COUNCIL OF CBSE AFFILIATED SCHOOLS IN THE GULF
GULF SAHODAYA EXAMINATION 1995.

Class XI **M.Marks : 70**
Subject: PHYSICS (Theory) **Time : 3 hrs.**

General Instructions:

1. All questions are compulsory.
2. Marks for each question are indicated against it.
3. Question numbers 1-10 are very short answer questions, each carrying 1 mark.
4. Question numbers 11-22 are short answer questions, each carrying 2 marks.
5. Question numbers 23-29 are also short answer questions, each carrying 3 marks.
6. Question numbers 30-32 are long answer questions, each carrying 5 marks.
7. Write down the serial number of the question before attempting it.
8. Use log tables, if necessary.

1. What are Units ? What is the advantage of choosing wavelength of light radiation as standard of length ?

Measurement involves comparison of the quantity to be measured with a reference standard. The reference standard of measurement is called a unit.

A*dvantages*: i) It is easily reproducible at all places.
ii) It does not change with time to time and from place to place.

2.What are Point Objects ? Give an example.

An object is said to be point object if it changes its position by distances which are much greater than its size. eg. A kite flying in the sky.

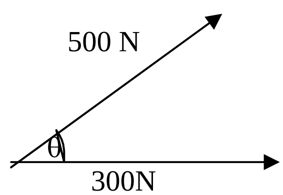
3. Can a body have acceleration when its velocity is zero ? Explain.

Yes. The acceleration of a body at the highest point when the body is thrown upwards.
ie. At the highest point of its motion, Velocity is 0, and acceleration is 9.8 m/s^2.

4. One of the rectangular components of a force of 500 N is 300 N. What is the angle between these vectors?

$\cos\theta = 300/500 = 0.6.$

$\therefore\ \theta = 53^o52'$



5. During rocket propulsion with constant rate of ejection of gas, will the acceleration of the rocket remain constant ? How does the velocity of the rocket change ? Explain.

No. The acceleration increases with constant rate of ejection of gas, change in momentum is constant.Since mass of rocket keeps decreasing there will be increase in acceleration and velocity.

6. Describethe motion of the centre of mass of a fire cracker that explodes during its flight.

Centre of mass of fragments continues along original parabolic trajectory.

7. Explain with reason why there is variation in acceleration due to gravity from pole to the equator.

The value of acceleration due to gravity on the surface of the earth is $g = \frac{GM}{R^2}$

Hence $g \propto 1/R^2$.

Again the polar radius is less than the equitorial radius of earth. Therefore the value of 'g' is more at the poles than at the equator.

8. Unlike solids and liquids, why do gases have two specific heats such as specific heat at

constant volume and constant pressure ?

Unlike solids and liquids which mainly expand on heating, gases have appreciable increase in pressure also. Heat required to raise the temperature of given amount of gas under constant volume and constant pressure are different.

9. For a particle in simple harmonic motion how do the following quantities vary with displacement from mean position.(i) The potential energy, (ii) The total energy.

(i)Since the potential energy is proportional to square of the displacement in S.H.M. potential energy increases. ii) The total energy remains constant.

10.What is a non-dispersive medium ?

It is a medium in which speed of a wave does not depend on its frequency (or wavelength).

11.The period of oscillation of a small drop of liquid under surface tension depends on the density ρ, radius r and surface tension. Obtain an expression for the period using method of dimensions.

Let T be the time period of oscillation.

$$T \propto \rho^a r^b \sigma^c \qquad \therefore T = K \rho^a r^b \sigma^c \text{ -------- } (1)$$

where K is a dimensionless proportionality constant and a, b and c are constants to be determined.

Writing down the dimensional formula for each quantity in equation (1)

$$M^o L^o T^1 = (M^1 L^{-3})^a (L)^b (M^1 T^{-2})^c = M^a L^{-3a} L^b M^c T^{-2c}$$

$$M^o L^o T^1 = M^{a+c} L^{-3a+b} T^{-2c}$$

According to the principle of homogeneity of dimensions, the dimensions of all the terms on either side of this equation must be the same.

Equating the exponents of M, L and T we get $a+c = 0$

$-3a + b = 0$ and $-2c = 1$ $\therefore c = -½$

$a = +½$ and $b = 3/2$

$\therefore$ from eqn. (1) $T = K \rho^{1/2} r^{3/2} \sigma^{-½}$

$T = K (\rho r^3/\sigma)^{½}$ or $T = K \sqrt{\dfrac{\rho r^3}{\sigma}}$

12.The following observations were made during an experiment to find the radius of curvature of a concave mirror using spherometer. l = 4.4 cm, h = 0.065 cm. Calculate the maximum possible error if the radius of curvature R is given by $R = \dfrac{l^2}{6h} + \dfrac{h}{2}$ **.**

Now $R = \dfrac{l^2}{6h} + \dfrac{h}{2}$ Taking log on both sides. log R = 2 log l - log 6 - log h + log h - log2

(*Contd....3)*

Differentiating on both sides $\dfrac{\Delta R}{R} = 2\dfrac{\Delta l}{l} - 0 - \dfrac{\Delta h}{h} + \dfrac{\Delta h}{h} - 0$

Converting the negative errors into positive ones we have

$$\therefore \frac{\Delta R}{R} = \frac{2\Delta l}{l} + \frac{2\Delta h}{h}$$

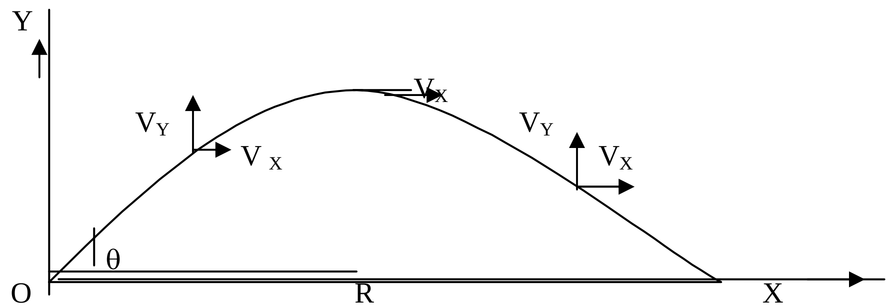
Δl = 0.1 cm - least count of metre scale and Δh = .001 cm - least count of spherometer.

$$\frac{\Delta R}{R} = \frac{2 \times 0.01}{4.4} + \frac{2 \times 0.001}{0.065} = 0.0454 + 0.0307 = 0.0761$$

$\therefore$ Maximum possible error = 0.0761 x 100 = 7.6 %

13.Show that the horizontal range of a projectile with initial speed Vo and angle of projection θ is $\dfrac{Vo^2}{g}$ **Sin 2θ .**

Let us assume that the body is projected with an initial velocity Vo at an angle θ with the horizontal direction.The velocity Vo can be resolved into two components VoCosθ along the horizontal (Vx) and VoSinθ along vertical direction (Vy) as shown.The horizontal component Vo Cosθ remains constant but the vertical component goes on decreasing because of the action of acceleration due to gravity on it.

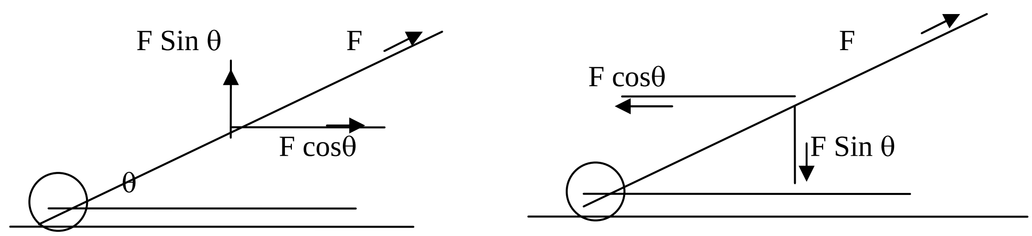


The distance between the point of projection and the point where the trajectory meets the horizontal plane through the point of projection is called the range of projectile (OA). Horizontal range is the distance covered by the projectile with uniform velocity Vo Cosθ in time equal to time of flight.

Range $R = V_o \cos\theta \times$ time of flight $= V_o \cos\theta \times \frac{2 V_o \sin\theta}{g}$

$= \frac{V_o^2}{g} 2 \sin\theta \cos\theta$, $\quad R = \frac{V_o^2}{g} \sin 2\theta$.

14. Explain why : (i) It is easier to pull a lawn mower than to push it.
(ii) A cricketer moves his hands backwards when holding a catch.



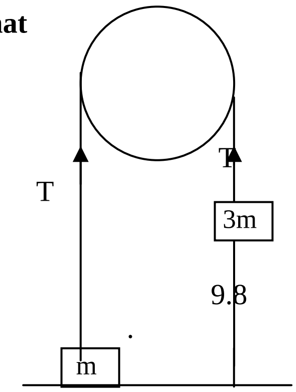
(i) When a lawn mower is pulled with a force‘F’which makes an angle‘θ‘with the horizon tal as shown, the vertical component FSinθ of the applied force acts opposite to the weight and it reduces the effective weight.On the other hand if the same force is applied to push a lawnmower, the vertical
component FSinθ of the applied force adds to the weight of the mower as shown, and hence its effective weight increases. As the effective weight is lesser, when the lawn mower is pulled, it is easier to pull the lawn mower than to push it.

(ii) When a cricketer catches a ball, his hands receive an impulse which is the product of the force applied and the time taken to complete the catch.By moving his hands backwards,the cricketer increases the time duration of the impact. Hence he experiences a smaller force.
Since force = Impulse/Time it does not hurt, if the hands are moved backwards.

* **

15.A mass m on the floor is connected to a mass 3m by a string passing over a frictionless pulley.

If the mass 3m is initially at a height of 9.8 m when released, with what velocity, will it strike the ground ? ($g = 9.8\ m/s^2$)



When the mass 3m is released, let **a** be the common acceleration of 3m and m, and T be the tension inthe string.

For mass 3 m, $3\ mg - T = 3ma$ (i)

For mass m, $T - mg = ma$ (ii)

Adding equations (I) and (ii) we get, $2mg = 4\ ma$. $a = g/2$.

From the equations of motion, $V^2 - U^2 = 2\ as$. $\therefore V^2 = 2\ as$ (U = 0)

$V = 2 \times 9.8/2 \times 9.8$ (Given s = 9.8 m)

$V = 9.8\ m/s$

16.The sun can be considered to be a sphere of mass 2×10^{30} kg performing rotation about its axis with a period of 25.6 days. If it were to shrink to half its present size, what would be the new period of rotation ? (Moment of inertia of a sphere of mass M and radius R,$I=2/5\ MR^2$).

If ω is the angular velocity of rotation of the earth, the period of rotation T is, $T = \frac{2\pi}{\omega}$

According to the conservation of angular momentum,

$$I_1 \omega_1 = I_2 \omega_2$$

where $I_1 = 2/5\ M R_1^2$ and $I_2 = 2/5\ M R_2^2$ are the moments of inertia of the sun before and after shrink, respectively.

$$M R_1^2 \frac{2\pi}{T_1} = M R_2^2 \frac{2\pi}{T_2}, \qquad \frac{R_1^2}{T_1} = \frac{R_2^2}{T_2}$$

Given $R_2 = \frac{R_1}{2}$ $\quad \frac{R_1^2}{T_1} = \frac{R_1^2}{4T_2}$,

$T_1 = 25.6$ days. $T_2 = T_1/4 = 25.6 / 4 = 6.4$ days

17**. Obtain an expression for the height of geo stationary satellite from the surface of earth**.

Let us assume that the satellite of mass 'm' goes around the earth at a distance 'r' from the centre of the earth with an orbital speed V. If the height of the satellite above the earth's surface is h, then $r = R+h$, where R is the mean radius of the earth.

The centripetal force = Gravitational force.

$$\frac{mV^2}{r} = \frac{GMm}{r^2}, \qquad \text{M is the mass of the earth.}$$

The orbital speed, $V = \frac{2\pi r}{T}$ $\left(\frac{\text{Circumference}}{\text{Period}}\right)$ $\quad \therefore \frac{4\pi^2 r^2}{T^2} = \frac{GM}{r}$

But $GM = gR^2$

$$r^3 = \frac{g R^2 T^2}{4\pi^2}$$

$$r = \left(\frac{g R^2 T^2}{4\pi^2}\right)^{1/3}$$

Height of satellite from the surface of the earth, $h = r - R$

$$h = \left(\frac{g R^2 T^2}{4\pi^2}\right)^{1/3} - R$$

18.At what temperature is the root mean square speed of an atom of argon gas equal to R.M.S speed of an atom of helium gas at -20^{o} C. (Given atomic mass of Ar = 39.9 and atomic mass of He = 4)

We know that, $V_{rms} = \sqrt{3RT/M}$

Suppose Vrms and V'rms are r.m.s speeds of argon and helium gas atoms at temperatures T and T^1 respectively. **(P.T.O)**

$$\therefore \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3RT^1}{M^1}}$$

Given $T^1 = -20 + 273 = 253$ K. $\therefore T = T^1 \times M / M'$

$T = 253 \times 39.9 / 4 = 2523.7$ K

19.State Newton's Law of Cooling. What is the limitation of this law?

Newton's law of cooling states that the rate of loss of energy by radiation is proportional to the temperature difference of the hot body and the surroundings.

The temperature difference between body and the surroundings should be small.

20.A particle executing simple harmonic motion along a straight line has the magnitude of velocity 0.3 m/s and 0.2 m/s when the particle is at a distance of 0.1m and 0.2m respe ctively from the mean position.What is the amplitude of S.H.M ?

In simple harmonic motion the velocity V at a displacement x is given by

$V = \omega (A^2 - x^2)^{1/2}$ where A Amplitude

$V_1 = .3$ m/s , x1 = 0.1 m

$V_2 = 0.2$ m/s , x2 = 0.2 m

Substituting for V_1 and V_2, and x_1, x_2 we get

$0.3 = \omega (A^2 - 0.1^2)^{1/2}$ and $0.2 = \omega (A^2 - 0.2^2)^{1/2}$

Dividing and squaring $\frac{.09}{.04} = \frac{A^2 - 0.01}{A^2 - 0.04}$

$\frac{9}{4} = \frac{A^2 - 0.01}{A^2 - 0.04}$,

$9A^2 - 0.36 = 4A^2 - .04$

$5A^2 = 0.32$, $A^2 = 0.064$

$\therefore$ Amplitude A = 0.253 m.

