CBSE Class 11 Physics
Sample Paper 08 (2019-20)

Maximum Marks:
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. Heliocentric theory proposed by Nicolas Copernicus was

    a. replaced by elliptical orbits to fit the taste of new rulers of Italy

    b. replaced by elliptical orbits to fit the data better

    c. replaced by circular orbits to fit the data better

    d. replaced by parabolic orbits to fit the data better

2. Which of the following statements not true?

    a. The net acceleration of a particle in uniform circular motion is always along the radius of the circle towards the centre

    b. The net acceleration of a particle in circular motion is always along the radius of the circle towards the centre

c. The velocity vector of a particle at a point is always along the tangent to the path of the particle at that point

d. The acceleration vector of a particle in uniform circular motion averaged over one cycle is a null vector

3. A body of mass 0.40 kg moving initially with a constant speed of 10 m /s to the north is subject to a constant force of 8.0 N directed towards the south for 30 s. Take the instant the force is applied to be t = 0, the position of the body at that time to be x = 0, and predict its position at t = –5 s.

a. 50 m

b. -55 m

c. -50 m

d. -60 m

4. Which is a constant for a freely falling object?

a. acceleration

b. speed

c. velocity

d. displacement

5. Physically, the notion of potential energy is applicable only to

a. The class of forces where work done against the force gets converted to thermal energy

b. The class of forces where work done against the force gets dissipated

c. The class of forces where work done against the force gets converted to kinetic energy

d. The class of forces where work done against the force gets stored up as energy.

6. You hang a flood lamp from the end of a vertical steel wire. The flood lamp stretches the wire 0.18 mm and the stress is proportional to the strain. How much would it have stretched for a copper wire of the original length and diameter? (young modulus of steel=2.0 X 10^{11} N/m^2 and young modulus of copper=1.1 X 10^{11} N/m^2)

a. 0.33 mm
b. 0.39 mm
c. 0.18 mm
d. 0.37 mm

7. The electrical resistance in ohms of a certain thermometer varies with temperature according to the approximate law : $R = R_o [1 + \alpha (T - T_o)]$ The resistance is 101.6 Ω at the triple-point of water 273.16 K, and 165.5 Ω at the normal melting point of lead (600.5 K). What is the temperature when the resistance is 123.4 Ω?

a. 364.8 K

b. 384.8 K

c. 404.8 K

d. 344.8 K

8. A refrigerator is to maintain eatables kept inside at 9° C. If room temperature is 36° C, calculate the coefficient of performance.

a. 11.4

b. 12.4

c. 11.8

d. 10.4

9. Estimate the average thermal energy of a helium atom at room temperature (27°C)

a. 6.0×10^{-21} J

b. 5.7×10^{-21} J

c. 6.2×10^{-21} J

d. 6.4×10^{-21} J

10. Electromagnetic waves are different from sound waves in that

a. they need no medium and are longitudinal

b. they need medium and are transverse

c. they need no medium and are transverse

d. they need medium and are longitudinal

11. Fill in the blanks: When a stone tied to a string is whirled in a circular path, the acceleration acting on it is always at _______ angles.

OR

Fill in the blanks: A cricket ball hit by a player comes under _______ dimensional motion.

12. Fill in the blanks: An ________ is a self evident truth and a ________ is a theory proposed to explain observed phenomena.
13. Fill in the blanks: When the particle is moving with a constant velocity, there is no change in velocity with time and hence, its acceleration is _______.
14. Fill in the blanks: The stress needed to cause the actual fracture of the material is known as ________ stress or ultimate tensile strength.
15. Fill in the blanks: The process of change of state directly from solid to vapour (or gas) in known as ________.
16. If $|\mathbf{A} \times \mathbf{B}| = \mathbf{A} \cdot \mathbf{B}$, what is the angle between A and B?
17. Is work done a scalar or a vector?
18. What is gauge pressure?
19. State zeroth law of thermodynamics?
20. Explosions on other planets are not heard on earth. Why?

OR

A transverse wave travels along x-axis. The particles of the medium must move in Which direction?

21. Explain how an object could have zero average velocity but non - zero average speed?
22. A particle starts from origin at t = 0 with a velocity $5\hat{i}$ m/s and moves in xy-plane under action of a force which produces a constant acceleration of $(3\hat{i} + 2\hat{j})$ m/s^2.
    i. What is the y-coordinate of the particle at the instant its x-coordinate is 84 m?
    ii. What is the speed of the particle at this time?

23. Show that the torque is only due to the transverse component of force applied.

24. Suppose there existed a planet that went around the sun twice as fast as the earth. What would be its orbital size as compared to that of the earth?

25. The maximum stress that can be applied to the material of a wire used to suspend on the elevator is 1.3×10^8 Nm^{-2}. If the mass of the elevator is 900 kg and it moves up with an acceleration of 2.2 ms^{-2}, then what is the minimum diameter of the wire?

26. a. Why the brake drums of a car are heated when it moves down a hill at constant speed?
    b. Why pendulum clocks generally go faster in winter and slow in Summer?

OR

In what ways are the gas thermometers superior to mercury thermometers?

27. At very low pressure and high temperature, the real gas behaves like ideal gas. Why?

OR

Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be $3\overset{o}{A}$.

28. The frequency 'ν' of vibration of stretched string depends upon

    i. its length l,
    ii. its mass per unit length 'm' and
    iii. the tension T in the string

Obtain dimensionally an expression for frequency ν.

29. A train takes 4 min to go between stations 2.25 km apart starting and finishing at rest. The acceleration is uniform for the first 40 s and the deceleration is uniform for the last 20 s.
Assuming the velocity to be constant for the remaining time, calculate the maximum speed, acceleration, and retardation, use the only graphical method.

