Half Yearly Portion Study Materials

11th Standard

Physics

Multiple Choice Questions

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

2) If $\pi = 3.14$, then the value of π^2 is

(a) 9.8596 (b) 9.860 (c) 9.86 (d) 9.9

3) A length-scale (I) depends on the permittivity (e) of a dielectric material, Boltzmann constant (kB), 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 I is dimensionally correct?

(a) $l = \sqrt{\frac{nq^2}{\epsilon k_B T}}$ **(b) $l = \sqrt{\frac{\epsilon k_B T}{nq^2}}$** (c) $l = \sqrt{\frac{q^2}{en^{\frac{2}{3}} k_B T}}$ (d) $l = \sqrt{\frac{q^2}{\epsilon n k_B T}}$

4) If a particle has negative velocity and negative acceleration, its speed

(a) increases (b) decreases (c) remains same (d) zero

5) 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 ms^{-2} (b) 2 ms^{-2} (c) zero (d) -1 ms^{-2}

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

(a) 1 (b) less than 1 **(c) greater than 1** (d) all the three cases

7) 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

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

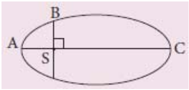
(a) dissipates kinetic energy as heat. (b) decreases the rotational motion. (c) decreases the rotational and transnational motion **(d) converts transnational energy into rotational energy**

9) The gravitational potential energy of the Moon with respect to Earth is

(a) always positive **(b) always negative** (c) can be positive or negative (d) always zero

10) The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C respectively. AC is the major axis and SB is

perpendicular to AC at the position of the Sun S as shown in the figure. Then



(a) $K_A > K_B > K_C$ (b) $K_B < K_A < K_C$ (c) $K_A < K_B < K_C$ (d) $K_B > K_A > K_C$

11) The work done by Sun on Earth at any finite interval of time is

(a) Positive, negative or zero (b) Strictly positive (c) Strictly negative (d) It is always zero

12) A small sphere of radius 2cm falls from rest in a viscous liquid. Heat is produced due to viscous force. Th e rate of production of heat when the sphere attains its terminal velocity is proportional to

(a) 2^2 (b) 2^3 (c) 2^4 **(d) 2^5**

13) The pressure in a water tap at the base of a building is 3 x 10^6 dynes/cm/ and on its top it is 1.6 x 10^6 dynes/cm^2. The height of the building is approximately __________.

(a) 7 m **(b) 14 m** (c) 70 m (d) 140 m

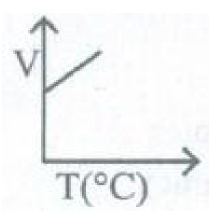
14) Bernoulli's principle does not explain ________.

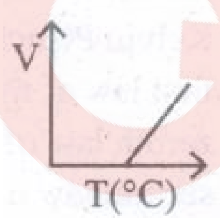
(a) curved path of a spinning ball **(b) surviving of a fish in a lake** (c) working of a paint sprayer (d) automatic blowing ofIthe roofs of houses during blizzard in hilly areas

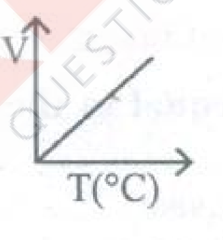
15) Water venturimeter works on the principle of _________.

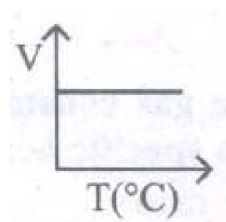
(a) Newton's third law of motion (b) Stokes's formula **(c) Bernoulli's theorem** (d) Hooke's law

16) Volume - temperature graph at atmospheric pressure for a mono atomic gas (V in m^3, Tin °C) is

(a) 

(b) 

(c) 

(d) 

17) A steel rod of length 25 cm has a cross-sectional area of 0.8 cm^2. The force required to stretch this rod by the same amount as the expansion produced by heating it through woe is (coefficient of linear expansion of steel is 10^{-5}/°C and Young's modulus of steel is 2 x 10^{10} N/m^2)

(a) 40 N (b) 80 N (c) 120 N **(d) 160 N**

18) At a given volume and temperature, the pressure of a gas __________.

(a) varies inversely as its mass (b) varies inversely as the square of its mass **(c) varies linearly as its mass** (d) is independent of its mass

19) During an adiabatic process, if the pressure of an ideal gas is proportional to the cube of its temperature, the ratio $\gamma=\frac{C_P}{C_v}$ is_______.

(a) 2 (b) $\frac{4}{3}$ (c) $\frac{5}{3}$ **(d) $\frac{3}{2}$**

20) A carnot engine operates with source at 127°C and sink at 27°C. the source supplies 40 KJ of heat energy, the work done by the engine is

(a) 1 KJ(b) 4 KJ**(c) 10 KJ**(d) 30 KJ

21) In an adiabatic change, the pressure and temperature of a mono - atomic gas are related as p x TC, where C equals

(a) $\frac{2}{5}$**(b) $\frac{5}{2}$**(c) $\frac{3}{5}$(d) $\frac{5}{3}$

22) The rms speed of the particles of fume of mass 5 x 10^{-17} kg executing Brownian motion in air at STP is ________.

(a) 1.5 ms^{-1}(b) 3.0 ms^{-1}**(c) 1.5 cms^{-1}**(d) 3.0 cms^{-1}

23) The magnitude of acceleration of particle executing SHM at the position of maximum displacement is

(a) zero(b) minimum**(c) maxmium**(d) none of these

24) A massless spring, having force constant k, oscillates with a frequency n when a mass m is suspended from it. The spring is cut into two equal halves and a mass 2m is suspended from one of the parts. The frequency of oscillation will now be _______

(a) n**(b) $n\sqrt{2}$**(c) $\frac{n}{\sqrt{2}}$(d) 2 n

25) Which of the following functions represent SHM?

