CBSE Class 11 Physics
Sample Paper 07 (2019-20)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

1. All questions are compulsory. There are 37 questions in all.
2. This question paper has four sections: Section A, Section B, Section C and Section D.
3. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
4. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.

Section A

1. Though the law gives women equal status in India, many people hold unscientific views on a woman's innate nature, capacity and intelligence and in practice give them a secondary status and role. Which of the following do not constitute valid support of the scientific view?

   a. Madame Curie's discovery of radioactivity

   b. Women's only role is at home

   c. Maitreyi, the woman seer and philosopher

   d. Emmy Noether's discovery of symmetry laws

2. The position of a particle is given by $r = 3.0t\hat{i} - 2.0t^2\hat{j} + 4.0\hat{k}$ Find the velocity and acceleration of the particle.

a. $5.0\hat{i} - 4.0t\hat{j}$, -3.0 $\hat{j}$

b. $2.0\hat{i} - 4.0t\hat{j}$, -2.0 $\hat{j}$

c. $3.0\hat{i} - 4.0t\hat{j}, -4.0\hat{j}$

d. $4.0\hat{i} - 4.0t\hat{j}$, -3.0$\hat{j}$

3. Force is a

   a. qualitative measure of the interaction between two bodies

   b. quantitative measure of the momentum between two bodies

   c. quantitative measure of the interaction between two bodies

   d. qualitative measure of the momentum of two bodies

4. A batter hits a baseball so that it leaves the bat at speed v_0 = 37.0 m/s at an angle a = 53.1^o. Find the position of the ball and its velocity (magnitude and direction) at t = 2.00s.

   a. 26.4 m/s at 23.2° above the horizontal

   b. 25.4 m/s at 23.2° above the horizontal

   c. 24.4 m/s at 24.2° above the horizontal

   d. 27.4 m/s at 21.2° above the horizontal

5. How many joules of energy does a 100-watt light bulb use per hour? How fast would a 70-kg person have to run to have that amount of kinetic energy?

   a. 360000 J, 101 m/s

   b. 320000 J, 130 m/s

   c. 380000 J, 120 m/s

   d. 340000 J, 140 m/s

6. A specimen of oil having an initial volume of 600 cm^3 is subjected to a pressure increase of 3.6 $\times$ 10^6 Pa and the volume is found to decrease by 0.45 cm^3 what is the bulk modulus of the material?
   a. 4.4 $\times$ 10^9 Pa
   b. 5.0 $\times$ 10^9 Pa
   c. 4.8 $\times$ 10^9 Pa
   d. 4.6 $\times$ 10^9 Pa

7. The ice and steam point have values 32 $^\circ$F and 212 $^\circ$F respectively, on the Fahrenheit scale. Corresponding values on the Centigrade scale are
   a. 0 $^\circ$C and 100 $^\circ$C
   b. 5 $^\circ$C and 102 $^\circ$C
   c. 10 $^\circ$C and 112 $^\circ$C
   d. -5 $^\circ$C and 95 $^\circ$C

8. An electric heater supplies heat to a system at a rate of 100W. If the system performs work at the rate of 75 joules per second, at what rate is the internal energy increasing?
   a. 35 W
   b. 20 W
   c. 15 W
   d. 25 W

9. Consider a mixture of non-interacting ideal gases: μ_1 moles of gas 1, μ_2 moles of gas 2, etc. in a vessel of volume V at temperature T and pressure P. It is then found that the equation of state of the mixture is :
   a. PV = ($\mu 1$ + μ_2 +...) R
   b. PV = ($\mu 1$ + μ_2 +...) RT

c. V = ($\mu 1$ + μ_2 +...) RT

d. P = ($\mu 1$ + μ_2 +...) RT

10. Beats arise when two waves having slightly different frequencies, ν_1 and ν_2 and comparable amplitudes, are superposed. The beat frequency is

    a. $\nu_{\text{beat}} = \nu_1 \sim 2\nu_2$

    b. $\nu_{\text{beat}} = 2\nu_1 \sim \nu_2$

    c. $\nu_{\text{beat}} = \nu_1 - \nu_2$

    d. $\nu_{\text{beat}} = \nu_1 + \nu_2$

11. Fill in the blanks: ________ is a branch of mechanics in which we study the objects at rest.

OR

Fill in the blanks: ________ is a branch of mechanics in which we study the objects at rest.

12. Fill in the blanks: ________ is a chemical reaction that releases energy in the form of light or heat.
13. Fill in the blanks: The magnitude of a vector is often called its _______, indicated by |v| = v.
14. Fill in the blanks: Bulk modulus for a perfectly rigid body is ________.
15. Fill in the blanks: The temperature at which the liquid starts to evaporate is called the ________ of the liquid.
16. A gunman always keep his gun slightly tilted above the line of sight while shooting. Why?
17. Why the clock pendulums are made of invar, a material of low value of coefficient of linear expansion?
18. What is conserved in Bernoulli's theorem?
19. Draw a P - V diagram for Liquid and gas at various temperatures showing critical point.
20. Why does sound travel faster in iron than in Water or air?

