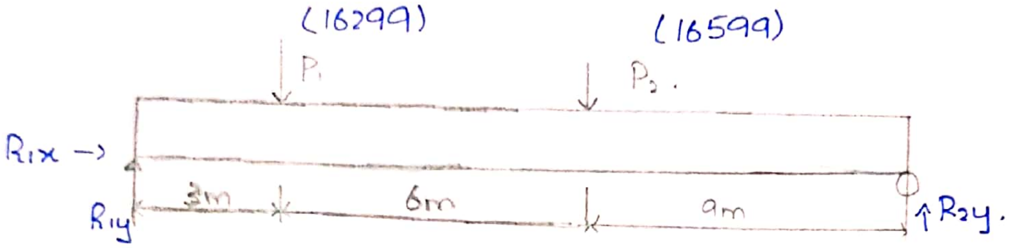
(1)

Name: Khizar Hayat. Id: 16099 Section: A

Instructor: Sir Majid Naeem. Course: Engineering Mechanics.

* Attempt all questions:

Q no 1) Find the support reactions:



Sol:

$P_1 = (200+16099) = 16299$, $P_2 = (500+16099) = 16599$.

Now finding all support reactions.

$R_{1x} = 0$ $\quad \Sigma F_x = 0$.

$R_{1y} + R_{2y} - 16299 - 16599 = 0 \rightarrow (1)$ $\quad \Sigma F_y = 0$

$(R_{2y} \times 18) - (16299 \times 3) - (16599 \times 6) = 0$

$18R_{2y} - 48897 - 99594 = 0$

$18R_{2y} - 148491 = 0$

$\frac{18R_{2y}}{18} = \frac{148491}{18}$

$\boxed{R_{2y} = 8249.5}$ N.

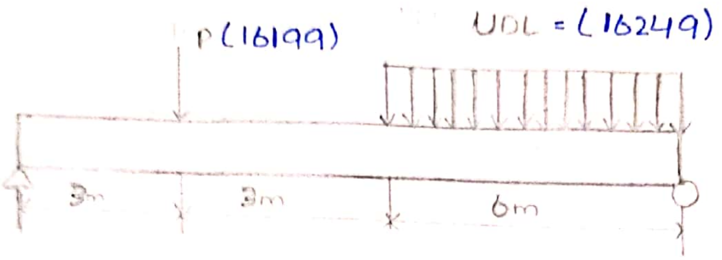
Put R_{2y} in eq (1)

$R_{1y} + 8249.5 - 16299 - 16599 = 0$

$R_{1y} - 24648.5 = 0$

$\boxed{R_{1y} = 24648.5}$ N.

Q no 2) Draw the neat shear force diagram. Show all your calculations.



Sol:

$P = (100 + 16099) = 16199$. $UDL = (150 + 16099) = 16249$.

Now we find support reaction first.

UDL Resultant, $P = (16249 \times 6) = 97494$ (acts as centre of UDL)

$R_{1x} = 0$, $\Sigma F_x = 0$.

$R_{1y} + R_{2y} - 16199 - 97494 = 0 \rightarrow$ ① , $\Sigma F_y = 0$

$(R_{2y} \times 12) - (16199 \times 3) - (97494 \times 9) = 0$

$12R_{2y} - 48597 - 877446 = 0$

$12R_{2y} - 926043 = 0$

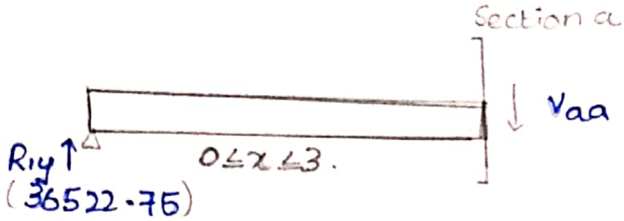
$\frac{12R_{2y}}{12} = \frac{926043}{12}$

$\boxed{R_{2y} = 77170.25}$ KN/m Put in ①.