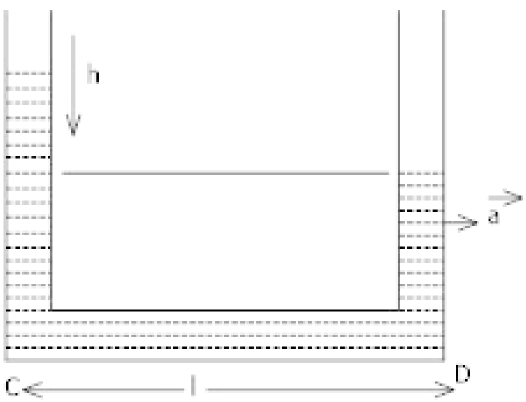
30. A small body tied to one end of the string is whirled in a vertical circle. Represent the forces on a diagram when the string makes an angle θ with initial position below the fixed point. Find an expression for the tension in the string. Also, find the tension and velocity at the lowest and highest points respectively.

31. How will you weigh the sun, that is estimate its mass? The mean orbital radius of the earth around the sun is 1.5×10^8 km.

32. Briefly discuss the use of Bernoulli's principle in working of an atomiser (i.e., the spray gun used for perfumes etc.).

OR

A liquid stands at the same level in the U - tube when at rest. If A is the area of cross-section of tube and g is the acceleration due to gravity, what will be the difference in height of the liquid in the two limbs when the system is given acceleration ‘a’?



33. Two rods A and B are of equal length. Each rod has its ends at temperatures T_1 and T_2. What is the condition that will ensure equal rates of flow of heat through the rods A and B?

34. Show that when a string fixed at its two ends vibrates in 1 loop, 2 loops, 3 loops and 4 loops, the frequencies are in the ratio 1 : 2 : 3 : 4.

35. i. State Newton's Second law of motion. Express it mathematically and hence obtain a relation between force and acceleration.

ii. A railway car of mass 20 tonne moves with an initial speed of 54 kmh^{-1}. On applying brakes, a constant negative acceleration of 0.3 ms^{-2} is produced.

a) What is the braking force acting on the railway car?

b) In what time will it stop?

c) What distance will be covered by railway car before it finally stops?

OR

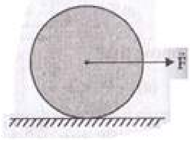
a. State Newton's second law of motion. Express it mathematically and hence obtain a relation between force and acceleration.

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. Establish the relation $\vec{\tau} = I\vec{\alpha}$ for rotation about a fixed axis.

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).



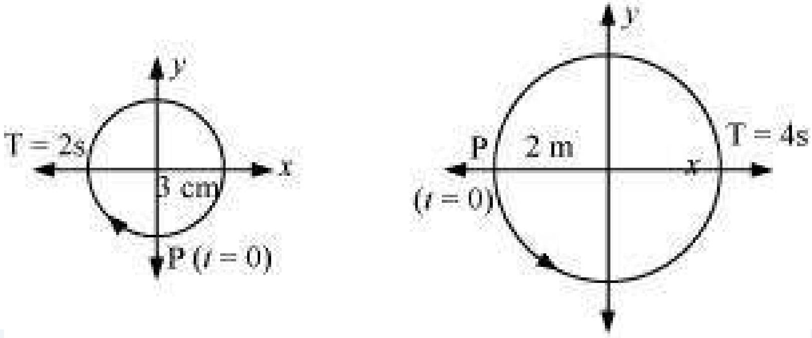
Now the disc is pulled with a force $\vec{F}$ as shown in the figure. What is the maximum value of F for which the disc rolls without slipping?

37. Using the correspondence of S.H.M. and uniform circular motion, find displacement,

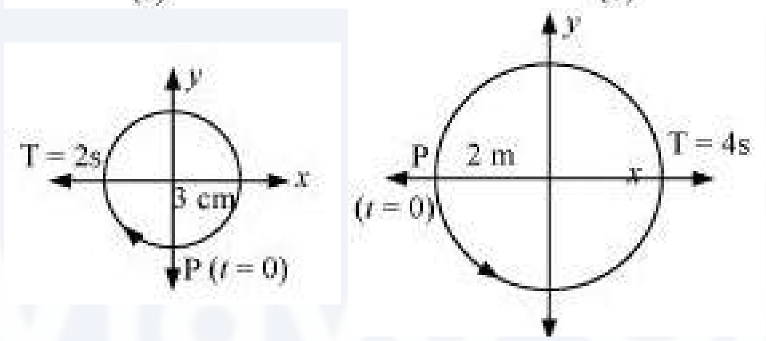
velocity, amplitude, time period and frequency of a particle executing S.H.M?

OR

In figures correspond to two circular motions. The radius of the circle, the period of revolution, the initial position, and the sense of revolution (i.e. clockwise or anti-clockwise) are indicated on each figure.



(a) (b)



Obtain the corresponding simple harmonic motions of the *x*-projection of the radius vector of the revolving particle P, in each case.

Solution
Section A

1. (b) replaced by elliptical orbits to fit the data better
   Explanation: Copernican heliocentrism is the name given to the astronomical model developed by Nicolaus Copernicus and published in 1543. It positioned the Sun near the center of the Universe, motionless, with Earth and the other planets rotating around it in circular paths modified by epicycles and at uniform speeds.

   This theory was replaced by Keplar. All planets move in elliptical orbits, with the sun at one focus. This is one of Kepler's laws. The elliptical shape of the orbit is a result of the inverse square force of gravity. The eccentricity of the ellipse is greatly exaggerated here.

