CBSE Class 11 Physics

Sample Paper 10 (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. Physics is a

    a. Applied Science

    b. Mathematical Science

    c. Engineering Science

    d. Natural Science

2. A projectile is fired a velocity of 150 meters per second at an angle of 30 degrees with the horizontal. What is the magnitude of the vertical component of the velocity at the time the projectile is fired?

    a. 225 m/s

b. 75 m/s

c. 150 m/s

d. 130 m/s

3. A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is 1 m s^{-1}.What is the trajectory of the bob if the string is cut when the bob is at its mean position?

   a. bob will fall vertically downwards

   b. bob will fall vertically downwards

   c. bob will go down in a parabolic path

   d. bob will go upwards

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

   a. 8.84 m $s^{-1}, 75^\circ$ with x-axis

   b. 6.54 m $s^{-1}, 74^\circ$ with x-axis

   c. 7.54 m $s^{-1}, 72^\circ$ with x-axis

   d. 8.54 m $s^{-1}, 70^\circ$ with x-axis

5. The work done by a conservative force

   a. depends on both the end points as well as the path

   b. depends on the path

   c. depends only on the end points

   d. depends only on the end point and the path

6. Material is said to be ductile if

a. material cross section is not significantly reduced at failure

b. material breaks suddenly at little elongation

c. a large amount of plastic deformation takes place between the elastic limit and the fracture point

d. fracture occurs soon after the elastic limit is passed

7. What mass of steam initially at 130°C is needed to warm 200 g of water in a 100-g glass container from 20.0°C to 50.0°C? Specific heat of container is $837 J/Kg^\circ C$

   Specific heat of steam is $2110 J/Kg^\circ C$

   Specific heat of water is $4186 J/Kg^\circ C$

   Latent heat of vapourisation is $2.26 \times 10^6 J/Kg$

   a. 16.9 g

   b. 14.9 g

   c. 10.9 g

   d. 12.9 g

8. The picture of heat as a fluid was discarded in favor of the modern concept of heat as a form of energy because

   a. Count Rumford observed that boring of brass cannon generated a lot of dust

   b. Count Rumford observed that boring of brass cannon generated a lot of smoke

   c. Count Rumford observed that boring of brass cannon generated a lot of heat

   d. Count Rumford observed that boring of brass cannon generated a lot of noise

9. 1 mole of a monoatomic gas is mixed with 3 moles of a diatomic gas. What is the molecular specific heat of the mixture at constant volume?

   a. 18.7 J / mol K

b. 15.2 J / mol K

c. 12.5 J / mol K

d. 22.6 J / mol K

10. When a wave undergoes reflection at rarer medium then it undergoes a phase difference of

    a. $\pi/2$

    b. $\pi/4$

    c. No change in phase

    d. π

11. Fill in the blanks:

    ________ relates the motion of objects to the forces which cause them.

    OR

    Fill in the blanks:

    An object can be considered as a point object if the distance travelled by it is ________ than its size.

12. Fill in the blanks:

    ________ is the mechanical energy required to disassemble a whole entity into separate parts.

13. Fill in the blanks:

    The path of a projectile projected at some angle with the horizontal (i.e., ground) is a ________ path.

14. Fill in the blanks:

    If a body is subjected to a uniform force from all sides, then the corresponding stress is called ________.

15. Fill in the blanks:

    The temperature at which liquid starts to freeze is known at the ________ point of the liquid.

16. What is the angle made by vector $\vec{A} = 2\hat{i} + 2\hat{j}$ with x-axis?

17. A trolley of mass 300 kg carrying a sandbag of 25 kg is moving uniformly with a speed of 27 km/h on a frictionless track. After a while, sand starts leaking out of a hole on the floor of the trolley at the rate of 0.05 kg s^{-1}. What is the speed of the trolley after the entire sand bag is empty?

18. Why are rain drops spherical?

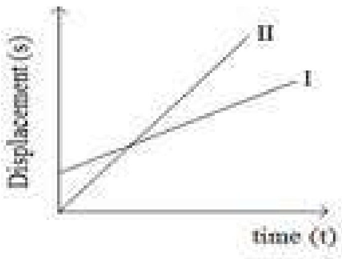
19. Find the values of two molar specific heats of nitrogen. Given, γ = 1.41 and R =8.31 J $mol^{-1}K^{-1}$.

20. The displacement of an elastic wave is given by the function $y = 3\sin\omega t + 4\cos\omega t$ where, y is in cm and t is in second. Calculate the resultant amplitude.

OR

Sound waves from a point source are propagating in all directions. What will be the ratio of amplitudes at distances of x meter and y meter from the Source?

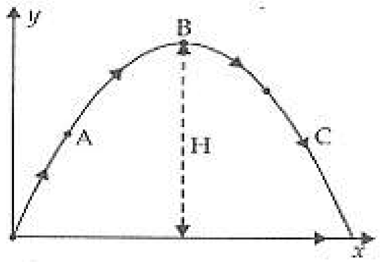
21. In Figure shows displacement - time curves I and II. What conclusions do you draw from these graphs?



xs

22. A particle is projected in the air at some angle to the horizontal, moves along the parabola as shown in the figure, where x and y indicate horizontal and vertical

directions respectively. Show in the diagram, direction of velocity and acceleration at points A, B and C.



23. Although both torque and work are defined as force multiplied by distance, they differ in there physical meaning. Why?

24. Three particles A, B and C, each of mass m, are placed in a line with AB = BC = d. Find the gravitational force on a fourth particle P of same mass, placed at a distance d from the particle B on the perpendicular bisector of the line AC.

25. A spherical ball contracts in volume by 0.0098% when subjected a pressure of 100 atmospheres. Calculate its bulk modulus, Given that 1-atmosphere pressure, is 1.013 $\times$ 10^5 Pa.

26. What do you mean by the term 'latent heat'? What are three types of latent heat?

OR

On a hot day, a car is left in sunlight with all the windows closed. After some time, it is found that the inside of the car is considerably warmer than the air outside. Explain, why?

