CBSE Class 11 Physics

Sample Paper 03 (2020-21)

Maximum Marks: 70

Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 33 questions in all.

ii. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.

iii. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.

iv. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

Section A

1. Is a force required to maintain a body in its state of uniform motion along a straight line?
2. A railway train 400 m long is going from New Delhi railway station to Kanpur. Can we consider the railway train as a point object?

OR

Which speed is measured by speedometer of scooter?

3. About which axis would a uniform cube have minimum rotational inertia?
4. What is the amount of work done in bringing a mass from the surface of the earth on one side to a point diametrically opposite on the other side?

OR

Where will a body weight more at Delhi or at Shimla? Why?

5. Does it matter if one uses gauge pressure instead of absolute pressure in applying Bernoulli's equation?
6. Two equal forces having their resultant equal to either. At what angle are they inclined?
7. Find the dimensional formulae of
    1. Kinetic energy
    2. Pressure.

OR

Human heart is an inbuilt clock. Comment.

8. What is the nature of the thermal change in air, when a sound wave propagates through it?

OR

If an explosion takes place at the bottom of lake or sea, will the shock waves in Water be longitudinal or transverse?

9. Show the variation of specific heat at constant pressure with temperature.
10. What will be the net effect on maximum height of a projectile when its angle of projection is changed from 30° to 60°, keeping the same initial velocity of projection?

11. **Assertion:** If the sum of the two unit vectors is also a unit vector, then magnitude of their difference is root of three.
    Reason: To find resultant of two vectors, we use square law.

    a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
    b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    c. Assertion is correct statement but reason is wrong statement.
    d. Assertion is wrong statement but reason is correct statement.

12. **Assertion:** If the volume of a body remains unchanged, when subjected to tensile strain, the value of Poisson's ratio is $-\frac{1}{2}$.
    Reason: Phosphor bronze has low Young's modulus and higher rigidity modulus.

a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c. Assertion is correct statement but reason is wrong statement.
d. Assertion is wrong statement but reason is correct statement.

13. **Assertion:** The root mean square velocity of molecules of a gas having Maxwellian distribution of velocities is higher than their most probable velocity, at any temperature.
Reason: A very small number of molecules of gas possess very large velocities

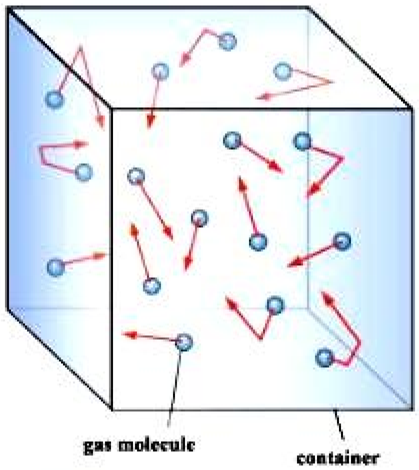
a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c. Assertion is correct statement but reason is wrong statement.
d. Assertion is wrong statement but reason is correct statement.

14. **Assertion:** In a one dimensional perfectly elastic collision between two moving bodies of equal masses, the bodies merely exchange their velocities after collision.
Reason: If a lighter body at rest suffers perfectly elastic collision with a very heavy body moving with a certain velocity, then after collision both travel with same velocity.

a. Assertion and reason both are correct statements and reason is correct explanation for assertion.
b. Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c. Assertion is correct statement but reason is wrong statement.
d. Assertion is wrong statement but reason is correct statement.

Section B

15. **Read the case study given below and answer any four subparts:**
Gas molecules move in random motion inside the container. The **pressure exerted** by the gas is due to the continuous collision of the molecules against the walls of the container. Due to this continuous collision, the walls experience a continuous force which is equal to the total momentum imparted to the walls per second.



i. If the mass of each molecule is halved and speed is doubled, find the ratio of initial and final pressure:
   a. 1:2
   b. 1:4
   c. 1:8
   d. 1:16
ii. The pressure exerted by the gases is:
   a. directly proportional to the density
   b. directly proportional to the square of the density
   c. inversely proportional to the density
   d. none of these
iii. If the force of attraction between the molecules suddenly disappears, then what will be the change in pressure:
   a. pressure remains constant
   b. pressure increase
   c. pressure decrease
   d. none of these
iv. If the pressure of a given gas is halved at a certain temperature. what will be its volume:
   a. becomes double
   b. becomes half
   c. remains constant
   d. none of these
v. Dimension formula for R?

