+1 PHYSICS
PUBLIC EXAM (2018- 2019) - TENTATIVE ANSWER KEY - B SET

PART - I

Total Marks : 70

Answer the following Objectve type questions $15\times 1 = 15$

1) c 2.5 rad	9) a 10 m
2) b convection	10) c
3) d Torque and energy	11) c W = 0
4) c 1/2	12) a 0.157 ms^{-1}
5) c bigger will grow until they collapse	13) c increases
6) c 66.67 J	14) b sin (x + vt)
7) d decrease	15) d 0.2%
8) d remains the same	

PART - II

Write any six of the following questions . Q. No. 24 is compulsory. $6\times 2 = 12$

16. Write any two errors of systgematic errors. Explain them.

1) **Instrumental errors**
- When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise.
- If a measurement is made with a meter scale whose end is worn out, the result obtained will have errors. These errors can be corrected by choosing the instrument carefully.

2) **Imperfections in experimental technique or procedure**
- These errors arise due to the limitations in the experimental arrangement. As an example, while performing experiments with a calorimeter, if there is no proper insulation, there will be radiation losses.
- This results in errors and to overcome these, necessary correction has to be applied.

17. what is projectile? Give two examples
- When an object is thrown in the air with some initial velocity (NOT just upwards), and then allowed to move under the action of gravity alone, the object is known as a projectile.

Examples of projectile are

1. An object dropped from window of a moving train.
2. A bullet fired from a rifle.

18. State Newton's Second law of motion?
- This law states that ,
- The force acting on an object is equal to the rate of change of its momentum

$$\vec{F} = \frac{\overrightarrow{dp}}{dt}$$

19. A car takes a turn with the velocity 50 ms^{-1} on a circular road of radius of curvatirue 10m. calculate the centrifugal force experienced by a person of mass 60 kg inside the car?

so given,

mass=60kg , r=10m , v=50m/s

$f=mv^2/r$

$f=60\times50\times50/10$

$f=60\times50\times5$

$f=300\times50$

f=15000N

20. Why is it more difficult to revolve a stone tied to a longer string then a stone tied to a shorter string.

- It is difficult to revolve the stone by tying it to a longer string than tying it to a shorter string because the moment of inertia of stone tied with longer string is more than that tied with smaller string.

21. State Stefan - Boltzmann Law and write its expression

Stefan Boltzmann law states that,

the total amount of heat radiated per second per unit area of a black body is directly proportional to the fourth power of its absolute temperature. $E \propto T^4$ or $E = \sigma T^4$ Where, σ is known as Stefan's constant. Its value is 5.67×10^{-8} W m^{-2} k^{-4}

22. list the factors affecting Brownian motion

Factors affecting Brownian Motion

1. Brownian motion increases with increasing temperature.
2. Brownian motion decreases with bigger particle size, high viscosity and density of the liquid (or) gas.

23. Soldiers are not allowed to march on a bridge. Give reason.

- Soliders are not allowed to march on a bridge.
- This is to avoid resonant vibration of the bridge.
- While crossing a bridge, if the period of stepping on the ground by marching soldiers equals the natural frequency of the bridge, it may result in resonance vibrations. This may be so large that the bridge may collapse.

24. The surface tension of a soap solution is 0.03 Nm^{-1}. How much work is done in producing soap bubble of radius 0.05 m?

work done = total surface area x surface tension

$W = 2 \times 4\pi r^2 \times T$

= 2 x 4 x 3.14 x (0.05)2 x 0.03

= 0.0025 x 0.03 x 8 x 3.14

= 1.884 x 10-3 J

Without unit reduce ½ marks

PART - III

Answer any six of the following . Q. No. 33 is compulsory. **6× 3 = 18**

25. what is the torque of the force $\vec{F} = 3\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$ acting at a point $\vec{r} = 2\hat{\imath} + 3\hat{\jmath} + 5\hat{k}$ about the origin?