27. Calculate the total number of degrees of freedom possessed by the molecules in 1 cm^3 of H_2 gas at temperature 273 K and 1 atm pressure?

OR

A tank used for filling helium balloons has a volume of 0.6 m^3 and contains 2.0 mol of helium gas at 20.0°C. Assuming that the helium behaves like an ideal gas.

i. What is the total translational kinetic energy of the molecules of the gas?
ii. What is the average kinetic energy per molecule?

28. A great physicist of this century (P.A.M. Dirac) loved playing with numerical values of Fundamental constants of nature. This led him to an interesting observation. Dirac found that from the basic constants of atomic physics (c, e, mass of electron, mass of proton) and the gravitational constant G, he could arrive at a number with the dimension of time. Further, it was a very large number, its magnitude being close to the present estimate on the age of the universe (15 billion years). From the table of fundamental constants in this book, try to see if you too can construct this number (or any other interesting number you can think of). If its coincidence with the age of the universe were significant, what would this imply for the constancy of fundamental constants?

29. A particle length executes the motion described by
$x(t) = x_0 \left(1 - e^{-rt}\right); t \geq 0, x_0 > 0$

   a. where does the particle start and with what velocity?
   b. find the maximum and minimum values of x(t), v(t), a(t). Show that x(t) and a(t) increases with time and v(t) decreases with time.

   Main concept used: By calculating v(t) and a(t) with the help of x(t), then determining the maximum and minimum value of x(t),v(t) and a(t).

30. Prove that in an elastic collision in one dimension the relative velocity of approach before impact is equal to the relative velocity of separation after impact.

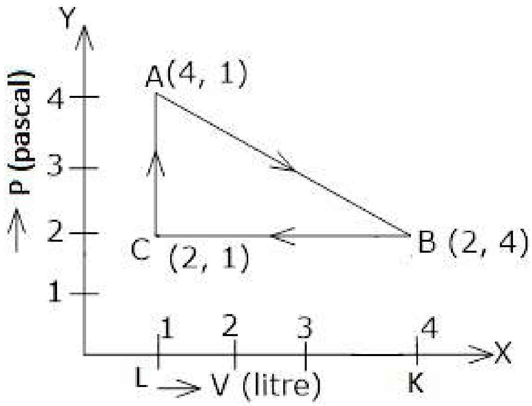
31. Assuming the earth to be a sphere of uniform mass density, how much would body weigh halfway down to the centre of the earth if it weighted 250 N on the surface?

32. Water flows through a horizontal pipe of which the cross - section is not constant. The pressure is 1cm of mercury where the velocity is 0.35m/s. Find the pressure at a point where the velocity is 0.65m/s.

OR

State the principle on which Hydraulic lift work and explain its working?

33. Deduce the work done in the following complete cycle.



34. The earth has a radius of 6400 km. The inner core of 1000 km radius is solid. Outside it, there is a region from 1000 km to a radius of 3500 km which is in molten state. Then again from 3500 km to 6400 km the earth is solid. Only longitudinal (P) waves can travel inside a liquid. Assume that the P wave has a speed of 8 km/second in solid parts and of 5 km/second in liquid parts of the earth. An earthquake occurs at some place close to the surface of the earth. Calculate the time after which it will be recorded in a seismometer at a diametrically opposite point on the earth if wave travels along diameter.

35. i. Obtain an expression for the centripetal force required to make a body of mass m moving with a speed v around a circular path of radius r.
    ii. A disc revolves with a speed of $33\frac{1}{3}$ rev/min, and has a radius of 15 cm. Two coins are placed at 4 cm and 14 cm away from the centre of the record. If the co-efficient of friction between the coins and the record is 0.15, which of the coins will revolve with the record? (Take g = 10 m/s^2)

OR

a. State three basic laws of motion. Show that the first law of motion gives the definition of force and the second law of motion gives the measure of force.
b. A truck starts from rest and accelerates uniformly at 2.0 ms^{-2}. At t = 10 s, a stone is dropped by a person standing on the top of the truck (the height of the top of the truck is 6 m from the ground). What are the magnitudes and directions of velocity, and acceleration of the stone at t = 11 s? (Neglect air resistance.)

36. A solid cylinder rolls up an inclined plane of angle of inclination 30°. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of 5 m/s.

a. How far will the cylinder go up the plane?
b. How long will it take to return to the bottom?

OR

Find the centre of mass of a uniform

i. half-disc,
ii. quarter-disc.

37. Take the position of mass when the spring is unstreched as x = 0, and the direction from left to right as the positive direction of x-axis. Give x as a function of time t for the oscillating mass if at the moment we start the stopwatch (t = 0), the mass is

a. at the mean position,
b. at the maximum stretched position, and
c. at the maximum compressed position.

In what way do these functions for SHM differ from each other, in frequency, in amplitude or the initial phase?

OR

A tunnel is dug through the centre of the Earth. Show that a body of mass *'m'* when dropped from rest from one end of the tunnel will execute simple harmonic motion.

Solution
Section A

1. (d) Natural Science

   Explanation: The natural sciences seek to understand how the world and universe around us works. There are five major branches (top left to bottom right): Chemistry, astronomy, earth science, physics, and biology.
2. (b) 75 m/s

   Explanation: Initial velocity u = 150 m/s

   Angle $\theta = 30^{\backslash\text{textdegree}}$

   Vertical component is given by

   $v_y = usin\theta = 150sin30^{\backslash\text{textdegree}} = 150 \times \frac{1}{2}$

   = 75 m/s
3. (c) bob will go down in a parabolic path

   Explanation: At the mean position, the bob has a horizontal velocity. so when the string is cut, it will fall along a parabolic path under the effect of gravity.
4. (d) 8.54 m s^{-1}, 70° with x-axis

   Explanation:

