest in horizontal position on an elevated edge. The value of x (consider the figure) is such that the rod will have maximum angular acceleration α, as soon as it is set free.



(A) x is equal to $\frac{\ell}{2\sqrt{3}}$ **(B)** α is equal to $\frac{g\sqrt{3}}{2\ell}$

(C) α is equal to $\frac{g\sqrt{3}}{\ell}$ **(D)** x is equal to $\frac{\ell}{\sqrt{3}}$

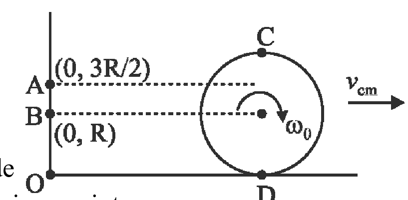
23. In the adjacent figure, a uniform disc of mass 2m and radius $\ell/2$ is lying at rest on a smooth horizontal surface. A particle 'A' of mass m is connected to a light string of length ℓ. whose other end is attached to the circumference of the disc. Initially strign is just taut and tangential to the disc, particle A is at rest. In the same horizontal plane another particle B of same mass m moving with velocity v_0 perpendicular to string collides elastically with A. Just after impact which of the following statements will be true



(A) Tenstion is the string is $\frac{2mv_0^2}{5\ell}$ **(B)** Acceleration of the centre of the disc is $\frac{v_0^2}{5\ell}$

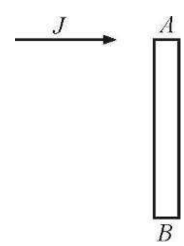
(C) Tension in the string is $\frac{mv_0^2}{5\ell}$ **(D)** Acceleration of the centre of the disc is $\frac{2v_0^2}{5\ell}$

24. A cylinder is rolling without sliding on a smooth horizontal surface as shown. O is origin, B and A are two points on y-axis C and D are topmost and bottom most point of cylinder at the given instant. Mark the correct statements.



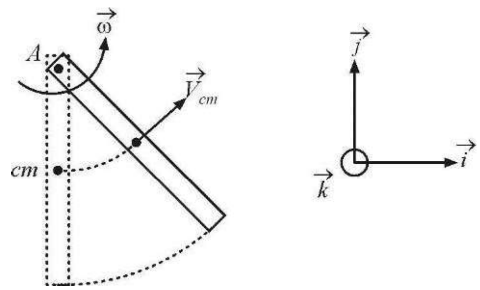
(A) Angular momentum of body about C and D will be same in magnitude
(B) Angular momentum of cylinder wil be minimum about A among the given points
(C) Angular momentum will be minimum about B
(D) Angular momentum about O and C will be same in magnitude

25. A rod AB of mass M and length L lies on a smooth horizontal table. An impulse J is applied to end A as shown in the figure immediately after imparting the impulse:



(A) The radius of curvature of trajectory of A as seen from the ground is $\frac{8}{9}$L.
(B) The radius of curvature of trajectory of B as seen from the ground is $\frac{2}{9}$L.
(C) The instantaneous axis of rotation is at a distance of $L/6$ form the mid-point of the rod.
(D) The mid-point of the rod will move along a straight line.

26. A uniform rod of length l and mass m is rotating about a fixed axis perpendicular to the paper (xy-plane) and passing through its one of the end A. At the instant shown in the figure rod's angular velocity is ω and velocity of the centre of mass of the rod is $\vec{v}_{cm}$. The moment of inertia of the rod about an axis passing through point A and kinetic energy of rod respectively.



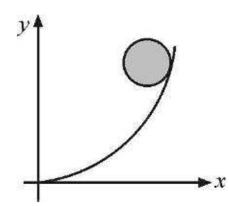
(A) $\vec{L}_A = I_A\vec{\omega} = \left(I_{cm} + \frac{ml^2}{4}\right)\vec{\omega}, K = \frac{1}{2}mv^2_{cm} + \frac{1}{2}I_{cm}\omega^2$

(B) $\vec{L}_A = I_A\vec{\omega} = m\vec{r}_{cm} \times \vec{v}_{cm} + I_{cm}\vec{\omega}, K = \frac{1}{2}mv^2_{cm} + \frac{1}{2}I_{cm}\omega^2$

(C) $\vec{L}_A = I_A\vec{\omega} = \left(I_{cm} + \frac{ml^2}{4}\right)\vec{\omega}, K = \frac{1}{2}I_A\omega^2$

(D) $\vec{L}_A = I_A\vec{\omega} = m\vec{r}_{cm} \times \vec{v}_{cm} + I_{cm}\vec{\omega}, K = \frac{1}{2}I_A\omega^2$

27. A small disc of mass in is released on a parabolic curve in a vertical plane such that gravity acts along negative y-axis. The equation of parabolic curve is $x^2 = \frac{2a}{\sqrt{3}}y,$ where 'a' is a positive constant. Frictional force between disc and curve are sufficient for pure rolling. When disc is reached at $x = a$ then choose the correct option(s).



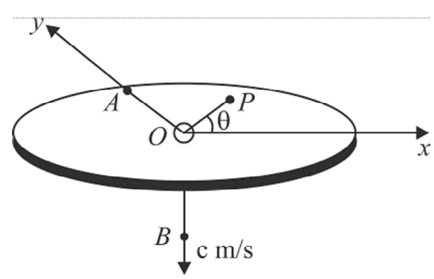
(A) Acceleration of disc along the trajectory is $\sqrt{3g}$

(B) Acceleration of disc along the trajectory is $\frac{g}{\sqrt{3}}$.

(C) Frictional force between disc and curve is $\frac{mg}{2\sqrt{3}}$.

(D) Frictional force between disc and curve is $\frac{mg}{\sqrt{3}}$.

28. A small object is placed on a smooth table at a distance r_0 from a hole in the centre of table. An ideal inextensible chord is attached to the object through this hole. The object is set into motion with initial velocity of magnitude v_0 at right angle to the chord and at the same time, the chord is pulled through the hole at uniform speed c m/s. Initially object is at point $A(0, r_0)$ and at any time t, it is at point $P(r\cos\theta, r\sin\theta)$. Neglect the dimension of object. Choose CORRECT option(s)



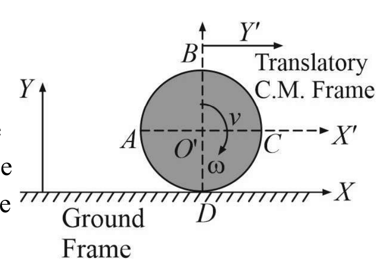
(A) Tension in the chord at any time t is $\frac{mr_0^2v_0^2}{(r_0 - ct)^3}$

(B) Tension in the chord at any time t is $\frac{2mr_0^2v_0^2}{(r_0 - ct)^3}$

(C) Angular speed of the object at any time t is $\frac{2r_0v_0}{(r_0 - ct)^2}$

(D) Angular speed of the object at any time t is $\frac{r_0v_0}{(r_0 - ct)^2}$

29. A thin rigid uniform circular disc rolls without slipping on a horizontal rigid surface (or the ground). At a certain instant, its position w.r.t. ground frame is as shown in the figure.



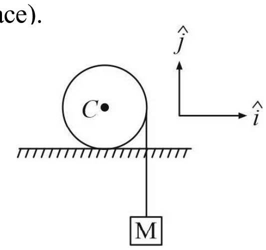
(A) Sector ABC has greater kinetic energy than sector ADC w.r.t. ground frame

(B) Sector BO'C has greater kinetic energy than sector $CO'D$ w.r.t ground frame

(C) Sector BO'C has the same kinetic energy as sector $AO'B$ w.r.t. ground frame

(D) All the sectors $AO'B$, $BO'C$, $CO'D$ and $AO'D$ have same kinetic energy w.r.t. the centre of mass frame

30. A disc of mass M and radius r has massless string wrapped over it with one end fixed on disc and other end connected to block of same mass M. Initially system is held at rest. Now system is released from rest. Immediately after system is released (assume there is no slipping at any contact surface).



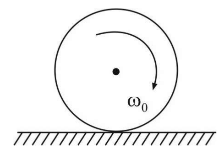
(A) Acceleration of block in ground frame is $\frac{2}{5}g\hat{i}-\frac{2}{5}\hat{j}$

(B) Acceleration of block in the frame of centre of disc is $-\frac{2}{5}g\hat{i}-\frac{2}{5}\hat{j}$

(C) Acceleration of block in ground frame is $-\frac{2}{5}\hat{j}$

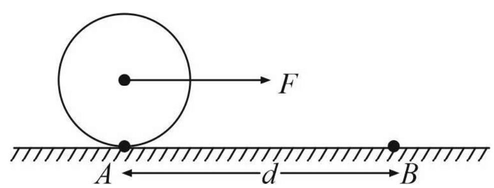
(D) Tenstion in string is 3 mg/5

31. A disc is given an initial angular velocity ω_0 and placed on rough horizontal surface as shown. The quantities which will not depend on the coeffcient of friction is/are



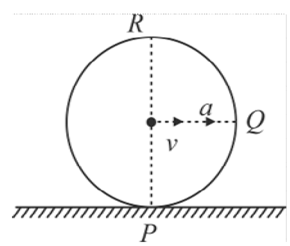
(A) The time until rolling begins.
(B) The displacement of centre of mass of the disc until rolling begins.
(C) The veocity when rolling begins.
(D) The work done by the force of friction.

32. A uniform ring is connected to a light axle with light spokes so as to from a wheel. The wheel is placed on a horizontal surface with its plane vertical and a constant horizontal force F is applied to the axle. Surface AB is rough and surface right to B is smooth. The wheel does not slip when it moves from A to B and takes time T to move the distance d between A and B.



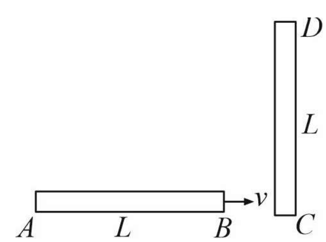
(A) Rotational KE remains constant right of B
(B) Energy is dissipated from A to B
(C) Linear acceleration of centre of mass of the ring right of B is more than linear acceleration left of B
(D) Linear acceleration of centre of mass of the wheel undergoes constant non-zero acceleration to the right of B.

33. A uniform wheel is rolling without slipping on a horizontal surface. At a certain instant, its centre of mass has velocity 'v' and acceleration 'a' of P, Q and R are three points on the rim of the disc as shown in the figure. Acceleration of.



(A) P is vertically upwards
(B) Q may be vertically downwards
(C) R cannot be horizontal
(D) Some point on the rim may be horizontal leftwards.

34. A rod CD of length L and mass M is placed horizontally on a frictionless horizontal surface as shown. A second identical rod AB which is also placed horizontally (perpendicular to CD) on the same horizontal surface is moving along the surface with a velocity v in a direction perpendicular to rod CD and its end B strikes the rod CD at end C and sticks to if rigidly. Then,



(A) Velocity of centre of mass of the system just after impact is $\frac{v}{4}$.

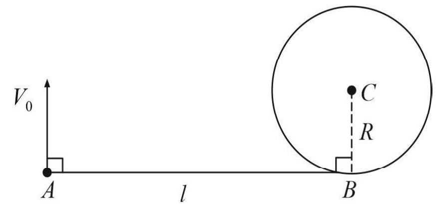
(B) The ω (angular speed) of system just after collision is $\frac{3v}{5L}$.

(C) Velocity of centre of mass of the system just after impact is $\frac{v}{2}$.

(D) The ω (angular speed) of system just after collision is $\frac{5v}{3L}$.

Paragraph for Q. 35 - 37

A particle A is attached through an ideal thread to a point B on the circumference of a smooth vertical cylinder as shown in the figure. Thread is horizontal and the particle can slide on a smooth horizontal plane. The particle is now given a horizontal speed V_0 perpendicular to thread as shown. For the subsequent motion, answer the following questions: (l = length of thread, R = radius of cylinder):



35. Angular momentum of particle is conserved about point:

(A) B **(B)** C **(C)** Midpoint of BC **(D)** None of these.

36. From start upto the moment particle strikes the cylinder, external torque required to keep the cylinder in equilibrium:

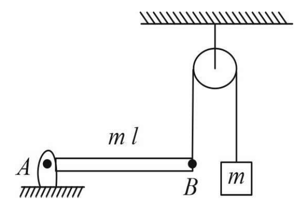
(A) It always zero **(B)** Continuously increases
(C) First increases then decreases. **(D)** Remains constant.

37. If the motion starts at t = 0, the time at which particle strikes the cylinder is:

(A) $\frac{l^2}{RV_0}$ **(B)** $\frac{l^2}{2RV_0}$ **(C)** $\frac{l^2}{3RV_0}$ **(D)** None of these

Paragraph for Q. 38 - 39

A uniform rod AB is hinged at the end A in a horizontal position as shown in the figure. The other end of the rod is connected to a block through a massless string as shown. The pulley is smooth and massless. Masses of the block and the rod are same and are equal to $'m'$.



38. Then just after release of block from this position, the tension in the thread is :

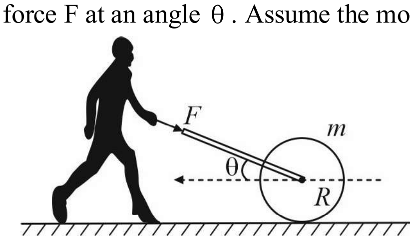
(A) $\frac{mg}{8}$ **(B)** $\frac{5mg}{8}$ **(C)** $\frac{11mg}{8}$ **(D)** $\frac{3mg}{8}$

39. Then just after release of block from this position, the magnitude of reaction exerted by hinge on the rod is :

(A) $\frac{3mg}{16}$ **(B)** $\frac{5mg}{16}$ **(C)** $\frac{9mg}{16}$ **(D)** $\frac{7mg}{16}$

Paragraph for Q. 40 - 42

A gardener presses the grasscutter with a force F at an angle θ. Assume the motion of grasscutter as pure rolling. Find the



40. Friction between the grasscutter (assumed as a disc) and grouind.

(A) $\frac{F\sin\theta}{3}$ **(B)** $\frac{F\cos\theta}{3}$ **(C)** $\frac{2F}{3}$ **(D)** $\frac{2F\cos\theta}{3}$

41. Acceleration of COM of the roller (disc). Assume that mass of the disc is m and neglect the mass of the connecting rod.

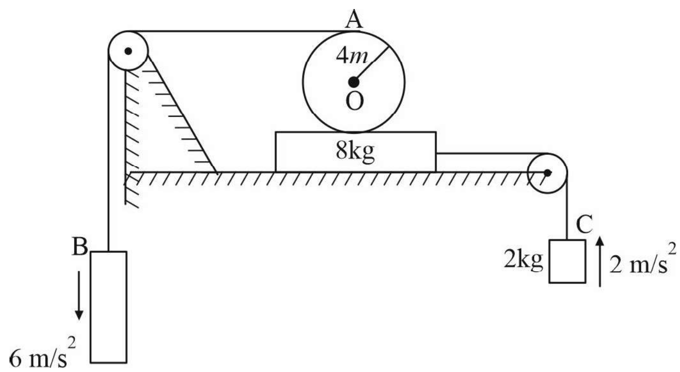
(A) $\frac{2F\cos\theta}{3m}$ **(B)** $\frac{F\sin\theta}{3m}$ **(C)** $\frac{2F\sin\theta}{3m}$ **(D)** $\frac{F\cos\theta}{3m}$

42. Maximum force F for no relative sliding if the coefficient of friction between the roller and ground is μ.

(A) $\dfrac{\mu mg\cos\theta}{\cos\theta+3\mu\sin\theta}$ **(B)** $\dfrac{\mu mg\sin\theta}{\cos\theta+3\mu\sin\theta}$ **(C)** $\dfrac{3\mu mg}{\cos\theta-3\mu\sin\theta}$ **(D)** $\dfrac{3\mu mg}{\cos\theta+3\mu\sin\theta}$

Paragraph for Q. 43 - 45

Figure shows a unform smooth solid cylinder A of radius 4 *m* rolling without slipping on the 8 kg plank which, in turn, is supported by a fixed smooth surface. Block B is known to accelerate down with 6 m/s^2 and block C moves down with acceleration $2 m/s^2$.



43. What is the angular acceleration of the cylinder?

(A) $\frac{4}{5} rad\ s^{-2}$ **(B)** $\frac{6}{5} rad\ s^{-2}$ **(C)** $2\,rad\ s^{-2}$ **(D)** $1\,rad\ s^{-2}$

44. What is the ratio of the mass of the cylinder to the mass of block B ?

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

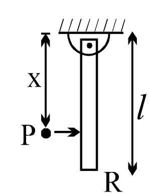
45. If unwrapped length of the thread between the cylinder and block B is 20 *m* at the beginning, when the system was released from rest, what would it be 2 *s* later ?

(A) 28 *m* **(B)** 30 *m* **(C)** 22 *m* **(D)** 32.5 *m*

MATRIX MATCH TYPE

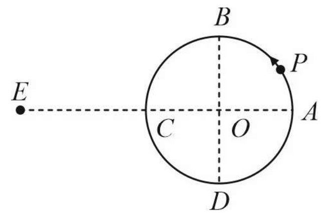
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column I are labelled as (A), (B), (C) & (D) whereas statements in Column II are labeled as p, q, r, s & t. More than one choice from Column II can be matched with Column I.

46. A particle P strikes the uniform rod R normally, elastically at a distance x from hinge as shown in the figure. The rod of length *l* is suspended vertically with upper end hinged.



Column I(Arrangement)		**Column II**(For the collision)	
(A)	If x = $\frac{l}{2}$, elastic collision	**(p)**	Linear momentum of (P+R) system increases
(B)	If x = *l*, elastic collision	**(q)**	Linear momentum of (P+R) system decreases
(C)	If x = $\frac{l}{2}$, P sticks to R	**(r)**	KE of the particle P decreases
(D)	If x = *l*, P sticks to R	**(s)**	Angular momentum of the (P+R) system is conserved about hinge.

47. A particle P moves with constant speed on a circle in anticlockwise direction as shown in figure

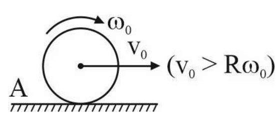


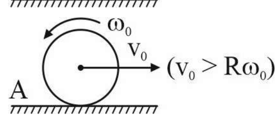
Match Column I with Column II :

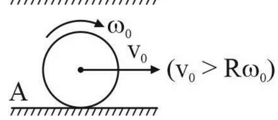
	Column I		Column II
(A)	Angular momentum of the particle about O	**(p)**	Is minimum when the particle is at A
(B)	Angular momentum of the particle about E	**(q)**	Is maximum when the particle is at A
(C)	Angular velocity of the particle about O	**(r)**	Does not remain constant
(D)	Angular velocity of the particle about E	**(s)**	Remains constant

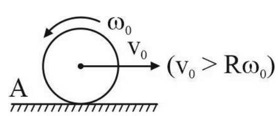
48. In each situation of Column I, a uniform disc of mass m and radius R rolls on a rough fixed horizontal surface as shown. At t = 0 (initially) the angular velocity of the disc is ω_0 and velocity of the centre of mass of the disc is v_0 (in horizontal direction). The relation between v_0 and ω_0 for each situation and also initial sense of rotation is given for each situation in Column I. Then match the statements in Column I with the corresponding results in Column II .

Column I

(A) 

(B) 

(C) 

(D) 

Column II

(p) The angular momentum of the disc about point A (as shown in the figure) remains conserved.

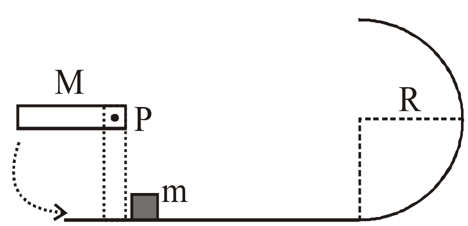
(q) The kinetic energy of the disc after it starts rolling without slipping is less than its initial kinetic energy

(r) In the duration disc rolls with slipping, the friction acts on the disc towards the left.

(s) In the duration disc rolls with slipping, the friction acts on the disc for some time to the right and for some time to the left.

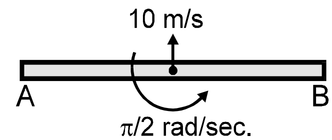
SUBJECTIVE INTEGER TYPE

49. A rod of length R and mass M is free to rotate about a horizontal axis passing through hinge P as shown in the figure. First it is taken aside such that it becomes horizontal and then released. At the lowest point the rod hits the block B of mass m and stops. If mass of rod is $\sqrt{60}$ kg, find mass of the block if it just complete the circle.

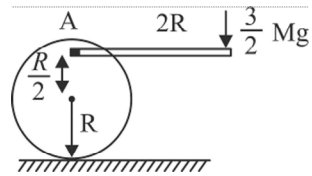


50. A uniform rod of length $\ell = 1$m is free to move and rotate in gravity-free space. When an impulse is given to one end of the rod, perpendicular to its length, its centre of mass moves with velocity v = 1 m/s. What will be its angular velocity (in rad/s) about its centre of mass.

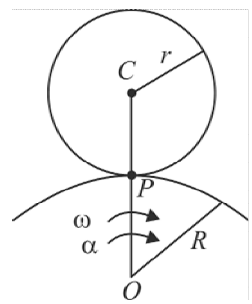
51. A uniform rod AB of length 4m and mass 12 kg is thrown such that just after the projection the centre of mass of the rod moves vertically upwards with a velocity 10 m/s and at the same time it is rotating with an angular velocity $\frac{\pi}{2}$ rad/sec about a horizontal axis passing through its mid point. Just after the rod is thrown it is horizontal and is as shown in the figure. Find the acceleration (in m/sec^2) of the point A in m/s^2 when the centre of mass is at the highest point. (Take g = 10m/s^2 and $\pi^2 = 10$)



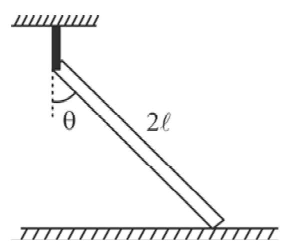
52. A disc of mass M and radius R is placed on a rough horizontal surface. A light rod of length 2 R is fixed to the disc at point A as shown in the figure and force $\frac{3}{2}Mg$ is applied at the other end. Find the minimum value of 10μ where μ is coefficient of friction (upto one decimal place) between disc and horizontal surface so that disc starts to roll without slipping.



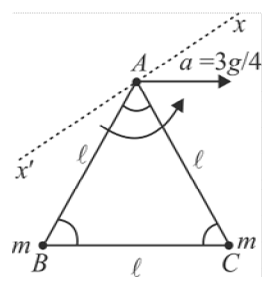
53. A uniform cylinder of mass m and radius r rolls on a fixed cylindrical surface of radius R. At a certain instant, the line OC has an angular velocity ω and angular acceleration α. Find:
Ifthe acceleration of point of contact P of the cylinder with respect to the surface is $\frac{7R(R+r)\omega^2}{kr}$
Then find value of k.



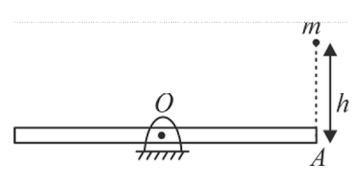
54. A uniform rod of length 2ℓ and mass m is suspended from one end by inextensible string and other end lies on smooth ground. The angle made by rod with vertical is $\theta = \sin^{-1}(1/\sqrt{3})$. If N_1 and N_2 represents the contact force from ground on rod just before and just after cutting string then find the ratio of N_1 / N_2.



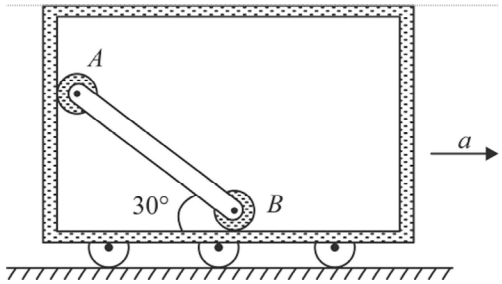
55. A rigid triangular fram consists of three massless rods of length $\ell = 2.5$ m each and point masses of mass m each at vertex B and C respectively. Frame is haning vertically from point A about which it can rotate freely about an axis xx' which is perpendicular to plane of frame as shwon in figure. Point of suspension of frame, i.e. A, is accelerating with constant acceleration $a = 3g/4$ in horizontal direction and initially frame is at rest w.r.t. support A. Minimum initial angular velocity $\omega = x(3)^{1/4}$ (in rad/s) provided to system, so that it can complete vertical circular motion in the frame of support A. Calculate the value of x. (take $g = 10$ m/s^2)



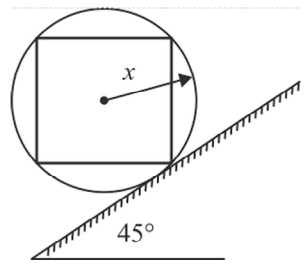
56. A uniform rod of length 12 metre and mass m is hinged at midpoint and lies horizontally at rest. Rod is free to rotate in vertical plane about hinge O. A particle of mass m is released from height h as shown in figure. Particle collides with end A and sticks to it. Calculate minimum height h (in metre) so that system can complete vertical circular motion.



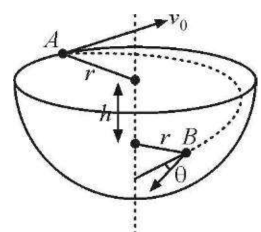
57. If a car is moving rightward with acceleration $a = g\sqrt{k}$ m/s rightward as shown in the figure. Find the value of k so that, rod maintains its orientation as shown in the figure. Neglect the friction and mass of the small rollers at A and B.



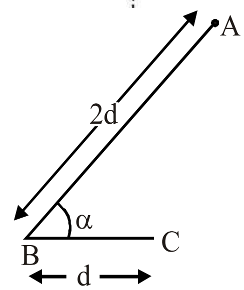
58. For identical rods, each of mass m are welded at their ends to form a square, and the corners are then welded to a light metal hoop of radius r. If the rigid assembly of rods and hoop is allowed to roll down the inclined rough surface. If the minimum value of the coefficient of static friction which will prevent slipping is $\frac{k}{10}$. Find the value of k.



59. A small particle is given an initial velocity $v_0 = 10\ m/s$ along the tangent to the brim of a fixed smooth hemisphere bowl of radius $r_0 = 15\sqrt{2}\ m$ as shown in the figure. The particle slides on the inner surface and reaches point B, a vertical distance h = 15 m below A and a distance r from the vertical center line, where its velocity v makes an angle θ with the horizontal tangent to the bowl through B. If $\theta = 15K°$. Find the value of K. (take g = 10 m/s^2) Vertical centre line



60. A uniform iron ribbon of mass 3m and length 3d is bent at B as shown in the figure and placed on a horizontal table in vertical plane. A fly of mass m is sitting at point A. Angle αis at which the ribbon is just about to topple? Find 8cos α.



JEE Advanced Revision Booklet	Gravitation

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

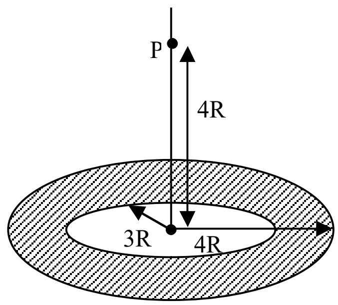
1. A satellite is projected with velocity $\sqrt{5/6}$ times its escape speed from earth's surface. The initial velocity of the satellite is parallel to the surface of earth. The maximum distance of the satellite from the centre of earth will be :

(A) $3R$ **(B)** $4R$ **(C)** $5R$ **(D)** $8R$

2. Two satellites S_1 and S_2 revolve around a planet in coplanar circular orbits in the same sense. Their periods of revolution are 1 hour and 8 hours respectively. The radius of the orbit of $S_1$is 10^4 km. When S_1 is closest to S_2, the angular speed of S_2 as observed by an astronaut in S_1 is :

(A) π rad/hr **(B)** 2π rad/hr **(C)** $\pi/3$ rad/hr **(D)** $\pi/2$ rad/hr

3. A thin uniform annular disc of mass M has outer radius 4R and inner radius 3R as shown in the figure. The work required to take a unit mass from point P on its axis to infinity is :



(A) $\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$ **(B)** $\frac{2GM}{7R}\left(4\sqrt{2}+5\right)$ **(C)** $\frac{GM}{4R}$ **(D)** $\frac{2GM}{5R}\left(\sqrt{2}-1\right)$

4. At what distance from the centre of the moon is the point at which the strength of the resultant field of earth's and moon's gravitational fields equal to zero ? The earth's mass is 81 times that of moon and the distance between centres of these planets is 60R where R is the radius of earth.

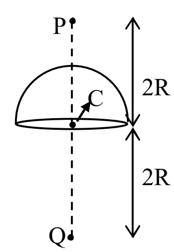
(A) 6R **(B)** 4R **(C)** 3R **(D)** 5R

5. When a satellite in a circular orbit around the earth enters the atmospheric region, it encounters air resistance to its motion. Then which of the following is incorrect :

(A) it loses mechanical energy **(B)** its kinetic energy increases

(C) its kinetic energy decreases **(D)** its angular momentum about the earth decreases

6. Gravitational field due to uniform thin hemispherical shell at point P is I, then the magnitude of gravitational field at Q is : (mass of hemisphere is M. radius R).



(A) $\frac{GM}{2R^2}-I$ **(B)** $\frac{GM}{2R^2}+I$

(C) $\frac{GM}{4R}-I$ **(D)** $2I-\frac{GM}{2R^2}$

7. A particle is projected form the earth's surface with an initial speed of 4 *km/sec*. What will be the maximum height attained by the particle in *km*:

(A) 382.6 **(B)** 914.3 **(C)** 435.2 **(D)** 637.6

8. A body placed in a capsule will be weightless with respect to the capsule, when the capsule, in the gravitational field of the Earth is :

(A) free falling vertically
(B) a projectile near the surface of the earth
(C) falling with a constant acceleration
(D) projected from the surface of the earth with an escape velocity

9. A satellite is orbiting around the earth in a circular orbit of radius r. A particle of mass m is projected from the satellite in a forward direction with a velocity $v = \sqrt{2/3}$ times the orbital velocity (this velocity is given w.r.t. earth). During subsequent motion of the particle, its minimum distance from the centre of earth is :

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

10. A rocket is launched normal to the surface of the Earth, away from the Sun, along the line joining the Sun and the Earth. The Sun is 3×10^5 times heavier than the Earth and is at a distance 2.5×10^4 times larger than the radius of the Earth. The escape velocity from Earth's gravitational field is $v_e = 11.2\ \text{kms}^{-1}$. The minimum initial velocity (v_s) required for the rocket to be able to leave the *Sun-Earth system* is closest to

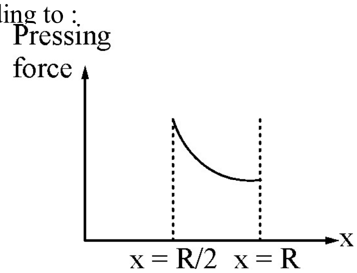
(*Ignore the rotation and revolution of the Earth and the presence of any other planet*)

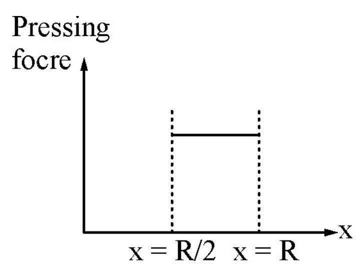
(A) $v_s = 62\,\text{kms}^{-1}$ **(B)** $v_s = 42\,\text{kms}^{-1}$ **(C)** $v_s = 72\,\text{kms}^{-1}$ **(D)** $v_s = 22\,\text{kms}^{-1}$

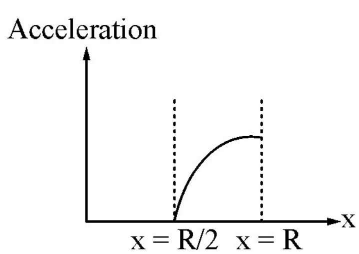
MULTIPLE CORRECT ANSWERS TYPE

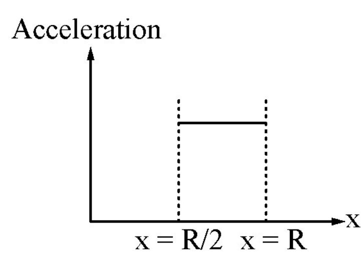
Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

11. A tunnel is dug along a chord of earth at perpendicular distance $R/2$ from the earth's centre. The wall of the tunnel may be assumed to be frictionless. A particle is released from one end of the tunnel. The pressing force by the particle on the wall, and the acceleration of the particle vary with x(distance of the particle from the centre) according to :

(A)


(B)


(C)


(D)


12. An orbiting satellite will escape if

(A) Its speed is increased by 41%
(B) Its speed in the orbit is made $\sqrt{(1.5)}$ times of its initial value
(C) Its *KE* is doubled **(D)** It stops moving in the orbit

13. Two satellites S_1 and S_2 of equal masses go round a heavy planet in coplanar circular orbits of radii R and 4R.

(A) The ratio of periods of revolution of S_1 and S_2 is 1 : 8
(B) Their speeds are in the ratio 2 : 1
(C) Their angular momenta are in the ratio 1:2
(D) None of these

14. A massive uniform sphere has an eccentric spherical cavity inside it, with the centre of cavity at a distance of ℓ from the centre of massive sphere. A small particle placed inside the cavity will experience a gravitational force :

(A) of zero magnitude
(B) a magnitude and direction different at different positions in the cavity
(C) constant irrespective of its position
(D) of magnitude proportional to ℓ

15. Planck's constant *h*, speed of light *c* and gravitational constant *G* are used to form a unit of length *L* and a unit of mass *M*. Then the correct option (s) is(are) :

(A) $M \propto \sqrt{c}$ **(B)** $M \propto \sqrt{G}$ **(C)** $L \propto \sqrt{h}$ **(D)** $L \propto \sqrt{G}$

16. A double star is a system of two stars of masses *m* and 2 *m* rotating about their centre of mass only under their mutual gravitational attraction. If *r* is the separation between the two starts then their time period of rotation about their centre of mass will be proportional to :

(A) $r^{\frac{3}{2}}$ **(B)** r **(C)** $m^{\frac{1}{2}}$ **(D)** $m^{-\frac{1}{2}}$

17. An artificial satellite of mass *m* is moving in a circular orbit around the earth of mass *M* and radius *R* with a speed equal to half of the magnitude of escape velocity on the surface of earth). Then

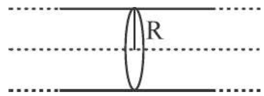
(A) If the satellite is stopped suddenly in the orbit and is allowed to fall freely towards the earth, the speed with which it hits the surface of earth is $\sqrt{gR}$
(B) The escape velocity with respect to the earth in the same orbit is $\sqrt{\frac{GM}{R}}$
(C) The energy spent in shifting this satellite to an orbit at a further height R/2 from the present orbit is $\frac{GMm}{12R}$
(D) The energy spent in shifting this satellite to an orbit at a further height R/2 from the present orbit is $\frac{GMm}{20R}$

18. Two particle of mass *m* and 4*m* are at rest at an infinite separation. They move towards each other under mutual gravitational attraction. If G is the universal gravitational constant. Then at separation r, (Assume zero reference potential energy at infinite separation).

(A) The total energy of the two object is zero
(B) Their relative velocity of approach is $\left(\frac{10Gm}{r}\right)^{1/2}$ in magnitude
(C) The total kinetic energy of the object is $\frac{4Gm^2}{r}$
(D) Net angular momentum of both the particles is zero about any point

Paragraph for Q. 19 - 21

Consider a hypothetical planet which is very long and cylindrical. The density of the planet is ρ and its radius is R.



19. What is the possible orbital speed of the satellite in moving around the planet in circular orbit in a plane which is perpendicular to the axis of planet?

(A) $R\sqrt{\pi G\rho}$ **(B)** $2R\sqrt{\pi G\rho}$ **(C)** $R\sqrt{2\pi G\rho}$ **(D)** $D\sqrt{\frac{G\rho}{2\pi}}$

20. If an object is projected radially outwards from the surface such that it reaches upto a maximum distance of $3R$ from the axis then what should be the speed of projection?

(A) $R\sqrt{\frac{2}{3}\pi\rho G}$ **(B)** $2R\sqrt{\pi\rho G\ln 3}$ **(C)** $R\sqrt{\frac{4}{3}\pi\rho G}$ **(D)** $R\sqrt{\frac{2}{3}\pi\rho G\ln 3}$

21. Assume that the planet is rotating about its axis with time period T. How far from the axis of the planet do the **geo synchronous tele-communications satellite** orbit?

(A) $RT\sqrt{\pi G\rho}$ **(B)** $2RT\sqrt{\pi G\rho}$ **(C)** $RT\sqrt{2\pi G\rho}$ **(D)** $RT\sqrt{\frac{G\rho}{2\pi}}$

MATRIX MATCH TYPE

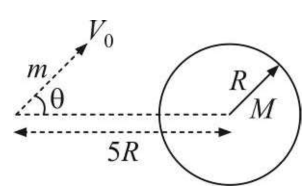
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column I are labelled as (A), (B), (C) & (D) whereas statements in Column II are labeled as p, q, r, s & t. More than one choice from Column II can be matched with Column I.

22. **Match the column**

	Column I		Column II
(A)	Geostationary satellite	**(p)**	Circular orbit
(B)	Total energy of earth satellite system is constant in	**(q)**	Elliptical orbit
(C)	Angular momentum of satellite about centre of earth is constant in	**(r)**	Equatorial plane orbit
(D)	Orbital speed of satellite may be constant	**(s)**	Non-equatorial plane orbit

SUBJECTIVE INTEGER TYPE

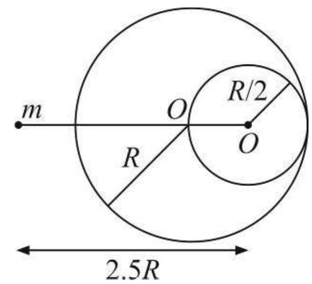
23. A spaceship is sent to investigate a planet of mass M and radius R. While hanging motionless in space at a distance $5R$ from the centre of the planet, the spaceship fires an instrument package of mass m, which is much smaller than the mass of the spaceship. For angle θ the package just graze the surface of the planet? If $\theta = \sin^{-1}\left(\frac{1}{K}\sqrt{1+\frac{8GM}{5V_0^2 R}}\right)$, find K.



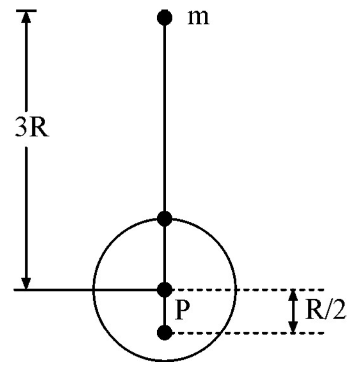
24. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $1/4^{\text{th}}$ of its value at the surface of the planet. If the escape velocity from the planet is $v_{esc} = v\sqrt{N}$, then the value of N is __________. (Ignore energy loss due to atmosphere)

25. Distance between centres of two stars is $10a$. The masses of these stars are M and $16M$ and their radii are a and $2a$, respectively. A body is fired straight from the surface of the larger star towards the smaller star. Its minimum initial speed to reach the surface of the smaller star is $\frac{3}{2}\sqrt{\frac{KGM}{a}}$ find value of K.

26. A solid sphere of radius $R/2$ is cut out of a solid sphere of radius R that the spherical cavity so formed touches the surface on one side and the centre of the sphere on the other side, as shown. The initial mass of the solid sphere was M. If a particle of mass m is placed at a distance $2.5R$ from the centre of the cavity. If the gravitational attraction on the mass m is $\frac{KGMm}{100R^2}$, find $\frac{K}{23}$.



27. A point mass m is released from rest at a distance of $3R$ from the centre of a thin-walled hollow sphere of radius R and mass M as shown. The hollow sphere is fixed in position and the only force on the point mass is the gravitational attraction of the hollow sphere. There is a very small hole in the hollow sphere through which the point was falls as shown. The velocity of a point mass when it passes through point P at a distance $R/2$ from the centre of the sphere is $\sqrt{\frac{nGM}{3R}}$, find n.



28. The gravitational potential energy of a satellite revolving around the earth in circular orbit is -4MJ. Find the additional energy (in MJ) that should be given to the satellite so that it escapes from the gravitational field of earth. Assume earth's gravitational force to be the only gravitational force on the satellite and no atmospheric resistance.

29. A binary star consists of two stars A (mass $2.2M_s$) and B (mass $11M_s$), where M_s is the mass of the sun. They are separated by distance d and are rotating about their centre of mass, which is stationary. The ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass is :

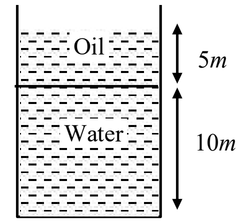
30. Gravitational acceleration on the surface of a planet is $\sqrt{6}/11g$, where g is gravitational acceleration on the surface of the earth. The average mass density of the planet is planet is 2/3 times that the earth. If the escape speed on the surface of the earth is taken to be 11 Kms^{-1}, the escape speed on the surface of the planet in Kms^{-1}will be:

JEE Advanced Revision Booklet	Liquids

SINGLE CORRECT ANSWER TYPE

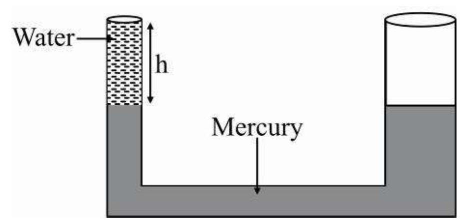
Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A vessel of uniform cross section (open at the top with an orifice at the bottom contains oil (relative density 0.8) on top of water. Water flows out of the vessel. The initial speed of water for the values given in the figure is nearly. (Take g = 10 m/s^2)



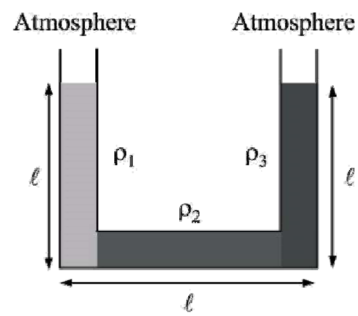
(A) 10.0 *m/s* **(B)** 8.0 *m/s*
(C) 16.7 *m/s* **(D)** 5.0 *m/s*

2. Two communicating vessels contain mercury. The diameter of one vessel is n times than the diameter of the other. A column of water of height h is poured into the left vessel. The mercury level will rise in the right-hand vessel (s = relative density of mercury and ρ = density of water) by



(A) $\dfrac{n^2 h}{(n+1)^2 s}$ **(B)** $\dfrac{h}{(n^2+1)s}$
(C) $\dfrac{h}{(n+1)^2 s}$ **(D)** $\dfrac{h}{n^2 s}$

3. Three liquids having densities ρ_1, ρ_2 and ρ_3 are filled in a U-tube. Length of each liquid column is equal to ℓ, $\rho_1 > \rho_2 > \rho_3$ and liquids remain at rest (relative to the tube) in the position shown in the figure. It is possible that :

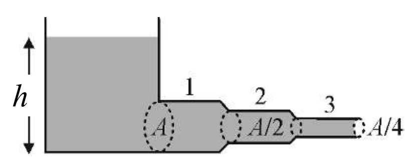


(A) U-tube is accelerating leftwards
(B) U-tube is accelerating upwards with acceleration *g*
(C) U-tube is moving with a constant velocity
(D) None of the above

4. A sphere of solid material of specific gravity 8 has a concentric spherical cavity and just sinks in water. The ratio of radius of cavity to that of outer radius of the sphere must be :

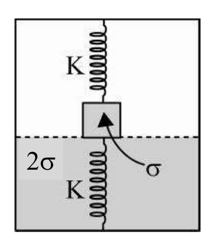
(A) $\dfrac{7^{1/3}}{2}$ **(B)** $\dfrac{5^{1/3}}{2}$ **(C)** $\dfrac{9^{1/3}}{2}$ **(D)** $\dfrac{3^{1/3}}{2}$

5. In the figure shown the velocity and pressure of the liquid at the small cross section (2) are given by : (If P$_0$ is the atmospheric pressure).



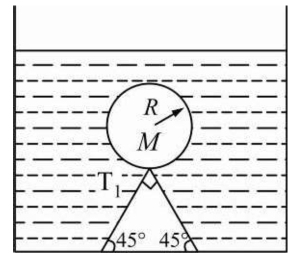
(A) $\sqrt{2hg}, P_0 + \dfrac{\rho hg}{2}$ **(B)** $\sqrt{hg}, P_0 + \dfrac{\rho hg}{2}$
(C) $\sqrt{\dfrac{hg}{2}}, P_0 + \dfrac{3\rho hg}{4}$ **(D)** $\dfrac{\sqrt{hg}}{2}, P_0 + \dfrac{3\rho hg}{4}$

6. A cubic block of side *a* is connected with two similar vertical springs as shown. Initially, bottom surface of the block of density σ touches the surface of the fluid of density 2σ while floating. A weight is placed on the block so that it is immersed half the fluid, then the weight is :



(A) $a\left(\dfrac{K}{2} + a^2\sigma g\right)$ **(B)** $a\left(K + a^2\sigma g\right)$
(C) $a\left(K + \dfrac{a^2}{2}\sigma g\right)$ **(D)** $\dfrac{a}{2}\left(K + a^2\sigma g\right)$

7. A hollow sphere of mass M and radius R is immersed in a tank of water $(\text{density } \rho_w)$. The sphere would float if it were set free. The sphere is tied to the bottom of the tank by two wires which makes angle $45°$ with the horizontal as shown in the figure. The tension T_1 in the wire is:



(A) $\dfrac{\frac{4}{3}\pi R^3\rho_w g - Mg}{\sqrt{2}}$ **(B)** $\frac{2}{3}\pi R^3\rho_w g - Mg$

(C) $\frac{4}{3}\pi R^3\rho_w g - Mg$ **(D)** $\frac{4}{3}\pi R^3\rho_w g + Mg$

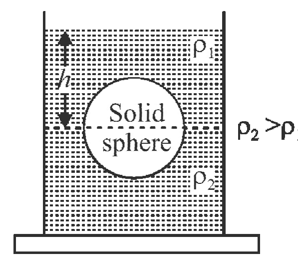
8. A body of density ρ' is dropped from rest at a height h into a lake of density ρ where $\rho > \rho$. Neglecting all dissipative forces calculate the maximum depth to which the body sinks before returning to float on the surface.

(A) $\dfrac{h}{\rho-\rho'}$ **(B)** $\dfrac{h\rho'}{\rho}$ **(C)** $\dfrac{h\rho'}{\rho-\rho'}$ **(D)** $\dfrac{h\rho}{\rho-\rho'}$

9. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is :

(A) $M\omega^2L/2$ **(B)** $M\omega^2L$ **(C)** $M\omega^2L/4$ **(D)** $M\omega^2L^2/2$

10. A solid sphere of radius r is floating at the interface at the interface of two immiscible liquids of densities ρ_1 and $\rho_2 (\rho_2 > \rho_1)$, half of its volume lying in each. The height of the upper liquid column from the interface of the two liquids is h. The force exerted on the sphere by the upper liquid is (atmoshperic pressure $= p_0$ and acceleration due to gravity is g):



(A) $P_0\pi r^2 + \left(h - \frac{2}{3}r\right)\pi r^2\rho_1 g$ **(B)** $\left(h - \frac{2}{3}r\right)\pi r^2\rho_1 g$

(C) $\frac{2}{3}\pi r^3\rho_1 g$ **(D)** $P_0 \times \pi r^2$

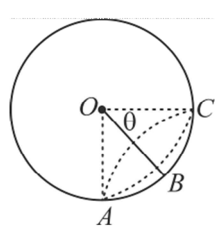
11. A cylinderical wooden float whose base area S and the height H drifts on the water surface. Density of wood d and density of water is ρ. What minimum work must be performed to take the float out of the water?