2. (b) The net acceleration of a particle in circular motion is always along the radius of the circle towards the centre
   Explanation: The net acceleration of a particle in circular motion is along the radius of the circle towards the centre Only **in case of uniform circular motion.**
3. (c) -50 m
   Explanation:

   Let $u = 10\,ms^{-1}, F = -8\,N,\ T = 30\,s\ and\ m = 0.4\,kg$
   $a = \frac{F}{m}$
   $= \frac{-8}{0.4}$
   = - 20 m/s^2

   At t= -5 s, there is no force acting on the particle,

   so,

   $$x = ut = 10 \times (-5) = -50\ m$$

4. (a) acceleration

Explanation: An object that falls through a vacuum is subjected to only one external force, the gravitational force, expressed as the weight of the object. An object that is moving only because of the action of gravity is said to be free-falling and its motion is described by Newton's second law of motion. With algebra we can solve for the acceleration of a free-falling object. The acceleration is constant and equal to the gravitational acceleration g which is 9.8 meters per square second at sea level on the Earth. The weight, size, and shape of the object are not a factor in describing a free fall.

5. (d) The class of forces where work done against the force gets stored up as energy.
   Explanation: Potential energy is the stored energy of an object. It is the energy by virtue of an object's position relative to other objects. Potential energy is often associated with restoring forces such as a spring or the force of gravity. It is applicable only for conservative forces.
6. (a) 0.33 mm **Explanation:** Let length of wire in both cases ne L
   extension in case of steel $\Delta L_{\text{steel}} = 0.18\text{mm}$
   young modulus $y = \frac{\text{stress}}{\text{strain}}$
   as stress in both case is same
   $y_{\text{steel}} = \frac{\text{stress}}{\text{strain}_{\text{stress}}} \Rightarrow (1)\ y_{\text{copper}} = \frac{\text{stress}}{\text{strain copper}} \Rightarrow (2)$
   equation 1 $\div$ equation 2
   $\frac{y_{steel}}{y_{\text{copper}}} = \frac{\text{strain}_{\text{copper}}}{\text{strain}_{steel}}$
   $\frac{2.0\times10^{11}}{1.1\times10^{11}} = \frac{\frac{\Delta L_{\text{copper}}}{L}}{\frac{\Delta L_{\text{steel}}}{L}}$
   $\Delta L_{\text{copper}} = \frac{2.0\times0.18}{1.1}$
   $\Delta L_{\text{copper}} = 0.327\text{mm} \approx 0.33\text{mm}$
7. (b) 384.8 K
   Explanation: It is given that:

   $R = R_0\ [1 + \alpha\ (T - T_0)]$ ... **(i)**

   where,
   R_0 and T_0 are the initial resistance and temperature respectively

   R and T are the final resistance and temperature respectively
   α is a constant

At the triple point of water, T_0 = 273.15 K

Resistance of lead, R_0 = 101.6 Ω

At normal melting point of lead, T = 600.5 K

Resistance of lead, R = 165.5 Ω

Substituting these values in equation **(i)**, we get:

$R = R_0 [1 + \alpha (T - T_0)]$

165.5 = 101.6 [1 + α(600.5 - 273.15)]

1.629 = 1 + α(327.35)

$\therefore \alpha$ = 0.629 / 327.35 = 1.92×10^{-3} K^{-1}

For resistance, R_1 = 123.4 Ω

$R_1 = R_0 [1 + \alpha (T - T_0)]$

where,

T is the temperature when the resistance of lead is 123.4 Ω

123.4 = 101.6 [1 + 1.92×10^{-3}(T - 273.15)]

Solving for T, we get

T = 384.8 K.

8. (d) 10.4

   Explanation:

$$K = \frac{T_L}{T_H - T_L} = \frac{282}{309 - 282} = 10.4$$

9. (c) 6.2×10^{-21} J

   Explanation:

$$E = \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 300 = 6.2 \times 10^{-21} J$$

   k = boltzman constant

10. (c) they need no medium and are transverse

    Explanation: Electromagnetic waves are transverse waves, they move perpendicular to the direction of propagation of wave (the direction in which energy is transferred) and EM waves(Electromagnetic waves) can travel in vacuum, thus doesn't require any medium also.

11. Right

OR

two

12. Axiom, model

13. zero

14. Breaking

15. Sublimation

16. As we know, $\mathbf{A} \times \mathbf{B}$ = AB sinθ

    and A.B = AB cos θ

    It is given that the cross product of A and B is equal to its dot product, hence

    AB sinθ = AB cosθ

    $\Rightarrow \quad \frac{\sin\theta}{\cos\theta} = 1$

    $\Rightarrow \tan\theta = 1$

    $\Rightarrow \theta = 45^\circ$

17. Work done is a scalar physical quantity, it is a dot / scalar product of force and displacement.

18. Gauge Pressure is the difference between absolute pressure and atmospheric pressure.

    $p_{gauge} = \rho gh$

    ρ is the density of a fluid of depth h.

19. According to this, when the thermodynamic system A and B are separately in thermal equilibrium with a third thermodynamic system C, then the system A and B are in thermal equilibrium with each other as well.

20. This is because no material medium is present over a long distance between earth and planets and is absence of material medium for propagation, sound waves cannot travel.

OR

In the y-Z plane or in plane perpendicular to x-axis.