$R_{1y} + 77170.25 - 16199 - 97494 = 0$

$R_{1y} - 36522.75 = 0$

$\boxed{R_{1y} = 36522.75}$ KN/m

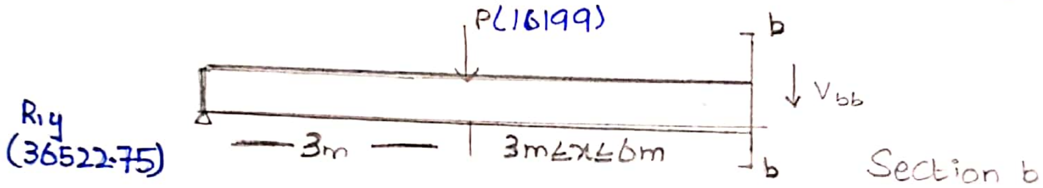


$-V_{aa} + 36522.75 = 0$

$V_{aa} = 36522.75\ KN/m \rightarrow (1)$

at $x = 0$, $V_{aa} = \boxed{36522.75}$ KN/m

at $x = 3$, $V_{aa} = \boxed{36522.75}$ KN/m



$-V_{bb} + 36522.75 - 16199 = 0$

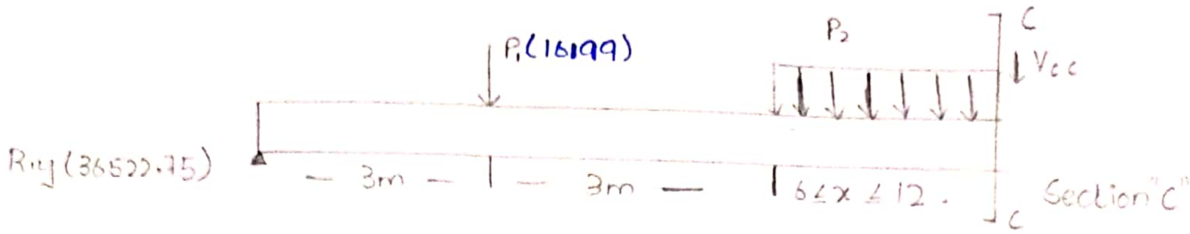
$-V_{bb} + 20323.75 = 0$

$V_{bb} = 20323.75\ KN/m \rightarrow (2)$

at $x = 3$, $V_{bb} = \boxed{20323.75}$ KN/m

at $x = 6$, $V_{bb} = \boxed{20323.75}$ KN/m

Section c Vcc on next page.



UDL Resultant.

$P_2 = 16249(x-6)$.

$-V_{cc} - 16249(x-6) - 16199 = 0$

$-V_{cc} - 16249x + 97494 - 16199 = 0$

$-V_{cc} - 16249x + 81295 = 0$

$V_{cc} = 81295 - 16249x$. → (3)

at $x=6$, $V_{cc} = 81295 - 16249(6)$.

$\boxed{V_{cc} = -16199}$ KN/m

at $x=12$, $V_{cc} = 81295 - 16249(12)$.

$\boxed{V_{cc} = -113693}$ KN/m.