21.A spring balance has a scale that reads from 0 to 50 kg.The length of the scale is 20 cm. A body suspended from the spring when displaced and released oscillates with a period of 0.6 seconds. What is the weight of the body ?

Spring constant $K = \frac{\text{Force}}{\text{displacement}}$

$= \frac{Mg}{x} = \frac{50 \times 9.8}{20 \times 10^{-2}}$

$K = 2.45 \times 10^3$ N/m

The oscillation of a body is simple harmonic. The time period of oscillation is simple harmonic motion,

$$T = 2\pi \sqrt{\frac{M}{K}}$$

where M is the mass of the body $M = \frac{KT^2}{4\pi^2} = \frac{2.45 \times 10^3 \times (.6)^2}{4 \times (3.14)^2} = 22.36$ kg.

$\therefore$ Weight of the body W = Mg = 22.36 x 9.8

W = 219 N.

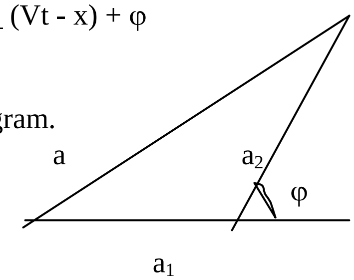
22. State the principle of superposition of waves. Using this principle explain the formation of constructive and destructive interference.

It states that when two or more waves travel in a medium in such a way that each wave represents its separate motion individually, then the resultant displacement of particle of the medium at any time is equal to the vector sum of the individual displacements. **(P.T.O)**

If $\overline{Y_1}$, $\overline{Y_2}$, $\overline{Y_3}$ ...... $\overline{Y_n}$ are displacements at a point, where the n waves superpose each other then the resultant displacement at that point is given by $Y = Y_1 + Y_2 + \ldots Y_n$

Let Y_1 and Y_2 be the disturbance at a point P of the medium due to the two waves and φ be the phase difference between the two disturbances at point P.

Then, $Y_1 = a_1 \sin \frac{2\pi}{\lambda} (Vt - x)$ $\qquad Y_2 = a_2 \sin \frac{2\pi}{\lambda} (Vt - x) + \varphi$



Where a_1 and a_2 denote the amplitude of the two waves.

The resultant amplitude 'a' at point P is obtained using the vector diagram.

$a^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos\varphi$

The Constructive Interference takes place at the points where the phase difference $\varphi = 0, 2\pi, 4\pi$ ......

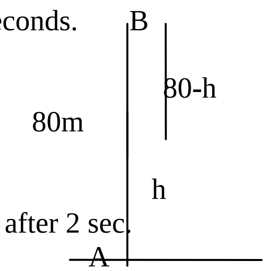
ie. $\varphi = 2n\pi$, where $n = 0,1,2,3,....$ $\qquad a^2_{max} = (a_1+a_2)^2$

Similarly, the destructive interference takes place at the points where the phase difference

$\varphi = \pi, 3\pi, 5\pi, ...$ ie, $\varphi = (2n+1)\pi$

$a^2_{min} = (a_1-a_2)^2$

23. Two stones A and B are thrown simultaneously with speed of 20 m/s. Stone A is thrown vertically upwards from the ground level while stone B is thrown vertically downwards from a height of 80m above A. When and where will the two stones meet ?



Suppose the two stones meet at a height h above the ground level after t seconds.

For stone A

$h = 20t - ½\ 9.8\ t^2$ (1) [From the eqn. $S = Ut + ½\ gt^2$]

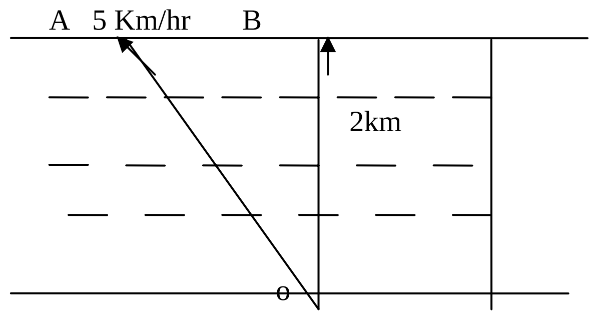
For Stone B

$-(80-h) = -h = -20t - ½\ 9.8\ t^2$ (2)

Equating and solving the equations, we get, t = 2 sec, nd h = 20.4m.

That is at a height of 20.4m above the ground level the two stones will meet after 2 sec.

24. A boatman can row with a speed of $10kmh^{-1}$ in still water. If the river flows steadily at $5\ kmh^{-1}$, in which direction should the boatman row to reach a point directly opposite from where he started ? If the width of the river is 2 km, how long will it take for him to cross the river ?



In fig. OA represents the speed of the boat(10 km/hr)

and AB represents the speed of the river (5 km/hr).

From the Δ OAB, we have $\sin\theta = ½$

or $\theta = \sin^{-1}(1/2)$ $\qquad \theta = 30^o$.

Thus, the man should row the boat upstream in a direction OA, making an angle of 30^o with the direction OB .

Component of velocity along the width of the river (OB)

$\therefore V = \sqrt{10^2 - 5^2} = \sqrt{75}\ kmh^{-1}$

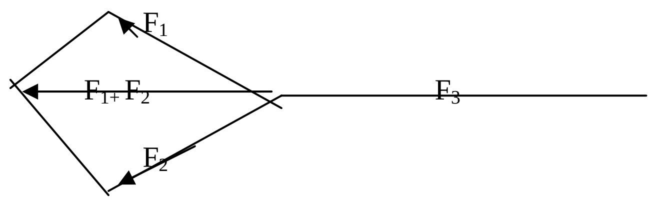
$\therefore$ time $t = \frac{\text{distance}}{\text{velocity}} = \frac{2}{5\sqrt{3}}$

$t = 0.23$ Hrs.

25.a) What are concurrent forces ? Can 3 equal concurrent forces be in equilibrium ? Explain.
b)Distinguish static and kinetic friction.How do the force of static and kinetic friction compare?

a) Forces acting at the same point on a body are called concurrent forces. The condition necessary for equilibrium of a body under the action of concurrent forces is that the vector sum of all the forces acting shall be equal to zero.

Consider three concurrent forces $\overline{F_1}$, $\overline{F_2}$ and $\overline{F_3}$ acting on a rigid body as shown in fig.



If the rigid body is in equilibrium, then the resultant of F_1 and F_2 should be equal in magnitude to the magnitude of F_3 and opposite in direction.

So, $F_3 = -(F_1 + F_2)$

The resultant of F1 and F_2 can be obtained by applying parallelogram law of vectors.

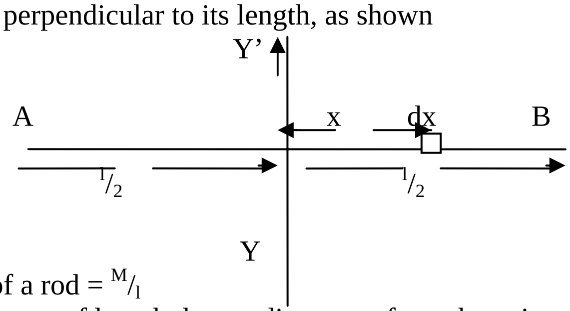
$F_1 + F_2 + F_3 = 0.$

(b) The force of friction that comes into play between the surfaces of two bodies before the actual motion starts is called 'static friction'. It varies between zero to maximum value,which depends upon nature of surfaces in contact.

The force of friction acting between the two surfaces when one surface is in steady motion over the other surface is called 'kinetic friction'. It acts in a direction opposite to the direction of the instantaneous velocity. The kinetic friction is always less than the static friction.

26.Obtain an expression for the moment of inertia of a thin uniform rod about an axis through its centre and perpendicular to its length.

Consider a thin uniform rod AB of mass M and length 'l' rotating about an axis (YY^1) passing through its centre and perpendicular to its length, as shown



Mass per unit length of a rod = $^M/_l$

Let us consider an element of length dx at a distance x from the axis.

Mass of the element = $^M/_l$ dx.

Moment of inertia of an element about an axis YY' = $(^M/_l\ dx)x^2$

Moment of inertia of the rod AB about an axis YY' ,

$$I = 2\,\frac{M}{l}\int_0^{l/2} x^2\,dx = \frac{2M}{l}\int_0^{l/2} x^2.dx.$$

$$= \frac{2M}{l}\left[\frac{x^3}{3}\right]_o^{l/2}$$

$$= \frac{2M}{l}\,\frac{l^3}{24}$$

$$I = \frac{M l^2}{12}\ .$$

27.State Newton's law of universal gravitation. How did Newton arrive at the law?

It states that "Any two particles of matter anywhere in the universe attract each other with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them, the direction of the force being along the line joining the particles."

$F = \frac{GM_1 M_2}{R^2}$. G = Gravitational Constant

Newton compared the acceleration of the falling body (Apple) with centripetal acceleration of the moon, which led him to the law of gravitation.Newton assumed that both moon and the body are accelerated towards the centre of the earth. Also assuming the moon's orbit to be circular, he calculated centripetal acceleration as, $a = \frac{V^2}{R}$

Radius of the moons orbit (R) = 3.84×10^4m.

Period of moons revolution (T) = 27.3 days = 27.3 x 24 x 3600 secs.

$$a = \frac{V^2}{R} = \left(\frac{2\pi R}{T}\right)^2 \times \frac{1}{R} = \frac{4\pi^2}{T^2} R$$

Ω 2.72×10^{-3} m/s^2

$$\frac{a}{g} = \frac{1}{3600}$$

Also observed that, $\frac{a}{g} = \frac{R^2}{r}$,

r - distance of the body (apple) from the centre of earth.

In other words, the acceleration of the body and hence the force is inversely proportional to the square of its distance from the centre of earth. This led Newton to postulate that the gravitational force vary inversely as the square of the distance.

28.A composite wire of uniform diameter 3mm consisting of a copper wire of length 2.2m and steel wire of length 1.6m stretches under a load by 0.7mm. Calculate the load.
[Y of copper = 1.1×10^{11} Nm^{-2} , Y of steel = 2×10^{11} Nm^{-2}]

Given the total extension, $\Delta l = \Delta l_c + \Delta l_s = 7 \times 10^{-4}$m, Youngs Modulus, $Y = \frac{F l}{A \Delta l}$

$$\Delta l = \frac{F l}{YA}$$

$$\frac{F l_c}{Y_c A} + \frac{F l_s}{Y_s A} = 7 \times 10^{-4}\ m$$

(A is same for steel and copper)

$$\frac{F}{A}\left(\frac{l_c}{Y_c} + \frac{l_s}{Y_s}\right) = 7 \times 10^{-4} m$$

$$\frac{F}{A}\left(\frac{1.6}{2x10^{11}} + \frac{2.2}{1.1x10^{11}}\right) = 7x10^{-4}$$

$$\frac{F}{Ax10^{11}}[.8 + 2] = 7 x 10^{-4}$$

$$F = \frac{7x10^{-4} x 10^{11} x 3.14 x (1.5x10^{-3})^2}{2.8} \quad \text{(Area of cross section } A = \pi r^2\text{)}$$

$$F = \frac{7x3.14x2.25x10}{2.8}$$

F=176.6N.

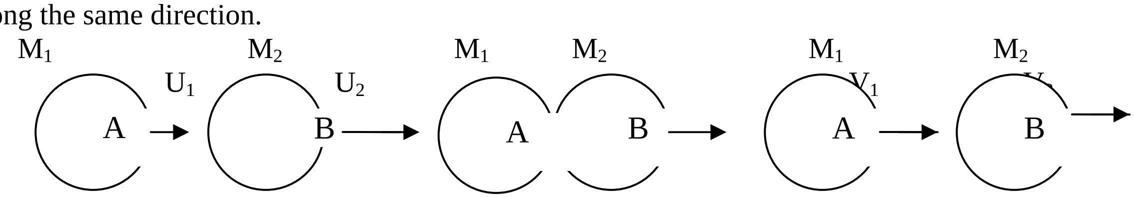
29. What are standing waves ? Draw graphical sketches to illustrate their formation.

When two sets of progressive waves having the same amplitude and frequency, but travelling in opposite directions with the same velocity meet each other in a combined space the result of their superposition is a set of waves, which only expand and shrink, but do not proceed in either direction. These waves are called ‘standing waves’.

The above figures illustrate the formation of the stationary waves that result from the super position of two identical waves A and B travelling in opposite direction. Also it shows the conditions of the medium at different time intervals. It is to be noted that the points like O,P,Q are never displaced. These points are called nodes, and the points like R, S have their maximum displacements alternately positive and negative. These points are called ‘antinodes’.

30.Two bodies of masses M_1 and M_2 moving with velocities U_1 and U_2 in the same straight line undergoes an elastic collision in one dimension. Derive an expression for the velocity of bodies after collision.

Consider two perfectly elastic bodies A and B of masses M1 and M2 moving along the same straight line with velocities U_1 and U2 respectively. Let us assume that the two bodies suffer head on collision and continue moving along the same straight line with velocities V_1 and V_2 along the same direction.



Before collision During Collision After Collision

As in an elastic collision, momentum is conserved, we have

$$M_1 U_1 + M_2U_2 = M_1 V_1 + M_2V_2 \quad (1)$$ **(P.T.0)**

Since kinetic energy is also conserved in an elastic collision, we have

$$M_1 U_1^{\,2} + M_2U_2^2 = M_1 V_1^{\,2} + M_2V_2^2 \quad (2)$$

From equation (1) $\quad M_1 (U_1 - V_1) = M_2 (V_2 - U_2) \quad (3)$

and from equation (2) we get, $\quad M_1 (U_1^{\,2} - V_1^{\,2}) = M_2 (V_2^2 - U_2^2) \quad (4)$

Dividing equation (4) by equation (3) $\quad \dfrac{U_1^{\,2} - V_1^{\,2}}{U_1 - V_1} = \dfrac{V_2^2 - U_2^2}{V_2 - U_2}$

$$\frac{(U + V_1)(U_1 - V_1)}{(U_1 - V_1)} = \frac{(V_2 + U_2)(V_2 - U_2)}{(V_2 - U_2)}$$

$$U_1 + V_1 = U_2 + V_2$$

$$\text{or } U_1 - U_2 = V_2 - V_1 \quad (5)$$

Let us find the velocity of body A after collision. From equation (5), we have

$$V_2 = U_1 - U_2 + V_1$$

Substituting for V_2 in equation (1)

$$M_1 U_1 + M_2U_2 = M_1 V_1 + M_2(U_1 - U_2 + V_1)$$

$$M_1 U_1 + M_2U_2 = M_1 V_1 + M_2U_1 + M_2V_1 - M_2U_2$$

$$U_1 (M_1 - M_2) + 2M_2U_2 = V_1 (M_1 + M_2)$$

$$V_1 = \frac{(M_1 - M_2) U_1 + 2M_2U_2}{M_1 + M_2}$$

Again from equation (5) $\quad V_1 = V_2 - U_1 + U_2$

Substituting for V_1 in equation (1) and simplifying we get,

$$V_2 = \frac{(M_2 - M_1) U_2 + 2M_1U_1}{M_1 + M_2}$$

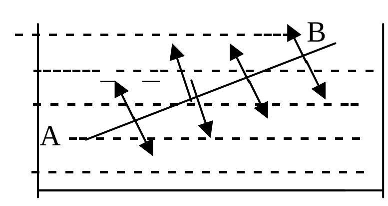
31. Explain the phenomenon of surface tension and obtain an expression for the rise of liquid in a capillary tube.

