MODEL PAPER – I
PHYSICS

I PUC

Time: 3hrs **Max Marks: 70**

PART – A

I. Answer the following: **10 x 1 = 10**

1. "Each term of the physical equation must be of equal dimensions".
2. When $\theta = 45^0$

   $$R = v_0^2 \frac{\sin 2\theta}{g} = \frac{v_0^2 \sin 2(45^0)}{g}$$

   $$R_{max} = \frac{v_0^2}{g}$$

   $\therefore$ R is maximum when $\theta = 45^0$
3. A force that does not depend on the path followed is a "non –conservative force"
4. Gravitational constant is defined as the force of attraction which exists between two unit masses separated by a unit distance.
5. Bulk modulus = $\frac{\text{Stress(shear)}}{\text{Strain(shear)}}$

   $$= \frac{[ML^{-1}T^{-2}]}{[M^0L^0T^0]}$$

   Bulk modulus has dimensions $[ML^{-1}\ T^{-2}]$
6. For a completely enclosed static fluid, pressure applied at one point is transmitted equally and undiminished in all possible directions throughout the fluid.
7. Maximum velocity of the liquid up to which the liquid maintains streamline flow is called critical velocity.
8. acceleration = $-\omega^2 y$

   Maximum displacement is amplitude

   $\Rightarrow y = A$

   $\therefore a_{max} = -\omega^2 A$
9. $$\lambda = \frac{2\pi}{k} = \frac{2\pi}{10\pi}$$

   $\lambda = 0.2\text{m}$
10. Harmonics in the ratio 1:3:5…. are observed in a closed pipe

    $\therefore$ only odd harmonics are present in the closed pipe

PART – B

II. Answer any FIVE of the following: **5 x 2 = 10**

11. Two basic forces are:

    i) gravitational force

    ii) electromagnetic force

    iii) strong nuclear force

    iv) weak nuclear force

12. 1 joule = 10^7 erg

Let 1 joule = x erg

Both joule and erg represent energy

But in ST system and CGS system respectively

$[E] = [ML^2\, T^{-1}]$

Let M_1, L_1 and T_1 represent mass length and time in SI system

Let M_2, L_2 and T_2 represent mass length and time in CGS system

Consider

1 joule = x erg

$$1[M_1 L_1 T_1^{-2}] = x[M_1\, L_2^2\, T_2^{-2}]$$

$$x = \frac{[M_1 L_1^2 T_1^{-2}]}{[M_2 L_2^2\; T_2^{-2}]}$$

$$x = \left[\frac{M_1}{M_2}\right]\left[\frac{L_1^2}{L_2^2}\right]\left[\frac{T_1^{-2}}{T_2^{-2}}\right] \qquad (1)$$

$$\left[\frac{M_1}{M_2}\right] = \frac{kg}{g} = \frac{10^3\,\cancel{g}}{\cancel{g}} = 10^3$$

$$\left[\frac{L_1}{L_2}\right] = \frac{m}{cm} = \frac{m}{10^{-2}m} = \frac{1}{10^{-2}} = 10^2$$

$$\left[\frac{T_1}{T_2}\right] = \frac{s}{s} = 1$$

$\therefore$ equation (1) becomes

$$x = (10^3)(10^2)^2(1)$$

$$= 10^3(10^4)\;(1)$$

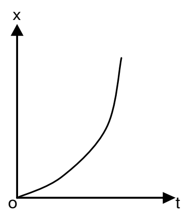
$$x = 10^7$$

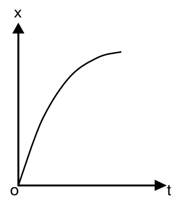
$$\therefore 1\,joule = 10^7\,erg$$

13. The acceleration of a particle undergoing uniform circular motion is called centripetal acceleration

$a_c = r\omega^2$

14.

i) 

ii) 

15. The angle between the tangent to the liquid surface at the point of contact and the solid surface inside the liquid is called angle of contact.

16. (i) Velocity is maximum at equilibrium position

(ii) Velocity is minimum at extreme position.

