Class 11 - Physics
Sample Paper - 01 (2023-24)

Maximum Marks: 70
Time Allowed: : 3 hours

General Instructions:

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study-based questions of four marks each and Section E contains three long answer questions of five marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

Section A

1. Young's modulus of steel is 1.9×10^{11} N/m^2. When expressed in CGS units of dynes/cm^2, it will be equal to (1N = 10^5 dyne, 1m^2 = 10^4 cm^2)
   a) 1.9×10^{10}
   b) 1.9×10^{11}
   c) 1.9×10^{12}
   d) 1.9×10^{13}
2. The human ear is most sensitive to sound in the frequency range of:
   a) 1000 to 2000 Hz
   b) 200 to 400 Hz
   c) 10000 to 20000 Hz
   d) 20 to 20000 Hz
3. Centre of gravity can be defined:
   a) as that point where the total gravitational torque on the body is greater than zero
   b) as the center of mass
   c) as that point where the total gravitational torque on the body is zero
   d) as that point where the total gravitational force on the body is zero
4. What will be the height of a liquid column in a capillary tube on the surface of the moon?
   a) 1/6th of what was on earth's surface
   b) Six times that on the earth's surface
   c) It will remain unchanged
   d) 36 times that on earth's surface
5. The formula for gravitational potential energy associated with two particles of masses m_1 and m_2 separated by distance r is given by
   a) $v = -\frac{Gm_1}{r}$

b) v $= -\frac{Gm_1m_2}{r}$
c) v $= -\frac{Gm_2}{r}$
d) v $= -\frac{Gm_1m_2}{2r}$

6. A source of sound gives 5 beats per second when sounded with another source of frequency 100 second^{-1}. The second harmonic of the source, together with a source of frequency 205 sec^{-1} gives 5 beats per second. What is the frequency of the source?
   a) 100 second^{-1}
   b) 105 second $^{-1}$
   c) 205 second^{-1}
   d) 95 second^{-1}
7. Motion along a straight line is called __________.
   a) parabolic motion
   b) circular motion
   c) oscillatory motion
   d) rectilinear motion
8. A transverse wave is represented by y = sin (ωt - kx) For what value of the wavelength is the wave velocity equal to the maximum particle velocity?
   a) $\frac{\pi A}{2}$
   b) πA
   c) 2 πA
   d) A
9. Pressures inside two soap bubbles are 1.01 atm and 1.03 atm, ratio between their volumes is
   a) 3 : 1
   b) none of these
   c) 27 : 1
   d) 127 : 101
10. There is no atmosphere on the moon, because
    i. it is closer to the earth and also it has the inactive inert gases in it.
    ii. it is too far from the sun and has very low pressure in its outer surface.
    iii. escape velocity of gas molecules is greater than their root mean square velocity.
    iv. escape velocity of gas molecules is less than their root mean square velocity.
    a) Option ii
    b) Option i
    c) Option iii
    d) Option iv
11. Two rings of radii R and nR made from the same wire have the ratio of moments of inertia about an axis passing through their centre equal to 1 : 8. The value of n is
    a) 2
    b) 4
    c) $2\sqrt{2}$
    d) $\frac{1}{2}$
12. When water is heated from 0°C to 10°C its volume

a) increases continuously

b) first decreases and then increases

c) decreases continuously

d) first increases and then decreases

13. **Assertion:** n small balls each of mass m colliding plastically each second on surface which velocity u. The force experienced by the surface is 2mnu.

Reason: On elastic collision, the ball rebounds with the 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.

14. **Assertion:** The value of AQ is always zero in adiabatic process.

Reason: Adiabatic process is always a cyclic process.

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.

15. **Assertion (A):** If earth were a hollow sphere, gravitational field intensity at any point inside the earth would be zero.

Reason (R): Net force on a body inside the sphere is zero.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

16. **Assertion (A):** In projectile motion, the angle between the instantaneous velocity and acceleration at the highest point is 180°.

Reason (R): At the highest point, velocity of projectile will be in horizontal direction only.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

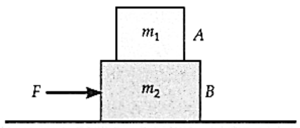
Section B

17. At what temperature (in °C) will the speed of sound in air be 3 times its value at 0°C?

18. 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?

19. A gas bubble, from an explosion underwater, oscillates with a period T proportional to $p^a d^b E^c$, where p is the static pressure, d is the density of water and E is the total energy of the explosion. Find the values of a, b and c.

20. A block A of mass 4 kg is placed on another block B of mass 5 kg, and the block B rests on a smooth horizontal table. For sliding the block A on B, a horizontal force of 12 N is required to be applied on it. How much maximum horizontal force can be applied on B so that both A and B move together? Also find out the acceleration produced by this force.



