EXERCISE

1. One of the combinations from the fundamental physical constants is $\frac{hc}{G}$. The unit of this expression is

a) kg^2 b) m^3

c) s^{-1} d) m

Unit Of

$$\frac{hC}{G} = \frac{\text{Js ms}^{-1}}{\text{Nm}^2\text{kg}^{-2}}$$

$$= \frac{\text{Nm s m s}^{-1}}{\text{Nm}^2\text{kg}^{-2}} = kg^2$$

2. If the error in the measurement of radius is 2%, then the error in the determination of volume of the sphere will be

a) 8% b) 2%

c) 4% d) 6%

Volume of the sphere $V = \frac{4}{3}\pi r^3$

$$\frac{\Delta V}{V} x100 = 3\frac{\Delta r}{r} x100 = 3(2\%) = 6\%$$

3. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively then the error in measurement of acceleration due to gravity is

a) 4% [Related to AMPMT 2008]

b) 5%

c) 6%

d) 7%

TIme period of the pendulum

$$T = 2\pi\sqrt{\frac{l}{g}} \rightarrow g = 4\pi^2\frac{l}{T^2}$$

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\frac{\Delta T}{T} = 1\% + 2(3\%) = 7\%$$

4. The length of a body is measured as 3.51 m, if the accuracy is 0.01mm, then the percentage error in the measurement is

a) 351% b) 1%

c) 0.28% d) 0.035%

percentage of $\frac{\Delta l}{l} = \frac{0.01}{3.51} x100 = 0.28\%$

Question	Answer
5. Which of the following has the highest number of significant figures? a) 0.007 m^2 b) 2.64×10^{24} kg c) 0.0006032 m^2 d) 6.3200 J	option (d) Rule : All zeros to the right of a decimal point and to the right of a non zero digit are significant
6. If $\pi = 3.14$, then the value of π^2 is a) 9.8596 b) 9.860 c) 9.86 d) 9.9	$\pi^2 = 3.14 \times 3.14 = 9.8596$ As the input data has three significant figure, The answer should be restricted to significant figure by rounding off $\pi^2 = 9.86$
7. Which of the following pairs of physical quantities have same dimension? a) force and power b) torque and energy c) torque and power d) force and torque	Dimension of torque = $[ML^2T^{-2}]$ Dimension of Energy = $[ML^2T^{-2}]$
8. The dimensional formula of Planck's constant h is [AMU, Main, JEE, NEET] a) $[ML^2T^{-1}]$ b) $[ML^2T^{-3}]$ c) $[MLT^{-1}]$ d) $[ML^3T^{-3}]$	Dimension of $h = \frac{E}{\nu} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$ $= [ML^2T^{-1}]$
9. The velocity of a particle v at an instant t is given by $v = at + bt^2$. The dimensions of b is a) [L] b) $[LT^{-1}]$ c) $[LT^{-2}]$ d) $[LT^{-3}]$	$v = at + bt^2$ By the principle of homogeneity, Dimension of v = Dimension of at = Dimension of bt^2 Dimension of b = $\frac{LT^{-1}}{T^2} = LT^{-3}$
10. The dimensional formula for gravitational constant G is [Related to AIPMT 2004] a) $[ML^3T^{-2}]$ b) $[M^{-1}L^3T^{-2}]$ c) $[M^{-1}L^{-3}T^{-2}]$ d) $[ML^{-3}T^2]$	$[M^{-1}L^3T^{-2}]$

11. The density of a material in CGS system of units is $4\ g\ cm^{-3}$. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be

a) 0.04 b) 0.4

c) 40 d) 400

$$n_1[M_1L_1^{-3}] = n_2[M_2L_2^{-3}]$$

$$n_2 = n_1\left(\frac{M_1}{M_2}\right)\left(\frac{L_1}{L_2}\right)^{-3} = 4x\left(\frac{1}{100}\right)\left(\frac{1}{10}\right)^{-3}$$

$$n_2 = 4x\frac{1000}{100} = 40 unit$$

12. If the force is proportional to square of velocity, then the dimension of proportionality constant is [JEE-2000]

a) $[MLT^0]$ b) $[MLT^{-1}]$

c) $[ML^{-2}T]$ d) $[ML^{-1}T^0]$

Force α (velocity)^2

$$F = kv^2 \Longrightarrow k = \frac{F}{v^2}$$

$$\text{Dimension of k} = \frac{MLT^{-2}}{(LT^{-1})^2} = ML^{-1}$$

13. The dimension of $(\mu_0\varepsilon_0)^{-\frac{1}{2}}$ is [Main AIPMT 2011]

(a) length (b) time

(c) velocity (d) force

Dimension of $\mu_o = [M^{-1}L^{-3}T^4A^2]$

Dimension of $\varepsilon_o = [MLT^{-2}A^{-2}]$

Dimension of $(\varepsilon_o\mu_o)^{-\frac{1}{2}}$

$$= ([M^{-1}L^{-3}T^4A^2][MLT^{-2}A^{-2}])^{-\frac{1}{2}}$$

$$= (L^{-2}T^2)^{-\frac{1}{2}} = LT^{-1}$$

=Dimension of Velocity

14. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are taken as three fundamental constants. Which of the following combinations of these has the dimension of length?. [NEET 2016 (phase II)]

(a) $\frac{\sqrt{hG}}{c^{\frac{3}{2}}}$ (b) $\frac{\sqrt{hG}}{c^{\frac{5}{2}}}$

(c) $\sqrt{\frac{hc}{G}}$ (d) $\sqrt{\frac{Gc}{h^{\frac{3}{2}}}}$

By the method of dimension

$l \alpha\ h^a\ G^b\ C^c$ --------(1)