17. Points in a wave where displacement is zero is called “node”

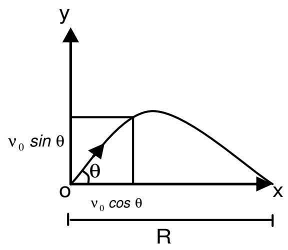
Points in a wave where displacement is maximum is an “antinode”

18. Detergent when added with water acts as a partially soluble impurity and tend to decrease surface tension of water. Hence a detergent solution can enter through fine spaces of fabric and remove the accumulated stains thereby achieving cleansing action

PART – C

III. Answer any FIVE of the following: **5 x 3 = 15**

19. Range is defined as the maximum horizontal distance reached by the projectile during its motion



Consider

$$v_{x_0} = \frac{R}{t_f}$$

$$\boxed{R = v_{x_0} t_f}$$

$$v_{x_0} = v_0 \cos\theta$$

$$t_f = \frac{2v_0 \sin\theta}{g}$$

$$R = (v_0 \cos\theta) = \frac{2v_0 \sin\theta}{g}$$

$$R = \frac{v_0^2(2\sin\theta\cos\theta)}{g}$$

$$\boxed{R = \frac{v_0^2 \sin 2\theta}{g}}$$

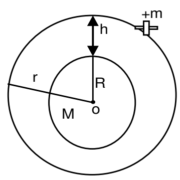
20. 1) The direction of frictional force between two surface is contact is always opposite to the relative motion of the body
2) Static frictional force is a self adjusting force and increases with the increase in applied force until the motion just begins
3) Limiting friction between two bodies depend on the material and nature of surface in contacts and is totally independent of area of contact
4) Magnitude of $(f_s)_{max}$ is directly proportional to the normal reaction N between two surfaces,

$$\mathbf{(f_s)_{max} \propto N}$$

21.

Elastic collision	**Inelastic collision**
i) In elastic collisions momentum is conserved	i) In inelastic collisions momentum is not conserved
ii) In elastic collisions kinetic energy conserved	ii) In inelastic collisions kinetics energy is not conserved
Ex: collision of 2 billiard balls	Ex: collision of 2 automobiles

22. Let O be centre of earth
R be radius of earth
Let h be distance between earth's surface and satellite
For a satellite revolving around earth



[centripetal force] = [Gravitational force of attraction between earth & satellite]

$$\frac{mv_0^2}{r} = \frac{GMm}{r^2}$$

$$v_0^2 = \frac{GM}{r}$$

But $r = R + h$

$$\Rightarrow v_0^2 = \frac{GM}{R+h}$$

$$\boxed{v_0 = \sqrt{\frac{GM}{R+h}}} \qquad ...(1)$$

w.k.t $g = \frac{GM}{R^2}$

$\Rightarrow GM = gR^2$

Putting above expression in eq^n (1)

$$\boxed{v_0 = \sqrt{\frac{gR^2}{R+h}}} \qquad ...(2)$$

This is the expression for orbital velocity of a satellite.

If satellite is close to earth,

$$(2) \Rightarrow v_0 = \sqrt{\frac{gR^{\cancel{2}}}{\cancel{R}}}$$

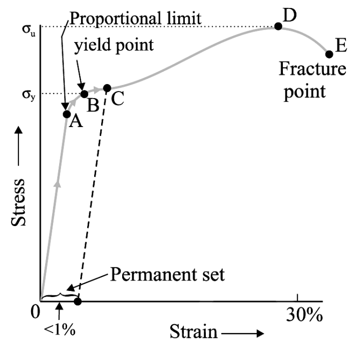
$$\therefore \boxed{v_0 = \sqrt{gR}}$$

23.

Stress – Strain Curve

Consider a wire of uniform cross section which is subject to a continuously increasing stress.

The graphical representation of stress versus strain is as shown below:



The stress-strain curve vary from material to material. The curve helps us to understand how a given material deforms with increasing load.

In the region between O to A, the cure is linear. In this region, Hooke's law is obeyed. Hence the body regains its original dimensions when the applied forces are removed thereby behaving as an elastic body.

In the region from A to B, stress and strain are not proportional. Still, the body returns to its original dimension when the load is removed. The point B in the curve is called yield point (elastic limit) and the corresponding stress is known as yield strength (σ_y) of the material.

If the load is further increased, the stress developed exceeds the yield strength and strain rapidly increases even for a small change in stress which is shown by the curve between B and D.

When the load is removed at point C between B and D, the body does not regain its original dimension. Then the material is said to have a permanent set. The point D on the curve is the ultimate tensile strength (σ_u) of the material.

Beyond point D, fracture occurs at point E and is called fracture point.

If the ultimate strength and fracture points D and E are close, then the material is said to be brittle. If they are far apart, the material is said to be ductile.