a. $M^1L^1T^{-1}$

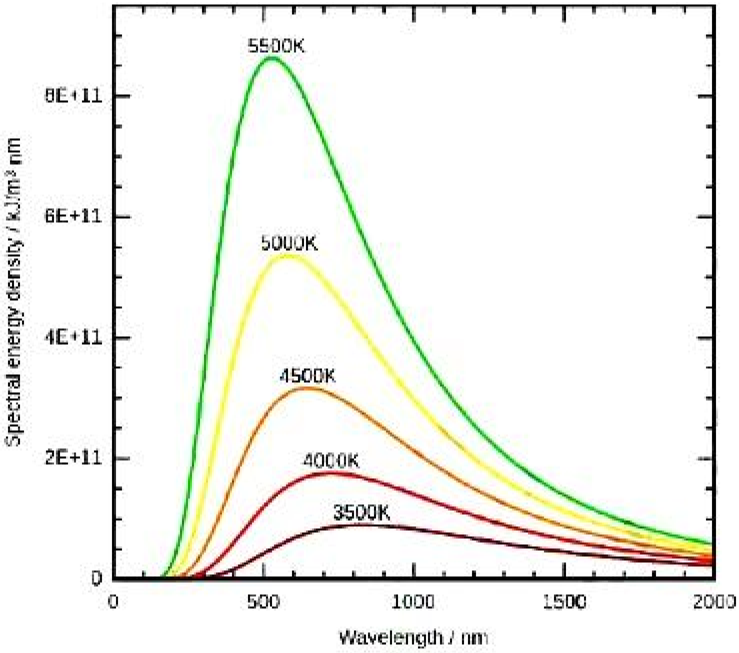
b. $M^{-1}L^0T^1$

c. $M^1L^2T^2K^{-1}$

d. $M^1L^2T^{-2}K^{-1}$

16. **Read the case study given below and answer any four subparts:**

Blackbody radiation is a term used to describe the relationship between an object's temperature, and the wavelength of electromagnetic radiation it emits. A black body is an idealized object that absorbs all electromagnetic radiation it comes in contact with. It then emits thermal radiation in a continuous spectrum according to its temperature.



i. If a black body is heated from 27°C to 927°C, then the ratio of the radiation emitted by the body at the two temperatures will be:

a. 1:4

b. 1:16

c. 1:256

d. 1: 64

ii. The temperature of a black body is gradually increased. The color of the body will change from:

a. White-green-red

b. Red-yellow-blue

c. Red-violet-yellow

d. none of these

iii. Radiation emitted by a surface is directly proportional to
   a. Third power of its temperature
   b. Equal to its temperature
   c. Twice power of its temperature
   d. Fourth power of its temperature

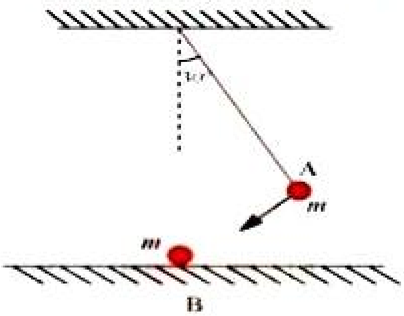
iv. An ideal black body is represented by:
   a. A metal coated with a black dye
   b. A glass surface coated with coal tar
   c. A hollow enclosure blackened from inside and having a small hole
   d. none of these

v. Energy released by a radiating surface is not continuous but is in the form of successive and separate packets of energy called:
   a. photon
   b. phonon
   c. electron
   d. neutron

Section C

17. State three essential requisites of geostationary satellite.

18. The bob A of a pendulum released from 30° to the vertical hits another bob B of the same mass at rest on a table as shown in figure. How high does the bob A rise after the collision? Neglect the size of the bobs and assume the collision to be elastic.



OR

A coolie is holding a bag by applying a force of 15 N. He moves forward and covers the horizontal distance of 8 m and then he climbs up and covers the vertical distance of 10 m. What will be the work done by him?

The net work done by coolie is the sum of work done to cover the horizontal direction and the work done to climb up in the vertical direction.

19. If the length of a simple pendulum is increased by 25%, then what will be the change in its time period?

OR

State the laws of a vibrating simple pendulum.

20. A nucleus is at rest in the laboratory frame of reference. Show that if it disintegrates into two smaller nuclei, the products must be emitted in opposite directions.

21. A body travels half of its total path in the last second of its free fall from rest. What is the duration of the fall?

22. If a progressive wave travelling in positive x-direction having the amplitude of 6 cm, frequency 200 Hz and velocity is 400 m/s, then write the equation of that progressive wave.

23. A door is hinged at one end and is free to rotate about a vertical axis (Figure). Does its weight cause any torque about this axis? Give reason for your answer.

24. In the relation p = $(a/b)e^{-(az/\theta)}$, p is the pressure, z is the distance, and θ is the temperature. What is the dimensional formula of b?

OR

The orbital velocity ν of a satellite may depend on its mass m, distance r from the centre of earth and acceleration due to gravity g. Obtain an expression for orbital velocity.

25. A car starting from rest accelerates at the rate 'f' through a distance 's', then continues at constant speed for sometime 't' and then decelerate at the rate 'f/2' to come to rest. If the total distance is 5s, then prove that s = $\frac{1}{2}ft^2$.

Section D

26. A railway car of mass 20 tonne moves with an initial speed of 54 kmh^{-1}. On applying

brakes, a constant negative acceleration of 0.3 ms^{-2} is produced.

a. What is the braking force acting on the railway car?
b. In what time will it stop?
c. What distance will be covered by railway car before it finally stops?

27. Two resistors of resistances R_1 =(100 ± 3) Ω and R_2 =(200 ± 4)Ω are connected (i) in series, (ii) in parallel. Find the equivalent resistance of the (i) series combination (ii) parallel combination.

OR

Estimate the average mass density of a sodium atom assuming its size to be about 2.5$\mathring{A}$. (Use the known values of Avogadro's number and the atomic mass of sodium). Compare it with the density of sodium in its crystalline phase: 970 kg m^{-3}. Are the two densities of the same order of magnitude? If so, why?

28. Discuss the motion of a swimmer who wants to cross a river in the shortest possible time.

OR

n aeroplane is flying in a horizontal direction with a velocity of 600 km /h and at a height of 1960 m. When it is vertically above the point A on the ground, a body is dropped from it. The body strikes the ground at point B. Calculate the distance AB.

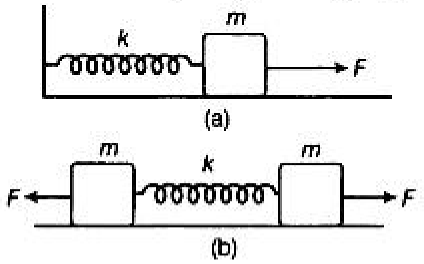
29. Discuss briefly energy distribution of a black body radiation. Hence deduce wien's displacement law?
30. Two particles of masses 1.0 kg and 2.0 kg are placed at a separation of 50 cm. Assuming that the only forces acting on the particles are their mutual gravitation, find the initial accelerations of the two particles.