(A) $\dfrac{Sdg^2H^2}{4\rho}$ **(B)** $\dfrac{Sgd^2H^2}{2\rho}$ **(C)** $\dfrac{Sgd^2H^2}{\rho}$ **(D)** $\dfrac{Sgd^2H^2}{3\rho}$

12. An isolated and charged spherical soap bubble has a radius ‘r’ and the pressure inside is atmospheric. If ‘T’ is the surface tension of soap solution, then charge on drop is:

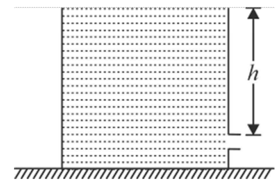
(A) $2\sqrt{\dfrac{2rT}{\varepsilon_0}}$ **(B)** $8\pi r\sqrt{2rT\varepsilon_0}$ **(C)** $8\pi r\sqrt{rT\varepsilon_0}$ **(D)** $8\pi r\sqrt{\dfrac{2rT}{\varepsilon_0}}$

13. Consider a small water drop in air. If T is the surface tension, then what is the force due to surface tension acting on the smaller section ABC ?



(A) $2\pi TR$ **(B)** $2\pi TR\sin\theta$ **(C)** $2\pi TR\sin^2\theta$ **(D)** $2\pi TR\sin^3\theta$

14. In the figure shown, a light container is kept on a horizontal rough surface of coefficient of friction $\mu = \frac{Sh}{V}$. A very small hole of area S is made at depth 'h'. Water of volume 'V' is filled in the container. The friction is not sufficent to keep the container at rest. The acceleration of the container initially is:



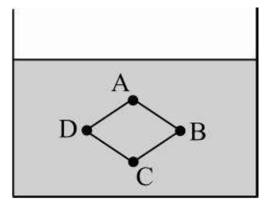
(A) $\frac{V}{Sh}g$ **(B)** g

(C) zero **(D)** $\frac{Sh}{V}g$

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

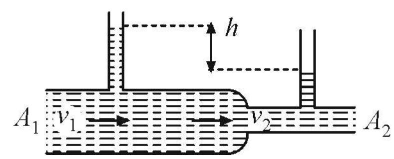
15. Figure shows a container filled with a liquid of density ρ. Four points A, B, C and D on the vertices of a vertical square. Points A and C lie on a vertical line and points B and D lies on a horizontal line. Choose the correct statement(s) about the pressure at the four points.



(A) $P_D = P_B$ **(B)** $P_A < P_B = P_D < P_C$

(C) $P_D = P_B = \frac{P_C - P_A}{2}$ **(D)** $P_D = P_B = \frac{P_C + P_A}{2}$

16. A liquid flows through a horizontal tube. The velocities of the liquid in the two sections, which have areas of cross section A_1 and A_2 are v_1 and v_2 respectively. The difference in the levels of the liquid in the two vertical tubes is h. Then



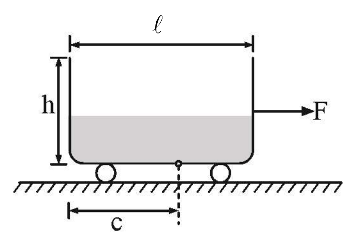
(A) The volume of the liquid flowing through the tube in unit time is A_1v_1

(B) $v_2 - v_1 = \sqrt{2gh}$

(C) $v_2^2 - v_1^2 = 2gh$

(D) The energy per unit mass of the liquid is the same in both sections of the tube

17. A rectangular vessel of dimension $(l \times b \times h)$ and mass M contains a liquid of density ρ. The vessel has an orifice at its bottom at a distance c from the rear wall as shown in the figure.



(A) The maximum volume of the water that can be stored when the vessel is accelerated is $hcb/2$

(B) The maximum volume of the water that can be stored when the vessel is accelerated is $hlb/2$

(C) Force F that must be applied when maximum water stored is $\left[M + \frac{hcb\,\rho}{2}\right]\frac{hg}{c}$

(D) Force F that must be applied when maximum water stored is $\left[M + \frac{hcb\rho}{2}\right]\frac{lg}{c}$

18. A wooden block is floating in a water tank. The block is pressed to the bottom. During the process, a work is done. Which of the following statements are false?

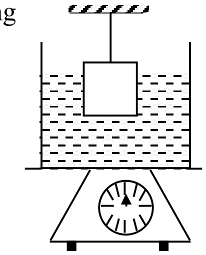
(A) Work done is equal to work done against upthrust exerted by the water

(B) Work done is equal to work done against upthrust plus loss of gravitational potential energy of the block

(C) Work done is equal to work done against upthrust minus loss of gravitational potential energy of the block

(D) Work done is equal to loss of gravitational potential energy of the block

19. The mass of block is m_1 and that of liquid with the vessel is m_2. The block is suspended by a string (tension T) partially in the liquid. The reading of the weighting machine placed below the vessel.



(A) is $(m_1 + m_2)\,g$

(B) is greater than $(m_1 + m_2)\,g$

(C) is equal to $(m_1 g + m_2\,g - T)$

(D) is less than $(m_1 + m_2)\,g$

20. A body floats on water and also on an oil of density 1.25. Which of te following is/are true?

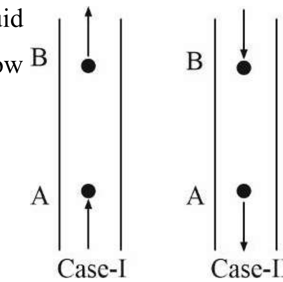
(A) The body loses more weight in oil than in water

(B) The volume of water displaced is 1.25 times that of oil displaced.

(C) The body experiences equal upthrust from water and oil

(D) To make the body just sink, one will need 1.25 times load in case of oil than in case of water

21. Two tubes of uniform cross-section are held vertically. u_A and u_B are the velocities of fluid flow at A and B respectively, and p_A and p_B are pressure at A and B respectively. Arrow show the direction of fluid flow.



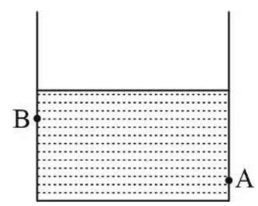
(A) In case I, $u_A > u_B$ and $p_A > p_B$

(B) In case I, $u_A = u_B$ and $p_A > p_B$

(C) In case II, $u_A > u_B$ and $p_A < p_B$

(D) In case II, $u_A = u_B$ and $p_A > p_B$

22. The container carrying some liquid shown in the diagram is given some small acceleration $\vec{a}$.



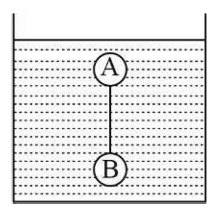
(A) If $\vec{a}$ is directed upwards, $P_A - P_B$ increases

(B) If $\vec{a}$ is directed towards right, $P_A - P_B$ decreases

(C) If $\vec{a}$ is directed downwards, $P_A - P_B$ remain same

(D) If $\vec{a}$ is directed towards left, $P_A - P_B$ remain same

23. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into an equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if:

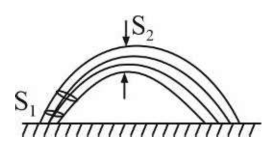


(A) $d_A < d_F$ **(B)** $d_B > d_F$

(C) $d_A > d_F$ **(D)** $d_A + d_B = 2d_F$

24. Water jet is projected at an angle to the horizontal. At the point of projection, the area of the jet is S_1 and at the highest point, the area of the jet is S_2. The initial velocity of projection is u.

(A) The angle of projection is $\cos^{-1}\left(\frac{S_1}{S_2}\right)$



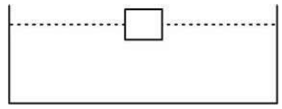
(B) The range on the level ground is $\frac{2u^2}{g}\frac{S_1}{S_2}\sqrt{1-\frac{S_1^2}{S_2^2}}$

(C) The maximum height reached from the ground is $\frac{2u^2}{g}\left(1-\frac{S_1^2}{S_2^2}\right)$

(D) The rate of volume flow is $S_2 u$

Passage For Questions 25 - 27

A cube made of wood having specific gravity 0.4 and side length `a' is floated in a large tank fullof water.



25. Which action would change the depth to which block is submerged?

(A) more water is added in the tank **(B)** atmospheric pressure increases

(C) the tank is accelerated upwards **(D)** none of these

26. If the cube is depressed slightly, it executes SHM from it's position. What is it's time period?

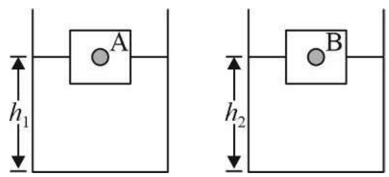
(A) $2\pi\sqrt{\frac{a}{g}}$ **(B)** $2\pi\sqrt{\frac{5a}{2g}}$ **(C)** $2\pi\sqrt{\frac{2a}{5g}}$ **(D)** $\frac{4\pi}{5}\sqrt{\frac{a}{g}}$

27. What can be the maximum amplitude of it's vertical simple harmonic motion?

(A) $\frac{a}{2}$ **(B)** $0.4a$ **(C)** $0.6a$ **(D)** $0.2a$

Passage For Questions 28 - 30

Two ice cubes of side 10 cm, having cavity of volume $20\ \text{cm}^3$ at centre of cube but filled with different materials A and B respectively. The specific gravity of material A is 4.9 and specific gravity of material B is 1.9. Now these cubes are placed in two different vessels of same base area as shown in figure. The water level before putting blocks in vessels are same. Assume that ice melts uniformly from all sides and with same constant rate in both the vessels. (specific gravity of ice = 0.9)



28. Find the ratio of initial submerged volumes of the blocks containing A and B respectively :

(A) $\frac{49}{46}$ **(B)** 1 : 1 **(C)** $\frac{49}{19}$ **(D)** 4 : 1

29. Choose the correct statement :

(A) Both cubes sink simultaneously

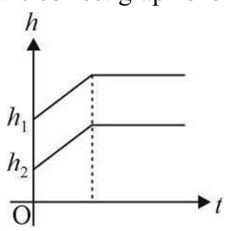
(B) A and B sink only after complete melting of ice

(C) A sinks prior to B

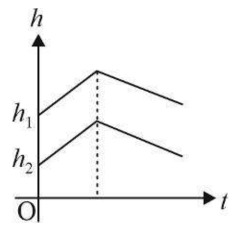
(D) B sinks prior to A

30. Choose the correct graph showing the variation of heights of water-level in two vessels with time :

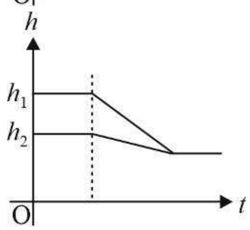
(A)



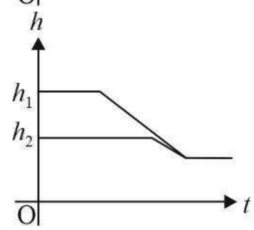
(B)



(C)



(D)



Passage For Questions 31 - 33

You may have heard of g -LOC. In simple terms, it is gravity induced loss of consciousness. This seems surprising. How can gravity lead to a loss of consciousness. For this, we have to remember that brain functions properly when the heart maintains a proper blood pressure in the brain. The brain is higher than heart by about 30 cm, so blood pressure at brain is less than that at the heart. When there is a sudden change in acceleration, the pressure at heart changes. If this decreases the pressure in brain, the brain system can stop functioning. This decrease in pressure can be fatal.

It is seen that when the effective acceleration due to gravity is $3g$, the person can undergo g-LOC. For this problem, we can assume that density of blood $= 1\times 10^3$ kg/m^3.

31. Assume that a pilot flying a plane takes a horizontal turn with a speed of 100 m/s. What is the minimum radius he can take?

(A) $\frac{1000}{3}$ m **(B)** $250\sqrt{2}$ m **(C)** 250 m **(D)** $\frac{250}{3}$ m

32. What is the pressure difference between heart and brain when there is g-LOC?

(A) 1000 Pa **(B)** 3000 Pa **(C)** 6000 Pa **(D)** 9000 Pa

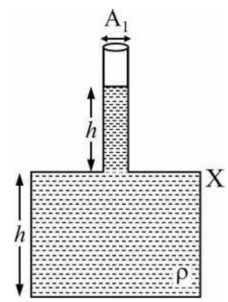
33. In which of the following cases, a person can undergo g-LOC?

(A) A person falls down vertically **(B)** A person jumps with a parachute

(C) A person slides on a slide **(D)** A person sits in a rocket fired vertically up

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labelled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.



34. The vessel has two sections of areas of cross-section A_1 *and* A_2. A liquid of density ρ fills both the sections, up to a height h in each. Neglect atmospheric pressure.

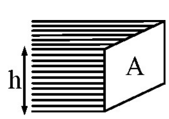
	Column 1		Column 2
(P)	The pressure at the base of the vessel	**1.**	$2h\rho gA_2$
(Q)	The force exerted by the liquid on the base of vessel	**2.**	$2h\rho g$
(R)	The weight of the liquid is less than	**3.**	$h\rho g(A_2 - A_1)$
(S)	Download force on the liquid by the walls of the vessel at the level X	**4.**	$2h\rho gA_1$

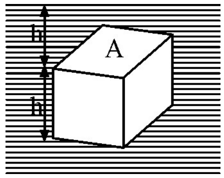
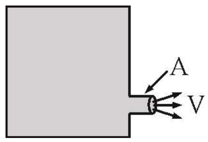
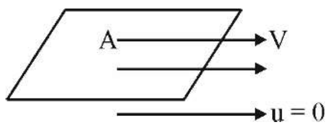
Codes :

	P	Q	R	S		P	Q	R	S
(A)	2	1	1	3	**(B)**	2	1	4	3
(C)	4	1	1	3	**(D)**	2	1	3	4

35. **MATCH THE FOLLOWING :**

	Column 1		Column 2
(P)	Hydrostatic force on the side wall of the cubical vessel, ρ = density of liquid	**1.**	$A\rho v^2$



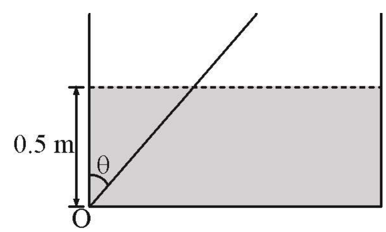
(Q)	Buoyant force on the cube, ρ = density of liquid 	**2.**	$\frac{1}{2}A\rho v^2$
(R)	Impact (reaction) force on the vessel by the liquid coming out of the vessel, ρ = density of liquid 	**3.**	ρghA
(S)	Aerodynamic force acting on the flat roof surface of area A, ρ = density of air 	**4.**	$\frac{1}{2}\rho ghA$

Codes :

	P	Q	R	S		P	Q	R	S
(A)	4	3	2	1	**(B)**	4	1	1	1
(C)	4	3	1	2	**(D)**	4	2	1	3

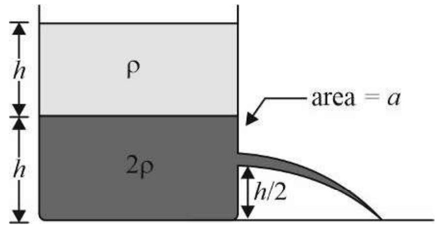
SUBJECTIVE INTEGER TYPE

36. A wooden plank of length 1 *m* and uniform cross section is hinged at one end to the bottom of a tank as shown in the figure. The tank is filled with water up to a height of 0.5 *m*. The specific gravity of the plank is 0.5. If θ is the angle that the plank makes with the vertical equilibrium position. (Exclude the case $\theta = 0$). Find the value of $\frac{1}{cos^2\theta}$.



37. *n* drops of water, each of radius 2*mm*, fall through air at a terminal velocity of 8 *cm/s*. If they coalesce to form a single drop, then the terminal velocity of the combined drop is 32 *cm/s*. The value of *n* is __________.

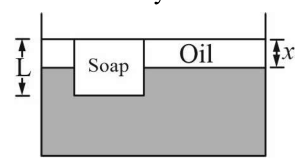
38. A fixed cylindrical tank having large cross-section area is filled with two liquids of densities ρ and 2ρ and in equal volumes as shown in the figure. A small hole of area of cross-section $a = \sqrt{6}\,\text{cm}^2$ is made at height $\frac{h}{2}$ from the bottom. Find the area of cross-section of stream of liquid in cm^2 just before it hits the ground.



39. A cube (density 0.5 gm/cc) of side 10 cm is floating in water kept in a cylinderical beaker of base area 1500 cm^2. When a mass m is kept on wooden block the level of water rises in the beaker by 2 mm. Find the mass m (in gm).

40. A ballon has a volume of 0.09 m^3 below the surface of the water (density 10^3 kg/m^3) at a depth of 40 m. If the temperature remains constant, what is its volume in m^3 when it is at the surface where the pressure is $1\times10^5\text{ N/m}^2$?

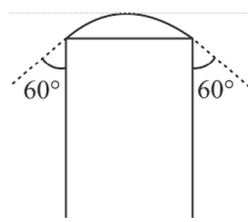
41. A rectangular bar of soap has density 800 kg/m^3 floats in water of density 1000 kg/m^3. Oil of density 300 kg/m^3 is slowly addes, forming a layer that does not mix with the water. When the top surface of the oil is at the same level as the top surface of the soap, what is the ratio of the oil layer thickness to the soap's thickness, x / L?



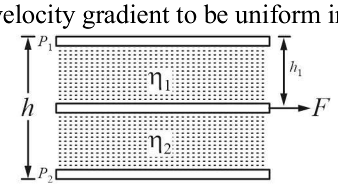
42. A barometer of length 0.99 m reads 0.76 m. The volume of air measured at atmospheric pressure to be introduced into space to cause the length of mercury column to drop to 0.57 m is in cm^3 (the cross-section of the barometer tube is 0.1cm^2)?

43. A sphere of radius 10 cm and density 500 kg/m^3 is under water of density 1000 kg/m^3. The acceleration of the sphere is 9.80 m/s^2 upward. Viscosity of water is 1.0 centipoise. If $g = 9.81\text{ m/s}^2$, the velocity of the sphere in m/s is _____.

44. A soap bubble is being blown on a tube of radius 1 cm. The surface tension of the soap solution is 0.05 N/m and the bubble makes an angle of 60° with the tube as shown. The excess of pressure over the atmospheric pressure in the tube is______ (in Pa)



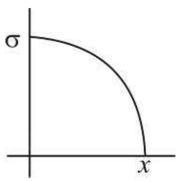
45. A thin horizontal movable plate is separated from two fixed horizontal plates P_1 and P_2 by two highly viscous liquids of coefficient of viscosity η_1 and η_2 as shown, where $\eta_2 = 4\eta_1$. Area of contact of movable plate with each fluid is same. If the distance between two fixed plates is h, and the distance of movable plate from upper fixed plate such that the movable plate can be moved with a constant velocity by applying a minimum constant horizontal force F on movable plate is h, then h/h_1, is ____. (assume velocity gradient to be uniform in each liquid)

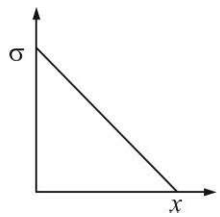


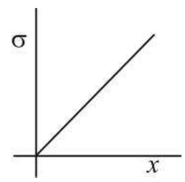
SINGLE CORRECT ANSWER TYPE

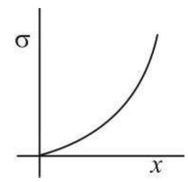
Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A uniform rod rotating in gravity free region with certain constant angular velocity. The variation of tensile stress with distance x form axis of rotation is best represented by which of the following graphs:

(A) 

(B) 

(C) 

(D) 

2. The specific heat of a metal at low temperatures varies according to $S = aT^3$ where a is a constant and T is the absolute temperature. The heat energy needed to raise temperature of unit mass of the metal from $T = 1\ K$ to $T = 2\ K$ is:

(A) $3\ a$ **(B)** $\frac{15a}{4}$ **(C)** $\frac{2a}{3}$ **(D)** $\frac{12a}{5}$

3. A thin copper wire of length L increase in length by 1% when heated from temperature T_1 to T_2. What is the percentage change in area when a thin copper plate having dimensions $2L \times L$ is heated from T_1 to T_2?

(A) 1% **(B)** 2% **(C)** 3% **(D)** 4%

4. A rod of length $2m$ at $0°C$ and having expansion coefficient $\alpha = (3x+2) \times 10^{-6}\ °C^{-1}$ where x is the distance (in cm) from one end of rod. The length of rod at $20°C$ is :

(A) $2.124\ m$ **(B)** $3.24\ m$ **(C)** $2.0120\ m$ **(D)** $3.124\ m$

5. A cylinder of radius R made of a material of thermal conductivity k_1 is surrounded by a cylindrical shell of inner radius R and outer radius $2R$ made of a material of thermal conductivity k_2. The two ends of the combined system are maintained at different temperatures. There is no loss of heat from the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is:

(A) $k_1 + k_2$ **(B)** $\frac{k_1 k_2}{k_1 + k_2}$ **(C)** $\frac{1}{4}(k_1 + 3k_2)$ **(D)** $\frac{1}{4}(3k_1 + k_2)$

6. A long solid cylinder is radiating power. It is remolded into a number of smaller cylinders, each of which has the same length as original cylinder. Each small cylinder has the same temperature as the original cylinder. The total radiant power emitted by the pieces is twice that emitted by the original cylinder. How many smaller cylinders are there? Neglect the energy emitted by the flat faces of cylinder.

(A) 3 **(B)** 4 **(C)** 5 **(D)** 6

7. A black body calorimeter filled with hot water cools from $60°C$ to $50°C$ in 4 min and $40°C$ to $30°C$ in 8 min. The approximate temperature of surrounding is :

(A) $10°C$ **(B)** $15°C$ **(C)** $20°C$ **(D)** $25°C$

8. A steel wire with cross section 3 cm^2 has elastic limit 2.4×10^8 pa. The maximum upward acceleration that can be given to 1200 kg elevator supported by this cable if the stress is not to exceed 1/3rd of the elastic limit is : ($g = 10\ m/s^2$)

(A) $9ms^{-2}$ **(B)** $10ms^{-2}$ **(C)** $11ms^{-2}$ **(D)** $12ms^{-2}$

9. Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 is thrice that of S_2. Both the spheres are heated to the same high temperature and placed in the same room having lower temperature but are thermally insulated from each other. The ratio of the initial rate of cooling of S_1 to that of S_2 is:

(A) $\frac{1}{3}$ **(B)** $\frac{1}{\sqrt{3}}$ **(C)** $\frac{\sqrt{3}}{1}$ **(D)** $\left(\frac{1}{3}\right)^{1/3}$

10. A clock with an iron pendulum and periodic time 1 sec keeps correct time at 10°C. The error in seconds per day if the temperature is 20°C is : (Take $\alpha = 10 \times 10^{-6}/°C$)

(A) 4.32 sec **(B)** 8.64sec **(C)** 2 sec **(D)** 1 sec

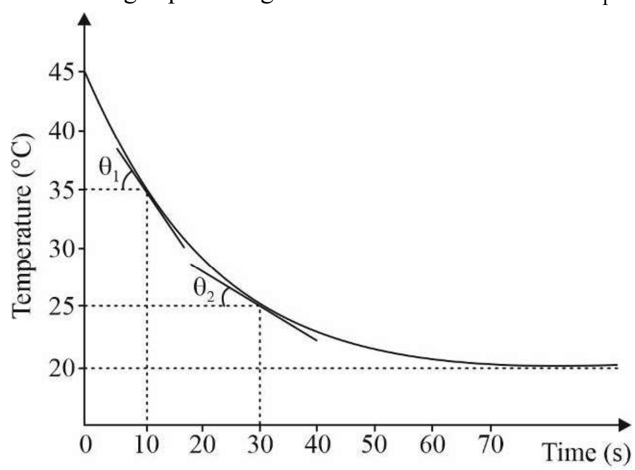
11. The temperature of a well stirred liquid kept open to a cold surrounding is plotted against time. The value of $\sec^2 \theta_1$ is:

(A) $1 + 9\tan^2\theta_2$

(B) $1 + \tan^2\theta_2$

(C) $1 + 3\tan^2\theta_2$

(D) $3 + \tan^2\theta_2$



MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

12. Which of the following are correct ?

(A) The bulk modulus of an incompressible liquid is infinity.
(B) Bulk modulus of a perfectly rigid body is infinity.
(C) According to Hooke's law, the ratio of the stress and strain remains constant.
(D) None of the above

13. The water equivalent of a copper calorimeter is 4.5 *g*. If the specific heat of copper is 0.09 $cal/g/°C$

(A) mass of the calorimeter is 0.5 *kg* **(B)** thermal capacity of the calorimeter is 4.5 $cal/°C$
(C) heat required to raise the temperature of the calorimeter by $8°C$ will be 36 *cal*
(D) heat required to melt 15 *g* of ice at $0°C$ placed in the calorimeter will be 1200 *cal*

14. A composite rod consists of a steel rod of length 25 *cm* and area 2*A* and a copper rod of length 50 *cm* and area *A* are joined end to end. The composite rod is subjected to an axial load *F*. If the Young's modulus of steel and copper are in the ratio 2:1, then:

(A) The extension produced in copper rod will be more.
(B) The extension in copper and steel parts will be in the ratio $2:1$.
(C) The stress in the copper rod will be more.
(D) No extension will be produced.

15. Four rods *A*, *B*, *C*, *D* of same length and material but of different *radii* r, $r\sqrt{2}$, $r\sqrt{3}$, and $2r$ respectively are held between two rigid walls. The temperature of all rods is increased by same amount. If the rods do not bend, then

(A) The stress in the rods are in the ratio $1:2:3:4$.
(B) The force on the rod exerted by the wall are in the ratio $1:2:3:4$.
(C) The energy stored in the rods due to elasticity are in the ratio $1:2:3:4$.
(D) The strains produced in the rods are in the ratio $1:2:3:4$.

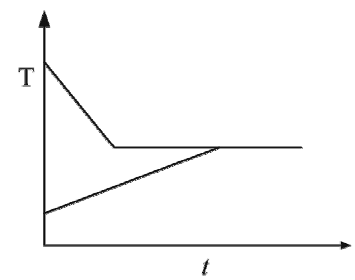
16. One end of a conducting rod is maintained at temperature $50°C$ and at other end, ice is melting at $0°C$. The rate of melting of ice is doubled if :

(A) The temperature is made $200°C$ and the area of cross-section of the rod is halved
(B) The temperature is made $100°C$ and length of rod is made four times
(C) Area of cross-section of rod is halved and length is doubled
(D) The temperature is made $100°C$ and the area of cross-section of rod and length both are doubled.

17. Iron floats over mercury because density of mercury is more than the density of iron. Coefficient of volumetric expansion of iron and mercury are $35 \times 10^{-6} °C^{-1}$ and $180 \times 10^{-6} °C^{-1}$. Now consider an iron cube floating in a bowl of mercury at $0°C$. When temperature is increased upto $25°C$, then choose the correct options.

(A) Cube is submerged more at $25°C$
(B) Cube is submerged less at $25°C$
(C) Percentage change in the fraction of volume submerged is about 1%
(D) Percentage change in the fraction of volume submerged is about 0.4%

18. A sample A of liquid water and a sample B of ice of identical mass are kept in two neighbouring chambers in an otherwise insulated container. The chambers can exchange heat with each other. The graph of temperatures of the two chambers is plotted with time. $S_{\text{ice}} = \dfrac{S_{\text{water}}}{2}$.

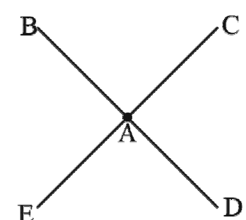


(A) Finally the contents in sample A is water
(B) Equilibrium temperature is freezing point of water
(C) Ice melts partly
(D) Finally the contents in sample B is ice only

19. Two surfaces of same nature and area but of different material are heated to same temperature. They are allowed to cool down in same surroundings. If $\dfrac{dQ}{dt}$ represents rate of loss of heat and $\dfrac{d\theta}{dt}$ represents rate of fall of temperature, then initially for both :

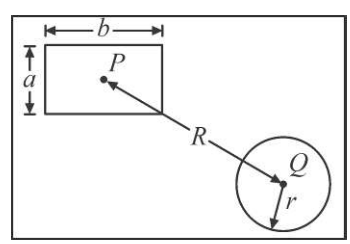
(A) $\dfrac{dQ}{dt}$ is same **(B)** $\dfrac{dQ}{dt}$ is different **(C)** $\dfrac{d\theta}{dt}$ is same **(D)** $\dfrac{d\theta}{dt}$ is diferent

20. Four identical rods which have thermally insulated lateral surfaces are joined at point A. Points B, C, D and E are connected to large reservoirs. If heat flows into the junction from point B at rate of 1 W and from point C at $3W$ inside, flows out from D at $5W$, which relation(s) is/are correct for temperature of these points?



(A) $T_A < T_E$ **(B)** $T_B = T_C$ **(C)** $T_C > T_D$ **(D)** $T_B = T_E$

21. There is a rectangular metal plate in which two cavities in the shape of rectangle and circle are made, as shown with dimensions. P and Q are centres of these cavities. On heating the plate, which of the following quantities increase ?



(A) πr^2 **(B)** ab
(C) R **(D)** b

22. A bimetallic strip is made up to two metals with different α :

(A) On heating, it bends towards the metal with high α
(B) On heating, it bends towards the metal with low α
(C) On cooling, it bends towards the metal with high α
(D) On cooling, it bends towards the metal with low α

23. Two spherical black A and B, having radii r_A and $r_B = 2r_A$ emit radiation with peak intensities at wavelength $400\,nm$ and $800\,nm$ respectively. If their temperature are T_A and T_B respectively in Kelvin scale, their emissive powers are E_A and E_B then :

(A) $\frac{T_A}{T_B} = 2$ **(B)** $\frac{T_A}{T_B} = 4$ **(C)** $\frac{E_A}{E_B} = 8$ **(D)** $\frac{E_A}{E_B} = 4$

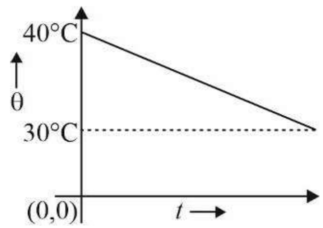
Paragraph for Q. 24 - 26

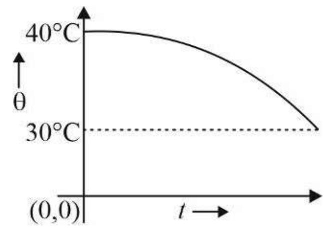
A body cools in a surrounding of constant temperature 30°C. Its heat capacity is 2 J/°C. Initial temperature of the body is 40°C. Assume Newton's law of cooling is valid. The body cools to 36°C in 10 minutes.

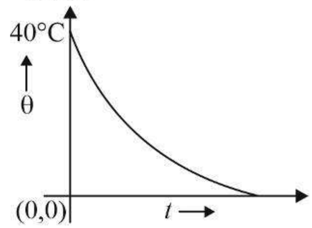
24. In futher 10 minutes it will cool from 36°C to :

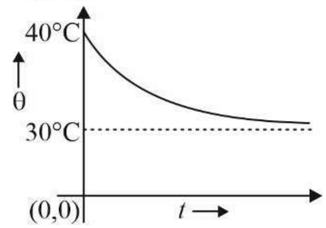
(A) 34.8 °C **(B)** 32.1 °C **(C)** 32.8 °C **(D)** 33.6 °C

25. The temperature of the body in °C denoted by θ versus time t is best denoted as :

(A)


(B)


(C)


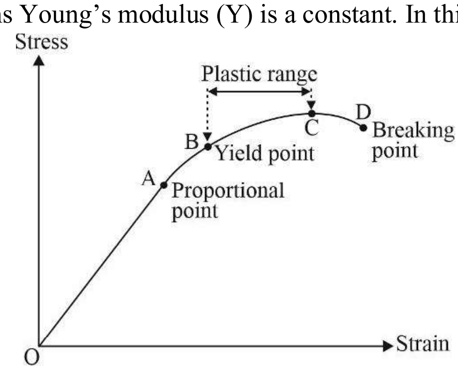
(D)


26. When the body temperature has reached 36°C, it is heated again so that it reaches to 40 °C in 10 minutes. Assume that the rate of loss of heat at 38 °C is the average rate of loss for the given time. The total heat required from a heater by the body is:

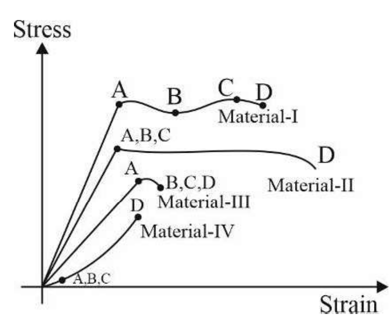
(A) 7.2 J **(B)** 0.728 J **(C)** 16 J **(D)** 32 J

Paragraph for Q. 27-29

Figure shows the relationship between tensile stress and strain for a typical material. Below the proportional point A, stress is directily proportional to strain which means Young's modulus (Y) is a constant. In this region the material obeys Hooke's law.



Provided the strain is below the yield point `B' the material returns to its original shape and size when the force is removed. Beyond the yield point, the material retains a permanent deformation after the stress is removed. For stresses beyond the yield point, the material exhibit plastic flow, which means that it coninues to elongate for little increases in the stress.Beyond C a local constriction occurs. The material fractures at D (i.e., breaking point).



The graph below shows the stress-strain curve for 4 different materials.

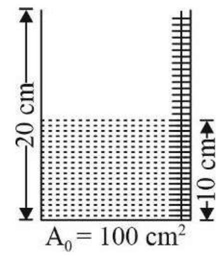
27. Material which is good for making wire making wires by stretching, is:
(A) Material-I **(B)** Material-II **(C)** Material-III **(D)** Material-IV

28. Material which is most brittle, is:
(A) Material-I **(B)** Material-II **(C)** Material-III **(D)** Material-IV

29. If you bought a new shoe which bites in the beginning and later on fits perfectly, then the material used to making the shoe is:
(A) Material-I **(B)** Material-II **(C)** Material-III **(D)** Material-IV

Paragraph for Q. 30-32

At 20 °C a liquid is filled upto 10 cm height in a container of glass of length 20 cm and cross-sectional area 100 cm^2. Scale is marked on the surface of container. This scale gives correct reading at 20 °C. Given $\gamma_L = 5\times10^{-5}k^{-1}$, $\alpha_g = 1\times10^{-5}\ °C^{-1}$



30. The volume of liquid at 40 °C is:
(A) 1002 cm **(B)** 1001 cc **(C)** 1003 cc **(D)** 1000.5 cc

31. The actual height of liquid at 40 °C is:
(A) 10.01 cm **(B)** 10.006 cm **(C)** 10.6 cm **(D)** 10.1 cm

32. The reading of scale at 40 °C is:
(A) 10.01 cm **(B)** 10.004 cm **(C)** 10.006 cm **(D)** 10.04 cm

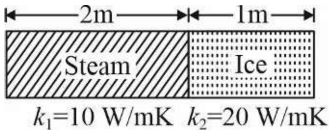
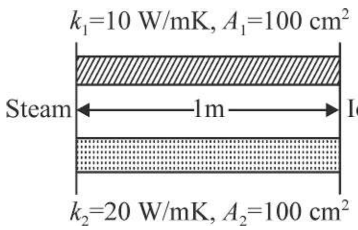
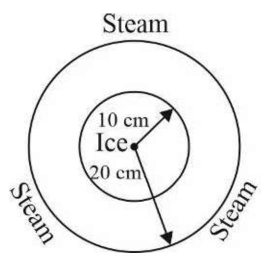
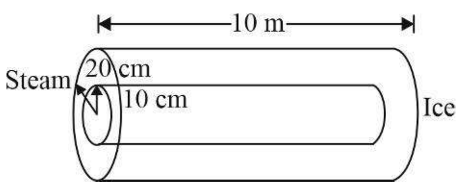
MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

33. Consider a wire of length l, cross-sectional area A and Young's modulus Y and match Column 1 with Column 2 :

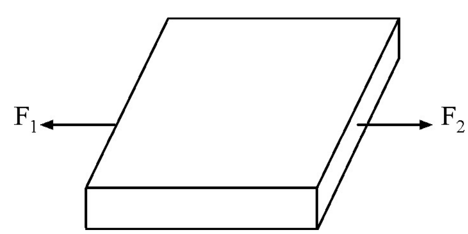
	Column-1		**Column-2**
(A)	If the wire is pulled at its ends by equal and opposite forces of magnitude F so that it undergoes an elongation x, according to Hooke's law. $F = kx$, where (k) of the wire will depend on	**(p)**	Young's modulus Y
(B)	Let us suspend the wire vertically from a rigid support and attach a mass m at its lower end. If the mass is slightly pulled down and released, it executes *S.H.M.* of a time period that will depend on	**(q)**	Elongation (x)
(C)	If the given wire is fixed between two rigid supports and its temperature is decreased thermal stress that develops in the wire will depend on.	**(r)**	Length (l)
(D)	Work done in stretching the wire to a new length ($l + x$) will depend on	**(s)**	Area of cross-section (A)

34. In column-I, certain situations are depicted where steam at 100°C is used to melt ice at 0°C by means of a conducting body which is insulated to prevent heat losses to surrounding. Match the numerical value of question asked in each entry to the corresponding entry I column-II. Symbols have usual meaning.

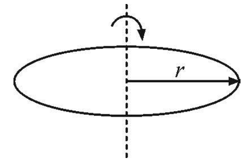
Column I	**Column II**
(A)  Find temperature of interface of two rods in °C.	**(p)** 10
(B)  Find total rate of heat transfer through the two rods in SI units.	**(q)** 20
(C)  Hollow sphere of $k = \frac{1}{32\pi}$ W/mK. Find thermal resistance in SI units	**(r)** 30
(D)  Hollow cylinder of $k = \frac{\pi}{10}$ W/mk. Find temperature gradients in SI units.	**(s)** 40

NUMERICAL VALUE TYPE

35. Two opposite forces F_1 = 120 N and F_2 = 80 N act on an elastic plank of modulus of elasticity $Y = 2 \times 10^{11} N/m^2$ and length l = 1 m placed over a smooth horizontal surface. The cross - sectional area of the plank is S = 0.5 m^2. The change in length of the plank is $x \times 10^{-9} m$. Find the value of x.



36. A ring of radius r made of wire density ρ is rotated about a stationary vertical axis passing through its centre and perpendicular to the plane of the ring as shown in the figure. Determine the angular velocity (in rad/s) of ring at which the ring breaks. The wire breaks at tensile stress σ. Ignore gravity. Take $\sigma / \rho = 4$ in SI unit, and $r = 1m$.

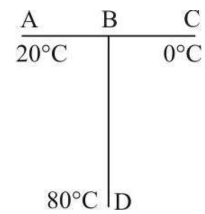


37. 2 kg of ice at $-15°C$ is mixed with 2.5 kg of water at $25°C$ in an insulating container. If the specific heat capacities of ice and water are 0.5 $cal / g°C$ and 1 $cal / g°C$ find the amount of water present in the container (in kg) ?

38. Four cylindrical rods of same material with length and radius $(\ell, r), (2\ell, r), (2\ell, 2r)$ and $(\ell, 2r)$ are connected between two reservoirs at $0°C$ and $100°C$. Find the ratio of the maximum to minimum rate of conduction in them.

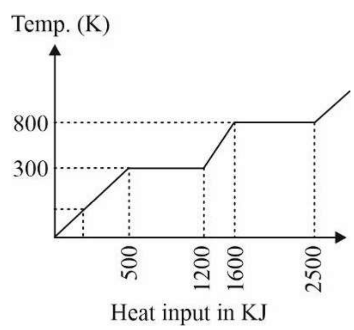
39. A solid sphere of radius R made of material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass m is placed on the piston to compress the liquid, the fractional change in the radius of the sphere $\delta R / R$ is given by mg/nAK. Where n is :

40. Three conducting rods of same material and cross-section are shown in figure. Temperature of A, D and C are maintained at $20°C, 80°C$ and $0°C$ respectively. Find the ratio of length BD and BC if there is no heat flow in AB.

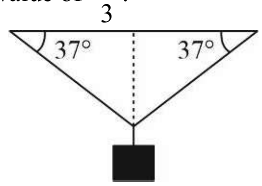


41. In a container of negligible heat capacity, 200 gm ice at 0°C and $\frac{262}{3}$ gm steam at 100°C are added to 200 gm of water that has temperature 55°C. Assume no heat is lost to the surroundings and the pressure in the container is constant 1.0 atm. ($L_f = 80$ cal / gm, $L_v = 540$ cal / gm, $s_w = 1$ cal / gm °C). Find the amount (in gm) of the steam left in the system.

42. A heating curve has been plotted for a solid object as shown in the figure. If the mass of the object is 200 g, then latent heat of vaporization for the material of the object, is $\frac{n}{2} \times 10^6$ J/kg. [Power supplied to the object is constant and equal to 1 kW]. Find the value of n.



43. A block is hung by means of two identical wires having cross-sectional area A $(1\ \text{mm}^2)$ as shown in the diagram. If temperture is lowered by ΔT (10 °C), find the mass (in kg) to be added to hanging mass such that junction remains at initial position. Given that coefficient of linear expansion $\alpha = 2 \times 10^{-5}$ /°C and Young's modulus $Y = 5 \times 10^{11}$ N/m^2 for the wire. If your answer is N, find the value of $\frac{N}{3}$.



44. Liquid cools from 50°C to 45°C in 5 minutes and from 45°C to 41.5°C in the next 5 minutes. Calculate the temperature of surrounding.

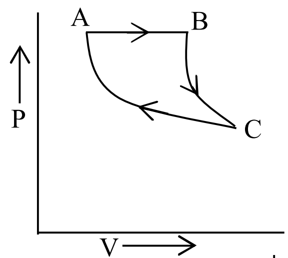
45. A body which has a surface area $5.0\ cm^2$ and a temperature 727°C radiates 300 J of energy each minute. What is its emissivity? Stefan constant $5.67 \times 10^{-8}\ W / m^2 K^4$

JEE Advanced Revision Booklet	KTG and Thermodynamics

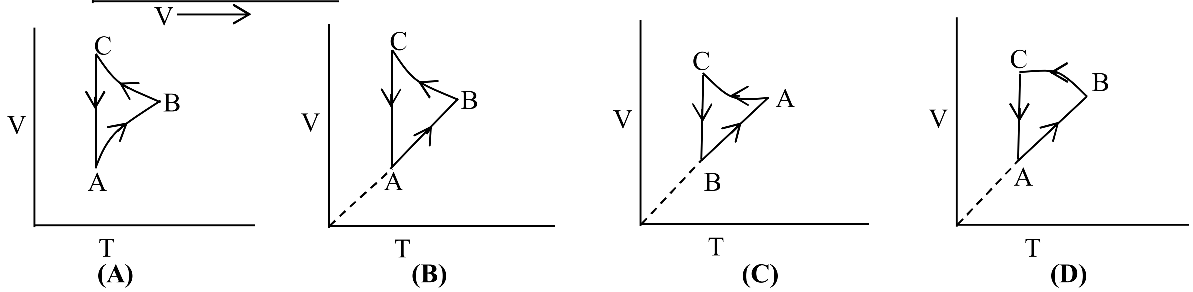
SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. For a given thermodynamic process, the P – V diagram is as shown below:
Which of the following is the V – T diagram for the process?



A $\rightarrow$ B : isobaric
B $\rightarrow$ C : adiabatic
C $\rightarrow$ A : isothermal



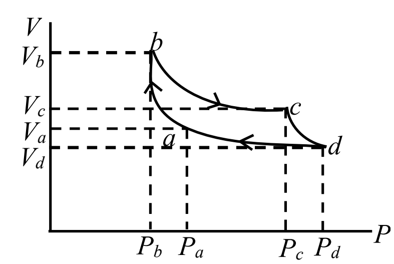
2. An insulated container is divided into two equal portions. One portion contains an ideal monoatomic gas at pressure P and temperature T, while the other portion is a perfect vacuum. If a hole is opened between the two portions, the change in internal energy of the gas is

(A) zero **(B)** equal to work done by the gas
(C) equal to work done on the gas **(D)** 3RT/2

3. A cyclic process *ABCD* shown in *V-P* diagram with two adiabatic and two isothermal process for *n* mole of monoatomic gas is shown in the figure. The ratio of $\dfrac{P_b}{P_c}$ is :

(A) $\dfrac{P_a}{P_d}$ **(B)** $\left(\dfrac{P_a}{P_d}\right)^{\gamma-1}$

(C) $\dfrac{P_d}{P_a}$ **(D)** $\left(\dfrac{P_d}{P_a}\right)^{\gamma}$



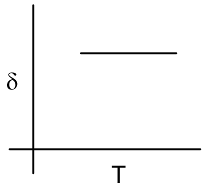
4. When the state of a system changes from A to B adiabatically the work done on the system is 322 Joule. If the state of the same system is changed from A to B by another process, and 100 Joules of heat is required then work done on the system in this process will be

(A) −222 Joule **(B)** 38.2 Joule **(C)** 15.9 Joule **(D)** 15.9 Joule

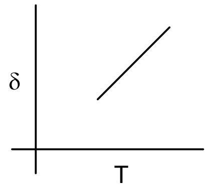
5. If a monoatomic gas undergoes a thermodynamic process for which its molar heat capacity is equal to the universal gas constant. The process in terms of V and T is

(A) $VT^{-1/2}$ = constant **(B)** $VT^{1/2}$ = constant
(C) $V^2 T^2$ = constant **(D)** VT = constant

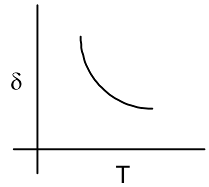
6. An ideal gas is initially at a temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remains constant. The quantity $\delta = \dfrac{\Delta V}{V\Delta T}$ varies with temperature as :



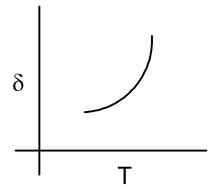
(A)



(B)



(C)



(D)

7. An ideal gas has molar heat capacity C_v at constant volume. The gas undergo the process $T = T_0(1-\alpha V)$ where α, T_0 is constant and V is volume. Then molar heat capacity of the gas is :

(A) $C_V + \dfrac{R}{\alpha V}(1-\alpha V)$ **(B)** $C_V - \dfrac{R}{\alpha V}(1-\alpha V)$

(C) $C_V - \dfrac{R}{2\alpha V}(1+\alpha V)$ **(D)** $C_V + \dfrac{R}{2\alpha V}(1+\alpha V)$

8. A gaseous mixture consists of 2 moles of O_2 and 4 moles of Ar at a temperature T. Neglecting all vibrational moles, the total internal energy of the system is

(A) 4RT **(B)** 15RT **(C)** 9RT **(D)** 11RT

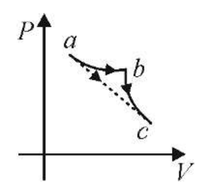
9. The pressure and density of a diatomic gas ($\gamma = 7/5$) change adiabatically from (P,ρ) to (P',ρ'). If $\rho'/\rho = 32$, then P'/P should be:

(A) 1/128 **(B)** 128 **(C)** 32 **(D)** None

10. The relation between internal energy U, pressure P and volume V of a gas in an adiabatic process is $U = a + bPV$ where a and b are constants. What is the value of the ratio of the specific heats ?