I. Y = sin ωt - cos ωt

II. y = $\sin^3 t$

III. y = 5 cos $\left(\frac{3\pi}{4} - 3\omega t\right)$

IV. y = 1 + ωt + $\omega^2 t^2$

(a) I and III(b) I and II(c) only I(d) I, II and III

26) A boat at anchor is rocked by waves of velocity 25m/s, having crests 100 m apart. The boat bounces up once in every ________

(a) 4.0s(b) 2500s(c) 0.25s(d) 75s

27) If the amplitude of sound is doubled and the frequency reduced to one-fourth, the intensity will _________.

(a) increase by a factor of 2 (b) decrease by a factor of 2 **(c) decrease by a factor of 4** (d) remain unchanged

28) The speed of a wave in a medium is 760 m/s. 1f3600 waves are passing through a point in the medium in 2 minutes, then its wavelength is_______

(a) 13.8 m**(b) 25.3 m**(c) 41.5 m(d) 57.2 m

29) The ratio of intensities of two waves is 16 : 9. If they produce interference, then the ratio of maximum and minium intensities will be _______.

(a) 4: 3**(b) 49:1**(c) 64: 27(d) 81 : 49

30) A closes organ pipe of length 20 cm is sounded with a tuning fork in resonance. What is the frequency of the tuning fork? (v = 332 m/s)________

(a) 300 Hz(b) 350 Hz(c) 375 Hz(d) 415 Hz

2 Marks

31) Why is it convenient to express the distance of stars in terms of light year (or) parsec rather than in km?

Answer : The distances of astronomical objects like stars, planets etc from the earth are huge. The distance on the earth are relatively small so it can be measured in km, m.

For Example:
The distance to be next nearest big galaxy Andromeda is
21,000,000,000,000,000,000 krn.
i.e. 21 x 10^{18} km.
This no. is so large that it becomes hard to write and to interpret.
So astronomical units like the light year, parsec A.U for large distances.

32) Show that a screw gauge of pitch 1 mm and 100 divisions is more precise than a vernier caliper with 20 divisions on the sliding scale.

Answer : Least count of screw gauge
$= \frac{Pitch}{No.of\ divisions}$
$= \frac{1}{100} = 0.01\ mm$ (or) 0.001 cm
Least count of vernier calipers
$= 1MSD - 1 - 1VSD = (1 - 19/20)MSD$
$= \frac{1}{20}$ = 0.05 cm.
So screw gauge is more precise than vernier.

33) Write the largest and the smallest practical unit of mass.

Answer : Chandrasekhar Limit (CSL) is the largest practical unit of mass.1 CSL = 1.4 times the mass of the Sun. The smallest practical unit of time is Shake.
1 Shake = 10^{-8} s.

34) What is the formula representation of Mean Absolute error?

Answer : Mean Absolute error,
$\triangle a_m = \frac{1}{n}\sum_{i=1}^{n} |\triangle a_i|$

35) An object at an angle such that the horizontal range is 4 times of the maximum height. What is the angle of projection of the object?

Answer : Horizontal range = 4 (maximum height)
Angle of projection θ = ?
R = 4 $h_{maximum}$
Range R = $\frac{u^2 sin^2\theta}{g}$
$h_{maximum} = \frac{u^2 sin^2\theta}{2g}$
R = 4 $h_{maximum}$
$\frac{u^2 sin^2\theta}{g} = 4 \times \frac{u^2 sin^2\theta}{2g}$
$sin2\theta = 2sin^2\theta$
$2sin\theta cos\theta = 2sin^2\theta$
$\therefore \quad tan\theta = 1 \Rightarrow \theta = 45^\circ$

36) If Earth completes one revolution in 24 hours, what is the angular displacement made by Earth in one hour. Express your answer in both radian and degree.

Answer : Time taken for earth to complete one revolution = 24 hr
Angle covered by e = 360° = 2π radians
For one revolution i.e. 24 hrs, the angular
displacement is 2π radians
$\therefore$For one hour, the angular displacement

$\theta=\frac{2\pi}{24}=\frac{\pi}{12}(or)\frac{180^{\circ}}{12}=15^{\circ}$

$\theta=\frac{\pi}{12}or15^{\circ}$

37) What are the assumptions made in the projectile motion?

Answer : (i) Air resistance is neglected.

(ii) The effect due to rotation of Earth and curvature of Earth is negligible.

(iii) The acceleration due to gravity is constant in magnitude and direction at all points of the motion of the projectile.

38) Can we predict the direction of motion of a body from the direction of force on it?

Answer : If an object is thrown vertically upward, the direction of motion is upward, but gravitational force is downward.

39) The momentum of a system of particles is always conserved. True or false?

Answer : True

40) If two objects of masses 2.5 kg and 100 kg experience the same force 5 N, what is the acceleration experienced by each of them?

Answer : From Newton's second law (in magnitude form), F = ma.

For the object of mass 2.5 kg, the acceleration is a = $\frac{F}{m}=\frac{5}{2.5}$=2 ms^{-2}

For the object of mass 100 kg, the acceleration is a = $\frac{F}{m}=\frac{5}{100}$=0.05 ms^{-2}

41) Define gravitational potential energy.

Answer : The gravitational potential energy (U) at some height h is equal to the amount of work required

to take the object from ground to that height h with constant velocity.

42) Two different unknown masses A and B collide. A is initially at rest when B has a speed v. After collision B has a speed v/2 and moves at right angles to its original direction of motion. Find the direction in which A moves after collision

Answer : Momentum is conserved in both x and y-direction.

In x - direction

M_BV_B=0 + M_AV_A' cosϕ ....(1)

In y - direction

O=M_BV_B'-M_AV_A' sinϕ .....(2)

$\frac{2}{1}tan\phi=\frac{V_B'}{V_B}=\frac{1}{2}$

tanϕ=$\frac{1}{2}$ ∴ ϕ=26.6^0(or) $26^036'$

43) A gun fires 8 bullets per second into a target X. If the mass of each bullet is 3 g and its speed 600 s^{-1}. Then, calculate the power delivered by the bullets.