Torque of a Force $\vec{F}$ acting on a point with position vector $\vec{r}$ is given by

$\vec{\tau} = \vec{r} \times \vec{F}$

We have,

$\vec{F} = 3\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$

$\vec{r} = 2\hat{\imath} + 3\hat{\jmath} + 5\hat{k}$

$$\vec{\tau} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 2 & 3 & 5 \\ 3 & -2 & 4 \end{vmatrix}$$

$\vec{\tau} = \hat{\imath}[(3)(4) - (-2)(5)] - \hat{\jmath}[(2)(4) - (3)(5)] + \hat{k}[(3)(3) - (2)(-2)]$

$\vec{\tau} = \hat{\imath}[12 + 10] - \hat{\jmath}[8 - 15] + \hat{k}[-9 - 4]$

$\vec{\tau} = 22\hat{\imath} + 7\hat{\jmath} - 13\hat{k}$

26. What is the various types of friction? Suggest few methods to reduce friction?

i) Static friction: it is the opposing force that is set up between the surfaces of contact of two bodies, when one body tends to slide over the surface of another body.

ii) Kinetic friction: it is the opposing force that is set up between the surfaces of contact of the two bodies. When one body is in relative motion over the surface of another body.

iii) Rolling friction: the force which opposes the rolling motion is called rolling friction.

iv) Sliding friction: the opposing force that comes into play when one body is actually sliding over the surface of the other body is called sliding friction.

Methods to reduce friction

i) Lubricating using oil, grease, etc.

ii) Polishing the surfaces

iii) Providing air cushion between two moving solid surfaces

iv) Converting sliding friction into rolling friction using wheels and ball bearings.

v) Streamlining the shape or cars, aero planes, jets, etc.

27. A heavy body and a light body have same momentum. Which one of them has more kinetic energy and why?

- Since both have same momentum the lighter one has high velocity according to the equation p=mv
- Therefore lighter body has higher kinetic energy because $K=p^2/2m$.

28. Find the rotational kinetic energy of a ring of mass 9 kg and radius 3 m rotating with 240 rpm about an axis passing through its centre and perpendicular to its plane.

The rotational kinetic energy is, $KE = \frac{1}{2} I\omega^2$

The moment of inertia of the ring is, $I = MR^2$

$$I = 9 \times 3^2 = 9 \times 9 = 81\,kg\,m^2$$

The angular speed of the ring is,

$$\omega = 240\,rpm = \frac{240 \times 2\pi}{60}\,rad\,s^{-1}$$

$$KE = \frac{1}{2} \times 81 \times \left(\frac{240 \times 2\pi}{60}\right)^2 = \frac{1}{2} \times 81 \times (8\pi)^2$$

$$KE = \frac{1}{2} \times 81 \times 64 \times (\pi)^2 = 2592 \times (\pi)^2$$

$$KE \approx 25920\,J \quad \because (\pi)^2 \approx 10$$

$$KE = 25.920\ kJ$$

29. what do you mean by the term weightlessness? Explain the state of weightlessness of a freely falling body?

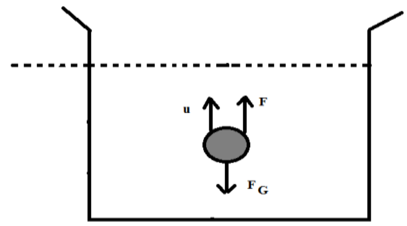
- Freely falling objects experience only gravitational force. As they fall freely, they are not in contact with any surface (by neglecting air friction).
- The normal force acting on the object is zero.
- The downward acceleration is equal to the acceleration due to the gravity of the Earth. i.e (a = g). From equation. we get.
  - **a = g ∴ N = m (g – g) = 0.**
- This is called the state of weightlessness.
- When the lift falls (when the lift wire cuts) with downward acceleration a = g, the person inside the elevator is in the state of weightlessness or free fall.

30. Derive an expression for the terminal velocity of a sphere falling through a viscous liquid?

- Consider a sphere of radius *r* which falls freely through a highly viscous liquid of coefficient of viscosity η.
- Let the density of the material of the sphere be ρ and the density of the fluid be σ.
- Gravitational force acting on the sphere $F_G = mg = \frac{4}{3}\pi r^3 \rho g$
- Upthrust **U** = $\frac{4}{3}\pi r^3 \sigma g$ viscous force **F** = $6\pi\eta r v_t$
- At terminal velocity v_t **downward force = upward force**

  $F_G - U = F$, $\frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g = 6\pi\eta r v_t$

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



- The terminal speed is directly proportional to the square of its radius.
- If σ is greater than ρ the terminal velocity is negative.
- That is why air bubbles rise up through water or any fluid.
- This is also reason for the clouds in the sky to move in the upward direction.