(A) $\dfrac{a}{b}$ **(B)** $\dfrac{b+1}{b}$ **(C)** $\dfrac{\alpha+1}{\alpha}$ **(D)** $\dfrac{b}{\alpha}$

11. In the figure, the gas does 5J of work along isothermal process ab and 4 joule of work along adiabatic process bc. Then the change in the internal energy of the gas if the gas follows the straight path from a to c is :



(A) 9J **(B)** –9J

(C) –4J **(D)** None of these

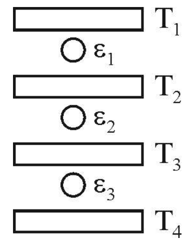
12. The velocity of sound in a gas at NTP is 0.68 times the rms velocity of the gas molecule at NTP. The number of degrees of freedom of the molecules is :

(A) 5 **(B)** 6 **(C)** 3 **(D)** 4

13. A cylinder made of perfectly conducting material closed at both ends is divided into two equal parts by a heat proof piston. Both parts of the cylinder contain the same masses of a gas at a temperature $t_0 = 27°$ and pressure $P_0 = 1$ atm. Now if the gas in one of the parts is slowly heated to t = 57° C, the distance moved by the piston from the middle of the cylinder will be (length of the cylinder = 84 cm)

(A) 3 cm **(B)** 5cm **(C)** 2 cm **(D)** 1 cm

14. Three Carnot engines operate in series between a heat source at a temperature T_1 and heat sink at temperature T_4 (se figure). There are two other reservoirs at temperature T_2 and T_3, as shown, with $T_1 > T_2 > T_3 > T_4$. The three engines are equally efficient if:



(A) $T_2 = \left(T_1 T_4^2\right)^{1/3}; T_3 = \left(T_1^2 T_4\right)^{1/3}$

(B) $T_2 = \left(T_1^2 T_4\right)^{1/3}; T_3 = \left(T_1\ T_4^2\right)^{1/3}$

(C) $T_2 = \left(T_1^3 T_4\right)^{1/4}; T_3 = \left(T_1\ T_4^3\right)^{1/4}$

(D) $T_2 = \left(T_1 T_4\right)^{1/2}; T_3 = \left(T_1^2 T_4\right)^{1/3}$

15. A Carnot engine, having an efficiency of $\frac{1}{10}$ heat engine, is used as refrigerator. If the work done on the system is 10J, the amount absorbed from the reservoir at lower temperature:

(A) 90 J **(B)** 1 J **(C)** 100 J **(D)** 99 J

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

16. Two gases have the same initial pressure, volume and temperature. They expand to the same final volume, one adiabatically and the other isothermal.

(A) the final temperature is greater for the isothermal process
(B) the final pressure is greater for the isothermal process
(C) the work done by the gas is greater for the isothermal process.
(D) all the above options are incorrect

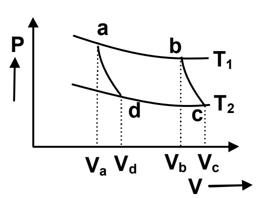
17. The molar heat capacity for an ideal gas

(A) is zero for an adiabatic process
(B) is infinite for an isothermal process
(C) depends only on the nature of the gas for a process in which either volume or pressure is constant
(D) is equal to the product of the molecular weight and specific heat capacity for any process

18. A system undergoes a cyclic process in which it absorbs heat, Q_1 and gives out heat, Q_2. The efficiency of the process is η and the work done is W.

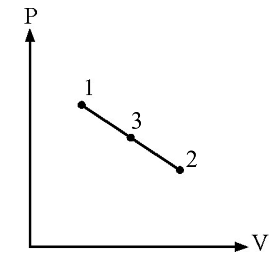
(A) $W = Q_1 - Q_2$ **(B)** $\eta = \frac{W}{Q_1}$ **(C)** $\eta = \frac{Q_2}{Q_1}$ **(D)** $\eta = 1 - \frac{Q_2}{Q_1}$

19. Two adiabatic processes bc and ad for the same gas are given to intersect two isotherms at T_1 and T_2 (as shown). Then



(A) $\frac{V_a}{V_b} = \frac{T_2}{T_1}$ **(B)** $\frac{V_a}{V_d} = \frac{T_1}{T_2}$ **(C)** $\frac{V_b}{V_c} = \left(\frac{T_2}{T_1}\right)^{\frac{1}{\gamma - 1}}$ **(D)** $V_a V_c = V_b V_d$

10. The diagram shown depicts three different states 1, 2 & 3 for an ideal gas. It is also known that temperatures at states (1) & (2) are same. Then:



(A) $1\rightarrow 2$ is an isothermal expansion process
(B) $1\rightarrow 3$ is an expansion process and is accompanied by cooling
(C) $3\rightarrow 2$ is an expansion process accompanied by cooling
(D) internal energy must increase in process $1\rightarrow 3$

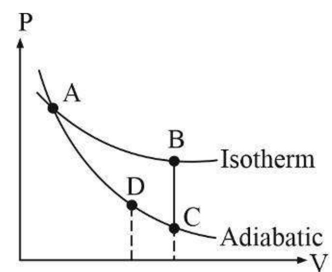
21. 2 moles of He are mixed with 2 moles of H_2 in a closed adiabatic container. Initially the mixture occupies 3 liters at 27°C. The volume is suddenly decreased to $\left(\frac{3}{2}\right)$ liters. Choose the correct option(s) (H_2 and He can be treated as ideal gases) :

(A) γ for mixture is $\frac{3}{2}$
(B) final temperature $= 300\sqrt{2}\,K$
(C) C_P for mixture is $2R$
(D) Work done in compression is totally converted into internal energy

22. Two moles of $O_2\left(\gamma=\frac{7}{5}\right)$ at temperature T_0 and 3 mole of $CO_2\left(\gamma=\frac{4}{3}\right)$ at temperature $2T_0$ are allowed to mix together in a closed adiabatic vessel. The resulting mixture finally comes in thermal equilibrium. Then :

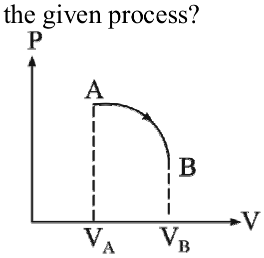
(A) Final temperature of the mixture is $\frac{23T_0}{14}$ **(B)** Final temperature of the mixture is $\frac{31T_0}{19}$
(C) Adiabatic exponent of the mixture formed is $\frac{14}{5}$
(D) Adiabatic exponent of the mixture formed is $\frac{19}{14}$

23. Figure shows various processes in the PV-plane for an ideal gas. The process ADC is an adiabatic, AB is an isotherm, and BC is a constant-volume process. The heat added to the gas along AB is 400 cal. The change in internal energy from C to A is + 1000 cal and the work done from D to C is 150 cal



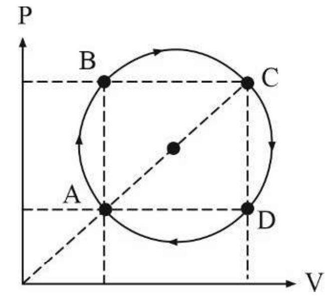
(A) work done by the gas from A to B is 400 cal
(B) heat added to the system from B to C is –1000 cal
(C) the change in internal energy from C to D is 150 cal
(D) work done by the gas from D to A is 850 cal

24. One mole of an ideal monoatomic gas is taken through process AB given by $P=\alpha-\beta V^2$ (where α and β are positive constants) on P-V diagram. Which of the following is the correct statement regarding the given process?



(A) Temperature is maximum at $V=\sqrt{\frac{\alpha}{3\beta}}$
(B) Temperature is minimum at $V=\sqrt{\frac{\alpha}{3\beta}}$
(C) At point A rate of increase of temperature of gas with volume is more than at point B
(D) Rate of increase of temperature of gas with volume is maximum at $V=\sqrt{\frac{\alpha}{\beta}}$

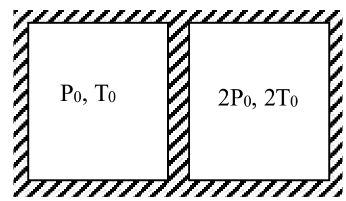
25. A sample of ideal gas of some mass is taken through the cyclic process shown in the figure. The temperature of the gas at state A is $T_A = 200\,K$, and at state C is $T_C = 1800\,K$. Choose the correct option :



(A) $\frac{V_A}{V_C} = \frac{1}{3}$ **(B)** $\frac{V_A}{V_B} = \frac{1}{9}$ **(C)** $\frac{P_A V_A}{P_C V_C} = \frac{1}{3}$ **(D)** $\frac{P_A V_A}{P_C V_C} = \frac{1}{9}$

Paragraph for Q.26 - 28

A conducting piston divides adiabatic cylinder of volume V_0 into two equal parts as shown in the figure. Both parts contain ideal monatomic gases. The initial pressure and temperature of gas in left compartment are P_0 and T_0 while that in right compartment are $2P_0$ and $2T_0$. Initially the piston is kept fixed and the system is allowed to acquire a state of thermal equilibrium.



26. The pressure in left compartment after thermal equilibrium is achieved is :

(A) P_0 **(B)** $\frac{3}{2}P_0$ **(C)** $\frac{4}{3}P_0$ **(D)** None of these

27. The heat that flown from right compartment to left compartment before thermal equilibrium is achieved is :

(A) P_0V_0 **(B)** $\frac{3}{4}P_0V_0$ **(C)** $\frac{3}{8}P_0V_0$ **(D)** $\frac{2}{3}P_0V_0$

28. If the pin which was keeping the piston fixed is removed and the piston is allowed to slide slowly such that a state of mechanical equilibrium is achieved. The volume of left compartment when piston is in equilibrium.

(A) $\frac{3}{4}V_0$ **(B)** $\frac{V_0}{4}$ **(C)** $\frac{V_0}{2}$ **(D)** $\frac{2}{3}V_0$

Paragraph for Questions 29 - 30

An ideal diatomic gas is filled in a piston. The number of moles is n. An unknown process `P' the coefficient of volume expansion γ is found to depend on absolute temperature T as per the relation $\gamma = \frac{3}{T}$.

29. For process `P' the molar specific heat of gas would be:

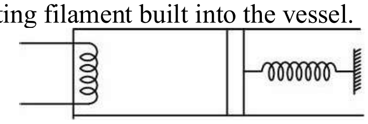
(A) $\frac{7}{2}R$ **(B)** $\frac{9}{2}R$ **(C)** $\frac{11}{2}R$ **(D)** None of these

30. If from initial state A, the gas is expanded *via* process `P' to double its volume and reach state B. Then volume is changed isobarically to reach state C and then *via* isothermal compression the gas is brought back to state A. Thus a cyclic process is created, and if a heat engine uses such a process. The efficiency of such an engine would be: (Given : ln 2 = 0.7, $(2)^{1/2} = 1.4$)

(A) 7.2 % **(B)** 12.5 % **(C)** 20.5 % **(D)** 25.2 %

Paragraph for Questions 31 - 32

A piston enclose some diatomic gas in the cyclindrical vessel with horizontal longitudinal axis as shown in the drawing. The initial pressure of the air is equal to the external atmospheric pressure of 10^5 Pa. The cross-sectional area of the piston is 0.03 m^2. An originally unstreted spring with spring constant 2000 N/m is attached to the piston. The walls of the vessel and the piston are perfectly insulated. The initial volume of the enclosed air is 0.024 m^3 and its initial temperature is 300 K. The air is heated to 360 K with a heating filament built into the vessel.



31. Find the displacement of the piston caused by the heating.

(A) 0.1 m **(B)** 0.2 m **(C)** 0.5 m **(D)** 0.3 m

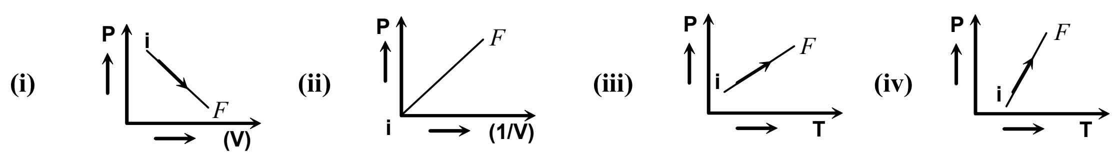
32. Find the energy delivered by the heating filament.

(A) 1000 J **(B)** 1200 J **(C)** 1400 J **(D)** 1510 J

MATRIX MATCH TYPE

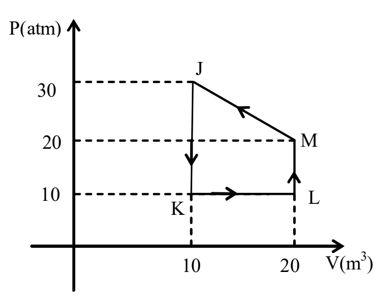
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

33. The diagrams below depict different processes for a given amount of an ideal gas. Match Column-I and II:



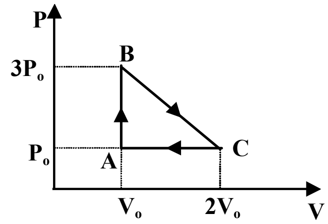
Column 1		**Column 2**	
(A)	In fig.(i) as the system proceeds from the initial state to the final state	**(p)**	Temperature will remain constant
(B)	In Fig. (ii), as the system proceeds from the initial state to the final state	**(q)**	Pressure will decrease
(C)	In fig. (iii), as the system proceeds from the initial state to the final state	**(r)**	Volume must increase
(D)	In fig. (iv), as the system proceeds from the initial state to the final state	**(s)**	Temperature may increase, may decrease or may first increase and then decrease

34. Heat given to process is positive, match the following option of column I with the corresponding option of column II



	Column 1		**Column 2**
(A)	JK	**(P)**	$\Delta W > 0$
(B)	KL	**(Q)**	$\Delta Q < 0$
(C)	LM	**(R)**	$\Delta W < 0$
(D)	MJ	**(S)**	$\Delta Q > 0$

35. One mole of an ideal monatomic gas is taken round the cyclic process ABCA as shown in the figure. Calculate ;



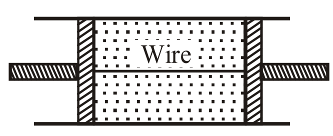
	COLUMN 1		**COLUMN 2**
(A)	The work done by the gas	**(p)**	$5/2\ P_0V_0$
(B)	The heat rejected by the gas in the path CA;	**(q)**	$\frac{25P_0V_0}{8R}$
(C)	The net heat absorbed by the gas in the path BC	**(r)**	P_0V_0
(D)	The maximum temperature attained by the gas during the cycle.	**(s)**	$\frac{P_0V_0}{2}$

SUBJECTIVE INTEGER TYPE

36. Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of gas A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The change in the pressure in A and B are found to be ΔP and $1.5\Delta P$ respectively. Then value of m_A (in *kg*) is _______ if $m_B = 3kg$.

37. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30K, and rise in temperature of the gas in B is T the value of T/6 is ____.

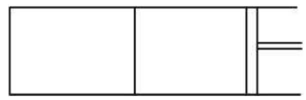
38. A cylindrical tube of uniform cross-sectional area A is fitted with two air tight frictionless pistons. The pistons are connected to each other by a metallic wire. Initially the pressure of the gas is P_0 and temperature is T_0. Atmospheric pressure is also P_0. Now the temperature of the gas is increased to $2T_0$, if the tension in the wire is K P_0A then the value of K is ______.



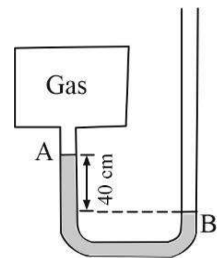
39. A diatomic gas of molecular weight 30 gm/mole is filled in a container at 300 K. It is moving at a velocity 100 m/s. If it is suddenly stopped, the rise in temperature of gas is $\left(\frac{10x}{R}\right)K$, where R is universal gas constant. Find the value of x in joule/mole.

40. One mole helium in a vessel gets the heat from outside and starts expanding to make its volume 2 times the original volume. The heat capacity of the gas in this process is constant and is $\frac{R}{2}$. What is the final temperature of gas (in K)? Initial temperature is 200 K and initial pressure is 40 kPa.

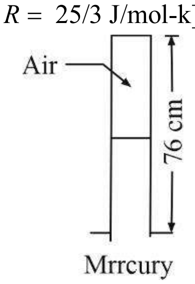
41. A cylindrical vessel is divided in two parts by a fixed partition which is perfectly heat conducting. The wall and piston are thermally insulated from surroundings. The left side contains 0.5 moles of gas with $C_v = 2R$ at temperature of 300 K. The right side contains 4 moles of mixture of gas with $C_v = 1.75R$ at same temperature of 300 K. The piston compresses slowly the right side from volume of V_0 to $\frac{V_0}{4}$. Find the total change in internal energy of gases. If $\Delta U = n \times 10^4$ J, fill n in OMR sheet. (Take $R = \frac{25}{3}$ S.I. unit)



52. Figure shows an ideal gas. Its pressure, volume and temperature are P_0, V_0 and T_0 respectively. Thin U-tube contains mercury. It was observed that there was a difference of 40 cm in the level of mercury column in two limbs. Now the gas is heated to temperature 1.5 T_0 and simultaneoulsy mercury was added in limb B to maintain the level of mercury in limb A at its original poistion. Find the new difference in the level of mercury in limb A and B (in cm). [Take : $P_{atm} = 76$ cm of Hg]



43. A glass tube has fixed length 76 cm above the mercury level. There is some space above mercury column in the tube that contains 10^{-3} moles of air at 300 K. Atmospheric pressure remains constant at 76 cm of Hg. If the temperature of the air column slowly decreases by 10 K, find the net heat lost by the air column. Given $\gamma_{air} = 1.4$. Neglect the effect of surface tension. [Take $R =$ 25/3 J/mol-k]



44. A 20.0% efficient real engine is used to speed up a train from rest to 4 m/s. It is known that an ideal (Carnot) engine having the same cold and hot reservoirs would accelerate the same train from rest to a speed of 6 m/s using the same amount of fuel. Assuming that the engines use air at 300 K as a cold reservoir, find the temperature of the steam serving as the hot reservoir. (write greatest integer value in Kelvin)

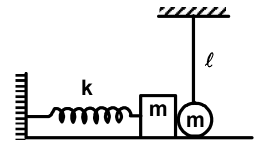
45. If a 25% efficient Carnot heat engine is run in reverse so that it functions as a refrigerator, what would be the engine's (that is, the refrigerator's) coefficient of performance (COP) ?

JEE Advanced Revision Booklet	Simple Harmonic Motion

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A pendulum makes perfectly elastic collision with block of m lying on a frictionless surface attached to a spring of force constant k. Pendulum is slightly displaced and released. Time period of oscillation of the system is



(A) $2\pi\left[\sqrt{\frac{\ell}{g}}+\sqrt{\frac{m}{k}}\right]$ **(B)** $\pi\left[\sqrt{\frac{\ell}{g}}+\sqrt{\frac{m}{k}}\right]$

(C) $2\pi\sqrt{\frac{\ell}{g}}$ **(D)** $2\pi\sqrt{\frac{m}{k}}$

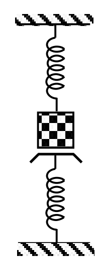
2. The amplitude of a damped oscillator decreases to 0.9 times its original magnitude in 5s. In another 10s, it will decrease to α times its original magnitude, where α equals:

(A) 0.7 **(B)** 0.81 **(C)** 0.729 **(D)** 0.6

3. Two simple pendulums of length 1m and 16 m respectively are both given small displacement in the same direction at the same instant. They will again be in the same phase after shorter pendulum has completed η vibrations. The value of η is

(A) 5 **(B)** 4 **(C)** 1/4 **(D)** 4/3

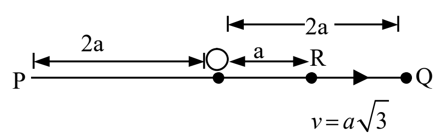
4. A mass *m* is suspended from a spring of force constant *k* and just touches another identical spring fixed to the floor as shown in the figure. The time period of small oscillations is :



(A) $2\pi\sqrt{\frac{m}{k}}$ **(B)** $\pi\sqrt{\frac{m}{k}}+\pi\sqrt{\frac{m}{k/2}}$

(C) $\pi\sqrt{\frac{m}{3k/2}}$ **(D)** $\pi\sqrt{\frac{m}{k}}+\pi\sqrt{\frac{m}{2k}}$

5. A particle of mass *m* is performing SHM along line *PQ* with amplitude $2a$ with mean position at *O*. At $t = 0$ particle is at point *R* ($OR = a$) and is moving towards *Q* with velocity $v = a\sqrt{3}$ *m*/sec. The equation can be expressed by :



(A) $x = a\left(\sqrt{3}\sin t + \cos t\right)$ **(B)** $x = 2a\left(\sqrt{3}\sin t + \cos t\right)$

(C) $x = 2a\left(\sin t + \sqrt{3}\cos t\right)$ **(D)** $x = a\left(\sin t + \sqrt{3}\cos t\right)$

6. If the potential energy of a harmonic oscillator of mass 2 kg in its equilibrium position is 5 joules and the total energy is 9 joules when the amplitude is one meter then the period of the oscillator (in sec) is :

(A) 1.5 **(B)** 3.14 **(C)** 6.28 **(D)** 4.67

(*Hint* : *Total energy* = $U(0) + 1/2\, kA^2$)

7. A particle executes a simple harmonic motion between $x = -A$ and $x = +A$, the time taken for it to move from $x = 0$ to $x = \frac{A}{2}$ is T_1 and to move from $\frac{A}{2}$ to $\frac{A}{\sqrt{2}}$ is T_2, then

(A) $T_1 < T_2$ **(B)** $T_1 = T_2$ **(C)** $T_1 = 2T_2$ **(D)** $T_2 = 2T_1$

8. If a simple pendulum has significant amplitude (upto a factor of 1/e of original) only in the period between $t=0$ to $t=\tau$ then τ may be called the average life of the pendulum. When the spherical bob of the pendulum suffers a retardation (due to viscous drag) proportional to its velocity with b as constant of proportionally, the average life time to the pendulum (assuming damping is small) in second is:

(A) $\frac{0.693}{b}$ **(B)** b **(C)** $\frac{1}{b}$ **(D)** $\frac{2}{b}$

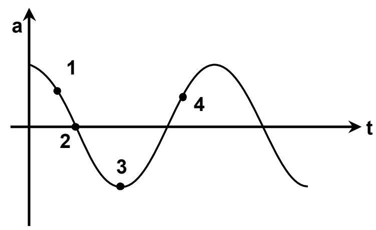
MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

9. Which of the following quantities are always negative in a simple harmonic motion?

(A) $\vec{F}\cdot\vec{a}$ **(B)** $\vec{v}\cdot\vec{r}$ **(C)** $\vec{a}\cdot\vec{r}$ **(D)** $\vec{F}\cdot\vec{r}$

10. Acceleration-time graph of a particle executing SHM is as shown in the figure. Select the correct alternative(s).



(A) Displacement of particle at 1 is negative. **(B)** Velocity of particle at 2 is positive.
(C) Potential energy of particle at 3 is maximum **(D)** Speed of particle at 4 is decreasing

11. Density of liquid varies with depth as $\rho = \alpha h$. A small ball of density ρ_0 is released from the free surface of the liquid. Then

(A) the ball will execute SHM of amplitude ρ_0/α
(B) the mean position of the ball will be at a depth $\rho_0/2\alpha$ from the free surface.
(C) the ball will sink to a maximum depth of $2\rho_0/\alpha$
(D) all of the above

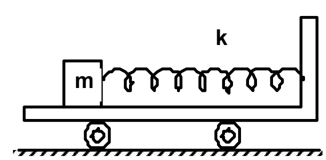
12. A particle starts SHM at time t = 0. Its amplitude is A and angular frequency is ω. At time t = 0 its kinetic energy is E/4. Assuming potential energy to be zero at mean position, then displacement-time equation of the particle can be written as

(A) $x = A\cos[\omega t + (\pi/6)]$ **(B)** $x = A\sin[\omega t + (\pi/3)]$
(C) $x = A\cos[\omega t - (2\pi/3)]$ **(D)** $x = A\cos[\omega t - (\pi/6)]$

13. A particle moves along the x-axis according to the equation $x = 4 + 3\sin(2\pi t)$, here x is in cm and t in second. Select the correct alternative(s).

(A) The motion of the particle is simple harmonic with mean position at x = 0
(B) The motion of the particle is simple harmonic with mean position at x = 4 cm
(C) The motion of the particle is simple harmonic with mean position at x = –4 cm
(D) Amplitude of oscillation is 3 cm

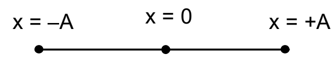
14. A block of mass m is attached to a massless spring of force constant k, the other end of which is fixed from the wall of a truck as shown in the figure. The block is placed over a smooth surface and initially the spring is unstretched. Suddenly the truck starts moving towards right with a constant acceleration a_0. As seen from the truck



(A) the particle will execute SHM. **(B)** the time period of oscillations will be $2\pi\sqrt{\frac{m}{k}}$

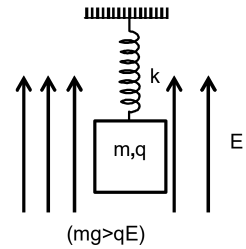
(C) the amplitude of oscillations will be $\frac{ma_0}{k}$ **(D)** the energy of oscillations will be $\frac{m^2 a_0^2}{k}$

15. Two particles undergo SHM along the same line with the same time period (T) and equal amplitudes **(A)**. At a particular instant one particle is at x = −A and the other is at x = 0. They move in the same direction. They will cross each other at



(A) t = 4T/3 **(B)** t = 3T/8 **(C)** x = A/2 **(D)** x = $A/\sqrt{2}$

16. A spring mass system as shown in figure is suspended in a constant electric field E. A charge q is given to the mass. Then the time period of oscillation of the system is



(A) $2\pi\sqrt{\frac{m}{k}}$ **(B)** $2\pi\sqrt{\frac{m}{2k}}$

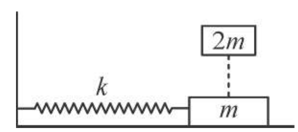
(C) $2\pi\sqrt{\frac{mg-qE}{k}}$ **(D)** $2\pi\sqrt{\frac{qE-mg}{k}}$

17. For a simple harmonic motion with given angular frequency ω, two arbitrary initial conditions are necessary and sufficient to determine the motion complete. These initial conditions may be :

(A) Initial position and initial velocity **(B)** Amplitude and initial phase

(C) Total energy of oscillation and amplitude **(D)** Total energy of oscillation and initial phase

18. An object of mass *m* is performing simple harmonic motion on a smooth horizontal surface as shown in the figure. Just as the oscillating object reaches its extreme position, another object of mass 2*m* is dropped on to oscillating object, which sticks to it. For this situation mark out the correct statement(s).



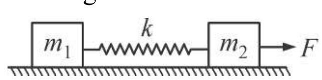
(A) Amplitude of oscillation remains unchanged

(B) Time period of oscillation remains unchanged

(C) The total mechanical energy of the system does not change

(D) The maximum speed of the oscillating object changes

19. Two blocks connected by a spring rest on a smooth horizontal plane as shown in the given figure. A constant force *F* starts acting on block m_2 as shown in the figure. Which of the following statements are not correct?



(A) Length of the spring increases continuously if $m_1 > m_2$.

(B) Blocks start performing SHM about centre of mass of the system, which moves rectilinearly with constant acceleration.

(C) Blocks start performing oscillations about centre of mass of the system with increasing amplitude.

(D) Acceleration of m_2 is maximum at initial moment of time only.

20. When the point of suspension of pendulum is moved, its period of oscillation

(A) Decreases when it moves vertically upwards with an acceleration *a*

(B) Decreases when it moves vertically downwards with acceleration greater than 2 *g*

(C) Increases when it moves horizontally with acceleration *a*

(D) All of the above

21. A spring of spring constant *K* is fixed to the ceiling of a lift. The other end of the spring is attached to a block of mass *m*. The mass is in equilibrium. Now the lift accelerates downwards with an acceleration. Now the lift accelerates downwards with an acceleration 2*g* :

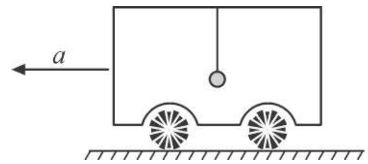
(A) The block will not perform SHM and it will stick to the ceiling.

(B) The block will perform SHM with time period $2\pi\sqrt{m/K}$.

(C) The amplitude of the block will be 2 *mg*/*K* if it perform SHM.

(D) The min. potential energy of the spring during the motion of the block will be 0.

22. Simple pendulum is kept suspended vertically in a stationary bus. The bus starts moving with an acceleration a towards left. As observed inside the bus : (Neglect frictional forces on pendulum and assume size of the ball to the very small.) :



(A) Time period of oscillation of the pendulum will be $2\pi\sqrt{\dfrac{l}{\sqrt{a^2+g^2}}}$ for any value of a

(B) Time period of oscillation of the pendulum will be $2\pi\sqrt{\dfrac{l}{\sqrt{a^2+g^2}}}$ only when $a << g$

(C) Angular amplitude of oscillation will be $\tan^{-1}\left(\dfrac{a}{g}\right)$ for any value of a

(D) Angular amplitude of oscillation will be $\tan^{-1}\left(\dfrac{a}{g}\right)$ only when $a << g$

23. A coin is placed on a horizontal platform, which undergoes vertical simple harmonic motion of angular frequency ω. The amplitude of oscillation is gradually increased. The coin will lave contact with the platform the first time

(A) At the mean position of the platform **(B)** At the mean position of the platform

(C) For an amplitude of $\dfrac{g}{\omega^2}$ **(D)** For an amplitude of $\sqrt{\dfrac{g}{\omega}}$

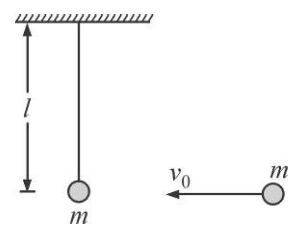
24. A simple pendulum consists of a bob of mass m and a light string of length l as shown in the given figure. Another identical ball moving with the small velocity v_0 collides with the pendulum's bob and sticks to it. For this new pendulum of mass $2m$, mark out the correct statement(s)

(A) Time period of the pendulum is $2\pi\sqrt{\dfrac{l}{g}}$.

(B) The equation of motion for this pendulum is $\theta = \dfrac{v_0}{2\sqrt{gl}}\sin\left[\sqrt{\dfrac{g}{l}}t\right]$.

(C) The equation of motion for this pendulum is $\theta = \dfrac{v_0}{2\sqrt{gl}}\cos\left[\sqrt{\dfrac{g}{l}}t\right]$.

(D) Time period of the pendulum is $2\pi\sqrt{\dfrac{2l}{g}}$



25. A simple pendulum is oscillating between extreme position P and Q about the mean position O. Which of the following statements are true about the motion of pendulum?

(A) At point O, the acceleration of the bob is different from zero.

(B) The acceleration of the bob is constant throughout the oscillation.

(C) The tension in the string is constant throughout the oscillation.

(D) The tension is maximum at O and minimum at P or Q

26. A horizontal spring-block system of mass 1 kg executes SHM of amplitude 10 cm. When the block is passing through its equilibrium position another mass of 1 kg is put on it and the two move together

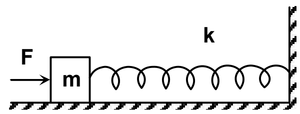
(A) amplitude will remain unchanged

(B) amplitude will become $5\sqrt{2}$ cm

(C) the frequency of oscillations will remain same

(D) the frequency of oscillations will decrease

27. A constant force F is applied on a spring block system as shown in the figure. The mass of the block is m and spring constant is k. The block is placed over a smooth surface. Initially the spring was unstretched. Choose the correct alternative(s).



(A) The block will execute SHM **(B)** Amplitude of oscillation is $F/2k$

(C) Time period of oscillation is $2\pi\sqrt{\dfrac{m}{k}}$ **(D)** Maximum speed of block $\dfrac{F}{\sqrt{mk}}$

Paragraph for Q.28 - 29

A 2 kg block hangs without vibrating at the bottom end of a spring with a force constant of 800 N/m. The top end of the spring is attached to the ceiling of an elevator car. The car is rising with an upward acceleration of 10 m/s^2. When the acceleration suddenly ceases at time $t = 0$. ($g = 10\ m/s^2$)

28. The amplitude of the oscillations is :

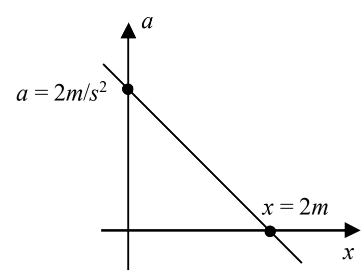
(A) 7.5 cm **(B)** 5 cm **(C)** 2.5 cm **(D)** 1 cm

29. The initial phase angle observed by a rider in the elevator, taking downward direction to be positive extreme position, is equal to (after the elevator ceases)

(A) zero **(B)** $\pi/2\ rad$ **(C)** $\pi\ rad$ **(D)** $3\pi/2\ rad$

Paragraph for Q. 30 - 31

A particle is performing SHM along x-axis. The graph between the acceleration of particle and its x-coordinate is shown. Using the graph answer the following question:



30. The time period of SHM will be :

(A) $2\pi\ sec$ **(B)** 1 sec **(C)** $\pi\ sec$ **(D)** None of these

31. What will be change in kinetic energy of the particle when it moves from $x = 0$ to $x = 2$ and mass of particle is $2kg$.

(A) $2J$ **(B)** $4J$ **(C)** $1J$ **(D)** $-2J$

32. Two particles A and B are performing SHM along x-and y-axis respectively with equal amplitude and frequency of 2cm and 1 Hz respectively. Equilibrium positions of the particles A and B are at the coordinates (3cm, 0) (0, 4cm) respectively. At $t = 0$, B is at its equilibrium position and moving towards the origin, while A is nearest to the origin and moving away from the origin. Equation of motion of particle B can be written as:

(A) $y = (2cm)\cos 2\pi t$ **(B)** $y = (4cm) - (2cm)\cos 2\pi t$

(C) $y = (2cm)\sin 2\pi t$ **(D)** $y = (4cm) - (2cm)\sin 2\pi t$

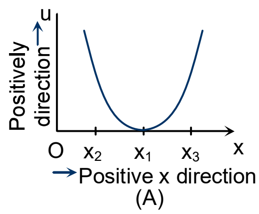
MATRIX MATCH TYPE

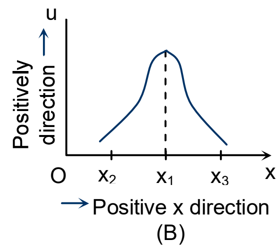
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

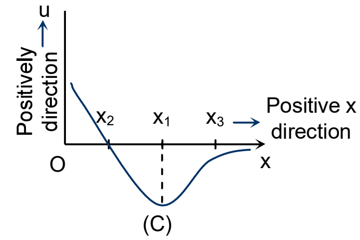
33. Figure **(A)** shows potential energy as a function of x for a particle that is moving in the x-direction under a conservative force.

Figure **(B)** shows potential energy as a function of x for another particle that is moving in the x-direction under a conservative force.

Figure **(C)** shows interaction potential energy as a function of x for a system of two particles that could move in the. x-direction under the mutual conservative force.







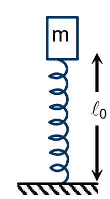
Column 1		Column 2	
(A	For the system in figure **(A)**	**(p)**	equilibrium position will be x = x_1 and equilibrium is unstable
(B)	For the system in figure **(B)**	**(q)**	equilibrium position will be x = x_1 and equilibrium is stable
(C)	For the system in figure **(C)**, let one of the particles be at x = 0 and consider different positions of the other particle, say, x_1, x_2 and x_3. Keeping in view the force acting on the other particle at x_1, x_2 and x_3	**(r)**	force on the particle for $x < x_1$ is in the negative x-direction and fro $x > x_1$, it is in the positive x-direction.
(D	consider a particle that performs S.H.M. along the x-direction with $x = x_1$ as the mean position. x_2 and x_3 are two other values of x such that $x_2 < x_1$ and $x_3 > x_1$; then	**(s)**	Force on the particle for $x \geq x_1$ will be the negative x-direction

SUBJECTIVE INTEGER TYPE

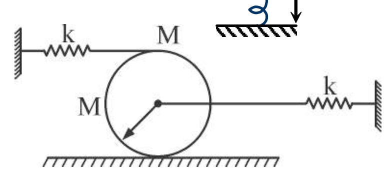
34. A pendulum has time period T in air. When it is made to oscillate in water, it acquired a time period $T' = \sqrt{2}T$. The specific gravity of the pendulum bob is equal to _______.

35. An object of mass 0.2 kg executes simple harmonic motion along X-axis with frequency of $25/\pi$ Hz. At the position x = 0.04 m, the object has kinetic energy of 0.5 J and potential energy of 0.4 J. if The amplitude of oscillation in meter is equal to A then the value of 100A will be_______.

36. A block of mass m attached with a spring and held by a person such that the spring is in natural length ℓ_0. Now the man releases the block, if the ratio of maximum compression in the spring in the given situation, to that of the compression at equilibrium position is K then find K.

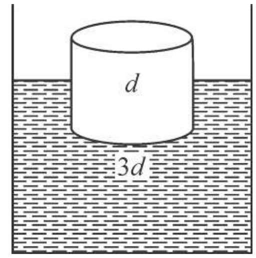


37. A solid uniform cylinder of mass M performs small oscillations due to the action of two springs, each having stiffness k. If time period of these oscillations in absence of any sliding is $T = 2\pi\sqrt{\dfrac{aM}{10k}}$, then find the value of a. (Springs have their neutral length initially)

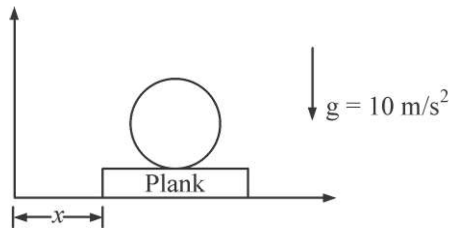


38. A particle executes SHM along a straight line with means position at $x = 0$, period 20 sec and amplitude 5 cm. Find the shortest time taken by the particle to go from $x = 4$ cm to $x = -3$ cm in seconds.

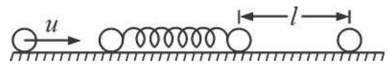
39. A cylindrical block of height 1 m is in equilibrium in a breaker as shown. Cross-sectional area of cylindrical block is one fourth of cross-sectional area of breaker. Density of cylindrical block is one third of liquid. Determine the time period of small oscillation (in seconds). (Given : $g = \pi^2 m/s^2$)



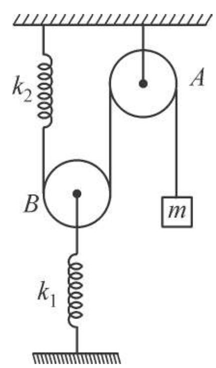
40. A solid cylinder is kept over a rough plane which is oscillating along x-axis according to equation $x = A \cos(10)t$, where x-axis according to equation $x = \text{A} \cos(10)\text{t}$, where x is in metre and t is in second. If coefficient friction between cylinder and plank is 0.3, then find maximum amplitude of plank (in cm) possible, so that cylinder never slips on plank.



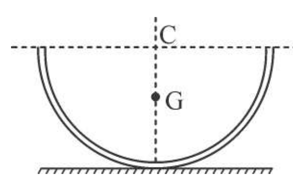
41. Two identical metal balls connected at the ends of a light spring of foe constant k form a dumbbell like spring of force constant k form a dumbbell like structure. The dumbbell rests on a frictionless horizontal floor and third identical ball is placed at distance l from the right ball of the dumbbell. All the three balls are in a line. A fourth identical ball moving with velocity u collides with left ball of the dumbbell. If all collisions are elastic and rightmost ball aquries a velocity u. the minimum value of l is $\pi u\sqrt{\frac{m}{xk}}$. Find x.



42. A block of mass m is tied to one end of a string which passes over a smooth fixed pulley A and under a light smooth movable pulley B as shown in figure. The other end of the string is attached to the lower end of a spring of spring constant k_2. Find the period of small oscillations of mass m about its equilibrium position.



43. A pipe in the form of a half ring of radius r is placed on a horizontal surface as shown in figure. If is rotated through, a small angle, and then released. Assuming that it rolls without sliding determine the period of oscillation



44. A pendulum with a length of 1.00 m is released form an initial angle of 15.0°. After 1100s, its amplitude is reduced by friction to 5°. What is the value of $\frac{m}{b}$ $(\ln 3 \simeq 1.1)$?

45. Damping is negligible for 0.32 kg mass hanging from a light 6.30 N/m spring. The system is driven by a force oscillating with an amplitude of 1.70 N. At what angular frequency will the force make the mass vibrate with an amplitude of 1 m?

JEE Advanced Revision Booklet	Wave Motion

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

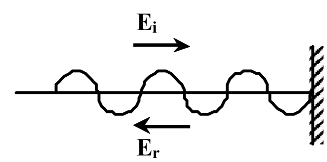
1. In a sonometer wire the fundamental frequency of the wire is 260*Hz*. In a sonometer the tension is maintained by suspending a 50.7 *kg* mass. When the suspended mass is completely submerged in water fundamental frequency becomes 240 *Hz*. The suspended mass has a volume

(A) 0.002 m^3 **(B)** 0.0075 m^3 **(C)** 0.004 m^3 **(D)** 0.006 m^3

2. A closed organ pipe resonates in its fundamental mode at a frequency of 200 *Hz* in O_2 at a certain temperature. If the pipe contains 2 moles of O_2 and, 3 moles of Ozone is now added to it, then what will be the fundamental frequency of same pipe at same temperature?

(A) 268.23 **(B)** 172.7 **(C)** 149.45 **(D)** None of these

3. What will be the ratio of amplitudes of the reflected wave to the incident wave in case a sinusoidal wave produced in a stretched string gets reflected and loses 36% of its energy in getting reflected from the fixed end of the string?



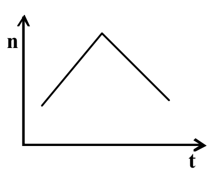
(A) 6 : 10 **(B)** 8 : 10 **(C)** 1 : 1 **(D)** None of these.

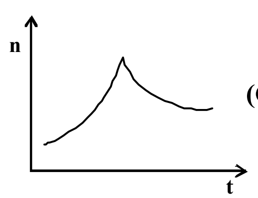
4. A sinusoidal wave (longitudinal or transverse) is propagating through a medium in the direction of –ve *x*-axis. The parameters of the waves are A, ω and k. The particle at $x = \lambda/4$ executes the motion $y(t) = A\, sin\omega t$. Possible equation of the wave is :

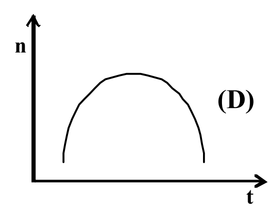
(A) $y(x, t) = A\, sin[\omega t - kx + (\pi/2)]$ **(B)** $y(x, t) = A\, sin[\omega t + kx + (\pi/2)]$

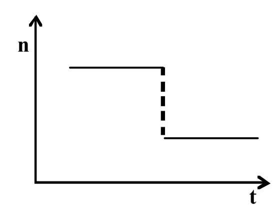
(C) $y(x, t) = A\, sin[\omega t - kx - (\pi/2)]$ **(D)** $y(x, t) = A\, sin[\omega t + kx - (\pi/2)]$

5. A railway engine whistling at a constant frequency moves with a constant speed. It goes past a stationary observer standing beside a railway track. The frequency (n) of the sound heard by the observer is plotted against time (t). Which of the following best represents the resulting curve?

(A)


(B)


(C)


(D)


6. A stationary observer receives sound waves from two tuning forks, one of which approaches and the other recedes with the same velocity. As this takes place, the observer hears beats with frequency 2 *Hz*. What is velocity of each tuning fork if their oscillation frequency is $\nu_o = 680$ *Hz* and the velocity of sound in air is $v_s = 340$ *m/s*

(A) 5 *m/s* **(B)** 0.5 *m/s* **(C)** 15 *m/s* **(D)** 50 *m/s*

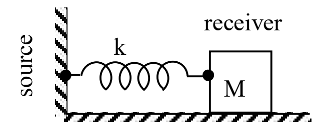
7. A man holding a sound source at the top of a tower emitting frequency of sound as $\nu = 1000Hz$. Suddenly it slips from his hand and falls down with '*g*' acceleration. The sources of frequency of sound heard by the man at $t = 4$ *sec*. (Velocity of sound = 320 *m/s*, $g = 10\ m/s^2$)

(A) 889*Hz* **(B)** 890*Hz* **(C)** 894*Hz* **(D)** 892*Hz*

8. A train moves towards a stationary observer with 34 *m/s*. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 *m/s*. The frequency registered is f_2. If speed of sound in air is 340 *m/s*, then the ratio $\frac{f_1}{f_2}$ is:

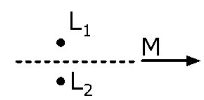
(A) 18/19 **(B)** 1/2 **(C)** 2 **(D)** 19/18

9. In the given arrangement a source is placed at the fixed end of the spring with spring constant 100 *N*/*m* and the receiver is attached to the moving end of the spring, which in turn is connected to a box of mass 4*kg*, which is oscillating horizontally with an amplitude of oscillation 2*m*. If the source emits a frequency of 990 *Hz* then : (Speed of sound = 330*m*/s)



(A) Maximum frequency received by the receiver is 990Hz
(B) Minimum frequency received by the receiver is 990Hz
(C) Frequency band width received by the receiver is 960Hz – 1020Hz.
(D) Maximum and minimum frequencies are received at the extreme positions

10. L_1 and L_2 are two small loud speakers which emit sound waves of the same amplitude but with a phase difference of π. A small receiver *M* moves along the perpendicular bisector of L_1L_2 in the direction as shown in the figure. The intensity of the sound recorded in the receiver is :



(a) continuously decreasing tending to zero at a very large distance
(b) alternates between a constant maximum and zero minimum
(c) alternates between a diminishing maximum and increasing minimum
(d) remains constant equal to zero

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

11. Displacement of particles in a string in *x*-direction and is represented by *y*. Account the following expression for *y*, those describing wave motion are

(A) $\cos kx \sin \omega t$ **(B)** $k^2x^2 - \omega^2 t^2$ **(C)** $\cos^2(kx + \omega t)$ **(D)** $\cos\left(kx^2 - \omega^2 t^2\right)$

12. Two sound waves of equal intensity *I*, generates beats. The intensity of sound I_s produced in beats will be

(A) I **(B)** $4I$ **(C)** $2I$ **(D)** $0 < I_s < 4I$

13. The equation of transverse displacement of a string clamped at both ends is y = 0.06 $\sin\left(\frac{2\pi x}{3}\right)\cos(120\pi t)$, where *x, y* are in meters and *t* is in second. The length of the string is 1.5 *m* and its mass is $3 \times 10^{-2}\ kg$. Then

(A) wavelength, frequency and speed of progressive waves are 3 *m*, 60 *Hz* and 180 *m/s*, respectively.
(B) tension in the string is 648 *N*
(C) amplitude at a distance $x = 0.375\ m$ is 4.2 *cm* at any time *t*.
(D) wavelength, frequency and speed of progressive wave are 3 *m*, 80 *Hz* and 240 *m/s*

14. A wave pulse moving in the positive *x*-direction along the *x*-axis is represented by the wave function $y(x, t) = \frac{2.0}{(x - 3.0t)^2 + 1}$, where *x* and *y* are in centimeters and t is in seconds. Then :

(A) The speed of particle at time $t = 1$ sec. and $x = 3\ cm$ is zero
(B) The speed of particle at time $t = 1$ sec. and $x = 3\ cm$ is 2 *cm*/*s*
(C) The speed of the pulse is 3.0 *cm*/*s*
(D) The speed of the pulse is 0.33 *cm*/*s*

15. Two whistles A & B each have a frequency of 500 Hz. A is stationary and B is moving towards the right (away from A) at a speed of 50 m/s. An observer is between the two whistles moving towards the right with a speed of 25 m/s. The velocity of sound in air is 350 m/s. Assume that there is no wind. Which of the following is/are true ?