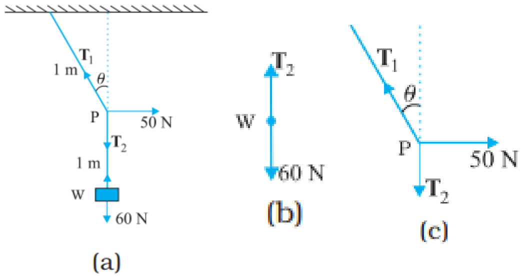
21. The distance of the planet Jupiter from the sun is 5.2 times that of the earth. Find the period of the Jupiter's revolution around the sun?

OR

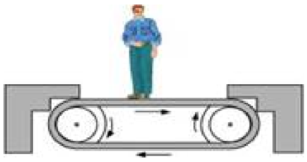
What is the difference between inertial mass and gravitational mass of a body?

Section C

22. Eight rain drops of radius 1 mm each falling down with terminal velocity of 5 cms^{-1} coalesce to form a bigger drop. Find the terminal velocity of the bigger drop.
23. Develop a relation between the co-efficient of linear expansion, co-efficient superficial expansion and coefficient of cubical expansion of a solid.
24. A parachutist bails out from an aeroplane and after dropping through a distance of 40 m, he opens the parachute and decelerates at 2 ms^{-2}. If he reaches the ground with a speed of 2 ms^{-1}, how long is he in the air? At what height did he bailout from the plane?
25. A mass of 6 kg is suspended by a rope of length 2 m from the ceiling. A force of 50 N in the horizontal direction is applied at the midpoint P of the rope, as shown. What is the angle the rope makes with the vertical in equilibrium? (Take g = 10 ms^{-2}). Neglect the mass of the rope.



26. Explain, why?
    i. 500 J of work is done on a gas to reduce its volume by compression adiabatically. What is the change in internal energy of the gas?
    ii. The coolant in a chemical or a nuclear plant, i.e. the liquid used to prevent the different parts of a plant from getting too hot should have high specific heat.
    iii. The climate of a harbour town is more temperate than that of a town in a desert at the same latitude.
27. Figure shows a man standing stationary with respect to a horizontal conveyor belt that is accelerating with 1 ms^{-2}. What is the net force on the man? If the coefficient of static friction between the man's shoes and the belt is 0.2, up to what acceleration of the belt can the man continue to be stationary relative to the belt? (Mass of the man = 65 kg.)



28. Briefly discuss how Pascal's law is affected by gravity. Hence obtain Pascal's law of transmission of pressure.

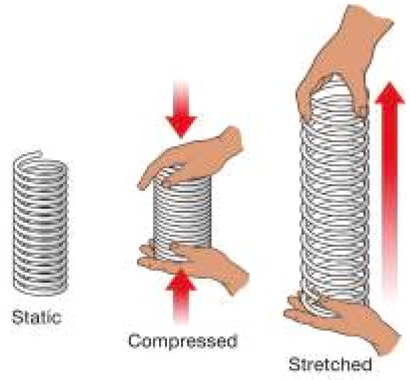
OR

To what height should a cylindrical vessel be filled with a homogeneous liquid to make the force, with which the liquid presses the side of the vessel equal to the force exerted by the liquid on the bottom of the vessel?

Section D

29. **Read the text carefully and answer the questions:**
    Elastic potential energy is Potential energy stored as a result of the deformation of an elastic object, such as the stretching of a spring. It is equal to the work done to stretch the spring, which depends upon the spring constant k as well

as the distance stretched



i. If stretch in spring of force constant k is doubled, then the ratio of final to initial forces is:
 a) 4:1
 b) 1:4
 c) 2:1
 d) 1:2

ii. A light body and a heavy body have the same kinetic energy. which one has greater linear momentum?
 a) light body
 b) both heavy and light body
 c) none of these
 d) heavy body

iii. A spring is cut into two equal halves. How is the spring constant of each half affected?
 a) becomes double
 b) none of these
 c) becomes 1/4th
 d) becomes half

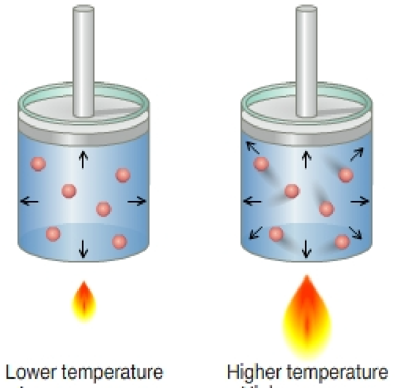
OR

When spring is compressed, its potential energy:
 a) none of these
 b) decrease
 c) first increase then decrease
 d) increase

iv. What type of energy is stored in the spring of a watch?
 a) potential energy
 b) none of these
 c) mechanical energy
 d) kinetic energy

30. **Read the text carefully and answer the questions:**

In a gas the particles are always in a state of random motion, all the particles move at different speed constantly colliding and changing their speed and direction, as speed increases it will result in an increase in its kinetic energy.