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

   We know velocity is given by

   $\vec{v} = \frac{dr}{dt}$

   So, $\vec{v} = 3.0\hat{i} + 4t\hat{j}$

   Velocity after 2 seconds

   $\vec{v}_2 = 3\hat{i} + 8\hat{j}$

Magnitude of velocity = $\sqrt{(3)^2+(8)^2}$

= $\sqrt{73}$ = 8.54 ms^{-1}

Direction is given by

$\theta = tan^{-1}(\frac{8}{3}) = 69.5 \approx 70^{\circ}$ with x-axis

5. (c) depends only on the end points

   Explanation: A force is said to be conservative if work done by this force is independent of path and is dependent only on end points .
6. (c) a large amount of plastic deformation takes place between the elastic limit and the fracture point

   Explanation: If The ultimate strength and fracture points are close in stress-strain curve, the material is said to be brittle. If they are far apart, the material is said to be ductile and show large plastic range.
7. (c) 10.9 g

   Explanation: Heat given by steam = heat taken by water + heat taken by container

   $$ms_s\Delta T_1 + mL + ms_w\Delta T_2 = ms_w\Delta T_3 + ms_c\Delta T_3$$
   $$(m \times 2110 \times 30) + \left(m \times 2.26 \times 10^6\right) + (m \times 4186 \times 50)$$
   $$= (0.2 \times 4186 \times 30) + (0.1 \times 837 \times 30)$$
   mass of steam $m = 10.9gm$

8. (c) Count Rumford observed that boring of brass cannon generated a lot of heat

   Explanation: If heat were actually a substance, as many scientists of the time believed, it was difficult to see how so much of it could be produced during the boring of a metal cannon. Rumford showed that the amount of heat was not related to the quantity of filings produced
9. (a) 18.7 J / mol K

   Explanation: for monoatomic gas
   $$C_V = \frac{3}{2}R$$
   $$C_P = \frac{5}{2}R$$
   from conservation of energy
   $$C_V = \frac{n_1C_{V_1}+n_2C_{V_2}}{n_1+n_2} = \frac{(1\times1.5R)+(3\times2.5R)}{1+3} = \frac{9}{4}R$$

$C_V = \frac{9}{4} \times 8.31 = 18.7 J/\text{mol}K$

10. (c) No change in phase

    Explanation: When a wave travel from a denser medium to rarer medium , the phase change of wave is zero. But from rarer medium to denser medium it is π.

11. Dynamics

OR

very large

12. Binding energy

13. parabolic

14. Hydraulic stress

15. Freezing

16. $\theta = \tan^{-1}\frac{2}{2} = 45^{\circ}$

17. The sand bag is placed on a trolley that is moving with a uniform speed of 27 km/h. The external forces acting on the system of the sandbag and the trolley is zero. When the sand starts leaking from the bag, there will be no change in the velocity of the trolley. This is because the leaking action does not produce any external force on the system. This is in accordance with Newton's first law of motion. Hence, the speed of the trolley will remain 27 km/h.

18. Surface tension is the property of a free liquid surface by virtue of which that liquid surface try to attain minimum surface area. Thus, Due to surface tension the drops try to occupy minimum surface area, and for a given volume, sphere has minimum surface area. So rain drops are spherical in shape.

19. Given, γ = 1.41 and $R = 8.31 Jmol^{-1}K^{-1}$.

    We know, $C_V = \frac{R}{(\gamma-1)} = \frac{8.31}{(1.41-1)}$ = 20.3 J $mol^{-1}K^{-1}$

    $\because \quad \frac{C_p}{C_V} = \gamma \Rightarrow C_p = C_V \cdot \gamma$

    $= 20.3 \times \quad 1.41$

$= 28.623 J mol^{-1} K^{-1}.$

20. Comparing the equation in the question with the general equation
$y = y_1 \sin \omega t + y_2 \cos \omega t$

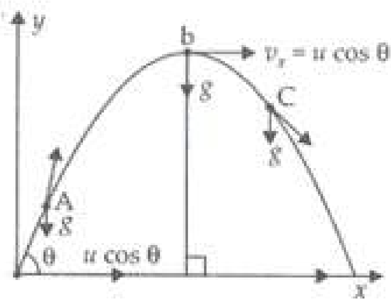
We get the resultant amplitude will be y = $\sqrt{y_1^2 + y_2^2} = \sqrt{9 + 16}$
$= \sqrt{25}$ = 5 cm

OR

Intensity = ampiltude$^2 \propto \frac{1}{(distance)^2}$
$\therefore$ required ratio = y/x

21. i. Both the curves are representing uniform linear motion.
ii. Uniform velocity of II is more than the velocity of I because slope of curve (II) is greater.

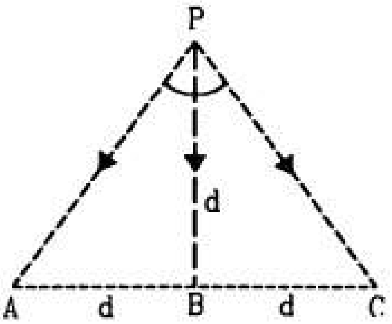
22. The motion of projectile is always parabolic or its part. Its velocity at any point of its path is always tangentially toward the direction of motion so velocities at points A, B and C are tangentially shown,
The point B is at its maximum height of trajectory. So the vertical component of B v_y = 0 and horizontal component is u cosθ.



As the direction of acceleration is always in the direction of the force acting on it. The gravitational force is acting on the body hence the direction of acceleration is always vertically downward equal to acceleration to gravity (g).

23. Although both torque and work are defined as force multiplied by distance, they differ in their physical meanings. Work is a scalar quantity and is equal to the scalar product of force and displacement i.e., W = $\vec{F} . \vec{s}$ = F s cos θ.
Torque is a measure of the rotational effect of force about an axis and is equal to the

vector product of force and position vector of point of application of force from the rotational axis i.e., $\vec{\tau} = \vec{r} \times \vec{F} = Fr\sin\theta\,\hat{n}$

24. 

The force at P due to A is $F_A = \frac{Gm^2}{(AP)^2} = \frac{Gm^2}{2d^2}$ along PA.