24. "The ratio of amount of heat absorbed to the amount of work done" is called as co-efficient of performance (β)

w.k.t

$\beta = \frac{Q_2}{W}$

also $W = Q_1 - Q_2$

$\therefore \beta = \frac{Q_2}{Q_1 - Q_2}$

$$\boxed{\beta = \frac{Q_2}{Q_1 - Q_2}}$$

25. Characteristics are:

i) SHM is a periodic motion

ii) acceleration of a body undergoing SHM is directly proportional to the displacement of the body

iii) the acceleration of a body executing SHM is directed towards its mean position

26. The apparent change in frequency of sound due to the relative motion b/w the source and the listener is "Doppler effect" of sound

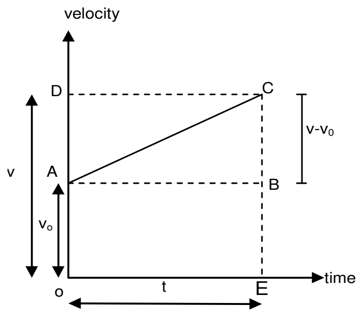
i) $f' = \left[\dfrac{v + v_L}{v - v_S}\right] f$

ii) $f' = \left[\dfrac{v + v_L}{v}\right] f$

PART – D

IV. Answer any TWO of the following: 2 x 5 = 10

27. Consider a v-t graph of a body accelerating uniformly



w.k.t area below v-t curve gives distance travelled

x = area below v-t curve

x = area of $\Delta ABC +$ area of rectangle $OABE$

$$x = \frac{1}{2} \times t \times (v - v_0) + t x v_0$$

But $v = v_0 + at$

at = $v - v_0$

$$\boxed{t = \frac{v - v_0}{a}}$$

$$\Rightarrow x = \frac{1}{2}\left(\frac{v - v_0}{a}\right)(v - v_0) + v_0\left(\frac{v - v_0}{a}\right)$$

$$= \frac{1}{a}\left[\frac{(v - v_0)^2}{2} + v_0(v - v_0)\right]$$

$$= \frac{1}{a}\left[\frac{v^2 + v_0^2 - \cancel{2vv_0} + \cancel{2vv_0} - 2v_0}{2}\right]$$

$$x = \frac{1}{a}\left[\frac{v^2 - v_0^2}{2}\right]$$

$$x = \frac{v^2 - v_0^2}{2a}$$

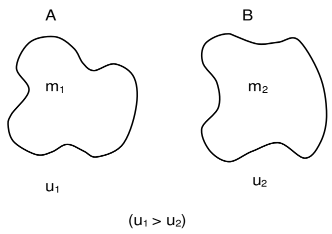
$$v^2 - v_0^2 = 2ax$$

$$\boxed{v^2 = v_0^2 + 2ax}$$

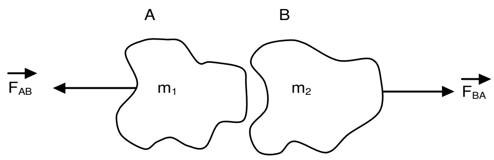
28. "The net momentum of an isolated system of interacting particles remains unaltered in absence of all external force"

<u>Proof</u>:

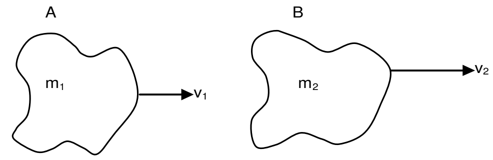
Before collision



During collision



After collision



Consider 2 bodies A and B of masses m_1 and m_2 moving with initial velocities u_1 and u_2 such that $u_1 > u_2$ moving in same direction

Let two bodies collide each other at some instant of time

During collision,

$\overrightarrow{F_{AB}}$ be force acting on body A by body B and $\overrightarrow{F_{BA}}$ be force acting on body B by A

According Newton 3rd law of motion

$\boxed{\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}}$

Negative sign indicates forces are oppositely directed.

After collision, let two bodies move with final velocities v_1 & v_2.