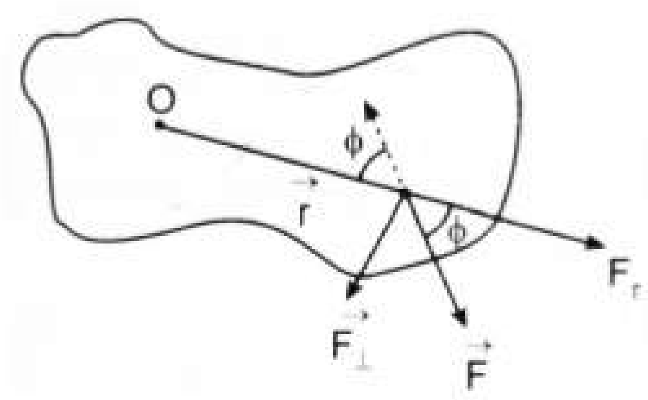
21. Average velocity, $v = \frac{\text{Net displacement}}{\text{Total time taken}}$
and average speed,
$s_{\text{av}} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$
If an object moves such that it returns back to the same position so that displacement is zero but distance is not zero.(eg. motion in a circle)
Average velocity = 0
and Average speed = $\frac{2s}{t}$

22. Given,
Initial velocity u = $5\hat{\mathbf{i}}\mathrm{m/s}, a = (3\hat{\mathbf{i}} + 2\hat{\mathbf{j}})\mathrm{m/s^2}$
Then from equation of kinematics,

r(t) = $v_0 t + \frac{1}{2}at^2$ and $v = \sqrt{v_x^2 + v_y^2}$
r(t) = $= 5\hat{\mathbf{i}}t + \frac{1}{2}(3\hat{\mathbf{i}} + 2\hat{\mathbf{j}})t^2$
$= \left(5t + \frac{3}{2}t^2\right)\hat{\mathbf{i}} + t^2\hat{\mathbf{j}}$
On comparing the corresponding terms,

x(t) = $5t + \frac{3}{2}t^2$
$\Rightarrow$ y(t) = $1t^2$

1. The speed of the particle can be calculated by differentiating the position vector w.r.t time.
If x(t) = 84 m, then t = 6 s
$\therefore$ y(6) = 36 m
2. $v = \frac{dy}{dt} = \frac{d\left(5t+\frac{3}{2}t^2\right)\hat{\mathbf{i}}+t^2\hat{\mathbf{j}}}{dt}$
$= (5 + 3t)\hat{\mathbf{i}} + 2\hat{t}\hat{\mathbf{j}}$
At t = 6 s, v = $23\hat{\mathbf{i}} + 12\hat{\mathbf{j}}$
$\therefore v = \sqrt{(23)^2 + (12)^2}$ = 26 m/s

23. 

Consider a rigid body capable of rotating about an axis passing through point O and let a force $\vec{F}$ be applied at a point A of the body having the position vector $\vec{r}$ considering the axis of rotation as the origin.

Now torque, $\overrightarrow{\tau} = \overrightarrow{r} \times \overrightarrow{F}$

Then the magnitude of torque is

τ = rF sinϕ where ϕ is the angle between $\vec{r}$ and $\vec{F}$.

The force $\vec{F}$ can be resolved into two components, namely, the radial component F_r = F cosϕ and the transverse component $F_{\perp}$ = F sin ϕ. Now radial component of force passes through the line joining the point of application of force and the point about which the torque needs to be computed. The angle between them is 0, and hence the cross product is also zero.

$\therefore \tau = r(F \sin \phi) = rF_{\perp}$

Thus, the only transverse component of force contributes towards the torque.

24. Suppose, $T_P \; and \; T_E$ denote the time periods of the planet and the earth, respectively. If $R_P \; and \; R_E$ denote the corresponding orbital size

$\Rightarrow \frac{T_P^2}{T_E^2} = \frac{R_P^3}{R_E^3}$

$\left(\frac{R_P}{R_E}\right)^3 = \left(\frac{T_P}{T_E}\right)^2 \Rightarrow \frac{R_P}{R_E} = \left(\frac{T_P}{T_B}\right)^{2/3}$

Since $T_P = \frac{1}{2}T_E, \frac{T_P}{T_E} = \frac{1}{2}$

$\therefore \frac{R_P}{R_E} = \left(\frac{1}{2}\right)^{2/3} = 0.63$

25. As the elevator moves up, the tension in the wire,

$F = mg + ma = m(g + a) = 900 \times (9.8 + 2.2) = 10800N$

Stress in the wire = $\frac{F}{A}$ = $\frac{F}{\pi r^2}$

Clearly, when the stress is maximum, r is minimum.

$\therefore$ Maximum stress = $\frac{F}{\pi r^2_{\text{min}}}$

or r^2_{min} = $\frac{F}{\pi \times \text{Maximum stress}}$

= $\frac{10800}{3.14 \times 13 \times 10^8} = 0.2645 \times 10^{-4} m$

or $r_{min} = 0.5142 \times 10^{-2} m$

Minimum diameter

$= 2r_{min} = 2 \times 0.5142 \times 10^{-2} = 1.0284 \times 10^{-2} m$

26. a. When the car moves downhill, the decrease in gravitational potential energy is converted into work against force of friction between brake shoe and drum which appears as heat.

b. Time period of pendulum $T = 2\pi\sqrt{\frac{l}{g}}$ or $T \propto \sqrt{l}$

In winter l becomes shorter so its time period reduces, i.e. the pendulum takes less time to complete an oscillation, so it goes faster. In summer l increases resulting in increase in time period, i.e. the pendulum takes more time for a complete oscillation, so the clock goes slower.

OR

A gas thermometer is more superior to a mercury thermometer, as its working is independent of the nature of gas (working substance) used. As the variation of pressure (or volume) with temperature is uniform, the range, in which temperature can be measured with a gas thermometer is quite large. Further, a gas thermometer is more sensitive than a mercury thermometer.