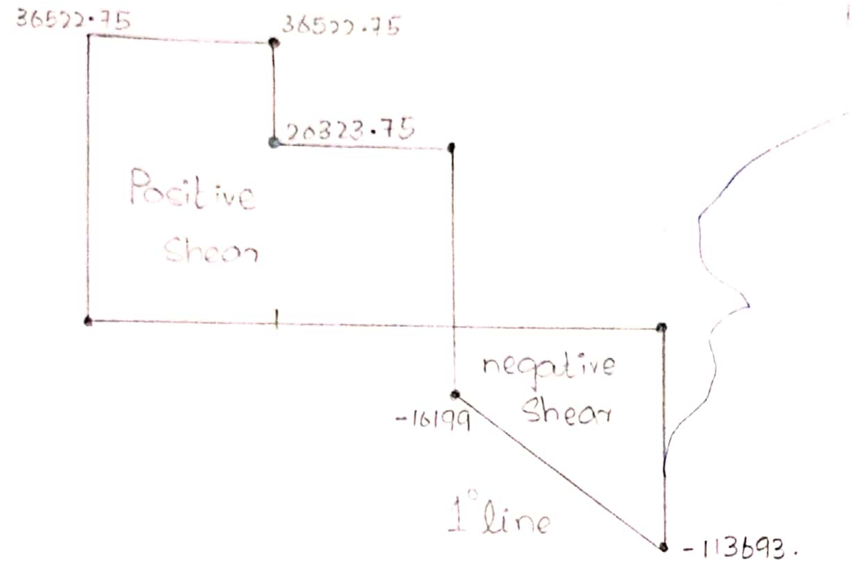
Now to find zero shear point eq (3) = 0

$81295 - 16249x = 0$

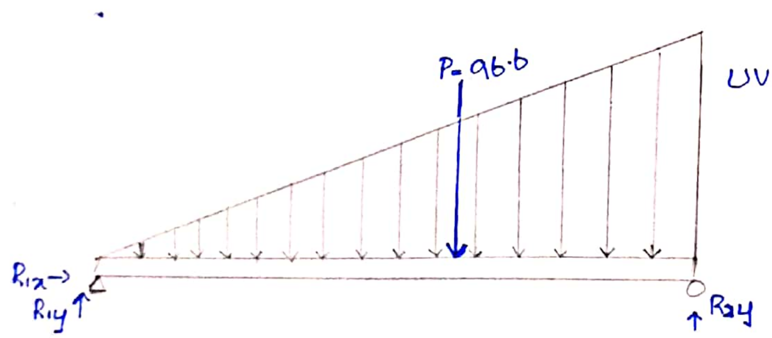
$\frac{16249x}{16249} = \frac{81295}{16249}$.

$\boxed{x = 5.003}$. at this value $V_{cc} = 0$.

Shear Force Diagram:



Qno3) Draw neat shear force and bending moment diagrams. Show all your calculations.



$UVL = \frac{16099}{1000} = 16.099\ kN/m$

Sol:→

UVL Resultant = $P_1 = \left(\frac{16.099 \times 12}{2}\right) = 96.6\ KN/m$

Distance from lower side $= \left(\frac{2}{3} \times 12\right) = 8m$

Distance from higher side $= \left(\frac{1}{3} \times 12\right) = 4m$.

$R_{1x} = 0$.

$R_{1y} + R_{2y} - 96.6 = 0 \rightarrow (1)$

$$(R_{2y} \times 12) - 96.6 = 0$$

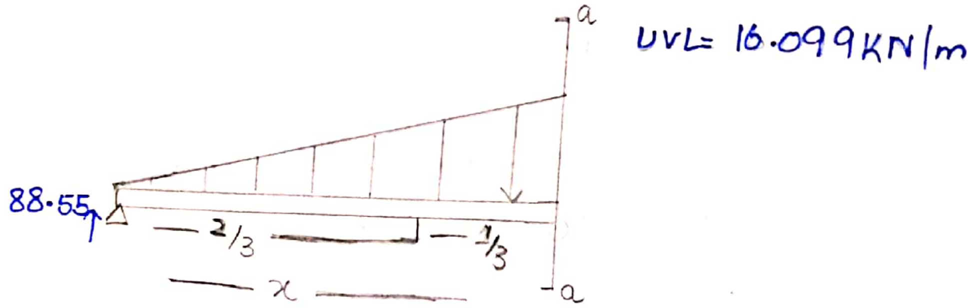
$$12R_{2y} - 96.6 = 0$$

$$\frac{12R_{2y}}{12} = \frac{96.6}{12}$$

$$\boxed{R_{2y} = 8.05.} \text{ KN/m}$$ Put in (1)

$$R_{1y} + 8.05 - 96.6 = 0$$

$$\boxed{R_{1y} = 88.55} \text{ KN/m}$$



From law of similar triangles.

$$\frac{16.099}{12} = \frac{W_o \text{ KN/m}}{x}$$ By cross multiplication

$$W_o = \left[\frac{16.099}{12}x\right] \text{ KN/m}$$

Now we know Resultant , $P = [W_o \times x]/2$.

$$P = \frac{16.099x^2}{24}.$$

Now

$$-V_{aa} - \left(\frac{16.099x^2}{24}\right) + 88.55 = 0$$

$$V_{aa} = 88.55 - \left(\frac{16.099x^2}{24}\right) \cdot \longrightarrow (2)$$

at $x = 0$, $\boxed{V_{aa} = 88.55}$ KN/m

at $x = 12$, $V_{aa} = 88.55 - \left[\frac{16.099(12)^2}{24}\right]$.

$V_{aa} = 88.55 - \left[\frac{16.099(144)}{24}\right]$

$V_{aa} = 88.55 - 96.594$.