Answer : P = 8 x (kinetic energy of each bullet per second)^2

=8 x $\frac{1}{2}$ x (3 x 10^{-3}) x $(600)^2$

P=4320W

P=4.320 kW

44) The power output of an automobile engine is advertised to be 200 hp at 600 rpm. What is the corresponding torque?

Answer : P = 200 hp = 200 hp x $\frac{76\omega}{1hp}$ = 1.49 x 10^5 ω

ω = 6000 rev/min

$= 6000 \times \frac{2\pi}{60} = 628$ rad/sec

$\tau = \frac{\rho}{\omega} = \frac{1.49\times10^5}{628} = 237.5$ Nm

45) Suppose we go 200 km above and below the surface of the Earth, what are the g values at these two points? In which case, is the value of g small?

Answer : The height above the earth h = 200 km

g_h = ? R_e = 6371 km

$g_h = g\left(1 - \frac{2h}{R_e}\right)$

$g_h = g\left(1 - \frac{2\times200}{6371}\right) = \frac{5971}{6371}g$

g_h= 0.937 g (or) gh = 0.94g

The depth below the earth d = 200km

g_d= ? R_e = 6371 km

$g_d = g\left(1 - \frac{d}{R_e}\right)$

$= g\left(1 - \frac{200}{6371}\right) = g\left(\frac{6171}{6371}\right)$

g_{up} = 0.94 g.

46) What is the effect of rotation of the earth on the acceleration due to gravity?

Answer : The acceleration due to gravity' decreases due to rotation of the earth. This effect is zero at poles & maximum at the equator.

47) For a given material, the youngs modulus is 2 - 4 times that of rigidity modulus. What is its poisson's ratio?

Answer : $Y = 2G(1+\sigma)$

So, 2-4G=2G(1+σ)

or σ=1.2-1=0.2

48) What is an equation of state? Give an example

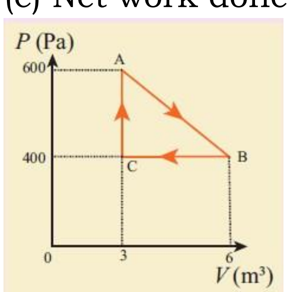
Answer :

49) An ideal gas is taken in a cyclic process as shown in the figure. Calculate

(a) work done by the gas.

(b) work done on the gas

(c) Net work done in the process



Answer : (a) Work done by the gas (along AB)

W =P△V

= 600 x 3 = 1800 J = 1.8 kJ

(b) Work is done on the gas (along BC) (Isobaric compression)

VI =-P△V

= -400 x (6 - 3)

= -1200 J

=-1.2 kJ

(c) Net work done in the process = Area under the curve AB = Rectangle area +triangle area

Triangle are = $\frac{1}{2}$ x b x h

$$= \frac{1}{2} \times \triangle V \times \triangle h$$

= $\frac{1}{2}$ x 3 x 200

= 300J

Rectangle area = I x b

=400 x 3

= 1200 J

Net work done= 1200 + 300

= 1500 J

W = 1.5 J

50) What is the meaning of temperature?

Answer : **(i)** Temperature is the degree of hotness or coolness of a body. Hotter the body higher is its temperature. The temperature will determine the direction of heat flow when two bodies are in thermal contact.

(ii) The SI unit of temperature is Kelvin (K).

51) A perfect gas goes from state A to state B by absorbing 8 x 10^5 J of heat and doing 6.5 x 10^5J of external work. It is now transferred between the same two states in another process in which it absorbs 10^5 J of heat.' In second process. Find the work done in the second process.

Answer : According to the first law of thermodynamics

.ΔU=ΔQ-ΔW

In the first process ΔU = 8 x 10^5 - 6.5 x 10^5= 1.5 x 10^5J

Now ΔU, being a state function, remains the same in the second process,

ΔW= ΔQ-ΔU= 1 x 10^5 -1.5 x 10^5

ΔW=-0.5 x 10^5J

The negative sign shows that work is done on the gas.

52) What is meant by periodic and nonperiodic motion?. Give any two examples, for each motion.

Answer : 1. Periodic motion: Any motion which repeats itself in a fixed time interval is known as periodic motion. Examples: Hands in pendulum clock, swing of a cradle, the revolution of the Earth around the Sun, waxing and waning of Moon, etc.

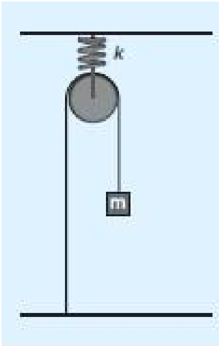
2. Non-Periodic motion:

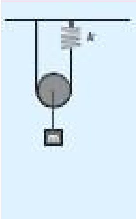
Any motion which does not repeat itself after a regular interval of time is known as non-periodic motion.

Example: Occurance of Earth quake, eruption of volcano, etc.

53) Compute the time period for the following system if the block of mass m is slightly displaced vertically down from its equilibrium position and then released. Assume

that the pulley is light and smooth, strings and springs are light.





Answer : Case(a)

Pulley is fixed rigidly here. When the mass displace by y and the spring will also stretch by y. Therefore, F = T = ky

$T=2\pi\sqrt{\frac{m}{k}}$

Case(b)

Mass displace by y, pulley also displaces by y. T = 4ky.

$T=2\pi\sqrt{\frac{m}{4k}}$

54) A0.950 kg mass hangs vertically from a spring that he a spring constant of 8.50 N/m. The mass is set into vertical oscillation and after 600 s, you find that the amplitude of the oscillation is $\frac{1}{10}$ that of initial amplitude. What is the damping constant associated with this motion?

Answer : The amplitude is A =Aoe$^{-\alpha t}$

Divide by Ao' take natural logarithms and solve for α

$\frac{A}{A_0}=e^{-\alpha t}\Rightarrow l_n\left(\frac{A}{A_0}\right)=-\alpha t$

$\Rightarrow=-\frac{1}{t}l_n\left(\frac{A}{A_0}\right)$

Since $\alpha=\frac{\beta}{2m}$, the β =2m$_\alpha$.Thus

$\beta=-\frac{2m}{t}l_n\left(\frac{A}{A_0}\right)$

Now substituting 0.950 kg for m, 600 s, for t, and 0.10 for $\left(\frac{A}{A_0}\right)$

$\beta=-\frac{2m}{t}l_n\left(\frac{A}{A_0}\right)=-\frac{2(0.950kg)}{600s}l_n$0.10

= 7.3 x 10^{-3}kg / s.