i. If the temperature of the gas increases from 300 K to 600 K then the average kinetic energy becomes:
   a) same
   b) becomes double
   c) becomes half
   d) none of these

ii. What is the average velocity of the molecules of an ideal gas?
   a) Infinite
   b) Same
   c) None of these
   d) Zero

iii. Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will ________.
   a) decrease
   b) none of these
   c) increase
   d) remains same

iv. Find the ratio of average kinetic energy per molecule of Oxygen and Hydrogen:
   a) 1:1
   b) 4:1
   c) 1:2
   d) 1:4

OR

The velocities of the three molecules are 3v, 4v, and 5v. calculate their root mean square velocity?
   a) 4.0 v
   b) 4.02 v
   c) 4.08 v
   d) 4.04 v

Section E

31. A person normally weighing 50 kg stands on a mass less platform which oscillates up and down harmonically at a frequency of 2.0 s^{-1} and an amplitude 5.0 cm. A weighing machine on the platform gives the persons weight against time.

i. Will there be any change in weight of the body, during the oscillation? Figure In extensible string.
ii. If answer to part (a) is yes, what will be the maximum and minimum reading in the machine and at which position?

OR

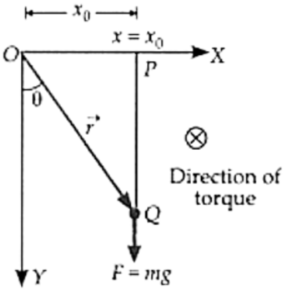
The motion of a particle executing simple harmonic motion is described by the displacement function, x(t) = Acos(ωt + ϕ) If the initial (t = 0) position of the particle is 1 cm and its initial velocity is ω cm /s, then what are its amplitude and initial phase angle? The angular frequency of the particle is π s^{-1}. If instead of the cosine function, we choose the sine function to describe the SHM, x = Bsin(ωt + ϕ), then what are the amplitude and initial phase of the particle with the above initial conditions?

32. A marble rolls along a table at a constant speed of 1.00 m/s and then falls off the edge of the table to the floor 1.00 m below,
    i. How long does the marble take to reach the floor?
    ii. At what horizontal distance from the edge of the table does the marble land?
    iii. What is its velocity as it strikes the floor?

OR

a. What is the angle between $\vec{A}$ and $\vec{B}$ if $\vec{A}$ and $\vec{B}$ denote the adjacent sides of a parallelogram drawn form a point and the area of the parallelogram is $\frac{1}{2}AB$?
b. State and prove triangular law of vector addition.

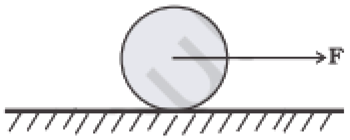
33. A particle of mass m is released from point P at x = x_0 on the X-axis from origin O and falls vertically along the Y-axis, as shown in Fig.



i. Find the torque t acting on the particle at a time t when it is at point Q with respect to O.
ii. Find the angular momentum L of the particle about O at this time t.
iii. Show that $\tau = \frac{dL}{dt}$ in this example.

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?

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Solution

Section A

1. (c) 1.9×10^{12}

   Explanation: According to the problem,

   Young's modulus, Y = 1.9×10^{11} N/m^2

   1N in SI system of units = 10^5 dyne in C.G.S system.

   Hence, Y = $1.9 \times 10^{11} \times 10^5$ dyne/m^2

   In C.G.S length is measured in unit cm, so we should also convert m into cm.

   $\therefore$ Y = $1.9 \times 10^{11}\left(\frac{10^5 \mathrm{dyne}}{10^4 \mathrm{cm}^2}\right)$ [$\because$ 1m = 100 cm]

   = 1.9×10^{12} dyne/cm^2
2. (d) 20 to 20000 Hz

   Explanation: Humans are most sensitive to (i.e. able to discern at lowest intensity) frequencies between 2,000 and 5,000 Hz. The human ear can respond to minute pressure variations in the air if they are in the audible frequency range, roughly 20 Hz - 20 kHz. This incredible sensitivity is enhanced by an effective amplification of the sound signal by the outer and middle ear structures.
3. (c) as that point where the total gravitational torque on the body is zero

   Explanation: The point at which the entire weight of a body may be thought of as centered so that if supported at this point the body would balance perfectly, so it can also be defined as that point where the total gravitational torque on the body is zero.
4. (b) Six times that on the earth's surface

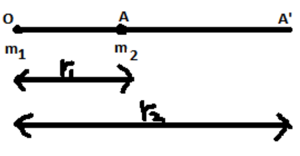
   Explanation: The height to which the liquid rises in a capillary tube is inversion all proportional to the acceleration due to gravity.

   $h=\frac{2 S \cos \theta}{r \rho g}$

   thus if all other parameters are fixed

   $h \propto \frac{1}{g}$

   On the surface of the moon, acceleration due to gravity is $\frac{1}{6}$th as that on the surface of the earth. Therefore the water will rise to a height 6 times that on earth's surface.
5. (b) $\mathrm{v}=-\frac{G m_1 m_2}{r}$

   Explanation: 

   Change in gravitational potential energy of a system is defined as the -ve of the work done by the gravitational force as the configuration of the system is changed.