27. An ideal gas is one which has Zero volume of molecule and no intermolecular forces. Now:

i. At very low pressure, the volume of gas is large so that the volume of molecule is negligible compared to volume of gas.
ii. At very high temperature, the kinetic energy of molecules is very large and effect of intermolecular forces can be neglected.
Hence real gases behave as an ideal gas at low pressure and high temperature.

OR

Diameter of an oxygen molecule, $d = 3\overset{o}{A}$

Radius, $r = \frac{d}{2} = \frac{3}{2}$ = 1.5 $\overset{o}{A} = 1.5 \times 10^{-8}\text{cm}$

Actual volume occupied by 1 mole of oxygen gas at STP = 22400 cm^3

Molecular volume of oxygen gas, $V = \frac{4}{3}\pi r^3 \cdot N$

Where, N is Avogadro's number = 6.023 $\times$ 1023 molecules/mole

$\therefore V = \frac{4}{3} \times 3.14 \times \left(1.5 \times 10^{-3}\right)^3 \times 6.023 \times 10^{23} = 8.51\text{cm}^3$

Ratio of the molecular volume to the actual volume of oxygen $= \frac{8.51}{22400}$

$= 3.8 \times 10^{-4}$

28. Let the frequency of vibration of the string be given by

ν = $Kl^a m^b T^c$................(i)

where K is a dimensionless constant

Dimensions of the various quantities are

ν = $[T^{-1}]$, l = [L], T = [T] ,m = $[ML^{-1}]$

tension(T) = $[MLT^{-2}]$

Substituting these dimensions in equation (i), we get

$[T^{-1}] = [L]^a[ML^{-1}]^b[MLT^{-2}]^c$

expanding the above equation we get

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

Equate dimensions of M, L and T on both sides of equation (homogeneity rule), we get

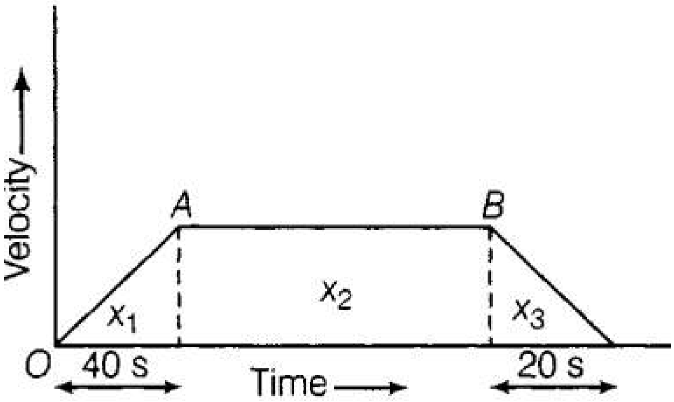
b + c = 0 ,a -b + c =0 and - 2c = -1

on solving, a = -1, $b = -\frac{1}{2}$ and $c = \frac{1}{2}$ put these values in equation (i) we get

$\therefore \nu = Kl^{-1}m^{-1/2}T^{1/2}$

or, $\nu = \frac{K}{l}\sqrt{\frac{T}{m}}$

29. The motion of the train is shown in the following velocity-time graph.



Assume that v represents the maximum speed of the train. If x_1 be the distance covered during the first 40 seconds, then

$\frac{v}{2} \times 40 = x_1$ or $x_1 = 20v$

Since total time is 4 min (240 seconds) therefore, the time corresponding to velocity-time graph AB is (240 - 40 - 20) s i.e. 180 s. If x_2 be the distance covered during this time, then $x_2 = 180v$.

If x_3 be the distance covered during the last 20 s, then we have

$x_3 = \frac{v}{2} \times 20 = 10v$

Now, $x_1 + x_2 + x_3 = 20v + 180v + 10v$

$\Rightarrow 2250 = 210\,v$ (given that distnace = 2.25 km = 2.25 $\times$ 1000 m = 2250 meters)

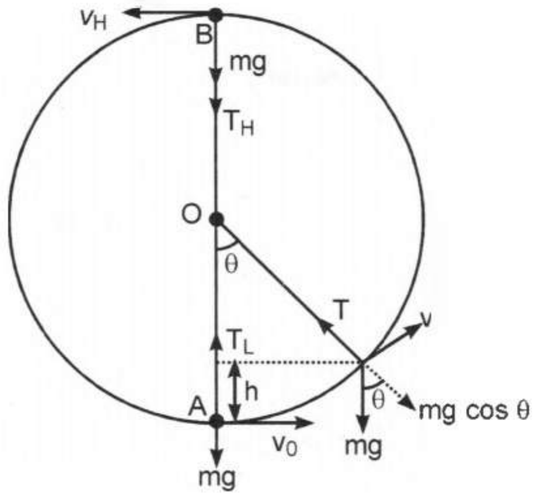
$\Rightarrow v = \frac{225}{21}\,\text{ms}^{-1} = 10.7$ m/s

Hence, the maximum speed = 10.7 m/s

Therefore, Acceleration = $\frac{v}{40} = \frac{10.7}{40}\,\text{ms}^{-2} = 0.2675\ \text{ms}^{-2}$

and Retardation = $\frac{v}{20} = \frac{10.7}{20}\,\text{ms}^{-2} = 0.535\ \text{ms}^{-2}$

30. Consider a small body of mass m attached to one end of a string (of length l) and whirled in a vertical circle of radius 'r'. Let body starts motion from its initial position A, just below the fixed point O, with a speed v_o.