Total initial momentum before collision} = $m_1u_1 + m_2u_2$

Total initial momentum after collision} = $m_1v_1 + m_2v_2$

Consider

$$\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}$$

$$m_1\overrightarrow{a_A} = -m_2\overrightarrow{a_B}$$

But $\overrightarrow{a_A} = \dfrac{\overrightarrow{v_1} - \overrightarrow{u_1}}{t}$

and $\overrightarrow{a_B} = \dfrac{\overrightarrow{v_2} - \overrightarrow{u_2}}{t}$

$$m_1\left[\frac{v_1 - u_1}{\cancel{t}}\right] = -m_2\left[\frac{v_2 - u_2}{\cancel{t}}\right]$$

$$m_1\overrightarrow{v_1} - m_1\overrightarrow{u_1} = -m_2\overrightarrow{v_2} + m_2\overrightarrow{u_2}$$

$$m_1\overrightarrow{v_1} + m_2\overrightarrow{v_2} = m_1\overrightarrow{u_1} + m_2\overrightarrow{u_2}$$

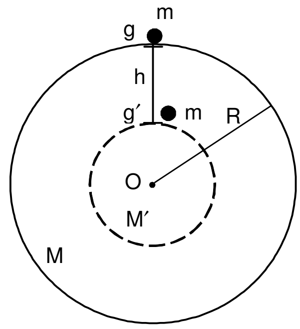
$\therefore$ Total momentum is conserved

29. **Expression for variation of acceleration due to gravity with depth**

Consider an object of mass on placed on earth surface.

Let M be the mass of earth and R be its radius.

Let g be the acceleration due to gravity at the earth surface. Then, $g = \dfrac{GM}{R^2}$ ....(1)



let g′ be the acceleration due to gravity at a depth h below the earth surface and corresponds to mass M′ and radius (R – h).

Acceleration due to gravity at a depth h is

$g' = \dfrac{GM'}{(R-h)^2}$ ....(2)

Eqn (2) ÷ Eqn (1) gives $\dfrac{g'}{g} = \dfrac{M'}{M}\dfrac{R^2}{(R-h)^2}$

But $\dfrac{M'}{M} = \dfrac{\rho\frac{4}{3}\pi(R-h)^3}{\rho\frac{4}{3}\pi R^3} = \dfrac{(R-h)^3}{R^3}$

$\dfrac{g'}{g} = \dfrac{(R-h)^3}{R^3}\dfrac{R^2}{(R-h)^2}$

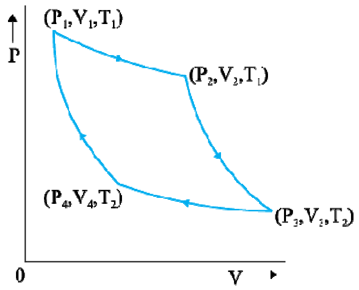
$\dfrac{g'}{g} = \dfrac{R-h}{R} = 1 - \dfrac{h}{R}$

$$\boxed{g' = g\left[1-\frac{h}{R}\right]}$$

∴ It is clear that acceleration due to gravity decreases with the depth from the earth surface.

V. Answer any TWO of the following: **2 x 5 = 10**

30. Carnot heat engine is a reversible heat engine whose efficiency is greater than efficiency of all practically designed heat engines



There are 2 isothermal and 2 adiabatic process involved in a Carnot cycle

Initially, let (P_1, V_1) be pressure and volume of working substance and (P_1, V_1) constitutes point A in P-V diagram

Step I: Cylinder with working substance is placed on source and working substance is allowed to undergo isothermal expansion. Pressure and volume (P_1, V_1) change to new value (P_2, V_2) and corresponds to point B on the curve

Step II: Cylinder is now placed on insulating stand and allowed to expand adiabatically. Pressure and Volume changes from (P_2, V_2) to (P_3, V_3) and constitute a point C

Step III: Cylinder is now placed on sink and allowed to compress isothermally. Pressure and volume changes from (P_3, V_3) to (P_4, V_4) and constitute a point D

Step IV: Cylinder is again placed on insulating stand and allowed to compress adiabatically

Pressure and Volume changes from (P_4, V_4) to (P_1, V_1)

Area enclosed under loop ABCDA represents work done by working substance in one cycle

31. Case 1: Expression for potential energy

Consider $\boxed{a=-\omega^2 y}$

Consider F= ma

$F=m(-\omega^2 y)$

$\boxed{F=-m\omega^2 y}$

If particle undergoes small displacement dy. Then small work dW is done again force and is given by dW = -Fdy