The phenomenon by virtue of which the free surface of a liquid behaves like an elastic membrane under tension tending to contract so as to have minimum surface area is called 'Surface Tension'.

In order to define surface tension of a liquid, consider an imaginary line AB drawn in the free surface of the liquid.The molecules lying just on its one side try to pull away from the molecules lying just on the other side in order to decrease the surface area.

Hence the surface tension is measured as the force per unit length acting on either side of a line in the liquid surface in equilibrium.

If F is the force acting on either side of the line AB of length 'l' then surface tension $\sigma = \dfrac{F}{l}$.



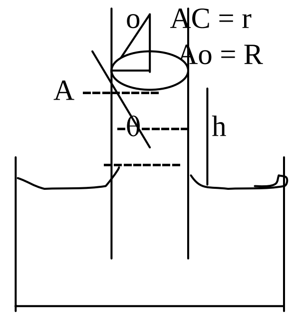
The force acts in a direction tangential to the surface and perpendicular to the line.

Expression for the capillary rise of liquid

Consider a capillary tube of radius r dipped in a liquid of surface tension σ, and density ρ. The shape of the meniscus of liquid in the capillary tube is nearly spherical if the capillary tube is of a sufficiently narrow bore. Let P be the pressure on the concave side of meniscus and 'p' on the other side of it. Then the excess pressure is given by $P - p = \dfrac{2\sigma}{R}$, where R is the radius of concave meniscus.

(P.TO)

Since $P > p$, the water will rise in the tube and reach a height 'h' above the horizontal surface outside the tube until the excess $2\sigma/R$ becomes equal to the hydrostatic pressure due to a height'h' of the liquid column. Thus at equilibrium state, $h\rho g = \frac{2\sigma}{R}$



$$\therefore \; h = \frac{2\sigma}{R\rho g} \quad \text{---------} \; (1)$$

If θ is the angle of contact between the liquid and material of the tube, then ∠OAC is also equal to θ. In a right angled triangle ACO, we have, $\cos\theta = r/R$, $R = \frac{r}{\cos\theta}$

Substituting the value of R in the equation (1) we get,

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

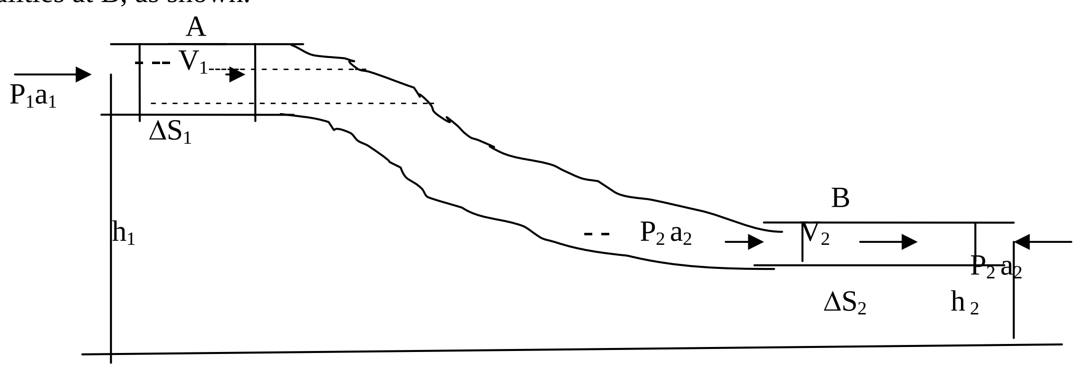
OR

31. State and prove Bernoulli's Theorem.

Bernoulli's theorem states that "the total energy of an incompressible, non-viscous fluid in a streamline flow remains constant throughout the flow."

Consider a non-viscous and incompressible fluid flowing steadily through a pipe of non-uniform cross-section. Let us consider the flow of the fluid between two sections A and B of the tube.

Let a_1 be the area of cross-section at A, V_1 , the fluid velocity, P_1 the fluid pressure and h_1 the mean height above the ground level . Let a_2, V_2, P_2 and h_2 be the values of the corresponding qualities at B, as shown.



Ground Level

Let ΔS_1 and ΔS_2 are the small distances through which the fluid advances in time Δt at A and B.

Hence $\Delta S_1 = V_1 \; \Delta t$ and $\Delta S_2 = V_2 \; \Delta t$.

The work done by the force $P_1 a_1$ on the fluid at A , W_1 = Force x distance

$= P_1 a_1 V_1 \, \Delta t$

The work done against the force $P_2 a_2$ by the fluid at B, $W_2 = P_2 a_2 V_2 \, \Delta t$

The net work done on the fluid by the fluid pressure, $W = W_1 - W_2$

$W = P_1 a_1 V_1 \; \Delta t - P_2 a_2 V_2 \; \Delta t$ (1)

If ΔM_1 and ΔM_2 be the mass of the fluid that crosses the sections A and B in a time Δt then,

$\Delta M_1 = P_1 a_1 V_1 \; \Delta t \rho$ (Mass = Volume x Density) , Similarly $\Delta M_2 = P_2 a_2 V_2 \rho$.

Since Mass of the incompressible fluid is conserved, $\Delta M_1 = \Delta M_2 = \Delta M$

$P_1 a_1 V_1 \Delta t \rho = P_2 a_2 V_2 \; \Delta t \rho = M$

$a_1 V_1 \Delta t = P_2 a_2 \Delta t = \frac{\Delta M}{\rho}$

(P.T.O)

The net work done $W = \frac{\Delta M}{\rho}(P_1 - P_2)$ $[a_1V_1 = a_2V_2]$ (2)

Potential energy of mass M at A = ΔMgh_1

Potential energy of mass M at B = ΔMgh_2

$\therefore$ Decrease in potential energy = $\Delta Mg(h_1 - h_2)$ (3)

The work done by the fluid and the decrease in its potential energy together are responsible for an increase in the kinetic energy of the fluid.

$\therefore$ Increase in kinetic energy = $\frac{1}{2}\Delta M(V_2^2 - V_1^2)$ (4)

From the principle of conservation of energy and, from (2) , (3) + (4) , we get

$$\frac{\Delta M}{\rho}(P_1 - P_2) + \Delta Mg(h_1 - h_2) = \Delta M(V_2^2 - V_1^2)$$

$$\frac{P_1}{\rho} + gh_1 + \frac{1}{2}V_1^2 = \frac{P_2}{\rho} + gh_2 + \frac{1}{2}V_2^2$$

(OR) $$\frac{P}{\rho} + gh + \frac{1}{2}V^2 = \text{constant}$$

$$P + \rho gh + \frac{1}{2}\rho V^2 = \text{constant.}$$

This is Bernoulli's theorem.

32. What are reversible and irreversible processes? What are the four essential components of Carnot's ideal heat engine ? Explain the four stages of operation in Carnot's Cycle.

Any process which can be made to proceed in reverse direction with equal ease by variations in its conditions, so that all changes occuring in the direct process are exactly reversed in the reverse process is called a reversible process.

eg. All mechanical processes taking place under the action of conservation forces.

Any process which cannot be made to proceed in reverse direction is called an irreversible process. eg. dissolving of sugar or salt in water is an irreversible process.

Carnot's engine consists of the following essential parts.

(i)Heat Source, (ii) Heat Sink, (iii)The Cylinder , (iv) Insulating Stand .

Carnot's Cycle:The working substance is taken around the following reversible cycle of four steps.

i)Isothermal expansion: The cylinder containing the working substance is placed in contact with the heat source so that the working substance acquires the constant temperature T_1 of the source. The slow movement of the piston will ensure that the gas expands isothermally from the initial state A ($P_1 V_1$) to the final state B (P_2V_2) along the isothermal curve AB at temperature T_1 .Let Q_1 be the heat absorbed during this process and W_1 be the work done by the gas during expansion.

$$Q_1 = W_1 = R\,T_1 \log e \frac{V_2}{V_1} = \text{Area ABEM}$$

ii) Adiabatic Expansion: The cylinder is now placed on the insulting stand and the piston is moved further so that the gas again expands adiabatically. The expansion is allowed to continue till its temperature falls to T_2 , the temperature of the sink. This expansion is represented by BC. Let P_3 and V_3 be the pressure and volume corresponding to the point C.

Work done by the gas from B to C, $W_2 = \frac{R}{\gamma - 1} T_1 - T_2$ = Area BCFE

iii) Isothermal Compression: The cylinder is now placed on the sink at a temperature T_2. The piston is moved downward to compress the working substance isothermally. Thus the temperature of working substance will remain constant at T_2. This is represented by CD.

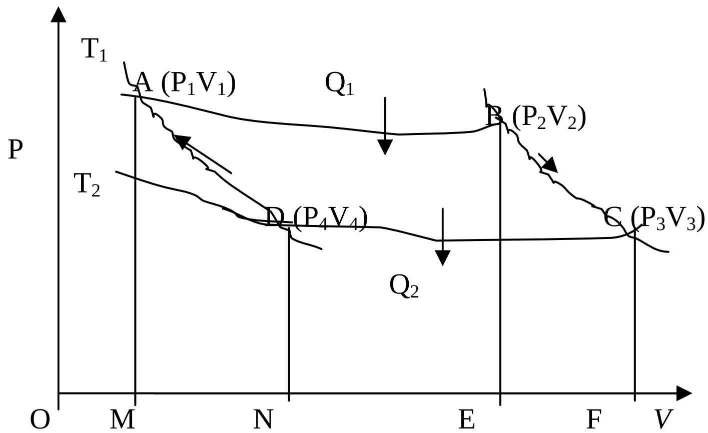
Let P_4 , V_4 be the pressure and volume corresponding to the point D and W_3 is the workdone on the gas. Let Q_2 be the amount of heat rejected to the sink, at a temperature of T_2.

(P.T.O)

$$Q_2 = W_3 = -R\,T_2 \log_e \frac{V_4}{V_3} = R\,T_2 \log_e \frac{V_3}{V_4}$$

$= \text{Area DCFN}$

(-ve sign indicates that work has been done on the working substance)



iv) Adiabatic Compression: The cylinder is now placed on insulating stand and the piston is moved down further in such a way that the gas is compressed adiabatically. The process is continued till the temperature of the gas rises to T1 and finally the point A is reached.This process is represented by DA.

The work done on the gas W_4 is given by.

$$W_4 = -\frac{R}{\gamma-1}(T_2-T_1) = \frac{R}{\gamma-1}(T_1-T_2)$$

$= \text{Area ADNM}$

(The negative sign indicates that work has been done on the gas).

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"Education is the ability to listen to almost anything without losing your temper or self- confidence"
-ROBERT FROST-

Council of CBSE affiliated Schools in the Gulf
Gulf Sahodaya Examination – 1997.
Physics(Theory)

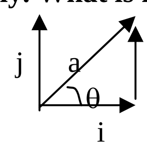
Marks : 70
Class – XI **Time : 3 Hrs.**

General Instructions :

All questions are compulsory.
Marks for each question are indicated against it.
Question numbers 1 to 8 are very short answer questions, each carrying 1 mark. These are to be answered in one or two sentences.
Question numbers 9 to 18 are short answer questions, each carrying 2 marks.
Question numbers 19 to 27 are also short answer questions, each carrying 3 marks.
Question numbers 28 to 30 are long answer questions, each carrying 5 marks.
Draw neat and labelled diagrams wherever necessary.
Use log tables, if necessary.

1. i and j are unit vectors along x and y axes respectively. What is magnitude and direction of the vectors i+j?

$a = \sqrt{i^2+j^2}$ $\tan\theta = 1$ $\therefore \theta = 45$
$=\sqrt{2}$.



2. Will three forces 3N, 4N and 5N keep a body in equilibrium?
Yes. When the resultant of 3N and 4N is equal and opposite to 5N.

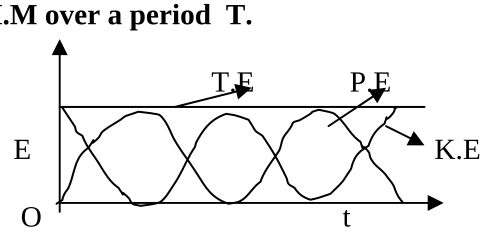
3. State the parallel axis theorem.
It states that the moment of inertia of a rigid body about any axis is equal to its moment of inertia about a parallel axis through its centre of mass plus the product of the mass of the body and the square of the perpendicular distance between the axes.

4. What is the time period of a Geo-stationary satellite?
1 day / 24 hrs / 86400 sec.

5. Define coefficient of thermal conductivity.
It is defined as the quantity of heat flowing per second across the unit cube where two opposite faces are maintained at unit temperature difference.

6. Write down the displacement equation for a S.H.M with amplitude 0.02m, frequency 50 s^{-1} and epoch $\pi/6$ radian.
The standard equation is $y = A\sin(\omega t+\phi)$
Given equation , $y = 0.02\sin(314t+\pi/6)$,
Comparing the two equations we get,
$\omega=314$ Rad/sec.

7. On one and the same graph show the variation of P.E, K.E and T.E of a particle executing S.H.M over a period T.



8. The shortest length of an air column is a pipe closed at one end resonating with a fork of frequency 480 s^{-1} is 0.18m. Calculate the velocity of sound in air.