The forces acting on the body, when the string makes an angle θ with the initial position are shown in the figure. Here, mg is the weight of body and T the tension in the string. If v be the instantaneous velocity at this point, then a centripetal force $F=\frac{mv^2}{l}$ is required radially inward. From figure, it is clear that in equilibrium the centripetal force is provided by resultant of two forces i.e.,

$T-mg\cos\theta=\frac{mv^2}{l}$

or $T=mg\cos\theta+\frac{mv^2}{l}$ ....(1)

If the body has covered a vertical distance h, then from law of conservation of mechanical energy, we have

$\frac{1}{2}mv_0^2=\frac{1}{2}mv^2+mgh$

$\Rightarrow v^2=v_0^2-2gh$ ...(i)

which is the required expression for the velocity of a particle at any point.

At the lowest point θ = 0° and h = 0, hence we have

v_L = v = v_0 ....[from (i) putting h = 0]

Thus,

$T_L=mg\cos 0^\circ+\frac{m}{l}v_L^2=mg+\frac{mv_0^2}{l}$

and at the highest point θ = 180° and h = $2l$. Hence,

$v_H^2=v^2=v_0^2-4gl$ [from (i) putting h = $2l$]

or $v_H=\sqrt{v_0^2-4gl}$

and $T_H=mg\cos 180^\circ+\frac{mv_H^2}{l}=mg(-1)+\frac{m}{l}\left(v_0^2-4gl\right)=\frac{mv_0^2}{l}-5mg$

which is the required expression for the Tension.

31. The orbital period is the time a given astronomical object takes to complete **one**

orbit around another object, and applies in astronomy usually to planets or asteroids orbiting the Sun, moons orbiting planets, exoplanets orbiting other stars, or binary stars.

Orbital radius of the Earth around the Sun, $r = 1.5 \times 10^{11}\mathrm{m}$

Time taken by the Earth to complete one revolution around the Sun,

T = 1 year = 365.25 days

$= 365.25 \times 24 \times 60 \times 60 s$

Universal gravitational constant, $G = 6.67 \times 10^{-11}\mathrm{Mm^2kg^{-2}}$

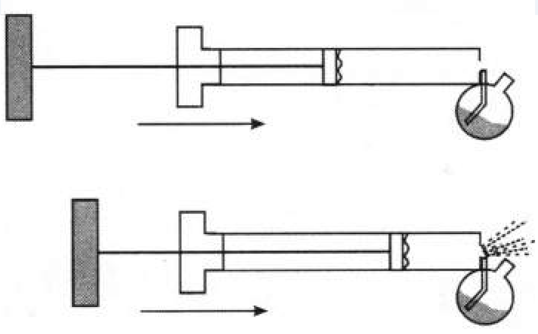
$M = \frac{4\pi^2 r^3}{Gt^2}$

$= \frac{4 \times (3.14)^2 \times \left(1.5 \times 10^{11}\right)^3}{6.67 \times 10^{-11} \times (365.25 \times 24 \times 60 \times 60)^2}$

$= \frac{133.24 \times 10}{6.64 \times 10^4} = 2.0 \times 10^{30} kg$

Hence, the mass of the Sun is $2 \times 10^{30}\mathrm{kg}$

32. An atomiser or sprayer is used to spray very fine drops of liquids and their vapours in perfumes and deodorant bottles.



It works on Bernoulli's principle.

In an atomiser, a horizontal tube is joined to a reservoir bulb through a stem. One end of horizontal tube is in the form of a fine nozzle and a piston or a rubber bulb is attached to its other end.
When the piston is pushed inwards, the air in the tube rushes out through the nozzle

with large flow speed and reduces the pressure in the tube. This creates a pressure difference. Due to which the liquid rises in the stem. The liquid is mixed up with air on the top of the stem and the mixture is blown away through the nozzle in the form of a fine spray.

OR

Let l = Length of the horizontal portion of tube. Mass of liquid in the portion CD = Volume $\times$ Density

Let P = Density of water

Volume = Area $\times$ Length

A = Area of cross – section of tube.

= a $\times$ l

So, Mass of liquid in portion CD = (Al) $\times$ ρ = Alρ

Force on the above Mass towards left = M $\times$ $\overline{a}$

$\overline{a}$ = acceleration

Force = Alρ $\times$ $\overline{a}$ ...(i)

Also, due to difference in height of liquid, the downward force exerted on liquid in the horizontal portion CD

$\Rightarrow$Pressure $= \frac{\text{force}}{\text{Area}}$

Pressure = hρ g

h = height; ρ = Density; g = acceleration due to gravity

So, Force = Pressure $\times$ Area

Force = h ρ g $\times$ A ...(ii)

Equating equation (i) and equation (ii) for force on C D :

Alρ $\times$ a = hρ g $\times$ A

$$h = \frac{al}{g}$$

33. By the formula of conduction of heat

$$Q = \frac{\text{KA}(\theta_1 - \theta_2)t}{x}$$

Q = heat flow

K = co-efficient of thermal conductivity of substance

A = area of cross-sectional of body

θ_1 = Temperature of hot surface of body

θ_2 = Temperature of cold surface of body

X = distance between hot and cold surfaces

t = time for transfer of heat

For rod A :