Substituting dimensions

$$[L] = [ML^2T^{-1}]^a[M^{-1}L^3T^{-2}]^b[LT^{-1}]^c$$

comparing power of M ,L and T

$$0 = a - b \Longrightarrow a = b$$

$$1 = 2a + 3b + c$$

$$0 = -a - 2b - c$$

solving we get, $a = \frac{1}{2} : b = \frac{1}{2}; c = \frac{-3}{2}$

on substituting in (i) we get $l = \frac{\sqrt{hG}}{c^{\frac{3}{2}}}$

15. A length-scale (l) depends on the permittivity (ε) of a dielectric material, Boltzmann constant (k_B), the absolute temperature (T), the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the particles. Which of the following expression for l is dimensionally correct?. [JEE (advanced) 2016]

(a) $l = \sqrt{\dfrac{nq^2}{\varepsilon k_B T}}$

(b) $l = \sqrt{\dfrac{\varepsilon k_B T}{nq^2}}$

(c) $l = \sqrt{\dfrac{q^2}{\varepsilon n^{\frac{2}{3}} k_B T}}$

(d) $l = \sqrt{\dfrac{q^2}{\varepsilon n k_B T}}$

By the convention

$$\frac{q^2}{\varepsilon_o r} = F.r = E \quad \text{Also KT} = \text{E},$$

$$\frac{q^2}{\varepsilon_o r KT} = .r$$

Dimension of $\dfrac{q^2}{\varepsilon_o r KT}$ = [L]

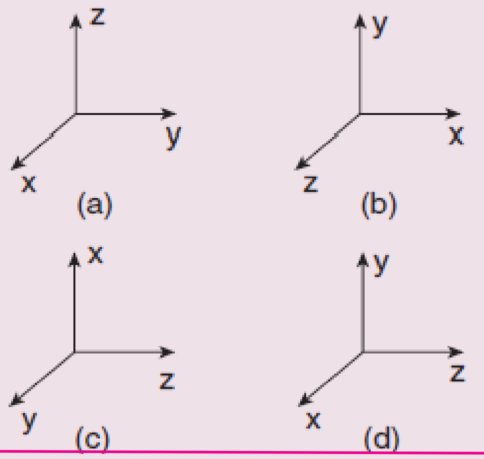
Dimension of n = $[L^{-3}]$

By Trial method,

(a) $\sqrt{L^{-3}.L} = \sqrt{L^{-2}} = \dfrac{1}{L}$

(b) $\sqrt{\dfrac{L}{L^{-3}}} = L^2 = L$ (option b is correct)

1. Which one of the following Cartesian coordinate systems is not followed in physics?



In PHYSICS we use right handed system. Hence the co-ordinate given in choice d is not used.

2. Identify the unit vector in the following.

(a) $\hat{i}+\hat{j}$ (b) $\frac{\hat{i}}{\sqrt{2}}$

(c) $\hat{k}-\frac{\hat{j}}{\sqrt{2}}$ (d) $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

Unit Vector is one which has magnitude equal to one

$$\left|\hat{i}+\hat{j}\right|=\sqrt{1+1}=\sqrt{2}\neq 1$$

$$\left|\frac{\hat{i}}{\sqrt{2}}\right|=\sqrt{\left(\frac{1}{\sqrt{2}}\right)^2}=\frac{1}{\sqrt{2}}\neq 1$$

$$\left|\hat{k}-\frac{\hat{j}}{\sqrt{2}}\right|=\sqrt{\left(\frac{1}{\sqrt{2}}\right)^2+1}=\sqrt{\frac{3}{2}}\neq 1$$

$$\left|\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right|=\sqrt{\left(\frac{1}{\sqrt{2}}\right)^2+\left(\frac{1}{\sqrt{2}}\right)^2}=1$$

3. Which one of the following physical quantities cannot be represented by a scalar?

(a) Mass

(b) length

(c) momentum

(d) magnitude of acceleration

Physical quantities which cannot be represented by scalar must be a vector quantity. Among the given choice the vector quantity is momentum

4. Two objects of masses m_1 and m_2 fall from the heights h_1 and h_2 respectively. The ratio of the magnitude of their momenta when they hit the ground is (AIPMT 2012)

(a) $\sqrt{\frac{h_1}{h_2}}$ (b) $\sqrt{\frac{m_1 h_1}{m_2 h_2}}$

(c) $\frac{m_1}{m_2}\sqrt{\frac{h_1}{h_2}}$ (d) $\frac{m_1}{m_2}$

Velocity on reaching ground is $v=\sqrt{2gh}$

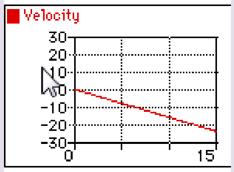
Ratio of momenta $\frac{p_1}{p_2}=\frac{m_1\sqrt{2gh_1}}{m_2\sqrt{2gh_2}}=\frac{m_1}{m_2}\sqrt{\frac{h_1}{h_2}}$

5. If a particle has negative velocity and negative acceleration, its speed

(a) increases (b) decreases

(c) remains same (d) zero

An object which moves in the negative direction has a negative velocity. If the object is speeding up then its acceleration vector is directed in the same direction as its motion (in this case, a negative acceleration). The velocity-time



6. If the velocity is $\vec{v} = 2\hat{i} + t^2\hat{j} - 9\vec{k}$, then the magnitude of acceleration at t = 0.5 s is

(a) $1 m s^{-2}$ (b) $2 m s^{-2}$

(c) zero (d) $-1 m s^{-2}$

acceleration $\vec{a} = \frac{dv}{dt} = \frac{d}{dt}(2\hat{i} + t^2\hat{j} - 9\hat{k})$

$$\vec{a} = 2t\hat{j}$$

Magntitude of acceleration $= 2t$

when t = 0.5 s $a = 2(0.5) = 1 \ ms^{-2}$

7. If an object is dropped from the top of a building and it reaches the ground at t = 4 s, then the height of the building is (ignoring air resistance) ($g = 9.8 ms^{-2}$)