Fundamental frequency of vibration in a closed pipe $\gamma = C/4l$,
where C - velocity of sound and l - length of air column.
480 = C/(4 x 0.18),
$\therefore$ C = 480 x 0.72 = 345.6 m/s.

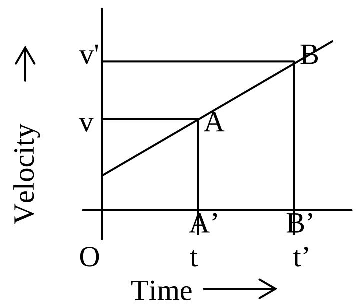
9. Name the different ways of expressing an error. The volume of 11.48 kg of a substance is 2.4m^3. Express its density in correct significant figures.

There are three ways of expressing an error.
(i)Absolute error. (ii) Relative error. (iii) Percentage error.
Density = mass / volume
= 11.48 / 2.4 = 4.78
= 4.8 kg/m^3.

10. For an uniformly accelerated motion, show that the area under velocity time graph represents displacement.

The velocity-time graph for the uniformly accelerated motion of a particle is a straight line sloping upwards as shown in fig.

A and B are two points on velocity- time graph corresponding to times t and t' respectively. Then AA' = v and BB'= v' represent the velocities of the object at times t and t' respectively.
Also A'B' = t' - t



Area of trapezium, ABB'A' = ½ (AA' + BB') x A'B'
= ½ (v + v') x (t' – t) ---------- 1

Now, from definition of acceleration,

$$a = \frac{v' - v}{t' - t}$$

or $t' - t = (v' - v) / a$

Substituting for (t' – t) in equation 1, we have,

$$\text{Area ABB'A'} = \frac{1}{2}(v + v')\frac{(v - v')}{a}$$

$$= (v'^2 - v^2)/2a \quad \text{---------} \quad 2$$

But from the equation $v'^2 - v^2 = 2a(x' - x)$

$$(v'^2 - v^2) / 2a = x' - x$$

Therefore equation 2 gives,
Area ABB'A' = x' – x

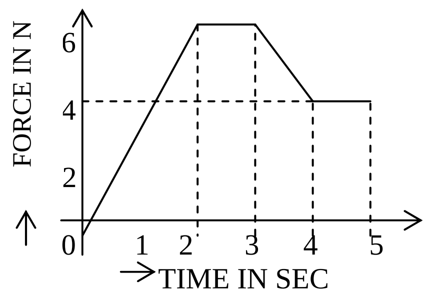
i.e distance covered by an object having uniformly accelerated motion in a time interval (t' – t) is numerically equal to the area under velocity-time graph between t and t'.

11. A bomb is dropped from an aeroplane when it is directly above a target at a height of 1500m. The aeroplane is going horizontally with a speed of 720 km/h. By how much distance will the bomb miss the target?

The vertical height $y = ut + \frac{1}{2}at^2$
Since the vertical velocity is zero initially, 1500 = ½x10x t^2
$\therefore$ t^2 = 300
t = 17.32 s
Horizontal distance covered during the time interval 17.32sec = Horizontal velocityx17.32
= 200 x 17.32 = 3464 m

(i.e) The bomb will miss the target by 3464m.

12.The initial speed of a body of mass 2kg is $5ms^{-1}$. A variable force acts for 5 sec in the direction of motion of the body as shown in the fig. Calculate the impulse of the force and the final speed of the body.



Since the area under force-time gives the impulse,

The impulse = ½ x6x2 + 6x1 + ½x 2x1+4+4 = 6 + 6+ 1 + 4+4

τ = 21 Ns.

Impulse = change in momentum

= m(u – v) = 21

$\therefore$ v – u = 21/2

$\therefore$ The final speed, v = 10.5 + 5 = 15.5 m/s.

13.Explain the following with suitable examples (a) conservative forces and (b) non conservative forces.

A force is said to be conservative if the work done by it on a particle that moves between two points depends only on this points and not the path followed.

Eg. 1) Gravitational force , 2) Electrostatic force between two charges.

A force is said to be non-conservative if the work done by the force on a particle that moves between two points depends on the path taken between those points.

Eg. 1) Frictional force 2) Induction force in a cyclotron .

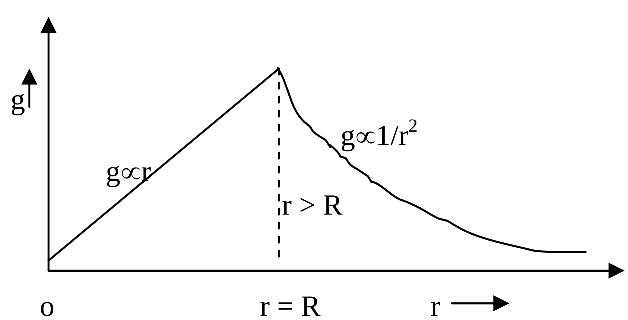
14.Sate and verify the law of conservation of angular momentum.

It states that "If no external torque acts on a system, then the total angular momentum of the system always remains conserved".

Eg: The angular velocity of a planet around the sun increases when it comes near the sun.

When a planet revolving around the sun in an elliptical orbit comes near the sun, the moment of inertia of the planet about the sun decreases. In order to conserve angular momentum, the angular velocity shall increase. Similarly, when the planet is away from the sun, there will be a decrease in the angular velocity.

15.Draw a graph to show the variation of acceleration due to gravity from the centre of the earth to infinitely large distance above the surface of the earth. Also calculate the height above the earth at which the acceleration due to gravity becomes one half of its value on the surface of the earth. (R = 6.4X 10^6 m)



Let h be the height at which the acceleration due to gravity (g') is half of its value on the surface of the earth .

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

Given g' = ½ g

$$\therefore \frac{1}{2} = \frac{1}{(1 + h/R)^2} \quad \text{or} \quad 1 + \frac{h}{R} = \sqrt{2}$$

$$\frac{h}{R} = 1.414 - 1$$

$$\therefore \quad h = 0.414 \times 6.4 \times 10^6$$

$$= 2.65 \times 10^6 \text{ m}$$

16.State Hooke's law. Graphite consists of planes of carbon atoms. Between the atoms in the planes there are strong inter atomic forces. Between the atoms in different planes there are only very weak forces. What kind of elastic properties you expect for graphite?

It states that "Within the elastic limit, the stress is proportional to strain".

Stress α Strain

$$\frac{\text{Stress}}{\text{Strain}} = \text{Constant}$$

Shear modulus / Rigidity modulus of elasticity.

17.Using the first law of thermodynamics, show that $C_p - C_v = R$

Refer Question No. 32(a) in 1996

18.Calculate the thermal efficiency of a heat engine that works between 227 °C and 27 °C. The thermal efficiency of a heat engine can never be 100%. Why?

Efficiency $\eta = (1 - T_2/T_1) \times 100$

Given $T_1 = 227 + 273 = 500K$

$T_2 = 27 + 273 = 300K.$

$\therefore \eta = (1 - 300/500) \times 100$ %

$= \frac{200}{500} \times 100$ %

$= 40\%.$

The temperature of the sink T_2 cannot be practically zero, and hence the efficiency can **never be 100%.**

19.The time period of a body executing simple harmonic motion depends upon (i) amplitude `A', (ii) Force Constant `K'(force per unit displacement) and (iii) mass `m' of the body. Deduce an expression for the time period by method of dimensions.

The time period, $T \alpha A^x K^y m^z$

$T = C A^x K^y m^z$ (1) . Where C is a dimensionless constant of proportionality.

After taking dimensions of the terms on both sides, we have,

$$[T] = C [L]^x [M^1 T^{-2}]^y [M]^z$$

$$= C L^x M^y T^{-2y} M^z$$

$$L^0 M^0 T^1 = C M^{y+z} L^x T^{-2y}$$

According to the principle of homogenity, the dimensions on the two sides must be the same.

$y + z = 0,\ x = 0,\ -2y = 1$

$\therefore\ y = -½$ and $z = ½$.

Substituting the values in equation 1 $\quad T = C\,K^{-1/2}\,m^{1/2}$

$$T = C\sqrt{\frac{m}{K}}$$

It shows that the time period T does not depend on Amplitude (A).

20.A body travels 200m in the first two seconds and 220m in the next four seconds. What will be the velocity at end of 7 seconds from start?

The displacement $s = ut + ½\,at^2$

At the end of 2 seconds,

$200 = 2u + ½\,a \times 4$

$\therefore\ 100 = u + a$ -------------- 1

At end of 6 seconds,

$420 = 6u + ½\,a \times 36$

$70 = u + 3a$ ------------------ 2

Solving the equation 1 and 2, we get

$a = -15\ ms^{-2}$, and $u = 115\ ms^{-1}$

$\therefore$ Velocity at the end of 7 seconds,

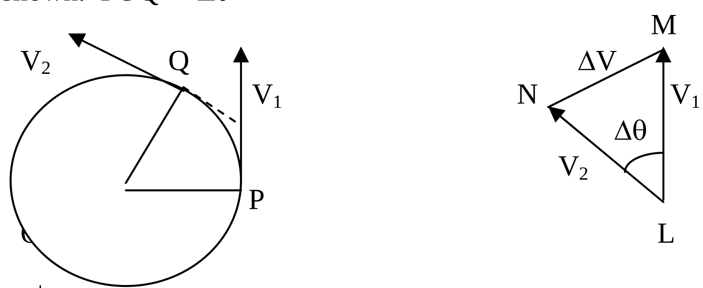
$v = u + at$

$= 115 - 15 \times 7 = 10\ ms^{-1}$

21.Deduce an expression for the centripetal acceleration of a body moving with a constant speed in a circular path.

Consider an object moving around a circle of radius R with a constant speed v. When a particle moves uniformly, the magnitude of the velocity vector remains constant during the motion, but the direction changes continuously. Hence an object experiences acceleration towards the center called <u>centripetal acceleration</u>.

At any instant t, let the particle be at P. The direction of velocity will be along the tangent at any point. Let v_1 and v_2 be the velocity of the object at an interval of time Δt when at the points P and Q as shown. POQ = $\Delta\theta$



On a vector diagram let ⌊M and ⌊N represent the two velocities v_1 and v_2 in magnitude and direction. Then MN = Δv represents the change in velocity in time Δt.

Now the triangles POQ and MLN are similar, because they have the same vertex angle.

Hence,

$$\frac{MN}{PQ} = \frac{LN}{OQ}$$

$$\frac{\Delta v}{PQ} = \frac{v}{R}$$

where v is the magnitude of v_1 and v_2.

If Δt is small, the chord becomes very nearly equal to the arc PQ.

$$PQ = v \times \Delta t$$

$$\therefore \frac{\Delta v}{v \times \Delta t} = \frac{v}{R}$$

$$\frac{\Delta v}{\Delta t} = \frac{v^2}{R}$$

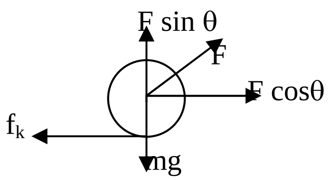
When $\Delta t \to 0$, $\frac{\Delta v}{\Delta t} = \frac{dv}{dt}$ gives the magnitude of acceleration of an object.

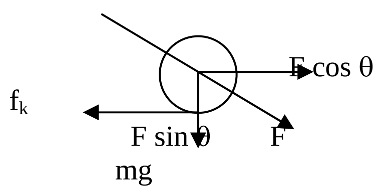
(i.e) $a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$

$$\therefore a = \frac{v^2}{R}$$

22. A lawn roller of mass 250kg is pulled by a force of 500N inclined at an angle of 60° with the horizontal. (a) Calculate the effective force opposing the motion, if the roller moves with an acceleration of 0.5 ms^{-2}. (b) Calculate the acceleration if the roller is pushed with the same force acting at the same inclination.(c)Account for the change in acceleration.

(a)When the roller is pulled, the different forces acting on it are as shown in fig.





Let f_k - force of friction (opposing force)

a - acceleration

$\therefore$ $ma = F\cos\theta - f_k$

$250 \times 0.5 = 500 \times \cos 60 - f_k$

$\therefore$ $f_k = 125N$.

But $f_k = \mu N$, where μ - Coefficient of friction and N – Normal reaction

$= \mu (mg - F\sin\theta)$

$$\therefore \mu = \frac{f_k}{(mg - F\sin\theta)} = 0.06.$$

(b) When the roller is pushed

The force of friction, $f_k' = \mu N$

$= \mu (mg + F\sin\theta)$

$= 0.06 (2500 + 500 \times \frac{\sqrt{3}}{2})$

$f_k' = 176$ N

If a' be the acceleration, then

$ma' = F\cos\theta - f_k$

$\therefore$ $a' = \frac{500 \times \cos 60 - 176}{250} = \frac{250 - 176}{250}$

$a' \cong 0.3$ ms^{-2}.

(c)When the roller is pushed, the normal reaction increases. Consequently the force of friction also increases and the acceleration decreases.

23. Derive an expression for the moment of inertia of an uniform circular disc of radius R and mass M about an axis passing through its center and perpendicular to its plane.

Refer Question No. 26 (1996).

24. A satellite orbits the earth at a height of 500 km from its surface. Compute its (a) kinetic energy (b) potential energy and (c) total energy.

(Given : Mass of the satellite (m) = 300kg, Mass of the earth (M) = 6 x 10^{24} kg Radius of the earth (R) = 6.4 x 10^6 m, and G = 6.67 x 10^{-11} $Nm^2\ kg^{-2}$)

(a) Distance of the satellite from the centre of the earth (r) = R + H

If `v' is the speed of the satellite in its orbit, then

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$\text{Kinetic energy, KE} = \frac{1}{2} mv^2 = \frac{\frac{1}{2} GMm}{r} = \frac{GMm}{2(R+h)}$$

(P.T.O)

$$= \frac{6.67\times10^{-11} \times 6.0\times10^{24} \times 300}{2(6.4\times10^6 + 0.5\times10^6)}$$

$$= \frac{6.67 \times 6 \times 3 \times 10^{15}}{2 \times 6.9 \times 10^6}$$

$\therefore$ KE = 8.7 x 10^9 J.

(b) Potential Energy $= -\frac{GMm}{r} = -\frac{2\ GMm}{2r}$

P.E = -2 KE = -2 x 8.7 x 10^9

$\therefore$ P. E = -17.4 x 10^9 J.

(c) Total Energy, TE = PE + KE

= -17.4 x 10^9 + 8.7 x 10^9

$\therefore$ TE = -8.7 x 10^9 J.