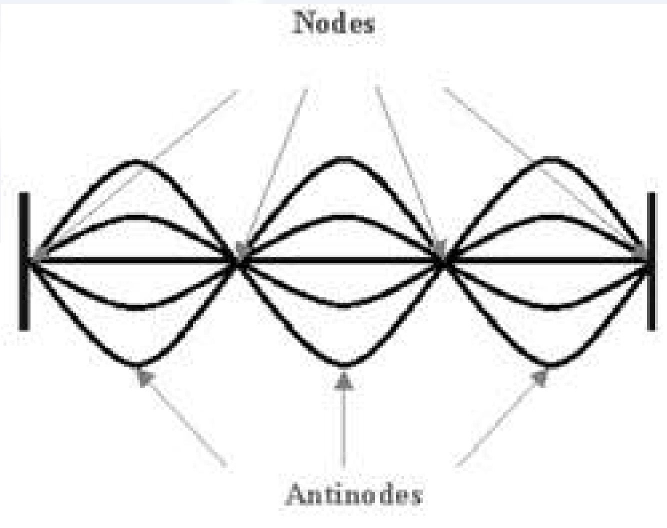
$\frac{Q_A}{t} = \frac{K_A(T_1 - T_2)A_A}{x}$.............(1)

And $\frac{Q_B}{t} = \frac{K_A(T_1 - T_2)A_B}{x}$.........................(2)

For equal rates of flow, $\frac{\theta_A}{t} = \frac{\theta_B}{t}$

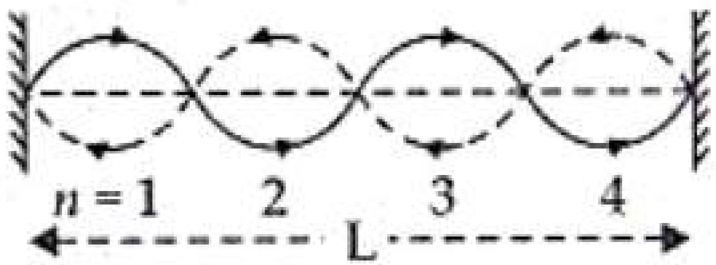
So $K_A A_A = K_B A_B$

34. Stationary waves are produced by the superposition of two waves of same frequency and amplitude travelling with same velocity in opposite directions. Due to the constructive interference, these waves produce certain fixed points along the medium which undergo zero displacement. Nodes are known as the points of no displacement. Midway between every nodes are regions of maximum displacement. These points are called antinodes.



Let n be the number of loops in the string and the length of each loop is $\frac{\lambda}{2}$.

$\therefore L = \frac{n\lambda}{2}$ or $\lambda = \frac{2L}{n}$



Now, speed of wave is,

$v=\nu\lambda$ and $\lambda=\frac{v}{\nu}$

So, $\frac{v}{\nu}=\frac{2L}{n}$

Thus, $\nu=\frac{n}{2L}v$

For n = 1, $\nu_1=\frac{v}{2L}=\nu_0$

If n = 2, then $\nu_2=\frac{2v}{2L}=2\nu_0$

If n = 3, then $\nu_3=\frac{3v}{2L}=3\nu_0$

If n = 4, then $\nu_4=\frac{4v}{2L}=4\nu_0$

$\therefore \nu_1:\nu_2:\nu_3:\nu_4=1:2:3:4$

Hence proved.

35. i. 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.

$\vec{P}=m\vec{v}$

$\Rightarrow\vec{F}=\mathrm{km}\frac{d\vec{v}}{dt}$

$\vec{F}=\mathrm{km}\vec{a}$ (In S.I. unit K = 1)

Therefore, $\vec{F}=m\vec{a}$

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

a) The braking force on railway car F = ma = 20000 $\times$ (-0.3) = - 6000 N

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

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

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

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

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

$\Rightarrow -225=-0.6s$

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

Thus, total distance travelled before stopping is equal to 375 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

$\vec{F} \propto \frac{d\vec{p}}{dt}$

$\vec{F} = k\frac{d\vec{p}}{dt}$

where, k represent the proportionality constant.

$\vec{P} = m\vec{v}$

$\Rightarrow \vec{F} = \mathrm{km}\,\frac{d\vec{v}}{dt}$

$\vec{F} = \mathrm{km}\,\vec{a}$ (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,

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

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

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

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:

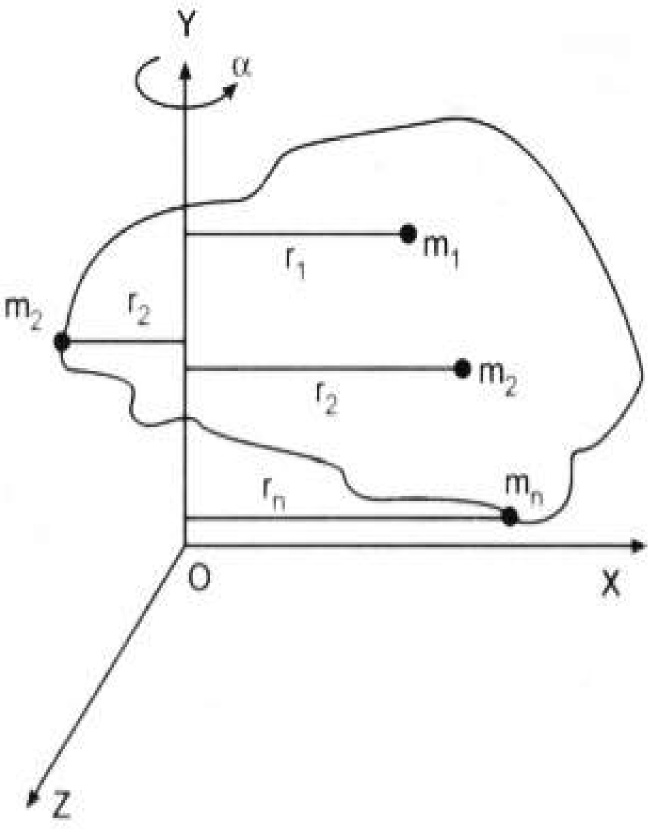
$s_2 = vt + \frac{1}{2} a'' t^2$

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

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

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

36.