(A) the apparent frequency of whistle B as heard by A is 437 Hz approximately
(B) the apparent frequency of whistle B as heard by observer is 469 Hz approximately
(C) the difference in the apparent frequencies of A and B as heard by the observer is 4.5 Hz
(D) the apparent frequencies of the whistles as observed by each other are the same

16. The equation of motion of a longitudinal wave is $y = 0.15\sin[4\pi t - \pi x]$ Where x & y are measured in meters an t in second.

(A) The distance between two successive points having phase difference π is 1m
(B) The wave travels along negative x-axis
(C) The frequency of the wave is 2Hz
(D) At 20 cm. Displacement of the particle, kinetic energy of the latter is zero. At t = 4 sec.

17. Along the straight line joining two consecutive displacement-nodes in a pure stationary sound wave, at different points.

(A) the S.H.M.'s will be in different phases
(B) the velocities are in phase
(C) the accelerations are in phase
(D) the frequencies are equal

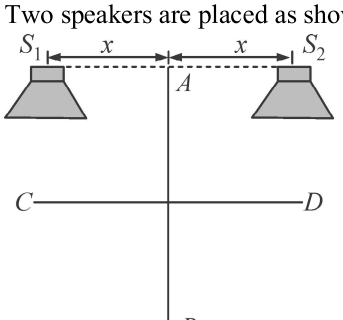
18. Mark out the correct statement(s) w.r.t. wave speed and particle velocity for a transverse travelling mechanical wave on a string.

(A) The wave speed is same for the entire wave, while particle velocity is different for different points at a particular instant.
(B) Wave speed depends upon property of the medium but not on the wave properties.
(C) Wave speed depends upon both the properties of the medium and on the medium and on the properties of wave.
(D) Particle velocity depends upon properties of the wave and not on medium properties.

19. Three simple harmonic waves, identical in frequency n and amplitude A moving in the same direction are superimposed in air in such a way, that the first, second and the third wave have the phase angle $\phi, \phi + (\pi/2)$ and $(\phi + \pi)$, respectively at a given point P in the superposition. Then as the waves progress, the superposition will result in .

(A) A periodic, non-simple harmonic wave of amplitude 3A
(B) A stationary simple harmonic wave of amplitude 3A
(C) A simple harmonic progressive wave of amplitude A
(D) The velocity of the superposed resultant wave will be the same as the velocity of each wave

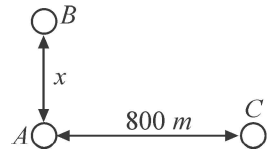
20. Two speakers are placed as shown in figure.



Mark out the correct statement(s)

(A) If a person is moving along AB, he will hear the sound as loud, faint, loud and so on
(B) If a person moves along CD, he will hear loud, faint, loud and so on
(C) If a person moves along AB, he will hear uniform intense sound
(D) If a person moves along CD, he will hear uniform intense sound

21. A radio transmitter at position A operates at a wavelength of 20 m. A second, identical transmitter is located at a distance x from the first transmitter, at position B. the transmitters are phase locked together such that the second transmitter is lagging $\pi/2$ out of phase with the first. For which of the following values of $BC - CA$ will the intensity at C be maximum.

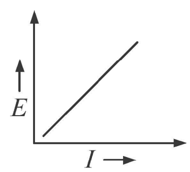


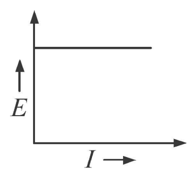
(A) $BC - CA = 60\ m$
(B) $BC - CA = 65\ m$
(C) $BC - CA = 55\ m$
(D) $BC - CA = 75\ m$

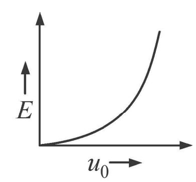
22. A source S of sound wave of fixed frequency N and an observer O are located in air initially at the space points A and B, a fixed distance apart. State in which of the following cases, the observer will NOT see any Doppler effect and will receive the same frequency N as produced by the source.

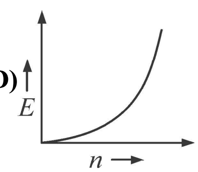
(A) Both the source S and observer O remain stationary but a wind blows with a constant speed in an arbitrary direction.
(B) The observer remains stationary but the source S moves parallel to and in the same direction and with the same speed as the wind.
(C) The source remains stationary but the observer and the wind have the same speed away from the source.
(D) The source and the observer move directly against the wind but both with the same speed.

23. A sonic source, located in a uniform medium, emits waves of frequency n. If intensity, energy density (energy per unit volume of the medium) and maximum speed of oscillations of medium particle are, respectively, I, E and u_0 at a point, then which of the following graphs are correct?

(A) 

(B) 

(C) 

(D) 

Paragraph for Q. 24- 26

A long string having a cross-sectional area $0.80\ mm^2$ and density $12.5\ g/cm^3$ is subjected to a tension of 64 N along the x-axis. One end (at $x = 0$) of this string is attached to a vibrator moving in transverse direction at a frequency of 20 Hz. At t = 0, the source is at a maximum displacement $y = 1.0 cm$.

24. Find the speed of the wave travelling on the string.

(A) $20 m/s$ **(B)** $10\ m/s$ **(C)** $80\ m/s$ **(D)** $40\ m/s$

25. Write the equation for the wave.

(A) $y = (1.0\ cm)\cos[(40\pi s^{-1})t - \{\pi/2\ m^{-1})x\}]$
(B) $y = (1.0\ cm)\cos[(40\pi s^{-1})t + \{\pi/2\ m^{-1})x\}]$
(C) $y = (1.0\ cm)\cos[(40\pi s^{-1})t - \{\pi/4\ m^{-1})x\}]$
(D) $y = (1.0\ cm)\cos[(40\pi s^{-1})t + \{\pi/4 m^{-1})x\}]$

26. What is the displacement of the particle of the string at $x = 50\ cm$ at time $t = 0.05 s$?

(A) $\frac{1}{\sqrt{2}} cm$ **(B)** $\sqrt{2}\ cm$ **(C)** $\frac{\sqrt{3}}{2} cm$ **(D)** $\frac{1}{\sqrt{3}} cm$

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

27. Consider a situation (i) that two sound waves, $y_1 = (0.2m)\ sin\ 504\ \pi(t - x/300)$ and $y_2 = (0.6m)\ sin\ 496\pi\ (t - x/300)$, are superimposed. Consider another situation (ii) that two sound waves, $y'_1 = (0.4\text{m})\sin\ 504\pi(t - x/300)$ and $y'_2 = (0.4m)\ sin\ 504\pi(t + x/300)$, are superimposed.

	Column 1		Column 2
(A)	In situation (i)	**(p)**	Stationary waves are formed
(B)	In situation (ii)	**(q)**	There will be the phenomenon of 'Beats'
(C)	When two waves of same frequency and amplitude and travelling in opposite directions superimpose	**(r)**	Amplitude of the resultant wave will vary periodically with position
(D)	If the intensity of sound alternately increases and decreases periodically as a result of superposition of waves of slightly different frequency	**(s)**	Amplitude of the resultant wave will vary periodically

28. Referring to the above question, match Column-I and II:

	Column 1		Column 2
(A)	Frequency of resultant wave in situation(i) in *Hz* will be	**(p)**	0.8 *m*
(B)	Maximum amplitude of the resultant wave in situation (ii) will be	**(q)**	250
(C)	In situation (i), in a time of 1 sec, intensity of sound at a point will become maximum on how many occasions?	**(r)**	4
(D)	Ratio of maximum and minimum intensities situation (i) will be	**(s)**	zero

SUBJECTIVE INTEGER TYPE

29. The amplitude of a wave disturbance propagating in the positive x-direction is given by $y = \dfrac{1}{\sqrt{1+x^2}}$ at $t = 0$ and by $y = \dfrac{1}{\sqrt{2-2x+x^2}}$ at $t = 1s$, where x and y are in metres. The shape of the wave disturbance does not change during propagation. Find the velocity (in *m/s*) of the wave propagation.

30. A band playing music at a frequency f is moving towards a wall at a speed v_b. A motorist is following the band with a speed v_m. If v is the speed of sound, find the beat frequency heard by the motorist. ($v_b = v_m = 20\ m/s$, Speed of sound in air 320 m/s, $f = 30\ Hz$)

31. A block having mass 8 kg, is suspended from a support through a string having linear mass density $20 \times 10^{-4}\ kg/m$. Find the speed (with respect to the string) with which speed (in *cm/s*) a wave pulse can proceed at the bottom of the string if the point of support moves with an acceleration $8\hat{i} - 4\hat{j}$. Take $g = 10\ m/s^2$.

32. A string fixed at both ends is vibrating in its lowest mode of vibration for which midpoint has maximum displacement. Frequency of vibration in this mode is 1 *Hz*. What will be the frequency (in *HZ*) of vibration, when it vibrates in the next mode such that this point again has maximum displacement?

33. In a stationary wave pattern which is formed after reflection of a wave from an obstacle. The ratio of the amplitude at an antinodes to the amplitude at node is 4. If X percentage of energy is reflected, then find the value of $X/9$.

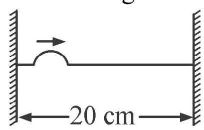
34. Two waves given by following equation travels in a same string

$$y_1(x, t) = 2A\ sin(kx - \omega t + \phi)$$

$$y_2(x, t) = A\ cos\ \omega t\ sin\ kx$$

if the maximum displacement in the string is KA then find K.

35. A string of length 20 cm and linear mass density 0.40 g/cm is fixed both ends and is kept under a tension of 16N. A wave pulse is produced at t = 0 near an end as shown figure which travels towards the other end.



When will the string have the shape shown in the figure again? (in $\times 10^{-2} s$)

36. A 4.0 kg block is suspended from the ceiling of an elevator through a string having a linear mass density $19.2 \times 10^{-3}\ kg/m$. The speed (with respect to the string) with which a wave pulse can proceed on the string if the elevator accelerates up at the rate of $2.0\ m/s^2$ is 12.n. What is the value of n? Take $= g = 10 m/s^2$

37. A plane progressive wave is given by $x = (40\ cm)\ \cos\ (50\pi/t - 0.02\pi y)$ where y is in cm and t in s. The particle velocity at y = 25 m in time $t = \frac{1}{100} s$ will be $10\pi\sqrt{n}\ m/s$. What is the value of n.

38. An ant with mass m is standing peacefully on top of a horizontal, stretched rope. The rope has mass per unit length μ and is under tension F. Without warning, a student starts a sinusoidal transverse wave of wavelength λ propagating along the rope. The motion of the rope is in a vertical plane. What minimum wave amplitude (in mm) will make the ant feel weightless momentarily? Assume that m is so small that the presence of the ant has no effect on the propagation of the wave.

[Given: $\lambda = 0.5 m, \mu = 0.1 kg/m, F = 3.125\ N$, take $g = \pi^2$]

39. A tuning fork of frequency 200 Hz is in unison with a sonometer wire. How many beats are heard in 30 s if the tension is increased by 1% (in terms of × 10)

40. A closed and an open organ pipe of same length are set into vibrations simultaneously in their fundamental mode to produce 2 beats. The length of open organ pipe is now halved and of closed organ pipe is doubled. Now find the number of beats produced.

41. The average power transmitted across a cross-section by two sound waves moving in the same direction are equal. The wavelengths of two sound waves are in the ratio of 1:2, then find the ratio their pressure amplitudes.

42. Loudness of sound from an isotropic point source at a distance of 70 cm is 20 dB. What is the distance (in m) at which it is not heard.

43. An ambulance sounding a horn of frequency 264 Hz is moving towards a vertical wall with a velocity of $5 ms^{-1}$. If the speed of the sound is $330\ ms^{-1}$, how many beats per second will be heard by an observer standing a few meters behind the ambulance?

44. The intensity of sound from a point source is $1.0 \times 10^{-8}\ W/m^2$ at a distance of 5.0 m from the source. What will be the intensity at a distance of 25 m from the source? (in $\times 10^{-10}\ W/m^2$)

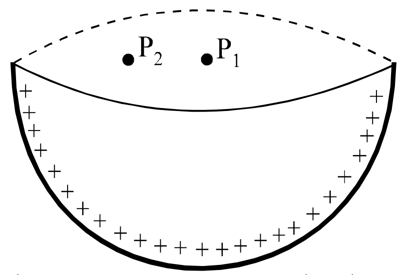
45. A string 120 cm in length sustains a standing wave, with the points of the string at which the displacement amplitude is equal to 3.5 mm being separated by 15.0 cm. Find the maximum displacement amplitude. To which overtone do these oscillations correspond?

JEE Advanced Revision Booklet	Electrostatics

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. Consider a uniformly charged hemispherical shell shown below. Indicate the directions (not magnitude) of the electric field at the central point P_1 and an off-centre point P_2 on the drumhead of the shell.



(A) $\uparrow$; $\nwarrow$ **(B)** $\uparrow$; $\nearrow$ **(C)** $\uparrow$; $\uparrow$ **(D)** $\uparrow$; $\leftarrow$

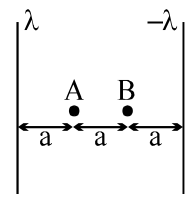
2. On an imaginary planet the acceleration due to gravity is same as that on Earth but there is also a downward electric field that is uniform close to the planet's surface. A ball of mass m carrying a charge q is thrown upward at a speed v and hits the ground after an interval t. What is the magnitude of potential difference between the starting point and the top point of the trajectory?

(A) $\dfrac{mv}{2q}\left(v-\dfrac{gt}{2}\right)$ **(B)** $\dfrac{mv}{q}\left(v-\dfrac{gt}{2}\right)$ **(C)** $\dfrac{mv}{2q}(v-gt)$ **(D)** $\dfrac{2mv}{q}(v-gt)$

3. A system consists of a uniformly charged sphere of radius R and a surrounding medium filled by a charge with the volume density $\rho = \alpha/r$, where α is a positive constant and r is the distance from the centre of the sphere. Find the charge of the sphere for which the electric field intensity E outside the sphere is independent of r.

(A) $\alpha/2\in_0$ **(B)** $2/\alpha\in_0$ **(C)** $2\pi\alpha R^2$ **(D)** None of these

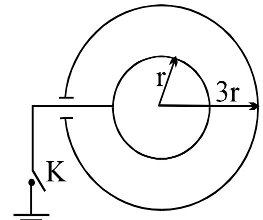
4. Between two infinitely long wires having linear charge densities λ and $-\lambda$ there are two points A and B as shown in the figure. The amount of work done by the electric field in moving a point charge q_0 from A to B is equal to :



(A) $\dfrac{\lambda q_0}{2\pi\varepsilon_0}\ln 2$ **(B)** $-\dfrac{2\lambda q_0}{\pi\varepsilon_0}\ln 2$

(C) $\dfrac{2\lambda q_0}{\pi\varepsilon_0}\ln 2$ **(D)** $\dfrac{\lambda q_0}{\pi\varepsilon_0}\ln 2$

5. Figure shows two conducting thin concentric shells of radii r and 3r. The outer shell carries charge q and inner shell is neutral. The amount of charge which flows from inner shell to the earth after the key K is closed, is equal to:



(A) –q/3 **(B)** q/3

(C) 3q **(D)** –3q

6. A circular disk of radius 'a' has uniform surface charge density σ on one side. The potential at a point P on the circumference is:

(A) $\dfrac{\sigma a}{\pi\varepsilon_0}$ **(B)** $\dfrac{2\sigma a}{\pi\varepsilon_0}$ **(C)** $\dfrac{\sigma a}{2\pi\varepsilon_0}$ **(D)** $\dfrac{4\sigma a}{\pi\varepsilon_0}$

7. Four point charges, $+q$, $+q$ and $-q$, $-q$ are placed on the vertices of a regular tetrahedron of edge length a. Each vertex has one point charge. The magnitude of equivalent dipole moment of the tetrahedron is:

(A) Zero **(B)** $qa\sqrt{2}$ **(C)** 2qa **(D)** Not Defined

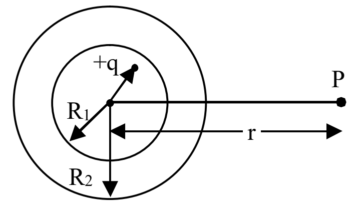
8. Positive charge Q is distributed uniformly over a circular ring of radius R. A particle having a mass m and a negative charge $-q$, is placed on its axis at distance X $(x \ll R)$ from the centre. The particle is now released from rest. Then the time period of oscillation of the particle will be. (Neglect gravity)

(A) $\left[\dfrac{4\pi^3\varepsilon_0 mR^3}{Qq}\right]^{1/2}$ **(B)** $\left[\dfrac{8\pi^3\varepsilon_0 mR^3}{Qq}\right]^{1/2}$ **(C)** $\left[\dfrac{32\pi^3\varepsilon_0 mR^3}{Qq}\right]^{1/2}$ **(D)** $\left[\dfrac{16\pi^3\varepsilon_0 mR^3}{Qq}\right]^{1/2}$

9. Three concentric metallic spherical shells of radii R, 2R, 3R, are given the charges Q_1, Q_2, Q_3 respectively. It is found that the surface charge densities on the outer surface of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1 : Q_2 : Q_3$ is :

(A) 1 : 2 : 3 **(B)** 1 : 3 : 5 **(C)** 1 : 4 : 9 **(D)** 1 : 8 : 18

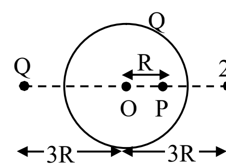
10. A conducting shell having inner radius R_1 and outer radius R_2 contains a charge $+q$ which is placed at a distance x from its centre. Field at an exterior point P which is situated at a distance r from centre of shell ($r > R_2$)



(A) Depends on x **(B)** Depends on R_1 and R_2

(C) Depends only on r **(D)** None of these

11. A solid conducting sphere of radius $2R$, carrying charge Q is surrounded by two point charges Q and $2Q$ as shown in the figure. The electric field at point P due to the induced charges on conducting sphere is :



(A) $\dfrac{7}{16}\dfrac{KQ}{R^2}$ towards right **(B)** $\dfrac{1}{8}\dfrac{KQ}{R^2}$ towards right

(C) $\dfrac{KQ}{R^2}$ towards right **(D)** Zero

12. Two small electric dipoles of dipole moment $p\hat{j}$ and $-p\hat{i}$ are situated at (0, 0, 0) and (r, 0, 0) respectively. The electric potential at a point $\left(\dfrac{r}{2}, \dfrac{\sqrt{3}r}{2}, 0\right)$ is :

(A) $\dfrac{p\left(\sqrt{3}+1\right)}{8\pi \in_0 r^2}$ **(B)** 0 **(C)** $\dfrac{p}{2\pi \in_0 r^2}$ **(D)** $\dfrac{p}{8\pi \in_0 r^2}$

13. The centres of two identical small spheres are 1 m apart. They carry charges of opposite kind and attract each other with a force f. When they are connected by a conducting wire of negligible capacitance they repel each other with a force f/3. Find the ratio of charges carried by the spheres initially.

(A) 4 : 1 **(B)** 3 : 1 **(C)** 2 : 1 **(D)** 1 : 1

MULTIPLE CORRECT ANSWERS TYPE

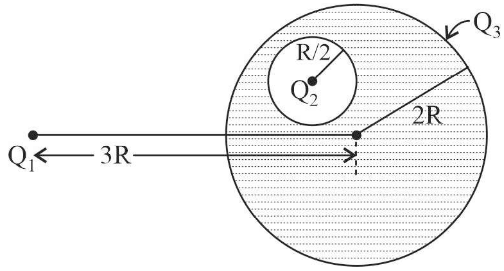
Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

14. A particle of mass m and charge q is thrown in a region where uniform gravitational field and electric field are present. The path of particle **(Neglect relativistic effects)**

(A) may be a straight line **(B)** may be a circle

(C) may be a parabola **(D)** may be a hyperbola

15. A spherical conductor of radius 2R has a spherical cavity of radius $\frac{R}{2}$. The cavity does not enclose the centre of sphere. Charges Q_1 and Q_2 are placed as shown in figure. Q_2 is at the center of cavity. An additional charge Q_3 is given to the sphere.



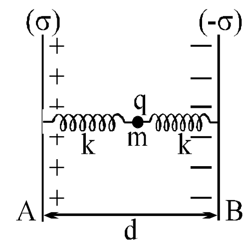
(A) The potential of the sphere is $\frac{KQ_1}{3R}+\frac{K(Q_2+Q_3)}{2R}$

(B) The potential inside the cavity at a distance $r\left(r<\frac{R}{2}\right)$ from the center of cavity is $\left\{\frac{kQ_1}{3R}-\frac{2kQ_2}{R}+\frac{kQ_2}{r}+\frac{kQ_3}{2R}+\frac{kQ_2}{2R}\right\}$

(C) The value of potential outside the sphere at a distance r from the center of sphere is $\frac{k(Q_2+Q_3)}{r}+\frac{kQ_1}{r'}$ where r' is the distance from Q_1

(D) The charge that will flow into ground if the sphere is grounded $Q_2+Q_3+\frac{2Q_1}{3}$

16. Two large conducting plates having surface charge densities $+\sigma$ and $-\sigma$, respectively, are fixed 'd' distance apart. A small test charge q of mass m is attached to two identical springs as shown in the adjacent figure. The charge q is now released from rest with springs in natural length. Then q will [neglect gravity]



(A) perform SHM with angular frequency $\sqrt{\frac{2k}{m}}$

(B) perform SHM with amplitude $\frac{\sigma q}{2k\in_0}$

(C) not perform SHM, but will have a periodic motion

(D) remain stationary

17. Imagine a dipole is at the centre of an imaginary spherical surface. If magnitude of electric field at a certain point on the surface of sphere is 10 N/C, then which of the following **cannot** be the magnitude of electric field anywhere on the surface of sphere

(A) 4 N/C **(B)** 8 N/C **(C)** 16 N/C **(D)** 32 N/C

18. Which of the following aspects is correct, when an uncharged metal sphere is placed in a uniform electric field & electrostatic condition has been achieved

(A) The metal sphere will become charged now.

(B) The induced charges appearing on the surface of the sphere produce an electric field, at each point within the sphere & outside sphere.

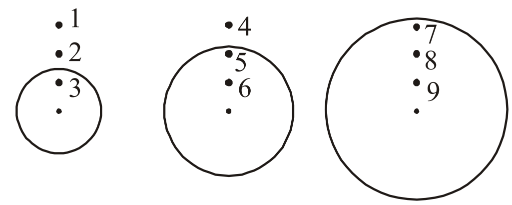
(C) The electric field lines, just outside the sphere are normal to the spherical surface.

(D) The electric field lines in the spherical region decrease, as soon as the sphere is placed.

19. Three equal point charges (Q) are kept at the three corners of an equilateral triangle ABC of side a. P is a point having equal distance a from A, B and C. If E is the magnitude of electric field and V is the potential at point P, then

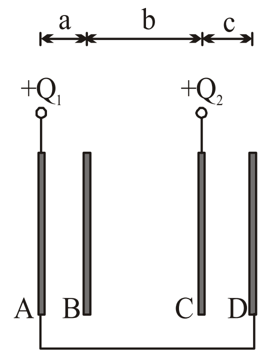
(A) $E=\frac{3Q}{4\pi\varepsilon_0 a^2}$ **(B)** $E=\frac{\sqrt{6}Q}{4\pi\varepsilon_0 a^2}$ **(C)** $V=\frac{3Q}{4\pi\varepsilon_0 a}$ **(D)** $E=\frac{3\sqrt{6}Q}{4\pi\varepsilon_0 a^2}$

20. Figure shows three spherical shells in separate situations, with each shell having the same uniform positive net charge. Points 1, 4 and 7 are at the same radial distances from the centre of the their respective shells; so are points 2, 5 and 8 ; and so are points 3, 6 and 9. With the electric potential taken equals to zero at an infinite distance, choose correct statement.



(A) Point 3 has highest potential
(B) Point 1, 4 and 7 are at same potential
(C) Point 9 has lowest potential
(D) Point 5 and 8 are at same potential

21. Figure shows an arrangement of four identical rectangular plates A, B, C and D each of area S.Ignoring the separation between the plates in comparison to the plate dimensions, the correct option(s) are :

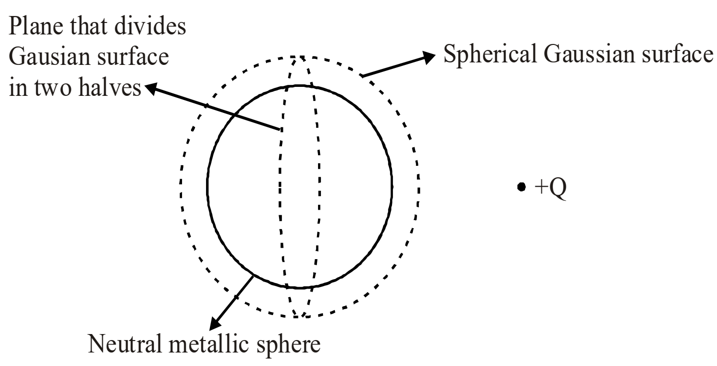


(A) Potential difference between plates A & B is independent of Q_1.
(B) Potential difference between plates C & D is independent of Q_1.
(C) Potential difference between plates A & B is independent of Q_2.
(D) Potential difference between plates C & D is independent of Q_2.

22. Choose the correct statement(s)
(A) Electrons in a conductor have no motion in the absence of a potential difference across it.
(B) Two identical metallic spheres of exactly equal masses are taken. One is given a positive charge Q coulombs and the other an equal negative charge. Their masses after charging are different.
(C) A line of force in an electric field is the path traced by a unit positive charge, free to move in that field.
(D) The energy of a charged conductor is stored partly inside the conductor and partly outside the conductor.

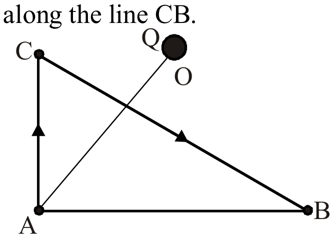
23. In a uniform electric field, when we move from origin to x = 1m, the potential changes by 10V. Which of the following can be a possible magnitude of the electric field.
(A) 10 V/m **(B)** 15 V/m **(C)** 5 V/m **(D)** 20 V/m

24. Figure shows a neutral metallic sphere with a point charge +Q placed near its surface. Electrostatic equilibrium conditions exist on metallic sphere. Mark the correct statements:



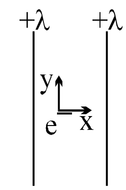
(A) Net flux through Gaussian surface due to charge Q is zero
(B) Net flux through Gaussian surface due to charges appearing on the outer surface of metallic sphere must be zero
(C) If point charge Q is displaced towards metallic sphere, magnitude of net flux through right hemispherical closed Gaussian surface increases.
(D) If point charge Q is displaced towards metallic sphere, charge distribution on outer surface of sphere will change

25. There is a fixed positive charge Q at O and A and B are points equidistant from O. A positive charge + q is taken slowly by an external agent from A to B along the line AC and then along the line CB.



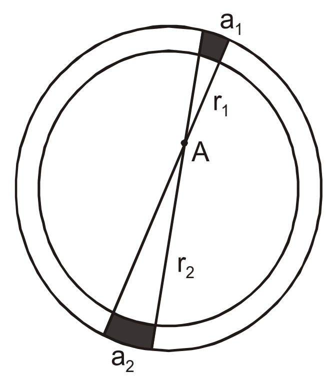
(A) The total work done on the charge is zero
(B) The work done by the electrostatic force from A to C is negative
(C) The work done by the electrostatic force from C to B is positive
(D) The work done by electrostatic force in taking the charge from A to B is dependent on the actual path followed.

26. An electron is placed just in the middle between two long fixed line charges of charge density $+\lambda$ each. The wires are in the xy plane (Do not consider gravity)



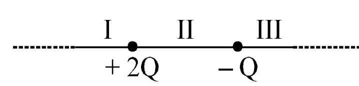
(A) The equilibrium of the electron will be unstable along x-direction
(B) The equilibrium of the electron will be neutral along y-direction
(C) The equilibrium of the electron will be stable along z-direction
(D) The equilibrium of the electron will be stable along y-direction

27. A wire having a uniform linear charge densityλ, is bent in the form of a ring of radius R. Point A as shown in the figure, is in the plane of the ring but not at the centre. Two elements of the ring of lengths a_1 and a_2 subtend very small same angle at the point A. They are at distances r_1 and r_2 from the point A respectively.



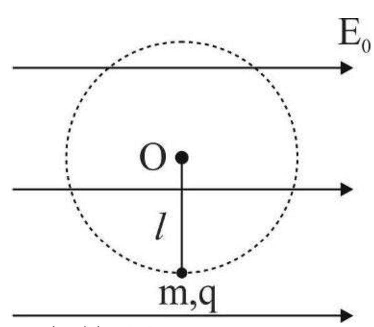
(A) The ratio of charge of elements a_1 and a_2 is r_1/r_2.
(B) The element a_1 produced greater magnitude of electric field at A than elementa_2.
(C) The elements a_1 and a_2 produce same potential at A.
(D) The direction of net electric field at A is towards element a_2.

28. The figure shows, two point charges $q_1 = 2Q$ (>0) and $q_2 = -Q$. The charges divide the line joining them in three parts I, II and III



(A) Region III has a local maxima of electric field
(B) Region I has a local minima of electric field
(C) Equilibrium position for a test charge lies in region (II)
(D) The equilibrium for constrained motion along the line joining the charges is stable for a negative test charge in region (III).

29. The given charged particle of charge q and mass m is in circular motion in vertical plane. String is massless and it's one end is fixed at point O. Velocity of projection is minimum so that it just completes vertical circle. Electrical field is uniform, horizontal and in the plane of vertical circle $\left(qE_0 = mg\right)$:

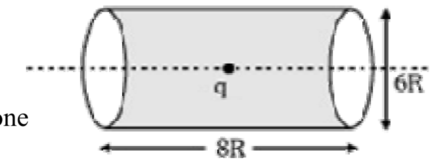


(A) Minimum velocity during the circular motion is $\sqrt{2g\ell}$
(B) Difference between minimum and maximum tension is $6\sqrt{2}mg$
(C) At the position of maximum tension angle made by the string with the vertical is 45°
(D) Maximum velocity during this circular motion is $\sqrt{10g\ell}$

30. Small identical balls with equal charges are fixed at the vertices of a regular polygon of N sides, each of length d. At a certain instant, one of the ball is released. After a long time interval, the adjacent ball to the previous one is released. The difference in kinetic energies of the two released balls is K at a sufficiently long distance from the polygon.

(A) Final kinetic energy of the first ball is greater than that of the second ball
(B) Final kinetic energy of the second ball is greater than that of the first ball
(C) Charge on each ball is $\sqrt{2\pi\varepsilon_0 dK}$ **(D)** Charge on each ball is $\sqrt{4\pi\varepsilon_0 dK}$

31. A point charge q is placed at the mid point on the axis of the given cylinderical surface which is open at it's end points. (Length of the cylinder is 8R and diameter is 6R)



(A) Flux through two circular surfaces is $\frac{q}{5\varepsilon_0}$

(B) Flux through curved surface is 8 times more than that through one circular surface.

(C) If q is at shifted to center of one circular end then flux through cylinder will be $q/2\varepsilon_0$

(D) All the above statements are correct

32. A ring has charge Q and radius R. If a charge q is placed at its centre then the increase in tension in the ring is

(A) Directly proportional to $Q \times q$ **(B)** Inversely proportional to R^2

(C) Inversely proportional to R^3 **(D)** Independent of R

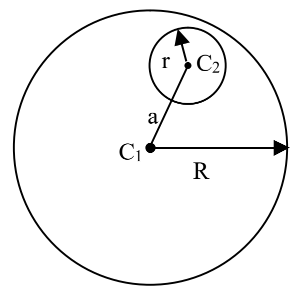
33. A conducting disc of radius R is rotating with an angular velocity ω. Assuming mass of electrons is m and charge is e, the potential difference between the centre of the disc and the edge will be:

(A) Directly proportional to ω^2 **(B)** Inversely proportional to R^2

(C) Directly proportional to R^2 **(D)** Inversely proportional to e

Paragraph for Q.34.–35.

A cylindrical cavity runs inside a uniformly positively charged solid cylinder of radius R such that the axis of cavity is parallel to axis of cylinder. Radius of cavity is *r* and separation between the axis of cylinder and cavity is a. The figure shows cross-section view such that plane of cross-sectional area is perpendicular to the axis of cylinder. The volume charge density for the system is ρ. Now answer the following question :



34. Consider any point P inside the cavity in a cross-sectional plane as shown in figure given in the above passage. Direction of field at point P is :

(A) From point C_1 to C_2 **(B)** From point C_2 to C_1

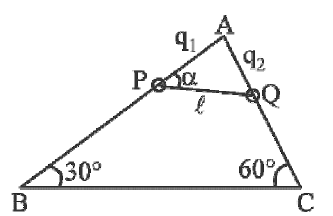
(C) From point C_1 to P **(D)** From point C_2 to P

35. Magnitude of electric field intensity inside the cavity is :

(A) $\frac{\rho a}{2 \epsilon_0}$ **(B)** $\frac{\rho R}{2 \epsilon_0}$ **(C)** $\frac{\rho r}{2 \epsilon_0}$ **(D)** $\frac{\rho R}{2 \epsilon_r}$

Paragraph for Q. 36.–39.

A rigid insulated wire frame in the form of a right-angled triangle *ABC*, is set in a vertical plane as shown figure. Two beads of equal masses *m* each and carrying charges q_1 and q_2 are connected by a cord of length ℓ and can slide without friction on the wires. The beads are stationary.



36. The value of angle α is:

(A) 30° **(B)** 45° **(C)** 60° **(D)** 75°

37. The tension in the chord is :

(A) mg **(B)** $\frac{q_1 q_2}{4\pi\varepsilon_0 \ell^2}$ **(C)** $mg + \frac{q_1 q_2}{4\pi\varepsilon_0 \ell}$ **(D)** zero

38. The normal reaction on bead Q is:

(A) mg **(B)** $\sqrt{2}\ mg$ **(C)** $2mg$ **(D)** $\sqrt{3}\ mg$

39. If the cord is cut, the magnitude of the product $|q_1 q_2|$ of the charges for which the beads continue to remain stationary is:

(A) $\dfrac{mg\ell^2}{4\pi\varepsilon_0}$ **(B)** $\dfrac{\sqrt{3}mg\ell^2}{4\pi\varepsilon_0}$ **(C)** $\sqrt{3}\,(4\pi\varepsilon_0)mg\ell^2$ **(D)** $(4\pi\varepsilon_0)mg\ell^2$

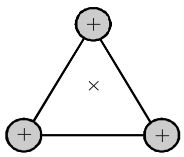
MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

40. In the following diagrams, all the charges have equal magnitude

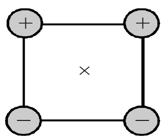
Column 1

(A)



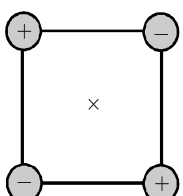
Equilateral triangle

(B)



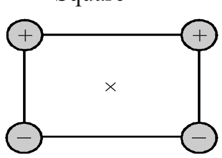
Square

(C)



Square

(D)



Rectangle

Column 2

(P) The potential is zero at the centre 'x'

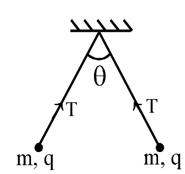
(Q) The electric field is zero at the centre 'x'

(R) The electric field at a point on the axis passing through the centre 'x' perpendicular to the plane of the figure is parallel to the axis

(S) The electric field at a point on the axis passing through the centre 'x' perpendicular to the plane of the figure is perpendicular to the axis.

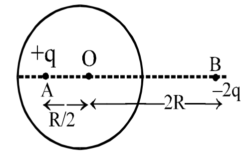
(T) The potential energy of the system is negative.

41. In the figure shown two identical small charged balls having mass m and charge 'q' are suspended with the help of two light inextensible silk strings each of length 'l'. At equilibrium the angular separation between the strings is 'θ'



	Column 1		**Column 2**
(A)	If θ is very small then charge 'q' is proportional to	**(P)**	$\theta^{3/2}$
(B)	Tension T in string is proportional to	**(Q)**	l
(C)	If system is taken in a satellite. Then tension T is proportional to	**(R)**	π
(D)	Angular separation between the charges (at equalibrium) in the satellite is	**(S)**	l^{-2}

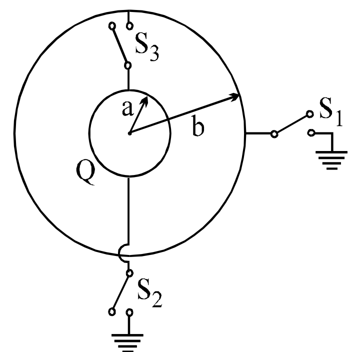
42. A thin uncharged spherical conducting shell of radius 'R' is shown in figure. Two point charges +q and –2q are fixed at point A (inside shell) & point B outside shell as shown in figure :



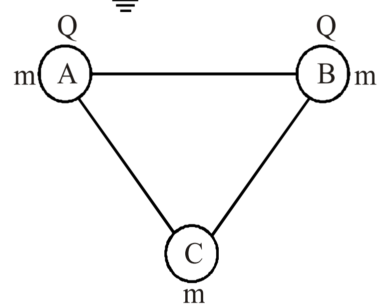
	Column 1		Column 2
(A)	Electric potential at 'O'	**(P)**	$-\dfrac{Kq}{R}$
(B)	Electric potential at 'O' due to charge induced on inner surface of shell	**(Q)**	$+\dfrac{Kq}{R}$
(C)	Electric field strength at 'O'	**(R)**	zero
(D)	Electric field strength at 'O' due to charge on outer surface of shell	**(S)**	cannot be calculated easily

SUBJECTIVE INTEGER TYPE

43. The figure shows a conducting sphere 'A' of radius 'a' which is surrounded by a neutral conducting spherical shell B of radius 'b' (>a). Initially switches S_1, S_2 and S_3 are open and sphere 'A' carries a charge Q. First the switch 'S_1' is closed to connect the shell B with the ground and then opened. Now the switch 'S_2' is closed so that the sphere 'A' is grounded and then S_2 is opened. Finally, the switch 'S_3' is closed to connect the spheres together. Find 5Q if Q is the heat (in Joule) which is produced after closing the switch S_3. [Consider b = 4 cm, a = 2 cm and Q = 8 μC]

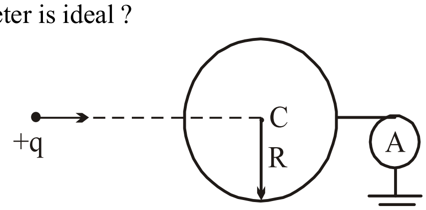


44. Three balls of equal mass m are connected by light insulating inextensible threads of length ℓ each and kept on a level smooth non conducting ground. The balls A and B are given charge Q each. The strings are all taut. The string connecting A and B suddenly snaps. What is the maximum speed (in m/s) of C during the resulting motion? Q = 1μC, ℓ= 1.5 m, mass m = 1 gm.

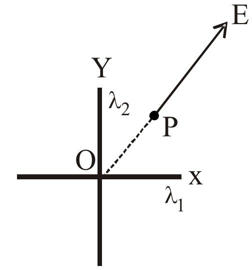


45. The electric field strength depends only on the x, y and z coordinates according to the law $E = \dfrac{a(x\hat{i}+y\hat{j}+z\hat{k})}{\left(x^2+y^2+z^2\right)^{3/2}}$,where a = 280 Nm^2/c is a constant. Find $V_0/4$ if V_0 is the potential difference between (3, 2, 6) and (0, 3, 4) (in volts).

46. If a charge q (1 mc) is moving towards the centre of an earthed conducting sphere of radius 1m with a velocity 2mm s^{-1}. Find $4i$ if i is the current (in μA) flowing in the ammeter shown in figure, when q is at a distance 2m from centre of sphere. Ammeter is ideal ?



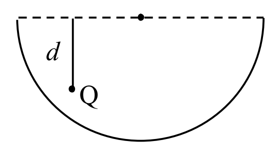
47. Two mutually perpendicular infinite wires along x-axis and y-axis carry charge densities λ_1 and λ_2. The electric line of force at P is along the line $y = \frac{1}{\sqrt{3}}x$, where P is also a point lying on the same line then find λ_2 / λ_1.



48. A particle is uncharged and is thrown vertically upward from ground level with a speed of $5\sqrt{5}\ m/s$. As a result, it attains a maximum height h. The particle is then given a positive charge +q and reaches the same maximum height h when thrown vertically upward with a speed of 13 m/s. Finally, the particle is given a negative charge -q. Ignoring air resistance, determine the speed (in m/s) with which the negatively charged particle must be thrown vertically upward, so that it attains exactly the same maximum height h. Consider a uniform electric field in downward direction.

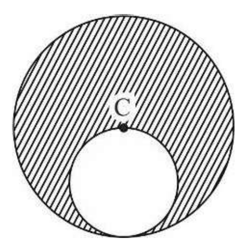
49. The potential inside a charged ball depends only on the distance from its centre as $\phi = ar^2 + b$, where a and b are constants. Find n if the space charge density $\rho(r)$ inside the ball is $-n\varepsilon_0 a$.

50. A charge Q is located some where inside a hemisphere such that depth of charge from base of hemisphere is d. it is found that flux associated with the hemisphere is $\frac{2Q}{3\epsilon_0}$. If the charge is raised vertically through a height $2d$, then flux is $\frac{\alpha Q}{3\epsilon_0}$, what is value of α

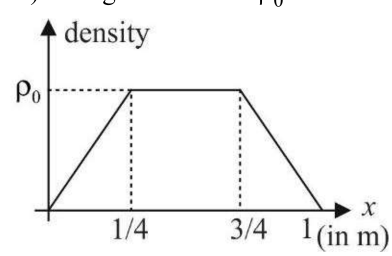


51. A rod AB of mass m and ℓ is positively charged with linear charge density λ coulm. It is pivoted at end A and is hanging freely. If a horizontal electric field E is switched on in the region, the initial angular acceleration of the rod is X times of $\frac{E\lambda}{2M}$ then X is

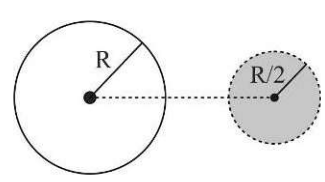
52. A solid sphere of radius 'R' is uniformly charged with charge density ρ in its volume. A spherical cavity of radius $\frac{R}{2}$ is made in the sphere as shown in the figure. The electric potential at the centre of the sphere is $\frac{n\rho R^2}{12\epsilon_0}$. Find the value of n.



53. The volume charge density as a function of distance X from one face inside a unit cube is varying as shown in the figure. Then the total flux (in S.I. units) through the cube if $\rho_0 = 8.85 \times 10^{-12}\ C/m^3$ is :

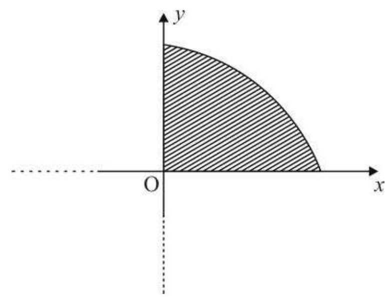


54. A ring of radius ($R = 6\varepsilon_0$)m having a linear charge density ($\lambda = 2/\pi$) C/m moves towards a solid imaginary sphere of radius $\frac{R}{2}$, so that the centre of ring of ring passes through the centre of sphere. The axis of the ring is perpendicular to the line joining the centres of the ring and the sphere. The maximum flux through the sphere in this process is:

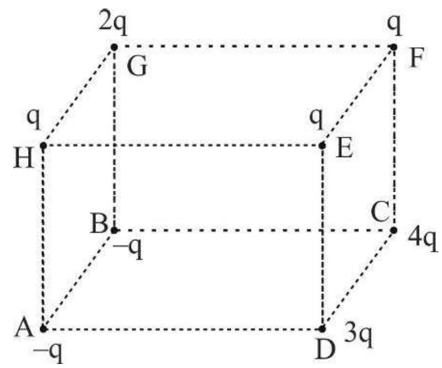


55 A non-conducting spherical ball of radius R contains a spherically symmetric charge with volume charge density $\rho = kr^n$, where r is the distance from the center of the ball and n is a constant. What should be n such that the electric field inside the ball is directly proportional to square of distance from the centre.

56. A uniform surface charge of density $\sigma = 20\,\varepsilon_0$ SI units, is given to a quarter of a disc extending upto infinity in the first quadrant of x-y plane. The centre of the disc is at the origin O. Find the potential difference between the points (0, 0, 1) & (0, 0, 2)

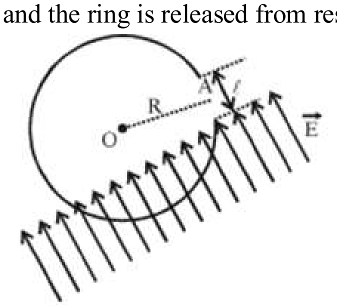


57. Eight point charges are placed at eight corners of a cube as shown in figure. If maximum value of flux passing through one of the surface of cube is $\dfrac{nq}{24\varepsilon_0}$. Find the value of n.



58. In a certain region of space a uniform and constant electric field is present. A proton is fired from a point 'A' in the field with speed $v = 4\times10^4$ m/s at an angle of α with the field direction. The proton reaches a point B in the field where its velocity makes an angle β with the field direction. If $\dfrac{\sin\alpha}{\sin\beta} = \sqrt{3}$. The electric potential difference between the points A and B is X times of 4V. Find X, taking m_p (mass of proton) $=1.6\times10^{-27}$ kg and e (magnitude of electronic charge) $=1.6\times10^{-19}\,C$.

59. A thin rigid insulating ring of mass m = 0.1 kg and radius R = 1 m is free to rotate about a fixed vertical axis O, perpendicular to the plane of the ring (see Figure). Ring uniformly charged in length and its charge is Q = 100π C . A very small piece of the ring in the area of point A cut so that you will get a gap of length *l =0.1 m*. A uniform electric field E = 4 N/C is applied parallel to '*l*' and the ring is released from rest.