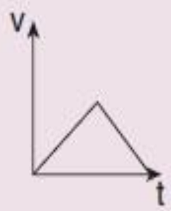
(a) 77.3 m (b) 78.4 m

(c) 80.5 m (d) 79.2 m

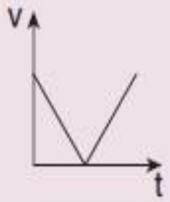
$$h = ut + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$$

$$= \frac{1}{2} x 9.8 x (4)^2 = 78.4 m$$

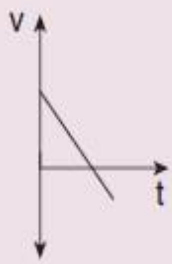
8. A ball is projected vertically upwards with a velocity v. It comes back to ground in time t. Which v-t graph shows the motion correctly? (NSEP 00-01)



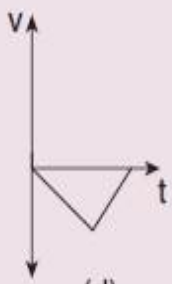
(a)



(b)



(c)

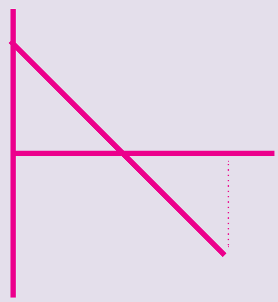


(d)

When body projected vertically upward, its velocity decreases and on reaching ground its velocity is equal to velocity of projection.but in negative direction. Also As the body reaches the ground, the vertical displacement is zero.which is the area under the v - t curve.

Graph (c) represent the above condition

Note : the Graph C should be like this



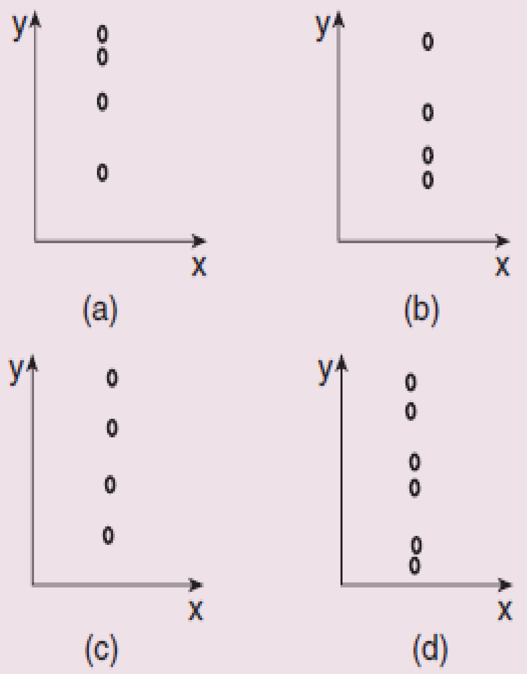
9. If one object is dropped vertically downward and another object is thrown horizontally from the same height, then the ratio of vertical distance covered by both objects at any instant t is

(a) 1 (b) 2

(c) 4 (d) 0.5

In horizontal projection, and vertical dropping, the two bodies will experince the same acceleration. Hence the vertical distance covered in same time is equal
Hence the ratio is 1

10. A ball is dropped from some height towards the ground. Which one of the following represents the correct motion of the ball?



During the downward fall of an object its velocity will increase with increase in time,
The graph (a) represent the above condition

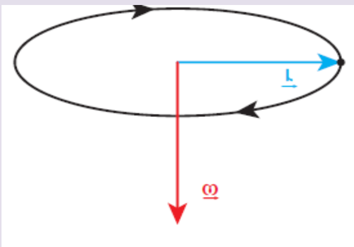
11. If a particle executes uniform circular motion in the xy plane in clock wise direction, then the angular velocity is in

(a) +y direction

(b) +z direction

(c) -z direction

(d) -x direction



- z directions (cross product condition)

12. If a particle executes uniform circular motion, choose the correct statement (NEET 2016)

(a) The velocity and speed are constant.

(b) The acceleration and speed are constant.

(c) The velocity and acceleration are constant.

(d) The speed and magnitude of acceleration are constant.

In Uniform circular motion, the linear velocity is along the tangent to the circle, which goes on changing. Only speed and magnitude of acceleration are constant

13. If an object is thrown vertically up with the initial speed u from the ground, then the time taken by the object to return back to ground is

(a) $\frac{u^2}{2g}$ (b) $\frac{u^2}{g}$

(c) $\frac{u}{2g}$ (d) $\frac{2u}{g}$

$$S = ut - \frac{1}{2}gt^2$$

$$0 = ut - \frac{1}{2}gt^2 ==> t = \frac{2u}{g}$$

14. Two objects are projected at angles 30° and 60° respectively with respect to the horizontal direction. The range of two objects are denoted as R_{30^0} and R_{60^0}. Choose the correct relation from the following

(a) $R_{30^0} = R_{60^0}$

(b) $R_{30^0} = 4R_{60^0}$

(c) $R_{30^0} = \frac{R_{60^0}}{2}$

(d) $R_{30^0} = 2\ R_{60^0}$

The range of projectile for complementary angles of projection are same

Here 30 and 60 are the complementary angle .Hence $R_{30} = R_{60}$

$$R = \frac{u^2}{g}\sin 2\theta$$

For 30^o projection

$$R_{30} = \frac{u^2}{g}\sin 60 = \frac{\sqrt{3}u^2}{2g}$$

for 60^o Projection

$$R_{60} = \frac{u^2}{g}\sin 120 = \frac{u^2}{g}\sin(90+30)$$

$$R_{60} = \frac{u^2}{g}\cos 30 = \frac{\sqrt{3}u^2}{2g}$$

15. An object is dropped in an unknown planet from height 50 m, it reaches the ground in 2 s. The acceleration due to gravity in this unknown planet is