   $U_f \ -U_i \ =W_{gr}=V(PotentialEnergy)$

   Change in gravitational potential energy of two point masses m_1 and m_2 as their separation is changed from r_1 to r_2 is given by

   $U\left(r_2\right)-U\left(r_1\right)=G m_1 m_2\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$

   If, at infinite separation, gravitational potential energy is assumed to be zero, then the gravitational potential energy of the above two point mass system at separation r,

$U(r)=-G\frac{m_1m_2}{r}$
$\therefore V=-G\frac{m_1m_2}{r}$
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6. (b) 105 second $^{-1}$

   Explanation: Frequency of the source = 100 $\pm$ 5 = 105 or 95 Hz

   The second harmonic of the source = 210 Hz or 190 Hz

   As the second harmonic gives 5 beats/sec with a sound of frequency 205 Hz, the second harmonic should be 210 Hz.

   $\therefore$ Frequency of the source = 105 Hz
7. (d) rectilinear motion

   Explanation: Rectilinear motion is another name for straight-line motion. This type of motion describes the movement of a particle or a body. A body is said to experience rectilinear motion if any two particles of the body travel the same distance along two parallel straight lines.
8. (c) 2 πA

   Explanation: Maximum particle velocity = Wave velocity

   $\omega A=\frac{\omega}{k}$

   or $k=\frac{2\pi}{\lambda}=\frac{1}{A}$

   $\therefore \lambda$ = 2 πA
9. (c) 27 : 1

   Explanation: Excess pressures in the two bubbles will be (1.01 -1) or 0.01 atm and (1.03 - 1) or 0.03 atm.

   $\frac{p_1}{p_2}=\frac{r_2}{r_1}$

   $\Rightarrow \frac{r_1}{r_2}=\frac{p_2}{p_1}=\frac{0.03}{0.01}$ = 3

   $\therefore \frac{V_1}{V_2}=\left(\frac{r_1}{r_2}\right)^3$ = 3^3 = 27 : 1
10. (d) Option iv

    Explanation: The required escape velocity of gas molecules is less than their root mean square velocity.
11. (a) 2

    Explanation: As radius of second ring is n times, length and hence mass of wire used is also n times.

    $\therefore \frac{I_1}{I_2}=\frac{MR^2}{nM(nR)^2}=\frac{1}{n^3}=\frac{1}{8}\therefore n=2$
12. (b) first decreases and then increases

    Explanation: Density of water is maximum at 4^{o}C. So during heating from 0^{o}C to 10^{o}C, its density increases at first and then it decreases resulting in the decrease in volume at first and then increase in its volume.
13. (a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

    Explanation: In elastic collision, kinetic energy remains conserved therefore the ball rebounds with the same velocity. According to Newton’s second law.

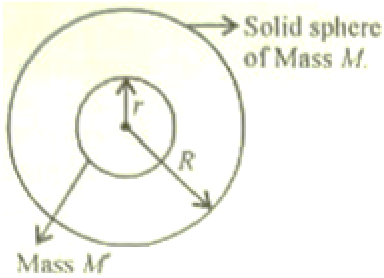
    F $\times$ t = change in linear momentum.

    $\therefore$ F $\times$ 1 = m $\times$n(u + u) or F = 2mnu
14. (c) Assertion is correct statement but reason is wrong statement.

    Explanation: Assertion is correct statement but reason is wrong statement.

15. (a) Both A and R are true and R is the correct explanation of A.

Explanation:



A uniform shell of matter exerts no gravitational force on a particle located inside it. This also means if a particle is located inside a uniform solid sphere of matter at a distance r from its centre, the gravitational force exerted on the particle is due only to the mass M' that lies within a sphere of radius r. This mass M' is given by M' = $\rho\frac{4\pi r^3}{3}$, where ρ is the density of the sphere.

16. (d) A is false but R is true.

Explanation: At the highest point, the instantaneous velocity is acting horizontally and acceleration of projectile (acceleration due to gravity) is acting vertically downward. Therefore, angle between velocity and acceleration at the highest point is 90°.

Section B

17. We know that, speed of sound, v $\propto \sqrt{T}$, T being absolute temperature.

where, T is in kelvin.

$\therefore \frac{V_t}{V_0} = \sqrt{\frac{273+t}{273+0}}$ = 3 (say, the required temperature is t°C)

$\Rightarrow \frac{273+t}{273}$ = 9

$\Rightarrow$ t = (9 $\times$ 273) - 273 = 2184°C

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

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

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

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

Therefore,

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

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

19. Let T = K p^a d^b E^c,

where K = a dimensionless constant.