The force at P due to C is $F_C = \frac{Gm^2}{(CP)^2} = \frac{Gm^2}{2d^2}$ along PC.

The force at P due to B is $F_B = \frac{Gm^2}{d^2}$ along PB.
The resultant of $F_A, F_B\ and\ F_C$ will be along PB.
Clearly $\angle APB = \angle BPC = 45^o$.
Component at F_A along $PB = F_A cos 45^\circ = \frac{Gm^2}{2\sqrt{2}d^2}$
Component at Fc along $PB = F_C\ cos 45^\circ = \frac{Gm^2}{2\sqrt{2}d^2}$
Component at F_B along $PB = \frac{Gm^2}{d^2}$
The resultant of the three forces =
$\frac{Gm^2}{d^2}\left(\frac{1}{2\sqrt{2}} + \frac{1}{2\sqrt{2}} + 1\right) = \frac{Gm^2}{d^2}\left(1 + \frac{1}{\sqrt{2}}\right)$ along PB.

25. Here $\frac{\Delta V}{V}$ = 0.0098% = $\frac{0.0098}{100}$ = 9.8×10^{-5}, p = 100 atmosphere = $100 \times 1.013 \times 10^5$ Pa.
$\therefore$ Bulk modulus b = $-\frac{p}{\Delta V/V}$ = $-\frac{100 \times 1.013 \times 10^5}{(-9.8 \times 10^{-5})}$ = 1.034×10^{11} Pa.

26. It is observed that heat is required for change of state, although the temperature remains constant throughout the change of state.If mass m of a substance undergoes a change from one state
to the other, then the quantity of heat required is given by Q = mL or L = $\frac{Q}{m}$
Here, L is known as latent heat and is defined as the amount of heat required/released for complete conversion of unit mass of substance from one state to another.
SI unit of latent heat is J/kg.
Latent heat is of three types. Latent heat for a solid-liquid state change is called the

"latent heat of fusion". Latent heat for a liquid-gas state change is called the "latent heat of vaporisation" and that for a solid-gas state change is called the "latent heat of sublimation".

OR

Glass transmits about 50% of heat radiation coming from a hot source like the sun but does not allow the radiation from moderately hot bodies to pass through it. Due to this, when a car is left in the sun, heat radiation from the sun gets into the car but as the temperature inside the car is moderate, they do not pass back through its windows. Hence, inside of the car becomes considerably warmer.

27. At 273 K temperature and 1 atm pressure means STP condition.

$\therefore$ Number of H_2 molecules in volume of 22400 cm^3 at STP = 6.02×10^{23}(Avogadro's number)

Hence, number of H_2 molecules in 1 cm^3 of volume at STP

$= \frac{6.02 \times 10^{23}}{22400} = 2.6875 \times 10^{19}$

Now, number of degrees of freedom associated with each H_2 (diatomic) molecule = 5

Total number of degrees of freedom associated with $1cm^3$ of gas = total number of molecules × total degrees of freedom

= $2.6875 \times 10^{19} \times 5 = 1.34375 \times 10^{20}$

OR

i. We know that kinetic energy, $(KE)_{trans}$ = $\frac{3}{2}$nRT, R being universal gas constant.

   Given, n = 2 mol, T = 273 + 20 = 293 K

   $\therefore (\mathrm{KE})_{\text{trans}} = \frac{3}{2}(2)(8.31)(293) = 7.3 \times 10^3 \mathrm{J}$

ii. Average KE per molecule

   $= \frac{1}{2} m v_{rms}^2 = \frac{3}{2} k_B T = \frac{3}{2} \times \left(1.38 \times 10^{-23}\right) \times (293)$

   $= 6.07 \times 10^{-21} \mathrm{J}$

28. Paul Dirac was a British theoretical physicist who made fundamental contributions to the development of quantum mechanics, quantum field theory and quantum electrodynamics, and is particularly known for his attempts to unify the theories

of quantum mechanics and relativity theory.

One relation consists of some fundamental constants that give the age of the Universe by:

$$=\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\times\frac{1}{m_p m_e^2 c^3 G}$$

Where,

t = Age of Universe

e = Charge of electrons = $1.6\times10^{-19}C$

ε_0 = Absolute permittivity

m_p = Mass of protons = 1.67×10^{-27} kg

m_e = Mass of electrons = 9.1×10^{-31} kg

c = Speed of light = 3×10^{8} m/s

G = Universal gravitational constant $= 6.67\times10^{11}\,\mathrm{Nm^2kg^{-2}}$

Also, $\frac{1}{4\pi\varepsilon_0}=9\times10^{9}$ Nm^2/C^2

Substituting these values in the equation, we get

$$t=\frac{\left(1.6\times10^{-19}\right)^4\times\left(9\times10^{9}\right)^2}{\left(9.1\times10^{-31}\right)^2\times1.67\times10^{-27}\times\left(3\times10^{8}\right)^3\times6.67\times10^{-11}}$$

$$=\frac{(1.6)^4\times81}{9.1\times1.67\times27\times6.67}\times10^{-76+18+62+27-24+11}s$$

$$=\frac{(1.6)^4\times81}{9.1\times1.67\times27\times6.67\times365\times24\times3600}\times10^{-76+18+62+27-24+11}years$$

$\approx 6\times10^{-9}\times10^{18}$ years

= 6 billion years

(which is the approximate age of our universe)

29. a. When t = 0; x(t) = $x_0(1 - e^{-0}) = x_0(1 - 1) = 0$

$$x(t=0)=x_0\,\gamma e^{-0}=x_0\gamma(1)=\gamma x_0$$

b. x(t) is maximum when $t=\infty[x(t)]_{\max}=x_0$

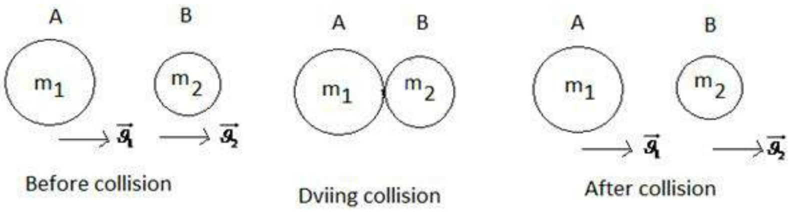
x(t) is minimum when t = $0[x(t)]_{min}$ = 0

v(t) is maximum when t = 0; $v(0)=x_0\gamma$

v(t) is minimum when $t=\infty;v(\infty)=0$

a(t) is maximum when $t=\infty;a(\infty)=0$

a(t) is minimum when t = 0; $a(0)=-x_0\gamma^2$

30. 