31. Explain linear expansion of solid.

Linear expansion

- In solids, The expansion in length is called linear expansion.
- In solids, for a small change in temperatureΔT, the fractional change in length. $\frac{\Delta L}{L} \, \alpha \, \Delta T$.
- The coefficient of linear expansion $\alpha_L = \frac{\Delta L}{L\Delta T}$
- ΔL = change in length, L = Original length.
- The unit of coefficient of linear expansion is ${}^0C^{-1} (or) K^{-1}$

32. Write down any six postulates of kinetic theory of gases.

1. All the molecules of a gas are identical, elastic spheres.
2. Th e molecules of diff erent gases are diff erent.
3. Th e number of molecules in a gas is very large and the average separation between them is larger than size of the gas molecules.
4. Th e molecules of a gas are in a state of continuous random motion.
5. The molecules collide with one another and also with the walls of the container.
6. These collisions are perfectly elastic so that there is no loss of kinetic energy during collisions.

33. Two waves of wavelength 99 cm and 100 cm both travelling with the velocity of 396 ms-1 are made to interface. Calculate the number of beats produced by them.

Given : $\lambda_1 = 99\ cm = 0.99\ m$ and $\lambda_2 = 100\ cm = 1\ m$

Velocity of wave $v = 396\ m/s$

Frequency of first wave $f_1 = \frac{v}{\lambda_1} = \frac{396}{0.99}$

Frequency of second wave $f_2 = \frac{v}{\lambda_2} = \frac{396}{1}$

Thus number of beat produced per second $b = f_1 - f_2 = 396\left[\frac{1}{0.99} - \frac{1}{1}\right]$

$\therefore b = 4$

PART - IV

Answer all the question **$5\times 5 = 25$**

34. a) Explain the principle of homogeneity of dimensional and derive an expression fo the force F acting on a body moving in a circular path depending on the mass of the body (m), velocity (v) and radius (r) of the circular path. Obtain the expression for the force by the dimensional analysis method (take the value k = 1)

Principle of homogeneity of dimensions

- The principle of homogeneity of dimensions states that the dimensions of all the terms in a physical expression should be the same.
- For example, in the physical expression $v^2 = u^2 + 2as$, the dimensions of v^2, u^2 and 2as are the same and equal to $[L^2T^{-2}]$.

The force F acting on a body moving in a circular path depends on mass of the body (m), velocity (v) and radius (r) of the circular path. Obtain the expression for the force by dimensional analysis method. (Take the value of k=1)

Solution

$F \propto m^a v^b r^c$

$F = k\, m^a v^b r^c$

where k is a dimensionless constant of proportionality. Rewriting above equation in terms of dimensions and taking k = 1, we have

$[MLT^{-2}] = [M]^a[LT^{-1}]^b[L]^c = [M^aL^bT^{-b}L^c]$

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

Comparing the powers of M, L and T on both sides

a = 1; b + c = 1 -b = -2

2 + c = 1 b = 2

a = 1 b = 2 and c = -1

From the above equation we get

$F = m^a v^b r^c$

$F = m^1v^2r^{-1}$

or $F = \frac{mv^2}{r}$

(Or)

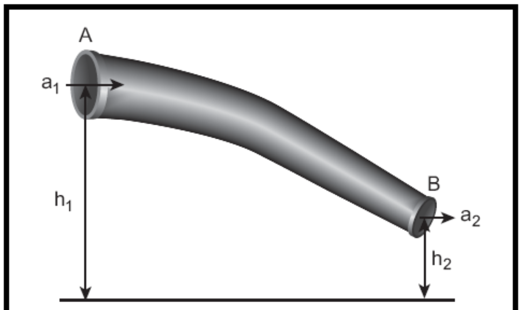
b) State and Prove Bernoulli's theorem for a flow of incompressible, non-viscous and streamlined flow of liquid