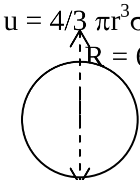
25. What are the various forces acting on a spherical body of radius r and of density ρ dropped into a liquid of density σ and of coefficient of viscosity η. Also deduce an expression for the terminal velocity attained by the body.

The various forces acting on a body are,

(i) Weight (mg),

(ii) Upward thrust (u)

(iii) The viscous force (R)



Consider a small spherical body of radius r falling through a large column of a viscous liquid of density σ and coefficient of viscosity η. Let ρ be the density of the material of the body.

Total upward force acting on the body = 4/3 $\pi r^3 \sigma g$ + 6 $\pi \eta r v_t$

Where v_t is the terminal velocity.

Force acting on downwards = mg = 4/3 $\pi r^3 \rho g$

In equilibrium, Downward force = Upward force

$$4/3\ \pi r^3 \rho g = 4/3\ \pi r^3 \sigma g + 6\ \pi \eta r v_t$$

$$4/3\ \pi r^3 (\rho - \sigma) g = 6\ \pi \eta r v_t$$

$$V_t = \frac{2}{9} \frac{r^2 (\rho - \sigma) g}{\eta}$$

This is the expression for terminal velocity.

26. State the Stefan's law. Assuming the sun to be a perfect black body, estimate the surface temperature of the sun from the following data.

Average radius of the earth's orbit (r) = 1.5 x 10^{11} m
Average radius of the sun (R) = 7 x 10^{8} m
Solar Constant (S) = 1400 w/m^2
Stefan's Constant (σ) = 5.67 x 10^{-8} w$m^{-2}k^{-4}$

Stefan's law states that "the total energy emitted by a unit area of a perfect radiator per second is proportional to the fourth power of its absolute temperature".

$$Q \propto T^4$$

$$Q = \sigma T^4 \quad \text{where } \sigma \text{ is Stefan's constant.}$$

Suppose T is the absolute temperature of the surface of the sun. Then total energy radiated per second from sun's surface,

$$E = 4\pi R^2 \sigma T^4 \text{ ------------ } 1$$

Total energy radiated by the sun per second is equal to the total energy received by the sphere of radius 1.5x10^{11} m (Radius of the earth's orbit). **(P.T.O)**

(i.e) $4\pi R^2 \sigma T^4 = 4\pi r^2 S$

$$T^4 = \frac{r^2 S}{R^2 \sigma}$$

$$\therefore T = \sqrt[4]{\frac{r^2 S}{R^2 \sigma}}$$

$$T = \sqrt[4]{\frac{(1.5\text{x}10^{11})^2 \text{ x } 1400}{(7\text{x}10^{8})^2 \text{ x } 5.6\text{x}10^{-8}}}$$

T = 5802 K.

27. Show that the oscillations of a simple pendulum are simple harmonic in nature and hence deduce an expression for the time period of the pendulum.

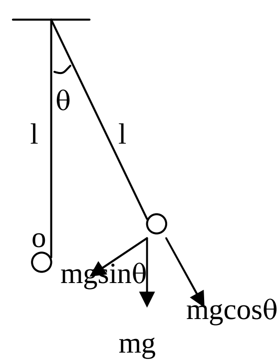
Suppose the metallic bob of weight mg is suspended from point S with a string of length l. Let P be the position and θ be angle subtended by the string with vertical at any instant t. The weight mg can be resolved into two components as mg cosθ and mg sinθ as shown. The component mg cosθ balances the tension of the string and mg sinθ acts as the restoring force on the bob. Thus the acceleration acts towards the mean position.

$\therefore$ The equation of the motion of the bob is

$$d^2x / dt^2 = -g \sin \theta$$

For smaller angles sinθ = θ

$$d^2x / dt^2 = -g\,\theta$$
$$= -g\,x/l$$



As g and l are constant the acceleration of the bob is proportional to the displacement. Hence the motion is simple harmonic. $\therefore -\omega^2 x = -g\,x/l$

$\omega = \sqrt{g/l}$ Time peroid $T = 2\pi \sqrt{l/g}$

28. Two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 in the same straight line undergoes an elastic collision in one dimension. Derive expressions for the velocity of the bodies after collision.

Refer Qn No. 30 (1995)

29.State any four postulates of kinetic theory of gases. Based on the postulates deduce an expression for the pressure exerted by an ideal gas.

Postulates of kinetic theory of gases.

(i)The molecules of a gas are perfectly elastic rigid spheres. They are all considered to be identical in all respects

(ii)The molecules are in a state of continuous random motion, moving in all directions with all possible velocities.

(iii)The molecules in their motion collide with one another and with the walls of the containing vessel. At each collision their velocities change in direction and magnitude.

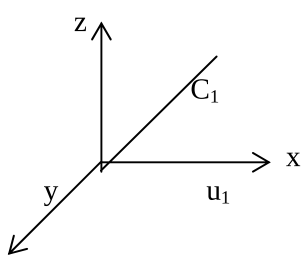
(iv)Between collisions the molecules move in a straight line with uniform velocity and the distance between two successive collisions is called the mean free path.

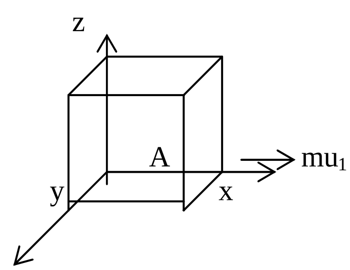
Pressure exerted by a gas

Consider a gas enclosed in a vessel in the form of a cube of edge of length l. Let `n' be the number of molecules and m the mass of each molecule. Assume a molecule moving with a velocity C_1, which can be resolved into three components u_1, v_1 and w_1 along the axis of x, y and z parallel to the three edges of the cubical vessel.

Then $C_1^2 = u_1^2 + v_1^2 + w_1^2$.

(P .T.O)





Let the molecule considered to strike the face A with velocity u_1 perpendicular to x-axis. Since the components v and w are parallel to the face A, only the component u_1 will be effective in the collisions. Since the collisions are perfectly elastic the molecule rebounds with a velocity u_1.

$\therefore$ Change in momentum = $- mu_1 - mu_1 = -2\, mu_1$

Time interval between two successive collisions of the molecule at the face A, $t = 2l / u_1$

$\therefore$Momentum imparted to the face A per unit time = Rate of change of momentum

$$= \frac{2mu_1}{t} = 2mu_1 \times \frac{u_1}{2l} = \frac{mu_1^2}{l}$$

According to Newton's second law, the force is equal to the rate of change of momentum.

Hence the force due to the molecule = $\frac{mu_1^2}{l}$

As there are `n' number of molecules, the total force exerted by all the molecules along the x-axis is,

$$F_x = \frac{mu_1^2}{l} + \frac{mu_2^2}{l} + \ldots\ldots + \frac{mu_n^2}{l}$$

$$= \frac{mn}{l}\frac{(u_1^2 + u_2^2 + \ldots\ldots + u_n^2)}{n}$$

$$F_x = \frac{mn\,\overline{u^2}}{l}$$

where $\overline{u^2} = \frac{(u_1^2 + u_2^2 + \ldots\ldots + u_n^2)}{n}$ is the average value of u^2 over all the n molecules.

Since the pressure is force exerted per unit area, the pressure exerted by the molecules on the face A along x-axis,

$$P_x = \frac{mn\,\overline{u^2}}{l^3}$$

Similarly the pressure along y and z axis are,

$$P_y = \frac{mn\,\overline{v^2}}{l^3}$$

$$P_z = \frac{mn\,\overline{w^2}}{l^3}$$

Now the pressure exerted by the gas is same in all directions, hence the average pressure P of the gas,

$$P = \frac{P_x + P_y + P_z}{3}$$

$$= \frac{1}{3} \times \frac{mn}{V}(\overline{u^2} + \overline{v^2} + \overline{w^2}) \qquad \text{(Volume } V = l^3)$$

$$P = \frac{1}{3}\rho\,\overline{C^2}$$

where $\overline{C^2} = \overline{u^2} + \overline{v^2} + \overline{w^2}$ is the mean of the squares of speeds of individual molecules and is called the mean square speed.

30.State the principle of superposition of waves. What are beats? Show that beat frequency is equal to the difference in parent frequencies.

(P.T.O)

The principle of superposition states that "when two or more waves simultaneously cross the particle in a medium, the resultant displacement of particle is given by the algebraic sum of the individual displacements given to it by the waves."

The periodic variations of the intensity of the wave resulting from the superposition of two waves of different frequencies are known as phenomenon of beats.

Consider two harmonic waves of frequencies γ_1 and γ_2 travelling in the +x direction in a medium and reaching the point x of the medium simultaneously. For the sake of simplicity let us suppose that the given point is situated at x = 0, so that the displacements of a particle of the medium at that point due to two interfering waves at any instant may be represented as,

$$y_1 = A_1 \sin 2\pi\gamma_1 t$$

and $y_2 = A_2 \sin 2\pi\gamma_2 t$

Using the principle of superposition, the resultant displacement is given by,

$$y = y_1 + y_2$$

$$= A(\sin 2\pi\gamma_1 t + \sin 2\pi\gamma_2 t) \qquad \text{(Assume } A_1 = A_2)$$

$$= 2A \cos\left(2\pi\frac{(\gamma_1 - \gamma_2)\,t}{2}\right) \times \sin\left(2\pi\frac{(\gamma_1 + \gamma_2)}{2}\,t\right)$$

$$y = R\sin 2\pi\left(\frac{\gamma_1 + \gamma_2}{2}\right)t$$

where $R = 2A\cos 2\pi\frac{(\gamma_1 - \gamma_2)t}{2}$ is the amplitude of the resultant wave.

The amplitude R is maximum,(+ve or –ve), if

$$\cos 2\pi(\gamma_1 - \gamma_2)\,t = \pm 1$$

(i.e) $\pi(\gamma_1 - \gamma_2)\,t = n\pi$, where n = 0,1,2, ...

$$\therefore\ t = 0,\ \frac{1}{\gamma_1 - \gamma_2},\ \frac{2}{\gamma_1 - \gamma_2},\ \ldots\ldots$$

The time interval between two consecutive maxima, (i.e) Beat period `T' is,

$$T = \frac{1}{\gamma_1 - \gamma_2}$$

Hence the beat frequency is $\gamma = \gamma_1 - \gamma_2$

(i.e) Beat frequency is equal to the difference in frequencies.-

(OR)

30.**What are stationary waves. Explain graphically how stationary waves are produced.**

When two sets of identical waves travelling in opposite directions with the same velocity meet each other in a confined space, the result of their superposition is a set of waves, which only expand and shrink, but do not proceed in either direction. These waves are called <u>stationary waves</u> or <u>standing waves</u>.

The figure illustrates the formation of the stationary waves that result from the superposition of two identical waves A and B travelling along the same line in opposite directions. Initially at t =0, the two waves are in phase with each other and the resultant displacement is as represented in (a). One eighth of a period later (i.e) at t = T/8, The first wave has advanced $\lambda/8$ towards the left and the second wave has advanced $\lambda/8$ towards right, and their positions, and the resultant is as represented in (b). At t = T/4, each wave has advanced through $\lambda/4$ in its own directions. At this instant the two waves are completely out of phase with one another and momentarily they neutralize each other's effect at every point. The resultant wave is now a straight line as is represented in fig (c).

At t = 3T/8, each wave advanced through $3\lambda/8$ in its own direction and the resultant wave is the reciprocal of that at t = T/8 (d) and the resultant for the time t = T/2 is the reciprocal of that a t = 0 in which particles have their maximum displacements in the opposite direction to these in fig (a). Similarly the resultant wave for the instants t = 5T/8, 3T/4, 7T/8 will have same form as in t = 3T/8, T/4, T/8 respectively and finally at t = T, each wave has advanced through one full wave length in its direction.

The fig. Shows that the points like O, P, Q . . . . are permanently at rest. These points are called nodes, and the points like R, S . . . . have their maximum displacements alternately positive and negative. These points are called antinodes.

COUNCIL OF CBSE AFFILIATED SCHOOLS IN THE GULF
GULF SAHODAYA EXAMINATION, GRADE XI – 1998
PHYSICS (Theory)

Max marks : 70.
Time Allowed : 3 Hrs.

General Instructions.

(i) All questions are compulsory.
(ii) Question numbers 1 to 8 carry one mark each.
(iii) Question numbers 9 to 18 carry two marks each.
(iv) Question numbers 19 to 27 carry three marks each.
(v) Question numbers 28 to 30 are long answer questions each carrying five marks.
(vi) Use log tables, if necessary.

1. If the error in the measurement of distance is 2%, calculate the error in the measurement of volume.

$$\frac{\Delta V}{V} \times 100 = 3\left(\frac{\Delta l}{l}\right) \times 100$$

$$= 3 \times 2$$

$\therefore$ Error in the volume = 6%

2. What is the dimension of (a/b) in the relation v = a + bt, where (v) is the velocity and (t) is the time taken.

Since the dimensional formula of 'v' is $L^1 T^{-1}$, the dimensional formula for 'a' should also be $L^1 T^{-1}$, and that of b is $L^1 T^{-2}$.

$\therefore$ Dimension of (a/b) = [T].

3. Does the work done in moving a body depend on how fast or how slow the body is moved?

No, the time is not involved in work.

4. A spring of spring constant (K) is cut into two equal halves. What is the spring constant of each part?

Spring constant K = F/x.

If the spring is cut into two equal halves, the extension produced will become half for the same force.

$\therefore$ The new spring constant, $K' = \frac{F}{(x/2)}$

$$K' = 2\,F/x = 2K.$$

Hence the spring constant is doubled.

5. A force of 10 N changes the velocity of a body from 5 ms^{-1} to 10 ms^{-1} in 10 seconds. How much force is required to bring about the same change in 5 seconds.

Force $F = \frac{\text{Change in momentum}}{\text{Time taken}} = m\frac{dv}{dt}$

$$10 = m\frac{dv}{dt_1}$$

$$F' = m\frac{dv}{dt_2}$$

$$\therefore \frac{F'}{10} = \frac{dt_2}{dt_1} = \frac{10}{5} = 2$$

$\therefore$ F' = 20 N.

6. What is the rotational analogue of a mass of a body?

Moment of Inertia.

7. What is meant by Gravitational potential? Write expression at the surface of the Earth, assuming the Earth to be a sphere of radius (R) and mass (M), supposed to be concentrated at its centre.