55) Write down the factors affecting velocity of sound in gases.

Answer : (i) Pressure

(ii) Temperature

(iii) Density

(iv) humidity and

(v) wind

3 Marks

56) What are the advantages of the SI system?

Answer : (i) This system makes use of only one unit for one physical quantity, which means a rational system of units.

(ii) In this system, all the derived units can be easily obtained from basic and supplementary units, which means it is a coherent system of units.

(iii) It is a metric system which means that multiples and submultiples can be expressed as powers of 10.

57) The mass and volume of a body are found to be 4±0.03 kg and 5±0.01 m^3 respectively. Then find the maximum possible percentage error in density.

Answer : $Mass\ m = 4 \pm 0.03$ kg (m + △ m)

Volume $V = 5 \pm .01 m^3 (V + \triangle V)$

Density =?

Error in mass $= \frac{\triangle m}{m} = \frac{0.03}{4} \times 100$

= 0.75%

Error in volume $= \frac{\triangle V}{V} = \frac{0.01}{5} \times 100$

= 0.2%

$Density = \frac{mass}{volume}.$

Error in density = error in mass + error in volume

= 0.75% +0.2% = 0.95%

58) "The scope of physics is really vast" - comment.

Answer : (i) Discoveries in physics are of two types; accidental discoveries and well-analysed research outcome in the laboratory based on intuitive thinking and prediction.

(ii) For example, the famous equation of Albert Einstein, E = mc^2 was a theoretical prediction in 1905 and experimentally proved in 1932 by Cockcroft and Walton.

(iii) The pharmaceutical industry uses this technique very effectively to design new drugs. Bio compatible materials for organ replacement are predicted using quantum prescriptions of physics before fabrication. Thus, experiments and theory work hand in hand complimenting one another.

(iv) Physics has a huge scope as it covers a tremendous range Of magnitude of various physical quantities (length, mass, time, energy etc). It deals with systems of very large magnitude as in astronomical phenomena as well as those with very small magnitude involving electrons and protons.

(v) **Range of time scales:** astronomical scales to microscopic scales, 10^{18}S to $1O^{-22}$s

59) What does the slope of 'position-time' graph represent? Which physical quantity is obtained from it?

Answer : (i) Graphically the slope of the position-time graph will give the velocity of the particle.

(ii) At the same time, if velocity-time graph is given, the distance and displacement are determined, by calculating the area under the curve.

Velocity is given by $\frac{dx}{dt} = v$

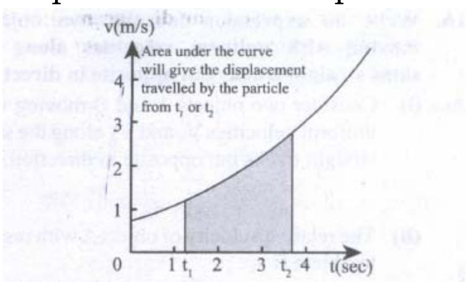
(iii) Therefore, dx = vdt

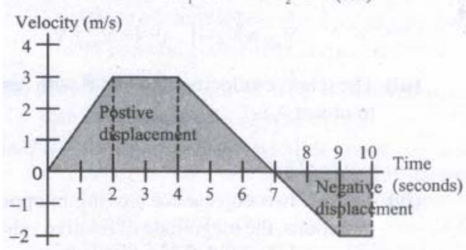
By integrating both sides, $\int_{x_1}^{x_2} dx = \int_{x_1}^{x_2} v \quad dt$

Integration is equivalent to area under the given curve.

(iv) So the term $\int_{t_1}^{t_2} vdt$ represents the area under the curve v as a function of time.

(v) Since the left hand side of the integration represents the displacement travelled by the particle from time t_1 to t_2, the area under the velocity time graph will give the displacement of the particle.





Displacement in the velocity - time graph

(vi) If the area is negative, it means that displacement is negative, so the particle has travelled in the negative direction.

60) An athlete covers 3 rounds on a circular track of radius 50 m. Calculate the total distance and displacement travelled by him.

Answer : The total distance the athlete covered = 3 x circumference of track

Distance = 3 x 2π x 50 = 300π m (or)

Distance = 300 x 3.14 = 942 m

The displacement is zero, since the athlete reaches the same point A after three rounds from where he started.

61) What is Centripetal force? Write the expression for it?

Answer : (i) If a particle is in uniform circular motion, there must be centripetal acceleration towards the center of the circle.

(ii) If there is acceleration then there must be some force acting on it with respect to an inertial frame. This force is called centripetal force.

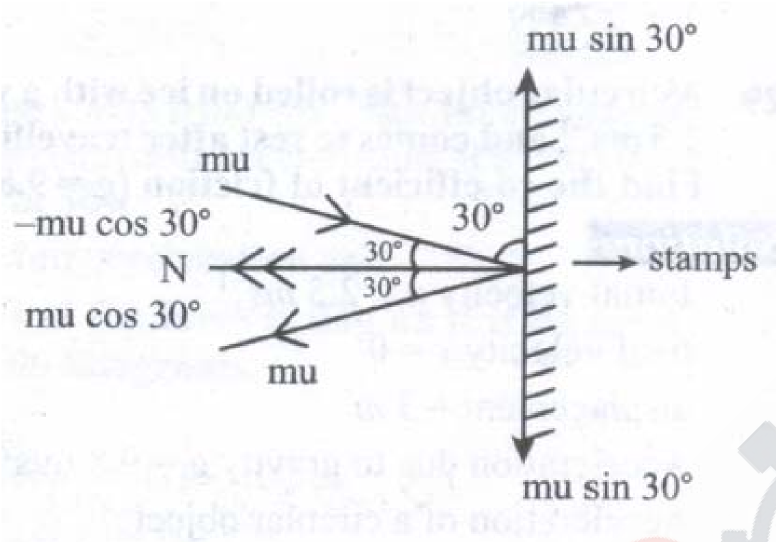
(iii) The centripetal acceleration of a particle in the circular motion is given by $a = \frac{V^2}{r}$ and it acts towards center of the circle. According to Newton's second law, the centripetal force is given by

$$F_{Cp} = ma_{cp} = \frac{MV^2}{r} \quad a = \frac{V^2}{r}$$

(iv) The word Centripetal force means center seeking force in vector notation $F_{Cp} = \frac{MV^2}{r}\hat{r}$