Section E

31. One end of a U-tube containing mercury is connected to a suction pump and the other end to atmosphere. A small pressure difference is maintained between the two columns. Show that, when the suction pump is removed, the column of mercury in the U-tube executes simple harmonic motion.

OR

Fig. (a) shows a spring of force constant k clamped rigidly at one end and a mass m attached to its free end. A force F applied at the free end stretches the spring. Fig. (b) shows the same spring with both ends free and attached to a mass m at either end. Each end of the spring in Fig. (b) is stretched by the same force F



i. What is the maximum extension of the spring in both the cases?
ii. If the mass in Fig. (a) and the two masses in Fig. (b) are released, then what is the period of oscillation in each case?

32. A sphere of mass m moving with a velocity u hits another stationary sphere of the same mass. What will be the ratio of the velocities of two spheres after the collision? Take e as the coefficient of restitution.

OR

A rain drop of radius 2 mm falls from a height of 500 m above the ground. It falls with decreasing acceleration (due to viscous resistance of the air) until at half its original height, it attains its maximum (terminal) speed, and moves with uniform speed thereafter. What is the work done by the gravitational force on the drop in the first and second half of its journey? What is the work done by the resistive force in the entire journey if its speed on reaching the ground is 10 ms^{-1}?

33. A 14.5 kg mass, fastened to the end of a steel wire of unstretched length 1.0 m, is whirled in a vertical circle with an angular velocity of 2 rev/s at the bottom of the circle. The cross-sectional area of the wire is 0.065 cm^2. Calculate the elongation of the wire when the mass is at the lowest point of its path.

OR

Explain the following:

i. Concrete beams used in large buildings have greater depth than breadths.
ii. Load bearing bars are generally made in I-section.
iii. Pillar with distributed ends is preferred over a pillar with rounded ends.

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Solution

Section A

1. No, external force is not required to maintain a body in its state of uniform motion along a straight line.
2. Yes, because length of the train is smaller as compared to the distance between New Delhi and Kanpur.

OR

The speedometer gives the speed at a particular time. So instantaneous speed of the scooter is measured by the speedometer.

3. For a uniform cube, the mass is concentrated on its diagonal and it's the longest axis for rotation, hence about diagonal it will have maximum moment of inertia.
4. The work done is zero because the gravitational potential difference is zero.

OR

As with the increase in height the acceleration due to gravity decrease so at Shimla the body will weigh less than at Delhi.

5. No, unless the atmospheric pressures at the two points where Bernoulli's equation is applied, are significantly different.
6. Let us assume, A = F, B = F, R = F (given that two forces are equal and their resultant is equal to either of the
From parallelogram law of vector addition we have, R = $\sqrt{A^2 + B^2 + 2AB\cos\theta}$
$R^2 = A^2 + B^2 + 2AB\cos\theta$
$F^2 = F^2 + F^2 + 2F^2\cos\theta$
$1 = 2(1 + \cos\theta)$
$\cos\theta = \frac{1}{2} - 1 = \frac{-1}{2}$
$\theta = \cos^{-1}\left(-\frac{1}{2}\right) = 120^\circ$
7. i. K.E = $\frac{1}{2}mv^2$; using the dimensions of mass and velocity, the dimensional formula of

KE is $[ML^2T^{-2}]$

ii. Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]}$ = $[ML^{-1}T^{-2}]$.

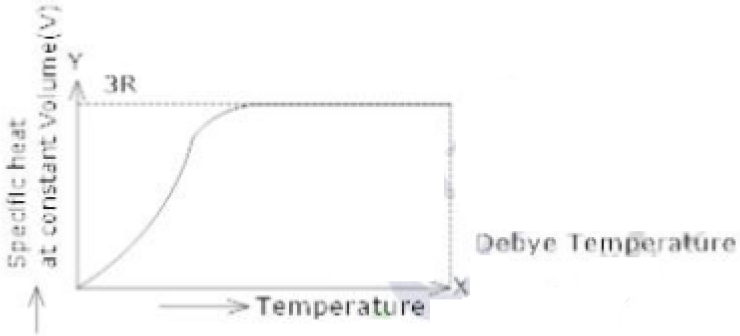
OR

The human heart is considered as an inbuilt clock because it beats at regular time intervals under normal conditions, like another clock.

8. When the sound wave travel through air adiabatic changes take place in the medium.

OR

Explosion at the bottom of lake or sea create enormous increase in pressure of medium (water). A shock Wave is thus a longitudinal wave travelling at a speed which is greater than that of ordinary Wave.

9. 

10. Maximum height H of a projectile is given by the equation H = $v_0^2\sin^2\theta/2g$

Here, $H \propto \sin^2\theta$

$\frac{H_1}{H_2} = \frac{(\sin 30^\circ)^2}{(\sin 60^\circ)^2} = \frac{1}{4} \times \frac{4}{3} = \frac{1}{3}$

or $H_2 = 3H_1$

Thus the maximum height reached becomes three times the original height of projectile.

11. (c) Assertion is correct statement but reason is wrong statement.

Explanation: Assertion is true but reason is false.