Putting the dimensions of various quantities,

T = [ML^{-1} T^{-2}]^a [ML^{-3}]^b [ML^2 T^{-2}]^c

or M^0L^0T = M^{a+b+c} $L^{\sim a \sim 3b + 2c}$ $T^{-2a - 2c}$

Equating the powers of M, L and T on both sides, we get

a + b + c = 0, - a - 3b + 2c = 0, - 2a - 2c = 1

On solving,

a = $-\frac{5}{6}$, b = $\frac{1}{2}$, c = $\frac{1}{3}$

20. Here m_1 = 4 kg, m_2, = 5 kg

Force applied on block A = 12 N

This force must atleast be equal to the kinetic friction applied on A by B.

$\therefore$ 12 = f_k = μ_k R = μ_k m_1 g

or 12 = μ_k $\times$ 4 g

or $\mu_k = \frac{12}{4g} = \frac{3}{g}$

The block B is on a smooth surface. Hence to move A and B together, the (maximum) force F that can be applied on B is equal to the frictional forces applied on A by B and applied on B by A.

F = μ_k m_1g + μ_k m_2 g = μ_k (m_1 + m_2)g

$= \frac{3}{g}$(4 + 5)g = 27 N

As this force moves both the blocks together on a smooth table, so the acceleration produced is

$a = \frac{F}{m_1+m_2} = \frac{27}{4+5}$ = 3 ms^{-2}

21. Te = 1 year R_J = 5.2 R_e

According to the Kepler's third law

T^2 is directly proportional R^3

$\left(\frac{T_J}{Te}\right)^2 = \left(\frac{R_J}{\mathrm{Re}}\right)^3$

T_J = (5.2) $\frac{3}{2}$ $\times$ 1year

T_J = 11.86 year

OR

The inertial mass of a body is a measure of its inertia and is given by the ratio of the external force applied on it to the acceleration produced in it. The gravitational mass of a body, on the other hand, is a measure of the gravitational pull acting on it due to the earth. The gravitational mass is measured by a common balance.

Section C

22. Radius of each small drop, r = 1 mm = 0.1 cm

Terminal velocity of each small drop, v = 5 cms^{-1}

Volume of bigger drop = Volume of 8 small drops

$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

or R = 2r = 2 $\times$ 0.1 cm = 0.2 cm

Terminal velocity of each small drop is given by

v = $= \frac{2}{9}\frac{r^2}{\eta}(\rho - \rho')$ g ...(i)

Terminal velocity of bigger drop is given by

V = $\frac{2}{9}\frac{R^2}{\eta}(\rho - \rho') g$ ...(ii)

Dividing equation (ii) by (i), we get

$\frac{V}{v} = \frac{R^2}{r^2}$

or V = $v \times \frac{R^2}{r^2} = 5 \times \frac{(0.2)^2}{(0.1)^2}$

= 5 $\times$ 4 = 20 cms^{-1}

23. Since, co-efficient of linear expansion, α = $\frac{\Delta L}{L\Delta T}$

ΔL = change in length

L = length

ΔT = change in temperature, for an infinitesimally small change in temperature

$\alpha = \frac{dL}{LdT}$

Similarly, co-efficient of superficial expansion, β = $\frac{dS}{SdT}$

dS = infinitesimal change in area

S = original area

dT = infintesimaly change in temperature

S = L^2, $\beta = \frac{1}{L^2}\frac{dL^2}{dT} = 2L\frac{dL}{dT}$

$\beta = 2\alpha$

Similarly, co-efficient of cubical expansion, $\gamma = \frac{dV}{VdT}$

dV = infinitesimal change in volume

V = original volume

dT = infinitesimal change in temperature

$\gamma = \frac{1}{L^3}\frac{dL^3}{dT} = 3\frac{1}{L}\frac{dL}{dT} = 3\alpha$

$\alpha = \frac{\beta}{2} = \frac{\gamma}{3}$

24. When the parachutist falls freely :

    u = 0, v = 9.8 ms^{-2}, s = 40m, t = ?, u = ?

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

    $\therefore 40 = 0 + \frac{1}{2} \times 9.8 \times t^2$

    or t = $\sqrt{\frac{80}{9.8}} = \frac{20}{7}$ s = 2.86 s

    Also, v = u + gt = 0 + 9.8 $\times \frac{20}{7}$ = 28 ms^{-1}

    When the parachutist decelerates uniformly:

    u = 28 ms^{-1}, a = -2 ms^{-2}, 5 = 2 ms^{-1}

    Time taken, t = $\frac{v-u}{a} = \frac{2-28}{-2}$ = 13 s

    Distance, s = ut + $\frac{1}{2}at^2$ = 28 $\times$ 13 $-\frac{1}{2}\times$ 2 $\times$ $(13)^2$

    = 364 - 169 = 195 m

    Total time of parachutist in air

    = 2.86 + 13 = 15.86 s

    Height at which parachutist bails out

    = 40 + 195 = 235 m

25. Figure (b) and (c) are known as free-body diagrams. Figure (b) is the free-body diagram of W and Figure (c) is the free-body diagram of point P.