- According to Bernoulli's theorem, the sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant. Mathematically,

$$\frac{P}{\rho} + \frac{1}{2}v^2 + gh = Constant$$

This is known as **Bernoulli's equation.**

- Let us consider a flow of liquid through a pipe AB as shown in Figure.
- Let *V* be the volume of the liquid when it enters *A* in a time *t* which is equal to the volume of the liquid leaving *B* in the same time.
- Let a_A, v_A and P_A be the area of cross section of the tube, velocity of the liquid and pressure exerted by the liquid at *A* respectively.
- Let the force exerted by the liquid at *A* is $F_A = P_A a_A$
- Distance travelled by the liquid in time *t* is $d = v_A t$
- Therefore, the work done is $W = F_A d = P_A a_A v_A t$
- But $a_A v_A t = a_A d = V$, volume of the liquid entering at *A*.
- Thus, the work done is the pressure energy (at *A*), $W = F_A d = P_A V$
- Pressure energy per unit volume at $A = \frac{Pressure\ energy}{Volume} = \frac{P_A}{V} = P_A$
- Pressure energy per unit mass at $A = \frac{Pressure\ energy}{Mass} = \frac{P_A V}{m} = \frac{P_A}{\frac{m}{V}} = \frac{P_A}{\rho}$



Flow of liquid through a pipe AB

- Since m is the mass of the liquid entering at A in a given time, therefore, pressure energy of the liquid at A is $E_{PA} = P_A V = P_A V \times \left(\frac{m}{m}\right) = m\frac{P_A}{\rho}$
- Potential energy of the liquid at A, $PE_A = mg\,h_A$
- Due to the flow of liquid, the kinetic energy of the liquid at A, $KE_A = \frac{1}{2}m\,v_A^2$
- Therefore, the total energy due to the flow of liquid at A, $E_A = EP_A + KE_A + PE_A$

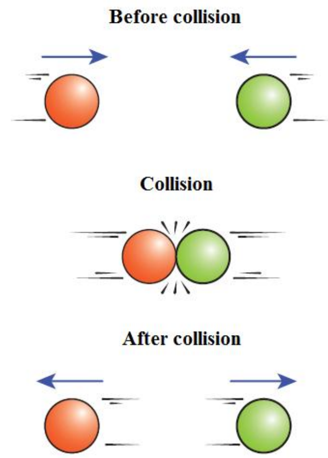
$$E_A = m\frac{P_A}{\rho} + \frac{1}{2}\,m\,v_A^2 + mgh_A$$

- Similarly, let a_B, V_B *and* P_B be the area of cross section of the tube, velocity of the liquid, and pressure exerted by the liquid at *B*.
- Calculating the total energy at EB, we get
- $E_B = m\frac{P_B}{\rho} + \frac{1}{2}\,m\,v_B^2 + mgh_B$
- From the law of conservation of energy, **EA = EB**
- $m\frac{P_A}{\rho} + \frac{1}{2}\,m\,v_A^2 + mgh_A = m\frac{P_B}{\rho} + \frac{1}{2}\,m\,v_B^2 + mgh_B$
- $\frac{P_A}{\rho} + \frac{1}{2}\ v_A^2 gh_A = \frac{P_B}{\rho} + \frac{1}{2}\ v_B^2 + gh_B = Constant$
- Thus the above equation can be written as
- $\frac{P}{\rho g} + \frac{1}{2}\frac{V^2}{g} + h = Constant$

- The above equation is the consequence of the conservation of energy which is true until there is no loss of energy due to friction.
- But in practice, some energy is lost due to friction.
- This arises due to the fact that in a fluid flow, the layers flowing with different velocities exert frictional forces on each other.
- This loss of energy is generally converted into heat energy.
- Therefore, Bernoulli's relation is strictly valid for fluids with zero viscosity or non-viscous liquids.
- Notice that when the liquid flows through horizontal pipe, then **h=0⇒**$\frac{P}{\rho g} + \frac{1}{2}\frac{V^2}{g} = Constant.$

35. a) Prove the law of conservation of momentum. Use it to fine the recoil velocity of a gun when a bullet is fired from it.

1) The Law of conservation of linear momentum is a vector law. It implies that both the magnitude and direction of total linear momentum are constant. In some cases, this total momentum can also be zero.



2) To analyse the motion of a particle, we can either use Newton's second law or the law of conservation of linear momentum. Newton's second law requires us to specify the forces involved in the process.