For Uniform circular Motion $F_{Cp} = -m\omega^2 r\hat{r}$

62) A cricket ball of mass 35 g hits a stumps at an angle of 30° with a velocity of 20 m/s. If the ball rebounds at 60° the to the direction of incidence, calculate the impulse received by the cricket ball.



Answer : Mass of ball(m) = $\frac{35}{100} = 0.035kg$

A ball hits by a stumps at an angle (θ_1) = 30°

Ball rebounds at an .angle (θ_2) = 60°

Change in momentum along horizontal direction

= -mu cos30° - (mu cos30^0)

= -2 mu cos30°

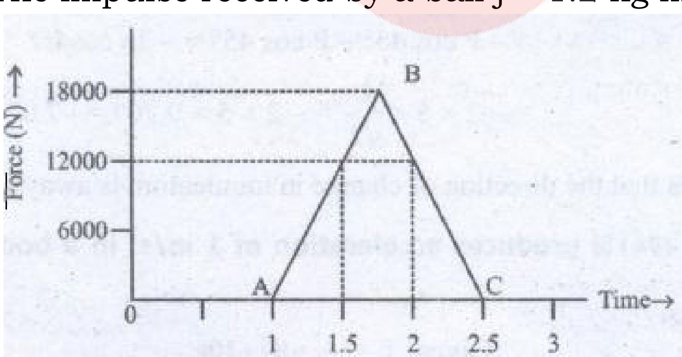
= -2 x 0.035 x 20 x cos30°

= -2 x 0.035 x20 x $\sqrt{\frac{3}{2}}$ $\left[\because cos30^0 = \sqrt{\frac{3}{2}}\right]$

= $-1.4 \times \frac{\sqrt{3}}{2} = 1.21 \quad kgms^{-1}$

The impulse received by a ball j = 1.2 kg ms^{-1}

63)



The diagram shows an estimated force-time graph for a baseball struck by a bat. Then find

(i) Impulse

(ii) Force

(iii) Maximum force

Answer : Formula:

(i) Impulse = Area ABC

$= \frac{1}{2}$ x 18000 x (2.5 -1)

=1.35 x 104 kg ms^{-1}

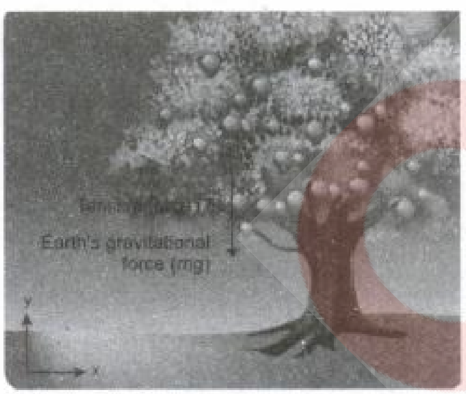
(ii) Force = $\frac{impulsw}{time} = \frac{1.35 \times 10^4}{(2.5-1)}$ = 9000N

(iii) Maximum force =.18000N

64) Apply Newton's second law to a mango hanging from a tree. (Mass of the mango is 400 gm).

Answer : Note: Before applying Newton's laws, the following steps have to be followed:

1. Choose a suitable inertial coordinate system to analyse the problem. For most of the cases we can take Earth as an inertial coordinate system.
2. Identify the system to which Newton's laws need to be applied. The system can be a single object or more than one object.
3. Draw the free body diagram.
4. Once the forces acting on the system are identified, and the free body diagram is drawn, apply Newton's second law. In the left hand side of the equation, write the forces acting on the system in vector notation and equate it to the right hand side of equation which is the product of mass and acceleration. Here, acceleration should also be in vector notation.
5. If acceleration is given, the force can be calculated. If the force is given, acceleration can be calculated.



By following the above steps:

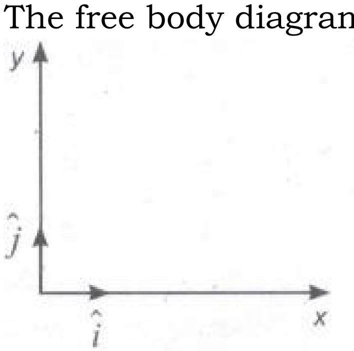
We fix the inertial coordinate system. on the ground as shown in the figure.

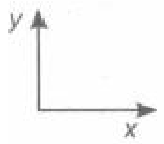
The forces acting on the mango are

(i) Gravitational force exerted by the Earth on the mango acting downward along negative y-axis.

(ii)Tension (in the cord attached to the mango) acts upward along positive y-axis.

The free body diagram for the mango is shown in the figure





$\bar{F}_g = mg(-\hat{j}) = -mg\hat{j}$

Here, mg is the magnitude of the gravitational force and $(-\hat{j})$ represents the unit vector in negative y-direction.

$\vec{T} = T\hat{j}$

Here T is the magnitude of the tension force and $(\hat{j})$ represents the unit vector in positive y direction.