$\boxed{V_{aa} = -8.05}$ KN/m

To find zero point shear take eq(2) = 0.

$$88.55 - \left(\frac{16.099}{24}x^2\right) = 0$$

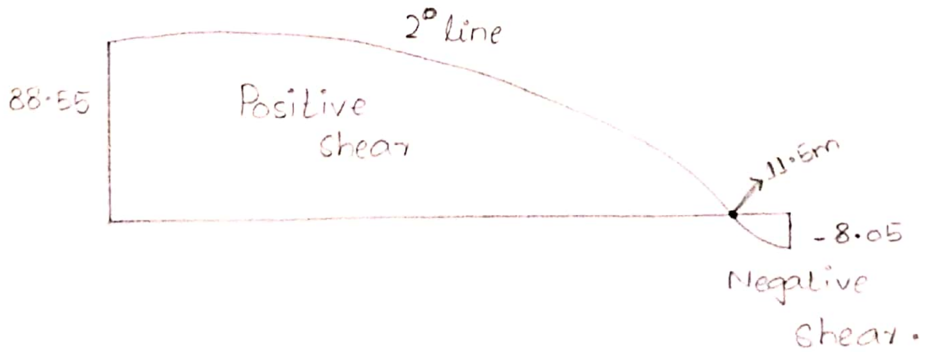
$$\frac{16.099x^2}{24} = 88.55$$

$$\frac{16.099x^2}{16.099} = \frac{2125.2}{16.099}$$

$x^2 = 132.008$ Take square root b.s

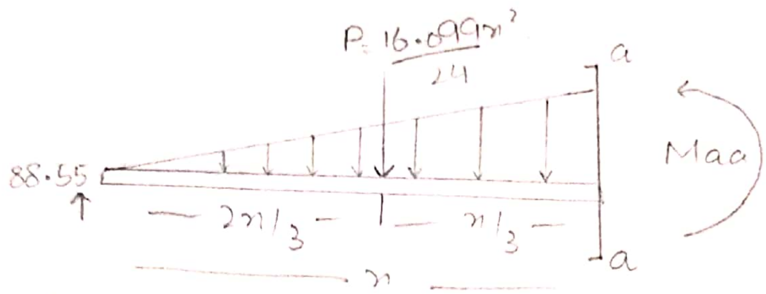
$\boxed{x = 11.5}$ at this point $V_{aa} = 0$.

Shear Force Diagram:



Now for bending moments, we know

$R_{1x} = 0$, $R_{1y} = 88.55$, $R_{2y} = 8.05$.



$M_{aa} + P(x/3) - 88.55x = 0$

$M_{aa} = 88.55x - P(x/3)$

$M_{aa} = 88.55x - \left(\frac{x}{3}\right)\left(\frac{16.099x^2}{24}\right)$

$M_{aa} = 88.55x - \frac{16.099x^3}{72} \longrightarrow (3)$

at $x = 0$, $\boxed{M_{aa} = 0 \text{ kN/m}}$.

at $x = 12$, $M_{aa} = 88.55(12) - \frac{16.099(12)^3}{72}$.

$M_{aa} = 1062.6 - \frac{27819.07}{72}$

$M_{aa} = 1062.6 - 386$

~~$M_{aa} = 1676.6$~~

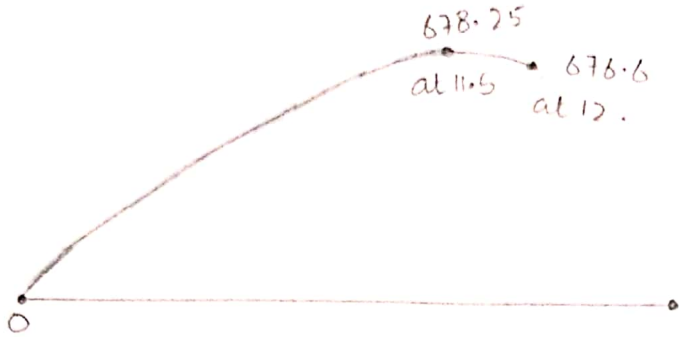
$\boxed{M_{aa} = 676.6 \text{ kN/m}}$

At $x = 11.5$, $M_{aa} = 88.55(11.5) - \frac{16.099(11.5)^3}{72}$.