- This is difficult to specify in real situations.
- But conservation of linear momentum does not require any force involved in the process.
- It is covenient and hence important.
- For example, when two particles collide, the forces exerted by these two particles on each other is difficult to specify.
- But it is easier to apply conservation of linear momentum during the collision process.

Examples

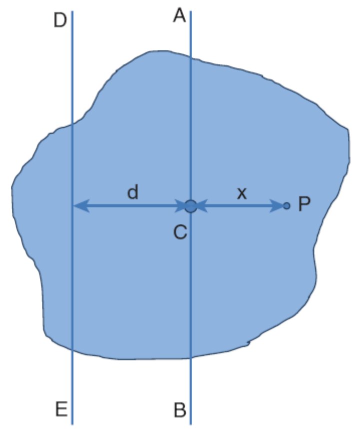
- Consider the firing of a gun. Here the system is Gun+bullet.
- Initially the gun and bullet are at rest, hence the total linear momentum of the system is zero.
- Let $\overrightarrow{P_1}$ be the momentum of the bullet and $\overrightarrow{P_2}$ the momentum of the gun before firing.

- Since initially both are at rest, $\overrightarrow{P_1} + \overrightarrow{P_2} = 0$
- Total momentum before fi ring the gun is zero, According to the law of conservation of linear momentum, total linear momemtum has to be zero after the firing also.
- When the gun is fi red, a force is exerted by the gun on the bullet in forward direction.
- Now the momentum of the bullet changes from $\overrightarrow{P_1}$ to $\overrightarrow{P_1'}$.
- To conserve the total linear momentum of the system, the momentum of the gun must also change from $\overrightarrow{P_2}$ to $\overrightarrow{P_2'}$.
- Due to the conservation of linear momentum, $\overrightarrow{P_1} + \overrightarrow{P_2} = 0.$
- It implies that$\overrightarrow{P_1'} = -\overrightarrow{P_2'}$ the momentum of the gun is exactly equal, but in the opposite direction to the momentum of the bullet.
- This is the reason after firing, the gun suddenly moves backward with the momentum ($\overrightarrow{P_2'}$).
- It is called 'recoil momemtum'. Th is is an example of conservation of total linear momentum.

(Or)

b) state and prove parallel axes theorem.

- As the moment of inertia depends on the axis of rotation and also the orientation of the body about that axis, it is different for the same body with different axes of rotation.
- ***Parallel axis theorem states that the moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its center of mass and the product of the mass of the body and the square of the perpendicular distance between the two axes.***
- Let us consider a rigid body as shown in Figure.



- Its moment of inertia about an axis AB passing through the center of mass is IC.
- DE is another axis parallel to AB at a perpendicular distance d from AB. The moment of inertia of the body about DE is I.
- We attempt to get an expression for I in terms of IC.
- For this, let us consider a point mass m on the body at position x from its center of mass.
- The moment of inertia of the point mass about the axis DE is, $m(x+d)^2$. The moment of inertia I of the whole body about DE is the summation of the above expression.

$$I=\Sigma m(x+d)^2$$

- This equation could further be written as,

$$I=\Sigma m(x^2+d^2+2xd)$$
$$I=\Sigma(mx^2+md^2+2dmx)$$
$$I=\Sigma mx^2+\Sigma md^2+2d\Sigma mx$$

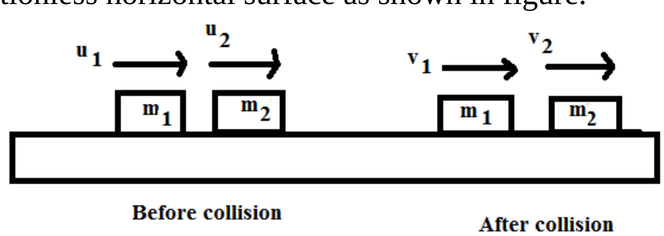
- Here, Σmx^2 is the moment of inertia of the body about the center of mass. Hence, $I_c = \Sigma mx^2$
- The term, $\mathbf{\Sigma mx = 0}$ because, x can take positive and negative values with respect to the axis AB.
- The summation **(Σmx)** will be zero.
- Thus, $I = I_c + \sum md^2 = I_c + (\sum m)d^2$
- Here, Σm is entire mass M of the object

$$I = I_c + Md^2$$

Hence, the parallel axis theorem is proved.