(a) $g = 20\ m\ s^{-2}$ (b) $g = 25\ m\ s^{-2}$

(c) $g = 15\ m\ s^{-2}$ (d) $g = 30\ m\ s^{-2}$

$$h = ut + \frac{1}{2}g_1 t^2$$

$$50 = \frac{1}{2}g_1(4)$$

$$g_1 = 25 ms^{-2}$$

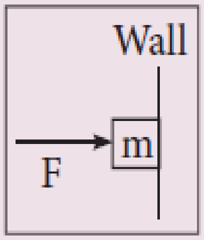
1. When a car takes a sudden left turn in the curved road, passengers are pushed towards the right due to
   (a) inertia of direction
   (b) inertia of motion
   (c) inertia of rest
   (d) absence of inertia

Inertia of direction

2. An object of mass m held against a vertical wall by applying horizontal force F as shown in the figure. The minimum value of the force F is

   (IIT JEE 1994)

   (a) Less than mg
   (b) Equal to mg
   (c) Greater than mg
   (d) Cannot determine



Given, mass of the block = m
Coefficient of friction between the block and the wall = μ
Let a force F be applied on the block to hold the block against the wall. The normal reaction of mass be N and force of friction acting upward be f .
In equilibrium, vertical and horizontal forces should be balanced separately

$$f = mg$$
$$F = N$$

But $f = \mu N = \mu F$

$$F = \frac{f}{\mu} = \frac{mg}{\mu}$$

Greater than mg

3. A vehicle is moving along the positive x direction, if sudden brake is applied, then
   (a) frictional force acting on the vehicle is along negative x direction
   (b) frictional force acting on the vehicle is along positive x direction
   (c) no frictional force acts on the vehicle
   (d) frictional force acts in downward direction

option (a)

4. A book is at rest on the table which exerts a normal force on the book. If this force is considered as reaction force, what is the action force according to Newton's third law?

(a) Gravitational force exerted by Earth on the book

(b) Gravitational force exerted by the book on Earth

(c) Normal force exerted by the book on the table

(d) None of the above

Option (C) Because, action and reaction should act on two different object and must be of same nature

5. Two masses m_1 and m_2 are experiencing the same force where $m_1 < m_2$. The ratio of their acceleration $\frac{a_1}{a_2}$ is

(a) 1

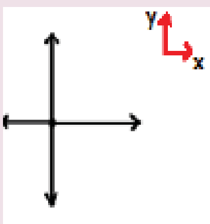
(b) less than 1

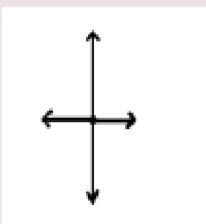
(c) greater than 1

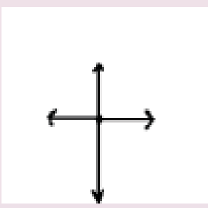
(d) all the three cases

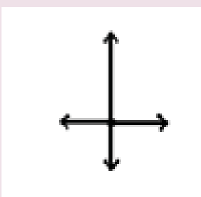
$$F_1 = F_2$$
$$m_1 a_1 = m_2 a_2$$
$$\frac{a_1}{a_2} = \frac{m_2}{m_1} > 1$$

6. Choose appropriate free body diagram for the particle experiencing net acceleration along negative y direction. (Each arrow mark represents the force acting on the system).

a) 

b) 

c) 

d) 

Since the body is accelerating along -y direction, the x component of force must be equal. and Y component of Force are unequal and more in negative y direction.

Option (c) satisfies the above condition

7. A particle of mass m sliding on the smooth double inclined plane (shown in figure) will experience

(a) greater acceleration along the path AB

(b) greater acceleration along the path AC

(c) same acceleration in both the paths

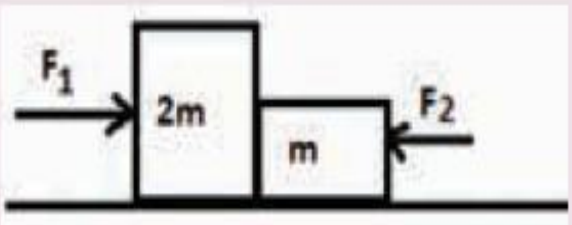
(d) no acceleration in both the paths.

The Force on the sliding object is mgsin θ

As path AC is more slope than AB, greater acceleration along the path AC

8. Two blocks of masses m and 2m are placed on a smooth horizontal surface as shown. In the first case only a force F_1 is applied from the left. Later only a force F_2 is applied from the right. If the force acting at the interface of the two blocks in the two cases is same, then $F_1 : F_2$ is

(Physics Olympiad 2016)



(a) 1:1 (b) 1:2

(c) 2:1 (d) 1:3

case I

$$\text{acceleration } a_1 = \frac{f_1}{m+2m} = \frac{f_1}{3m}$$

$$\text{Normal reaction } N_1 = ma_1 = \frac{f_1}{3}$$

case II

$$\text{acceleration } a_2 = \frac{f_2}{m+2m} = \frac{f_2}{3m}$$

$$\text{Normal reaction } N_2 = 2ma_2 = \frac{2f_2}{3}$$

$$N_1 = N_2$$

$$\frac{f_1}{3} = \frac{2f_2}{3} \implies \frac{f_1}{f_2} = \frac{2}{1}$$

9. Force acting on the particle moving with constant speed is

(a) always zero

(b) need not be zero

(c) always non zero

(d) cannot be concluded

Need not be zero

As in the case of particle moving in a circular path with constant speed has radial acceleration and hence centripetal force is acting

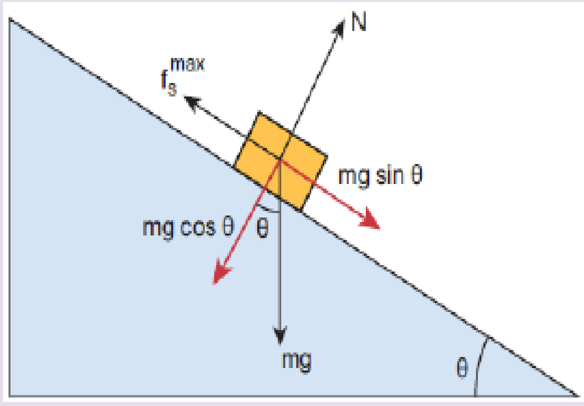
10. An object of mass m begins to move on the plane inclined at an angle θ. The coefficient of static friction of inclined surface is μ_s. The maximum static friction experienced by the mass is