OR

Why do tuning forks have two prongs?

21. Write the characteristics of displacement.
22. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, what is the magnitude and direction of acceleration of the stone?
23. A child sits stationary at one end of a long trolley moving uniformly with a speed V on a smooth horizontal floor. If the child gets up and runs about on the trolley in any manner, what is the speed of the CM of the (trolley + child) system?
24. A mass 'M' is broken into two parts of masses m_1 and m_2. How are m_2 and m related so that force of gravitational attraction between the two parts is maximum.
25. A wire of length L, area of cross-section A and young's modulus Y is stretched by an amount x. What is the work done?
26. 100 g of water is super cooled to –10°C. At this point, due to some disturbance mechanized or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze?

    [$S_w = 1cal/g/^{\circ}C$ and $L^W_{fusion} = 80cal/g$]

OR

What do you mean by molar specific heat of a substance? What is its SI unit?

27. Find the value of internal energy of one mole of a diatomic gas, which do not show vibrational mode. Also, find the value of C_V for the sample of above gas.

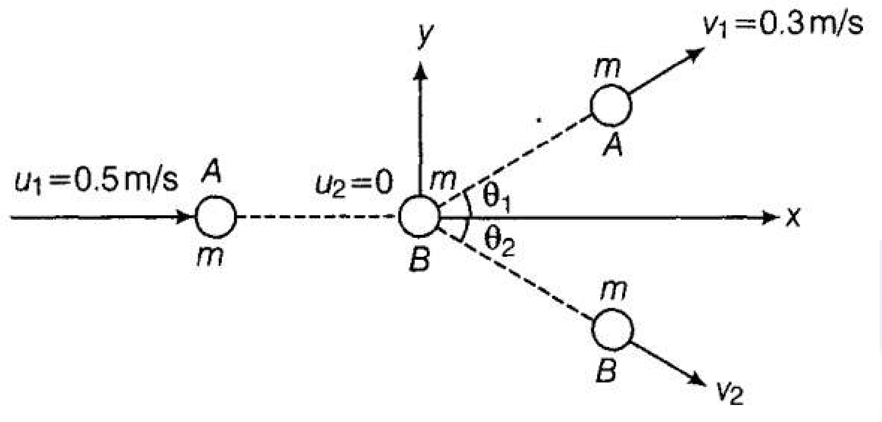
OR

Derive the Boyle’s law using kinetic theory of gases.

28. A new system of units is proposed in which unit of mass is α kg unit of length β m and unit of time γ s. How much will 5 j measure in this new system?
29. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Plot the x-t graph of his motion. Determine graphically and

otherwise how long the drunkard takes to fall in a pit 13 m away from the start.

30. Consider the collision depicted in figure to be between two billiard balls with equal masses $m_1 = m_2$. The first ball is called the cue while the second ball is called the target. The billiard player wants to sink the target ball in a corner pocket, which is at an angle $\theta_2 = 37^0$. Assume that the collision is elastic and that friction and rotational motion are not important. Obtain θ_1.



31. Obtain an expression showing variation of acceleration due to gravity with height.

32. Explain why?

   i. The blood pressure in humans is greater at the feet than the brain.
   ii. Atmospheric pressure at a height of about 6 km decreases to nearly half its value at the sea level through the height of the atmosphere is more than 100 km.
   iii. Hydrostatic pressure is a scalar quantity even though the pressure is force divided by area.

OR

The flow rate of water is 0.58 L/mm from a tap of diameter of 1.30 cm. After some time, the flow rate is increased to 4 L/min. Determine the nature of the flow for both the flow rates. The coefficient of viscosity of water is 10^{-3}Pa - s and the density of water is 10^3 kg/m^3.

33. An ideal refrigerator runs between -23°C and 27°C

i. Find the heat rejected to atmosphere for every joule of work input.
ii. Also, find heat extracted from cold body.
iii. Find coefficient of performance of the refrigerator.

34. What is the nature of sound waves in air? How is the speed of sound waves in atmosphere affected by the

i. temperature
ii. and humidity

35. a. State Newton’s second law of motion. Express it mathematically and hence obtain a relation between force and acceleration.

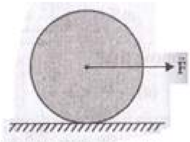
b. A body of mass 400 gm moving initially with a constant speed of 36 km h^{-1} towards the north is subjected to a constant force of 8.0 N directed towards the south for half of a minute. Beyond that time the body continues its motion with uniform velocity. No other forces are acting on the body throughout its motion. Take the instant the force is applied to be at t = 0 s, the position of the body at that time to be x = 0 m. Find out its position at t = -5 s, 25 s and 100 s respectively applying Newton's equations of motion.