According to the question the collision is elastic in nature

so,= P_f (as per law of conservation of momentum)

and (K.E)i = (K.E)f(Kinetic Energy remains conserved during elastic collision)

As per conservation of momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$m_1(u_1 - v_1) = m_2(v_2 - u_2)$ ...(i)

K.E. also remains conserved during the elastic collision

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

$m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2)$ ...(ii)

Dividing equation (2) by equation (1), we get

$u_1 - v_1 = v_2 + u_2$

$u_1 - u_2 = v_2 - v_1$

Relative velocity of approach = Relative velocity of separation.

31. Weight of the body at the earth's surface

$w = mg = 250N$...............(i)

Acceleration due to gravity at depth d from the earth's surface

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

here, $d = \frac{R}{2}$

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

$\Rightarrow g' = \frac{g}{2}$

$\therefore$ The weight of the body at depth d

$\Rightarrow w' = mg' = \frac{mg}{2}$

Using Eq. (i) we get

$w' = \frac{250}{2} = 125N$

$\therefore$ Weight of the body will be $125N$.

32. At one point, P_1 = 1 cm of Hg

= 0.01m of Hg

= $0.01 \times (13.6 \times 10^3) \times 9.8$ Pa

Velocity, V_1 = 0.35m|s

At another point, P_2 = ?

V_2 = 0.65m|s

Density of water, s = 10^3 Kg | m^3

According to Bernoulli's theorem,

$$P_1 + \frac{1}{2} s V_1^2 = P_2 + \frac{1}{2} s V_2^2$$

$$P_2 = P_1 - \frac{1}{2} s \left(V_2^2 - V_1^2\right)$$

$$= 0.01 \times 13.6 \times 10^3 \times 9.8 - \frac{1}{2} \times 10^3 \left((0.65)^2 - (0.35)^2\right)$$

$$= 13.6 \times 10^1 \times 9.8 - \frac{1}{2} \times 10^3 (0.4225 - 0.1225)$$

$$= 1332.8 - \frac{1}{2} \times 10^3 \times (0.3)$$

= $1332.8 - 0.15 \times 10^3$

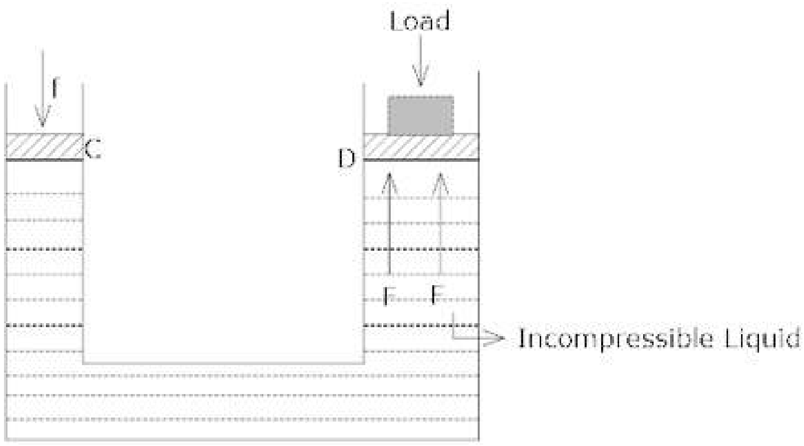
= 1332.8 - 150

= 1182.8 Pa or $\frac{1182.8}{9.8 \times 13.6 \times 10^3} m$ of Hg

P_2 = 0.00887 m 0f Hg

OR

Hydraulic lift works on the principle of the Pascal's law. According to this law, in a fluid at rest in a closed container, a change in pressure in one part is transmitted without loss to every portion of the fluid and to the walls of the container.
Working of Hydraulic effect:



a = Area of cross-section of piston at C

A = Area of cross-section of piston at D.

Let a downward force f be applied on the piston C. Then the pressure exerted on the liquid, $P = \frac{f}{a}$

According to Pascal's law, this pressure is transmitted equally to piston of cylinder D.

∴ Upward fore acting on the piston of cylinder D will be :

F = Pressure exerted by the smaller piston × area of cross-section of the larger piston = P $\times$ A

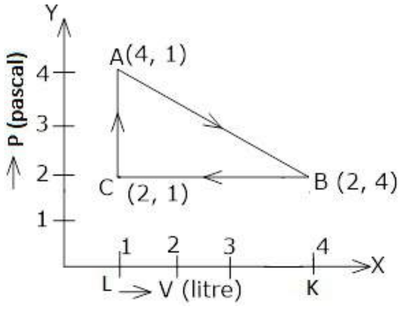
$= \frac{f}{a}A$

= $f \times \frac{A}{a}$

Now, as A ≫ a, hence F ≫ f

i.e. small fore applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which heavy load placed on larger piston is easily lifted upwards.

These lifts are used in automotive, shipping, construction, waste removal, mining, and retail industries as they're an effective means of raising and lowering people, goods, and equipment.

33. 