The maximum angular velocity ω of the ring in the subsequent motion will be :

60. A point dipole of dipole moment $p\hat{i}$ is placed on *x*-axis at (4m, 0, 0). The region is having an electric field intensity given by $\vec{E} = 3x^2\hat{i} + 6xy\hat{j} + 3z^2\hat{k}$ the force experienced by the dipole is X times of $6\,p\hat{i}$, where X is :

JEE Advanced Revision Booklet	DC Circuits and Capacitors

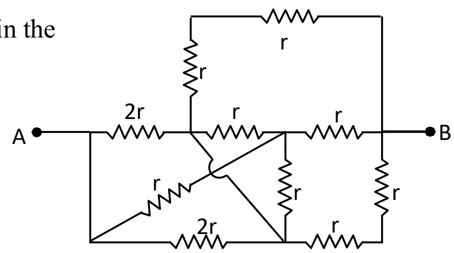
SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. Two scales on a voltmeter measure voltages up to 20.0 V and 30.0 V. The resistance connected in series with the galvanometer is 1680Ω for the 20.0 V scale and 2930 Ω for the 30.0 V scale. The resistance of the galvanometer and the full scale current are respectively

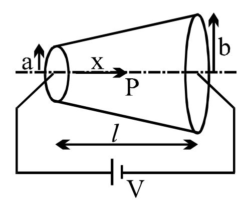
(A) 320Ω and 8 mA **(B)** 70Ω and 10 Ma
(C) 820Ω and 10 mA **(D)** 820Ω and 8 mA

2. The equivalent resistance between A and B in the arrangement of resistance, as shown, is :



(A) $4r$
(B) $3r$
(C) $2.5r$
(D) r

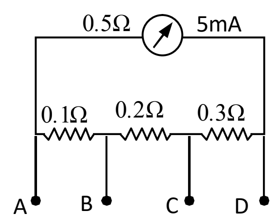
3. A conductor of resistivity ρ and resistance R, as shown in the figure, is connected across a battery of emf V. Its radius varies from 'a' at left end to 'b' at right end. The electric field at a point P at distance x from left end of it is:



(A) $\dfrac{Vl^2\rho}{\pi R\left(la+(b-a)x\right)^2}$ **(B)** $\dfrac{2Vl^2\rho}{\pi R\left(la+(b-a)x\right)^2}$

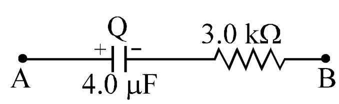
(C) $\dfrac{Vl^2\rho}{2\pi R\left(la+(b-a)x\right)^2}$ **(D)** none of these

4. A milli ammeter of range 5 mA and resistance 0.5Ω is joined in a circuit as shown. Find the value of current for which meter gives full scale deflection when A and B are used as terminals :



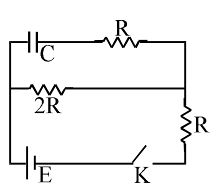
(A) 50 mA **(B)** 5mA
(C) 100 mA **(D)** 1 A

5. In the circuit segment shown, the potential difference $V_B - V_A = 11$ V at an instant when the $Q = 16$ μC. What can be said about the capacitor at this instant?



(A) it is absorbing power at the rate of 20 mW
(B) it is delivering power at the rate of 9.3 mW
(C) it is delivering power at the rate of 20 mW
(D) it is absorbing power at the rate of 9.3 mW

6. In the given circuit, the capacitor of capacitance C is charged by closing key K at t = 0. Find the time required to charge the capacitor upto maximum charge for the given circuit, if it were to be charged with the constant initial charging rate at t = 0 in the given circuit.

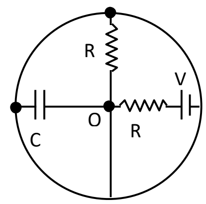


(A) $\dfrac{RC}{3}$ **(B)** $\dfrac{2RC}{5}$ **(C)** $\dfrac{2RC}{3}$ **(D)** $\dfrac{5RC}{3}$

7. A metal sphere of radius 'a' is surrounded by a concentric metal sphere of radius 'b' (b > a). The space between the spheres is filled with a material whose electrical conductivity σ varies with the electric field strength E according to relation $\sigma = kE$, where k is a constant. A potential difference V is maintained between two spheres. The current between the spheres is:

(A) $\left[\dfrac{4\pi kV^2}{\{\ell n(b/a)\}^2}\right]$ **(B)** $\left[\dfrac{2\pi kV^2}{\{\ell n(b/a)\}^2}\right]$ **(C)** $\left[\dfrac{\pi kV^2}{4\{\ell n(b/a)\}^2}\right]$ **(D)** $\left[\dfrac{8\pi kV^2}{\{\ell n(b/a)\}^2}\right]$

8. Charge on capacitor in steady state :

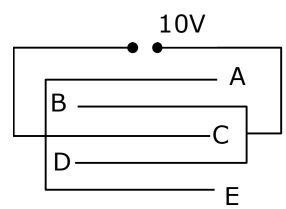


(A) CV
(B) $CV/2$
(C) $CV\left(1-\dfrac{1}{2R}\right)$
(D) Zero

9. From a supply of identical capacitors rated 8 μF, 250 V, the minimum number of capacitors required to form a composite 16 μF, 1000 V capacitor is :

(A) 2 **(B)** 4 **(C)** 16 **(D)** 32

10. Five identical capacitor plates are arranged such that they make four capacitors each of 2μF. The plates are connected to a source of emf. 10 V. The charge on plate C is



(A) +20 μC **(B)** +40μC
(C) +60μC **(D)** +80μC

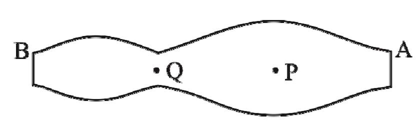
11. The plates of a parallel plate capacitor are given surface charge densities $+\sigma, -\sigma$. A dielectric slab of dielectric constant 'ε' is introduced between the plates. If the area of plates is A, then the force by a capacitor plate on the facing dielectric surface is :

(A) $\dfrac{\sigma^2(\varepsilon-1)A}{\varepsilon_0^2}$ **(B)** $\dfrac{\sigma^2(\varepsilon-1)A}{2\varepsilon_0\,\varepsilon}$ **(C)** $\dfrac{\sigma^2(\varepsilon-1)A}{2\varepsilon_0}$ **(D)** $\dfrac{\sigma^2(\varepsilon-1)A}{2\varepsilon_0^2}$

MULTIPLE CORRECT ANSWERS TYPE

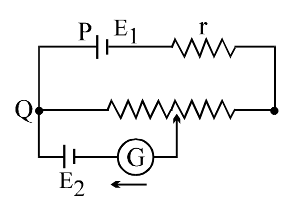
Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

12. A source of constant potential difference is connected across a conductor having irregular cross-section as shown in figure. Then:



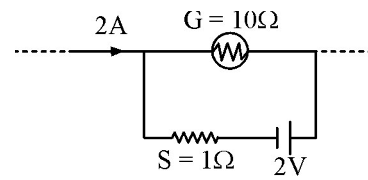
(A) Electric field intensity at P is greater than that at Q
(B) Rate of electrons crossing per unit area of cross-section at P is less than that at Q
(C) The rate of generation of heat per unit length at P is greater than that at Q
(D) Mean kinetic energy of free electron at P is greater than that at Q

13. In the potentiometer circuit of given figure, the galvanometer reveals a current in the direction shown wherever the sliding contact touches the wire. This could be caused by



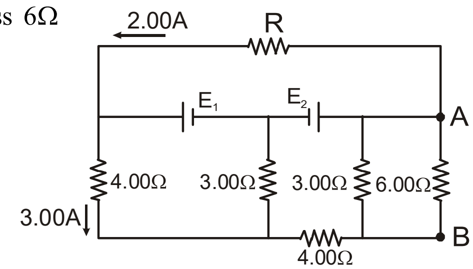
(A) E_1 being too low **(B)** r being too high
(C) a break in PQ **(D)** E_2 being too low

14. The galvanometer shown in the figure has resistance 10Ω .It is shunted by a series combination of a resistance S = 1Ω and an ideal cell of emf 2V. A current 2A passes as shown. Then:



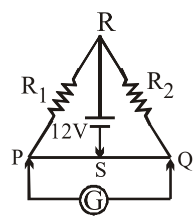
(A) The reading of the galvanometer is 1A
(B) The reading of the galvanometer is zero
(C) The potential difference across the resistance S is 1.5 V
(D) The potential difference across the resistance S is 2 V

15. In the circuit shown in figure, E_1 and E_2 are two ideal sources of unknown emfs. Some currents are shown. Potential difference appearing across 6Ω resistance is $V_A - V_B = 10V$.



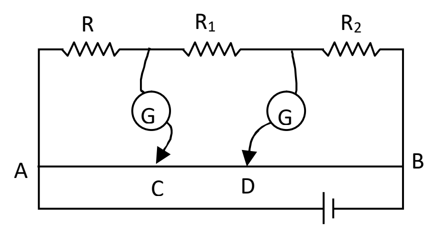
(A) The current in the 4.00 Ω resistor is 5A.
(B) The unknown emf E_1 is 36 V.
(C) The unknown emf E_2 is 54 V.
(D) The resistance R is equal to 9 Ω.

16. In the circuit shown, $R_1 = R_2 = 10\ \Omega$ and resistance per unit length of wire $PQ = 1\Omega$/cm and length PQ =10 cm. If R_2 is made 20 Ω then to get zero deflection in galvanometer: (S is midpoint of wire PQ).



(A) The jockey at P can be moved towards right 2 cm.
(B) The jockey at Q can be moved towards right 2 cm.
(C) The jockey at S can be moved towards left a distance 5/3 cm.
(D) The jockey at all positions fixed and R_1 should be made 20 Ω.

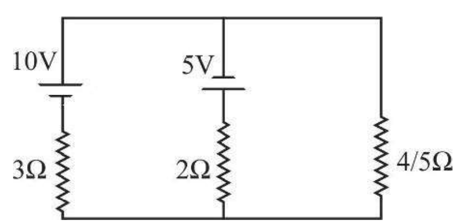
17. The diagram shows a modified meter bridge, which is used for measuring two unknown resistance at the same time. When only the first galvanometer is used, for obtaining the balance point, it is found at point C. Now the first galvanometer is removed and the second galvanometer is used, which gives balance point at D. Using the details given in the diagram, find out the value of R_1 and R_2.



AB = L; AC = L/4 and AD = $\frac{2\ell}{3}$

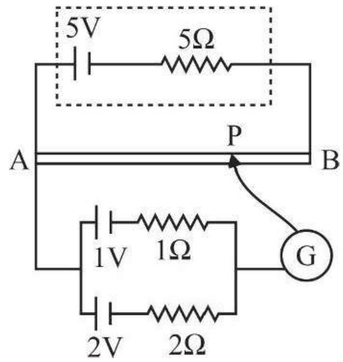
(A) $R_1 = 5R/3$ **(B)** $R_2 = 4R/3$
(C) $R_1 = 4R/3$ **(D)** $R_2 = 5R/3$

18. Choose the correct statement(s) :



(A) The 10V battery is getting discharged **(B)** The 5V battery is getting charged
(C) The 5V battery is getting discharged **(D)** The 10V battery is getting charged

19. A battery of emf $\varepsilon_0 = 5V$ and internal resistance 5Ω is connected across a long uniform wire AB of length 1 m and resistance per unit length $5\Omega\ m^{-1}$. Two cells of $\varepsilon_1 = 1V$ and $\varepsilon_2 = 2V$ are connected as shown in the figure. Then:



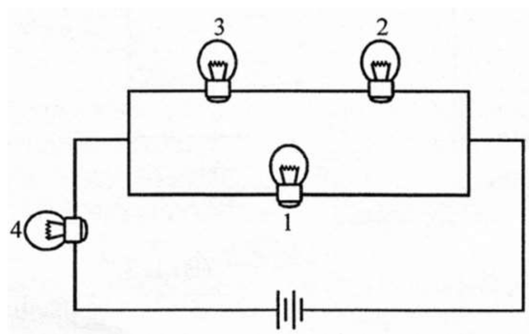
(A) The null point is at A

(B) If the jockey is touched to point B the current in the galvanometer will be flowing towards B

(C) When Jockey is connected to point A no current is flowing through 1 V battery

(D) The null point is at distance of 8/15 m from A

20. All bulbs consume same power. The resistance of bulb 1 is 36Ω.



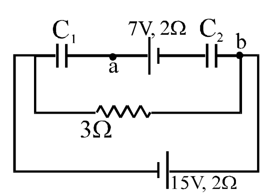
(A) Resistance of bulb 3 is $9\,\Omega$

(B) resistance of bulb 4 is $4\,\Omega$

(C) Voltage output of the battery if the power of each bulb is 4W is 16 V

(D) None of these

21. In the figure shown, $C_1 = 11\mu F$ and $C_2 = 5\ \mu F$, then at steady state :



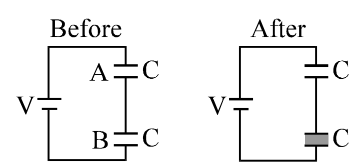
(A) the potential difference across C_1 is $5V$

(B) the potential difference across C_2 is $2V$

(C) the potential difference between points a and b is $-4V$

(D) the potential difference between the terminals of 15 V battery is $9V$

22. Two identical capacitors are connected in series as shown in the figure. A dielectric slab (κ > 1) is placed between the plates of the capacitor B and the battery remains connected. Which of the following statement(s) is/are correct following the insertion of the dielectric?



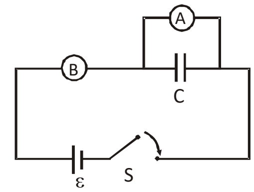
(A) The charge supplied by the battery increases.

(B) The capacitance of the system increases.

(C) The electric field in the capacitor B increases.

(D) The electrostatic potential energy decreases.

23. A capacitor of capacitance C is connected to two voltmeters A and B. A is an ideal voltmeter having infinite resistance, while B has resistance R. The capacitor is uncharged and then the switch S is closed at $t = 0$.Then:



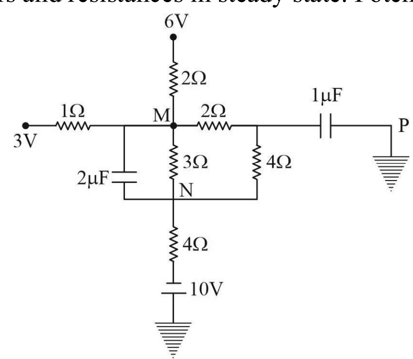
(A) Readings of B and A will be ε and zero at $t = 0$

(B) During time interval $(0 \le t \le \infty)$ readings of B and A are changing

(C) Reading of A and B will be equal at $t = RC \ln 2$

(D) None of these

24. Figure shows a network of capacitors and resistances in steady state. Potentials of some of the points are given. Then :



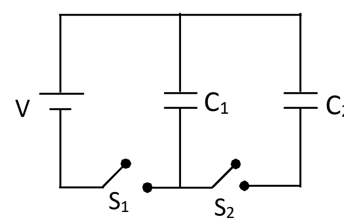
(A) Potential at M = 2.6 V

(B) Potential at N = –1.6 V

(C) Charge across 2μf capacitor is 8.4 μC

(D) Charge across 2μf capacitor is 4.2μC

25. Consider the circuit shown, where $C_1 = 6\mu F$, $C_2 = 3\mu F$ and $V = 20V$. Capacitor C_1 is first charged by closing the switch S_1. Switch S_1 is then opened, and the charged capacitor is connected to the uncharged capacitor C_2 by closing S_2. Then:



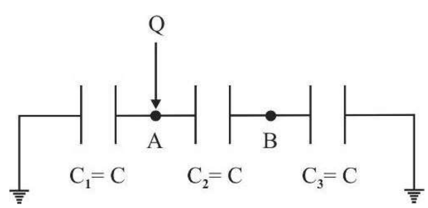
(A) Total charge that has flown through the battery is 120 μC

(B) Final charge on C_2 after opening switch S_1 & closing switch S_2 is 80 μC

(C) Final charge on C_2 after opening switch S_1 & closing switch S_2 is 40μC

(D) Total heat produced after closing switch S_2 is 1.8 mJ

26. Three uncharged parallel plate capacitors are connected in the given figure. Now charge Q is given to point A with the help of some external source. Then choose the correct statements:



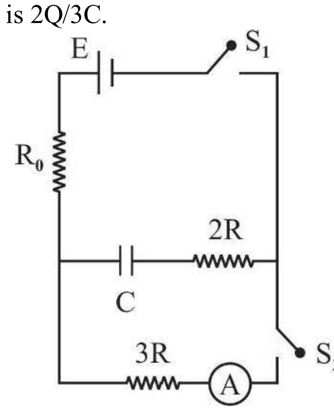
(A) Charge on capacitor C_1 is 2Q/3

(B) Charge on capacitor C_2 is 2Q/3

(C) Charge on capacitor C_3 is 2Q/3

(D) Potential at point A is 2Q/3C.

27. The capacitor 'C' is initially uncharged. Switch S_1 is closed for a long time while S_2 remains open. Now at t= 0, S_2 is closed while S_1 is opened. All the batteries are ideal and connecting wires are resistance less.



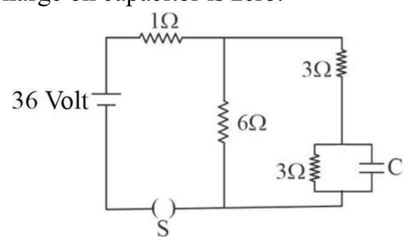
(A) At time t = 0 (just after S_2 is closed), reading of ammeter is $\dfrac{E}{5R}$

(B) At time t = 0 (just after S_2 is closed), reading of ammeter is zero

(C) Heat developed till time $t = 5\,RC\,ln2$ in resistance 3R is $\dfrac{9}{40}CE^2$

(D) After time t > 0 charge on the capacitor follows the equation $CEe^{-t/5RC}$

28. In the given circuit diagram, initial charge on capacitor is zero.



Choose correct option(s):

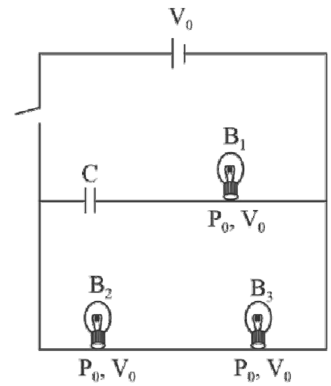
(A) Current through battery just after closing of switch is 12 Amp.

(B) Current through capacitor just after closing of switch is 8 Amp.

(C) Switch is closed and when steady state of current is achieved the current through battery is 9 Amp

(D) Switch is closed and when steady state of current is achieved the current through $6\,\Omega$ is 4.5 Amp.

29. An uncharged capacitor is connected in circuit as shown in figure. Power ratings of bulbs are given. At $t = 0$, switch is closed:



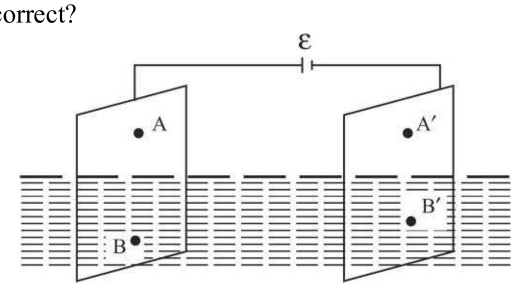
(A) At $t = 0$, power consumption in circuit is $\frac{3P_0}{2}$

(B) After a long time power consumption in circuit is $\frac{P_0}{2}$

(C) Brightness of B_1 decreases with time

(D) Initially brightness of B_2 is less than B_1, but later B_2 will be brighter

30. A parallel plate capacitor is dipped in a dielectric liquid vertically, so that half of capacitor is in liquid. Plates of capacitor are joined to an ideal battery of emf ε. A, B, A' and B' are four points on plate at facing surface as shown. Which of the following is/are correct?



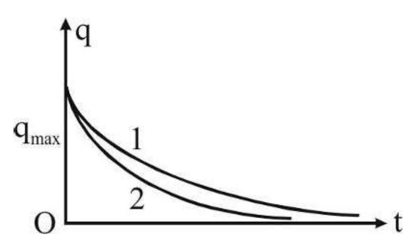
(A) $V_A - V_{B'} = V_A - V_{A'}$

(B) $V_A - V_{B'} = V_B - V_{A'}$

(C) Electric field around A in air = Electric field around B' in liquid.

(D) Electric field around B in liquid = Electric field around B' in liquid.

31. The instantaneous charge on a capacitors in two discharging RC circuits is plotted with respect to time in figure. Choose the correct statement(s) (where E_1 and E_2 are emf of two DC sources in two different charging circuits).



(A) $E_1 = 2E_2$ if $C_1 = \frac{C_2}{2}$

(B) $\frac{R_1}{R_2} > \frac{C_2}{C_1}$

(C) $R_1 > R_2$ if $E_1 = E_2$

(D) $\frac{E_2}{C_1} = \frac{E_1}{C_2}$

32. An uncharged capacitor C is charged upto steady state by using a battery of emf E connected through a resistor R. If P_R = rate of heat being dissipated in resistor and P_C = rate of energy being stored in the capacitor and P_E is rate of work done by battery, then.

(A) $P_E = P_C + P_R$ at every instant **(B)** P_R has maxima at $t = 0$

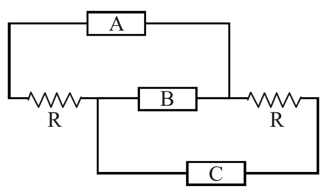
(C) $P_E = P_C > P_R$ just before steady state **(D)** $\int_0^\infty P_C dt = \int_0^\infty P_R dt = \int_0^\infty \frac{1}{2} P_E dt$

33. A parallel plate capacitor of capacitance 10 μF is connected to a cell of emf 10 Volt and fully charged. Now a dielectric slab (k = 3) of thickness equal to the gap between the plates, is completely filled in the gap, keeping the cell connected. During the filling process:

(A) The increase in charge on the capacitor is 200 μC.
(B) The heat produced is zero.
(C) Energy supplied by the cell = increase in stored potential energy + work done on the person who is filling the dielectric slab.
(D) Energy supplied by the cell = increase in stored potential energy + work done on the person who is filling the dielectric slab + heat produced.

Paragraph for Q. 34. to 35.

A circuit is shown below.



34. If A is an ideal ammeter, B an ideal Battery of voltage V, and C an ideal voltmeter, what will be the $\dfrac{\text{reading of } C}{\text{reading of } A}$?

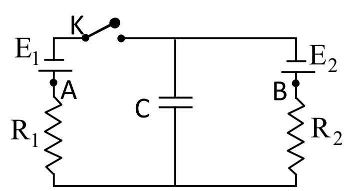
(A) R **(B)** 2R **(C)** $\frac{R}{2}$ **(D)** 0

35. If A is a capacitor, B is an ideal ammeter and C is an ideal battery of voltage V, what is the voltage across the capacitor?

(A) V **(B)** $\frac{V}{2}$ **(C)** 2V **(D)** 0

Paragraph for Q. 36 - 38

In the circuit shown initially capacitor is charged through E_2



36. Just after the switch K is closed, the magnitude of current in amperes through resistance R_1 is :

(A) $\frac{E_1 - E_2}{R_1}$ **(B)** $\frac{E_2}{R_2}$ **(C)** $\frac{E_1}{R_1} + \frac{E_2}{R_2}$ **(D)** $\frac{E_1}{R_2} + \frac{E_2}{R_1}$

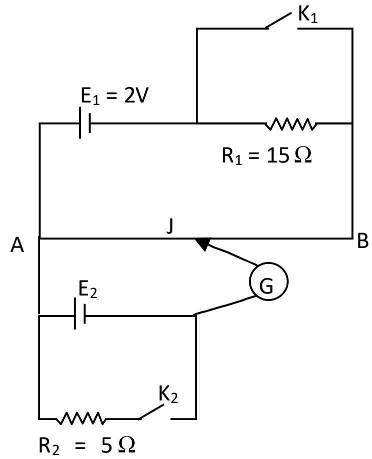
37. V_A and V_B are potential of points A and B respectively. After the switch K is closed the potential difference $V_B - V_A$

(A) Remains constant **(B)** Decreases
(C) Increases and then becomes constant after long time
(D) Decreases and then becomes constant after long time

38. Long after the switch K is closed, the magnitude of charge on the capacitor in steady state is :

(A) $\left(\frac{\varepsilon_1}{R_1}\right)C$ **(B)** $\left(\frac{\varepsilon_2}{R_2}\right)C$ **(C)** $\left(\frac{\varepsilon_1 R_2 + \varepsilon_2 R_1}{R_1 + R_2}\right)C$ **(D)** $\left(\frac{\varepsilon_1 R_1 + \varepsilon_2 R_2}{R_1 + R_2}\right)C$

Paragraph for Q.39. – 40.



In the circuit shown, AB is a 10Ω uniform 50cm long slide wire. E_1 is 2 V accumulator of negligible internal resistance. R_1 and R_2 are 15Ω and 5Ω respectively. When k_1 and k_2 are both open, the galvanometer shows no deflection when AJ = 31.25. When k_1 and k_2 are both closed the balance length AJ = 5 *cm*

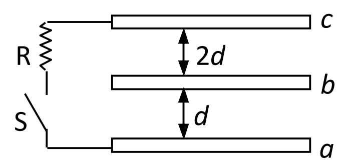
39. The internal resistance of the cell E_2 is:

(A) 7.5Ω **(B)** 8Ω
(C) 10Ω **(D)** 2Ω

40. The balance length AJ when k_2 is open and k_1 is closed is:

(A) 12.5 *cm* **(B)** 13.5 *cm*
(C) 14.5 *cm* **(D)** 15.5 *cm*

Paragraph for Q.41.- 43.



Three identical large metal plates *a*, *b* and *c* each of area *A* are placed at a separation as shown. Plate *C* is initially uncharged, while plate *a* and *b* are given initial charge $-Q$ and $+Q$ respectively. A resistance *R* is also connected with a switch *S*. Initially switch *S* is open. Switch *S* is closed at time *t* = 0. At any time *t*, charge on upper face of plate *b* is q_1 and charge on lower face of plate *b* is q_2.

(Given $Q = 60\mu C,\ \dfrac{\epsilon_0 A}{d} = 6\mu F,\ R = 1000\Omega$)

41. Before closing switch *S*, the energy stored between the plates *a* and *c* are :

(A) $100\mu J$ **(B)** $200\mu J$ **(C)** $300\mu J$ **(D)** $450\mu J$

42. Value of q_1 is (in μC):

(A) $20\left(1-e^{-500t}\right)$ **(B)** $30\left(1-e^{-500t}\right)$ **(C)** $40+20e^{-500t}$ **(D)** $20e^{-500t}$

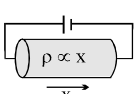
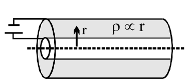
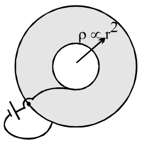
43. Long time after the switch S is closed the value of q_2 is :

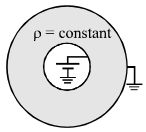
(A) $10\mu C$ **(B)** $20\mu C$ **(C)** $30\mu C$ **(D)** $40\mu C$

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

44. Column 1 has some conductor across which battery is connected as shown. Variation of resistivity ρ is also indicated. Which of the quantities in column 2 remain constant throughout the volume of conductor.

Column 1	Column 2
(A) 	**(p)** Magnitude of electric field
(B) 	**(q)** Magnitude of current density
(C) 	**(r)** Electric power dissipated per unit volume

(D) 

(s) Drift speed of free electron

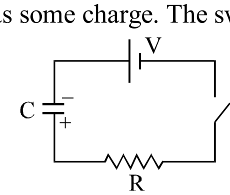
(t) None of these

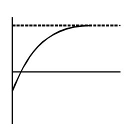
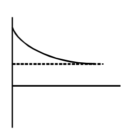
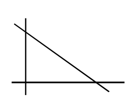
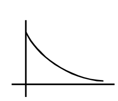
45. On a parallel plate air capacitor of capacitance C_0 having plate separation d, following steps are performed in the order as given in column 1.

(A) Capacitor is charged by connecting it across a battery of EMF V_0.
(B) Dielectric of dielectric constant k and thickness d is inserted
(C) Capacitor is disconnected from battery
(D) Separation between plates is doubled

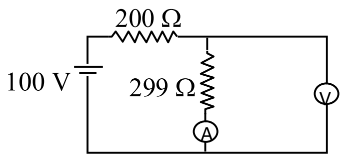
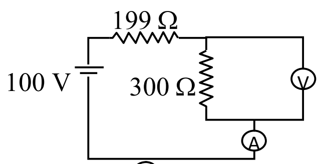
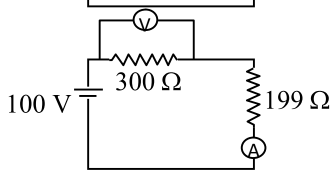
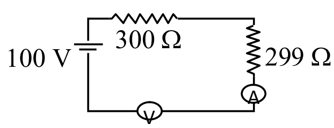
Column1 (Steps performed in order)		**Column 2** Final value of Quantity (Symbols have usual meaning)	
(A)	(a)→(d)→(c)→(b)	**(p)**	$Q = \frac{C_0V_0}{2}$
(B)	(d)→(a)→(c)→(b)	**(q)**	$Q = \frac{kC_0V_0}{k+1}$
(C)	(b)→(a)→(c)→(d)	**(r)**	$C = \frac{kC_0}{k+1}$
(D)	(a)→(b)→(d)→(c)	**(s)**	$V = \frac{V_0(k+1)}{2k}$

46. In the given circuit, initially capacitor has some charge. The switch is closed at t = 0.



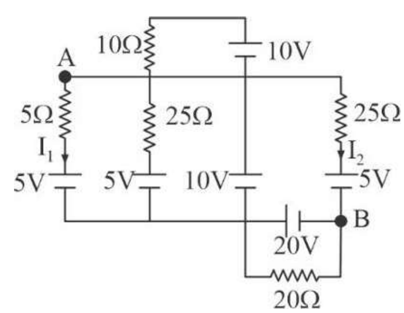
Column 1 : Variables		**Column 2 : Possible graphs**	
(A)	Charge v/s time	**(p)**	
(B)	Current v/s time	**(q)**	
(C)	Charge v/s current	**(r)**	
(D)	Energy stored in capacitor v/s time	**(s)**	

47. In the circuit shown in each situation of column-I, all cells are ideal, resistance of ammeter is 1ohm and resistance of voltmeter is 600 ohm. Match each situation in column-I with corresponding voltmeter and ammeter reading given in column-II.

Column I	Column II
(A) 	**(p)** Ammeter reading $\frac{1}{6}A$
(B) 	**(q)** Voltmeter reading is 50 V
(C) 	**(r)** Voltmeter reading is $\frac{600}{11}V$
(D) 	**(s)** Ammeter reading is $\frac{1}{4}A$

SUBJECTIVE INTEGER TYPE

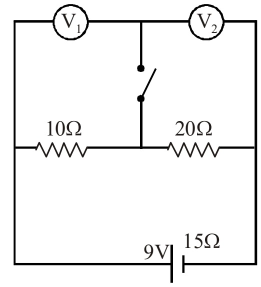
48. The circuit consists of resistors and ideal cells. I_1 and I_2 are current through branches indicated in the figure. V_A and V_B are the potential at points A and B on the circuit. The value of $\frac{I_2}{I_1}$ is:



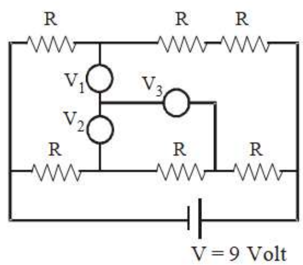
49. A resistance R of thermal coefficient of resistivity $= \alpha$ is connected in parallel with a resistance $= 3R,$ having thermal coefficient of resistivity $= 2\alpha.$ The value of α_{eff} is $\frac{x\alpha}{4}.$ Calculate x? (α is very small)

50. A beam of fast moving electrons having cross-sectional area A = 1 cm^2 falls normally on a flat surface. The electrons are absorbed by the surface and the average pressure exerted by the electrons on this surface is found to be P = 9.1 Pa. If the electrons are moving with a speed v = 8×10^7 m/s, then find the effective current (in A) through any cross-section of the electron beam. (Mass of electron = 9.1×10^{-31} kg)

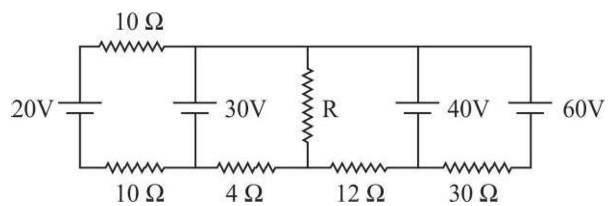
51. In the circuit shown in the figure, the electromotive force of the battery is 9 V and its internal resistance is 15 Ω. The two identical voltmeters can be considered ideal. Let V_1 and V_1' be the reading of 1st voltmeter when switch is open and closed respectively. Similarly, V_2 and V_2' be the reading of 2nd voltmeter when switch is open and closed respectively. Find $\dfrac{V_2 - V_1}{V_2' - V_1'}$.



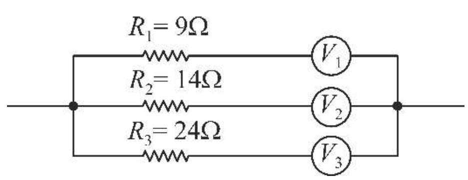
52. In the circuit shown below, all the three voltmeters are identical and have very high resistance. Each resistor has the same resistance. The voltage of the ideal battery shown is 9V. Find the reading of voltmeter V_3 (in volts).



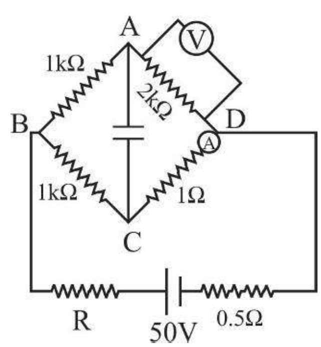
53. In the given circuit, find the value of R so that thermal power generated in R will be maximum.



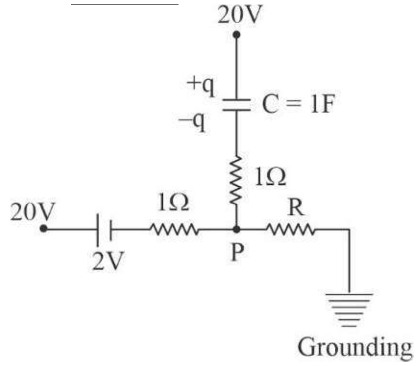
54. The figure shows a portion of an electric circuit. Resistors are known and are indicated on the diagram and the voltmeters are identical. If the voltmeters V_1 and V_2 read 7.5V and 5.0V respectively. Find the reading of voltmeter V_3 (in volts)?



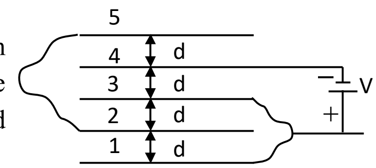
55. Calculate the energy stored in the capacitor of capacitance $2\mu F$, at the instant when the voltmeter 'V' gives a reading of 15V and the ammeter A reads 15 mA. Resistance of voltmeter is unknown and ammeter is 999Ω.



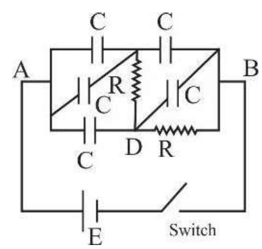
56. Figure shows a part of circuit at $t = 0$, change on capacitor as a function of time is given by $q = 3(1 - e^{-t})$ coulombs. If the value of R is 17/x then the value of x is________.



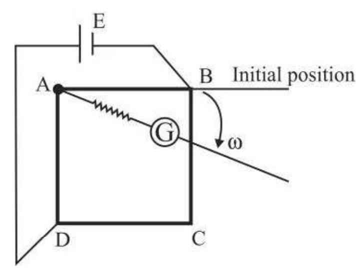
57. Five identical large conducting plates each of area A are placed parallel to each other at separation d. Plates 1 and 3 are connected by thin conducting wire and plate 2 and 5 are connected by another thin conducting wire. The junction of plate 1 and 3 and plate 4 are connected by a battery having emf V as shown.



The system is in steady state. Now, Plate 4 is moved upward slowly so, that it comes in contact with plate 5. The amount of work done by battery during motion of plate 4 is x mJ (Here $\frac{\epsilon_0 A}{d} = 30\mu F$, $V = 10$ volts). Find the value of x.

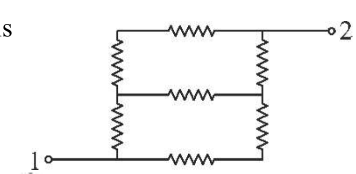


58. ABCD is a square frame made from different wires of same length and each having different uniform resistance per unit length. Resistances of wires forming sides AB, BC, CD and DA are 100Ω, 400 Ω, 500 Ω and 200 Ω respectively. An ideal cell is connected across B and D. A straight conducting wire containing a resistance and a galvanometer in series starts rotating about pivoted point A from initial position as shown with uniform angular velocity $\omega = \frac{\pi}{360}$ rad/sec.

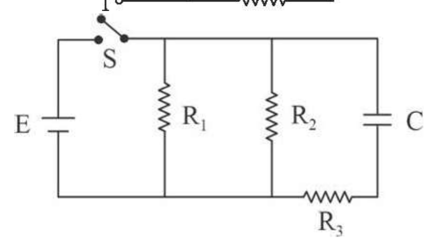


One end of the straight wire (rotating) is pivoted at A and other end always in sliding contact with a side of the square. The time after starting when galvanometer shows zero deflection is X times 37 sec. X is_________.

59. The equivalent resistance of network between terminals 1 & 2 is X times R. X is _______. (All resistances are equal to R.)



60. The capacitor is charged by closing the switch S. The switch is then opened and the capacitor is allowed to discharge. Let τ_1 and τ_2 be the time constant of the circuit during the charging and discharging of the capacitor respectively. Take $R_1 = R_2 = R_3 = R$ (Battery is ideal and connecting wire has negligible resistance). Ratio of $\frac{\tau_1}{\tau_2}$ is $\frac{2}{n}$. Find the value of n.



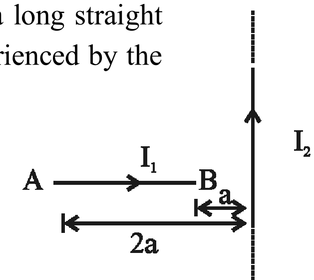
SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A conductor of mass m and length l is placed perpendicular to a horizontal uniform magnetic field B. Suddenly a certain amount of charge is passed through it, and it is found to jump to a height h. The amount of charge that passes through the conductor is :

(A) $\frac{m\sqrt{gh}}{Bl}$ **(B)** $\frac{m\sqrt{gh}}{2Bl}$ **(C)** $\frac{m\sqrt{2gh}}{Bl}$ **(D)** None of these

2. The segment AB of wire carrying current I_1 is placed perpendicular to a long straight wire carrying current I_2 as shown in figure. The magnitude of force experienced by the straight wire AB is :



(A) $\frac{\mu_0 I_1 I_2}{2\pi}\ln 3$ **(B)** $\frac{\mu_0 I_1 I_2}{2\pi}\ln 2$

(C) $\frac{2\mu_0 I_1 I_2}{2\pi}$ **(D)** $\frac{\mu_0 I_1 I_2}{2\pi}$

3. A tightly-wound long solenoid has n turns per unit length, radius r and carries a current i. A particle having charge q and mass m is projected from a point on the axis in the direction perpendicular to the axis. The maximum speed for which particle does not strike the solenoid will be :

(A) $\frac{\mu_0 qrni}{2m}$ **(B)** $\frac{\mu_0 qrni}{m}$ **(C)** $\frac{2\mu_0 qrni}{3m}$ **(D)** None of these

4. If the acceleration and velocity of a charged particle moving in a constant magnetic region is given by $\vec{a} = a_1\hat{i} + a_2\hat{k}$, $\vec{v} = b_1\hat{i} + b_2\hat{k}$. [$a_1$, a_2, b_1 and b_2 are constants], then choose the wrong statement :

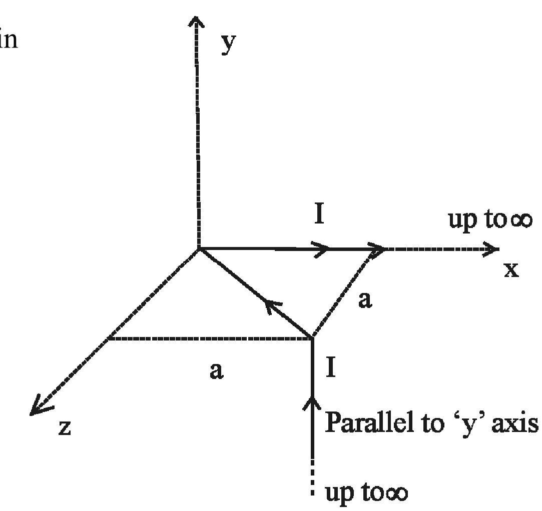
(A) Magnetic field may be along y-axis **(B)** $a_1 b_1 + a_2 b_2 = 0$

(C) Magnetic field is along x-axis **(D)** Kinetic energy of particle is always constant

5. A uniform solid non conducting sphere of radius R and total charge q rotates about its diametric axis with constant angular speed ω. The magnetic moment of the sphere is :

(A) $\frac{1}{3}qR^2\omega$ **(B)** $\frac{2}{3}qR^2\omega$ **(C)** $\frac{1}{5}qR^2\omega$ **(D)** $\frac{2}{5}qR^2\omega$

6. The magnetic field at the origin due to the current flowing in the wire as shown in figure below is :



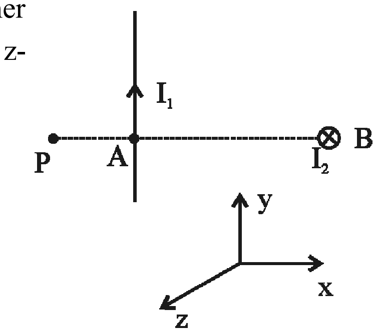
(A) $-\frac{\mu_0 I}{8\pi a}\left(\hat{i}+\hat{k}\right)$

(B) $\frac{\mu_0 I}{2\pi a}\left(\hat{i}+\hat{k}\right)$

(C) $\frac{\mu_0 I}{8\pi a}\left(-\hat{i}+\hat{k}\right)$

(D) $\frac{\mu_0 I}{4\pi a\sqrt{2}}\left(\hat{i}-\hat{k}\right)$

7. Two infinitely long linear conductors are arranged perpendicular to each other as shown in figure. If $I_1 = 2A$ along the y-axis and $I_2 = 3A$ along negative z-axis and AP = AB = 1 cm, the value of magnetic field strength $\vec{B}$ at P is :



(A) $\left(3\times10^{-5}T\right)\hat{j}+\left(-4\times10^{-5}T\right)\hat{k}$

(B) $\left(3\times10^{-5}T\right)\hat{j}+\left(4\times10^{-5}T\right)\hat{k}$

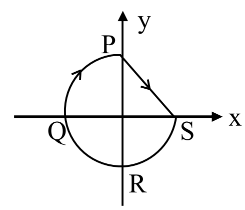
(C) $\left(4\times10^{-5}T\right)\hat{j}+\left(3\times10^{-5}T\right)\hat{k}$

(D) $\left(-3\times10^{-5}T\right)\hat{j}+\left(4\times10^{-5}T\right)\hat{k}$

8. There exists a uniform magnetic and electric field each of magnitude 1 T and 1 V/m respectively along positive y-axis. A charged particle of mass 1 kg and of charge 1 C is having velocity 1 m/sec along x-axis and is at origin at t = 0. Then the co-ordinate of particle at time π seconds will be:

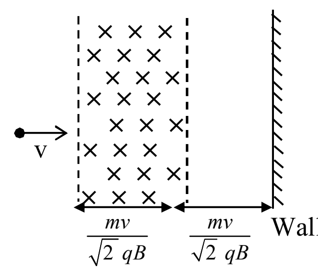
(A) (0, 1, 2) **(B)** $(0, -\pi^2/2, -2)$ **(C)** $\left(2, \pi^2/2, 2\right)$ **(D)** $\left(0, \pi^2/2, 2\right)$

9. A current carrying loop is placed in a uniform magnetic field pointing in negative *z* direction. Branch *PQRS* is a three quarter circle, while branch *PS* is straight. If force on branch *PS* is *F*, force on branch *PQR* is :



(A) $\sqrt{2}F$ **(B)** $\dfrac{F}{\sqrt{2}}$ **(C)** $\dfrac{\pi F}{\sqrt{2}}$ **(D)** $\sqrt{2}\pi F$

10. A particle of mass *m* and positive charge *q* enters a region of magnetic field with speed *v*. There is a region in which the magnetic field is absent, as shown. The particle after entering the region collides elastically with a rigid wall. Time after which the velocity of particle becomes anti-parallel to its initial velocity is :



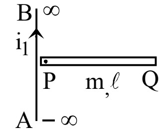
(A) $\dfrac{m}{2qB}(\pi+4)$ **(B)** $\dfrac{m}{qB}(\pi+2)$

(C) $\dfrac{m}{4qB}(\pi+4)$ **(D)** $\dfrac{m}{4qB}(2\pi+3)$

11. A particle (mass *m* and charge *q*) is at rest at origin. An electric field $\vec{E} = 10\hat{k}$ units and magnetic field $\vec{B} = -8\hat{i} + 6\hat{j}$ units is switched on in the region. Speed of the particle as function of its *z*-coordinate is :

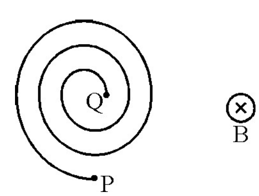
(A) $\sqrt{\dfrac{10qz}{m}}$ **(B)** $\sqrt{\dfrac{20qz}{m}}$ **(C)** $\sqrt{\dfrac{30qz}{m}}$ **(D)** $\sqrt{\dfrac{40qz}{m}}$

12. A metallic rod *PQ* is hinged at point *P* and it can rotate about point *P* in vertical plane as shown in the figure. If mass of rod is *m* and length ℓ, then the current in *PQ*, such that it remains in equilibrium as shown is : (Separation between *P* and current currying conductor *AB* is very small)



(A) $\dfrac{2mg\pi}{\mu_0 i_1}$ **(B)** $\dfrac{mg\pi}{2\mu_0 i_1}$ **(C)** $\dfrac{mg\pi}{4\mu_0 i_1}$ **(D)** $\dfrac{mg\pi}{\mu_0 i_1}$

13. Figure shows a spiral path of a particle which has entered a resistive medium where a uniform magnetic field acts perpendicular to the plane and into the plane of the spiral. Then the particle is :



(A) positively charged and entering at P

(B) positively charged and entering at Q

(C) negatively charged and entering at P

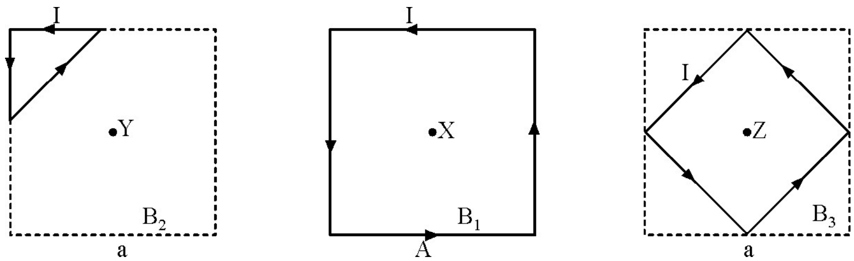
(D) negatively charged and entering at Q

14. A battery is connected between two points A and B on the circumference of a uniform conducting ring of radius r and resistance R. One of the arcs AB of the ring subtends an angle θ at the centre. The value of the magnetic induction at the centre due to the current in the ring is :

(A) zero, only if $\theta = 180°$ **(B)** zero for all values of θ

(C) proportional to $2(180° - \theta)$ **(D)** inversely proportional to r

15. The magnetic induction in vacuum at the centre of any square coil (of one turn) of side ' a ' and carrying a current I is kI / a where k is independent. The magnitude of the induction at X, Y, Z are B_1, B_2 and B_3 respectively. Then :



(A) $B_3 > B_1 > B_2$ **(B)** $B_2 > B_3 > B_1$ **(C)** $B_2 > B_1 > B_3$ **(D)** $B_1 > B_2 > B_3$

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

16. When a current carrying coil is placed in a uniform magnetic field with its magnetic moment anti-parallel to the field, then :

(A) torque on it is maximum **(B)** torque on it is zero

(C) potential energy is maximum **(D)** dipole is in unstable equilibrium

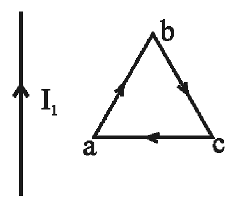
17. If a long cylindrical conductor caries a steady current parallel to its length, then :

(A) the electric field along the axis is zero **(B)** the magnetic field along the axis is zero

(C) the magnetic field outside the conductor is zero

(D) the electric field outside the conductor is zero

18. An infinitely long straight wire is carrying a current I_1. Adjacent to it there is another equilateral triangular wire having current I_2. Choose the wrong options.