$dW=-\left(-m\omega^2 y\right)dy$

$dW=m\omega^2 ydy$

But $m\omega^2=k=\text{force constant}$

$dW=kydy$

Total work done is

$$W=\int_0^y dW$$

$$W=\int_0^y kydy$$

$$W=k\int_0^y ydy$$

$$W=k\left.\frac{y^2}{2}\right|_0^y$$

$$W=k\left(\frac{y^2}{2}-0\right)$$

$$W=\frac{ky^2}{2}$$

$$W=\frac{m\omega^2 y^2}{2}$$

$\boxed{W=\frac{1}{2}m\omega^2 y^2}$ But $W=E_p\ \therefore \boxed{E_p=\frac{1}{2}m\omega^2 y^2}$

Case II Expression for kinetic energy

w.k.t

$$E_k=\frac{1}{2}mv^2$$

But $v=\omega\sqrt{A^2-y^2}$

$\Rightarrow v^2=\omega^2(A^2-y^2)$

$$E_k=\frac{1}{2}m(\omega^2(A^2-y^2))$$

$$\boxed{E_k=\frac{1}{2}m\omega^2(A^2-y^2)}$$

Total Energy of a particle is sum of E_p & E_k

$$E=E_p+E_k$$

$$=\frac{1}{2}m\omega^2(A^2-y^2)+\frac{1}{2}m\omega^2 y^2$$

$$=\frac{1}{2}m\omega^2 A^2-\cancel{\frac{1}{2}m\omega^2 y^2}+\cancel{\frac{1}{2}m\omega^2 y^2}$$

$$\boxed{\therefore E=\frac{1}{2}m\omega^2 A^2}$$

But $\omega = 2\pi f$

$$E = \frac{1}{2}m(2\pi f)^2 A^2$$

$$= \frac{1}{2}m4\pi^2 f^2 A^2$$

$$\boxed{\therefore E = 2\pi^2 f^2 A^2 m}$$

32. Newton formula for speed of sound is given by

$$\boxed{v = \sqrt{\frac{P}{\rho}}}$$

According to Newton, speed of sound is given by

$$\boxed{v = \sqrt{\frac{E}{\rho}}}$$

where E is modulus of elasticity
ρ is the density of air.

For gaseous medium,

E = k

k = bulk modulus

$$\therefore \boxed{v = \sqrt{\frac{k}{\rho}}} \quad (1)$$

According to Laplace, the changes in pressure and volume occur under adiabatic conditions instead of isothermal conditions.

The eqn. of state for an adiabatic process is

$$Pv^{\gamma} = \text{constant}$$

Where $\gamma = \frac{c_p}{c_v}$

Consider $PV^{\gamma} = \text{constant}$

Taking log on both sides,

$$\log_e(PV^{\gamma}) = \text{constant}$$

$$\log_e P + \log_e V^{\gamma} = \text{constant}$$

On differentiation,

$$\frac{1}{P}dP + \gamma\frac{1}{V}dV = 0$$

$$\frac{dP}{P} + \gamma\frac{dV}{V} = 0$$

$$\frac{dP}{P} = -\frac{\gamma dV}{V}$$

The –ve sign indicates that with the increase in pressure volume decreases.

$$\frac{dP}{P} = \frac{\gamma dV}{V}$$

$$\frac{dP}{\frac{dV}{V}} = \gamma P$$

But $\frac{dP}{\frac{dV}{V}} = k$

$$\Rightarrow K = \gamma P$$

Substituting K in eqn. (1), we get

$$\boxed{v = \sqrt{\frac{\gamma P}{\rho}}}$$

This mathematical relation is called Newton – Laplace formula for speed of sound.

VI. Answer any THREE of the following: **3 x 5 = 15**

33. Data

$\theta = 30^0$

$v_0 = 20\,ms^{-1}$

(i) H = ?

g = 10ms^{-2}

W.K.T

$H = \frac{v_0^2 \sin^2\theta}{2g}$

$= \frac{(20)^{2\cdot} \sin^2(30^0)}{2(10)}$

$\therefore H = 5m$

(ii) R = ?