OR

a. State Newton’s second law of motion. Express it mathematically and hence obtain a relation between force and acceleration.

b. A body of mass 400 gm moving initially with a constant speed of 36 km h^{-1} towards the north is subjected to a constant force of 8.0 N directed towards the south for half of a minute. Beyond that time the body continues its motion with uniform velocity. No other forces are acting on the body throughout its motion. Take the instant the force is applied to be at t = 0 s, the position of the body at that time to be x = 0 m. Find out its position at t = -5 s, 25 s and 100 s respectively applying Newton's equations of motion.

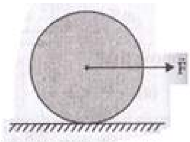
36. A uniform disc of radius R, is resting on a table on its rim. The coefficient of friction between disc and table is μ (Figure).



Now the disc is pulled with a force $\vec{F}$ as shown in the figure. What is the maximum value of F for which the disc rolls without slipping?

OR

A uniform disc of radius R, is resting on a table on its rim. The coefficient of friction between disc and table is μ (Figure).

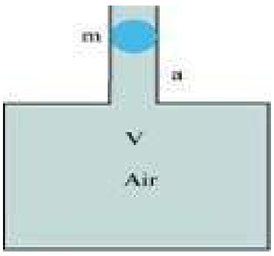


Now the disc is pulled with a force $\vec{F}$ as shown in the figure. What is the maximum value of F for which the disc rolls without slipping?

37. 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

An air chamber of volume V has a neck area of cross-section a into which a ball of mass m just fits and can move up and down without any friction (Figure). Show that when the ball is pressed down a little and released, it executes SHM. Obtain an expression for the time period of oscillations assuming pressure-volume variations of air to be isothermal.



Solution

Section A

1. (b) Women's only role is at home

   Explanation: There are so many women scientists who gave science a new defination. Madam Curie is the one who discovered radio activity. So it is not a scientific view that women are only for household work.
2. (c) $3.0\hat{i} - 4.0t\hat{j}, -4.0\hat{j}$

   Explanation:

   Position vector $\vec{r} = 3.0t\hat{i} - 2.0t^2\hat{j} + 4.0\hat{k}$

   We know velocity is given by

   $\vec{v} = \frac{d\vec{r}}{dt}$

   So $\vec{v} = 3.0\hat{i} - 4.0t\hat{j}$

   Acceleration is given by

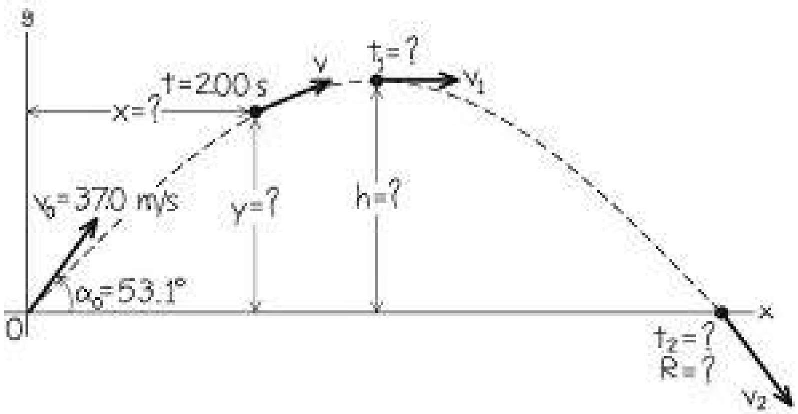
   $\vec{a} = \frac{d\vec{v}}{dt}$

   So, $\vec{a} = -4.0\hat{j}$
3. (c) quantitative measure of the interaction between two bodies

   Explanation: Newton's second law of motion gives the quantitative definition of force. The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object
4. (c) 24.4 m/s at 24.2° above the horizontal

   Explanation:

   We want to find x, y, v_x, and v_y at t = 2.00 s.



The initial velocity of the ball has components

v_{ox} = v $_{o}$ cos α_o = $37.0 \times cos 53.1^\circ$

= 22.2 m/s

v_{oy} = vo $_{o}$ sin α_o = $37.0 \times sin 53.1^\circ$

= 29.6 m/s

From above equations value of x and y at the = 2.0 s

x = v_{ox} t = 22.2×2.0 = 44.4 m

$y = v_{oy}t - \frac{1}{2}gt^2$

$= 29.6 \times 2.0 - \frac{1}{2} \times 9.8 \times (2.0)^2$

= 39.6 m

$v_x = v_{ox} = 22.2\ m/s$

$v_y = v_{oy} - gt$

$= 29.6 - 9.8 \times 2.0 = 10.0 m/s$

The y-component of velocity is positive at t=2.0 s, so the ball is still moving upward the magnitude and direction of the velocity are