$\overrightarrow{F_{net}} = F_g + \vec{T} = -mg\hat{j} + T\hat{j} = (T - mg)\hat{j}$

From Newton's second law $\overrightarrow{F_{net}} = m\vec{a}$

Since the mango is at rest with respect to us (inertial coordinate system) the acceleration is zero $(\vec{a} = 0)$

So, $\overrightarrow{F_{net}} = m\vec{a}$=0

$(T - mg)\hat{j}$=0

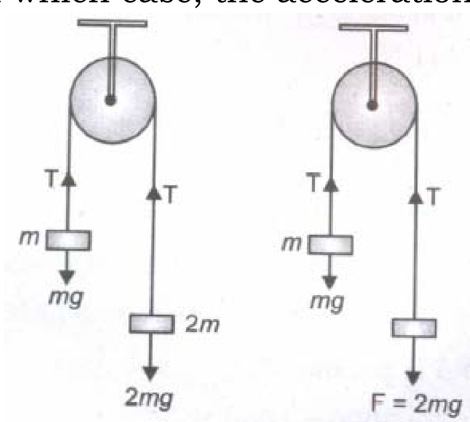
By comparing the components on both sides of the above equation, we get T - mg = 0. So the tension force acting on the mango is given by T = mg.

Mass of the mango m = 400 g and g = 9.8 ms^{-2}

Tension acting on the mango is T = 0.4 x 9.8 = 3.92 N.

65) The pulley arrangement of figure are identical. The mass of the rope is negligible. In (a) mass m is lifted up by attaching a mass (2m) to the other end of the rope. In (b), m is lifted up by pulling the other end of the rope with a constant downward force F = 2 mg. In which case, the acceleration of m is more?

Answer :



Case (a): $a = \left(\frac{2m-m}{2m+m}\right) g$

$a = \frac{g}{3}$

Case (b): FBD of mss m

ma' = T - mg

ma' = 2mg - mg

$\Rightarrow$ ma' = mg

a' = g

So in case (b) acceleration of m is more.

66) A ball of mass0.1 kg collides elastically with a ban of unknown mass at rest. If 0.1 kg ball rebounds at 1/3 of the original speed, find the mass of other ball.

Answer : $v_1 = \frac{(m_1-m_2)m_1}{m_1+m_2}$ (Given ml = 0.1 kg; u_1 = u and $v_1 = \frac{-\mu}{3}$)

$\therefore \frac{-\mu}{3} = \left(\frac{0.1-m_1}{0.1+m_2}\right) u$

By solving we get m2 = 0.2 kg

67) Find the expression for radius of gyration.

Answer : (i) A rotating rigid body with respect to any axis, is considered to be made up of point masses m_1, m_2, m_3, ... m_n at perpendicular distances (or positions) r_1, r_2, r_3....r_n respectively.

(ii) The moment of inertia of that object can be written as,

I=$\sum m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \ldots + m_n r_n^2$

If all the n number of individual masses to be equal,

$m=m_1=m_2=m_3=\ldots=m_n$

then,

I=$mr_1^2 + mr_2^2 + mr_3^2 + \ldots + mr_n^2$

=$m(r_1^2 + r_2^2 + r_3^2 + \ldots + r_n^2)$

= $nm\left(\frac{r_1^2+r_2^2+r_3^2+\ldots+r_n^2}{n}\right)$

I=MK^2

where, nm is the total mass M of the body and K is the radius of gyration.

K=$\sqrt{\frac{r_1^2+r_2^2+r_3^2+\ldots+r_n^2}{n}}$

(iii) The expression for radius of gyration indicates that it is the root mean square (rms) distance of the particles of the body from the axis of rotation.

68) Find the radius of gyration of a disc of mass M and radius R rotating about an axis passing through the center of mass and perpendicular to the plane of the disc.

Answer : The moment of inertia of a disc about an axis passing through the center of mass and perpendicular to the disc is, $I = \frac{1}{2}MR^2$

In terms of radius of gyration, I=MK^2

Hence, $Mk^2 = \frac{1}{2}MR^2; K^2 = \frac{1}{2}R^2$

$K = \frac{1}{\sqrt{2}}R or K = \frac{1}{1.414}R or K = (0.707)R$

From the case of a rod and also a disc, we can conclude that the radius of gyration of the rigid body is always a geometrical feature like length, breadth, radius or their combinations with a positive numerical value multiplied to it.

69) Find the period of oscillation of a simple pendulum of length α suspended from the roof a vehicle which moves without friction down an inclined plane of inclination α.

Answer : The effective value of acceleration due to gravity

g' = g cos α

$T = 2\pi\sqrt{\frac{l}{g'}}$

$= 2\pi\sqrt{\frac{l}{cos\alpha}}$

70) Write the equation of state for an ideal gas.

Answer : (i) N = μ N_A

Where N_A is Avogadro number (6.023 x 1023mol^{-1})

Substituting for N from equation (1), the equation (8.1) becomes

(ii) PV = N_A 11NAkT. Here N_A k=R called universal gas constant and its value is 8.314 j /mol .K

So the ideal gas law can be written for u mole of gas as

PV = μRT

(iii) This.is called the equation of state for an ideal gas. It relates the pressure, volume and temperature of thermodynamic system at equilibrium.

5 Marks

71) Check the dimensional consistency of the following equations.

(i) de-Broglie wavelength,$\lambda = \frac{h}{mv}$

(ii) Escape velocity, v = $\sqrt{\frac{2GM}{R}}$

Answer : (i)Given $\lambda = \frac{h}{mv}$

As wavelength is a distance,

LHS = $\therefore [\lambda] = L$

Also, RHS =$[\frac{h}{mv}] = \frac{Planck's\ constant}{mass \times velocity} = \frac{ML^2T^{-1}}{MLT^{-1}} = L$

$\therefore$ Dimensions of LHS = Dimensions of RHS.

Hence the given equation is dimensionally consistent.

(ii)Given v= $\sqrt{\frac{2GM}{R}}$

LHS = [V] =LT^{-1}

$RHS = [\frac{2GM}{R}]^{\frac{1}{2}} = [\frac{M^{\frac{1}{2}}L^3T^{-2}.M}{L}]^{\frac{1}{2}} = [L^2T^{-2}]\frac{1}{2} = LT^{-1}$

$\therefore$ Dimensions of LHS = Dimensions of RHS.