It is defined as the amount of work done in bringing a unit mass from infinity to that point in the gravitational field without acceleration.

$$V = -\frac{GM}{R}.$$

8. In which medium, do the sound waves travel faster, solids, liquids or gases? Why?

Sound waves travel faster in solids. This is because coefficient of elasticity of solids is much greater than liquids and gases.

9. Derive a relation for the distance travelled by a uniformly accelerated body in one dimension in the n^{th} second of its motion.

Let a body be moving with a constant acceleration 'a'. If its initial velocity be u, then its velocity after (n – 1) and n seconds will be u+(n-1)a, u+na.

$\therefore$ Average velocity of the body during the n^{th} second,

$$V_{av} = \frac{u + (n-1)a + u + na}{2}$$

$$= u + \frac{a}{2}(2n-1)$$

The distance covered in the n^{th} second,

S_n = Average velocity x time

$$= \left[u + \frac{a}{2}(2n-1)\right][n - (n-1)]$$

$$S_n = u + \frac{a}{2}(2n-1).$$

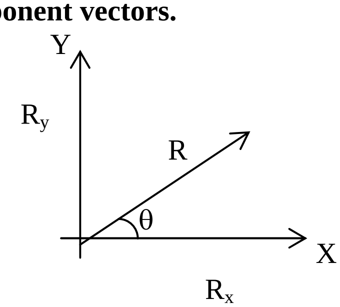
10. A vector R makes an angle θ with the x-axis. Find its components along x and y-axis. Also find the dot product of the two component vectors.

The component along x-axis,

$R_x = R\cos\theta$

And along y-axis,

$R_y = R\cos\theta$



The dot product of the two component vectors $= R_x \cdot R_y$

$= R_x R_y \cos\theta$

$\vec{R_x} \cdot \vec{R_y} = 0$ (Cos 90 = 0) :2:

11. Derive an expression for the horizontal range of a projectile fired at an angle 'θ' with the horizontal with an initial velocity 'u'.

Refer Question No.13 (1995).

12. Find the centripetal force on a body of mass (m) moving with a uniform angular velocity ω in a circle of radius (r).

Refer Question No.21 (1997).

13.Define impulse. A bullet of mass 10 gm moving with a velocity 20 ms^{-1} strikes and comes to rest inside a wall. Find the impulse imparted to the wall by the bullet?

Impulse of force is measured as the product of impulsive force and the time for which the force acts.

Impulse (J) = Change in momentum.

$= m(v-u)$

$= 0.01 \times 20 = 0.2$ Ns.

14.A car of mass 2000kg is vertically lifted up with a constant velocity 20cms^{-1} by a crane. What is the power supplied by the crane and express it in H.P. (g = 10 ms^{-2})

Power = Force x Velocity

$= mg \times 20 \times 10^{-2}$

$= 2000 \times 10 \times 20 \times 10^{-2}$

P = 4000 Watts.

(or)

$$\text{Power } P = \frac{4000}{746} = 5.36 \text{ HP.}$$

15. Estimate the escape velocity of a body from a planet whose mass is eight times and radius four times that of the Earth (given escape velocity of a body from the surface of the Earth is 11.2 km s^{-1}).

Let V_e and V_b be the escape velocity of the earth and the body, then

$$V_e = \sqrt{\frac{2GM_e}{R_e}} \quad \text{and} \quad V_b = \sqrt{\frac{2GM_b}{R_b}}$$

$$\frac{V_b}{V_e} = \sqrt{\frac{M_b}{M_e} \times \frac{R_e}{R_b}}$$

Given $M_b = 8\, M_e$, and $R_b = 4\, R_e$.

$$\therefore \quad \frac{V_b}{11.2} = \sqrt{2}$$

$\therefore\ V_b = 1.414 \times 11.2 = 15.8$ km s^{-1}.

16. A liquid drop of diameter 18 cm breaks into 729 droplets of equal size. If the surface tension of the liquid is 0.07 Nm^{-1}, calculate the change in the surface energy.

Let R and r be the radii of big drop and small drop.

Volume of 1 big drop = Volume of 729 small droplets.

$$\frac{4}{3}\pi R^3 = 729 \times \frac{4}{3}\pi r^3$$

$$r^3 = \frac{R^3}{729}$$

$$r = \sqrt[3]{\frac{9^3}{729}} = \frac{9}{9} = 1 \text{ cm}$$

$r = 10^{-2}$ m.

$\therefore$ Initial surface area = $4\pi R^2$

Final surface area = $4\pi r^2 \times 729$

$$\begin{aligned}\therefore \text{ Change in surface area } &= 729 \times 4\pi r^2 - 4\pi R^2 \\ &= 4\pi(729 \times (10^{-2})^2 - (9 \times 10^{-2})^2) \\ &= 4\pi \times 10^{-4}(729 - 81) \\ &= 4 \times 3.14 \times 648 \times 10^{-4} \\ \Delta S &= 81.39 \times 10^{-2} \text{ m}^2.\end{aligned}$$

$$\begin{aligned}\text{Change in surface energy } &= \Delta S \times \text{Surface tension} \\ &= 81.39 \times 10^{-2} \times 0.07 \\ W &= 5.7 \times 10^{-2} \text{ Joules.}\end{aligned}$$

17. At what distance from the mean position is the kinetic energy and potential energy of a simple harmonic oscillator same?

Kinetic energy of a particle executing S.H.M of amplitude A at x,

$$KE = \frac{1}{2} m\omega^2(A^2 - x^2)$$

Potential energy at x,

$$PE = \frac{1}{2} m\omega^2 x^2$$

Given $\frac{1}{2} m\omega^2(A^2 - x^2) = \frac{1}{2} m\omega^2 x^2$

$$A^2 - x^2 = x^2$$

$$2x^2 = A^2$$

$$x = \frac{A}{\sqrt{2}}$$

At a distance of $A/\sqrt{2}$ from mean position potential energy is equal to kinetic energy.

18.What is meant by beats? Represent the formation of beats graphically and explain it.

The periodic variations of the intensity of the wave resulting from the superposition of two waves of different frequencies is known as phenomenon of beats.

The following figures show that the displacements due to the two waves of equal amp litude (a & b) and the resultant displacement on the basis of principle of superposition (c).

Let us assume that T_1 and T_2 be the time periods and m and n be the frequencies of two interfering waves ($T_1 < T_2$). Suppose that the disturbances of a particular point are initially in phase so that the resultant amplitude has an instantaneous value equal to twice that the either component.

Let the time be measured from this instant and after a time t secs the disturbance again be in phase. Then the source m will have made one more vibration than the source n,

(i.e.) $mt = nt + 1$

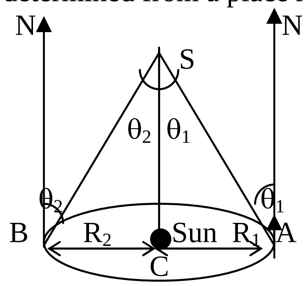
$$t = \frac{1}{m - n}$$

Since the time interval between successive maxima is $t = 1/(m-n)$, it follows that the number of beats per unit time is (m-n) which is the beat frequency.

19. What is parallax? Explain the parallax method to find the distance of a nearby star by taking the semi-major axis of Earth's orbit as the basis.

Parallax means the apparent shift in position of a heavenly body against the background of more distant stars when viewed from two different positions.

Let us select some very distant star N whose direction and position may be considered to be unchanged even after six months. The parallax angle θ_1 between the distant star N and near star S is determined from a place A on earth. **(P.T.O)**



Let us select some very distant star N whose direction and position may be considered to be unchanged even after six months. The parallax angle θ_1 between the distant star N and near star S is determined from a place A on earth. Then the parallax angle θ_2 is determined after six months from B which is diametrically opposite to A.

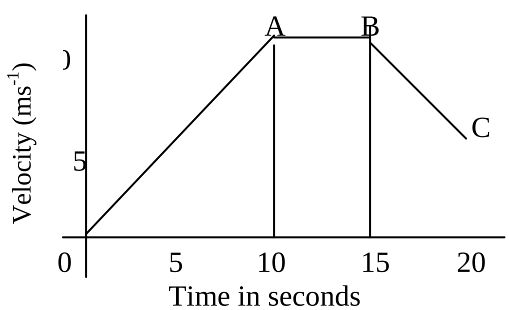
Total angle subtended by the star S on the earth's orbital diameter AB is equal to $(\theta_1+\theta_2=\theta)$. Since θ_1 & θ_2 are small, $\tan\theta_1 \approx \theta_1$ and $\tan\theta_2 \approx \theta_2$.

$$\frac{\tan\theta_1 + \tan\theta_2}{SC} = \frac{\theta_1 + \theta_2}{SC} = \theta = \frac{R_1}{SC} + \frac{R_2}{SC} = \frac{R_1 + R_2}{SC} = \frac{D}{SC}$$

$\therefore$ The distance, $SC = \frac{D}{\theta}$

Thus knowing the diameter of earth's orbit around the sun and the parallax θ (in radians) of the star, the distance SC of the star can be determined.

20. Velocity-time graph of a moving body is shown below. Compute the acceleration of the body in the regions represented by OA, AB and BC of the graph.



Acceleration a = $\frac{\text{Change in velocity}}{\text{Time taken}}$

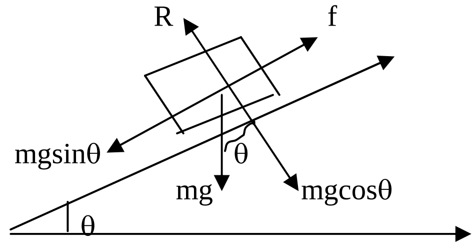
In the region OA, a = 10/10 = 1 ms^{-2}

In the region AB, a = 0/5 = 0 ms^{-2}

In the region BC, a = -5/5 = -1 ms^{-2}

21. A body of mass M is sliding on an inclined plane making an angle 'θ' with the horizontal. If μ is the coefficient of friction between the mass and the surface, represent the different forces acting on the body, when the body is in motion. Also find the acceleration of the body.

Let M be the mass of the body sliding on an inclined plane making an angle θ with horizontal. The different forces acting on the body are shown in the figure. ***(P.T.O)***



(P.T.O)

If the body is moving down an inclined plane, the force which is tending to move it down is MgSinθ and the force of friction which opposes its motion is μR = μMgCosθ, where μ is the coefficient of friction.

If 'a' is the acceleration produced by the resultant force then,

$$Ma = MgSin\theta - \mu MgCos\theta$$

$$a = g(Sin\theta - \mu Cos\theta).$$

22.(a)A body of mass M moving with a velocity v collides head on with a body of mass (m) at rest. Find the velocities of the masses after collision.

(b) State the condition for which the total kinetic energy of the body of mass M is transferred to the stationary body.

(a) Consider a body of mass M moving with a velocity u collides head on with a body of mass m at rest. Let v_1 and v_2 be the velocities of two bodies after collision.

Momentum before collision = Mu

Momentum after collision = $Mv_1 + mv_2$

Since the momentum is conserved,

$$Mu = Mv_1 + mv_2$$

$$M(u - v_1) = mv_2 \quad \text{----------------} \quad (1)$$

In an elastic collision kinetic energy is also conserved.

$$\tfrac{1}{2} Mu^2 = \tfrac{1}{2} Mv_1^2 + \tfrac{1}{2} mv_2^2$$

$$M(u^2 - v_1^2) = mv_2^2 \quad \text{----------------} \quad (2)$$

$$\frac{Eq\ 2}{Eq\ 1} = \frac{(u + v_1)(u - v_1)}{(u - v_1)} = v_2$$

$$\therefore \quad v_2 = u + v_1.$$

Substitute the value of v_2 in equation 1,

$$M(u - v_1) = m(u + v_1)$$

$$u(M - m) = v_1(M + m)$$

$$\therefore \quad v_1 = \frac{(M - m)}{M + m}$$

Similarly

$$M(u - v_2 + u) = mv_2$$

$$2Mu = v_2(M + m)$$

$$\therefore \quad v_2 = \frac{2Mu}{M + m}$$

(b) If the masses of two bodies are equal (i.e.) M = m, then $v_1 = 0$ and $v_2 = v$.
i.e. 100% kinetic energy is transferred to the stationary body when the masses are same.

23.Derive an expression for the acceleration due to gravity at a depth (d) from the surface of the earth. What is the value of acceleration due to gravity at the centre of the earth?

The acceleration due to gravity at any point on the surface of the earth

$$g = Gm / R^2 \quad \text{-------------(1)}$$

Let us assume that the density ρ of the earth is uniform, then the mass $M = (4/3)\pi R^3\rho$.

$\therefore$ The gravity $g = (4/3)\pi G R\rho$ ------------- (2)

Let g_d be the acceleration due to gravity at a point Q ata depth 'd' below the earth's surface. Hence the body experiences gravitational attraction only due to the sphere of radius(R – d).

$$\therefore g_d = \frac{GM_e}{(R-d)^2} \quad \text{------------ } 3$$

where M_e is the mass of the sphere of radius (R – d)

$$= (4/3)\pi(R-d)^3\rho.$$

$\therefore$ Equation 3 becomes,

$$g_d = \frac{G(4/3)\pi(R-d)^3}{(R-d)^2}$$

$$= (4/3)\pi G(R-d)\rho \quad \text{------------ } 4$$

$$\frac{\text{Eq 4}}{\text{Eq 2}} = \frac{g_d}{g} = \frac{R-d}{R} = 1 - \frac{d}{R}$$

$$\therefore \quad g_d = g\left(1 - \frac{d}{R}\right)$$

At the centre of the earth, d = R, $\therefore g_d = 0$.

24. Explain capillary action. Derive an expression for the rise of liquid of surface tension (S) through a capillary tube of radius (r), assuming as the angle of contact. (Density of the liquid is ρ).

The rise or fall of a liquid in a tube of very fine bore is called capillarity.

Expression for capillary ascent: Refer Question No.31 (1995).

25.What is Wein's displacement law? How do you account for the change in colour of a body on heating?

It states that "the wavelength of maximum intensity of emission of black body radiation is inversely proportional to the absolute temperature of the black body".

$$\lambda_m \; \alpha \; \frac{1}{T}$$

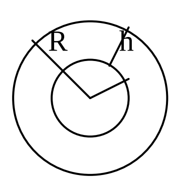
$$\lambda_m = \frac{b}{T}$$, where b is called Wein's Constant.