v = $\sqrt{(v_x)^2 + (v_y)^2}$

= $\sqrt{(22.2)^2 + (10)^2} = 24.4 m/s$

$\alpha = tan^{-1}(\frac{10.0}{22.2})$

= $tan^{-1} 0.45 = 24.2^\circ$

The ball is moving at 24.4 m/s in a direction 24.2° above the horizontal

5. (a) 360000 J, 101 m/s

Explanation:

$$P = \frac{\text{Energy}}{\text{Time}}$$

$$\text{Energy} = P \times \text{Time} = 100 \times 1 Hr$$

$\text{Energy } = 100 \times 1 \times 60 \times 60 = 360000J$

for a 70 Kg man $K = \frac{1}{2}mv^2$

speed of man $v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2 \times 360000}{70}} = 101m/s$

6. (c) 4.8×10^9 Pa **Explanation:** bulk modulus is defined as B $= -\frac{P}{\Delta V/V}$

   here P is volume stress which is equal to pressure

   given $P = 3.6 \times 10^6 \text{pa}\ \Delta V = -0.45\text{cm}^3 \quad V = 600\text{cm}^3$

   $B = -\frac{3.6 \times 10^6}{-0.45/600}$

   $B = 4.8 \times 10^9 pa$

7. (a) 0° C and 100° C

   Explanation:

   $\frac{C}{5} = \frac{F-32}{9}$

8. (d) 25 W

   Explanation:

   $\Delta Q = \Delta U + W$

   $\Delta U = 100 - 75 = 25\text{Watt}$

9. (b) PV = ($\mu 1$ + μ_2 +...) RT

   Explanation: Total pressure = Sum of partial pressure

   $P = P_1 + P_2 + \ldots\ldots.$

   $P = \frac{\mu_1 RT}{V} + \frac{\mu_2 RT}{V} + \ldots\ldots\ldots$

   $PV = (\mu_1 + \mu_2 + \ldots\ldots.)\,RT$

10. (c) ν_{beat} = $\nu_1 - \nu_2$

    Explanation: The beat frequency is always equal to the difference in frequency of the two notes that interfere to produce the beats. So if two sound waves with frequencies of 256 Hz and 254 Hz are played simultaneously, a beat frequency of 2Hz will be detected.

11. Statics

OR

Statics

12. Exothermic reaction

13. absolute value

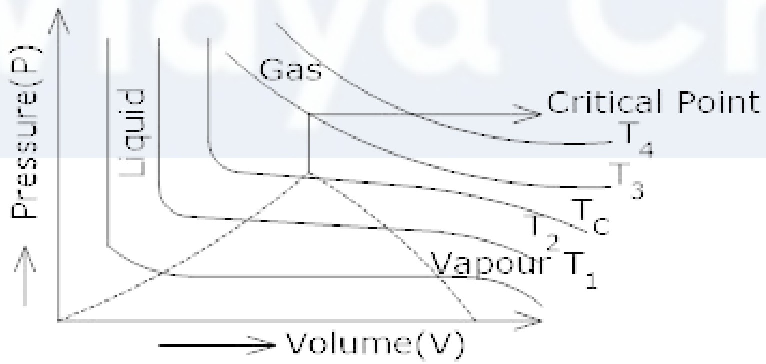
14. ∞

15. Boiling point

16. Because bullet follow parabolic trajectory under constant downward acceleration.

17. Invar is an alloy which has a small coefficient of linear expansion. The length of a pendulum made of Invar does not change with temperature and hence the time period of oscillation remains the same. Hence, the time shown by the clock is accurate.

18. According to Bernoulli's theorem, for an incompressible non-Viscous liquid (fluid) undergoing steady flow the total energy of liquid at all points is constant.

19. 

20. Sound travel faster in iron or solids because iron or solid is highly elastic as compared to water (liquids) or air (gases).

OR

The two prongs of a tuning fork set each other is resonant vibrations and help to maintain the vibrations for a longer time.

21. i. It is a vector quantity having both magnitude and direction.

ii. Displacement of a given body can be positive, negative or zero.

22. Given radius of the circular loop, r = length of the string = 80 cm = 0.8 m, frequency of revolutions, f = 14/25 rev / s^{-1}

$\therefore \omega = 2\pi f = 2 \times \frac{22}{7} \times \frac{14}{25} = \frac{88}{25} \text{rad/s}$

The centripetal acceleration

$$a = \omega^2 r = \left(\frac{88}{25}\right)^2 \times 0.80 = 9.90 \text{ms}^{-2}$$

The direction of centripetal acceleration is along the string, directed towards the centre of circular path.