    Consider the equilibrium of the weight W. Clearly, T_2 = 6 $\times$ 10 = 60 N. Consider the equilibrium of the point P under the action of three forces - the tensions T_1 and T_2, and the horizontal force 50 N. The horizontal and vertical components of the resultant force must vanish separately:

    T_1 cosθ = T_2 = 60N

    T_1 sinθ = 50 N

    Which gives that

    $\tan\theta = \frac{5}{6}$ or $= \tan^{-1}\left(\frac{5}{6}\right) = 40^\circ$

    Note the answer does not depend on the length of the rope (assumed massless) nor on the point at which the horizontal force is applied.

26. i. $\because$ process is adiabatic

       $\therefore \Delta$ = 0

       Work done on the gas, ΔW = -500J

       According to the first law of thermodynamics.

       ΔQ = ΔU + ΔW $\Rightarrow$ ΔU = -ΔW = 500J

    ii. This is because heat absorbed by a substance (coolant) is directly proportional to the specific heat of the substance.

    iii. This is because in a harbour town, the relative humidity is more than in a desert town. Hence, the climate of a harbour town is without extremes of hot and cold.

27. Conveyor belt is accelerating with 1 m/s^2. A man is stationary with respect to horizontal conveyor belt

    Hence, acceleration of man = acceleration of belt = 1m/s^2

    Hence, Net force on the man = ma = 65 $\times$ 1 = 65 N direction of this force is opposite to direction of conveyor belt.

Coefficient of friction between the man's shoes and belt = 0.2. Let a' is the acceleration of the belt can the man continue to be stationary relative to the belt.

In equilibrium condition,

Friction force = ma'

$0.2 \times m \times g$ = ma'

a' = $0.2 \times g = 0.2 \times 10$ = 2m/s²

28. PASCAL LAW :-

One of the most important facts about fluid pressure is that a change in pressure at one part of the liquid will be transmitted without any change to other parts. This rule is known as Pascal's law.

Take a vessel containing a liquid in the equilibrium at rest. Consider a volume element of liquid of height h. In the absence of gravity, according to Pascal's law, the pressure at the upper section A and lower section B of the volume element should be same.

However, taking gravity into consideration we find the following forces acting on the said volume element:

i. Force P_1 (ΔA) acting vertically downward at the top face A,
ii. Force P_2 (ΔA) acting vertically upward at the bottom face B, and

Weight mg of the liquid in the volume element acting vertically downwards. Here, ΔA is the cross-section area of the given volume element.

For volume element to be in equilibrium net force acting on it should be zero. Therefore, we have

$P_1 \triangle A + mg - P_2 \triangle A = 0 \text{ or } P_1 \triangle A + mg = P_2 \triangle A$

But m = mass of volume element = ΔA.h.ρ, where ρ = density of the liquid

$\therefore P_1 \triangle A + \triangle A h \rho g = P_2 \triangle A$

$\Rightarrow P_2 = P_1 + h \rho g$

According to the above equation, if the pressure P_1 is increased in any way, the pressure P_2 must increase by exactly the same amount.

The pressure applied to any part of an enclosed liquid at rest is transmitted undiminished to every portion of the liquid as well as the walls of the container.

OR

Let h be the height of the liquid column of density ρ taken in the cylindrical vessel of radius r.

Force exerted by the liquid on the bottom of the vessel = Total weight of the liquid column

= mg = $\pi r^2 h \rho g$

Area of the sides of the vessel = 2 πrh

Average pressure exerted by the liquid on the sides of the vessel

= $\frac{\text{Pressure at the top} + \text{Pressure at the bottom}}{2}$

= $= \frac{0 + h\rho g}{2} = \frac{1}{2} h \rho g$

Force exerted by the liquid on the sided of the vessel

= Pressure $\times$ Area = $\frac{1}{2} h \rho g \times 2 \pi r h$

As the above two forces are given to be equal, so

$\frac{1}{2} h \rho g \times 2 \pi r h = \pi r^2 h \rho g$ or h = r

i.e., Height of liquid column

= Radius of the cylindrical vessel.

Section D

29. i. (c) 2:1

Explanation: 2:1

ii. (d) heavy body

Explanation: heavy body

iii. (a) becomes double

Explanation: becomes double

OR

(d) increase

Explanation: increase

iv. (a) potential energy

Explanation: potential energy

30. i. (b) becomes double

Explanation: becomes double

ii. (d) Zero

Explanation: Zero

iii. (d) remains same

Explanation: remains same

iv. (a) 1:1

Explanation: 1:1

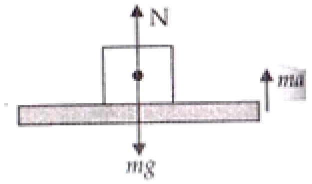
OR

(c) 4.08 v

Explanation: 4.08 v

Section E

31. a. Weight in weight machine will be due to the normal reaction (N) by platform. Consider the top position of platform, two forces acting on it are due to weight of person and oscillator. They both act downward.