With the rise in temperature of the black body, the wavelength of maximum intensity of emission shifts towards lower wavelength side and thus the colour of the body changes from red to yellow and then to white.

26. A mass (m) is dropped in a hole drilled across the diameter of the earth. If the earth is assumed to be a homogeneous sphere of radius R, show that the body executes simple harmonic motion. Also find the time period of oscillation.

Let M and R be the radius of the earth. At any instant, if the particle of mass m at a depth 'h' below the surface, then the particle will be attracted only by the portion of the earth of radius (R-h).

$\therefore$ Mass of the portion of earth



$$= \frac{\text{Mass}}{\text{Volume}} \times \text{Volume of the portion}$$

o R-h

$$= \frac{M}{(4/3)\pi R^3} \times (4/3)\pi(R-h)^3$$

$$= \frac{M(R-h)^3}{R^3}$$

$\therefore$ Hence force on the particle of mass m $= \frac{-GM(R-h)^3 \times m}{R^3(R-h)^2}$

$$= \frac{-GM(R-h)m}{R^3}$$

$\therefore$ Acceleration on the particle, $a = -GM(R-h) / R^3$

It is proportional to the displacement (R – h) and towards the centre. Hence the oscillation is simple harmonic. Comparing with the standard form,

$$\frac{d^2x}{dt^2} = -\omega^2 x = -\omega^2(R-h)$$

$$\therefore -\omega^2 = \frac{GM}{R^3} = \frac{GM}{R^2} \times \frac{1}{R} = \frac{g}{R}$$

$$-\omega = \sqrt{\frac{g}{\mathbf{R}}} \quad \text{(or)} \quad 2\pi = \sqrt{\frac{g}{\mathbf{R}}}$$

(or) $T = 2\pi\sqrt{\frac{R}{g}}$,where $g = \frac{GM}{R^2}$ is the acceleration due to gravity.

27.(a) Explain the phenomenon of reverberation of sound. Write an expression for the reverberation time of a hall of volume (V).

(b) Write any two methods to reduce the reverberation time.

(a) The persistence of audible sound even after the source has ceased to emit sound is called reverberation.

The time in which the intensity of a continuous note falls to one millionth of its original intensity is called the "Reverberation period".

The reverberation time of an auditorium of volume V, surface area S having an absorption coefficient 'a' is,

$$t_R = \frac{0.17\,V}{\Sigma aS}$$

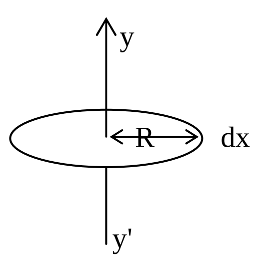
(b) The reverberation time of a room or a hall can be reduced by

(i) Providing a number of windows.(ii) Using good absorbent materials.

28.(a) Derive an expression for the moment of inertia of a circular ring of mass M and radius R about an axis passing through the centre and perpendicular to the plane of ring. Hence find the moment of inertia of the ring about any of its diameter.

(b) A body of moment of inertia (I) starting from rest acquires angular velocity (w) in a time (t). Find the torque acting on the body.

(a) Consider a thin uniform ring of mass M and radius R. The ring rotates about axis yy' passing through its centre perpendicular to the plane of the ring.



To calculate moment of inertia let us divide the ring into large number of segments each of length dx.

Mass per unit length of ring = $M / 2\pi R$

Mass of one segment = $(M / 2\pi R) \times dx$.

$\therefore$ Moment of inertia of the segment about the axis $dI = \frac{M}{2\pi R} \times dx \times R^2$

$\therefore$ Moment of inertia of the ring, $I = \frac{MR^2}{2\pi R} \int_0 dx$

$$= \frac{MR^2}{2\pi R} \times 2\pi R \qquad (\int dx = 2\pi R)$$

$$I = MR^2$$

According to the principle of perpendicular axes, sum of the moments of inertia about two perpendicular diameter through O.

$$2I_d = MR^2$$

$\therefore$ Moment of inertia about any diameter , $I_d = 1/2\ MR^2$

(b) Torque $\tau = I\alpha$

But $\alpha = \frac{\omega - 0}{t} = \frac{\omega}{t}$

$\therefore$ Torque $\tau = \frac{I\omega}{t}$

29. (a) State and prove Bernoulli's theorem.

(b) Write any two assumptions of kinetic theory of gases.

(a) Refer Question No.31 (1995), (b) Refer Question No.29 (1997)

30. (a) Briefly describe the working of a Carnot engine with the help of P.V. diagram.

(b) A Carnot engine is working between two temperatures 727 °C and 77 °C. Calculate the percentage of efficiency.

(a) Refer Question No.32(1995)

(b) Efficiency of the engine, $\eta = 1 - \frac{T_2}{T_1}$

$T_1 = 727 + 273 = 1000K$ and $T_2 = 300K$

$\therefore \eta = (1 - \frac{300}{1000}) \times 100\ \%$

$= (\frac{10 - 3}{10}) \times 100\ \%$

$= 70\ \%$

30. (a) Explain the principle and working of refrigerator and obtain an expression for its coefficient of performance.

(b)Find the average power consumed by a refrigerator if it transfers 25J of heat energy from temperature –3 °C to 27 °C.

(a) The refrigerator may be regarded as a heat engine which works in reverse direction. i.e., it performs a cyclic operation in the manner that absorbs some heat at lower temperature by doing some work and rejects a larger amount at a higher temperature and the system undergoing the cycle is called a refrigerant.

The following fig illustrates the working of a refrigerator

The gas is compressed to a high pressure by means of a compressor. The warm, high pressure gas is cooled by passing it through a spiral pipe C exposed to the surrounding air. The gas gets converted into liquid. The high pressure liquid is made to pass through a throttling valve T towards the low pressure side. Due to throttling, the temperature is lowered and a part of the liquid is converted into vapour. At B this mixture of liquid and vapour extracts heat from the surrounding materials and the liquid is converted into vapour at low pressure. The gas is sucked by the compressor. A repeated operation of the machine can cause substantial cooling. 10

<u>Coefficient of performance</u> : - It measures the efficiency of a refrigerator, and it is defined as the ratio of the quantity of heat extracted per cycle from the contents to the mechanical work W done by the external agency to do so.

(P.T.O)

If Q_2 is the heat absorbed, W is the work performed on the refrigerator, and Q_1 is the heat rejected, then, $W = Q_1 - Q_2$ and

$$C.O.P = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{1}{\left(\frac{Q_1}{Q_2} - 1\right)}$$

But for the Carnot's cycle, $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$

$$\therefore \ C.O.P,\ \beta = \frac{1}{\left(\frac{T_1}{T_2} - 1\right)} = \frac{T_2}{T_1 - T_2}$$

(b) Power required = Work done per second

Since $\frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$

$W = \frac{Q_2 (T_1 - T_2)}{T_2}$, Given $T_1 = 27 + 273 = 300K$ and $T_2 = -3 + 273 = 270K$

$$= 25\left(\frac{300 - 270}{270}\right) = \frac{25 \times 30}{270} = \frac{25}{9} = 2.78 \text{ Watts.}$$

COUNCIL OF CBSE AFFILIATED SCHOOLS IN THE GULF
GULF SAHODAYA EXAMINATION – 1999

Grade: XI Max. Marks : 70
Sub : Physics (Theory) Time : 3 Hrs

1. Determine λ, so that A=2î+λj + k and B = 4î-2j -2k are perpendicular to each other.

$\vec{A}.\vec{B}$ = AB Cosθ

θ = 0 ∴ A . B = 0

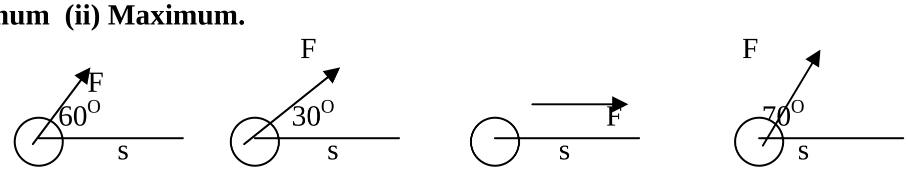
8 - 2 λ – 2 = 0

2λ = 6, λ = 3

2. In order to walk, why do we push our foot against the ground ?

When we walk on the ground forces of action and reaction are involved. While Walking on the ground, we push backward on the ground with our feet and the reaction of the ground sets us in motion.

3. A body of mass m is being moved by applying forces as shown below in figure, if the distance moved $_{I\,S\,I}$ from 0 is same in all the four cases, in which case the work done is (i) Minimum (ii) Maximum.



(i) (ii) (iii) (iv)

Ans:- Since the work done W = F S Cosø

a). W is Minimum in (iv)

b) .W is Maximum in (iii)

4.State the theorem of perpendicular axes.

It states that the moment of inertia of a plane lamina about an axis perpendicular to the plane lamina is equal to the sum of the moments of inertia of the lamina about two axes at right angles to each other, in its own plane, and intersecting each other at the point where the perpendicular axis passes through it.

5.Distinguish between elastic and inelastic collisions.

See Question No.15 in 1996

6.The acceleration due to gravity on a planet is 1.96 m/s^2. If it is safe to jump from a height of 2m on the earth, what will be the corresponding height on the planet.

$mg_e\ h = mg_p\ H$

$H = g_e h/g_p =$ 9.8x2/1.96 = 10m.

7.State wein's displacement law.

It states that ' thev product of the wavelength corresponding to which maximum energy emitted and absolute temperature of the block body is always constant.'

ie. λ_m T = b (Wein's constant).

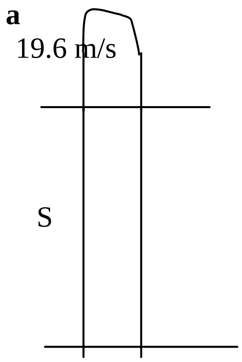
8.What are standing waves? Why are they called so?

See Question No.29 in 1995.

9.A physical quantity P is related to four observable a, b, c and d as follows,P =a^3b^2/dvc. The percentage errors of measurements in a,b,c and d are 1%, 3%, 4% and 2% respectively. What is the percentage error in the quantity P ?

See Question No.11 in 1996.

10.A ball thrown vertically upwards with a speed of 19.6 m/s from the top of a tower returns to the earth in 6 sec. Find the height of the tower.



u = +19.6 m/s
g = - 9.8m/s^2
t = 6 sec.
S = ?
From the equation of motion,

$S = ut + 1/2\ gt^2$
$= 19.6x6 + ½ (-9.8)x36$
$= 9.8(12-18) = -58.8m$

∴ Height of the tower = 58.8m

11.A helicopter of mass 1000kg rises with a vertical acceleration of 15 m/s^2. The crew and the passengers weight 300kg. Give the magnitude and direction of the action of the rotor of the helicopter on the surrounding air.

Total mass of the helicopter and the crew = 1000+300 = 1300kg
The action of the rotor on the surrounding air, = m (g + a) = 1300 (10 + 15)
= 32500 Newtons downwards.

12.State and explain the law of conservation of energy. Show that the energy in case of the free fall of a body is always conserved.

See Question No.30 (a) in 1996.

13.What do you mean by centripetal force? Derive an expression for centripetal force.

See Question No.21 in 1997.

14.What is the period of revolution around the sun, given that the diameter of its orbit is 30 times the diameter of the earth's orbit around the sun, both orbits being assumed to be circular.

According to kepler's law of planetary motion, $T^2 \propto r^3$

$$\frac{T_2^2}{T_1^2} = \frac{r_2^3}{r_1^3}$$

$T_2^2 = T_1^2\ (T_2/r_1)^3$
Given $r_2 = 30r_1$, T = 1year
∴ $T_2^2 = 1(30)^3 = 27000$,
$T_2 = 10\sqrt{270} = 164.3$ Years.

15.Calculate the work done in blowing a soap bubble of radius 10 cm, surface tension being 0.06 N/m .

Total Surface area of the bubble = $2 \times 4\pi r^2 = 8 \times 3.14 \times (0.1)^2$
Work done = Surface Tension x Increase in area.
$= 0.06 \times 8 \times 0.0314 = 1.5 \times 10^{-2}$ J.

16.A Carnot's engine working between 800k and 400k has a work output of 800j/cycle. How much heat energy is supplied to the engine from the source? (P.T.O).

Efficiency of Carnot's engine $\eta = (1-T_2/T_1)x100$
$= (1-400/800)x100\%$

$\eta = 50\%$

But η = out put / input

$50/100 = 800/ Q_1$

$\therefore$ Energy supplied to the engine, $Q_1 = 1600J$.

17.The displacement x (in cm) of an oscillating particle varies with time t (in sec) according to the equation $x = 2 \cos (0.5 \pi t + \pi/3)$. Find (i) the maximum acceleration of the particle (ii) time period of oscillation.

Here, the equation $x = 2 \cos (0.5\pi t + \pi/3)$.

Comparing with the general equation, $x = A \cos (\omega t + \o_o)$.

We get, $\omega = 0.5\pi^-$, A = 2 cm

Time period $T = 2\pi^-/\omega = 4$ Sec.

Maximum acceleration $a = \omega^2 a = \frac{\pi^2}{4} \times 2 = 4.9\ m/s^2$

18.Explain the phenomenon of reverberation of sound. Write an expression for the reverberation time of a hall of volume V. mention any two methods to reduce the reverberation time.

See Question No.27 in 1998.

19.Experiments show that the frequency (n) of a tuning fork depends upon the length (l) of the prong, the density (d) and the young's modulus (y) of the material. From dimensional considerations, find a possible relation for the frequency of a tuning fork.

$n \propto l^a d^b y^c$

$n = k\, l^a d^b y^c$ -------------- (1)

where k – proportionately constant, Substituting the dimensions, we get

$T^{-1} = k[L]^a\ [M^1L^{-3}]^b\ [M^1L^{-1}T^{-2}]^c$

$M^o L^o T\text{-}1 = kL^{a-3b-c}\ M^{b+c}\ T^{-2c}$

Comparing dimensions of M,L and T on the two sides,

$a - 3b - c = 0$, $b+c = 0$, and $-2c = -1$, (or) $c = ½$

$b = -½$, $a = -1$

putting the values of a,b,and c in equation (1)

$n = kl^{-1}\ d^{-½}\ y^{½}$ (or) $n = k/l\ \sqrt{y/d}$.

20.When a body has uniformly accelerated motion, show that the distance covered it in a certain interval is equal to the area under velocity-time graph for that time interval.