(a) mg

(b) $\mu_s mg$

(c) $\mu_s mg \sin\theta$

(d) μ_s mg cos θ



For maximum static friction

$f_s = \mu N = \mu mg \cos\theta$

---

11. When the object is moving at constant velocity on the rough surface,

(a) net force on the object is zero

(b) no force acts on the object

(c) only external force acts on the object

(d) only kinetic friction acts on the object

Net force on the object is zero

---

12. When an object is at rest on the inclined rough surface,

(a) static and kinetic frictions acting on the object is zero

(b) static friction is zero but kinetic friction is not zero

(c) static friction is not zero and kinetic friction is zero

(d) static and kinetic frictions are not zero

Option (c)

As long as the body is at rest , the frictional force present between the contact surface is static friction only, When the object moves, the static friction dissappears and kinetic friction come into play

13. The centrifugal force appears to exist (a) only in inertial frames (b) only in rotating frames (c) in any accelerated frame (d) both in inertial and non-inertial frames	only in rotating frame
14. Choose the correct statement from the following (a) Centrifugal and centripetal forces are action reaction pairs (b) Centripetal forces is a natural force (c) Centrifugal force arises from gravitational force (d) Centripetal force acts towards the center and centrifugal force appears to act away from the center in a circular motion	Option (d)
15. If a person moving from pole to equator, the centrifugal force acting on him (a) increases (b) decreases (c) remains the same (d) increases and then decreases	The centrifugal force at the pole is zero. As the person moving from pole to equator there will be a centrifugal force. Hence centrifugal force increases

EXERCISE

1. A uniform force of $(2\hat{i}+\hat{j})$ N acts on a particle of mass 1 kg. The particle displaces from position $(3\hat{j}+\hat{k})$ m to $(5\hat{i}+3\hat{j})$ m. The work done by the force on the particle is

(AIPMT model 2013)

(a) 9 J (b) 6 J

(c) 10 J (d) 12 J

Workdone $W = \vec{F} \bullet \vec{S}$

$\vec{S} = (5\hat{i}+3\hat{j})-(3\hat{j}+\hat{k}) = 5\hat{i}-\hat{k}$

W= $(2\hat{i}+\hat{j})\bullet(5\hat{i}-\hat{k})$=10 J

2. A ball of mass 1 kg and another of mass 2 kg are dropped from a tall building whose height is 80 m. After, a fall of 40 m each towards Earth, their respective kinetic energies will be in the ratio of

(AIPMT model 2004)

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

(c) $2:1$ (d) $1:2$

During free fall of a body (u =0), the acceleration due to gravity is same at all points

After reaching 40 m from the top both the bodies having same velocities.

$$\frac{E_{k1}}{E_{K2}} = \frac{\frac{1}{2}m_1v_1^2}{\frac{1}{2}m_2v_2^2} = \frac{m_1}{m_2} = \frac{1}{2}$$

3. A body of mass 1 kg is thrown upwards with a velocity 20 m s^{-1}. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction?.

(Take $g=10ms^{-2}$) (AIPMT 2009)

(a) 20 J (b) 30 J

(c) 40 J (d) 10 J

Initial energy $= P.E+K.E$

$$=\frac{1}{2}mu^2+0=\frac{1}{2}\text{x}\,1\,\text{x}\,(20)^2$$

$$=200\,J$$

Final energy $= P.E+K.E$

$$= 0+mgh=1\text{x}18\text{x}10=180J$$

Loss of Energy = $E_i-E_f=200-180=20J$

4. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water of the jet. What is the rate at which kinetic energy is imparted to water ?.

(AIPMT 2009)

(a) $\frac{1}{2}mv^2$ (b) mv^3

(c) $\frac{3}{2}mv^2$ (d) $\frac{5}{2}mv^2$

Mass of water flowing per second = mv

Rate of K.E imparted = $\frac{1}{2}Mv^2$

$$= \frac{1}{2}\text{mv} \text{x } v^2 = \frac{1}{2}mv^3$$

---

5. A body of mass 4 m is lying in xy-plane at rest. It suddenly explodes into three pieces. Two pieces each of mass m move perpendicular to each other with equal speed *v*. The total kinetic energy generated due to explosion is

(AIPMT 2014)

(a) mv^2 (b) $\frac{3}{2}mv^2$

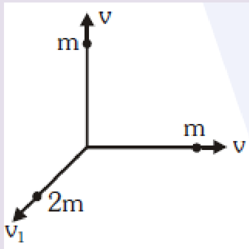
(c) $2mv^2$ (d) $4mv^2$

By Law of conservation of linear momentum

$$P_1 + P_2 + P_2 = 0$$

$$P_1 + P_2 = P_3$$

$$|P_1 + P_2| = |P_3|$$



$$2mv_1 = \sqrt{2}mv$$

Total KE generated = $\frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v_1^2$

$$= mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$$

---

6. The potential energy of a system increases, if work is done

(a) by the system against a conservative force

(b) by the system against a non-conservative force

(c) upon the system by a conservative force

(d) upon the system by a non-conservative force

Work is done against a conservative force

7. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?.