23. No change.

The child is running arbitrarily on a trolley moving with velocity v. However, the running of the child will produce no effect on the velocity of the centre of mass of the trolley. Here, the boy running on the trolley(either forward or backward) will exert an only internal force on running trolley. Only external forces can affect the centre motion of the body. This is because the force due to the boy's motion is purely internal. Internal forces produce no effect on the motion of the bodies on which they act. Since no external force is involved in the boy-trolley system, the boy's motion will produce no change in the velocity of the centre of mass of the trolley.

24. Let m_1 = m, then m_2 = M - m. Gravitational force of attraction between them when placed distance r apart will be = Gm(M-m)/r^2.

Differentiating it w.r.t. m, we get

$$\frac{dF}{dm} = \frac{G}{r^2}[m\frac{d}{dm}(M-m) + (M-m)\frac{dm}{dm}]$$

$$\frac{dF}{dm} = \frac{G}{r^2}[(m(-1) + M - m]$$

$$\frac{dF}{dm} = \frac{G}{r^2}(M - 2m)$$

if F is maximum, then dF/dm=0

$$0 = \frac{G}{r^2}(M - 2m)$$

m=M/2

25. given $\Rightarrow$ change in length $\triangle L = x$

youngs's modulus is given by Y = $\frac{\text{stress}}{\text{streching}} = \frac{P \times L}{A \times \triangle L}$

Restoring force $F = \frac{YAx}{L}$

Work done in streching the wire by amount, dx

dW = F.dx

Total work done in streching the wire from 0 + x

$$W = \int dW = \int_0^x F dx = \int_0^x \frac{YAx}{L} dx = \frac{YA}{L}\left[\frac{x^2}{2}\right]_0^x$$

$$W = \frac{YAx^2}{2L}$$

26. Water mass = 100 g

At -10°C ice and water mixture exists.

Heat required (given out) by -10$^{\circ}C$ ice to $0^{\circ}C$ ice = $ms\Delta t$

$$= 100 \times 1 \times [0 - (-10)]$$

$$Q = 1000\text{cal}$$

Let gm of ice melted Q = ml

$$m = \frac{Q}{L} = \frac{1000}{80} = 12.5g$$

So, there is m = 12.5 g water and ice in mixture. Hence temperature of mixture remains $0^{\circ}C$.

OR

Molar Specific heat

It is defined as the amount of heat energy required to raise the temperature of $1\ mole$ of that substance through $1K (or\ 1^{o}C)$.
$\therefore$ Molar specific heat $C = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$

where ΔQ = the amount of heat energy required to raise the temperature of per moles of the given substance through ΔT.

Its SI unit is $Jmol^{-1}K^{-1}$.

27. The molecule of a diatomic gas have three translational and two rotational degrees of freedom. So,

Degrees of freedom (f) = 3 + 2 = 5

Total energy(E) = $= 5\left(\frac{1}{2}k_BT\right) = \frac{5}{2}k_BT$, k_B being Boltzmann's constant.

As the gas is of one mole, so the total number of molecules is N_A(Avogadro's number).

So, the total energy of one mole of the gas can be found.

We can find the value of C_V by applying,

$C_V = \frac{d}{dT}\left(\frac{5}{2}RT\right) \Rightarrow C_V = \frac{5}{2}R$ [as, R = N_Ak_B = Universal gas constant]

OR

According to Boyle's law, temperature remaining constant, the volume v of a given mass of a gas is inversely proportional to the pressure P i.e. PV = constant.

Now, according to kinetic theory of gases, the pressure exerted by a gas is given by:-

P = Pressure

V = Volume

$\overline{V}$ = Average Velocity

m = Mass of 1 molecule

N = No. of molecules

M = mN (Mass of gas)

$P = \frac{1mN\overline{V}^2}{3V}$

$P_V = \frac{1}{3}M\overline{V}^2$

28. Dimension of Energy = $[ML^2T^{-2}]$

Now let $n_1 =$ value of energy in SI unit system

$n_2 =$ numerical value of energy in given unit system

LetM_1 =basic unit of mass in SI unit system

M_2 = basic unit of mass in given unit system

L_1 = basic unit of length in SI unit system

L_2 = basic unit of length in given system

T_1 = basic unit of time in SI unit system

T_2 = basic unit of time in given unit system

then,

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^1 \left[\frac{L_1}{L_2}\right]^2 \left[\frac{T_1}{T_2}\right]^{-2}$$