(mg = weight of the person with the oscillator is acting downwards, ma = force due to oscillation is acting upwards, N = normal reaction force acting upwards)

Now for the downward motion of the system with an acceleration a,

ma = mg - N .....(i)

When platform lifts form its lowest position to upward

ma = N - mg ......(ii)

$a=\omega^2 A$ is value of acceleration of oscillator

$\therefore$ From equation (i) we get,

$N=mg-m\omega^2 A$

Where A is amplitude, ω angular frequency and m mass of oscillator.

$\omega=2\pi\nu$

$\therefore \omega=2\pi\times 2=4\pi\ rad/\text{sec}$

Again using $A=5\ cm=5\times 10^{-2}m$ we get

$N=50\times 9.8-50\times 4\pi\times 4\pi\times 5\times 10^{-2}$

$=50\left[9.8-16\pi^2\times 5\times 10^{-2}\right]$ N

$=50\left[9.8-80\times 3.14\times 3.14\times 10^{-2}\right]$ N

$\Rightarrow N = 50[9.8 - 7.89] = 50 \times 1.91 = 95.50$N

So minimum weight is 95.50 N(for downward motion of the platform)

From equation (ii), N – mg = ma

For upward motion from the lowest to the highest point of oscillator,

$N = mg + ma$

$= m\left[9.81 + \omega^2 A\right] \quad \because a = \omega^2 A$

$= 50\left[9.81 + 16\pi^2 \times 5 \times 10^{-2}\right]$

$= 50[9.81 + 7.89] = 50 \times 17.70$ N = 885 N

Hence, there is a change in weight of the body during oscillation.

b. The maximum weight is 885 N, when platform moves from lowest to upward direction.
   And the minimum weight is 95.5 N, when platform moves from the highest point to downward direction.

OR

Given, displacement equation x(t) = Acos($\omega t + \phi$) ...(i)

At t = 0; x(0) = 1 cm, velocity of the particle v = ωcm/s

Angular frequency $\omega = \pi$ s^{-1}

$\Rightarrow 1 = A\cos(\omega t + \phi)$

For t = 0, 1 = A cosϕ..........(i)

Now, $v(t) = \frac{dx(t)}{dt} = \frac{d}{dt}A\cos(\omega t + \phi)$

$= -A\omega\sin(\omega t + \phi)$

Again at t = 0, $v = \omega$ cm/s

$\Rightarrow \omega = -A\omega\sin\phi$

$\Rightarrow -1 = A\sin\phi$...........(ii)

Squaring and adding eqs.(i) and (ii),

$A^2\cos^2\phi + A^2\sin^2\phi = (1)^2 + (-1)^2$

$A^2 = 2 \Rightarrow A = \pm\sqrt{2}$cm

Hence, the amplitude of the SHM = $\sqrt{2}$ cm

Dividing Eq. (ii) by (i), we get

$\frac{A\sin\phi}{A\cos\phi} = \frac{-1}{1}$ or $\tan\phi = -1$

$\Rightarrow \phi = -\frac{\pi}{4}$ or $\frac{7\pi}{4}$

Now, if instead of cosine, we choose the sine function in the displacement equation, then

x(t) = B sin($\omega t + \alpha$)

At t = 0, x = 1 cm, $\Rightarrow 1 = B\sin(0 + \alpha)$

or $B\sin\alpha = 1$............(iii)

Velocity v(t) = $\frac{dx(t)}{dt} = \frac{d}{dt}[B\sin(\omega t + \alpha)]$

$= +B\omega\cos(\omega t + \alpha)$

Again at t = 0, v(t) = ω cm/s

B cosα = + 1..............(iv)

Squaring and adding Eqs.(iii) and (iv),

$B^2\sin^2\alpha + B^2\cos^2\alpha = (1)^2 + (+1)^2$

$\Rightarrow B^2\sin^2\alpha + B^2\cos^2\alpha = 2$

$B^2\left(\sin^2\alpha + \cos^2\alpha\right) = 2$

$B^2 1 = 2 \Rightarrow B = \pm\sqrt{2}$cm

Hence, amplitude of the simple harmonic motion in both types of trigonometric wave equation expression = $\sqrt{2}$ cm

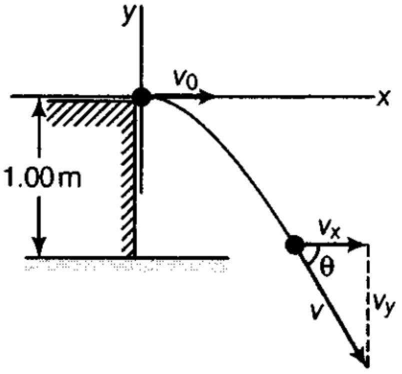
Dividing Eq. (iii) by (iv), we get

$\frac{B\sin\alpha}{B\cos\alpha} = \frac{1}{1}$ or $\tan\alpha = 1$

$\therefore \alpha = \frac{\pi}{4}$, only the phase angle differs for sine and cosine wave equation.