(a) $\sqrt{2gR}$ (b) $\sqrt{3gR}$

(c) $\sqrt{5gR}$ (d) $\sqrt{gR}$

Minimum velocity at the bottom of a vertical circle is $\sqrt{5gR}$

8. The work done by the conservative force for a closed path is

(a) always negative

(b) zero

(c) always positive

(d) not defined

Work done by a conservative force for a closed path is zero

9. If the linear momentum of the object is increased by 0.1%, then the kinetic energy is increased by

(a) 0.1 % (b) 0.2%

(c) 0.4% (d) 0.01%

$$E_k = \frac{p^2}{2m} \Longrightarrow E_k \alpha\, p^2$$

$$P^! = \left(p + \frac{0.1}{100}\right) = (1.001)p$$

$$\frac{K^1}{K} = \left(\frac{p^1}{p}\right)^2 = (1.001)^2 = 1.002$$

$$\text{Increase in K.E} = \frac{K^1 - K}{K} x100$$

$$= \left(\frac{K^1}{K} - 1\right) x100 = (1.002 - 1)x100$$

$$= 0.2\%$$

10. If the potential energy of the particle is $\alpha - \frac{\beta}{2}x^2$, then force experienced by the particle is

(a) $F = \frac{\beta}{2}x^2$ (b) $F = \beta x$

(c) $F = -\beta x$ (d) $F = -\frac{\beta}{2}x^2$

$$F = -\frac{dU}{dx} = -\frac{d}{dx}(\alpha - \frac{\beta}{2}x^2) = 0 + \frac{2\beta x}{2} = +\beta x$$

11. A wind-powered generator converts wind energy into electric energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to

(a) v (b) v^2

(c) v^3 (d) v^4

Let ρ be the density of the air and A be the cross-section area of the blades. Consider a cylindrical volume V with cross-sectional area A and length x The mass of air contained in volume Vis $m = \rho Ax$

and its kinetic energy $\frac{1}{2}mv^2 = \frac{1}{2}\rho Axv^2$

The time taken by the air to interact is t=x/v

Power generated =K/t $= \frac{\frac{1}{2}\rho Axv^2}{x/v} = \frac{1}{2}\rho Av^3$

12. Two equal masses m_1 and m_2 are moving along the same straight line with velocities $5\,ms^{-1}$ and $-9\,ms^{-1}$ respectively. If the collision is elastic, then calculate the velocities after the collision of m_1 and m_2, respectively

(a) $-4\,ms^{-1}$ and $10\,ms^{-1}$

(b) $10\,ms^{-1}$ and $0\,ms^{-1}$

(c) $-9\,ms^{-1}$ and $5\,ms^{-1}$

(d) $5\,ms^{-1}$ and $1\,ms^{-1}$

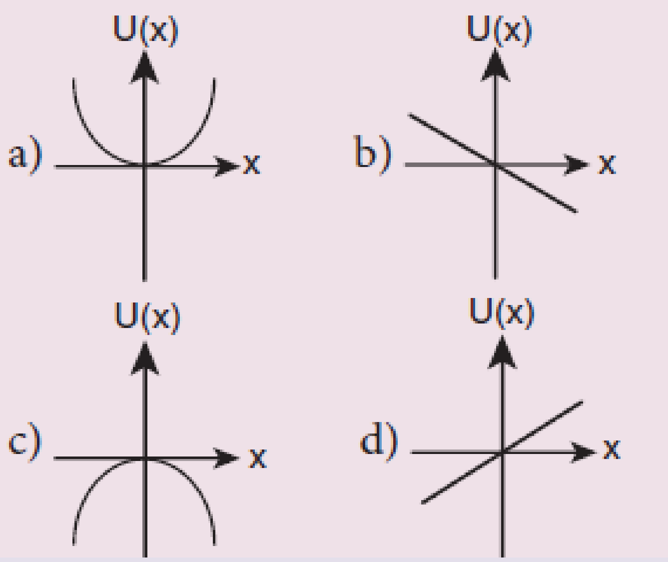
Two equal masses on elastic head on collision, interchange their velocities after collision.

Hence the velocities of m1 and m2 after collision is $-9ms^{-1}$, $5\,ms^{-1}$

Option (c)

13. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is a positive constant). If $U(0) = 0$, the graph of $U(x)$ versus x will be (where U is the potential energy function)

(IIT 2004)



$F = Kx$

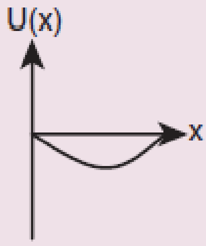
Potential Energy $= -\int F.dx = -\int kxdx = -K\frac{x^2}{2}$

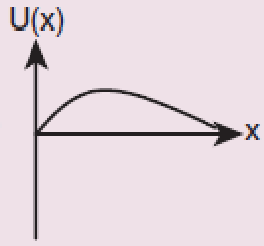
It is of the form $y = -Ax^2$,which is the parabola open downward.

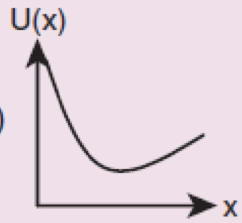
Option (c)

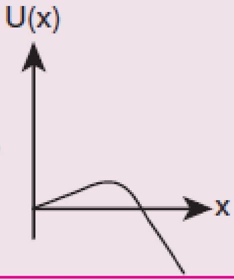
14. A particle which is constrained to move along x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here, k and a are positive constants. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is

(IIT 2002)

a) 

b) 

c) 

d) 

$$U(x) = -\int_0^x F.dx = -\int_0^x (kx + ax^3)dx$$

$$U(x) = \frac{Kx^2}{2} - \frac{ax^4}{4}$$

When U =0, x = 0

also

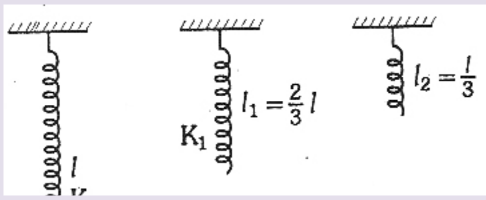
$$0 = \frac{Kx^2}{2} - \frac{ax^4}{4} ==> \frac{ax^2}{2} = K$$

$$x = \sqrt{\frac{2K}{a}}$$

15. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then, the long piece will have a force constant of