Let $\hat{A} + \hat{B} = \hat{R}$, then using parallelogram law of vector, we have

$1 = (1^2 + 1^2 + 2 \times 1 \times 1 \times \cos\theta)^{1/2}$

or $1 = 2(1 + \cos\theta)$

or $\frac{1}{2} - 1 = \cos\theta$

or $\cos\theta = -\frac{1}{2}$ or θ = 120°

$\therefore \quad |\hat{A} - \hat{B}| = |\hat{A} + (-\hat{B})|$

Now, the angle between $\hat{A}$ and $\hat{B}$ is = 180° - 120° = 60°

$\therefore$ The resultant of

$|\hat{A} + (-\hat{B})|$ = $(1^2 + 1^2 + 2 \times 1 \times 1 \cos 60°)^{1/2} = \sqrt{3}$

12. (c) Assertion is correct statement but reason is wrong statement.

Explanation: Let Δr and Δl be the change in radius and length of the wire.

$\therefore$ Change in volume $= \pi r^2 l - \pi(r - \Delta r)^2(l + \Delta l)$

$= \pi r^2 l - \pi\left(r^2 + \Delta r^2 - 2r\Delta r\right)(l + \Delta l)$

$\Delta V = \pi r^2 l - \pi r^2 l - \pi r^2 \Delta l - 2\pi r \Delta r l$

(neglecting terms containing Δr^2 and $\Delta r \Delta l$)

Now, ΔV = 0 (given)

$\therefore \quad 2\pi r \Delta r l = \pi r^2 \Delta l$

or $\frac{\Delta r l}{r \Delta l} = \frac{1}{2}$

poisson's ratio $= \frac{\text{Lateral strain}}{\text{Longitudinal strain}} = -\frac{\Delta r / r}{\Delta l / l} = -\frac{1}{2}$

Thus, statement A is correct. But statement B is wrong because Phosphor bronze has high Young's modulus and low rigidity modulus.

13. (c) Assertion is correct statement but reason is wrong statement.

Explanation:

$v_{\text{rms}} = \sqrt{\frac{3KT}{M}}$ and $v_{\text{max.}} = \sqrt{\frac{2KT}{M}}$

$\therefore$ $v_{rms} > v_{max}$. Most probable speed is that v^hich is possessed by the large number of molecules in the given system. There are other molecules whose speed is greater than this speed and some other, whose speed is less than this value. That is why root mean square speed of all the molecules become greater than the most probable speed.

14. (c) Assertion is correct statement but reason is wrong statement.

Explanation: For (A): Using the laws of conservation of linear momentum and energy, the velocities of two bodies after perfectly elastic collision are given by:

$v_1 = \frac{(m_1 - m_2)u_1 + 2m_2 u_2}{m_1 + m_2}$ ....(i)

$v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2}$ .....(ii)

If m_1 - m_2, we find that;

$v_1 = u_2$ and $v_2 = u_1$

i.e in perfectly elastic collision of two moving bodies of equal masses, the bodies merely exchange their velocities after collision. Thus, statement (A) is true.

For (R): In eqn. (i) and (ii), if $m_2 << m_1$, then $v_1 = u_1$, $u_2 = 2u_1$. Thus statement (R) is false.

Section B

15. i. (a)
    ii. (a)
    iii. (b)
    iv. (a)
    v. (d)
16. i. c
    ii. b
    iii. d
    iv. c
    v. a

Section C

17. i. The period of revolution of a satellite around the earth should be same as that of earth about its own axis (T=24 hrs)
    ii. The sense of rotation of satellite should be same as that of the earth about its own axis i.e. from west to east in anti-clockwise direction.
    iii. It should orbit in the equatorial plane and have same speed as that of earth.
18. Bob A will not rise at all.

    In an elastic collision between two equal masses in which one is stationary, while the other is moving with some velocity, the stationary mass acquires the same velocity, while the moving mass immediately comes to rest after collision. In this case, a complete transfer of momentum takes place from the moving mass to the stationary mass.

    Hence, Bob A of mass m, after colliding with bob B of equal mass, will come to rest, while bob B will move with the velocity of bob A at the instant of collision.

OR

Given, F = 1 5 N , S_1 = 8 m and s_2 =10m

As coolie is walking horizontally, therefore, the angle between the bag and distance covered is 90^o.

∴Work done to cover the distance of 8 m is given by:

$W_1 = Fs_1 \cos\theta$

$= 15 \times 8 \cos 90° = 0$ J ($\cos 90° = 0$)

When the coolie climb, then, $\theta = 0^\circ$

and the work done is given by:

$W_2 = Fs_2 \cos\theta$

$= 15 \times 10 \times \cos 0° = 150$ J ($\cos 0° = 1$)

The net work done by him:

$W = W_1 + W_2 = 0 + 150 = 150$ J

19. ∵Time period of a simple pendulum, T = $2\pi\sqrt{\frac{l}{g}}$ or $T \propto \sqrt{l}$

Percentage increase in time period of the pendulum,

$\frac{\Delta T}{T} \times 100 = (\frac{1}{2} \times \frac{\Delta l}{l} \times 100)\%$

$= (\frac{1}{2} \times 25)\%$

= 12.5 %

OR

The laws of a vibrating simple pendulum are as follows :

i. The period of oscillation is independent of the mass of the pendulum.
ii. The oscillation period does not depend on the amplitude of oscillation provided that the amplitude is small enough.
iii. The oscillation period is proportional to the square root of its length i.e., $T \propto \sqrt{l}$.
iv. The oscillation period is inversely proportional to the square root of the acceleration due to gravity at that place i.e., $T \propto \frac{1}{\sqrt{g}}$.

20. According to the principle of conservation of linear momentum, total momentum remains constant.

Before disintegration linear momentum = zero

After disintegration linear momentum = $m_1\overline{v_1} + m_2\overline{v_2}$

$\Rightarrow m_1v_1 + m_2v_2 = 0 \Rightarrow v_2 = -\frac{m_1v_1}{m_2}$

21. Let a body falls freely from a tower of height h and takes n seconds to reach the ground. Then taking downward direction as the positive direction, we have

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

Given u = 0 (free fall),

h = 0 + $\frac{1}{2}gn^2$ = $\frac{1}{2}gn^2$ ....(i)

The body travels half of its total path in the last second. Thus the body travels half of its total path in (n - 1) s.