Hence the given equation is dimensionally correct.

72) A ball is thrown upward with an initial velocity of 100ms^{-1}. After how much time will it return? Draw velocity-time graph for the ball and find from the graph.

(i) the maximum height attained by the ball

(ii) the height of the ball after 15 s. Take g= 10 ms^{-2}.

Answer : Given:

u = 100 ms^{-1}, g = -10 ms^{-2}

At highest point,v = 0

As v=u+gt

$\therefore$ 0 = 100 - 10 x t

$\therefore$ Time taken to reach highest point,

$t = \frac{100}{10} = 10s$

The ball will return to the ground at t = 20 s

Velocities of the ball at different instants at time will be as follows:

At t = 0, v = 100 -10 x 0 = 100 ms^{-1}

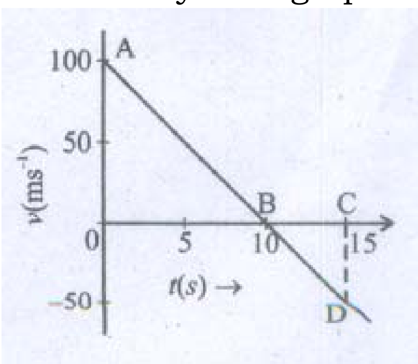
At t = 5 s, v = 100 -10 x 5 = 50 ms^{-1}

At t = 10 s, v = 100 - 10 x10 = 0

At t = 15 s,v = 100 -10 x 15 = - 50 ms^{-1}

At t = 20 s, v = 100 - 10 x 20 = - 100 ms^{-1}

The velocity-time graph will be as shown in the figure.



(i) Maximum height attained by the ball

= Area of $\triangle OAB$

$= \frac{1}{2} \times 10s \times 100ms^{-1} = 500m$

(ii) Height attained after 15 s

$= Area\ of \triangle AOB + Area\ of \triangle BCD$

$= 500 + \frac{1}{2}(15-10) \times (-50) = 500 - 125 = 375m$

73) Two ball bearing of mass m each moving in opposite directions with equal speeds v collide head on with each other. Predict the outcome of the collision, assuming it to be perfectly elastic.

Answer : $m_1 = m_2 = m$ (say)

u_1 =v, u_2=-V

As the collision is perfectly elastic velocities after the collision will be

$v_1 = \frac{m_1-m_2}{m_1+m_2}u_1 + \frac{2m_1}{m_1+m_2}u_2$

$= \frac{m-m}{m+m}.v + \frac{2m}{m+m}(-v) = 0 - v = -v$

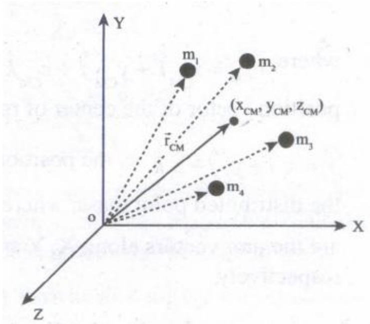
$v_2 = \frac{2m_1}{m_1+m_2}.u_1 + \frac{m_2-m_1}{m+m}.u_2$

$= \frac{2m}{m+m}.v + \frac{m-m}{m+m}(-v) \Rightarrow v + 0 = v$

Thus the two balls bounce back with equal speeds after the collision.

74) Derive an expression for the position vector of the center of mass of particle system.

Answer : (i) To find the center of mass for a collection of n point masses say, m_1, m_2, m_3....mn we have to first choose an origin and an appropriate coordinate system as shown in Figure.



(ii) Let, x_1, x_2, x_3... x_n be the X-coordinates of the positions of these point masses in the X direction from the origin. The equation for the X coordinate of the center of mass is,

$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$

where, $\sum m_i$ is the total mass M of all the particles, $(\sum m_i = M)$.

(iii) Hence

$x_{CM} = \frac{\sum m_i x_i}{M}$

(v) Similarly, we can also find y and z coordinates of the center of mass for these distributed point masses as indicated in Figure.

$y_{CM} = \frac{\sum m_i y_i}{M}$

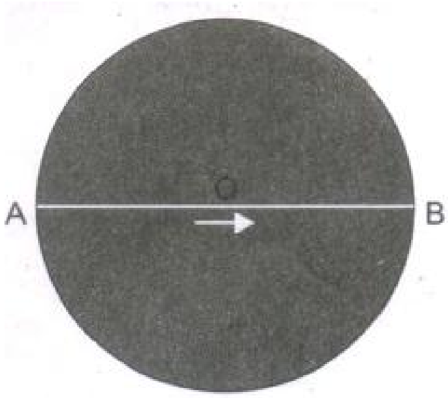
$z_{CM} = \frac{\sum m_i z_i}{M}$

(v) Hence, the position of center of mass of these point masses in a Cartesian coordinate system is (x_{CM}, y_{CM} z_{CM}) In general, the position of center of mass can be written in a vector form as,

$\overrightarrow{r_{CM}} = \frac{\sum m_i \vec{r}i}{M}$

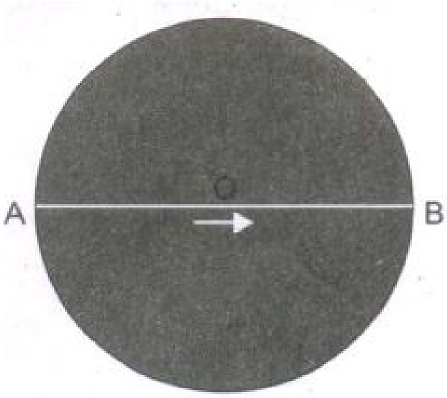
where, $\overrightarrow{r_{CM}} = x_{CM}\hat{i} + y_{CM}\hat{j} + z_{CM}\hat{k}$ is the position vector of the center of mass and $\overrightarrow{r_i} = x_i\hat{i} + y_i\hat{j} + z_i\hat{k}$ is the position vector of the distributed point mass; where $\hat{i}, \hat{j}$ and $\hat{k}$ are the unit vectors along X, Y and Z-axes respectively.