BC = KL = 4 - 1 = 3 $litre$ = 3 $\times$ $10^{-3} m^3$ ($\because 1m^3 = 1000 litre$)

AC = 4 - 2 = 2 pa

LC = 2 - 0 = 2 pa

i. Let W_{AB} is the work done during the process from A to B

Now, Work done = Area under the P - V curve

W_{AB} = area (ABKLA)

= area of ΔABC + area of rectangle BKLC

$= \left(\frac{1}{2} \times BC \times AC\right) + (KL \times LC)$

$W_{AB} = \left(\frac{1}{2} \times 3 \times 10^{-3} \times 2\right) + \left(3 \times 10^{-3} \times 2\right)$

$= 3 \times 10^{-3} + 6 \times 10^{-3}$

$W_{AB} = 9 \times 10^{-3} J$

Since gas expands during this process, hence, W_{AB} is positive

ii. Let work done during process(compression) B to C is W_{BC}

W_{BC} = - area of rectangle BCLK

(Negative because gas compresses during BC)

= - KL $\times$ LC

$W_{BC} = -3 \times 10^{-3} \times 2$

$= -6 \times 10^{-3} J$

iii. Let W_{CA} be the work done during the process from C to A:-

As there is no change in volume of gas in this process, W_{CA} = O

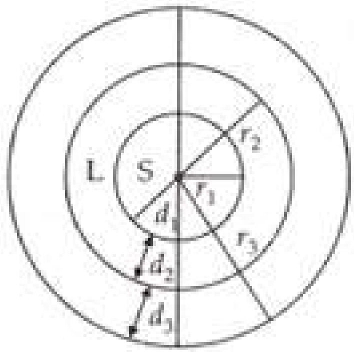
So, net work done during the complete cycle = W_{AB} + W_{BC} + W_{CA}

$= 9 \times 10^{-3} - 6 \times 10^{-3} + 0$

Net work done $= 3 \times 10^{-3} J$

34. Consider the figure. Here, r_1 = 1000 km, r_2 = 3500 km, r_3 = 6400 km,

So, $d_1 = r_1$ = 1000 km, $d_2 = r_2 - r_1$ = 3500 - 1000 = 2500 km, $d_3 = r_3 - r_2$ = 6400 - 3500 = 2900 km



Solid part along diametrically,

$= 2\,(d_1 + d_3) = 2(1000 + 2900)$

= $2 \times 3900\text{km}$

Time taken by wave in solid part $= \frac{3900 \times 2}{8}\ sec$

Liquid part along diametrically $= 2d_2 = 2 \times 2500$

$\therefore$ Time taken by seismic wave in liquid part $= \frac{2 \times 2500}{5}$ sec

Total time$= \frac{2 \times 3900}{8} + \frac{2 \times 2500}{5} = 2\left[\frac{3900}{8} + \frac{2500}{5}\right]$

$= 2[487.5 + 500] = 2 \times 987.5 = 1975\text{sec}$

$= 32\min 55\text{sec}$

35. i. In order to maintain uniform circular motion of a particle, a force is needed because uniform circular motion is an accelerated motion. The force is known as the centripetal force. Thus, centripetal force is the force required in order to make an object move along a circular path with uniform speed. The force acts along the radius and is directed towards the centre of circular path. The centripetal force F acting on a particle moving uniformly in a circle may depend upon mass (m), velocity (v), and radius (r) of the circle.

    We know that centripetal acceleration of a particle moving with a constant speed v along a circle of radius r is given by:

    $a_c = \frac{v^2}{r}$ ....(1)

    Hence, according to Newton's second law of motion, for a particle of mass m, we have

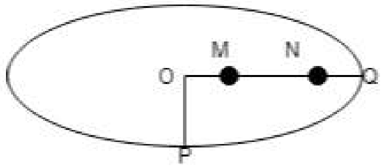
    The centripetal force F = ma_c = $\frac{mv^2}{r}$ [by using equation (1)]

    As v = rω, where ω is the angular velocity of the particle, then

    F = $\frac{m}{r}(r\omega)^2 = mr\omega^2$

which is the required expression for the centripetal force.

ii. Say, mass of each coin = m
Radius of the disc, OP = OQ = r = 15 cm = 0.15 m
Frequency of revolution, $\nu = 33\frac{1}{3}$ rev/min $= \frac{100}{3\times60}\ rev/sec = \frac{5}{9}\ rev/sec$
Coefficient of static friction, μ_s = 0.15
In the given situation, the coin having a force of static friction greater than or equal to the centripetal force provided by the rotation of the disc will revolve with the disc. If the static frictional force value is less than the centripetal force provided by the rotation of the disc, then the coin will slip from the disc.



<u>Coin placed at 4cm from the centre:</u>
Radius of revolution, OM = r' = 4 cm = 0.04 m
Angular frequency or angular velocity of the disc (shown in the figure also),
$\omega = 2\pi\nu = 2 \times \frac{22}{7} \times \frac{5}{9} = 3.49s^{-1}$
Static frictional force, f_s = μ_s mg = 0.15 $\times$ m $\times$ 10 = 1.5m N (This value is same for both the coins, as they have equal mass)
Centripetal force on this coin:
$F'_{centripetal} = mr'\omega^2$
$= m \times 0.04 \times (3.49)^2$
= 0.49m N
Since $f_s > F'_{centripetal}$, the coin will revolve along with the record.

<u>Coin placed at 14cm from the centre:</u>
Radius, ON = r" = 14 cm = 0.14 m
Angular frequency, $\omega = 3.49\ s^{-1}$
Static frictional force, f_s = 1.5m N (same, as was for the first coin)
Centripetal force on this coin is given as:
$F''_{centripetal} = mr''\omega^2$
$= m \times 0.14 \times (3.49)^2$ = 1.7m N
Since $f_s < F''_{centripetal}$, the coin will slip from the surface of the record.

OR

a. **Newton's First Law of Motion** also known as **Law of Inertia** states that every object persists to stay in uniform motion in a straight line or in the state of rest unless an external force acts upon it. In a simpler form, the first law of motion may also be stated as "If the net external force on a body is zero, its acceleration is zero. Acceleration can be non-zero only if there is a net external force on the body".

Newton's Second Law of Motion states that force is equal to the change in momentum per change in time. For a constant mass, force equals mass times acceleration, i.e.

F = ma

Thus, $\vec{F} \propto \frac{\Delta \vec{p}}{\Delta t}$ or $\vec{F} = k\frac{\Delta \vec{p}}{\Delta t}$, where k is a constant of proportionality, Δp is the change in momentum and p = mv.