$R = \frac{v_0^2 \sin 2\theta}{g}$

$= \frac{(20)^2 \sin_2(30^0)}{10}$

$= \frac{400 \times \sin 60^0}{10}$

$\therefore R = 34.64m$

(ii) $t_a = ?$

$t_a = \frac{v_0 \sin\theta}{g}$

$= \frac{20 \sin 30^0}{10}$

$= \frac{\cancel{20} \times 1}{\cancel{20}}$

$\therefore t_a = 1s$

$\therefore$ Ball takes 1 second to reach highest point

(iv) $t_f = ?$

$t_f = \frac{2v_0 \sin\theta}{g}$

$\frac{2(20)\sin 30^0}{10}$

$= \frac{4\cancel{0} \times 1}{2 \times 1\cancel{0}}$

$\therefore t_f = 2s$

$\therefore$ Ball stays for 2s in air

34. Data

$m = 0.015kg = 15 \times 10^{-3} kg$

$\nu_0 = 400\,ms^{-1}$

$\nu = 260\,ms^{-1}$

$x = 10cm = 10 \times 10^{-2} m = 10^{-1} m$

(i) F = ?

W.K.T $2ax = \nu^2 - \nu_0^2$

$2(a)(10^{-1}) = -(400)^2 + (260)^2$

$2a(10^{-1}) = -160000 + 67600$

$\frac{-92400}{2 \times 10^{-1}} = a$

$a = -46200 \times 10$
$\therefore a = -462000\,ms^{-1}$
W.K.T
F = ma
$F = 15 \times 10^{-3} \times (-462000)N$
$F = -6930000 \times 10^{-3}N$
$F = -6930N$
$\therefore$ Force acting is $-6930N$
2nd part
$\nu_0 = 400\,ms^{-1}$
$\nu = 0\,ms^{-1}$
$x = 15 \times 10^{-2}m$

35. Data
$v_0 = \frac{1}{3}v_e$
h = ?
$\nu_0 = \sqrt{\frac{GM}{R+h}}$
$v_e = \sqrt{2gR}$
$\Rightarrow \sqrt{\frac{GM}{R+h}} = \frac{1}{3}\sqrt{2gR}$
on squaring both sides
$\frac{GM}{R+h} = \frac{1}{9}(2gR)$
$\frac{gR^2}{R+h} = \frac{2}{9}gR$
$\frac{R}{R+h} = \frac{2}{9}$
$\therefore h = 3.5R$
$h = 3.5(6380\,km)$
$h = 22{,}330\,km$

36. Data
$\eta = \frac{1}{5}$
$\eta = 1 - \frac{T_2}{T_1}$
$\frac{1}{5} = 1 - \frac{T_2}{T_1}$
$\boxed{\frac{T_2}{T_1} = \frac{4}{5}}$ $\boxed{T_2 = \frac{4}{5}T_1}$ ...(1)

When the temperature of source is increased by $\frac{500}{3}K$, efficiency is doubled

$\eta' = 2\left(\frac{1}{5}\right) = \frac{2}{5}$
$\eta' = 1 - \frac{T_2}{T_1 + \frac{500}{3}}$
$\frac{2}{5} = 1 - \frac{3T_2}{3T_1 + 500}$

$$\frac{3T_2}{3T_1+500}=1-\frac{2}{5}$$

$$\frac{3T_2}{3T_1+500}=1-\frac{2}{5}$$

$$\frac{3T_2}{3T_1+500}=\frac{3}{5}$$

$$5T_2=3T_1+500$$

Sub(1)

$$5\left(\frac{4}{5}T_1\right)=3T_1+500$$

$$4T_1=3T_1+500$$

$$\boxed{T_1=500\text{K}}$$

$$\therefore T_2=\frac{4}{5}T_1=\frac{4}{5}(500)$$

$$\boxed{T_2=400\text{K}}$$

37. Let f_s be frequency produced by ship and f_m be that heard by th man

$f=420\text{Hz}$

$f'=320\text{Hz}$

Let v_s be speed of ship

$v_s=?$

Let v be speed of sound

$v=342\text{ms}^{-1}$

w.k.t

Here, $f'=\left[\frac{v+v_w-v_L}{v+v_w-v_s}\right]f$

$$320=420\left[\frac{342+0-0}{342+0(-v_s)}\right]$$

$$\frac{32\cancel{0}}{42\cancel{0}}=\frac{342}{342-v_s}$$

$f=420\text{Hz}$

$f'=320\text{Hz} \quad v=342\text{ms}^{-1}$

$v_L=0$

$v_s=-v_s$

$$f'=\left[\frac{v+v_w-v_L}{v+v_w-v_L}\right]f$$

$$f'=\left[\frac{v+0-0}{v+0-1-v_s}\right]f$$

$$f'=\left[\frac{v}{v+v_s}\right]f$$

$$320=\left(\frac{342}{342+v_s}\right)420$$

$$\therefore v_s=106.87\text{ ms}^{-1}$$