See Question No. 10 in 1997

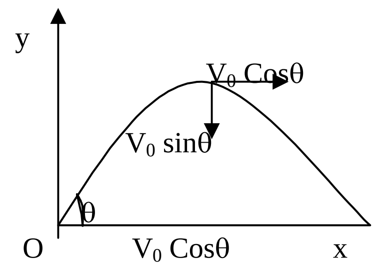
21.A projectile is fired at an angle θ with the horizontal.

a) Show that its trajectory is a parabola,

b) Obtain expressions for the maximum height attained.

Consider a projectile fired with a velocity V_0 at an angle θ with the horizontal from point 0 on the ground. At any point V_0 can be resolved into two components as $V_0 \cos\theta$ along x-axis and V_0 since along y-axis, $V_0 \cos\theta$ component remains same.

Horizontal velocity at an instant t = $V_x = V_0 \cos\theta$ --- (1)
Vertical velocity at an instant t = $V_y = V_0 \sin\theta - gt$ ----(2)
Horizontal distance $x = V_0 \cos\theta \times t$. -----(3)
Vertical distance $y = V_0 \sin\theta\, t - \frac{1}{2} gt^2$ -----(4)



$\therefore$ Form (3), $t = X / V_0 \cos\theta$

$\therefore$ The equation of the trajectory of the projectile,

$$y = V_0 \sin\theta \times X / V_0 \cos\theta - \frac{1}{2} g x^2 / V_0^2 \cos^2\theta$$

$$y = x \tan\theta - (g/2v^2\cos^2\theta)x^2 .$$

As the above equation is equation of parabola, it follows that a projectile fired at some angle with the horizontal moves along a parabolic path.

Maximum height attained:- It's the greatest height to which a projectile rises above the point of Projection.

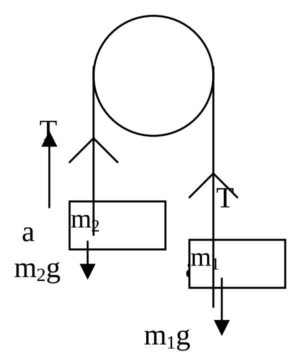
Time to reach the maximum height, $t = V_0 \sin\theta / g$.

$$\therefore h_{max} = V_0 \sin\theta \times V_0 \sin\theta / g - \frac{1}{2} g V_0^2 \sin^2\theta / g^2$$

$$h_{max} = V_0^2 \sin^2\theta / 2g.$$

22.Two masses m1 and m2 are connected at the ends of a light inextensible string that passes over frictionless pulley. Find the acceleration and tension in the string when the masses are released.

Let T be the tension in the string acts as shown in
Suppose the system moves with acceleration a as shown.



For mass m_1 ;

$m_1 g - T = m_1 a$ ………………………(i)

For mass m_2 ;

$T - m_2 g = m_2 a$ ………………………(ii)

Adding equation (i) and (ii) we get,

$(m_1 - m_2) g = (m_1 + m_2) a$

$\therefore$ acceleration $a = \dfrac{(m_1 - m_2)\, g}{(m_1 + m_2)}$

$$\frac{(i)}{(ii)} \quad \frac{m_1 g - T}{T - m_2 g} = \frac{m_1}{m_2}$$

Cross multiplying, $(m_1 g - T)m_2 = (T - m_2 g)m_1$

$m_1 m_2 g - m_2 T = m_1 T - m_1 m_2 g$

$$T = \frac{2 m_1 m_2 g}{m_1 + m_2} .$$

23.A toy rocket of mass 0.1 kg has a small fuel of mass 0.02 kg which it turns in 3 sec. Starting from rest on a horizontal smooth track, it gets a speed of 20m/s after the fuel is turns out, what is the approximate thrust on the rocket? What is the energy content per unit mass of the fuel?

(P.T.O)

Acceleration produced, a = $\underline{20 - 0}$ $\underline{20}$ m/s^2 .

3 3

Thrust (force) of the rocket, f = ma = 0.1 X 20/3 = 2/3 N.

K.E imparted to the rocket = ½ mu^2

= ½ X 0.1 $X(20)^2$

= 20 J.

∴ Energy imparted per unit mass of the fuel, = 20/0.02 = 1000J /kg.

24. Deduce an expression for the escape velocity of a body from the surface of the earth. How it is related to the orbital velocity.

The escape velocity is the minimum velocity with which a projectile must be projected in order that it may escape the earth's gravitational pull.

Consider a body of mass m at a distance r from the centre of the earth of mass M.

The work done by the body against the gravitational pull of the earth in moving upward through a small distance dr,

$$dw = F\,dr = \frac{GMm}{r^2}.\ dr$$

∴ The total work done in moving to an infinite distance away from it, is,

$$w = \int_R^{8} dw = GMm \int_R^{8} 1/r^2\ dr. = \frac{GMm}{R}$$

Where R is the radius of the earth.

Let V_e he the escape velocity. Then the initial kinetic energy that at least must be Equal to the work done by the body in escaping from the earth.

$$\therefore \tfrac{1}{2} m V_e^2 = \frac{GMm}{R} \qquad \therefore V_e = \sqrt{\frac{2GM}{R}}$$

$$\text{Since} \quad g = \frac{GM}{R^2}, \qquad gR = \frac{GM}{R}$$

$$V_e = \sqrt{2gR}\ . \quad \& \quad \text{The orbital velocity } V_0 = \sqrt{gR}$$

$$\therefore \text{The escape velocity } V_e = \sqrt{2} \text{ x orbital velocity.}$$

25. Define terminal velocity. Derive an expression for the terminal velocity V_t of a sphere of radius' r 'and density 'ρ' falling through a viscous fluid of density 'σ ' and coefficient of viscosity η.

See Question No. 25 in 1997.

26. A cylindrical wooden block floating over water is slightly depressed and released from the state of equilibrium. Show that the block executes S.H.M. also find the time period and frequency of oscillation.

Consider a wooden cylinder of mass m, cross section area 'A' density ρ_s, and Length 'L' floating in water of density ρ_l. According to the principle of floatation In equilibrium, weight of the cylinder = weight of the liquid displaced.

If the cylinder is depressed through a distance 'x' the buoyant force on it

Increases by ρ_l A x g (w.t of the liquid displaced)

∴ the restoring force on the cylinder $F = -A\,\rho_l\,x\,g$

Since $F \propto x$, the motion of cylinder is simple harmonic.

$\therefore$ Acceleration $a = -\dfrac{A\rho_l \times g}{m}$ where m = mass of the cylinder $m = A\,\rho_S\, l$

$$a = -\frac{A\,\rho_l \times g}{A\,\rho_S\, L}, \qquad a = -\frac{\rho_l\, g\, x}{\rho_S\, L}$$

In S.H.M the acceleration = $-\omega^2 x$

$$\therefore -\omega^2 x = -\frac{\rho_l\, g\, x}{\rho_s\, L} \qquad \omega = \sqrt{\frac{\rho_l\, g}{\rho_S\, L}} = \frac{2\pi}{T}$$

$$\therefore \text{Time period } T = 2\pi\sqrt{\frac{L\,\rho_S}{\rho_l g}}$$

27. A man standing near a railway line hears the whistle of an engine, which has a velocity 0f 20 m/s. what frequency does the man hear, when the engine is coming towards and going away from him, if the true frequency of the whistle is 1000 Hz. Speed of sound in air = 340 m/s.

When the engine coming towards the man,

$$\gamma_1 = \frac{C\gamma}{C - Vs} = \frac{340 \times 1000}{340 - 20} = \frac{340 \times 1000}{320} = 1062.5 \text{ Hz.}$$

When the engine going away,

$$\gamma_1' = \frac{c\gamma}{C + Vs} = \frac{340 \times 1000}{340 + 20} = \frac{340 \times 1000}{360} = 944.4 \text{ Hz.}$$

28. a) Distinguish between adiabatic and isothermal processes.

b) Using first law of thermodynamics derive the relation Cp – Cv = R..

a) See Question No. 19 in 1996.

b) Consider one mole of an ideal gas. Heat the gas at constant volume so that its temperature increases by dT.

Heat supplied = 1 Cv dT.

Since no external work is performed at constant volume, the heat supplied will be just equal to increase in internal energy of the gas.

$\therefore$ du = Cv dT ……………………….(i)

Now, let the gas be heated at constant pressure to again increase its temperature by dT. If dQ is amount of heat supplied, then, dQ = Cp dT …………………….(ii)

The heat supplied at constant pressure increases its internal energy by du as well as enables the gas to perform the work dW. If dV is increase in volume, then work performed by the gas,

dW = p. dV ……………………(iii)

According to first law of thermodynamics, dQ = du + dW

From equations (i),(ii), & (iii), $Cp\ dT = Cv\ dT + p.\ dV$
From the perfect gas equation, $P\ dV = R.\ dT.$

$$\therefore Cp\ dT = Cv\ dT + R.\ dT.$$

$$\mathbf{Cp = Cv + R}$$

$$Cp - Cv = R$$

29. Derive Bernoulli's theorem for non-viscous liquids. Write two applications.
Refer Question No. 31 in 1995.

(OR)

State any four postulates of kinetic theory of gases. Based on these postulates deduce **an expression for the pressure exerted by an ideal gas.**
Refer Question No. 29 in 1997.

30.a) Obtain an expression for the moment of inertia of a uniform thin disc about an axis through its centre and perpendicular to its plane.
b) Using the above result derive the moment of inertia of the disc about an axis passing through a point on its edge and normal to disc.

a) Refer Question No. 26 in 1996.

b) The centre of the disc is centre of mass of the disc. Therefore m . I of the about an axis through its centre of mass is ½ MR^2 .
If I' is moment of inertia of the disc about an axis through a point on its edge and normal to its place then from parallel axis theorem, we get
$I' = I_C + Mh^2$
$I_C = I = ½ MR^2$ and $h = R$

$$\therefore I' = ½ MR^2 + MR^2$$

$$I' = 3/2MR^2 .$$

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" Success is the acid test and performance is the best test "

TEST PAPER No. 1

PHYSICS (Theory) Max. Marks : 70

CLASS : XI Time Allowed : 3Hrs

General instructions;-

(i) All questions are compulsory.

(ii) Marks for each question are indicated against it.

(iii) Question numbers 1 to 5 are very short answer question ,carrying 1 mark each.

(iv) Question numbers 6 to 12 are short answer questions, each carrying 2 marks .

(v) Question numbers 13 to 24 are also short answer questions, each carrying 3 marks.

(vi) Question numbers 25 to 27 are long answer questions, each carrying 5 marks.

(vii) Use log tables if necessary.

Section – A (1 mark each)

1. What do you mean by impulse? Give its S.I. unit.
2. Where do we come across zero vectors in physics? Give one example.
3. What is meant by scientific method?
4. Give two points of difference between crystalline and amorphous solids.
5. Why does the moon have no atmosphere?

Section – B (2 marks each)

6. Explain the reflection method to locate the submarine.
7. What are inertial and non-inertial frames of reference? Give examples.
8. Show that the area under velocity-time graph represents the distance travelled.
9. Explain the statement "Two artificial satellites can revolve around the earth in a particular orbit at a constant speed, irrespective of the difference between their masses".
10. Calculate the excess pressure across a soap bubble of diameter 4 mm. Surface tension of soap bubble is 1.5 Nm^{-1}
11. A Pluto year is 247 times the earth year. How far is the Pluto from the sun, if the earth is 1.5×10^8 km away from the sun?

OR

A body of mass 10 kg is taken from the equator to the pole of the earth. Calculate the change in its weight if the radius of the earth is 6400km, time period of earth's rotation about its own axis is 24hrs.

12. (a) By what factor the rate of flow of water will increase, if the diameter of the bore of the capillary is doubled? (b) If a person stands near the fast moving train, why is there a possibility of his falling towards it?

Section – C (3 marks each)

13. Discuss the formula for the velocity of sound in air.
14. a) Define relative velocity.

    b) An aeroplane is flying due north with a velocity of 80 km/hr. If the wind blows due east at 20 km/hr, find the resultant velocity of an aeroplane with reference to earth.
15. What is the centripetal acceleration? Derive an expression for it.

16. a) Represent graphically a wave motion which is periodic but not simple harmonic.

b) Explain the relation between uniform circular motion and simple harmonic motion.

17. Given that the time period T of oscillation of a gas bubble from an explosion under water depends upon P, d and E. Where P $\rightarrow$ Pressure, d the density of water and E is the energy of explosion, find dimensionally a relation for T.

18. a) On what factors does the turning effect of a force depend? b) Deduce the relation between torque
and angular momentum .

19. A truck of mass 2500 kg is moving at a speed of 54 km/hr and is acted upon by two forces of 500N due to engine and a retarding force of 100N due to friction. Calculate the acceleration of the truck and distance moved by it in 10 minutes.

20. Draw labelled curves which show how the energy in the spectrum of radiation from a black body varies with wavelength at various temperatures. List four important points that emerge from the curves.

OR

What is an adiabatic process? Derive an expression for the work done during such process.

21. What is escape velocity? Obtain an expression for the escape velocity for a planet.

22. Obtain the expression for apparent frequency for a note, when the source and the listener are moving in the same direction with velocities u_s ans u_o respectively, with source following the listener.

23. A parachutist bails out from an aeroplane and after dropping through a distance of 19.6 m, he opens the parachute and decelerates at 2 ms^{-2}. If he reaches the ground with a velocity of 1.6 ms^{-1} for how long was he in the air? What was the height of the aeroplane when he bailed out from it? (g=9.8 ms^{-2}).

24. A pump on the ground floor of a building can pump up water to fill a tank of volume 30 m^3 in 15 min. If the tank is 40m above the ground and the efficiency of the pump is 30%, how much electric power is consumed by the pump? (Density of water = 1000 kg/m^3)

Section – D (5 marks each)

25. (a) Define thermal conductivity and state its S.I units.

(b) Assume that the thermal conductivity of copper is four times that of brass. Two rods of copper and brass having the same length and cross section are joined end to end. The free end of the copper rod is kept at 0 °C and free end of the brass is kept at 100 °C. Calculate the temperature of the junction of the two rods at equilibrium.

26. **State and prove Bernoulli's theorem.`**

OR

Define terminal velocity. Use Stoke s law to obtain equation for terminal velocity.

27. What do you mean by a collision? Discuss the elastic collision between two bodies along one dimension and derive an expression for the velocities after collision.