n_2 = New system of unit = ? n_1= S.I system of unit = 5 j

M_2 = α kg , M_1 = 1 Kg

L_2 = β m , L_1 = 1 m

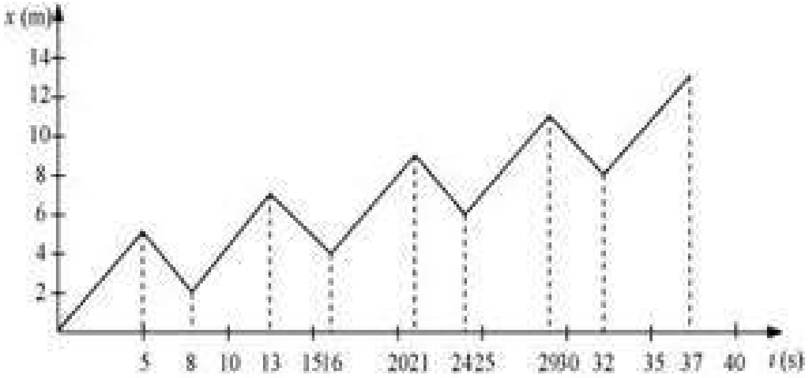
T_2 = γ s , T_1 = 1 second

$$n_2 = 5\left[\frac{1kg}{\alpha kg}\right]^1 \left[\frac{1m}{\beta m}\right]^2 \left[\frac{1\,\text{sec}}{\gamma\,\text{sec}}\right]^{-2}$$

$$n_2 = 5[\alpha^{-1}\beta^{-2}\gamma^2]$$

New system = $\frac{\gamma^2}{\alpha\beta^2} or [\alpha^{-1}\beta^{-2}\gamma^2]$

29. Distance covered with 1 step = 1 m
Time taken = 1 s
Net displacement (forward-backwards) = 2 steps = 2 m in every 8 sec. (5 sec forward and 3 sec backward)
So he goes first 8 m in 8 $\times$ $\frac{8}{2}$ = 32 sec and remaining 5 m (13 - 8) in next five steps which require 5 sec.
So total time is 37 sec.
The x-t graph of the drunkard's motion can be shown as:



30. From the law of conservation of linear momentum, we have

$mu_1 + 0 = mv_1 + mv_2$

or $u_1 = v_1 + v_2$ ....(i)

By conservation of energy, we have

$\frac{1}{2}mu_1^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$

or $u_1^2 = v_1^2 + v_2^2$

From Equation (i), we obtain ....(ii)

$u_1 \cdot u_1 = (v_1 + v_2) \cdot (v_1 + v_2)$

$= v_1 . v_1 + v_1 . v_2 + v_2 . v_1 + v_2 . v_2$

or $u_1^2 = v_1^2 + v_2^2 + 2\mathbf{v}_1 \cdot \mathbf{v}_2$

or $u_1^2 = u_1^2 + 2\mathbf{v}_1 \cdot \mathbf{v}_2$ [by using Equatio (ii)]

or $v_1 . v_2 = 0$

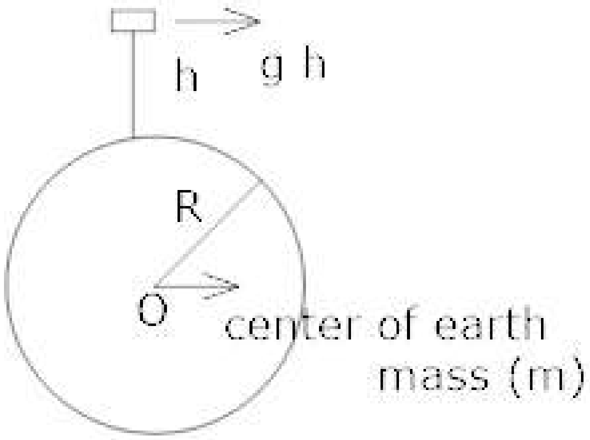
or $\theta_1 + \theta_2 = 90^\circ$

$\theta_1 = 90^\circ - \theta_2$

$= 90 - 37^0 = 53^0$

31. Now we know on the surface of earth Acceleration due to gravity is

$g = \frac{GM}{R^2}$ ....(1)



If g' is the acceleration due to gravity at a height ‘h’

Here (R + h) is the distance between the object and the center of earth.

$g' = \frac{GM}{(R+h)^2}$ ....(2)

Divide (2) by (1)

$\frac{g'}{g} = \frac{GM}{(R+h)^2} \times \frac{R^2}{GM}$

$\frac{gh}{g} = \frac{R^2}{(R+h)^2}$

$g' = \mathrm{g}\left(\frac{R^2}{(R+h)^2}\right)$

If h <<< R then the above relation

$g' = g\frac{R^2}{R^2(1+h/R)^2}$

$g' = g\frac{1}{(1+h/R)^2}$

g' = g (1 + $\frac{h}{R}$)$^{-2}$

Expanding Binomially and neglecting higher power

So as altitude h increases, the value of acceleration due to gravity falls.

$g' = g\left(\frac{1-2h}{R}\right)$

32. i. The blood pressure in humans is greater at the feet than the brain because the pressure of liquid column is given by p = hρg, where h is depth, ρ is density and g is acceleration due to gravity.
The pressure of the liquid column increases with depth. The height of blood column in human body is more at feet than at the brain.
ii. The atmospheric pressure at a height of about 6 km decreases to nearly half of its value at the sea level because the density of air is maximum near the surface of the earth and decreases rapidly with height. At a height of 6 km, the density of air

decreases to nearly half of its value at the sea level. Beyond 6 km height, the density of air decreases very slowly with height.

iii. Hydrostatic pressure is a scalar quantity because when force is applied on a liquid, the pressure is transmitted equally in all directions inside the liquid. Therefore, it has no fixed direction.