75) A thin horizontal circular disc is rotating about a vertical axis passing through its center. An insect goes from A to point B along its diameter as shown in Figure. Discuss how the angular speed of the circular disc changes?



Answer : As the disc is freely rotating, with the insect on it, the angular momentum of the system is conserved.

$L = I\omega$=constant



When the insect moves towards the center (from A to 0), the moment of inertia (I) increases. Thus, the angular velocity (co) increases. When it moves away from center (from 0 to B), the moment of inertia (I) decreases. Thus, the angular velocity (decreases.

76) Explain the freely falling apple on Earth using the concept of gravitational potential V(r)?

Answer : The gravitational potential V (r) at a point of height h from the surface of the Earth is given by,

V(r=R+h)= $\frac{GM_e}{(R+h)}$

The gravitational potential V(r) on the surface of Earth is given by,

V(r=R)= $\frac{GM_e}{R}$

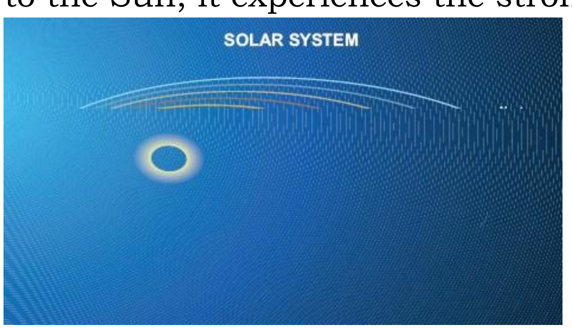
Thus we see that

V(r = R) < V(r = R + h)

Gravitational potential energy near the surface of the Earth at height h is mgh. The gravitational potential at this point is simply V(h) = U(h)/m = gh. In fact, the gravitational potential on the surface of the Earth is zero since h is zero. So the apple falls from a region of a higher gravitational potential to a region of lower" gravitational potential.

77) Qualitatively indicate the gravitational field of Sun on Mercury, Earth, and Jupiter shown in figure.

Answer : Since the gravitational field decreases as distance increases, Jupiter experiences a weak gravitational field due to the Sun. Since Mercury is the nearest to the Sun, it experiences the strongest gravitational field



Solar System

78) A student comes to school by a bicycle whose tire is filled with air at a pressure 240 kPa at 27°C. She travels 8 km to reach the school and the temperature of the bicycle

tire increases to 39°C. What is the change in pressure in the tire when the student reaches school?

Answer : 

We can take air molecules in the tire as an ideal gas. The number of molecules and the volume of tire remain constant. So the air molecules at 27°C satisfies the ideal gas equation $P_1V_1 = NkT_1$ and at 39°C it satisfies $P_2V_2 = NkT_2$

But we know

$V_1 = V_2 = V$

$\frac{P_1 V}{P_2 V} = \frac{NkT_1}{NkT_2}$

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$

$P_2 = \frac{312K}{300K} 240 \quad 10^3 Pa = 249.6 Pa$

79) The power radiated by a black body A is E_A and the maximum energy radiated was at the wavelength λA. The power radiated by another black body B is E_B = N E_A and the radiated energy was at the maximum wavelength, 1 2 λA. What is the value of N?

Answer : According to Wien's displacement law

λ_{max} T = constant for both object A and B

$\lambda_A T_A = \lambda_B T_B. \quad Here \quad \lambda_B = \frac{1}{2}\lambda_A$

$\frac{T_B}{T_A} = \frac{\lambda_A}{\lambda_B} = \frac{1}{\frac{1}{2}} = 2$

$T_B = 2T_A$

From Stefan-Boltzmann law

$\frac{E_B}{E_A} = \left(\frac{T_B}{T_A}\right)^4 = (2)^4 = 16 = N$

Object B has emitted at lower wavelength compared to A. So the object B would have emitted more energetic radiation than A.

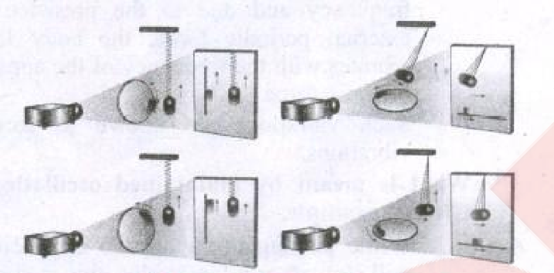
80) Describe Simple Harmonic Motion as a projection of uniform circular motion.

Answer : (i) Consider a particle of mass m moving with uniform speed along the circumference of a circle whose radius is r in anti-clockwise direction.

(ii) Let us assume that the origin of the coordinate system coincides with the center O of the circle.

(iii) If ω the angular velocity of the particle and θ the angular displacement of the particle at any instant of time t, then θ = ωt.

(iv) By projecting the uniform circular motion on its diameter gives a simple harmonic motion. This means that we can associate a map (or a relationship) between uniform circular (or revolution) motion to vibratory motion,
(v) Conversely, any vibratory motion or revolution can be mapped to uniform circular motion. In other words, these two motions are similar in nature.
(vi) Let us first project the position of a particle moving on a circle, on to its vertical diameter or on to a line parallel to vertical diameter Similarly, we can do it for horizontal axis or a line parallel to horizontal axis.
(vii) As a specific example, consider a spring mass system (or oscillation of pendulum). When the spring moves up and down (or pendulum moves to and fro), the motion of the mass or bob is mapped to points on the circular motion.
(viii) Thus, if a particle undergoes uniform circular motion then the projection of the particle on the diameter of the circle (or on a line parallel to the diameter) traces straightline motion which is simple harmonic in nature.
(ix) The circle is known as reference circle of the simple harmonic motion. The simple harmonic motion can -also be defined as the motion of the projection of a particle on any diameter of a circle of reference.



Motion of spring mass (or simple pendulum) related to uniform circular motion