Newton's Third Law of Motion: It states that "For every action, there is an equal and opposite reaction".

According to the first law of motion, in the absence of an external force, a body will maintain its position of rest or state of uniform motion along a straight line. Thus, to change the position of rest or uniform motion of a body, we shall have to apply an external force. If the external force is large enough, it may change the state of rest or of uniform motion. However, if the magnitude of the force is small then it may not be able to change that state. Hence, "force is that external cause (push or pull) which changes or tries to change the state of rest or of uniform motion along a straight line of a given body".

Also, we know that,

F = ma

where F is the vector sum of all forces acting on the body, m is the mass of body and equation can be regarded as a statement of Newton's 2nd law of motion. This relation can be used to have the measure of a force.

b. Horizontal and vertical components of initial velocity of the truck are u_x = 0 and u_y = 0 respectively.

Horizontal component of acceleration, a_x = 2 m/s^2

Now at time, t = 10 s

As per the first equation of motion, horizontal component of final velocity is given as:

$v_x = u_x + a_x t$

= 0 + (2 $\times$ 10) = 20 m/s

The horizontal component of final velocity of the truck and hence, the horizontal component of initial velocity of the stone is 20 m/s.

At t = 11 s, the horizontal component (v_x) of velocity of the stone, in the absence of air resistance, remains unchanged, i.e.,

v_x = 20 m/s

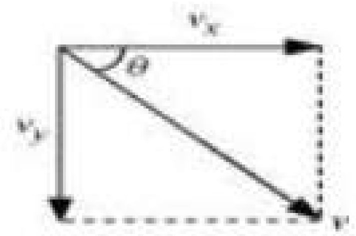
The vertical component (v_y) of velocity of the stone at that time is given by the first equation of motion as:

$v_y = u_y + a_y t$

Starting from rest upto t = 10 s, the stone don't have any vertical component of velocity. But from t = 10 s to t = 11 s, stone gains vertical component of velocity(v_y), whereas the horizontal component of the velocity remains same. Now for t=11-10 = 1 s, $a_y = g = 10\text{m/s}^2$

$\therefore v_y = u_y + a_y t = 0 + 10 \times 1 = 10\text{m/s}$

Hence the resultant velocity (v) of the stone using parallelogram law of vector addition is given as (in this case the angle between v_x and v_y is equal to 90^0):



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

$= \sqrt{20^2 + 10^2} = \sqrt{400 + 100}$

$= \sqrt{500} = 22.36 m/s$

Let θ be the angle made by the resultant velocity with the horizontal component of velocity, v_x

$\therefore \tan\theta = \left(\frac{v_y}{v_x}\right)$

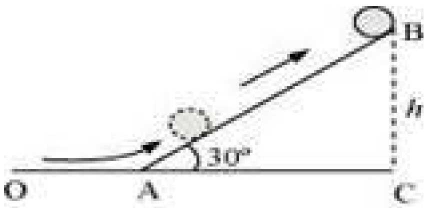
$\theta = \tan^{-1}\left(\frac{10}{20}\right)$

$= \tan^{-1}(0.5)$

= 26.57°

When the stone is just dropped from the truck, the horizontal force acting on it becomes zero. However, the stone continues to move under the influence of gravity having only the horizontal component of velocity and follows projectile motion. Hence, the acceleration of the stone is equal to 'g' i.e.10 m/s^2 acting downwards and stone covers a parabolic path i.e. the trajectory of stone becomes a parabola.

36. A solid cylinder rolling up an inclination is shown in the following figure.



Initial velocity of the solid cylinder, v = 5 m/s

Angle of inclination, $\theta = 30^{\circ}$

Height reached by the cylinder = h

a. Energy of the cylinder at point A will be purely kinetic due to the rotation and translational motion. Hence, total energy at A

= KE_{rot} + KE_{trans}

= $\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

The energy of the cylinder at point B will be purely in the form of gravitational potential energy = mgh

Using the law of conservation of energy, we can write:

$\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = mgh$

Moment of inertia of the solid cylinder, $I = \frac{1}{2}mr^2$

$\therefore \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2 + \frac{1}{2}mv^2 = mgh$

$\frac{1}{4}I\omega^2 + \frac{1}{2}mv^2 = mgh$

But we have the relation, $v = r\omega$

$\therefore \frac{1}{4}v^2 + \frac{1}{2}v^2 = gh$

$\frac{3}{4}v^2 = gh$

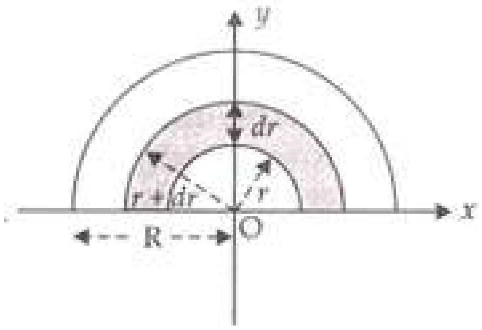
$\therefore h = \frac{3}{4}\frac{v^2}{g}$
$= \frac{3}{4} \times \frac{5 \times 5}{9.8} = 1.91\text{m}$

To find the distance covered along the inclined plane
In ΔABC:
$\sin\theta = \frac{BC}{AB}$
$\sin 30^\circ = \frac{h}{AB}$
$AB = \frac{1.91}{0.5} = 3.82\text{m}$
Hence, the cylinder will travel 3.82 m up the inclined plane.

b. $v = \left(\frac{2gh}{1+\frac{K^2}{R^2}}\right)^{\frac{1}{2}}$
$\therefore v = \left(\frac{2gAB\sin\theta}{1+\frac{K^2}{R^2}}\right)^{\frac{1}{2}}$
For the solid cylinder, $K^2 = \frac{R^2}{2}$
$\therefore v = \left(\frac{2gAB\sin\theta}{1+\frac{1}{2}}\right)^{\frac{1}{2}}$
$= \left(\frac{4}{3}gAB\sin\theta\right)^{\frac{1}{2}}$
The time taken to return to the bottom is:
$t = \frac{AB}{v}$
$= \frac{AB}{\left(\frac{4}{3}gAB\sin\theta\right)^{\frac{1}{2}}} = \left(\frac{3AB}{4g\sin\theta}\right)^{\frac{1}{2}}$
$= \left(\frac{11.46}{19.6}\right)^{\frac{1}{2}} = 0.7645$
So the total time taken by the cylinder to return to the bottom is (2×0.764)= 1.53 s.as time of ascend is equal to time of descend for the following problem.