(A) Net force on loop is leftwards **(B)** Net force on loop is rightwards

(C) net force on loop is upwards **(D)** net force on loop is downwards

19. A charged particle revolves in circular path in uniform magnetic field after accelerating by a potential difference of V volts. Choose the correct options if V is doubled.

(A) kinetic energy of particle will become two times

(B) radius in circular path will become two times

(C) radius in circular path will become $\sqrt{2}$ times

(D) angular velocity will remain unchanged

20. A long thick conducting cylinder of radius R carries a current uniformly distributed over its cross section. Choose correct options.

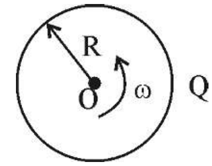
(A) The magnetic field strength is maximum on the surface

(B) The magnetic field strength is zero on the surface

(C) The strength of the magnetic field inside the cylinder will vary as inversely proportional to r, where r is the distance from the axis.

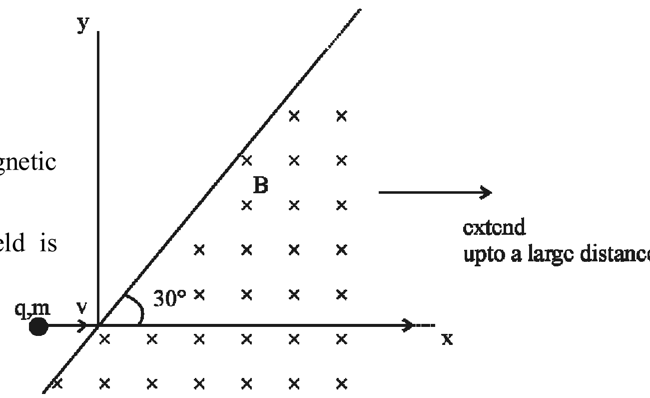
(D) The energy density of the magnetic field outside the conductor varies as inversely proportional to r^2, where 'r' is the distance from the axis.

21. A nonconducting disc having uniform positive charge Q, is rotating about its axis in anticlock wise direction with uniform angular velocity ω. The magnetic field at the centre of the disc is :



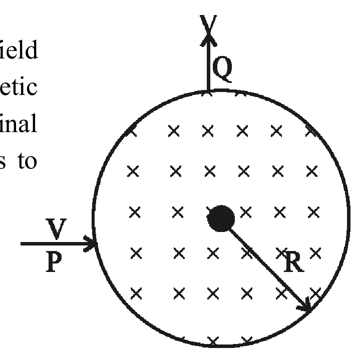
(A) directed outward
(B) having magnitude $\frac{\mu_0 Q\omega}{4\pi R}$
(C) directed inwards
(D) having magnitude $\frac{\mu_0 Q\omega}{2\pi R}$

22. A charged particle of charge q, mass m is moving with initial velocity 'v' as shown in figure in a uniform magnetic field B $\hat{k}$. Select the correct alternative/alternatives.



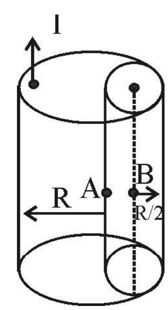
(A) velocity of particle when it comes out from magnetic field is $\vec{v} = v\cos 60°\hat{i} + v\sin 60°\hat{j}$
(B) time for which the particle was in magnetic field is $\frac{\pi m}{3qB}$
(C) distance travelled in magnetic field is $\frac{\pi m V}{3qB}$
(D) the particle will never come out of magnetic field

23. A particle of charge 'q' & mass 'm' enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is constant and uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(s) is(are) correct ?



(A) $B = \frac{mv}{qR}$
(B) $T = \frac{\pi R}{2v}$
(C) $T = \frac{\pi m}{2qB}$
(D) None of these

24. From a cylinder of radius R, a cylinder of radius R/2 is removed, as shown. Current flowing in the remaining cylinder is I. Magnetic field strength is:

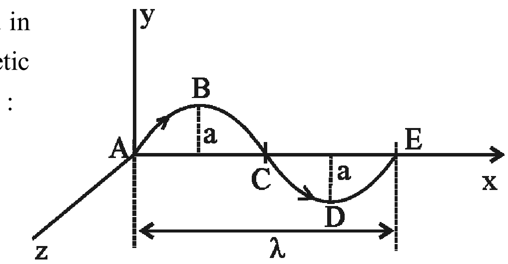


(A) zero at point A
(B) zero at point B
(C) $\frac{\mu_0 I}{3\pi R}$ at point A
(D) $\frac{\mu_0 I}{3\pi R}$ at point B

25. Consider three quantities $x = \frac{E}{B}$, $y = \sqrt{1/\mu_0\varepsilon_0}$ and $z = \frac{l}{CR}$. Here, l is length of a wire, C is a capacitance and R is a resistance. All other symbols have standard meanings.

(A) x, y have the same dimensions
(B) y, z have the same dimensions
(C) z, x have the same dimensions
(D) none of the three pairs have the same dimensions

26. A conductor ABCDE, shaped as shown, carries current I. It is placed in the x-y plane with the ends A and E on the x-axis. A uniform magnetic field of magnitude B exists in the region. The force acting on it will be :



(A) zero, if B is in the x-direction

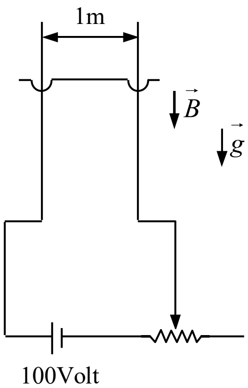
(B) λBI in the z-direction, if B is in the y-direction

(C) λBI in the negative y-direction, if B is in the z-direction

(D) λaBI , if B is in the x-direction

27. A horizontal rod of mass 2 kg is kept touching two vertical parallel rough rails, carrying current. There is a magnetic field $B = 2T$ present vertically downward. The rails are connected to battery of 100 V at $t = 0$.

The resistance of the circuit is 5Ω and starts to increase at constant rate $0.5\,\Omega/s$. The coefficient of friction between the rails and rod is $\mu = 3/4$ and separation between the rails in 1m. Then : ($g = 10\ m/s^2$)



(A) The friction force acting on the rod at $t = 0$ is 20 N

(B) The friction force acting on the rod at $t = 0$ is 30 N

(C) Acceleration of rod at $t = 0$ is $5m/s^2$

(D) At $t = 5$ sec, rod is about to start sliding

28. Consider a solid cylinder of radius R and very large length, with volume charge density ρ (charge/volume). Cylinder is rotated with constant angular velocity ω about its axis. Choose correct alternative(s).

(A) Magnetic field at the axis of cylinder is zero

(B) Magnetic field at the axis of cylinder is non zero

(C) Magnetic field at a point outside the cylinder is zero

(D) Magnetic field at a point outside the cylinder is non-zero

29. Consider two rings of copper wire. One ring is scaled up version of the other, twice large in all regards (radius, cross sectional radius). If current around the rings are driven by equal voltage source then choose the **CORRECT** alternative(s). Assume that cross-sectional radius is very small as compared to radius of rings.

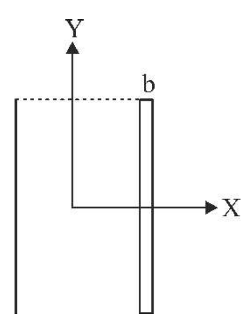
(A) Resistance of larger ring is half of the smaller ring

(B) Current in the larger ring is two times that in the smaller ring

(C) Magnetic field at their centres are same

(D) Magnetic field at centre of larger ring is twice as that at the centre of smaller ring

30. The figure contains an infinite slab having current per unit area of $\vec{J}_1 = J\hat{k}$ between the infinite planes at $x = -b$ and $x = b$. Slightly to the right of $x = b$, an infinite thin sheet is kept. It carries a current per unit length $\vec{k}_2 = 2bJ(-\hat{k})$. Choose the correct option(s):



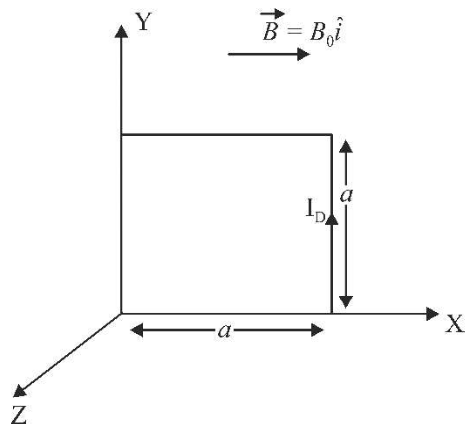
(A) The field due to sheet at any point is $\mu_0 Jb$

(B) The field due to sheet at any point is $\dfrac{\mu_0 Jb}{2}$

(C) The magnetic field due to slab at a point inside the slab must be independent of y co-ordinate and y component of field must be odd function of x.

(D) Magnetic field at a point (x, y) inside slab, due to slab is $\mu_0 Jx$

31. A uniform square wire frame of mass 4M and side ‘a’ is placed on horizontal frictionless surface (assumed to be $X-Y$ plane). The square contains a anticlockwise current I_0 as seen from positive Z axis. A uniform magnetic field $\vec{B}=B_0\hat{i}$ exists in the entire region. Initially system is held stationary by some external agent and system is released from rest at time $=0$.



(A) Initial angular acceleration of wire frame is $\dfrac{3I_0B_0}{2M}$

(B) Centre of mass of wire frame will do circular motion

(C) Centre of mass of wire frame will move on a straight-line

(D) The loop will start rotating due to magnetic torque. Torque due to gravity and normal force by horizontal surface on wire frame about its centre of mass is zero.

32. In a region having an electric field and a magnetic field, a positive point charge is released with the below given parameters

$$\begin{cases} \vec{E}=a\hat{i} \\ \vec{B}=b\hat{i}+c\hat{j}+d\hat{k} \\ \vec{v}=x\hat{i}+y\hat{j} \end{cases}$$

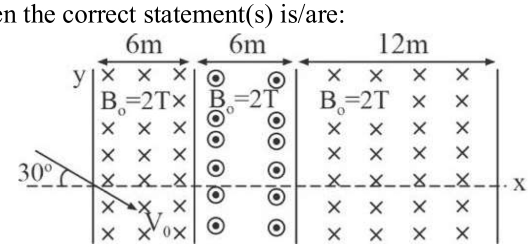
(A) For $a=0$ speed of particle remains constant

(B) For $c=0, d=0, y=0$ charged particle may move along straight line with increasing speed

(C) For $c=0, d=0, y\neq 0$ charged particle moves along helix of varying pitch

(D) For $a=0, \vec{v}\cdot\vec{B}=0$ charged particle may moves along circle

33. A particle having charge 1C and mass 1 kg enters a region having magnetic field of strength `$2T$ with a speed of 12 m/s, as shown in figure. Then the correct statement(s) is/are:



(A) The time for which the charge particle remains in magnetic field is $\dfrac{4\pi}{3}s$

(B) The velocity of charged particle becomes parallel to x-axis 6 times during its motion

(C) The distance between the point where the charge particle enters the uniform magnetic field and the point where it emerges out is 6 m

(D) The deviation of the charge particle when it emerges out of the magnetic field is $\dfrac{\pi}{3}$ rad

34. A particle of specific charge `α' is projected from origin at $t = 0$ with a velocity $\vec{V} = V_0\left(\hat{i} + \hat{k}\right)$ in a magnetic field $\vec{B} = -B_0\hat{k}$. Then : (Mass of particle = 1 unit)

(A) at $t = \dfrac{\pi}{\alpha B_0}$, velocity of the particle is $-V_0(\hat{i} - \hat{k})$

(B) at $t = \dfrac{\pi}{4\alpha B_0}$, speed of the particle is V_0

(C) at $t = \dfrac{2\pi}{\alpha B_0}$, magnitude of displacement of the particle is more than $\dfrac{2V_0}{\alpha B_0}$

(D) at $t = \dfrac{2\pi}{\alpha B_0}$, distance travelled by the particle is less than $\dfrac{2\sqrt{2}\pi V_0}{\alpha B_0}$.

35. We can definitely cange the voltage senstivity of galvanometer by changing

(A) Number of turns of coil **(B)** The dimensions of coil

(C) Material of coil **(D)** The magnetic field

Paragraph for Q.36 - 38

In a certain region of space, there exists a uniform and constant electric field of magnitude E along the positive y-axis of a coordinate system. A charged particle of mass m and charge $-q(q > 0)$ is projected from the origin with speed $2v$ at an angle of 60° with the positive x-axis in x-y plane. When the x-coordinate of particle becomes $\sqrt{3}mv^2 / qE$, a uniform and constant magnetic field of strength B is also switched on along positive y-axis.

36. Velocity of the particle just before the magnetic field is switched on is :

(A) $v\hat{i}$ **(B)** $v\hat{i} + \dfrac{\sqrt{3}v}{2}\hat{j}$ **(C)** $v\hat{i} - \dfrac{\sqrt{3}v}{2}\hat{j}$ **(D)** $2v\hat{i} - \dfrac{\sqrt{3}v}{2}\hat{j}$

37. x-coordinate of the particle as a function of time after the magnetic field is switched on is :

(A) $\dfrac{\sqrt{3}mv^2}{qE} - \dfrac{mv}{qB}\sin\left(\dfrac{qB}{m}t\right)$ **(B)** $\dfrac{\sqrt{3}mv^2}{qE} + \dfrac{mv}{qB}\sin\left(\dfrac{qB}{m}t\right)$

(C) $\dfrac{\sqrt{3}mv^2}{qE} - \dfrac{mv}{qB}\cos\left(\dfrac{qB}{m}t\right)$ **(D)** $\dfrac{\sqrt{3}mv^2}{qE} + \dfrac{mv}{qB}\cos\left(\dfrac{qB}{m}t\right)$

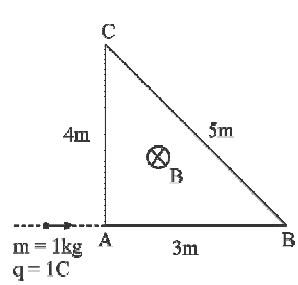
38. z-coordinate of the particle as a function of time after the magnetic field is switched on is :

(A) $\dfrac{mv}{qB}\left[1 - \cos\left(\dfrac{qB}{m}t\right)\right]$ **(B)** $\dfrac{-mv}{qB}\left[1 + \cos\left(\dfrac{qB}{m}t\right)\right]$

(C) $-\dfrac{mv}{qB}\left[1 - \cos\left(\dfrac{qB}{m}t\right)\right]$ **(D)** $\dfrac{mv}{qB}\left[1 + \cos\left(\dfrac{qB}{m}t\right)\right]$

Paragraph for Q.39 – 40

A small particle of mass m = 1kg and charge of 1C enter perpendicularly in a triangular region of uniform magnetic field of strength $2T$ as shown in figure.



39. Calculate maximum velocity of the particle with which it should enter so that it complete a half-circle in magnetic region:

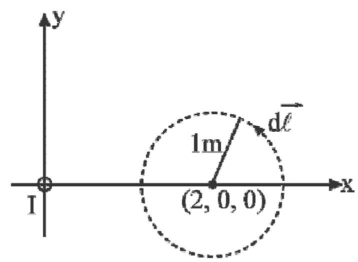
(A) $2\,m/s$ **(B)** $2.5\,m/s$ **(C)** $3\,m/s$ **(D)** $4\,m/s$

40. In previous question, if particle enters perpendicular with velocity 48 m/s in magnetic region. Then, how much time will it spend in magnetic region.

(A) $\frac{11\pi}{360}$ sec **(B)** $\frac{7\pi}{360}$ sec **(C)** $\frac{13\pi}{360}$ sec **(D)** $\frac{17\pi}{360}$ sec

Paragraph for Q.41 – 43

An infinitely long wire lying along z-axis carries a current 'I', flowing towards positive z-direction. There is no other current, consider a circle in x-y plane with centre at (2 meter, 0,0) and radius 1 meter. Divide the circle in small segments and let $d\vec{\ell}$ denote the length of a small segment in anticlockwise direction, as shown.



41. The path integral $\oint \vec{B}\cdot d\vec{\ell}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle is :

(A) $\frac{\mu_0 I}{8}$ **(B)** $\frac{\mu_0 I}{2}$ **(C)** $\mu_0 I$ **(D)** 0

42. Consider two points $A(3,0,0)$ and $B(2, 1, 0)$ on the given circle. The path integral $\int_A^B B\cdot d\vec{\ell}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle from A to B is:

(A) $\frac{\mu_0 I}{\pi}\tan^{-1}\frac{1}{2}$ **(B)** $\frac{\mu_0 I}{2\pi}\tan^{-1}\frac{1}{2}$ **(C)** $\frac{\mu_0 I}{2\pi}\sin^{-1}\frac{1}{2}$ **(D)** 0

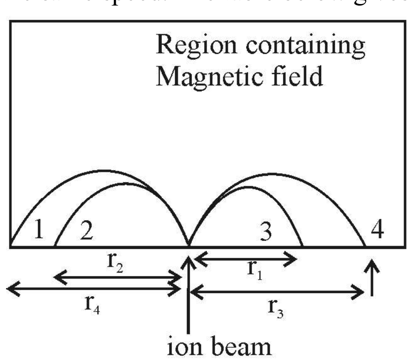
43. The maximum value of path integral $\int B\cdot d\vec{\ell}$ of the total magnetic field $\vec{B}$ along the perimeter of the given circle between any two points on the circle is:

(A) $\frac{\mu_0 I}{12}$ **(B)** $\frac{\mu_0 I}{8}$ **(C)** $\frac{\mu_0 I}{6}$ **(D)** 0

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

44. A beam consisting of four types of ions A, B, C and D enters a region that contains a uniform magnetic field as shown. The field is perpendicular to the plane of the paper, but its precise direction is not given. All ions in the beam travel with the same speed. The table below gives the mass and charge of the ions.



ION	Mass	Charge
A	2 m	+e
B	4 m	–e
C	2 m	–e
D	m	+e

$r_4 > r_3 = r_2 > r_1$

The ions fall at different positions 1,2,3 and 4, as shown. Correctly match the ions with respective falling positions.

Column 1		**Column 2**	
(A)	A	**(p)**	1

(B)	B	**(q)**	2
(C)	C	**(r)**	3
(D)	D	**(s)**	4

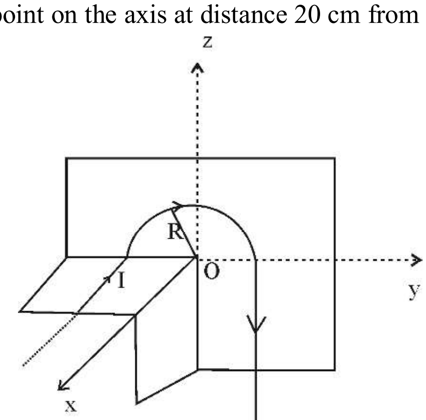
45. A particle with change Q is moving in fields of combination given below. Match for the possible path(s).

	Column 1		**Column 2**
(A)	Uniform $\vec{E}$	**(p)**	Straight line
(B)	Uniform $\vec{B}$	**(q)**	Parabola
(C)	Uniform $\vec{E} \parallel$ uniform $\vec{B}$	**(r)**	Non uniform right circular cylindrical helix
(D)	Uniform $\vec{E} \perp$ uniform $\vec{B}$	**(s)**	Uniform right circular cylindrical helix
		(t)	None

SUBJECTIVE INTEGER TYPE

46. A uniformly charged ring of radius 10 cm rotates at a frequency of 10^4 rps about its axis. The ratio of energy density of electric field to the energy density of the magnetic field at a point on the axis at distance 20 cm from the centre is 9.1×10^{a}. Find a.

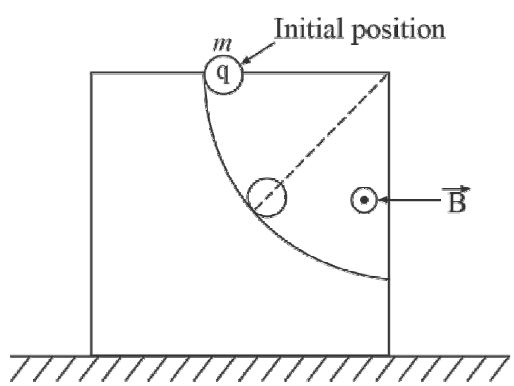
47. Assume linear parts to be very long and the curved part has radius R. Current in wire is *i*. If *i* = 10 A and R = 10 cm, then magnitude of the z component of magnetic field strength at O in tesla is 10^{-a}. Find a.



48. The magnetic field at a distance x on the axis of a circular coil of radius R is $\frac{1}{8}$th of that at the centre. If x equals $R\sqrt{K}$, find K.

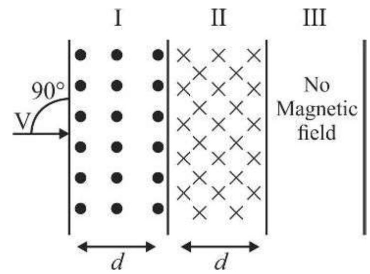
49. A square loop of side 6 cm carries a current of 30 A. The magnitude of magnetic field at a point P lying on the axis of the loop and a distance $\sqrt{7}$ cm is 2.7×10^{-K} T. Find K.

50. In the figure a charged small sphere of mass m and charge q starts sliding from rest on a vertical fixed smooth circular non-conducting track of radius R from the position shown. There exists a uniform perpendicular Magnetic Field. Then the maximum force exerted by track on the sphere is $Xmg + qB\sqrt{(YgR)}$ The Value of $X+Y$ is .



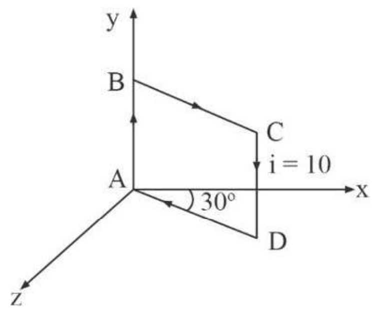
51. Three rings, each having equal radius R, are placed mutually perpendicular to each other and each having its centre at the origin of co-ordinate system. If current 'I' is flowing through each ring then the magnitude of the magnetic field at the common centre is $\left(\sqrt{\frac{X}{Y}}\right)$ times of $\frac{\mu_0 I}{R}$. then $X+Y$ will be

52. The magnetic field shown in the figure consists of two uniform regions. The width of the first part is 5 cm and the magnetic induction here is 0.001 T. The width of the other part is also 5 cm, with the direction of the induction being opposite in direction and 0.002 T in magnitude. The minimum speed of the electron arriving from the direction indicated in the figure so that it can come out through the magnetic field II into region III is X times $\frac{4}{9}\times10^{7}$ m/s then X will be (Mass of electron $=9\times10^{-31}$ kg)

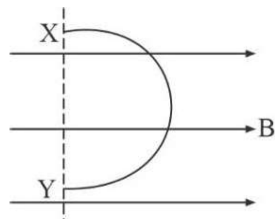


53. Figure shown a square current carrying loop $ABCD$ of side 10 cm and current $i=10\,A$

The magnetic moment $\vec{M}$ of the loop is $(0.05)\left(\hat{i}-\sqrt{x}\hat{k}\right)A-m^{2}$. Calculate x?



54. Semicircular loop of mass per unit length $\frac{\pi}{10}$ kg/m can rotate freely about fixed axis XY is placed on a horizontal surface with its plane parallel to the surface in a uniform magnetic field of magnitude 1 tesla as shown in figure. Find the minimum amount of current (in Amp) that should be passed in the loop can be rotated about side XY.



55. To increase the current sensitivity of a moving coil galvanometer by 50%, its resistance is increased so that the new resistance becomes twice its initial resistance. By what percentage does its voltage sensitivity change?

56. The current density inside a long solid cylindrical wire of radius *a* is in the direction of the central axis and varies linearly with radial distance *r* from the axis according of $J=J_0\frac{r}{a}$. If the magnetic field inside wire is given by $\frac{\mu_0 J_0 r^{x}}{ya}$ then find value of $x+y$.

57. A long thick wire has an inner radius *a*, an outer radius *b*. The total current circulating inside the wire is *I*. this current is uniformly distributed over the cross-section. Find the magnetic field (in μT) at a distance *r* from the axis of wire, (a = 1 cm, b = 2 cm, I = 5.5 A, r = 1.1 cm)

58. Two coaxial long solenoids of equal lengths have currents i_1, i_2, number of turns per unit length n_1, n_2 and radius 3 *m*, 5 *m* respectively. If $n_1 i_1 = n_2 i_2 = 250$ (in SI unit) and the two solenoids carry current in opposite sense, find the magnetic energy stored per unit length (in SI unit). (Take $\pi^2 = 10$)

59. A particle of charge q and mass m starts moving from the origin under the action of an electric field $\vec{E} = E\hat{i}$ and magnetic field $\vec{B} = B\hat{i}$ with a velocity $\vec{v} = v_0\hat{j}$. The speed of the particle will become $2v_0$ after a time $t = \frac{\sqrt{x} m v_0}{qE}$. Find the value of x.

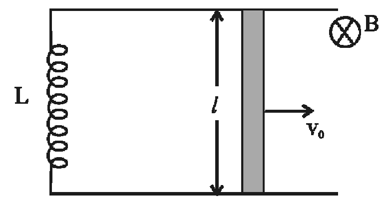
60. A neutral atom of atomic mass number 100 which is stationary at the origin in gravity free space emits an α-particle (A) in z-direction. The product ion is P. A uniform magnetic field exists in the x – direction. Disregard the electromagnetic interaction between A and P. If the angle of rotation of A after which A and P will meet for the first time is $\frac{12n\pi}{25}$ radians, what is the value of n?

JEE Advanced Revision Booklet	Electromagnetic Induction

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

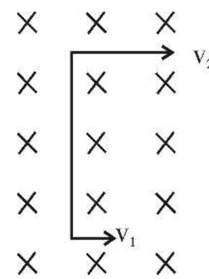
1. Two ends of an inductor of inductance L are connected to two parallel conducting wires. A rod of length l and mass m is given velocity v_0 as shown. The whole system is placed in perpendicular magnetic field B. Find the maximum current in the inductor. (Neglect gravity and friction)



(A) $\dfrac{mv_0}{L}$ **(B)** $\sqrt{\dfrac{m}{L}}v_0$

(C) $\dfrac{mv_0^2}{L}$ **(D)** None of these

2. In the figure magnetic field points into the plane of paper and the conducting rod of length l is moving in this field such that the lowest point has a velocity v_1 and the top most point has the velocity $v_2 (v_2 > v_1)$. The emf induced is given by :



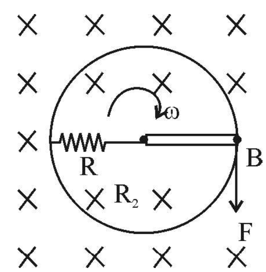
(A) $Bv_1 l$

(B) $Bv_2 l$

(C) $\dfrac{1}{2}B(v_2 + v_1)l$

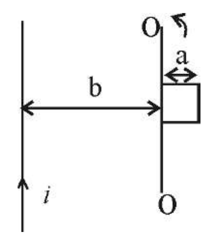
(D) $\dfrac{1}{2}B(v_2 - v_1)l$

3. A metallic ring of mass m and radius r with a uniform metallic spoke of same mass m and length r is rotated about its axis with angular velocity ω in a perpendicular uniform magnetic field B as shown. The central end of he spoke is connected to the rim of the wheel through a resistor R as shown. The resistor does not rotate, its one end is always at the centre of the ring and other end is always in contact with the ring. A force F as shown is needed to maintain constant angular velocity of the wheel. F is equal to (the ring and the spoke has zero resistance) :



(A) $\dfrac{B^2\omega r^2}{8R}$ **(B)** $\dfrac{B^2\omega r^2}{2R}$ **(C)** $\dfrac{B^2\omega r^3}{2R}$ **(D)** $\dfrac{B^2\omega r^3}{4R}$

4. A square loop of side a and a straight long wire are placed in the same plane as shown in figure. The loop has a resistance R and inductance L. The frame is turned through 180° about the axis OO'. What is the electric charge that flows through the loop ?



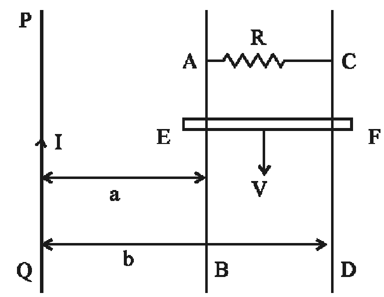
(A) $\dfrac{\mu_0 Ia}{2\pi R}\ln\left(\dfrac{2a+b}{b}\right)$ **(B)** $\dfrac{\mu_0 Ia}{2\pi R}\ln\left(\dfrac{b}{b^2-a^2}\right)$

(C) $\dfrac{\mu_0 Ia}{2\pi R}\ln\left(\dfrac{a+2b}{b}\right)$ **(D)** None of these

5. A flat coil of area A and n turns is placed at the centre of ring of radius r $\left(r^2 >> A\right)$ and resistance R. The two are coplanar. When current in the coil is increased from zero to i, the total charge circulating in the ring is :

(A) $\dfrac{\mu_0 nAi}{2rR}$ **(B)** $\dfrac{\mu_0 n^2 Ai}{2rR}$ **(C)** $\dfrac{\mu_0 nAi}{2\pi r}$ **(D)** $\dfrac{\mu_0 n^2 Ai}{4\pi rR}$

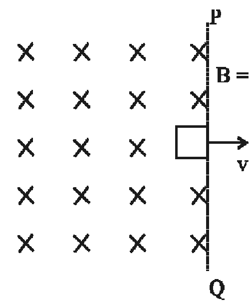
6. PQ is an infinite current carrying conductor. AB and CD are smooth conducting rods on which a conductor EF moves with constant velocity V as shown. The force needed to maintain constant speed of EF is :



(A) $\frac{1}{VR}\left[\frac{\mu_0 IV}{2\pi}\ln\left(\frac{b}{a}\right)\right]^2$ **(B)** $\left[\frac{\mu_0 IV}{2\pi}\ln\left(\frac{b}{a}\right)\right]\frac{1}{R}$

(C) $\left[\frac{\mu_0 IV}{2\pi}\ln\left(\frac{b}{a}\right)^2\right]\frac{V}{R}$ **(D)** $\left[\frac{\mu_0 IV}{2\pi}\ln\left(\frac{b}{a}\right)\right]$

7. Figure shows a square loop of side 1 m and resistance 1Ω. The magnetic field on left side of line PQ has a magnitude B = 1.0 T. The work done in pulling the loop out of the field uniformly in 1 s is :

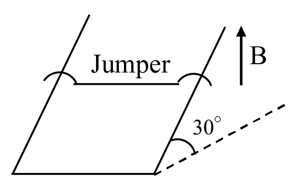


(A) 1 J
(B) 10J
(C) 0.1 J
(D) 100 J

8. An inductor L and a resistor R are connected in series with a direct current source of emf E. The maximum rate at which energy is stored in the magnetic field is :

(A) $\frac{E^2}{4R}$ **(B)** $\frac{E^2}{R}$ **(C)** $\frac{4E^2}{R}$ **(D)** $\frac{2E^2}{R}$

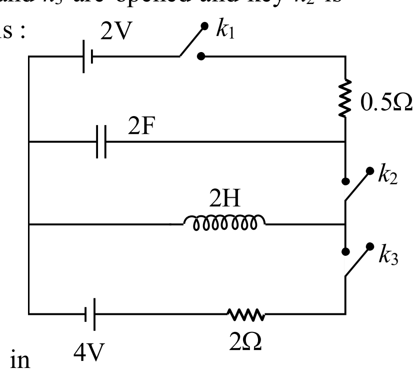
9. Consider a pair of smooth metallic rails joined at one of the ends. Rails are parallel and are inclined at 30° with horizontal. A jumper of mass *m*, length ℓ and resistance *R* slides down the rails with constant speed *v*. Magnetic field in the region is vertical. Strength of magnetic field is :



(A) $\sqrt{\frac{mgR}{3v\ell^2}}$ **(B)** $\sqrt{\frac{2mgR}{3v\ell^2}}$

(C) $\sqrt{\frac{3mgR}{v\ell^2}}$ **(D)** $\sqrt{\frac{\sqrt{3}mgR}{v\ell^2}}$

10. For the circuit shown here, keys k_1 and k_3 are closed for 1 second. Now keys k_1 and k_3 are opened and key k_2 is closed at the same instant. Maximum charge on the capacitor after key k_2 is closed is :

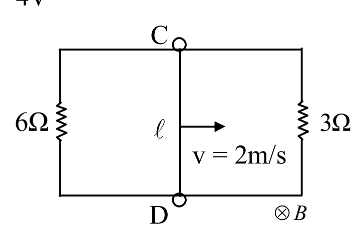


(A) $4\left(1-\frac{1}{e}\right)C$

(B) $4\sqrt{2}\left(1-\frac{1}{e}\right)C$

(C) $8\left(1-\frac{1}{e}\right)C$ **(D)** Zero

11. A rectangular loop with a sliding connector CD of length $\ell = 1.0\,m$ is situated in uniform and constant magnetic field $B = 2T$ perpendicular to the plane of loop. Resistance of connector CD is $r = 2$ ohm. Two resistances of 6 ohm and 3 ohm are connected as shown in figure. The external force required to keep the connector moving with constant velocity $v = 2\ m/s$ perpendicular to CD and in the plane of the loop is :



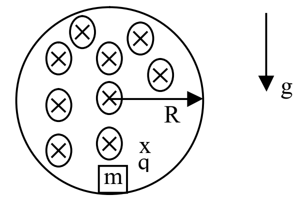
Uniform and constant magnetic field (Normal to plane of paper)

(A) 6 *N* **(B)** 4 *N*
(C) 2 *N* **(D)** 1 *N*

12. A conducting wire of length L fixed at both ends is vibrating in its fundamental mode with angular frequency ω and maximum amplitude A. there exists a uniform and constant magnetic field of induction B perpendicular to the plane of oscillations of the wire. The maximum emf induced in the wire is:

(A) $\frac{BA\omega L}{\pi}$ **(B)** $\frac{BA\omega L}{2\pi}$ **(C)** $\frac{2BA\omega L}{\pi}$ **(D)** $\frac{BA\omega L\pi}{2}$

13. The adjacent diagram shows a circular non-conducting track kept concentric to a magnetic field of magnitude B which exists in a cylindrical region of radius $r\left(r > R\right)$. If the magnetic field is switched off then the specific charge of the particle if it just completes a vertical circle is :



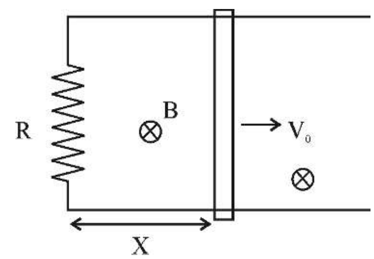
(A) $\frac{2}{B}\sqrt{\frac{3g}{R}}$ **(B)** $\frac{1}{B}\sqrt{\frac{2g}{R}}$

(C) $\frac{2}{B}\sqrt{\frac{5g}{R}}$ **(D)** $\frac{2}{B}\sqrt{\frac{3}{R}}$

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

14. A conducting rod of length l is moved at constant velocity 'V_0' on two parallel, conducting, smooth, fixed rails, that are placed in a uniform constant magnetic field B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rail. Then which of the following is/are correct:



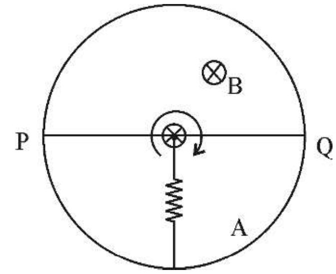
(A) The thermal power dissipated in the resistor is equal to rate of work done by external agent pulling the rod

(B) If applied external force is doubled then a part of external power increases the velocity of rod

(C) Lenz's law is not satisfied if the rod is accelerated by external force

(D) If resistance R is doubled then power required to maintain the constant velocity V_0 becomes half

15. In the figure shown, 'A' is a fixed conducting ring of negligible resistance and radius 'a'. PQ is a uniform rod of resistance r. It is hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity ω. There is a uniform magnetic field of strength 'B' pointing inwards, 'r' is a stationary resistance. Choose correct options.



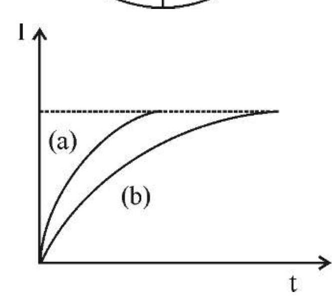
(A) Current through 'r' is zero.

(B) Current through 'r' is $\frac{2B\omega a^2}{5r}$

(C) Direction of current in external 'r' is from centre to circumference

(D) Direction of current in external 'r' is from circumference to centre

16. A series circuit consisting of a constant e.m.f. 'E', a self inductance 'L' and a resistance 'R' is closed at t = 0. The relation between the current I in the circuit and time t is as shown by curve 'a' in the figure. When one or more of parameters E, R and L are changed, the curve 'b' is obtained. The steady state current is same in both the cases. Then it is possible that:



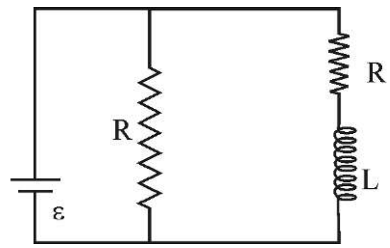
(A) E and R are kept constant and L is increased.

(B) E and R are kept constant and L is decreased

(C) E and R are both halved and L is kept constant

(D) E and L are kept constant and R is decreased

17. In the circuit diagram shown :



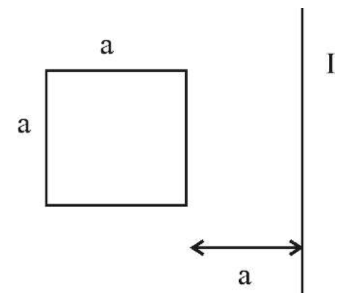
(A) time constant is L/R

(B) time constant is 2L/R

(C) steady state current in inductor is $\frac{2\varepsilon}{R}$

(D) steady state current in inductor is $\frac{\varepsilon}{R}$

18. An infinitely long wire is placed near a square loop as shown in figure. Choose the correct option(s).



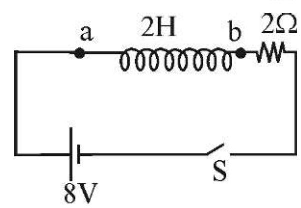
(A) The mutual inductance between the two is $\frac{\mu_0 a}{2\pi}\ln(2)$

(B) the mutual inductance between the two is $\frac{\mu_0 a^2}{2\pi}\ln(2)$

(C) If a constant current is passed in the straight wire in upward direction and loop is brought close to the wire then induced current in the loop is clockwise

(D) In the above condition, induced current in the loop is anticlockwise

19. In the circuit shown in figure, switch is closed at time t = 0. At time t = ln(2) second,



(A) Rate of energy supplied by the battery is 16 J/s

(B) Rate of heat dissipated across resistance is 8 J/s

(C) Rate of heat dissipated across resistance is 16 J/s

(D) $V_a - V_b = 4V$

20. A coil of area $2m^2$ and resistance 4Ω is placed perpendicular to a uniform magnetic field of 4T. The loop is rotated by 90° in 0.1 second. Choose the correct option(s).

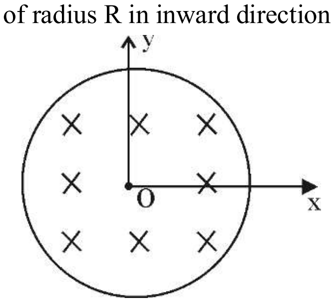
(A) Average induced emf in the coil is 8 V

(B) Average induced current in the circuit is 20 A

(C) 2C charge will flow in the coil in above period

(D) Heat produced in the coil in the above period can't be determined from the given data

21. Magnetic field in a cylindrical region of radius R in inward direction is as shown in figure. Choose correct options.



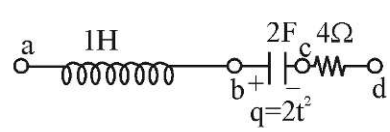
(A) An electron will experience no force kept at (2R, 0, 0) if magnetic field increases with time

(B) in the above situation, electron will experience the force in negative y-direction

(C) If a proton is kept at $\left(0, \frac{R}{2}, 0\right)$ and magnetic field is decreasing, then it will experience the force in positive x-direction

(D) If a proton is kept at (–R, 0, 0) and magnetic field is increasing, then it will experience force in negative y- direction

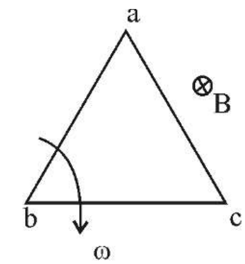
22. In the figure shown, q is in coulomb and t in second. At time t = 1 s,



(A) $V_a - V_b = 4V$ **(B)** $V_b - V_c = 1V$

(C) $V_c - V_d = 16\ V$ **(D)** $V_a - V_d = 20\ V$

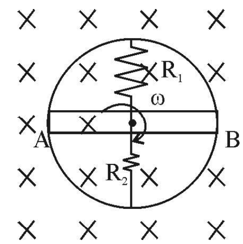
23. An equilateral triangular conducting frame is rotated with angular velocity ω in uniform magnetic field B as shown. Side of triangle is *l*. Choose the correct option(s).



(A) $V_a - V_c = 0$ **(B)** $V_a - V_c = \frac{B\omega l^2}{2}$

(C) $V_a - V_b = \frac{B\omega l^2}{2}$ **(D)** $V_c - V_b = -\frac{B\omega l^2}{2}$

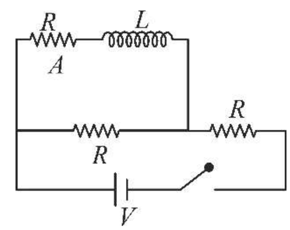
24. AB is a resistanceless conducting rod which forms a diameter of a conducting ring of radius *r* rotating in a uniform magnetic field B as shown. The resistor R_1 and R_2 do not rotate. Then current through the resistor R_1 is:



(A) $\frac{B\omega r^2}{2R_1}$ **(B)** $\frac{B\omega r^2}{2R_2}$

(C) $\frac{B\omega r^2}{2R_1R_2}(R_1+R_2)$ **(D)** $\frac{B\omega r^2}{2(R_1+R_2)}$

25. The ideal inductor is connected in circuit as shown:-



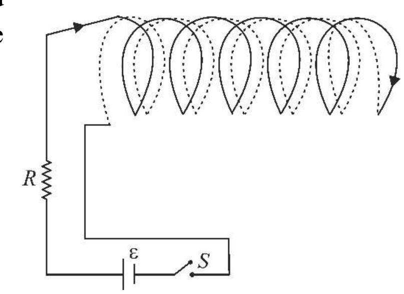
(A) Just after switch is closed, potential difference across L is V/2

(B) Long time after switch is closed, potential difference across A (a particular resistance see figure) is *V*/3.

(C) After a long time, switch is opened again, just after switch is opened, potential difference across *L* is $2V/3$.

(D) Potential difference across A (a particular resistance see figure) just after switch is opened (as in option C) is $V/2$.

26 Two identical solenoids each of self inductance L are joined and placed coaxially and overlapping in such a way that they carry equal and opposite current. This arrangement is joined to a resistance R and battery of emf ε. Switch is closed at $t = 0$. Identify the correct statement(s):



(A) Energy stored in the magnetic field increases with time.

(B) Time constant of the circuit is $\frac{2L}{R}$

(C) Time constant of the circuit is zero.

(D) Power delivered by battery remains constant.

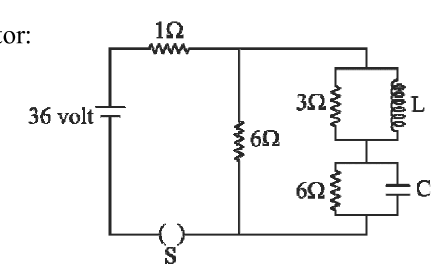
27. An infinite solenoid has radius *R* and *n* turns per unit length. The current grows linearly with time, according to $I_t = Ct$, in the solenoid. Here *C* is some constant. Let the induced electric field at distance *r* from axis of solenoid is *E*. Choose correct alternative(s).

(A) $E \propto r$ for $r < R$ **(B)** $E \propto 1/r$ for $r > R$

(C) If an infinite line charge having uniform linear charge density λ is placed along the axis, then electrostatic field produced by line charge and induced electric field are perpendicular to each other

(D) The induced field and electrostatic field produced by line charge placed along axis of solenoid can be added vectorically to get net electric field at a point.

28. In the given circuit initially capacitor is uncharged and no current through inductor:



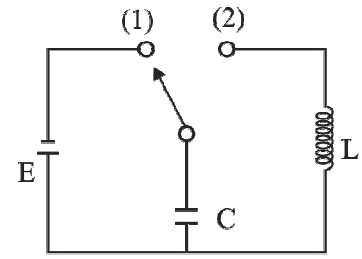
(A) Current through battery just after closing of switch is 12 A

(B) Current through capacitor just after closing of switch 8A

(C) Switch is closed and when steady state of current is achieved the current through battery 9A

(D) After steady state switch is re-opened just after reopening of switch the ratio of current through inductor and capacitor 1A

29. Initially key was placed on (1) till the capacitor got fully charged. Key is placed on (2) at t = 0. The this system will be similar to spring mass system where



(A) Time when the energy in both capacitor and inductor will be same $\frac{\pi}{4\sqrt{LC}}$

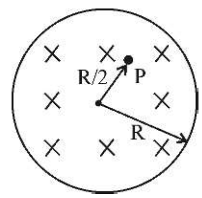
(B) Inductor play the role of mass and Capacitor plays the role of 1/K

(C) q is same as displacement and i is same as v.