36. a) what is elastic collision? Derive an expression for final velocities of two bodies which undergo elastic collision in one dimension.

- In a collision, the total initial kinetic energy of the bodies (before collision) is equal to the total final kinetic energy of the bodies (after collision) then, it is called as elastic collision. i.e.,
- **Total kinetic energy before collision = Total kinetic energy after collision**
- Consider two elastic bodies of masses m_1 and m_2 moving in a straight line (along positive x direction) on a frictionless horizontal surface as shown in figure.



Mass	Initial velocity	Final velocity
Mass m_1	u_1	v_1
Mass m_2	u_2	v_2

- In orde to have collision, we assume that the mass m_1 moves faster than mass m_2 (i.e.) $u_1 > u_2$.
- For elastic collision, the total linear momentum and kinetic energies of the two bodies before and after collision must remain the same.
- From the law of conservation of linear momentum.
- Total momentum before collision (p_i) = Total momentum after collision (P_f)

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2, \quad m_1(u_1 - v_1) = m_2(v_2 - u_2) \text{ ---------- (1)}$$

- Total momentum before collision (P_i) = Total kinetic energy after collision KE_f

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2, \quad m_1(u_1^2 - v_1^2) = m_2(u_2^2 - v_2^2)$$

$$m_1(u_1 + v_1)(u_1 - v_1) = m_2(v_2 + u_2)(v_2 - u_2) \text{ ------------- (2)}$$

Dividing we get $u_1 + v_1 = v_2 + u_2$, $\quad u_1 - u_2 = -(v_1 - v_2)$ --------------- (3)

Simplifying we get,

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1 + \left(\frac{2m_2}{m_1 + m_2}\right) u_2 \text{ ------ (4)}$$

$$v_2 = \left(\frac{2m_1}{m_1 + m_2}\right) u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) u_2 \text{ ------ (5)}$$

Case (1): if $m_1 = m_2$, $v_1 = u_1$, $v_2 = u_2$. The velocities exchange after collision.

Case (2): if $m_1 = m_2$ and $u_2 = 0$ then $v_1 = 0$, $v_2 = u_1$.

The first body comes to rest and the second body moves with the velocity of the first body.

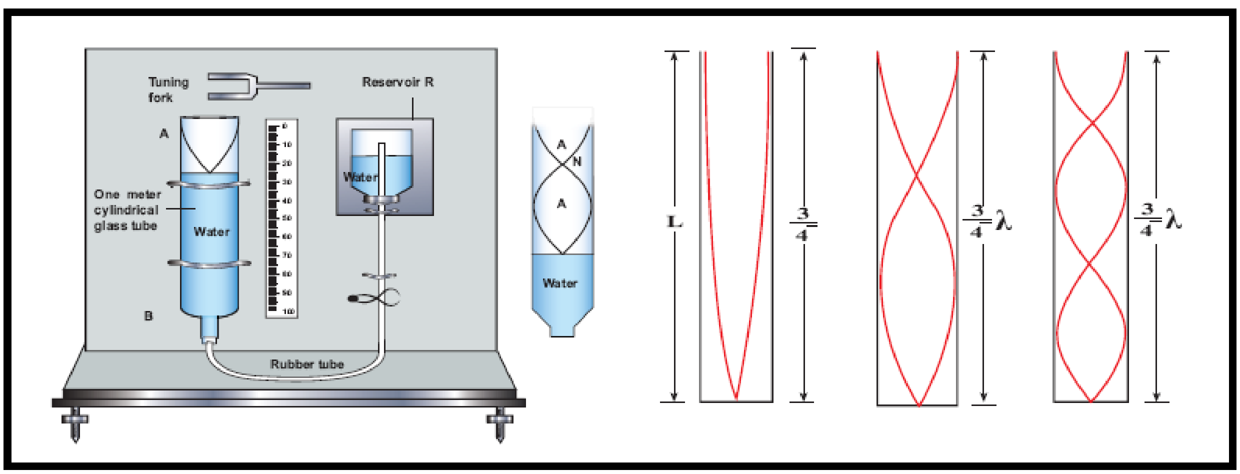
Case (3): The first body is vbery much lighter than the second body **($m_1 << m_2$) and $u_2 = 0$,** we get **$v_1 = - u_1$ and $v_2 = 0$**. It means the lighter body rebounds with the same velocity and the heavier body is at rest.