OR

Let mass of half disc is M.



i. Area of element $= \frac{\pi}{2}\left[(r+dr)^2 - r^2\right]$

$= \frac{\pi}{2}\left[r^2 + dr^2 + 2rdr - r^2\right]$

$= \pi rdr$

$\therefore$ Mass of elementary Ring $dm = \frac{2M}{\pi R^2} . \pi rdr$

$\mathrm{dm} = \frac{2M}{R^2} r . dr$

Let (x, y) are the co-ordinates of c.m. of this strip $(x, y) = \left(0, \frac{2r}{\pi}\right)$

$x = x_{cm} = \frac{1}{M}\int_0^R xdm = \int_0^R 0dm = 0$

$y_{cm} = \frac{1}{M}\int_0^R ydm = \frac{1}{M}\int_0^R \frac{2r}{\pi} \times \frac{2M}{R^2} rdr$

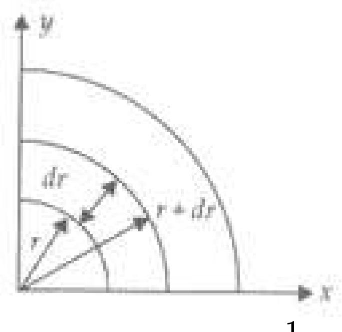
$= \frac{1}{m} \cdot \frac{4M}{\pi R^2}\int_0^R r^2 dr = \frac{4}{\pi R^2}\left[\frac{r^3}{3}\right]_0^R = \frac{4}{3\pi R^2} \cdot R^3$

$y_{cm} = \frac{4R}{3\pi}$

So centre of mass of circular half disc $= \left(0, \frac{4R}{3\pi}\right)$

ii. Mass per unit area of quarter disc

$\sigma = \frac{M}{\frac{\pi R^2}{4}} = \frac{4M}{\pi R^2}$.



Area of element = $\frac{1}{2}$

dm = $\frac{1}{2}\pi rdr \times \sigma = \frac{2Mr}{R^2} dr$

$X_{cm} = \int_0^R xdm = \frac{4R}{3\pi}$

Similarly $Y_{cm} = \frac{4R}{3\pi}$

center of mass = ($\frac{4R}{3\pi}$, $\frac{4R}{3\pi}$)

37. $\rightarrow$The functions have the same frequency and amplitude, but different initial phases.

Given:

Distance travelled by the mass sideways, A = 2.0 cm

Force constant of the spring, k = 1200 N m^{-1}

Mass, m = 3 kg

Angular frequency of oscillation is given by:

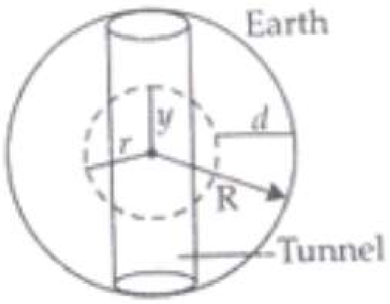
$$\omega = \sqrt{\frac{spring\ cons\tan t}{mass}}$$

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

$$= \sqrt{\frac{1200}{3}} = \sqrt{400} = 20\text{rads}^{-1}$$

a. When the mass is at the mean position, initial phase is 0.
   Displacement,$\rightarrow$ x = Asin ωt = 2sin 20t
b. At the maximum stretched position, the mass is toward the extreme right. Hence, the initial phase is $\frac{\pi}{2}$.
   Displacement,$\rightarrow x = A\sin\left(\omega t + \frac{\pi}{2}\right)$
   $= 2\sin\left(20t + \frac{\pi}{2}\right)$ = 2cos 20t
c. At the maximum compressed position, the mass is toward the extreme left. Hence, the initial phase is $\frac{3\pi}{2}$.
   Displacement$\rightarrow$, $x = A\sin\left(\omega t + \frac{3\pi}{2}\right)$
   $= 2\sin\left(20t + \frac{3\pi}{2}\right)$ = –2cos 20t
d. The functions have the same frequency $\left(\frac{20}{2\pi}Hz\right)$ and amplitude (2 cm), but initial phases are different $\left(0, \frac{\pi}{2}, \frac{3\pi}{2}\right)$.

OR



If the acceleration due to gravity of earth inside the earth is at a depth of d is g', then we know that,

$g' = g\left(1 - \frac{d}{R}\right) = g\left[\frac{R-d}{R}\right]$ .....(i)(g = acceleration due to gravity on the surface of the earth, R = Radius of earth)

Now if 'y' be distance of the point where acceleration due to gravity is g' from the centre of the earth, then $R - d = y$, and from equation (i) we get,

$\therefore g' = g\frac{y}{R}$

Force on the body of mass m placed at depth d from the surface of the earth is

$F = -mg' = -mg\frac{y}{R}$

$F \propto (-y)$, i.e. the force is proportional to displacement but opposite to the direction of displacement.

So motion of body in tunnel is SHM.

Now to get the time period of this simple harmonic motion we can write,

$ma = -mg'$

$\Rightarrow a = \frac{-g}{R}y$

$\therefore -\omega^2 y = \frac{-g}{R}y \left(\because a = -\omega^2 y\right)$

$\therefore \frac{2\pi}{T} = \sqrt{\frac{g}{R}}$ or $T = 2\pi\sqrt{\frac{R}{g}}$,

This is the time period of the simple harmonic motion executed by the body.