$\frac{h}{2}$ = 0 + $\frac{g}{2}(n-1)^2 \Rightarrow$ h = g (n - 1)^2 ...(ii)

Equating (i) and (ii), we get,

$\Rightarrow \frac{1}{2}gn^2$ = g(n - 1)^2

$\Rightarrow$ n = $\frac{\sqrt{2}}{\sqrt{2}-1} = 3.4142\ sec$

Hence the time of fall, n = 3.4142 sec

22. Given, amplitude (A) = 6 cm = 0.06 m

frequency (ν) = 200 Hz

Hence, wave number (k) = $\frac{2\pi}{\lambda} = \frac{2\pi}{v/\nu}\left[\because \lambda = \frac{v}{\nu}\right]$

$\Rightarrow$ k = $\frac{2\pi v}{\nu}$

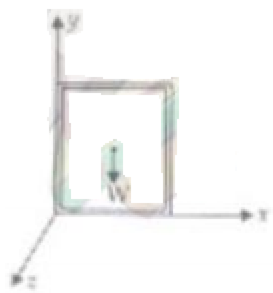
$= \frac{2\pi\times200}{400}$ = π m^{-1} and angular frequency,

$\omega = 2\pi v = 2\pi \times 200 = 400\pi$ rad/s

The standard equation of the progressive wave is y(x, t) = A sin (kx - ωt)

Putting the above values, we get the equation y(x, t) = 0.06sin(πx - 400πt)m

23. We know that $\vec{\tau} = \vec{r} \times \vec{F}$



Here axis of rotation of door is along Y-axis and door is in $x-y$ plane and force F can be applied along $\pm$ z-axis, the torque is experience by door. So a force can produce torque only along axis in the direction normal to force. Force due to gravity of door is parallel to the axis of rotation. So cannot produce torque along y-axis. Gravity due to door is along $-y$ axis. So it can rotate the door in axis along $\pm z - axis$.

Hence the weight of door cannot rotate the door along y-axis.

24. Since, $e^{-(az/\theta)}$ is dimensionless (exponential function), we have $az/\theta = 1$

or, $a = \frac{\theta}{Z} = \frac{K}{L} = [\mathrm{L}^{-1}\mathrm{K}]$

We find that a/b = dimensions of pressure (because $e^{-(az/\theta)}$ is dimensionless)

a/b = $[ML^{-1}T^{-2}]$

Therefore,

$b = \frac{a}{[\mathrm{ML}^{-1}\mathrm{T}^{-2}]} = \frac{[\mathrm{L}^{-1}\mathrm{K}]}{[\mathrm{ML}^{-1}\mathrm{T}^{-2}]}$

= $[M^{-1}T^{2}K]$

OR

Let the orbital velocity of satellite be given by the relation

$v = km^a r^b g^c$

where, k is a dimensionless constant and a, b, c are unknown powers.

Writing dimensions on two sides of equation, we have

$[M^0L^1T^{-1}] = [M]^a[L]^b[LT^{-2}]^c = [M^aL^{b+c}T^{-2c}]$

By equating the powers on both sides, we have

a = 0, b + c = 1, -2c = -1

On solving these equations, we get

a = 0, $b = +\frac{1}{2}$ and $c = +\frac{1}{2}$

$v = kr^{1/2}g^{1/2}$

$\Rightarrow v = k\sqrt{rg}$, which is the required expression.

25. For accelerated motion, we have

u = 0, a = f and s = s

As we know that, $v^2 - u^2 = 2as$,

$\therefore v_1^2 - 0^2 = 2fs \Rightarrow v_1 = \sqrt{2fs}$

Distance travelled, $s_2 = v_1t = t\sqrt{2fs}$

For decelerated motion, we have

$u=\sqrt{2fs}, a=-f/2\ and\ v=0$

As, $v^2 - u^2 = 2as$

$\therefore 0^2-(\sqrt{2fs})^2=2\times(-f/2)s_3$

Distance travelled, $s_3 = 2s$

Also it is given that the total distance is 5s i.e., $s + s_2 + s_3 = 5s$

$\Rightarrow s+t\sqrt{2fs}+2s=5s$

$\Rightarrow t\sqrt{2fs}=2s$

$\Rightarrow s=\frac{1}{2}ft^2$

Hence proved.

Section D

26. Here it is given that mass of the railway car, m = 20 tonne = 20000 kg, initial speed u = 54 km h^{-1} = 15 m s^{-1}, acceleration a = -0.3 m s^{-2} and final velocity v = 0.

   a. The braking force on railway car F = ma = 20000 × (-0.3) = - 6000 N

      where the negative sign shows that the force is opposing the motion.

   b. From relation v - u = at, we get

      $t=\frac{v-u}{a}=\frac{0-15}{(-0.3)}$ = 50 seconds

   c. Using the relation $v^2 - u^2 = 2as$, we get

      $(0)^2 - (15)^2 = 2\times(-0.3)\times s$

      $\Rightarrow -225=-0.6s$

      $s=\frac{225}{0.6}=375\text{m}$

      Thus, total distance travelled before stopping is equal to 375 m.