(a) $\frac{2}{3}k$ (b) $\frac{3}{2}k$

(c) $3k$ (d) $6k$



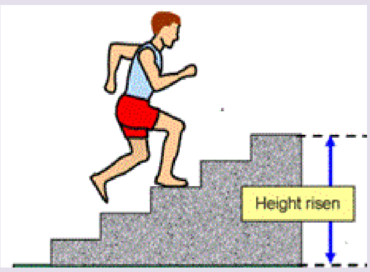
Let a spring of length of Force constant K is cut into two pieces, let l_1 and l_2 be the two pieces such that $l_1 = 2l_2$

$$l_1 + l_2 = l ==> 3l_2 = l ==> l_2 = \frac{1}{3}l$$

$$l_1 = \frac{2}{3}l$$

Force constant $K \alpha \frac{1}{l}$

$$K_1 = \frac{3}{2}K$$



EXERCISE

I. Multi Choice Question

SOLUTIONS

1. The center of mass of a system of particles does not depend upon,
   (a) position of particles
   (b) relative distance between particles
   (c) masses of particles
   (d) force acting on particle

   [AIPMT 1997, AIEEE 2004]

centre of mass of a system does not depend upon the force acting on the particle.

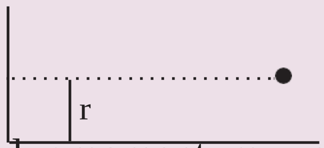
2. A couple produces,
   (a) pure rotation
   (b) pure translation
   (c) rotation and translation
   (d) no motion

   [AIPMT 1997]

A Couple produces pure rotation

3. A particle is moving with a constant velocity along a line parallel to positive X-axis. The magnitude of its angular momentum with respect to the origin is,
   (a) zero
   (b) increasing with x
   (c) decreasing with x
   (d) remaining constant

   [IIT 2002]



Angular momentum = moment of linear mometum

$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v}$

As v and r are constant. L also remain the same.

4. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force 30 N?
   (a) 0.25 rad s^{-2}
   (b) 25 rad s^{-2}
   (c) 5 m s^{-2}
   (d) 25 m s^{-2}.

   [NEET 2017]

M.I of the hollow cylinder about an axis

$I = MR^2 = 3(0.4)^2 = 0.48\ kgm^2$

Torque $\tau = F.R = 30 \times 0.4 = 12\,Nm$

$\tau = I\alpha \Longrightarrow \alpha = \frac{\tau}{I} = \frac{12}{0.48} = 25\ rad\,s^{-1}$

5. A closed cylindrical container is partially filled with water. As the container rotates in a horizontal plane about a perpendicular bisector, its moment of inertia,

(a) increases (b) decreases

(c) remains constant

(d) depends on direction of rotation.

As Moment of inertia depends on distribution of mass from the axis of rotation.

As the container roated about an axis which is perpendicular bisector, the water moves to the end of the tube due to centrifugal force, Hence Moment of inertia increases.

6. A rigid body rotates with an angular momentum L. If its kinetic energy is halved, the angular momentum becomes,

(a) L (b) L/2

(c) 2L (d) $L/\sqrt{2}$

[AFMC 1998, AIPMT 2015]

$$E_r = \frac{1}{2} I\omega^2 = \frac{1}{2}\frac{I^2\omega^2}{I} = \frac{1}{2}\frac{L^2}{I}$$

$$L^2 = 2IE_R \Longrightarrow L = \sqrt{2IE_k}; L\alpha\sqrt{E_R}$$

$$\frac{L^1}{L} = \frac{\sqrt{\frac{E_R}{2}}}{\sqrt{E_R}} = \frac{L}{\sqrt{2}}$$

7. A particle undergoes uniform circular motion. The angular momentum of the particle remain conserved about,

(a) the center point of the circle.

(b) the point on the circumference of the circle.

(c) any point inside the circle.

(d) any point outside the circle.

[IIT 2003]

Angular momentum = moment of linear mometum

$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m \vec{v}$

As $|\vec{v}|$ is constant. L will be constant only when $|\vec{r}|$ is constant.

8. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along,

(a) a line perpendicular to the plane of rotation

(b) the line making an angle of 45° to the plane of rotation

(c) the radius

(d) tangent to the path

[AIPMT 2012]

Angular momentum = moment of linear mometum

$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m \vec{v}$

Thus Angular mometum is perpendicular to the plane containing $\vec{r}$ and $\vec{v}$ hence it is directed along a line perpendicular to the plane of rotation.

9. Two discs of same moment of inertia rotating about their regular axis passing through center and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought in to contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is,

(a) $\frac{1}{4}I(\omega_1-\omega_2)^2$ (b) $I(\omega_1-\omega_2)^2$

(c) $\frac{1}{8}I(\omega_1-\omega_2)^2$ (d) $\frac{1}{2}I(\omega_1-\omega_2)^2$

[NEET 2017]

By conservation of angular momentum

$$L_1 + L_2 = L$$

$$I\omega_1 + I\omega_2 = 2I\omega$$

$$\omega = \frac{\omega_1+\omega_2}{2}$$

Loss in K.E = (K.E) $_{\text{initia}}$ – (KE)$_{\text{final}}$

$$\text{Loss in K.E} = \left[\frac{1}{2}I\omega_1^{\ 2} + \frac{1}{2}I\omega_2^{\ 2}\right] - \frac{1}{2}(2I)\omega^2$$

$$\frac{1}{2}I\left[\omega_1^{\ 2} + \omega_2^{\ 2} - 2\left(\frac{\omega_1+\omega_2}{2}\right)^2\right]$$

$$= \frac{1}{2}I\left[\frac{\omega_1^{\ 2}+\omega_2^{\ 2}-2\omega_1\omega_2}{2}\right] = \frac{1}{4}I(\omega_1-\omega_2)^2$$

---

10. A disc of moment of inertia I_a is rotating in a horizontal plane about its symmetry axis with a constant angular speed ω. Another discinitially at rest of moment of inertia I_b is dropped coaxially on to the rotating disc. Then, both the discs rotate with same constant angular speed. The loss of kinetic energy due to friction in this process is,