32. As the marble was rolling on the table, therefore it has horizontal velocity and it will act as a projectile as soon as it leaves the edge of the table and fall freely under the effect of gravity.

Since, the marble is initially moving horizontally, v_{y0} = 0 and v_{x0} = 1.00 m/s. We must consider the origin to be at the edge of the table, so that $x_0 = y_0 = 0$



i. t = ? and y = -1.00 m

$\therefore$ y = $\frac{-1}{2}gt^2$

$\Rightarrow t = \sqrt{\frac{-2y}{g}} = \sqrt{\frac{(-2)(-1.00)}{9.8}}$ = 0.452 s

ii. x = ?, when t = 0.452 s

$\therefore$ x = $v_{x0}t$ = 1.00 $\times$ 0.452 s = 0.452 m

iii. v = ?, θ = ? at t = 0.452 s

The x-component of velocity is constant throughout the motion,

$v_x = v_{x0}$ = 1.00 m/s

The y-component of velocity is given by

$v_y = v_{y0} - gt$ = 0 - 9.8 $\times$ 0.452 = - 4.43 m/s

$\therefore v = \sqrt{v_x^2 + v_y^2} = \sqrt{(1.00)^2 + (-4.43)^2}$ = 4.54 m/s, the magnitude of the resultant velocity of the motion.

$\theta = \tan^{-1}\left|\frac{v_y}{v_x}\right| = \frac{4.43}{1.00} = 77.3^\circ$

As the marble hits the floor, its velocity is 4.54 m/s directed 77.3° downward with respect to the horizontal.

OR

a. Area of a parallelogram $= |\vec{A} \times \vec{B}|$ = $AB\sin\theta$ ($\because$ Applying cross product)

Given, area of parallelogram $= \frac{1}{2}AB$

So, $\frac{1}{2}AB = AB\sin\theta$

$\frac{1}{2} = \sin\theta$

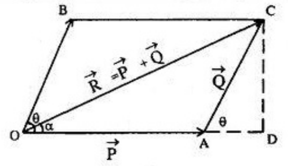
$\theta = \sin^{-1}\left(\frac{1}{2}\right)$

$\theta = 30^\circ$

b. Triangular law of vector addition states that if two vectors can be represented both in magnitude and direction by the sides of a triangle taken in order then their resultant is given by the third side of the triangle taken in opposite order.

Proof: in $\triangle$ADC

$(OC)^2 = (OD)^2 + (DC)^2$



$(OC)^2 = (OA + AD)^2 + (DC)^2$

$(OC)^2 = (OA)^2 + (AD)^2 + 2(OA)(AD) + (DC)^2$

$(OC)^2 = \left(P^2\right) + (Q\cos\theta)2 + 2(P)(Q\cos\theta) + (Q\sin\theta)^2$

$(OC)^2 = P^2 + Q^2\left(\sin^2\theta + \cos^2\theta\right) + 2PQ\cos\theta \quad \left(\because \frac{CD}{AC} = \sin(\theta)\ ,\ \frac{AD}{AC} = \cos(\theta)\right)$

$(R)^2 = P^2 + Q + 2PQ\cos\theta\left(\because \sin^2\theta + \cos^2 Q\right)$

$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

33. i. The force of gravity, F= mg produces the torque τ. Let $\vec{r}$ be the position vector of Q. Then the magnitude of the torque is given by

    $\tau = rF\sin\theta$

    $= r \times mg \times \frac{x_0}{r} = mgx_0 \left[\because \sin\theta = \frac{x_0}{r}\right]$

    The direction of the torque is directed into the plane of paper and perpendicular to it, as shown by ⊗.

    ii. The magnitude of the angular momentum is $L = rp\sin\theta = rmv\sin\theta$

    But the velocity v at point Q is given by v = u + at = 0 + gt = gt

    $\therefore \quad L = rmgt.\frac{x_0}{r} = mgx_0t$

    The direction of angular momentum is the same as that of torque.

    iii. Now L = mgx_0t

    Differentiating both sides with respect to f, we get

    $\frac{dL}{dt} = \frac{d}{dt}(mgx_0t) = mgx_0 = \tau$

    Hence the relation $\tau = \frac{dL}{dt}$ holds in this example.

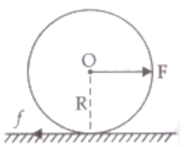
OR

Let a = is the linear acceleration of the disc

$\alpha =$ is the angular acceleration of the disc.

For linear motion, using newton second law of motion we get equation :-

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



M = mass of the disc. and f = is the 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, $I_d = \frac{1}{2}MR^2$

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

$\because a = R\alpha$

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

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

$\because N = Mg$

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

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