27. Here, $R_1 = (100 \pm 3)\ \Omega$, $R_2 = (200 \pm 4)\ \Omega$

   i. **Resistance in Series combination**

      $R = R_1 + R_2 = 100 + 200 = 300\ \Omega$

      $\Delta R = \pm(\Delta R_1+\Delta R_2)$

      $= \pm(3 + 4) = \pm 7\ \Omega$

      $\therefore \quad R=(300\pm7)\Omega$

   ii. **Resistance in Parallel Combination**

      $\frac{1}{R'}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{R_2+R_1}{R_1R_2}=\frac{200+100}{100\times200}=\frac{300}{20000}=\frac{3}{200}$

      $R'=\frac{200}{3}$ = 66.66667 $=66.7\Omega$ [upto one decimal place]

      $\frac{\Delta R'}{R'^2}=\pm\left[\frac{\Delta R_1}{R_1^2}+\frac{\Delta R_2}{R_2^2}\right]$

$$\Delta R' = \pm\left[\Delta R_1\left(\frac{R'}{R_1}\right)^2 + \Delta R_2\left(\frac{R'}{R_2}\right)^2\right]$$
$$= \pm\left[3\left(\frac{200}{3\times100}\right)^2 + 4\left(\frac{200}{3\times200}\right)^2\right] = \pm\left[3\left(\frac{4}{9}\right) + 4\left(\frac{1}{3}\right)\right] = \pm1.8\ \Omega$$

Hence, the equivalent resistance along with error in parallel combination is = (66.7 ± 1.8) Ω

OR

Diameter of sodium atom = Size of sodium atom = 2.5 $\overset{o}{A}$

Radius of sodium atom, $r = \frac{1}{2} \times diameter\ of\ sodium\ atom = \frac{1}{2} \times 2.5\overset{o}{A} = 1.25\overset{o}{A}$

$= 1.25 \times 10^{-10} m$ [1 $\overset{0}{A}$ = 10^{-10} m]

Volume of sodium atom, $V = \frac{4}{3}\pi r^3$

$= \frac{4}{3} \times 3.14 \times \left(1.25 \times 10^{-10}\right)^3$

According to the Avogadro's hypothesis, one mole of sodium contains 6.023×10^{23} (Avogadro's number) atoms and has a total mass of 23 g = 23×10^{-3} kg. (Since, we know that mass number of sodium atom is 23)

∴ Mass of one atom = $\frac{mass\ of\ one\ mole\ of\ sodium}{Avogadro's\ number} = \frac{23\times10^{-3}}{6.023\times10^{23}}\text{kg}$

Density of sodium atom, $\rho = \frac{mass\ of\ Na\ atom}{volume\ of\ Na\ atom} = \frac{\frac{23\times10^{-3}}{6.023\times10^{23}}}{\frac{4}{3}\times3.14\times\left(1.25\times10^{-10}\right)^3}$

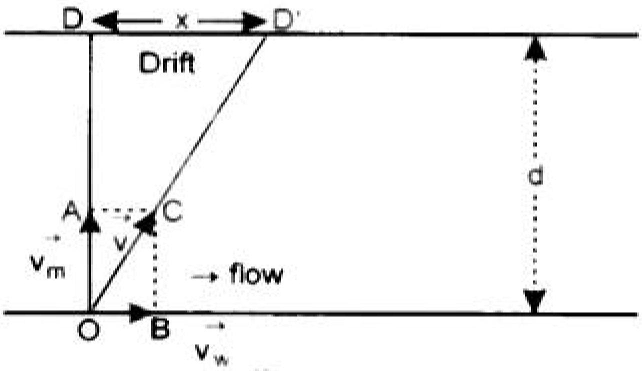
$= 4.67 \times 10^3 \text{kgm}^{-3}$

It is given that the density, d of sodium in crystalline phase is 970 kg m^{-3}.

$\therefore d < \rho$

Hence, the density of sodium atom and the density of sodium in its crystalline phase are not in the same order because in solid phase, atoms are packed closely but in crystalline phase they arrange a sequence, contain void too.So, density in solid phase is greater than in crystalline phase.

28. The figure given below is the diagrammatic representation of the motion of a swimmer who wants to cross a river in the shortest possible time.



Consider a man who wants to swim across a river of width d in the shortest possible time. For this purpose, the man should swim along a direction perpendicular to the direction of river flow. Let $\overrightarrow{v_m}$ and $\overrightarrow{v_w}$ be the velocities of the man and water flow in mutually perpendicular directions. The resultant velocity $\vec{v}$ of the swimmer will have a magnitude, which is given by

$|\vec{v}| = \sqrt{v_m^2 + v_w^2}$

or v = $\sqrt{v_m^2 + v_w^2}$

and time taken by the swimmer to cross the river is given by:

t = $\frac{d}{\text{Component of velocity along } d} = \frac{d}{v_m}$ ....(1)

However, the swimmer will reach the other bank downwards at a distance DD'= x and it is known as the 'drift' of the swimmer. The value of drift is given by:

$x = v_w \cdot t = \frac{v_w \cdot d}{v_m}$ [by using the relation (1)]

OR

When the bomb is dropped, it will have an initial horizontal velocity which is equal to the speed of the aeroplane. The velocity of the aeroplane in the horizontal direction is

u_x = 600 km/h = $600 \times \frac{5}{18} = \frac{500}{3} \mathrm{m/s}$

Velocity remains constant throughout the flight of the body.

Initial vertical velocity, $u_y = 0$ and y = h = 1960 m

Let t = time taken by the body to reach the ground.