(a) $\frac{1}{2}\frac{I_b^{\ 2}}{(I_a+I_b)}\omega^2$

(b) $\frac{I_b^{\ 2}}{(I_a+I_b)}\omega^2$

(c) $\frac{(I_b-I_a)^2}{(I_a+I_b)}\omega^2$

(d) $\frac{1}{2}\frac{I_bI_b}{(I_a+I_b)}\omega^2$ [AIPMT 2001

As no external torque is applied to the syste Angular momentum is constant

$$L_i = L_f$$

$$I_a\omega_a = I_f\omega_f$$

$$I_a\omega_a = (I_a+I_b)\omega_f$$

$$\omega_f = \left(\frac{I_a}{I_a+I_b}\right)\omega_a$$

Loss of Energy = Initial energy – final enery

$$\Delta E = \frac{1}{2}I_a\omega_a^2 - \frac{1}{2}(I_a+I_b)\omega_f^2$$

$$.. = \frac{1}{2}I_a\omega_a^2 - \frac{1}{2}(I_a+I_b)\left(\frac{I_a\omega_a}{I_a+I_b}\right)^2$$

$$= \frac{1}{2}I_a\omega_a^2 - \frac{1}{2}I_a^2\frac{\omega_a^2}{(I_a+I_b)}$$

$$=\frac{1}{2}\omega_a^2\left[I_a-\frac{I_a^2}{I_a+I_b}\right]$$

$$=\frac{1}{2}\omega_a^2\left[\frac{I_a^2+I_aI_b-I_a^2}{I_a+I_b}\right]$$

$$=\frac{1}{2}\left[\frac{I_aI_b}{I_a+I_b}\right]\omega_a^2$$

11. The ratio of the acceleration for a solid sphere (mass m and radius R) rolling down an incline of angle θ without slipping and slipping down the incline without rolling is,

(a) 5:7 (b) 2:3 (c) 2:5 (d) 7:5

[AIPMT 2014]

For Solid sphere abo

$K=\sqrt{\frac{2}{5}R^2}\Rightarrow$

For Rolling with out sliping

$$a=\frac{g\sin\theta}{1+\frac{K^2}{R^2}}==\frac{g\sin\theta}{1+\frac{2}{5}}=\frac{5}{7}g\sin\theta$$

For Slipping without rolling

$$a_1=g\sin\theta$$

$$\frac{a}{a_1}=\frac{\frac{5}{7}g\sin\theta}{g\sin\theta}=\frac{5}{7}$$

12. From a disc of radius R a mass M, a circular hole of diameter R, whose rim passes through the center is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis passing through it

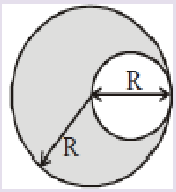
(a) $15MR^2/32$ (b) $13MR^2/32$

(c) $11MR^2/32$ (d) $9MR^2/32$

[NEET 2016]

M.I of Total disc about perpendicular axis

$$I_T=\frac{1}{2}MR^2$$



Mass of the removed portion

$$M_1=\frac{M}{4\pi R^2}x4\pi\left(\frac{R}{2}\right)^2=\frac{M}{4}$$

Moment of inertia removed disc (about same axis)

$$=\frac{1}{2}M_1\left(\frac{R}{2}\right)^2+M_1\left(\frac{R}{2}\right)^2$$

$$=\frac{1}{2}\frac{M}{4}\frac{R^2}{4}+\frac{MR^2}{16}=\frac{3}{32}MR^2$$

M.I of the remaining portion

$$I_{Remain}=I_T-I_R=\frac{1}{2}MR^2-\frac{3}{32}MR^2$$

$$=\frac{13}{32}MR^2$$

13. The speed of a solid sphere after rolling down from rest without sliding on an inclined plane of vertical height h is,

(a) $\sqrt{\frac{4}{3}gh}$ (b) $\sqrt{\frac{10}{7}gh}$

(c) $\sqrt{2gh}$ (d) $\sqrt{\frac{1}{2}gh}$

For Solid sphere about diameter

$$K=\sqrt{\frac{2}{5}R^2} \Rightarrow K^2=\frac{2}{5}R^2$$

Speed of the solid sphere on an incline

$$v=\sqrt{\frac{2gh}{\left[1+\frac{K^2}{R^2}\right]}}=\sqrt{\frac{2gh}{1+\frac{2}{5}}}$$

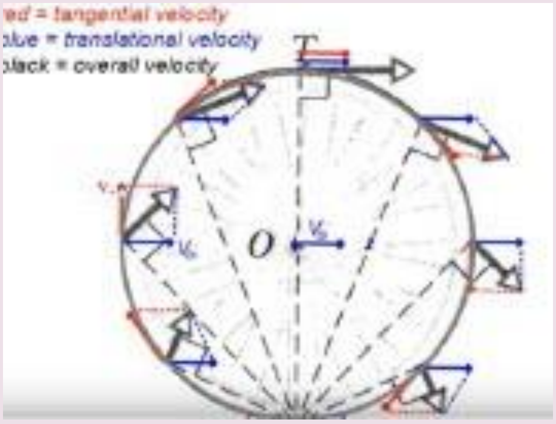
$$=\sqrt{\frac{2gh}{7/5}}=\sqrt{\frac{10gh}{7}}$$

14. The speed of the center of a wheel rolling on a horizontal surface is v_o. A point on the rim in level with the center will be moving at a speed of speed of,

(a) zero (b) v_o

(c) $\sqrt{2}\,v_o$ (d) $2v_o$

[PMT 1992, PMT 2003, IIT 2004]



Overall velocity at the height of centre is

$$v=\sqrt{v_o^{\,2}+v_o^{\,2}}=2v_o^{\,2}=\sqrt{2}v_o$$

15. A round object of mass M and radius R rolls down without slipping along an inclined plane. The fractional force,

(a) dissipates kinetic energy as heat.

(b) decreases the rotational motion.

(c) decreases the rotational and transnational motion

(d) converts transnational energy into rotational energy

[PMT 2005]

The frictional force converts Translational energy into rotational energy