(D) None

Paragraph for Q. 30 - 32

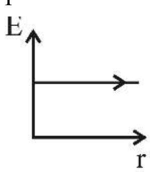
A uniform but time varying magnetic field B = $\left(2t^3 + 24t\right)T$ is present in a cylindrical region of radius R = 2.5 cm as shown in figure.



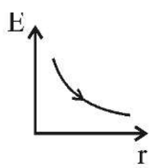
30. The force on an electron at P at t = 2.0 s is :

(A) 96×10^{-21} N **(B)** 48×10^{-21} N **(C)** 24×10^{-21} N **(D)** zero

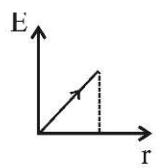
31. The variation of electric field at any instant as a function of distance measured from the centre of cylinder in first problem is :



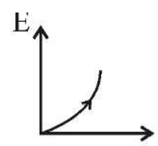
(A)



(B)



(C)



(D)

32. In the previous problem, the direction of circular electric lines at t = 1 s is :

(A) clockwise **(B)** anticlockwise

(C) no current is induced **(D)** cannot be predicted

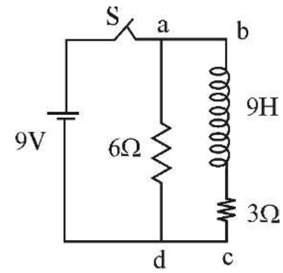
MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

33. In an L-C oscillation circuit, L = 1H, $C = \frac{1}{4}F$ and maximum charge in capacitor is 4C. Match the following two columns. Note that in column 2 all values are in SI units.

	Column 1		Column 2
(A)	Maximum current in the circuit	**p.**	16
(B)	Maximum rate of change of current in the circuit	**q.**	4
(C)	Potential difference across inductor when q = 2C	**r.**	2
(D)	Potential difference across capacitor when rate of change of current is half its maximum value	**s.**	8

34. In the circuit shown in figure, switch S remains closed for a long time. It is opened at time t = 0. Match the following two columns for $t = (ln2)$ second.

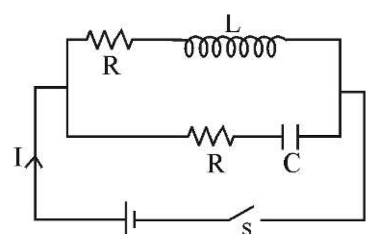


	Column 1		Column 2
(A)	Potential difference across inductor	p.	9 V
(B)	Potential difference across 3Ω resistance	q.	4.5 V
(C)	Potential difference across 6Ω resistance	r.	6 V
(D)	Potential difference between points b and c	s.	None of these

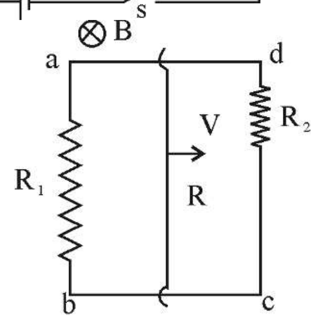
SUBJECTIVE INTEGER TYPE

35. The magnetic flux through a metal ring varies with time t according to $\phi_B = 3\left(at^3 - bt^2\right)Tm^2$ with a = 2.00 s^{-3} and b = 6.00 s^{-2}. The resistance of the ring is 3.0Ω. Find the maximum current (in ampere) induced in the ring during the interval from t = 0 to t = 2.0 s.

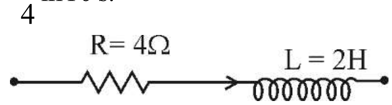
36. In the circuit diagram shown, initially there is no energy in the inductor and the capacitor. The switch is closed at t = 0. If $R = \sqrt{\dfrac{L}{C}}$ and current I is given as $I = \dfrac{V}{R}e^{-\frac{kt}{\sqrt{LC}}}$. Find k.



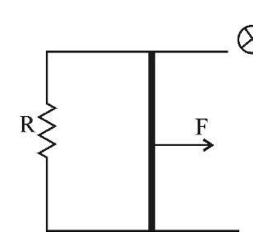
37. A rectangular loop with a sliding connector of length 0.5 m is locate[d in] a uniform magnetic field perpendicular to loop plane. The magnetic induction is equal to B. The connector has an electric resistance R, the sides ab and cd have resistance R_1 and R_2. Neglect the self inductance of the loop. The connector is moving with a uniform velocity V. Given $R = 0.1\Omega$, $R_1 = R_2 = 0.2\Omega$, B = 2.0 T , V = 1 m/s. Find the current flowing in the connector in ampere.



38. In the figure shown, $i = 10e^{-4t}$ where i is in ampere and t is in seconds. Find the magnitude of the potential difference across the inductor at $t = \dfrac{1}{4}\ln 10$ s.

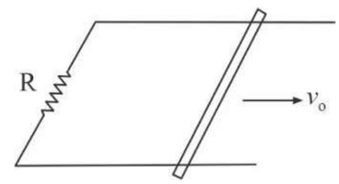


39. Figure shows the top view of a rod of length 1.2 m that can slide without friction. The resistance $R = 6.0\,\Omega$ and a 2.5 T magnetic field is directed perpendicularly downward into the paper.
Find the force F in newton required to move the rod to the right at a constant speed of 2.0 m/s.

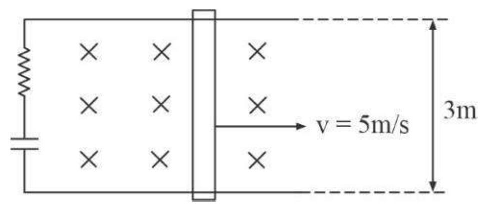


40. A uniform but time varying magnetic field $B = C - Kt$, where K and C are positive constants and t is time (in seconds), is applied perpendicular to the plane of a circular loop of radius 'a' and resistance R. Find the total charge (in coulomb) that will pass through any point of the loop by the time B becomes zero. [Given a = 2m, $R = \pi\Omega$, $C = 2T$]

41. A rod of mass $m = 2\,\text{kg}$ slides without friction along two parallel rails (at distance $d = 1.2\,\text{m}$ from each other); see figure. The rails are joined by a resistor to a resistance $R = 0.16\,\Omega$ and placed in a vertical magnetic field of induction $B = 0.4T$. The rod is pushed with velocity $v_0 = 2.88$ m/s. Find the distance (in m) covered by the rod until it stops. (frame is kept in horizontal plane)

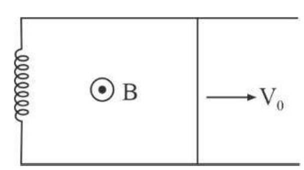


42 A resistance less rod of length $3m$ is being pulled in a uniform vertical magnetic field of magnitude $0.8\,T$ with constant speed of 5 m/s. The resistance of circuit is 4Ω and capacitance is $6\mu F$. Initially there is no charge on the capacitor. What is the current (in A) in circuit when charge on capacitor becomes $24\mu C$?

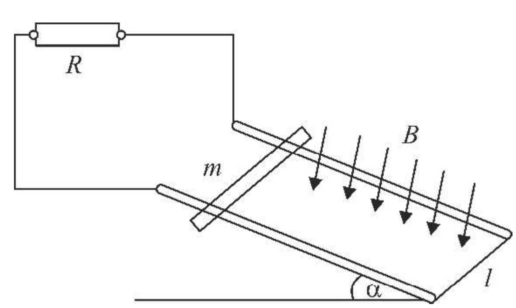


43. A ring made of a superconductor is placed into a homogeneous magnetic field whose intensity grows from zero to $B_0 = 2T$. The plane of the ring is perpendicular to the force lines of the field. The induced current appearing in the ring is 1/x (amp). The radius of the ring $r = \frac{1}{\sqrt{\pi}}\,\text{cm}$ and its inductance $L = 1\,\text{mH}$. Find x.

44. A loop is formed by two parallel conductors connected by a solenoid with inductance $L = 10^3$ H and a conducting rod of mass $m = 1\,\text{gm}$ which can freely slide (without friction) over a pair of conductors. The conductors are located in a horizontal plane in a uniform magnetic field $B = 4T$ in the direction soon. The distance between conductors is equal to $\ell = 1\text{m}$. At the moment $t = 0$, the rod is imparted an initial velocity V_0 to the right. Determine angular frequency (in rad/s) of oscillation of rod.



45. A homogeneous field of magnetic induction B is perpendicular to a track of gauge ℓ which is inclined at an angle $\alpha = 30°$ to the horizontal. A frictionless conducting rod of mass m straddles the two rails of the track as shown in the figure. If maximum speed of the conductor is $= \frac{mgR}{nB^2\ell^2}$. Then find n

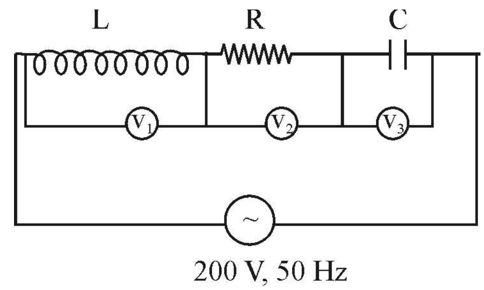


JEE Advanced Revision Booklet	AC Circuits and EM Waves

SINGLE CORRECT ANSWER TYPE

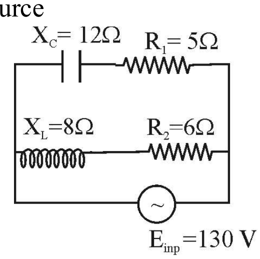
Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. If the reading of v_1 and v_3 are 100 volt each then reading of v_2 is:



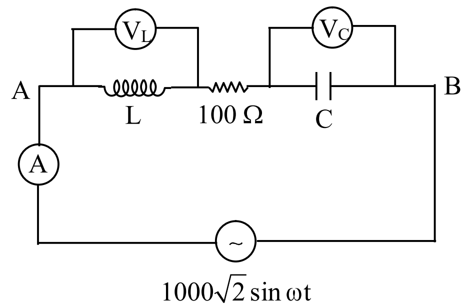
(A) 0 volt
(B) 100 volt
(C) 200 volt
(D) cannot be determined by given information

2. What is the amount of power delivered by the ac source in the circuit shown (in watts) ?



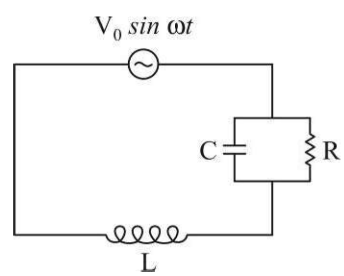
(A) 500 watt
(B) 1014 watt
(C) 1514 watt
(D) 2013 watt

3. In the circuit shown, the reading of ammeter is 10 A and that of $V_C = 200\ V$. The reading of V_L is :



(A) 200 V
(B) $200\sqrt{2}\,V$
(C) $\left(-200+1000\sqrt{2}\right)V$
(D) Zero

4. In the given AC circuit, if amplitude of current is independent of R then which of the following is correct ?



(A) $\omega = \dfrac{1}{\sqrt{LC}}$ **(B)** $\omega = \dfrac{1}{\sqrt{2LC}}$
(C) $\omega = \dfrac{1}{\sqrt{5LC}}$ **(D)** $\omega = \dfrac{1}{2\sqrt{LC}}$

5. For an electromagnetic wave described by $B = 8\times10^{-6}\sin(500\pi x - 3\times10^{11}\pi t)$, where B is in tesla, x is in metre and t is in second the incorrect parameter is:

(A) Frequency $= 1.5\times10^{11}\,Hz$ **(B)** Wavelength $= 4.0\times10^{-4}\,m$
(C) Speed $= 6.0\times10^{7}\,ms^{-1}$ **(D)** Maximum electric field is $320\,Vm^{-1}$

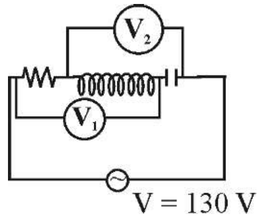
6. A 0.70 m radius cylindrical region contains a uniform electric field that is parallel to the axis and increasing at the rate $5.0\times10^{12}\,V/ms$. The magnetic field at a point 1.2 m from the axis has a magnitude of

(A) 0 **(B)** $7.0\times10^{-6}\,T$ **(C)** $11.1\times10^{-5}\,T$ **(D)** $2.3\times10^{-6}\,T$]

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

7. In a R-L-C series circuit shown, the reading of voltmeters V_1 and V_2 are 100 V and 120 V. Choose the correct statement(s).



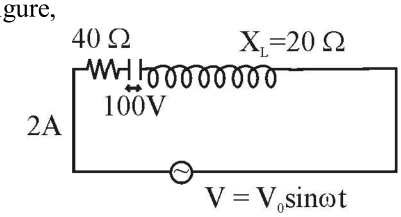
(A) Voltage across resistor, inductor and capacitor are 50 V, 86.6 V and 206.6 V respectively

(B) Voltage across resistor, inductor and capacitor are 10 V, 90 V and 30 V respectively

(C) Power factor of the circuit is $\frac{5}{13}$

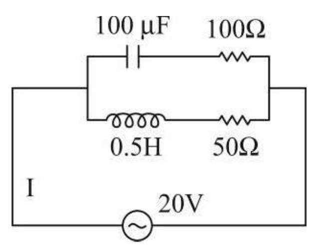
(D) Circuit is capacitive in nature

8. In the circuit shown in figure,



(A) $V_R = 80V$ **(B)** $X_C = 50\ \Omega$ **(C)** $V_L = 40$ V **(D)** $V_0 = 100$ V

9. In the given circuit, the AC source has $\omega = 100\, rad/s$. Considering the inductor and capacitor to be ideal, the correct choice(s) is(are) :



(A) The current through the circuit, I is 0.3A

(B) The current through the circuit, I is $0.3\sqrt{2}A$

(C) The voltage across 100Ω resistor $= 10\sqrt{2}V$

(D) The voltage across 50Ω resistor = 10V

10. In an AC series circuit it is given that $R = 10\Omega$, $X_L = 20\Omega$ and $X_C = 10\Omega$. Then choose the correct options.

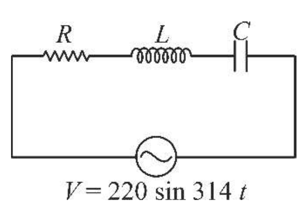
(A) voltage function will lead the current function

(B) Total impedance of the circuit is $10\sqrt{2}\,\Omega$

(C) phase angle between voltage function and current function is 45°

(D) power factor of circuit is $\frac{1}{\sqrt{2}}$

11. In the circuit shown the value of L is 5H and power factor of circuit is 0.8. It is also given that voltage drop across the capacitor is $\frac{2}{5}$ time the voltage drop across inductor :



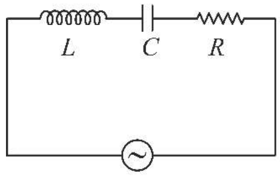
(A) Impedance of circuit is 1570Ω.

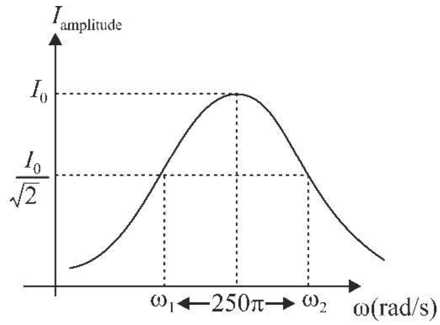
(B) Impedance of circuit is $1256\ \Omega$.

(C) Value of R is $1256\ \Omega$.

(D) Value of R is $502\ \Omega$.

12. In LCR series circuit, the value of $L=\frac{1}{25\pi}H, C=\frac{1}{100\pi}F$ and variation of current amplitude with angular frequency of source is shown in figure. The difference of angular frequency at which current amplitude is $\frac{I_0}{\sqrt{2}}$ is 250π rad/s. Then : (where : I_0 = maximum current amplitude)

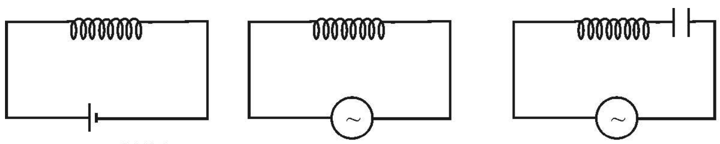




(A) The value of resonating frequency is 25Hz **(B)** The value of R is 5Ω
(C) The value of R is 10Ω **(D)** The value of $\omega_1+\omega_2$ is $10\pi\sqrt{650}$

Paragraph for Q.13 - 15

A steady current 4A flows in an inductor coil when connected to a 12 V dc source as shown in figure 1. If the same coil is connected to an ac source of 12 V, 50 rad/s, a current of 2.4 A flows in the circuit as shown in figure 2. Now after these observations, a capacitor of capacitance $1/50$ F is connected in series with the coil and with the same AC source as shown in figure 3:



13. The inductance of the coil is nearly equal to :
(A) 0.01 H **(B)** 0.02 H **(C)** 0.04 H **(D)** 0.08 H

14. The resistance of the coil is:
(A) 1Ω **(B)** 2Ω **(C)** 3Ω **(D)** 4Ω

15. The average power supplied to the circuit after connecting capacitance in series is approximately equal to:
(A) 24 W **(B)** 72 W **(C)** 144 W **(D)** None of these

Paragraph for Q.16 - 18

A plane- polarized electromagnetic wave of frequency $6\times10^8\,Hz$ is propagating through a region of space. Electric field is along positive z-direction and magnetic field is along positive y-direction at some instant. The peak value of electric field is 3 milli-volt/m.

16. The direction of propagation of wave is
(A) Positive x – direction **(B)** Negative x-direction
(C) Positive y-direction **(D)** Negative y-direction

17. The electromagnetic wave could be represented by :
(A) $B=(10^{-8})\sin 2\pi[2x-(6\times10^8)t]$ **(B)** $B=(10^{-11})\sin 2\pi[2x-(6\times10^8)t]$
(C) $B=(10^{-11})\sin 2\pi[2x+(6\times10^8)t]$ **(D)** $B=(10^{-8})\sin 2\pi[2x+(6\times10^8)t]$

18. Average energy density in the electromagnetic wave is :
(A) $4\times10^{-14}J/m^3$ **(B)** $2\times10^{-14}J/m^3$ **(C)** $2\times10^{-17}J/m^3$ **(D)** $4\times10^{-17}J/m^3$

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

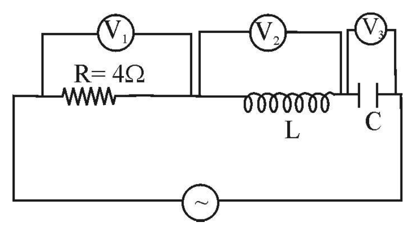
19. Match the following columns.

	Column 1 (Physical quantity)		**Column 2** (expression)
(A)	Total average energy density, U_{av}	**p.**	$\frac{1}{2}c\varepsilon_0 E_0^2$
(B)	Intensity of electromagnetic wave	**q.**	B_0^2 / μ_0
(C)	Radiation pressure (for a perfectly reflecting surface)	**r.**	$B_0^2 / 2\mu_0$
(D)	Index of refraction (n)	**s.**	$\sqrt{\varepsilon_r \mu_r}$

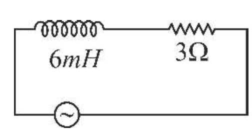
SUBJECTIVE INTEGER TYPE

20. An LCR series circuit with $100\,\Omega$ resistance is connected to an ac source of voltage 200 V and angular frequency 300 rad/s. When only the capacitance is removed, the current lags behind the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60°. Calculate the rms current in ampere in the circuit.

21. In the figure shown, the reading of voltmeters are V_1 = 20V, V_2 = 20V, and V_3 = 5V. Find the rms current in amperes.



22. In the given A.C. circuit the voltage leads the current. The instantaneous voltage is $\frac{1}{\sqrt{2}}$ times the maximum value and increasing, when current is zero. The value of angular frequency of the A.C. is X times 100 rad/sec. Where X is:



23. A DC ammeter and an AC thermal ammeter are connected to a circuit in series. When a DC is passed through the circuit, the DC ammeter shows $I_1 = 6$ A. When an AC flows through the circuit, the AC ammeter shows $I_2 = 8$ A. What will the difference in final readings (in amp) of ammeters, if the DC and the AC flow simultaneously through the circuit?

24. An ideal efficient transformer has primary power input of 10 kW. The secondary current when the transformer is on load is 25 A. If the primary : secondary turns ratio is 8 : 1, then the potential difference applied to the primary coil is X times 800 V where X is

25. A 50 Hz, 20 volt source is connected to a resistance of 100 ohm, an inductor and a capacitor, all in series. The time in sec when the resistance (thermal capacity) = 2 joule/°C) will get heated by 10°C is:
[Power factor for circuit is 1]

26. A coil with inductance L and resistance R is connected to an alternating source. The capacity of a capacitor connected in series with the coil such that active power of circuit does not change is given by $C = \frac{1}{n\omega^2 L}$. Find value of n.

27. A current of 1 A is used to charge a parallel plate capacitor with square plates. If the area of each plate is $0.6\,m^2$ the displacement current through a $0.3m^2$ area fully between the capacitor plates and parallel to them is $\frac{1}{n}A$. Find n.

28. A parallel plate capacitor consists of two circular plates of area $100\ cm^2$ each. The separation between the plates is 1 mm. If the displacement current is 17.7 A, then the rate of change of electric field between the plates is $2 \times 10^n\ NC^{-1}s^{-1}$, the value of n is _____________.

29. The amplitude of magnetic field at a distance r from a point source of power P (considering 100% efficiency) is $\sqrt{\frac{\mu_0 P}{k\pi r^2 C}}$, the value of k is __________.

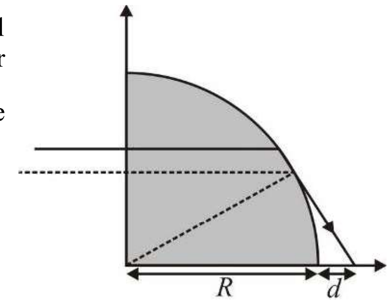
30. A pallet plate capacitor made of circular plate each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V AC supply with angular frequency of 300 rad/s.

The rms value of magnetic field at a point 3.0 cm from the axis between the plate is $n \times 10^{-13}$ (in Tesla). Then find the value of n

SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

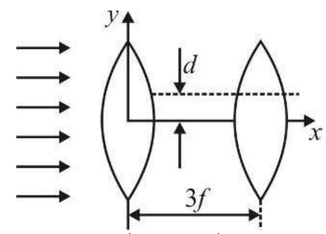
1. A uniform horizontal light beam is incident upon a prism (quarter cylindrical shape) as shown in the figure. The radius of the prism is R and the cylinder material has a refractive index $\frac{2}{\sqrt{3}}$. A patch on the table for a distance d from the surface of the cylinder is unilluminated. Find the value of d in terms of R.



(A) $R/2$ **(B)** R

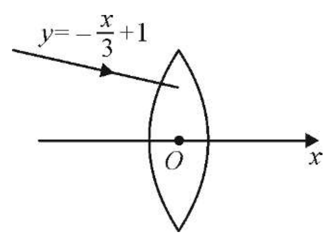
(C) $\sqrt{3}R$ **(D)** $2R$

2. In the figure shown, the focal length of the two thin convex lenses is the same f. They are separated by a horizontal distance $3f$ and their optical axis are displaced by a vertical separation 'd' ($d << f$), as shown. Taking the origin of coordinates O at the centre of the first lens, the x and y coordinates of the point where a parallel beam of rays coming from the left finally get focused, are given by :



(A) $(5f, 2d)$ **(B)** $(6f, d/2)$ **(C)** $(4f, 2d)$ **(D)** $(2f, 4d)$

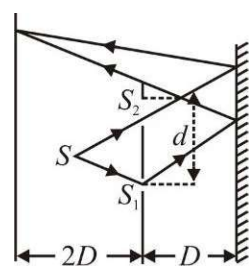
3. A convex lens of focal length 15 cm is placed at the origin with its optical axis coinciding with the x-axis. A ray of light given by $y = -\frac{x}{3} + 1$ is incident on the lens. The equation of refracted ray is (x and y are in cm)



(A) $y = -0.2x + 3$ **(B)** $y = -0.3x + 2$

(C) $y = -0.4x + 1$ **(D)** $y = -0.1x + 4$

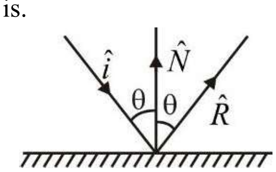
5. A double slit, $S_1 - S_2$ is illuminated by a light source S emitting light of wavelength λ. The slits are separated by a distance d. A plane mirror is placed at a distance D in front of the slits and a screen is placed at a distance $2D$ behind the slits. The screen receives light reflected only by the plane mirror. The fringe-width of the interference pattern on the screen is



(A) $\frac{D\lambda}{d}$ **(B)** $\frac{2D\lambda}{d}$

(C) $\frac{3D\lambda}{d}$ **(D)** $\frac{4D\lambda}{d}$

5. A light ray is reflected by a mirror. If unit vectors along the incident and normal direction are $\hat{I} = \frac{1}{\sqrt{3}}\hat{i} - \frac{1}{\sqrt{3}}\hat{j} + \frac{1}{\sqrt{3}}\hat{k}$ and $\hat{N} = \hat{i}$, then unit vector, $\hat{R}$ along reflected direction is.



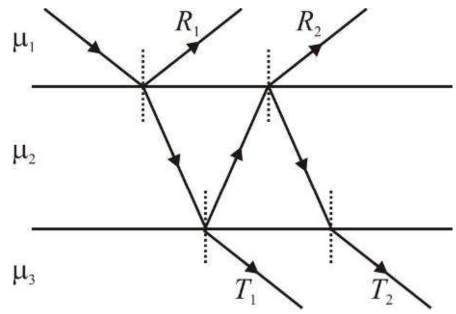
(A) $\frac{1}{\sqrt{7}}\left(\sqrt{2}\hat{i} + \sqrt{2}\hat{j} - \sqrt{3}\hat{k}\right)$ **(B)** $\frac{-1}{\sqrt{3}}\hat{i} - \frac{1}{\sqrt{3}}\hat{j} - \frac{1}{\sqrt{3}}\hat{k}$

(C) $-\frac{1}{\sqrt{3}}\hat{i} - \frac{1}{\sqrt{3}}\hat{j} + \frac{1}{\sqrt{3}}\hat{k}$ **(D)** $\frac{1}{\sqrt{3}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} + \frac{1}{\sqrt{3}}\hat{k}$

6. The plane of polarization of a plane polarized light (intensity I_0)is to be rotated by $\phi°$ using n identical polaroid sheets having equal angle between transmission axis of successive sheets. If the percentage intensity loss in this process is 57.8125% then the value of ϕ is:

(A) 45° **(B)** 90° **(C)** 30° **(D)** 60°

7. A ray of light l is incident on a thin film. Two reflected rays R_1 and R_2 and two transmitted rays T_1 and T_2 for the incident ray l are shown in the figure. If the rays R_2 and T_2 undergoes a phase change of π due to difference in refractive index of the mediums, then select the correct order of refractive indeces.



(A) $\mu_1 > \mu_2 > \mu_3$ **(B)** $\mu_1 < \mu_2 < \mu_3$ **(C)** $\mu_1 > \mu_2 < \mu_3$ **(D)** $\mu_1 < \mu_2 > \mu_3$

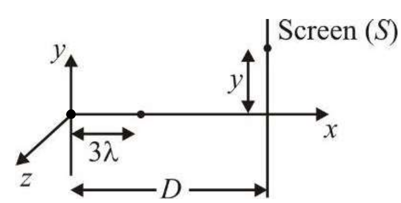
8. In a young's double slit experiment, 11 interference fringes are obtained within central diffraction maximum of a slit. If the distance between 1st diffraction minimum on either sides is 5.20 mm, distance between slits and screen is 208 cm,, and the wavelength of light is 500 nm then separation between the slits is:

(A) 8.8 mm **(B)** 4 mm **(C)** 8 mm **(D)** 4.4 mm

9. A ray beam of width 1 cm is incident from air to air-water boundary at an angle of 45°. What is the width of the refracted beam in water? (Refractive index of water = $\sqrt{2}$)

(A) $\frac{1}{2}$ cm **(B)** $\frac{1}{\sqrt{2}}$ cm **(C)** 1 cm **(D)** $\frac{\sqrt{3}}{\sqrt{2}}$ cm

10. Two coherent narrow slits emitting wavelength λ in the same phase are placed at (0, 0, 0) and (3λ, 0, 0) in an x-y-z space as shown in the figure. The light from the two slits interfere on a screen S which is parallel to y-z plane and is placed at a distance $D(D >> \lambda)$ from the origin. Find the distance y of the nearest point on the screen from the centre of the screen P, where intensity is equal to that at P

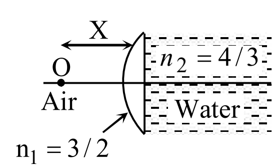


(A) D **(B)** $\sqrt{3}D$ **(C)** $\frac{\sqrt{5}D}{2}$ **(D)** $\sqrt{5}D$

11. A light ray incident along vector $2\hat{i} + 4\hat{j} + \sqrt{5}\hat{k}$ strikes on the x-z plane from medium I of refractive index $\sqrt{3}$ and enters into medium II of refractive index is μ_2. The value of μ_2 for which the value of angle of refraction becomes 90°, is :

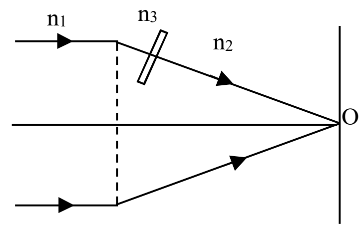
(A) $\frac{4\sqrt{3}}{5}$ **(B)** $\frac{3\sqrt{3}}{5}$ **(C)** $\frac{2\sqrt{3}}{5}$ **(D)** $\frac{\sqrt{3}}{5}$

12. A point source of light 'O' is kept on the principal axis of a thin plano-convex lens of radius of curvature 20 *cm* as shown. The refractive index of material of lens is 3/2, then medium towards right of plane surface is water of refractive index 4/3 and the medium on the left side of curved surface of lens is air. Considering only paraxial rays, the distance 'x' of the point source 'O' from the lens such that the rays become parallel on entering the water will be:



(A) 10 *cm* **(B)** 20 *cm* **(C)** 40 *cm* **(D)** None of these

13. In the figure shown in a YDSE, a parallel beam of light is incident on the slits from a medium of refractive index n_1. The wavelength of light in this medium is λ_1. A transparent slab of thickness 't' and refractive index n_3 is put infront of one slit. The medium between the screen and the plane of the slits is n_2. The phase difference between the light waves reaching point 'O' (symmetrical, relative to the slits) is :



(A) $\frac{2\pi}{n_1\lambda_1}(n_2 - n_3)t$ **(B)** $\frac{2\pi}{\lambda_1}(n_3 - n_2)t$

(C) $\frac{2\pi n_1}{2_2\lambda_1}\left(\frac{n_3}{n_2} - 1\right)t$ **(D)** $\frac{2\pi n_1}{\lambda_1}(n_3 - n_2)t$

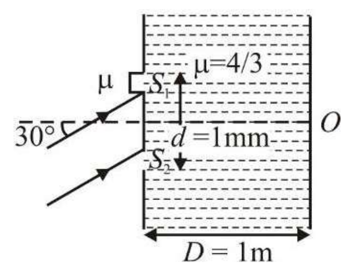
14. In a Young's double slit experiment D equals the distance of screen and d is the separation between the slits. The distance of the nearest point to the central maximum where the intensity is same as that due to a single slit, is equal to

(A) $\frac{D\lambda}{d}$ **(B)** $\frac{D\lambda}{2d}$ **(C)** $\frac{D\lambda}{3d}$ **(D)** $2D\lambda$

MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

15. The gap between the slit plane and the screen is filled with water and a parallel beam of monochromatic light of wavelength, $\lambda = 0.25$ mm and the intensity I_0 is incident at an angle 30° with the horizontal. A slab of thickness 0.5 mm and refractive index $\mu_s = 1.5$ is placed before S_1. Choose the correct option(s).

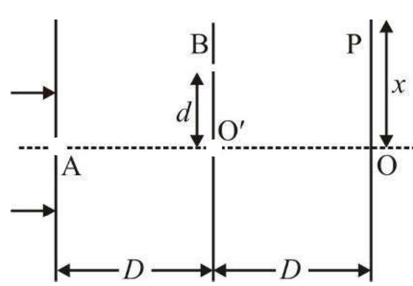


(A) central maxima is observed above O
(B) central maxima observed below O
(C) intensity at O is $4I_0$
(D) 3rd order maxima is at O

16. If white light is used in a Young's double-slit experiment,
(A) bright white fringe is formed at the centre of the screen
(B) fringes of different colours are observed clearly only in the first order
(C) the first-order violet fringe is closer to the centre of the screen than the first-order red fringe
(D) the first-order red fringe is closer to the centre of the screen than the first-order violet fringe

17. A particle moves towards a concave mirror of focal length 30 cm along its axis and with a constant speed of 4 cm/sec. At the instant the particle is 90 cm from the pole
(A) velocity of image is 1 cm/sec **(B)** velocity of image w.r.t. particle is 5 cm/sec
(C) particle and image move towards each other
(D) as the particle approaches pole, velocity of image increases

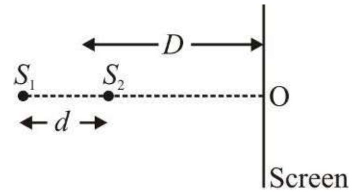
18. The minimum value of d so that there is a dark fringe at O is $d_{\min}$. For the value of d_{min}, the distance at which the next bright fringe is formed is x. Then :



(A) $d_{\min} = \sqrt{\lambda D}$ **(B)** $d_{\min} = \sqrt{\frac{\lambda D}{2}}$

(C) $x = \frac{d_{\min}}{2}$ **(D)** $x = d_{\min}$

19. Two point monochromatic and coherent sources of light of wavelength λ are each placed as shown in the figure below. The initial phase difference between the sources is zero O. ($D >> d$). Select the correct statement(s) :



(A) If $d = \frac{7\lambda}{2}$, O will be minima

(B) If $d = \lambda$, only one maxima can be observed on screen

(C) If $d = 4.8\lambda$, then a total 10 minimas would be there on screen

(D) If $d = \frac{5\lambda}{2}$, then intensity at O would be minimum

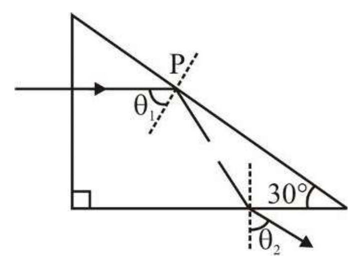
20. The slit 1 of a Young's double slit experiment is wider than slit 2, so that the light from slits are given as $A_1 = A_0 \sin \omega t$ and $A_2 = 3A_0 \sin\left(\omega t + \frac{\pi}{3}\right)$. Then resultant amplitude and intensity at a point where the path difference between them is zero, is A and t respectively, then :

(A) $A = \sqrt{13}A_0$ **(B)** $A = 4A_0$ **(C)** $I \propto 16A_0^2$ **(D)** $I \propto 13A_0^2$

21. Two transparent parallel plates are stacked face to face. The plate whose thickness $t_1 = 4.5$ cm has a refractive index $n_1 = \frac{3}{2}$ while the other plate whose thickness $t_2 = 2$ cm has a refractive index $n_2 = \frac{4}{3}$. A narrow light beam is incident on the first plate at an angle $i = 37°$ to the normal. The lateral shifts of the beam emerging from the second plate into air space due to I plate only, due to II plate only, and due to both the plates are d_1, d_2 and d respectively, then :

(A) $d_1 = 0.5$ cm **(B)** $d_1 = 1.129$ cm **(C)** $d \simeq 1.5$ cm **(D)** $d \simeq 2$ cm

22. A ray of light is incident normally on one face of 30° – 60° – 90° prism of refractive index 5/3 immersed in water of refractive index 4/3 as shown in figure.



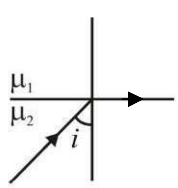
(A) The exit angle θ_2 of the ray is $\sin^{-1}\frac{5}{8}$

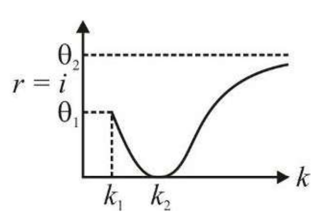
(B) The exit angle θ_2 of the ray is $\sin^{-1}\frac{5}{4\sqrt{3}}$

(C) Total internal reflection at point P ceases if the refractive index of water is increased to $\frac{5}{2\sqrt{3}}$ by dissolving some substance

(D) Total internal reflection at point P ceases if the refractive index of water is increased to $\frac{5}{6}$ by dissolving some substance

23. The figure shows a ray incident at an angle $i = \frac{\pi}{3}$. If the plot drawn shown in the variation of $|r - i|$ versus $\frac{\mu_1}{\mu_2} = k$, (r = angle of refraction)

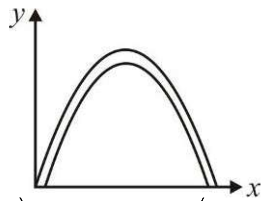




(A) the value of k_1 is $\frac{2}{\sqrt{3}}$ **(B)** the value of $\theta_1 = \frac{\pi}{6}$

(C) the value of $\theta_2 = \frac{\pi}{3}$ **(D)** the value of k_2 is 1

24. A reflecting surface is represented by the equation $Y = \frac{2L}{\pi}\sin\left(\frac{\pi x}{L}\right), 0 \le x \le L.$ A ray travelling horizontally becomes vertical after reflection. The coordination of the point (s) where this ray is incident are



(A) $\left(\frac{L}{4}, \frac{\sqrt{2}L}{\pi}\right)$ **(B)** $\left(\frac{L}{3}, \frac{\sqrt{3}L}{\pi}\right)$ **(C)** $\left(\frac{3L}{4}, \frac{\sqrt{2}L}{\pi}\right)$ **(D)** $\left(\frac{2L}{3}, \frac{\sqrt{3}L}{\pi}\right)$

25. A convex lens forms an image of an object on a screen. The height of the image is 9 cm. The lens is now displaced until an image is again obtained on the screen. The height of this image is 4 cm. The distance between the object and the screen is 90 cm.

(A) The distance between the two position of the lens is 30 cm
(B) The distance of the object from the lens in its first position is 36 cm.
(C) The height of the object is 6 cm.
(D) The focal length of the lens is 21.6 cm.

26. In displacement method, the distance between object and screen is 96 *cm*. The ratio of length of two images formed by a convex lens placed between them is 4.

(A) Ratio of the length of object to the length of shorter image is 2
(B) Distance between the two positions of the lens is 32 *cm*
(C) Focal length of the lens is 64/3 *cm*
(D) When the shorter image is formed, distance of the lens from the shorter image is 32 *cm*

27. In the figure light is incident at an angle θ which is slightly greater than the critical angle. Now, keeping the incident fixed a parallel slab of refractive index n_3 is placed on surface *AB*. Which of the following statements are correct :

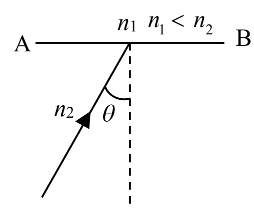


Fig. (A)

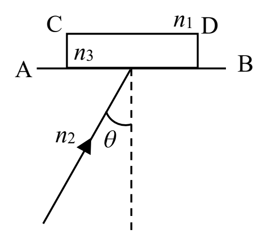


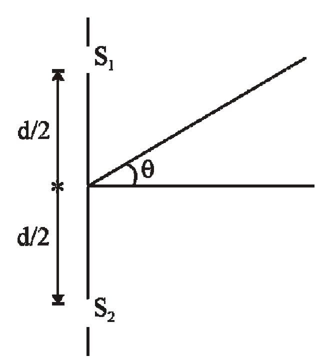
Fig. (B)

(A) Total internal reflection occurs at *AB* for $n_3 < n_1$
(B) Total internal reflection occurs at *AB* for $n_3 > n_1$
(C) The ray will return back to the same medium for all values of n_3
(D) Total internal reflection occurs at *CD* for $n_3 < n_1$

28. A convex lens made of glass $(\mu_g = 3/2)$ has focal length *f* in air. The image of an object placed infront of it is inverted" real and magnified. Now the whole arrangement is immersed in water $(\mu_w = 4/3)$ without changing the distance between object and lens. Then:

(A) The new focal length will become 4*f* **(B)** The new focal length will become $\frac{f}{4}$
(C) New image will be virtual and magnified **(D)** New image will be real inverted and smaller in size

29. In an interference arrangement similar to Young's double-slit experiment, the slits S_1 and S_2 are illuminated with coherent microwave sources, each of frequency 10^6 *Hz*. The sources are synchronized to have zero phase difference. The slits are separated by a distance $d = 150.0$ *m* The intensity $I(\theta)$ is measured as a function of θ, where θ is defined as shown, If I_0 is the maximum intensity, then $I(\theta)$ for $0 \le \theta \le 90°$ is given by:



(A) $I(\theta) = I_0/2$ *for* $\theta = 30°$ **(B)** $I(\theta) = I_0/4$ *for* $\theta = 90°$
(C) $I(\theta) = I_0$ *for* $\theta = 0°$
(D) $I(\theta)$ is constant for all values of θ

30. A point object is placed at 30 *cm* from a convex glass lens $\left(\mu_g = \frac{3}{2}\right)$ of focal length 20 *cm*. The final image of object will be formed at infinity if:

(A) Another concave lens of focal length 60 *cm* is placed in contact with the previous lens

(B) Another convex lens of focal length 60 *cm* is placed at a distance of 30 *cm* from the first lens

(C) The whole system is immersed in a liquid of refractive index 4/3

(D) The whole system is immersed in a liquid of refractive index 9/8

31. A thin film of thickness *t* and index of refraction 1.33 coats a glass with index of refraction 1.50. Which of the following thickness *t* will not reflect normally incident light with wavelength 640 *nm* in air?

(A) 120 *nm* **(B)** 240 *nm* **(C)** 360 *nm* **(D)** 480 *nm*

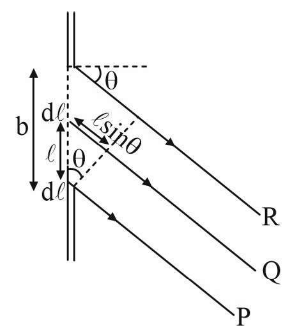
32. Imagine a Young's double slit interference experiment performed with electron waves associated with fast moving electrons coming from the electron gun. The distance between successive maximum will decrease if the:

(A) Accelerating voltage in electron gun is decreased

(B) Accelerating voltage is increased **(C)** Distance between screen and slits is increased

(D) Distance between the slits is increased

Paragraph for Questions 33 - 35



In the sitution shown parallel rays of monochromatic light (wavelength $= \lambda$) are incident normaly on a narrow slit of width *b*. There is a screen opposite to the slit at distance $D(d >>> d)$. The intensity obtained at the point opposity to the centre of slit is I_0

If the equation of distuburance on slit due to the incident wave is $y = \sin(\omega t)$. The slit width b can be divided into large number of elemental slits of width $'d\ell'$. If amplitude is directly proporational to slit width then the amplitude of disturbance from such element will be $\frac{A}{b} d\ell$.

So, the disturbances from ray P reaching on screen will be

$$y_P = \frac{A d\ell}{b} \sin \omega t$$

Similarly for any arbitrary ray Q the distribent on screen will be

$$y_Q = \frac{A d\ell}{b} \sin\left(\omega t + \frac{2\pi \ell \sin\theta}{\lambda}\right)$$

Now the resultant disturbance at any point at angle θ can be obtained using principle of superposition for all such elemental slits and using that, intensity can be obtained at the point.

33. The intensity at a paint on screen lying at angle θ with respect to central ine is:

(A) $\dfrac{I_0 \sin^2\left(\dfrac{2\pi b \sin\theta}{\lambda}\right)}{\left(\dfrac{2\pi b \sin\theta}{\lambda}\right)^2}$ **(B)** $\dfrac{I_0 \sin^2\left(\dfrac{\pi b \sin\theta}{\lambda}\right)}{\left(\dfrac{\pi b \sin\theta}{\lambda}\right)^2}$

(C) $\dfrac{I_0 \sin\left(\dfrac{2\pi b \sin\theta}{\lambda}\right)}{\left(\dfrac{2\pi b \sin\theta}{\lambda}\right)^2}$ **(D)** $\dfrac{I_0 \sin\left(\dfrac{\pi b \sin\theta}{\lambda}\right)}{\left(\dfrac{\pi b \sin\theta}{\lambda}\right)^2}$

34. The intensity at 2nd maxima is:

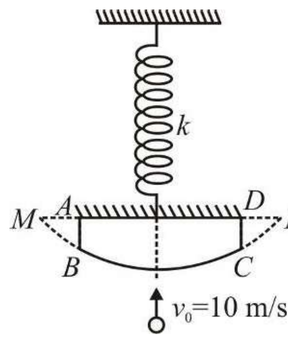
(A) $0.045I_0$ **(B)** $0.008I_0$ **(C)** $0.022I_0$ **(D)** $0.0161I_0$

35. Distance of 2nd maximum from central maximum is:

(A) $\frac{3\lambda D}{2b}$ **(B)** $\frac{5\lambda D}{2b}$ **(C)** $\frac{7\lambda D}{2b}$ **(D)** $\frac{2\lambda D}{b}$

Paragraph for Questions 36 - 38

The flat surface of a plano-convex lens is silvered and cut to give the shape of a cross-section as ABCD. The optical centre of the silvered lens is attached to a rigid support through a spring of force constant k. The radius of curvature of BC is 10 cm and the refractive index of the material of the lens is 1.5. The lens is initially at rest so that the elongation of the spring is x_0. A particle of mass $m = \frac{kx_0}{g}$ hits the lens elastically with velocity 10 m/s as shown in the figure. Taking $x_0 = \frac{0.1}{\pi^2}$ m and $g = 10 \text{ m/s}^2$.