Case (4) : The second body is very much lighter than the first body. **$M_2 << m_1$ and $u_2 = 0$,** we get **$v_1 = u_1$ and $v_2 = 2u_1$.** The heavier body continues to move with the same initial velocity. The lighter body will move with twice the intial velocity of the heavier body.

(Or)

b) How will you determine the velocity of sound using resonance air column apparatus?

- The resonance air column apparatus is one of the simplest techniques to measure the speed of sound in air at room temperature.
- It consists of a cylindrical glass tube of one meter length whose one end A is open and another end B is connected to the water reservoir R through a rubber tube as shown in Figure.



- This cylindrical glass tube is mounted on a vertical stand with a scale attached to it.
- The tube is partially filled with water and the water level can be adjusted by raising or lowering the water in the reservoir R.
- The surface of the water will act as a closed end and other as the open end.

- Therefore, it behaves like a closed organ pipe, forming nodes at the surface of water and antinodes at the closed end.
- When a vibrating tuning fork is brought near the open end of the tube, longitudinal waves are formed inside the air column.
- These waves move downward as shown in Figure and reach the surfaces of water and get reflected and produce standing waves.
- The length of the air column is varied by changing the water level until a loud sound is produced in the air column.
- At this particular length the frequency of waves in the air column resonates with the frequency of the tuning fork (natural frequency of the tuning fork).
- At resonance, the frequency of sound waves produced is equal to the frequency of the tuning fork. This will occur only when the length of air column is proportional to $\left(\frac{1}{4}\right)^{th}$ of the wavelength of the sound waves produced.
- Let the first resonance occur at length L_1, then

$$\frac{1}{4}\lambda = L_1$$

- But since the antinodes are not exactly formed at the open end, we have to include a correction, called end correction *e*, by assuming that the antinode is formed at some small distance above the open end. Including this end correction, the first resonance is

$$\frac{1}{4}\lambda = L_1 + e$$

- Now the length of the air column is increased to get the second resonance. Let L_2 be the length at which the second resonance occurs. Again taking end correction into account, we have

$$\frac{3}{4}\lambda = L_2 + e$$

- In order to avoid end correction, let us take the difference of equations, we get

$$\frac{3}{4}\lambda - \frac{1}{4}\lambda = (L_2 + e) - (L_1 + e)$$

$$\frac{1}{2}\lambda = L_2 - L_1 = \Delta L$$

$$\lambda = 2\Delta L$$

- The speed of the sound in air at room temperature can be computed by using the formula

$$v = f\lambda = 2f\Delta L$$

- Further, to compute the end correction, we get

$$e = \frac{L_2 - 3L_1}{2}$$

37. a) derive Mayer's relation for an ideal gas.

- Consider μ mole of an ideal gas in container with volume V, pressure P and temperature T.
- When the gas is heated at constant volume the temperature increases by dT.
- As no work is done by the gas, the heat that flows into the system will increase only the internal energy. Let the change in internal energy be dU. If C_v is the molar specific heat capacity at constant volume

$$dU = \mu C_v dT \text{ ------------ (1)}$$

- The gas is heated at constant pressure so that the temperature increases by dT. Q - heat supplied, dV - change in volume then **Q = μC_pdT ---------- (2)**
- If W is the work done by the gas, then **W = P dv**
- From the first law of thermodynamics **Q = du + W, μC_pdT = μC_vdT + Pdv -------- (3)**
- For one mole of an ideal gas **PV = μRT**

PdV + VdP = μRT.

- Since pressure is constant **dP = 0. Hence PdV = μRT----------- (4)**

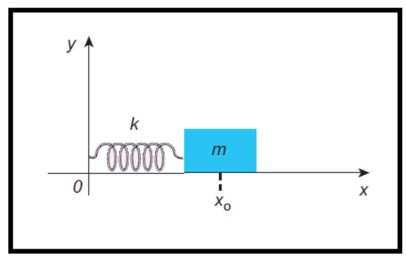
$$C_p = C_v + R, C_p - C_v = R \text{ --------- (5)}$$

- This relation is called Mayer's relation. This implies that, $C_p > C_v$. Also specific heat capacity at constant pressure is always greater than specific heat capacity at constant volume , $S_p > S_v$.