OR

Given, diameter, $D = 1.30 cm = 1.3 \times 10^{-2} m$

Coefficient of viscosity of water, $\eta = 10^{-3} Pa - s$

Density of water, $\rho = 10^3 kg/m^3$

The volume of the water flowing out per second is

$V = vA = v \times \pi r^2 = v\pi \frac{D^2}{4}$

Reynold's number, $R_e = \frac{\rho v D}{\eta} = \frac{4pv}{\eta \pi D}$

Case I When $V = 0.58 L/min = \frac{0.58 \times 10^{-3} m^3}{1 \times 60 s}$

$= 9.67 \times 10^{-6} m^3 s^{-1}$

$R_e = \frac{4 \times 10^3 \times 9.67 \times 10^{-6}}{10^{-3} \times 3.14 \times 1.3 \times 10^{-2}} = 948$

$\because R_e < 1000$, so the flow is steady or streamline

Case II When $V = 4 L/min$

$= \frac{4 \times 10^{-3}}{60} m^3 s^{-1} = 6.67 \times 10^{-5} m^3 s^{-1}$

$R_e = \frac{4 \times 10^3 \times 6.67 \times 10^{-5}}{10^{-3} \times 3.14 \times 1.3 \times 10^{-2}} = 6536$

$\because R_e > 3000$, so the flow will be turbulent.

33. Let heat rejected $Q_1 = x$ and $W = 1J$

Now, $Q_2 = Q_1 - W = x - 1$

Given, $T_1 = 273 + 27 = 300K$, $T_2 = 273 - 23 = 250K$

i. For an ideal process, $\frac{Q_2}{Q_1} = \frac{T_2}{T_1} \Rightarrow \frac{x-1}{x} = \frac{250}{300}$

$Q_1 = x = 6J$

ii. $Q_2 = 5J$

iii. Coefficient of performance

$\beta = \frac{T_2}{T_1 - T_2} = \frac{250}{300 - 250} = 5$

34. Sound waves in air are longitudinal waves in which compressions and rarefactions take place alternately and move forward.

i. According to the formula $v = \sqrt{\frac{\gamma P}{\rho}}$ = $\sqrt{\frac{\gamma RT}{M_0}}$
Thus, $v \propto \sqrt{T}$
With the increase in temperature T, the velocity v increases since it is directly proportional to the square root of absolute temperature.

ii. According to formula $v = \sqrt{\frac{\gamma RT}{M_0}}$, where M_0 is the molar mass. Molar mass of water vapour (H_2O) $\approx$ 18 is much less than the molar mass of nitrogen (N_2) $\approx$ 28 and oxygen $\approx$ 32. The effective molar mass M_0 of air decreases with the increase in water vapour. Therefore, the speed of sound in air increases with increase in humidity.

35. a. The second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force.
i.e. F $\propto$ rate of change of momentum
$\vec{F} \propto \frac{d\vec{p}}{dt}$
$\vec{F} = k\frac{d\vec{p}}{dt}$
where, k represent the proportionality constant.
$\vec{P} = m\vec{v}$
$\Rightarrow \vec{F} = \text{km}\,\frac{d\vec{v}}{dt}$
$\vec{F} = \text{km}\,\vec{a}$ (In S.I. unit K = 1)
Therefore, $\vec{F} = m\vec{a}$

b. Mass of the body, m = 400 gm = 0.40 kg
Initial speed of the body, u = 36 km/h = (36×5/18) = 10 m/s, due north
Force acting on the body, F = -8.0 N due north
Acceleration produced in the body, $a = \frac{F}{m} = \frac{-8.0}{0.40} = -20m/s^2$
(i) At t = -5 s
Acceleration, a' = 0 and initial velocity, u = 10 m/s. Both are acting in the same direction i.e. due north. Applying Newton's second equation of motion,
$s = ut + \frac{1}{2}a't^2$

$= 10 \times (-5) = -50\text{m}$

(ii) At t = 25s,

Acceleration, a'' = -20 m/s^2 and initial velocity, u = 10 m/s. Here also both are acting towards north. Applying Newton's second equation of motion,

$s' = ud' + \frac{1}{2}a''t^2$

$= 10 \times 25 + \frac{1}{2} \times (-20) \times (25)^2$

= 250 - 6250 = -6000m

At t = 100 s,

For $0 \leq t \leq 30s$:

During this time interval the body will continue its motion under the mentioned force i.e. Acceleration, a= -20 m/s^2