Consider a rigid body rotating about an axis OY, as shown in the figure.

When an external torque τ be applied on the rigid body about the rotational axis, its angular velocity changes which causes an angular acceleration 'α' in the rotating body. Obviously whole rigid body has same value of angular acceleration about the axis of rotation. However, particles of masses m_1 m_2, m_3, ...etc., situated at normal distances r_1 r_2, r_3, ... from the rotational axis have different values of linear acceleration given by a_1 a_2, a_3 .... etc.

If we consider, in general, any (say ith) particle of mass m_i situated at a normal distance r_i, its linear acceleration has a magnitude equal to

$a_i = r_i \cdot \alpha$ ....(1)

It means that external force on ith particle, $F_i = m_i a_i = m_i r_i \alpha$

Therefore, the torque acting about the rotational axis due to the force F_i is given by:

$\tau_i = F_i r_i$

or $\tau_i = (m_i r_i \alpha) r_i = \left(m_i r_i^2\right) \alpha$

Therefore, the total torque on the whole rigid body about the rotational axis is given by:

$\tau = \sum_{i=1}^{n}$ = $\tau_i = \sum \left(m_i r_i^2\right) \alpha$ ....(2)

But we know that, $I = \Sigma m_i r_i^2$, therefore from equation (2) we get

$\tau = I\alpha$

Hence, torque (τ) = moment of inertia (I) $\times$ angular acceleration (α)

Since the moment of inertia is a scalar, hence, we have

$\vec{\tau} = I\vec{\alpha}$ ....(2)

which is the required relation.

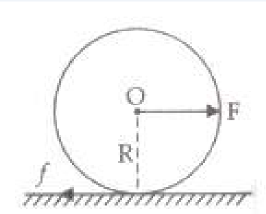
OR

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)



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, $I_d = \frac{1}{2}MR^2$

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

$\because a = R\alpha$

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

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

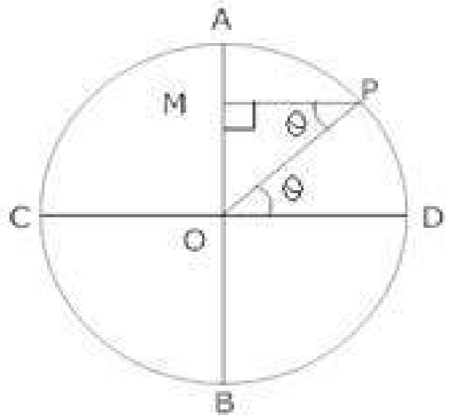
$\because N = Mg$

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

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

37. If initially at t = 0 particle was at D

Then at time t Particle is at point P



i. Then draw a perpendicular From P on AB,
If the displacement OM = Y
Ratios of circle of reference = Amplitude = a
then In ΔOMP, $\angle$POD = $\angle$OPM = θ ($\because$ Alternate Angles)
$sin\theta = \frac{OM}{OP}$
$\Rightarrow \sin\theta = \frac{y}{a}$, 'a' being radius of the above circle.
$\Rightarrow y = a\sin\theta$
Again $\theta = \omega t$
So, $y = a\sin\omega t$

ii. Velocity, $v = \frac{dy}{dt}$
$\Rightarrow v = \frac{d}{dt}(\mathrm{a}\sin\omega\mathrm{t})$
$\Rightarrow v = a\omega\cos\omega t$
again $\cos\theta = \sqrt{1-\sin^2\theta}$
So, $v = a\omega\times\sqrt{1-\sin^2\omega t}$
From equation of displacement : $\sin\omega t = \frac{y}{a}$
So, $v = a\omega\times\sqrt{1-\frac{y^2}{a^2}}$
$\Rightarrow v = aw\sqrt{\frac{a^2-y^2}{a^2}}$
$v = \omega\sqrt{a^2-y^2}$

iii. Acceleration : $f = \frac{dv}{dt}$
$\Rightarrow f = a\omega\times\omega(-\sin\omega t)$
$\Rightarrow f = -\omega^2 a\sin\omega t \Rightarrow f = -\omega^2 y$

iv. Time Period, $T = \frac{2\pi}{\omega}$

v. $freuency = \frac{1}{\mathrm{T}} = \frac{\omega}{2\pi}$

OR

a. $\Rightarrow$ Time period, T = 2 s

$\Rightarrow$Amplitude, A = 3 cm

$\Rightarrow$At time, t = 0, the radius vector OP makes an angle $\frac{\pi}{2}$ with the positive x-axis, i.e., phase angle

$\Rightarrow \phi = \frac{\pi}{2}$

$\Rightarrow$ Therefore, the equation of simple harmonic motion for the x-projection of OP, at time t, is given by the displacement equation:

$\Rightarrow x = A\cos\left[\frac{2\pi t}{T} + \phi\right]$

$= 3\cos\left(\frac{2\pi t}{2} + \frac{\pi}{2}\right) = -3\sin\left(\frac{2\pi t}{2}\right)$

$\therefore x = -3\sin\pi t\text{cm}$

b. $\Rightarrow$ Time period, T = 4 s

$\Rightarrow$Amplitude, a = 2 m

$\Rightarrow$At time t = 0, OP makes an angle π with the x-axis, in the anticlockwise direction. Hence, phase angle, $\Phi = +\pi$

$\Rightarrow$ Therefore, the equation of simple harmonic motion for the x-projection of OP, at time t, is given as:

$\Rightarrow x = a\cos\left(\frac{2\pi t}{T} + \phi\right) = 2\cos\left(\frac{2\pi t}{4} + \pi\right)$

$\therefore x = -2\cos\left(\frac{\pi}{2}t\right)m$