Now, y = $u_y t + \frac{1}{2} g t^2$

$\therefore \quad 1960 = \frac{1}{2} \times 9.8 \times t^2$

$\Rightarrow t = \sqrt{\frac{1960}{4.9}} = \sqrt{400} = 20\ s$

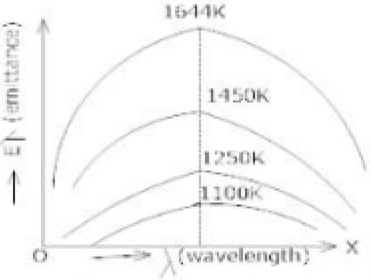
In 20 sec, the horizontal distance travelled is AB and is given by:

AB = $u_x t = \frac{500}{3} \times 20$

$= \frac{10000}{3}$ = 3333 m = 3.33 km

29. For a black body, the monochromatic emittance $(E\pi)$ of the black body and the wavelength (λ) of the radiation emitted.

So, at a given temperature of black body :



i. The energy emitted is not uniformly distributed among all the wavelengths.
ii. There is one particular wavelength (λm) corresponding to which energy is maximum and (λm) decreases with the increase in temperature of black body.
iii. Total energy emitted rapidly increases for any given wavelength.
iv. The wavelength corresponding to which energy emitted is maximum shifts towards shorter wavelength side i. e, λ_m is proportional to $\frac{1}{T}$ i.e $\lambda_m \alpha \frac{1}{T}$.

    or λ_m T = constant = b. This is the Wien's displacement law.

30. r = 50 cm = 0.5 m

Using universal law of gravitation, we know that the force of gravitation exerted by one particle on another is given by:

F = $\frac{Gm_1m_2}{r^2}$

= $\frac{6\cdot67\times10^{-11}\times(1)\times(2)}{(0\cdot5)^2}$

= 5.3×10^{-10} N.

The acceleration of 1 kg particle is given by:

$a_1 = \frac{F}{m_1} = \frac{5\cdot3\times10^{-10}}{1}$ = 5.3×10^{-10} m/s^2 .... (i)

This acceleration is towards the 2 kg particle.

The acceleration of the 2 kg particle is

$a_2 = \frac{F}{m_2} = \frac{5\cdot3\times10^{-10}}{2}$ = 2.65×10^{-10} m/s^2 .... (ii)

This acceleration is towards the 1 kg particle.

Section E

31. For calculation of this problem we can proceed in following manner -

Area of cross-section of the U-tube = A

Density of the mercury column = ρ

Acceleration due to gravity = g

Restoring force, F = Weight of the mercury column of a certain height

F = –(Volume × Density × g)

$F = -(A \times 2h \times \rho \times g) = -2\rho$ gh = –k × Displacement in one of the arms (h)

Where,

2h is the height of the mercury column in the two arms

k is a constant, given by $k = -\frac{F}{h} = 2A\rho g$

Time period, $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{2A\rho g}}$

Where,

m is the mass of the mercury column

Let l be the length of the total mercury in the U-tube.

Mass of mercury, m = Volume of mercury × Density of mercury

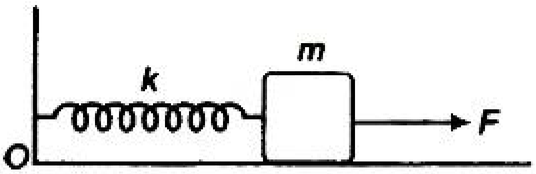
= Alρ

$\therefore\ T = 2\pi\sqrt{\frac{m}{2A\rho g}} = 2\pi\sqrt{\frac{l}{2g}}$

Hence, the mercury column executes simple harmonic motion with time period $2\pi\sqrt{\frac{l}{2g}}$.

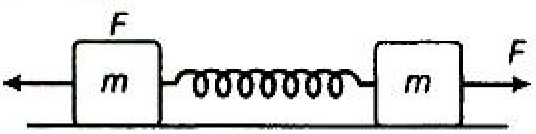
OR

i. For Case (a), as we know that the restoring force, F = -kx ⇒ |F| = kx



So, x = $\frac{F}{k}$

Case (b)



If x' is the extension in the spring, then drawing free body diagram of either mass (as the system under applied force is under equilibrium).

kx' = F

$\therefore x' = \frac{F}{k}$

In both the cases, extension is the same $\left(\frac{F}{k}\right)$.

ii. The period of oscillation in case(a)

As, restoring force(F) = -kx

where, x = given extension

But from Newton's 2nd law of motion we know that, F = ma

$\therefore ma = -kx \Rightarrow a = -\left(\frac{k}{m}\right)x$.......(i)

$a \propto -x$

On comparing eq.(i) with a = $-\omega^2$x, we get

$\omega = \sqrt{\frac{k}{m}}$ (angular frequency or velocity of the motion)

Period of oscillations, $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$

Case (b)

The system is divided into two similar systems with spring divided in two equal halves, forming spring constant

k' = 2k

Hence, F = - k'x

Putting k' = 2k (on cutting a spring in two halves, its k doubles)

F = -2kx

But from Newton's 2nd law of motion, F = ma

$\therefore$ ma = -2kx

$\Rightarrow a = -\left(\frac{2k}{m}\right)x$.........(ii)

On comparing Eq.(ii) with a = $-\omega^2$x, we get angular frequency or velocity,

$\omega = \sqrt{\frac{2k}{m}}$

Hence the required period of oscillation of the geven question,

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

32. Here, u_2 = 0 and let v_1 and v_2 be the velocities after collision in the same direction.

$\therefore e = \frac{v_2 - v_1}{u_1 - u_2}$
$= \frac{v_2 - v_1}{u - 0}$
or $v_2 - v_1 = e u$ .... (i)

According to the law of conservation of momentum, we have

$mu + m \times 0 = mv_1 + mv_2$

or $v_1 + v_2 = u$ .... (ii)

On adding Eqs. (i) and (ii), we have

$2v_2 = u + eu = u(1 + e)$

or $v_2 = \frac{u(1+e)}{2}$ .... (iii)
Substituting the value of v_2 in Eq. (ii), we get

$v_1 = u - v_2$
$= u - \frac{u(1+e)}{2}$
$= \frac{u(1-e)}{2}$ .... (iv)
Dividing Eq. (iii) by Eq. (iv), we get,
$\frac{v_2}{v_1} = \frac{1+e}{1-e}$, which is the required ratio.