36. The equivalent focal length of the silvered lens is :

(A) –5 cm **(B)** –10 cm **(C)** –15 cm **(D)** –20 cm

37. If $t = 0$ be the time of collision, then at time $t = \pi\sqrt{\frac{m}{k}}$, the speed of the image of the particle relative to the lens is :

(A) 40 m/s **(B)** 36 m/s **(C)** 32 m/s **(D)** none of these

38. If the lens were complete as MBCNM, then

(A) the image velocity will be more **(B)** the image velocity will be less
(C) the image will be more intense **(D)** can't be predicted

Paragraph for Questions 39 - 41

A container contains liquid upto a height of 30 cm and there is a point source at the centre of the bottom of the container. A rubber ring of radius r floats centrally on the liquid surface. The ceiling of the room is 3.0 m above the liquid surface. (Refractive index of liquid $= \sqrt{3}$)

39. The radius of disc on surface of water through which rays from point source are refracted into air is :

(A) $10\sqrt{2}\ cm$ **(B)** $15\sqrt{2}\ cm$ **(C)** $10\sqrt{3}\ cm$ **(D)** $15\sqrt{3}\ cm$

40. The radius of the shadow of the ring formed on the ceiling if $r = 10\sqrt{3}\,cm$ is :

(A) $270\sqrt{3}\ cm$ **(B)** $290\sqrt{3}\ cm$ **(C)** $310\sqrt{3}\ cm$ **(D)** $350\sqrt{3}\ cm$

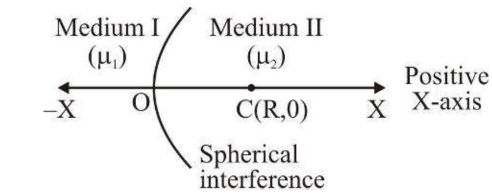
41. Find the maximum value of r for which the shadow of the ring is formed on the ceiling.

(A) $10\sqrt{2}\ cm$ **(B)** $15\sqrt{2}\ cm$ **(C)** $10\sqrt{3}\ cm$ **(D)** $15\sqrt{3}\ cm$

MATRIX MATCH TYPE

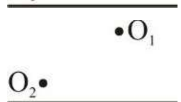
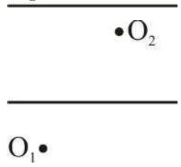
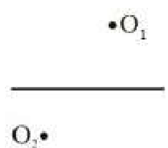
Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

42. A spherical interface whose radius is R divides the space in two parts such that the x-axis behaves as principal axis and origin O behaves as pole as shown in the figure. The refractive index of medium I is μ_1 and that of medium II is μ_2. Now match the column 1 with column 2 [Assume concept of paraxial rays]

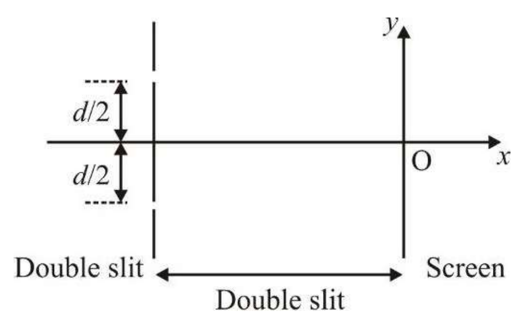


	Column 1		Column 2
(A)	Object is kept at point ($-a$, 0) and $\mu_1 < \mu_2$	**(p)**	Image may be real
(B)	Object is kept at point ($-a$, 0) and $\mu_1 > \mu_2$	**(q)**	Image may be virtual
(C)	Object is kept at point ($+a$, 0) and $\mu_1 < \mu_2$	**(r)**	The position of image may be in between the position of object and origin.
(D)	Object is kept at point ($+a$, 0) and $\mu_1 > \mu_2$	**(s)**	The position of image may be in between the position of object and centre of curvature of interface.

43. Column shows O_1 object and O_2 image. The optical system responsible can be a spherical mirror, plane mirror or a thin lens. In the case of the lens and spherical mirror, straight line shows the principal axis. Match column-1 and column-2.

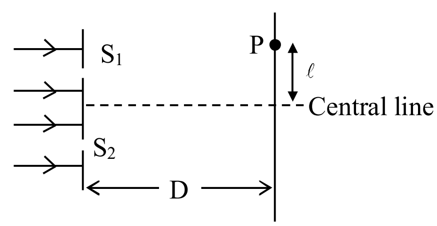
	Column 1		Column 2
(A)		**(p)**	Concave mirror between O_1 and O_2
(B)		**(q)**	Diverging lens between O_1 and O_2
(C)		**(r)**	Convex mirror between O_1 and O_2
(D)		**(s)**	Converging lens between O_1 and O_2
		(t)	Inclined plane mirror somewhere between O_1 and O_2

44. In a young's double slit experiment, a parallel beam of monochromatic light of wavelength 500 nm (in vacuum) is while the screen is placed at a fixed distance of 1 m from the plane of the slits. Different experimental setups are described and some physical quantities are measured in each setup as given in column 1 the corresponding results are given in column 2, in a different order. Match each case in column 1 with the appropriate result in column 2. Consider the figure.



	Column I		Column II
(A)	Light falls normally on the plane of slits and $d = 1$ mm	**(p)**	Ratio of maximum to minimum intensity on screen is 81
(B)	In the situation given in part (A), the upper slit is covered by a transparent film of refractive index 1.5 and of thickness 2.5 μm. The film absorbs 36% of the light incident on it.	**(q)**	The central maximum may be obtained at O
(C)	In situation (B), the direction of incident light is changed so that it makes an angle of 1.25×10^{-3} radian with the x-axis	**(r)**	The central maximum may be obtained 1.25 mm
(D)	In the setup in (B), the separation between the slits is decreased to 0.5 mm and the space between the slits and the screen is filled with a non absorbing liquid of refractive index 1.2.	**(s)**	y-coordinate of central maximum may 2.5 mm
		(t)	The fringe width is 0.5 mm

45. A parallel beam of light consisting of two wavelength $\lambda_1 = 4000$ Å and $\lambda_2 = 8000$ Å is incident perpendicular to plane of both slits in a typical Young's double slit experiment. The separation between both slits is $d = 2mm$ and the distance between slits and screen is $D = 1$ meter. In each situation of column-I a point P on screen is specified by its distance 'ℓ' from centre bright on screen. Match each situation of column-I with the corresponding statement in column-II.



	Column I		**Column II**
(A)	At P such that $\ell = 0$	**(p)**	Intensity is maximum for $\lambda_1 = 4000$ Å
(B)	At P such that $\ell = 0.1\ mm$	**(q)**	Intensity is minimum for $\lambda_1 = 4000$ Å
(C)	At P such that $\ell = 0.2\ mm$	**(r)**	Intensity is maximum for $\lambda_2 = 8000$ Å
(D)	At P such that $\ell = 0.4\ mm$	**(s)**	Intensity is minimum for $\lambda_2 = 8000$ Å

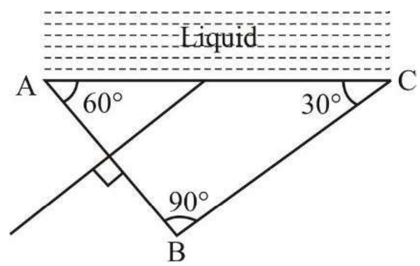
SUBJECTIVE INTEGER TYPE

46. A ray of light falling on a glass sphere of refractive index $\mu = \sqrt{3}$ such that the directions of the incident ray and emergent ray when produced meet the surface at the same point. The value of angle of incident is θ. Calculate the value of $\frac{\theta}{30°}$.

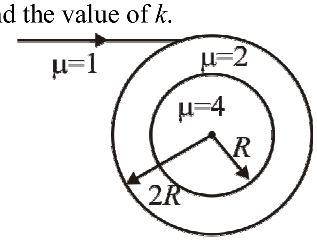
47. A point source of light is placed inside water and a thin converging lens of focal length f is placed just outside the surface of water. The image of source is formed at a distance of 50 cm from the surface of water. When the lens is placed just inside the water surface and the image is formed at a distance of 40 cm from the surface of water, if focal length of the lens in air is $f = \frac{100k}{3}$ cm, then find the value of k. (Given refractive index of lens is 3/2 and that of water is 4/3 and in both cases image is formed inside water for the viewer in air).

48. A plano-convex lens has a thickness of 4 cm. When placed on a horizontal table, with the curved surface in contact with it, the apparent depth of the bottom most point of the lens is found to be 3 cm. If the lens is inverted such that the plane face is in contact with the table, the apparent depth of the centre of the plane face is found to be $\frac{25}{8}$ cm. The radius of curvature of the convex surface of the lens is $\left(\frac{1}{x}\right)$ m. Find the value of x?

49. Light is incident normally on face AB of a prism as shown in the figure. A liquid of refractive index μ is placed on face AC of the prism. The prism is made of glass of refractive index 3/2. The maximum value of μ for which total internal takes reflection place on face AC is $\frac{6\sqrt{3}}{n}$. Find n.



50. Figure shows two spherical surfaces of radii R and $2R$ separating three transparent media of refractive index $\mu = 4$, $\mu = 2$ and $\mu = 1$. A ray of light travelling in medium $\mu = 1$ is incident on outer sphere tangentially. The net deviation suffered by light ray will be k 60°. Find the value of k.



51. Two objects are placed on the principal axis of a thin converging lens. One is 10 cm from the lens and the other is one the other side of the lens at a distance of 40 cm from the lens. The images of both objects are in the same plane. What is the focal length of the lens (in cm)?

52. In the figure shown below the transmission axes of the polarizing discs 1 and 3 are perpendicular to each other. The polarizing disc 2 is rotating on the common axis with angular speed ω. If an unpolarized light beam is incident on disc 1 with an intensity I_0 then intensity of emergent beam from disc 3 is given by $I = \frac{I_0}{a}(1 \cos b\omega t)$ Find $\frac{a}{b}$.

53. Two converging lens have focal length f = 10 cm and $f' = 20\,cm$. The optical axes of the lenses coincide. This lens system is used to form an image of an object kept at a certain distance from the first lens. In the situation, the size of the final image does not depend on the distance of the object from the first lens. What is the distance (in *cm*) between the two lens.

54. A thin equiconvex lens $(\mu = 3/2)$ is placed on a horizontal plane mirror. The space between the lens and mirror is filled with water $(\mu = 4/3)$. Now when a pin is be placed at a distance of 12 *cm* form the lens its image coincide with itself. Find the radius of curvature (in *cm*) of lens.

55. A lens forms the image of sun on a screen 30 *cm* away. How far (in decimeter) from the lens should a second lens of focal length 30 *cm* placed so that the screen has to be moved 8 *cm* towards the first lens for the new image to be in focus?

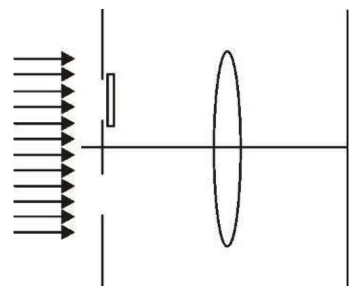
56. A narrow light beam is incident on a plane-parallel plate having a refractive index of $n = \frac{17}{16}$ at an angle of 30° to normal. As a result it is partially reflected and refracted. The refracted beam is reflected by the rear surface of the plate and then undergoes refraction again, emerging from the plate with a displacement of $4\sqrt{3}cm$ parallel to the primary reflected beam. The thickness of the plate is given as α m. Find the value of 40α.

57. A bright line in Young's double-slit experiment is 1.5 cm from the center of the pattern. The slit separation is 0.4 *mm*. The light has a wavelength of 750 *nm* and falls on a screen 1 m away. How many dark lines are there between the centre and the bright line at 1.5 *cm*?

58. Light of wavelength 627 *nm* illuminates two slits. What is the minimum path difference (in *nm*) between the waves from the slits for the resultant intensity to fall to 25% of the central maximum?

59. A glass plate $12 \times 10^{-3}\, mm$ thick is placed in the path of one of the interfering beam in a Young's double slit interference arrangement using monochromatic light of wavelength 6000 Å. If the central band shifts a distance equal to width of 10 bands. What is the thickness (in μ*m*) of the plate of diamond of refractive index 2.5 that has to be introduced in the path of second beam to bring the central band to original position?

60. The intensity received at the focus of the lens is *I* when no glass slab has been placed in front of the slit. Both the slits are of the same dimension and the plane wavefront incident perpendicularly on them, has wavelength λ. On placing the glass slab, the intensity reduces to 3*I*/4 at the focus. The minimum thickness of the glass slab (in μ*m*) if its refractive index is 3/2 is given by *t*. Find 15*t*. Given $\lambda = 6000\,Å$



SINGLE CORRECT ANSWER TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONLY ONE Choice is Correct.

1. A heavy nucleus having mass number 200 gets disintegrated into two small fragments of mass number 80 and 120. If binding energy per nucleon for parent atom is 6.5 M eV and for daughter nuclei is 7 *MeV* and 8 *MeV* respectively, then the energy released in the decay will be :

(A) 200 *eV* **(B)** – 220 *eV* **(C)** 220 *MeV* **(D)** 180 *MeV*

2. A hydrogen like atom is in a higher energy level of quantum number 6. The excited atom makes a transition to first excited state by emitting photons of total energy 27.2 eV. The atom from the same excited state make a transition to the second excited state by successively emitting two photons. If the energy of one photon is 4.25 eV, find the energy of other photon.

(A) 5.95 eV **(B)** 6.25 eV **(C)** 6.95 eV **(D)** 7.80 eV

3. The helium gas in an excited state makes transition from excited state of principal quantum number $n = 5$ to ground state. The most energetic photons have energy 52.224 eV, find the energy of least energetic photons :

(A) 1.224 eV **(B)** 2.42 eV **(C)** 3.22 eV **(D)** 3.82 eV

4. The potential difference applied to an X-ray tube is 5KV and the current through it is 3.2 mA. Then number of electrons striking the target per second is:

(A) 2×10^{16} **(B)** 5×10^{6} **(C)** 1×10^{17} **(D)** 4×10^{15}

5. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is:

(A) $\lambda_0 = \frac{2mc\lambda^2}{h}$ **(B)** $\lambda_0 = \frac{2h}{mc}$ **(C)** $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ **(D)** $\lambda_0 = \lambda$

6. Electrons in a sample of gas containing hydrogen like atom ($Z = 3$) are in fourth excited state. When photons emitted only due to transition from third excited state to second excited state are incident on a metal plate photoelectrons are ejected. The stopping potential for these photoelectrons is 4 *eV*. Now, if only photons emitted due to transition from fourth excited state to third excited state are incident on the same metal plate, the stopping potential for the emitted photoelectrons will be approximately equal to :

(A) 0.80 *eV* **(B)** 0.75 *eV* **(C)** 0.65 *eV* **(D)** 0.55 *eV*

7. Nuclei of radioactive element A are product at a rate 't^2' at any time t. The element A has decay constant λ. Let N be the number of nuclei of element A at any time t. At time $t = t_0$, dN/dt is minimum. Then the number of nuclei of element A at time $t = t_0$ is :

(A) $\frac{t_0 - \lambda t_0^2}{\lambda^2}$ **(B)** $\frac{\lambda t_0^2 - 2t_0}{\lambda^2}$ **(C)** $\frac{2t_0 - \lambda t_0^2}{\lambda}$ **(D)** $\frac{t_0 - \lambda t_0^2}{\lambda}$

8. The photon radiated from hydrogen corresponding to 2nd line of Lyman series is absorbed by a hydrogen like atom '*X*' in 2nd excited state. As a result the hydrogen like atom '*X*' makes a transition to n^{th} orbit. Then :

(A) $X = He^+ . n = 4$ **(B)** $X = Li^+ . n = 6$ **(C)** $X = He^+ . n = 6$ **(D)** $X = Li^{++} . n = 9$

9. The thermal power of a uranium reactor is 100 MW. Energy released in each fission is 3.2×10^{-11} J and the average number of neutrons released per fission is 2.5. The number of neutrons generated in unit time is :

(A) 7.8×10^{18} **(B)** 1.28×10^{19} **(C)** 3.2×10^{19} **(D)** 2.5×10^{18}

10. The de Broglie wavelength of an electron in the first excited state of a Hydrogen atom is:

[*h* is Planck's constant, *m* is the mass of the electron, *e* is the charge on the electron, $K = \frac{1}{4\pi\varepsilon_0}$]

(A) $\frac{h^2}{\pi K m e^2}$ **(B)** $\frac{h^2}{2\pi K m e^2}$ **(C)** $\frac{mh^2}{\pi K e^2}$ **(D)** $\frac{mh^2}{2\pi K e^2}$

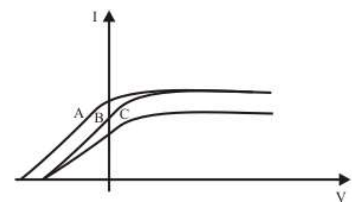
MULTIPLE CORRECT ANSWERS TYPE

Each of the following Question has 4 choices A, B, C & D, out of which ONE or MORE Choices may be Correct:

11. A neutron have K.E. = 15eV suffers head on collision with hydrogen atom in ground state at rest then after collision K.E. of : (Assume mass of neutron same as that of hydrogen).

(A) neutron is 1.4 eV **(B)** hydrogen is 1.4 eV **(C)** neutron is zero **(D)** hydrogen is 15 eV

12. Graph is drawn between photocurrent & accelerating potential, then



(A) A & B will have same intensity

(B) B & C will have same frequency

(C) B & C will have same intensity

(D) A & B will have same frequency

13. When protons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A expressed in eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50\text{e}V)$. If the de-Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then:

(A) The work function of A is 2.25 eV **(B)** The work function of B is 4.20 eV

(C) $T_A = 2.00\text{e}V$ **(D)** $T_B = 2.75\text{e}V$

14. Suppose the potential energy between electron and proton at a distance r is given by : $-\dfrac{Ke^2}{3r^3}$. The application of Bohr's theory to hydrogen atom in this case will change as follows :

(A) Energy in the nth orbit is proportional to n^6 **(B)** Energy is proportional to m^{-3} (m : mass of electron)

(C) Energy the nth orbit is proportional to n^{-2} **(D)** Energy is proportional to m^1 (m = mass of electron)

15. In the Bohr's model of the hydrogen atom:

(A) radius of the n^{th} orbit is proportional to n^2

(B) the total energy of the electron in the n^{th} orbit is inversely proportional to n

(C) the angular momentum of the electron in an orbit is an integral multiple of $(h/2\pi)$

(D) the magnitude of potential energy of the electron in any orbit is greater than its kinetic energy

16. From the following equations pick out the possible nuclear fusion reactions:

(A) ${}_6C^{13} + {}_1H^1 \longrightarrow {}_6C^{14} + 4.3\ \text{MeV}$ **(B)** ${}_6C^{12} + {}_1H^1 \longrightarrow {}_7N^{13} + 2\ \text{MeV}$

(C) ${}_7N^{14} + {}_1H^1 \longrightarrow {}_8O^{15} + 7.3\ \text{MeV}$

(D) ${}_{92}U^{235} + {}_0n^1 \longrightarrow {}_{54}Xe^{140} + {}_{36}Sr^{94} + {}_0n^1 + {}_0n^1 + \gamma + 200\ \text{MeV}$

17. In an X-ray tube, the voltage applied is 20 KV. The energy required to remove an electron from L shell is 19.9 KeV. In the X-rays emitted by the tube :

(A) minimum wavelength will be 62.1 pm

(B) energy of characterstic X-ray will be equal to or less than 19.9 KeV

(C) L_α X-ray may be emitted

(D) L_α X-ray will have energy 19.9 KeV

18. An electron in Hydrogen atom first jumps from second excited state to first excited state and then from first excited state to ground state. Let ratio of wavelength, momentum AND energy of photons emitted in these two cases be a, b and c respectively. Then,

(A) $c = \dfrac{1}{a}$ **(B)** $a = \dfrac{9}{4}$ **(C)** $b = \dfrac{5}{27}$ **(D)** $c = \dfrac{5}{27}$

19. The radioactivity of a nucleus may be due to various reasons. An unstable nucleus emits radiations if it goes to form a stable nucleus (or less unstable). Then the cause and result can be

(A) a nucleus of excess nucleons is α active

(B) an excited nucleus of excess protons is β^- active

(C) an excited nucleus of excess protons is β^+ active

(D) an nucleus of excess neutrons is β^- active

20. The ground state and first excited state energies of hydrogen atom are –13.6 eV and –3.4 eV respectively. If potential energy in ground state is taken to be zero. Then:

(A) Potential energy in the first excited state would be 20.4 eV

(B) Total energy in the first excited state would be 23.8 eV

(C) Kinetic energy in the first excited state would be 3.4 eV

(D) Total energy in the ground state would be 13.6 eV

21. Which of the following statement(s) is/are correct ?

(A) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons

(B) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons

(C) In nuclear fission, energy is released by fusing two nuclei of medium mass (approximately 100 amu)

(D) In nuclear fission, energy is released by fragmentation of a heavy nucleus

22. An O^{16} nucleus is spherical and has a charge radius R and a volume $V = \frac{4}{3}\pi R^3$. According to the empirical observations, the volume of the ${}_{54}X^{128}$ nucleus (assume it to be spherical) is V' and radius is R', Then:

(A) $V' = 8V$ **(B)** $V' = 2V$ **(C)** $R' = 2R$ **(D)** $R' = 8R$

23. 10 gm of a radioactive element is kept in a container. The element is β-active. Then after one half-life: (molar mass of the substance is 100 gm, Avogadro's number $= 6 \times 10^{23}$ per mole).

(A) The weight of the substance left in the container will be 5 gm.

(B) The weight of the active substance in the container will be nearly 10 gm.

(C) If all β-particles leave the container then the charge of the substance left is 4800 C

(D) if all β-particles leave the container then the charge of the substance left is 9600 C.

24. A metallic sphere of radius r remote from all other bodies is irradiated with a radiation wavelength λ which is capable of causing photoelectric effect.

(A) The maximum potential gained by the sphere will be independent of its radius

(B) The net positive charge appearing on the sphere after a long time will depend on the radius of the sphere

(C) The kinetic energy of the most energetic electrons emanating from the sphere will keep of declining with time

(D) The kinetic energy of the most energetic electrons emanating from the sphere initially will to independent of the radius of the sphere

25. Monochromatic light of wavelength 207 nm and intensity is made to fall on a metal plate A fixed inside a vacuum tube, leading to emission of photoelectrons. The incident light makes an angle 30° with plate A. The surface area of plate A is 20 cm^2 Another plate B is fixed inside the tube, directly facing plate A. If the potential of plate A is kept 4 V higher than plate B, the photoemission stops completely. If the potential of plate B is made higher than plate A, the photoelectric current rises, until it reaches a saturation value of 0.5 mA.

Choose the correct option(s):

[$hc = 1242$ eV-nm]

(A) The work function of plate A is 4.0 eV

(B) The longest wavelength of light that can cause emission from plate A is 621 nm

(C) When the current is at its saturation value, one electron is emitted from plate A for every 20 photons incident on it

(D) Once the current reaches its saturation value, it can further be increased by decreasing the wavelength of the incident light but not by increasing its intensity

26. An electron moving in a circular path of radius r in a plane perpendicular to a uniform magnetic field of intensity B has kinetic energy K and de Broglie wavelength λ. Choose the correct option(s):
[h is Planck's constant, e is the charge on an electron]

(A) $\lambda = \dfrac{h}{\sqrt{2mK}}$ **(B)** $r = \dfrac{h}{eB\lambda}$ **(C)** $K = \dfrac{eBrh}{2m\lambda}$ **(D)** $r = \dfrac{\sqrt{2mK}}{eB}$

27. An electron in the ground state in a Hydrogen atom absorbs a photon of wavelength λ and transitions to a new energy level such that the radius of its orbit becomes 16 times. The change of momentum of the Hydrogen atom due to the absorption of the photon is Δp_a. Choose the correct option(s):

(A) The ionization energy of the electron in the new orbit is $0.85 eV$

(B) $\lambda = 97.4$ nm **(C)** $\Delta p_a = 6.78 \times 10^{-27}$ kg m/s

(D) The electron can now transition to a lower energy level and emit a photon of wavelength 90 nm

28. Two radioactive decay processes are given below:

(1) ${}^{137}_{55}\mathrm{Cs} \rightarrow {}^{137}_{56}\mathrm{Ba}$ (2) ${}^{23}_{12}\mathrm{Mg} \rightarrow {}^{23}_{11}\mathrm{Na}$

The Q-value of these two processes, Q_1 and Q_2 respectively, are given by:

[Here, $m(X)$ denotes the mass of an atom of the element X, m_e denotes the mass of an electron, Q_0 denotes the amount of energy liberated when 1 u of mass converts to energy]

(A) $Q_1 = \left(m(\mathrm{Cs}) - m(\mathrm{Ba}) - m_e\right) Q_0$ **(B)** $Q_1 = \left(m(\mathrm{Cs}) - m(\mathrm{Ba})\right) Q_0$

(C) $Q_2 = \left(m(\mathrm{Cs}) - m(\mathrm{Ba}) + 2m_e\right) Q_0$ **(D)** $Q_2 = \left(m(\mathrm{Mg}) - m(\mathrm{Na}) + m_e\right) Q_0$

29. In an experiment on X-rays, high energy electrons, all of de Broglie wavelength λ_e, are made to collide with target plate made of a material of atomic number Z. The minimum wavelength observed in the continuous X-ray spectrum is λ_m. Choose the correct option(s):

(A) Wavelength of the observed K_α line is independent of λ_e but not independent of Z

(B) Wavelength of the observed K_α line is independent of neither λ_e nor Z

(C) The minimum wavelength observed in the continuous X-ray spectrum is independent of both λ_e and Z

(D) The minimum wavelength observed in the continuous X-ray spectrum is independent of Z but not independent of λ_e

30. Consider a Bohr orbit in the Hydrogen atom with principal quantum number n ($n > 1$). If an electron in this orbit makes a transition to the immediately lower orbit, it emits a photon of wavelength λ_L and the change in momentum experienced by the Hydrogen atom due to this emission be Δp_L. Let the largest wavelength of a photon that can ionise this Hydrogen atom (with the electron now in an orbit with principal quantum number $n - 1$) be λ_M. Choose the correct option(s):

(A) λ_L is proportional to $\dfrac{\left(n(n-1)\right)^2}{(2n-1)}$ **(B)** Δp_L is proportional to $\dfrac{1}{(n-1)^2}$

(C) Δp_L is proportional to $\dfrac{(2n-1)}{\left(n(n-1)\right)^2}$ **(D)** λ_M is proportional to $(n-1)^2$

Paragraph for Q. 31 - 33

A hydrogen like atom of atomic number Z is in excited state of quantum number $2n$. It can emit a maximum energy photon of 204 eV. If it makes transition to quantum state n, a photon of energy 40.8 eV is emitted. Ground state energy of hydrogen atom is –13.6 eV.

31. Find the value of n :

(A) 3 **(B)** 2 **(C)** 4 **(D)** 6

32. Find ground state energy (in eV) of this atom:

(A) –187.6 eV **(B)** –197.6 eV **(C)** –217.6 eV **(D)** –167.6 eV

33. Calculate minimum energy (eV) that can be emitted by this atom during de-excitation:

(A) 12.46 ev **(B)** 10.58 eV **(C)** 11.97 eV **(D)** 13.27 eV

Paragraph for Q. 34 - 35

A radioactive nucleus A decays into two different stable nuclei X and Y. The half-life for the decay of A into X is T_1 and the half-life for the decay of A into Y is T_2.

34. If at $t = 0$, there are N_0 nuclei A present in a sample, the time instant when there are exactly $\frac{N_0}{2}$ nuclei A present is:

(A) $\frac{2T_1T_2}{T_1+T_2}$ **(B)** $\frac{T_1T_2}{T_1+T_2}$ **(C)** T_1+T_2 **(D)** $\frac{T_1+T_2}{2}$

35. If at $t = 0$, there were no nuclei X and Y present, the ratio of number of nuclei X to number of nuclei Y at any instant, $\frac{N_X}{N_Y}$ is:

(A) $\frac{T_2}{T_1}$ **(B)** $\frac{T_1}{T_2}$ **(C)** $\frac{2T_2}{T_1+T_2}$ **(D)** $\frac{2T_1}{T_1+T_2}$

Paragraph for Q. 36 - 38

A radioisotope of potassium, K-40 decays into a stable isotope of calcium, Ca-40, and emits a beta particle. The binding energy per nucleon of the K-40 nucleus is 8.5 keV, and the binding energy per nucleon of the Ca-40 nucleus is 44.0 keV.

36. The maximum energy liberated in the decay of a K-40 nucleus into a Ca-40 nucleus is:

(A) 2000 keV **(B)** 1320 keV **(C)** 52.5 keV **(D)** 35.5 keV

37. If the K-40 nucleus is at rest before the disintegration, the ratio of the kinetic energy of the beta particle to the kinetic energy of the Ca-40 nucleus after the disintegration, $\frac{K_\beta}{K_{Ca}}$, is:

[Assume that mass of Ca-40 nucleus, $m(\text{Ca-40}) = 40$ u, mass of electron, $m_e = \frac{1}{1800}$ u]

(A) 7.2×10^5 **(B)** 5.18×10^8 **(C)** 7.2×10^4 **(D)** 5.18×10^9

38. If the mass of a K-40 atom is 39.9640 u, the mass of a Ca-40 atom is:

[1 u $= 931.5$ MeV/c^2]

(A) 39.9626 u **(B)** 39.9622 u **(C)** 39.9654 u **(D)** 39.9658 u

MATRIX MATCH TYPE

Each of the following question contains statements given in two columns, which have to be matched. Statements in Column 1 are labelled as (A), (B), (C) & (D) whereas statements in Column 2 are labeled as p, q, r, s & t. More than one choice from Column 2 can be matched with Column 1.

39. Column-I lists some parameters in a photoelectric experiment that can be controlled. Column-II lists the possible combinations of two quantities (Photoelectric current I_{PE} and maximum kinetic energy of a photoelectron $K_{\max}$) that can be affected by changing these parameters.

Column 1		Column 2	
(A)	Intensity of incident light	**(p)**	I_{PE} only
(B)	Wavelength of incident light	**(q)**	$K_{\max}$ only
(C)	Accelerating potential across the vacuum tube	**(r)**	Both I_{PE} and $K_{\max}$
(D)	Work function of the metal plate	**(s)**	Neither I_{PE} nor $K_{\max}$

40. Column-I lists some quantities pertaining to an electron in the n^{th} Bohr orbit in a Hydrogen atom. Match each quantity in Column-I with the correct item in Column-II to which the quantity is proportional to.

	Column 1		Column 2
(A)	De Broglie wavelength	**(p)**	$\frac{1}{n}$
(B)	Time period of revolution	**(q)**	$\frac{1}{n^4}$
(C)	Velocity	**(r)**	n^3
(D)	Centripetal acceleration	**(s)**	n

SUBJECTIVE INTEGER TYPE

41. The radius of an α-particle moving in a circle in a constant magnetic field is half the radius of an electron moving in circular path in the same field. The de-Broglie wavelength of α-particle is n times that of the electron. Find n (an integer).

42. Nuclei A and B convert into a stable nucleus C. Nucleus A is converted into C by emitting 2 α-particles and 3 β-particles. Nucleus B is converted into C by emitting one α-particle and 5 β-particles. At time t = 0, nuclei of A are 4 N_0 and nuclei of B are N_0. Initially number of nuclei of C are zero. Half-life of A (into conversion of C) is 1 minute and that of B is 2 minute.

Find the time at which rate of disintegration of A and B are equal (in minute).

43. $_{92}U^{238}$ changes to $_{85}At^{210}$ by a series of α and β decays. Find number of α-decays undergone (an integer).

44. Find recoil speed (approximately in m/sec) when a hydrogen atom emits a photon during the transition from $n = 5$ to $n = 1$.

45. An atom of atomic number Z = 11 emits K_α wavelength which is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ (an integer).

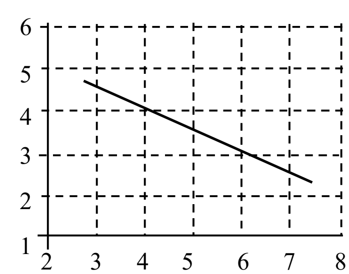
46. An electron in nth excited state in a hydrogen atom comes down to first excited state by emitting ten different wavelengths. Find value of n (an integer).

47. In ground state, find the ratio between acceleration of the electron in singly ionized helium atom and hydrogen atom.

48. The shortest wavelength of the Brackett series of a hydrogen like atom (atomic number Z) is the same as the shortest wavelength of the Balmer series of hydrogen atom. Find value of Z.

49. A radioactive sample decays through two different decay process α decay and β decay. Half life time for α decay is 3 hour and half life time for β decay is 6 hours. What will be ratio of number of radioactive nuclei initial to the number of radio active nuclei present after 6 hours.

50. To determine the half life of a radioactive element, a student plots a graph of $\ell n\left|\frac{dN(t)}{dt}\right|$ versus t. Here $\frac{dN(t)}{dt}$ is the rate of radioactive decay at time t. If the number of radioactive nuclei of this element decreases by a factor of p after 4.16 years, the value of p is ________.



51. An alpha particle with kinetic energy K has a head-on elastic collision with a deuterium nucleus at rest. After the collision, the kinetic energy of the alpha particle is K'. Then, $\frac{K}{K'} =$ _________.

52. An electron in the n^{th} Bohr orbit in a Hydrogen atom transitions to the ground state. The minimum value of n such that the emitted photon is able to eject an electron from a metal of work function 12.7 eV is ________.

53. A fixed, perfectly reflecting plane mirror of surface area $0.2\ m^2$ is illuminated by monochromatic light of wavelength 600 nm and intensity $3\ \text{W/m}^2$ which falls at an angle of incidence 60°. The force on the mirror due to the incident light is _________$\times 10^{-9}$ N.

[Speed of light = 3×10^8 N]

54. The ratio of the wavelength of the K-alpha X-ray of Chromium to the wavelength of the K-alpha X-ray of Iron is _________.

(Atomic number of Chromium = 24, atomic number of Iron = 26)

55. The wavelength of the photon emitted by an electron in transitioning from the second excited state to the ground state in an ionized Helium atom is ________ nm.

[$hc = 1242$ eV-nm]

56. Consider a nuclear fusion reaction $A + B \rightarrow C$. Nucleus A is moving with $KE = 5MeV$ and collides with nucleus B moving with $KE = 3MeV$ and forms nucleus C in excited state. Find the KE (in MeV) of C nucleus just after its formation given that its excitation energy is 10.3 MeV. Take masses of nuclei of A,B and C as 25.0, 10.0, 34.99 amu respectively. [Take : 1 amu = 930 MeV]

57. The peak emission from a black body at a certain temperature occurs at a wavelength of 6000 Å. On increasing its temperature, the total radiation emitted is increased 16 times. These radiations are allowed to fall on a metal surface. Photoelectrons emitted by the peak radiation at higher temperature can be bought to rest by applying a potential equivalent to the excitation potential corresponding to the transition for the level $n = 4$ to $n = 2$ in the Bohr's hydrogen atom. The work function of the metal is given by $\frac{\alpha}{100} eV$ where α is the numerical constant. Find the value of α. [Take : hc = 12420eV Å]

58. A neutron beam, in which each neutron has same kinetic energy is passed through a sample of hydrogen like gas (but not hydrogen) in ground state. Due to collision of neutrons with the ions of the gas, ions are excited and then they emit photons. Six spectral lines are obtained in which one of the lines is of wavelength (6200/51) nm. What is the minimum possible value of kinetic energy of the neutrons for this to be possible. The mass of neutron and proton can be assumed to be nearly same. Find the answer in the form $25\alpha \times 10^{-2} eV$ and fill value of α.

59. Electromagnetic radiation whose electric component varies with time as $E = C_1(C_2 + C_3 \cos \omega t)\cos \omega_0 t$, here C_1, C_2 & C_3 are constants, is incident on lithium and liberates photoelectrons. If the kinetic energy of most energetic electrons be 2.6 eV, the work function of lithium is (in eV). [Take : $\omega_0 = 2.4\pi \times 10^{15}$ rad/sec and $\omega = 8\pi \times 10^{14}$ rad/sec, planks constant $h = 6.6 \times 10^{34}$ MKS]

60. In a slow reaction heat is being evolved at a rate about 10 mW in a liquid. If the heat were being generated by the decay of ^{32}P, a radioactive isotope of phosphorus that has half-life of 14 days and emits only beta-particles with a mean energy of 700 keV, estimate the number of ^{32}P atoms in the liquid. Express your answer in form of $A \times 10^{15}$ and fill A. [Take : ln 2 = 0.675]

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Answer to JEE Advanced Revision Booklet

UNITS DIMENSIONS AND VECTORS

1	2	3	4	5	6	7	8	9	10
A	A	C	D	C	C	C	D	ABCD	ACD
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
ABCD	ABCD	ACD	AB	ABCD	ABCD	ABD	A	B	C
21	**22**			**23**	**24**	**25**	**26**	**27**	**28**
C	(A – s ; B – p ; C – q ; D – t)			A	2.0	3.0	3	2.0	4.0
29	**30**								
1.0	2.0								

KINEMATICS OF A PARTICLE

1	2	3	4	5	6	7	8	9	10
A	C	B	A	B	B	B	C	C	ABCD
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
AC	BC	BD	BD	ACD	ABC	ABCD	ACD	ABD	ABC
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	
ABCD	ABC	BC	AC	ACD	ABC	AC	C	D	
30			**31**			**32**			
(A-qs ; B – r ; C – p ; D – qs)			(A-qs ; B – p ; C-p ; D – qr)			(A – qs ; B –p ; C – r ; D – r)			
33			**34**	**35**	**36**	**37**	**38**	**39**	**40**
[A – q ; B – r ; C – q ; D – r)			20	1	5	1	8	4	3
41	**42**	**43**	**44**	**45**					
3	6	15	2	5					

DYNAMICS OF A PARTICLE

1	2	3	4	5	6	7	8	9	10
C	B	B	C	B	B	B	B	BD	ACD
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
ABCD	ABC	BCD	BC	AD	BD	AD	AC	AD	BC

21	22	23	24	25	26	27	28	29	30
ABCD	ACD	BD	BCD	D	B	B	A	A	B
31			**32**			**33**	**34**	**35**	**36**
(A-pr ; B – ps ; C – pr ; D -q)			(A – qs; B – pr ; C – qr ; D – qs)			10	5	1	9
37	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	
4	1	6.25	2	2	2	2	3	3	

ENERGY AND MOMENTUM

1	2	3	4	5	6	7	8	9	10
D	B	C	B	D	A	C	D	A	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
BC	ABC	AC	ACD	C	AC	ABC	ACD	AD	BCD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	ABC	ABCD	ABC	AC	AC	AC	BCD	ABC	ACD
31	**32**	**33**	**34**	**35**	**36**		**37**		
B	B	D	D	B	[A -s ; B- r ; C- q ; D - p]		[A – q ; B – r s ; C – q p ; D – r p]		
38	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**
1	2	1	2	3	3	6	10	5	24
48	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**
2	5	2	4	2	4	4	5	2	7
58	**59**	**60**							
4	6	6							

ROTATIONAL MOTION

1	2	3	4	5	6	7	8	9	10
C	A	A	B	D	D	B	A	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
ABCD	BC	AC	BC	ABC	BCD	AC	AD	AD	CD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
AC	AC	AB	ABD	ABCD	ABCD	BC	AD	ABCD	BCD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
CD	ACD	ABCD	BC	D	B	B	B	C	B
41	**42**	**43**	**44**	**45**	**46**		**47**		
A	C	D	B	A	[A- qrs, B-prs, C-qrs, D-prs]		[A – s ; B – q, r ; C – s ; D – p,r]		

48			49	50	51	52	53	54	55
[A – p,q ; B – p,q,r ; C – p, q ; D – p, q, r]			2	6	5	8	7	1	3
56	57	58	59	60					
8	3	4	3	7					

GRAVITATION

1	2	3	4	5	6	7	8	9	10
C	C	A	A	A	A	B	A	A	B
11	12	13	14	15	16	17	18	19	20
BC	AC	ABC	CD	ACD	AD	ABC	ABCD	C	B
21	22				23	24	25	26	27
D	[A-p, r] [B-p, q, r, s] [C-p, q, r, s] [D-p, r, s]				5	2	5	1	4
28	29	30							
2	6	3							

LIQUIDS

1	2	3	4	5	6	7	8	9	10
C	B	D	A	C	B	A	C	A	A
11	12	13	14	15	16	17	18	19	20
B	B	C	D	ABD	ACD	AC	ABD	CD	BC
21	22	23	24	25	26	27	28	29	30
BD	AB	ABD	AB	D	C	B	A	C	D
31	32	33	34	35	36	37	38	39	40
B	D	D	A	C	2	8	2	300	0.45
41	42	43	44	45					
0.29	10.50	11.11	10	3					

PROPERTIES OF MATTER

1	2	3	4	5	6	7	8	9	10
A	B	B	C	C	B	B	B	D	A
11	12	13	14	15	16	17	18	19	20
A	ABC	BCD	AC	BCD	AD	AD	BD	AD	ACD
21	22	23	24	25	26	27	28	29	30
ABCD	BC	AD	D	D	C	B	C	D	B
31	32	33		34			35	36	
B	B	[A – p r s ; B – p r s ; C – p ; D – p q r s]		[A-q; B-r ; C-s; D-p]			1	2	
37	38	39	40	41	42	43	44	45	
3	8	3	3	4	9	4	3	0.18	

KTG AND & THERMODYNAMICS

1	2	3	4	5	6	7	8	9	10
B	A	A	A	B	C	B	D	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	A	C	B	A	ABC	ABCD	ABD	CD	CD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
ABD	AD	ABC	AC	AD	B	C	C	C	C
31	**32**	**33**			**34**		**35**		
A	D	[A – q, r, s ; B – r ; C – r ; D – s]			[A – q ; B – p s ; C – s ; D – q r]		[A – r ; B – p ; C – s ; D – q]		
36	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
2	7	1	6	100	2	22	0.25	545	3

SIMPLE HARMONIC MOTION

1	2	3	4	5	6	7	8	9	10
B	C	B	D	A	B	C	D	CD	ABCD
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
AC	ABD	BD	ABC	BD	A	ABD	ABCD	ACD	AB
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
BCD	BC	AC	AB	AD	BD	AC	C	B	A
31	**32**	**33**			**34**	**35**	**36**	**37**	**38**
B	D	[A – q s ; B – p r; C – q s ; D – q s]			2	6	2	3	5
39	**40**	**41**	**42**		**43**		**44**	**45**	
4	1	9	$\left[T = 2\pi\sqrt{\dfrac{m(k_1 + 4k_2)}{k_1k_2}}\right]$		$\left[2\pi\sqrt{\dfrac{(\pi - 2)r}{g}}\right]$		500	5	

WAVE MOTION

1	2	3	4	5	6	7	8	9	10
B	B	B	D	D	B	A	D	C	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
AC	ABCD	BC	AC	ABC	AC	BCD	ABD	CD	BC
21	**22**	**23**	**24**	**25**	**26**	**27**			
CD	AD	ACD	C	A	A	[A – q s ; B – p r ; C – p r; D – q s]			
28			**29**	**30**	**31**	**32**	**33**	**34**	**35**
[A – q ; B – p ; C – r ; D – r]			1	4	2	3	4	3	2
36	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
4	2	2	3	7	1	7	8	4	5

ELECTROSTASTICS

1	2	3	4	5	6	7	8	9	10
C	B	C	D	B	A	B	D	B	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	A	B	AC	ABD	AB	AD	BCD	BC	AC

21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
AB	B	ABD	ABCD	ABC	ABC	ABCD	AD	BC	AD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	
ABCD	AB	ACD	A	A	C	C	A	D	
40			**41**			**42**			**43**
[A -q,r ; B-p,s,t ; C- p,q,t ; D- p,s,t]			[A - pq ; B - s ; C- s ; D – r]			[A- q ; B-p ; C- s ; D- r]			9
44	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
2	4	2	3	9	6	1	3	5	0.75
54	**55**	**56**	**57**	**58**	**59**	**60**			
2	1	2.5	9	4	20	4			

DC CIRCUIT AND CAPACITORS

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	D	A	A	C	D	A	D	D	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	B	ABC	BD	ABCD	AC	AB	AC	BD	ABC
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
ACD	AB	ABC	ABC	AC	ABCD	ACD	ABCD	ABCD	ABCD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
ABD	ABCD	ABC	A	D	A	A	C	A	A
41	**42**	**43**	**44**			**45**			
C	A	D	[A-qs ; B-p ; C-p ; D - t]			[A - p r s ; B – p r s ; C – r ; D - q r]			
46			**47**			**48**	**49**	**50**	**51**
[A - p q ; B - s ; C- r ; D -q]			[A-p, q; B-q, s; C-q, s; D-q]			1	5	2	1
52	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	
2	3	3	0	4	2.5	2	1.4	3	

MAGNETIC EFFECT OF CURRENT

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	B	A	C	C	C	B	D	A	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	D	C	B	A	BCD	BD	BCD	ACD	AD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
AD	ABC	ABC	CD	ABC	ABC	AD	BC	ABC	ACD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
AD	ABCD	AB	AC	CD	A	B	C	C	B
41	**42**	**43**	**44**			**45**			**46**
D	**B**	**C**	[A -s ; B - p ; C - q ; D – r]			[A-p, q; B-p, s; C-p, r; D-p]			9
47	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**
5	3	4	5	7	2	3	4	25	5
57	**58**	**59**	**60**						
7	2	3	4						

ELECTROMAGNETIC INDUCTION

1	2	3	4	5	6	7	8	9	10
B	C	D	D	A	A	A	A	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	C	C	ABC	BD	AC	AD	AC	ABD	BCD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
BCD	ABC	AC	A	ABC	CD	ABCD	ABCD	ABC	B
31	**32**	**33**		**34**				**35**	**36**
C	B	[A - s; B - p; C - s; D – s]		[A - s; B - q; C - p; D – p]				6	0
37	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	
5	8	3	8	4	2	5	4	2	

AC AND EM WAVE

1	2	3	4	5	6	7	8	9	10
C	C	A	B	D	C	ACD	ABC	AC	ABCD
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	
AC	AC	D	C	A	B	C	D	(A - r; B - p ;C – q ; D – s)	
20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
2	5	5	4	4	5	2	2	14	2
30									
115									

RAY OPTICS AND WAVE OPTICS

1	2	3	4	5	6	7	8	9	10
B	A	C	D	C	B	B	D	D	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	C	A	C	A	AC	ABCD	BD	ABCD	AD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
BC	AC	BCD	BD	BCD	ABCD	AC	AC	AC	AD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
BD	BD	B	D	B	B	B	C	B	C
41	**42**			**43**			**44**		
B	[A-p, q] [B-q, r, s] [C-p, q, r] [D-q, r, s]			[A-p, t] [B-r, t] [C-s, t] [D-s, t]			[A-q, t] [B-p, r, t] [C-p, q, s, t] [D-p, r]		
45			**46**	**47**	**48**	**49**	**50**	**51**	**52**
[A-p, r] [B-q] [C-p, s] [D-p, r]			2	4	4	8	4	16	4
53	**54**	**55**	**56**	**57**	**58**	**59**	**60**		
30	8	1	3	8	209	4	3		

MODERN PHYSICS

1	2	3	4	5	6	7	8	9	10
C	A	A	A	A	A	B	D	A	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
BC	AB	ABC	AB	ACD	ABC	BC	ACD	ACD	ABCD
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
AD	AC	BC	ABCD	BC	ACD	ABC	BC	AD	ACD
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	
B	C	B	B	A	B	D	A	[A – p ; B – r; C – r ; D – r]	
40			**41**	**42**	**43**	**44**	**45**	**46**	**47**
[A – s ; B – r; C – p; D – q]			1	6	7	4	6	6	8
48	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**
2	8	8	9	4	1	1.18	25.69	7	159
58	**59**	**60**							
255	4	160							