(Or)

b) Explain the horizontal oscillations of a spring.

- Consider a system containing a block of mass m attached to a massless spring with spring constant k placed on a smooth horizontal surface as shown in figure.
- Let x_0 be the equilibrium position or mean position of mass m when it is left undisturbed.
- Suppose the mass is displaced through a small displacement x towards right, from its equilibrium position and then released, it will oscillate back and forth about its mean position x_0.
- Let F be the restoring force which is proportional to displacement x.
- We **have** $F \alpha , F = -kx - - - - - (1)$
- The negative sign implies that the restoring force will always act opposite to the direction of the displacement.
- We assume that Hooke's law is valid and the oscillations are linear,
- From Newton's second law $m\frac{d^2x}{dt^2} = -kx, \frac{d^2s}{dt^2} = -\frac{k}{m}x \quad - - - - - - (2)$
- Comparing this with simple harmonic equation



$\frac{d^2y}{dt^2} = -\omega^2 y$ we get

$$\omega^2 = \frac{k}{m}, \omega = \sqrt{\frac{k}{m}} \, rad\, s^{-1} - - - - - - - - (3)$$

The frequency of oscillation is **f** = $\frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ **hertz**$- - - (4)$

The time period of oscillation is **T** = $\frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} - - - - - - (5)$

38. a) (i)write down the equation of a freely falling body under gravity

V = u + at

S = ut + $\frac{1}{2}at^2$

$v^2 = u^2 + 2as$

u - initial velocity, v - final velocity, S - displacement, t - time, a - acceleration

Particle start from rest u = 0.

v = gt

y = 1/2 gt^2

v^2 = 2gy

(ii) A ball is thrown vertically upwards with the speed of 19.6ms-1 from one top of a building and reaches the earth is 6s. find the height of the building.

The ball is thrown upwards with velocity 19.6 m/s. During the upward motion it experiences -9.8 m/s² acceleration due to which it comes to rest momentarily at the highest point in air. We can calculate the time taken to reach the heighest point.

v = u + at

0 = 19.6 - 9.8 t

t = 2 sec

So the ball reaches the topmost point in air in 2 seconds.

Distance travelled by the ball until it reaches the highest point :

$s = ut + at^2/2 = 19.6 \times 2 + 9.8 \times 2^2/2$

$s = 19.6 \times 2 + 19.6 = 19.6 \times 3 = 58.8$ m

Hence the ball travels 58.8 m above the
height of tower after throwing.

Now the ball comes down and experiences an acceleration of +9.8 m/s². The time in which it reaches down from the highest point is 4 sec (6-2) because 2 sec is consumed in reaching the highest point.

Now let us calculate the distance travelled by the ball to reach the earth in 4 sec.

$s = ut + at^2/2$

$s = 0 \times t + 9.8 \times 4^2/2$

$s = 9.8 \times 8$ m

This distance also includes the distance from the throwing point to the highest point, ie 58.8m.
So we need to subtract that distance from this calculated distance of 9.8×8 m.

So height of tower = 9.8× 8 - 58.8

= 9.8×8 - 9.8×3

= 9.8×5

= 49 m.

Hence height of the tower is 49 m.

(Or)

b) (i) Define orbital velocity and established an expression for it.

The horizontal velocity that has to be imparted to a satellite at a determined height so that it makes a circular orbit around the planet is called orbital velocity

$$\frac{Mv^2}{(R_E + h)} = \frac{GMM_E}{(R_e + h)^2}$$

$$v^2 = \frac{GM_E}{(R_E + h)}$$

$$v = \sqrt{\frac{GM_E}{(R_E + h)}}$$

(ii) Calculate the value of orbital velocity for an artificial satellite of earth orbiting at a height of 1000km (Mass of the earth = $\mathbf{6 \times 10^{24} Kg}$, $\mathbf{radius\ of\ the\ earth = 6400\ km}$).

$$v = \sqrt{\frac{GM_e}{R_e + h}}$$

$$v = \sqrt{\frac{6.67 \, x \, 10^{-11} x \, 6 \, x \, 10^{24}}{(6400+1000) x 10^3}}$$

$v = 7.353 \text{ kms}^{-1}$