Initial velocity, u = 10 m/s. Both of them are acting due north. Now here also applying Newton's second equation of motion,

$s_2 = ut + \frac{1}{2}a''t^2$

$= 10 \times 30 + \frac{1}{2} \times (-20) \times (30)^2$

= 300 - 9000

= -8700 M

For $30' < t \leq 100s$:

During this time interval the action of the force will no longer present. So in this part of time there will only be the uniform velocity. The velocity gained by the body after 30 s will act here as the uniform or constant velocity. As per the Newton's first equation of motion, for t = half of a minute = 30 s, final velocity is given as:

v = u + at

= 10 + (-20) $\times$ 30 = -590 m/s, due north

Velocity of the body after 30 s = -590 m/s, acceleration = 0

For motion between 30 s to 100 s, the body will continue its journey with uniform velocity, i.e., in 70 s:

$s_2 = vt + \frac{1}{2}a''t^2$

$= -590 \times 70 = -41300m$

$= -590 \times 70 = -41300\text{m}$

$\therefore$ Total distance, s'' = s_1 + s_2 = - 8700 - 41300 = - 50000 m

OR

a. The second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force.
i.e. F $\propto$ rate of change of momentum
$\vec{F} \propto \frac{d\vec{p}}{dt}$
$\vec{F} = k\frac{d\vec{p}}{dt}$
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$= -590 \times 70 = -41300\mathrm{m}$

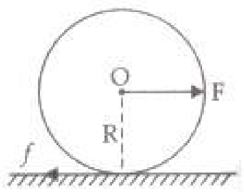
$\therefore$ Total distance, s" = s_1 + s_2 = - 8700 - 41300 = - 50000 m

36. Let a = the linear acceleration of the disc

$\alpha =$ angular acceleration of the disc.

For linear motion, using newtons second law of motion

$F - f = Ma$ ...(i)



M = mass of the disc. f = force of friction.

force of friction is responsible for torque. But torque due to F is zero as F is along ‘O’.

$\therefore$ Torque to disc $\tau = I_d\alpha$

Moment of inertia of the disc, $I_d = \frac{1}{2}MR^2$

$f \times R = \frac{1}{2} M R^2 \times \frac{a}{R}$

$\because a = R\alpha$

$fR = \frac{1}{2} MRa \Rightarrow Ma = 2f \rightarrow f = \frac{Ma}{2}$ ...(ii)

$F - f = 2f \rightarrow F = 3f \rightarrow f = \frac{F}{3}$

$\because N = Mg$

$f = \mu Mg = \frac{F}{3}$

$F = 3\mu Mg$ is the maximum force applied on disc to roll on surface without slipping.

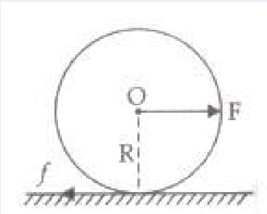
OR

Let a = the linear acceleration of the disc

$\alpha =$ angular acceleration of the disc.

For linear motion, using newtons second law of motion

$F - f = Ma$ ...(i)



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$\because N = Mg$

$f = \mu Mg = \frac{F}{3}$

$F = 3\mu Mg$ is the maximum force applied on disc to roll on surface without slipping.

37. 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 $\times$ Density $\times$ g)

$F = -(A \times 2h \times \rho \times g) = -2\rho$ gh = –k $\times$ 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 $\times$ 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

Given

$\Rightarrow$ Volume of the air chamber = V

$\Rightarrow$ Area of cross-section of the neck = a

$\Rightarrow$ Mass of the ball = m

The pressure inside the chamber is equal to the atmospheric pressure.

Let the ball be depressed by x units. As a result of this depression, there would be a decrease in the volume and an increase in the pressure inside the chamber.

Decrease in the volume of the air chamber, ΔV = ax

$\Rightarrow$ Volumetric strain $= \frac{\text{Change in volume}}{\text{Original valume}}$

$\Rightarrow \frac{\Delta V}{V} = \frac{ax}{V}$

$\Rightarrow$ Bulk Modulus of air, $B = \frac{\text{Stress}}{\text{Strain}} = \frac{-p}{\frac{ax}{V}}$

In this case, stress is the increase in pressure. The negative sign indicates that pressure increases with a decrease in volume.

$\Rightarrow p = \frac{-Bax}{V}$

$\Rightarrow$ The restoring force acting on the ball, F = p $\times$ a

$= \frac{-Ba^2x}{V}$

In simple harmonic motion, the equation for restoring force is:

$\Rightarrow$ F = -kx ... (ii)

Where k is the spring constant

Comparing equations (i) and (ii), we get:

$= \frac{Ba^2}{V}$

$\Rightarrow$ Time period, $T = 2\pi\sqrt{\frac{m}{k}}$

$= 2\pi\sqrt{\frac{Vm}{Ba^2}}$