OR

According to Work energy theorem, the net work done on a body is equal to change in kinetic energy of the body. This is known as Work Energy Theorem.
Work done by all the forces = Change in Kinetic Energy
$W_g + W_N + W_f = K_f - K_i$

Where, W_g = work done by gravity

W_N = work done by normal force

W_f = work done by friction

K_f = final kinetic energy

K_i = initial kinetic energy

Data Given -
Radius of the rain drop, r = 2 mm = 2×10^{-3} m
Volume of the rain drop, $V = \frac{4}{3}\pi r^3$
$= \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 kg$

Density of water, $\rho = 10^3 \text{kg m}^{-3}$

Mass of the rain drop, m = ρV

$$= \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 kg$$

Gravitational force, F = mg

$$= \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 \times 9.8N$$

The work done by the gravitational force on the drop in the first half of its journey:

W_1 = Fs

$$= \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 \times 9.8 \times 250$$

= 0.082 J

This amount of work is equal to the work done by the gravitational force on the drop in the second half of its journey, i.e., W_{II}, = 0.082 J

As per the law of conservation of energy, if no resistive force is present, then the total energy of the rain drop will remain the same.

∴Total energy at the top:

E_T = mgh + 0

$$= \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 \times 9.8 \times 500 \times 10^{-5}$$

= 0.164 J

Due to the presence of a resistive force, the drop hits the ground with a velocity of 10 m/s.

∴ Total energy at the ground:

$$E_0 = \frac{1}{2}mv^2 + 0$$

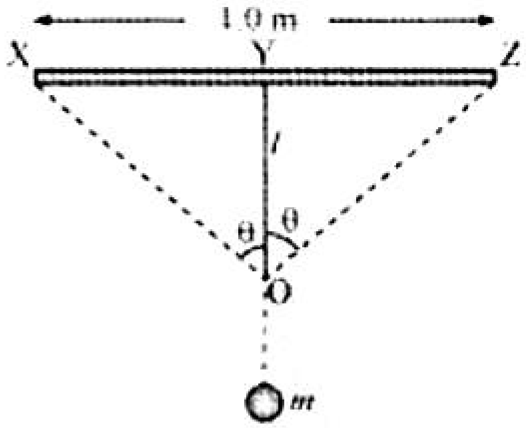
$$= \frac{1}{2} \times \frac{4}{3} \times 3.14 \times \left(2 \times 10^{-3}\right)^3 \times 10^3 \times 9.8 \times (10)^2$$

$$= 1.675 \times 10^{-3} J$$

∴ Work done by the Resistive force = E_G - E_T = - 0.162 J

here negative work done shows that energy was dissipated during the process and 0.162 Joule energy was lost during journey of the droplet.

33. Given: Mass, m = 14.5 kg, Length of the steel wire, l = 1.0 m



Angular velocity, $\omega = 2rev/s = 2 \times 2\pi rad/s = 12.56 rad/s$

Cross - section area of the wire, A = 0.065 cm$^2 = 0.065 \times 10^{-4} \mathrm{m}^2$

Let ΔL be the elongation of the wire when the mass is at the lowest point of its path.

At lowest point of vertical circle,

Net Force = Centripetal Force

$F - mg = mr\omega^2$ (where r is radius of vertical circle)

$F - mg = ml\omega^2$ (since r = l, l is length of wire)

$F = (14.5 \times 9.8) + (14.5 \times 1 \times 12.56^2)$

F = 2429.53 N

Young's modulus of steel, $Y = 2 \times 10^{11} Pa$

Now, Young modulus, $Y = \frac{Fl}{A\Delta l} \Rightarrow \Delta l = \frac{Fl}{YA}$

$\Delta l = \frac{2429.53 \times 1}{2 \times 10^{11} \times 0.065 \times 10^{-4}} \Delta l = 1.87 \times 10^{-3} \mathrm{m}$

OR

i. The major function of beam is to resist moment generated by applied load or to resist the deflection which generates again high Moment on beam. So this applied Moment is resisted through the special property of beam "EI" which includes type of material (Modulus of Elasticity) and dimensions of beam (width & depth). Concrete beams are commonly used in large buildings to support the weight of roof. It is found that depression of a beam of length l, breadth b and depth d when loaded at the centre by a load W and supported at the ends on walls in the middle is given by

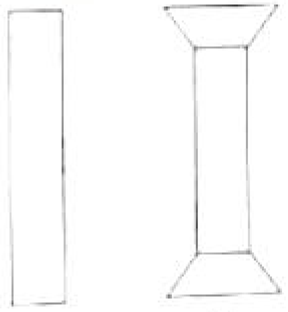
$\delta = \frac{Wl^3}{4bd^3\gamma}$

Thus, to have less depression we prefer a beam of greater depth (because $\delta \propto \frac{1}{d^3}$).

ii. A bar of rectangular section with large depth may buckle as shown in Fig. (b), when the load W is not at the right place. To avoid this, we use a I-section beam. It provides a large load bearing surface, enough depth to prevent bending. The shape reduces the weight of the beam without sacrificing the strength and hence reduces the cost.

(a) (b) (c)

iii. A pillar with distributed ends, as shown in Fig. (b) is preferred over a pillar with rounded ends because it supports much more load than a pillar with rounded ends.



(a) (b)