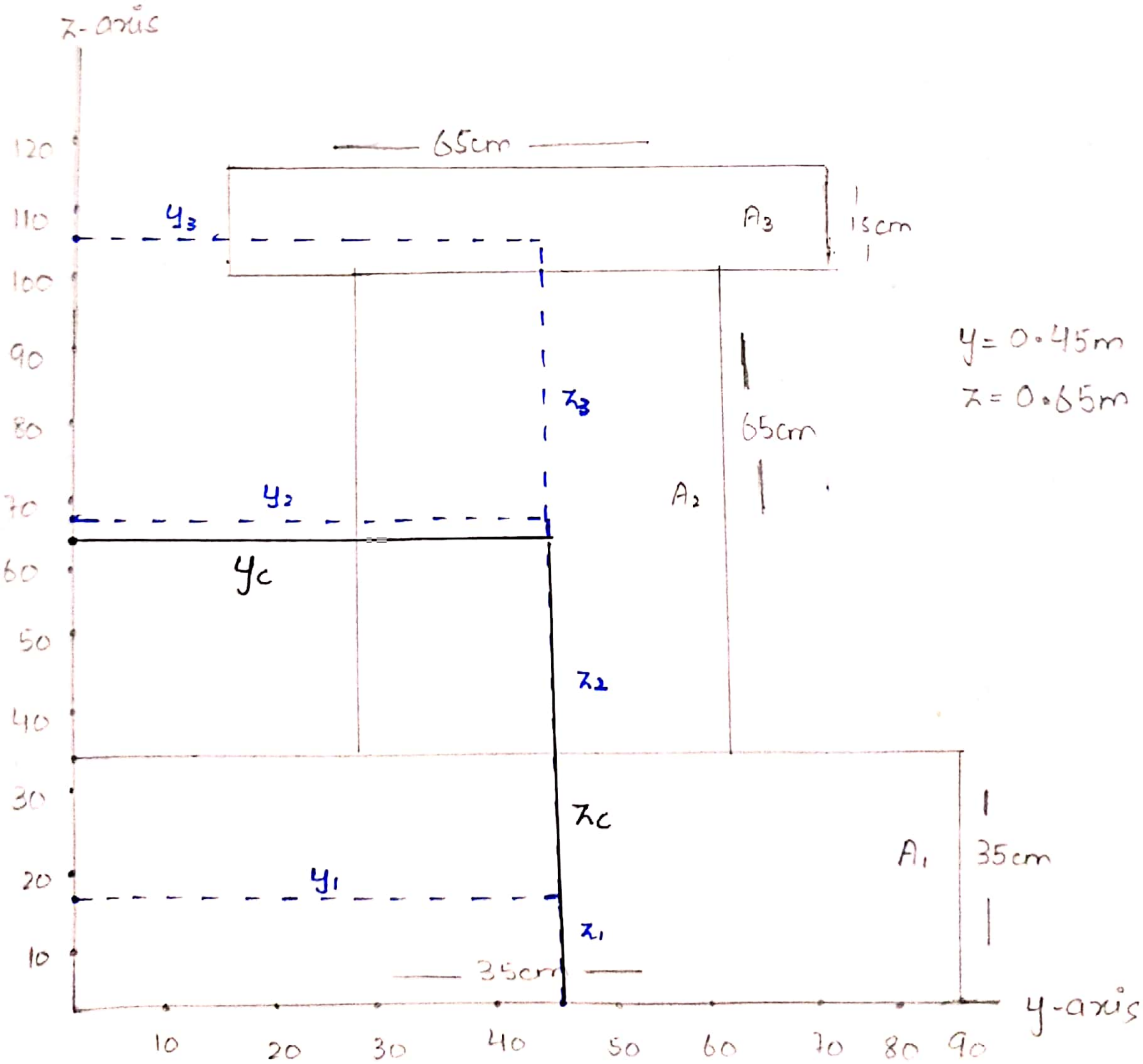
$M_{aa} = 1018.32 - 340$.

$\boxed{M_{aa} = 678.25 \text{ kN/m}}$.

Bending Moment Diagram :



Qno4 (a). Find the centroid of the given shape and also show calculations.



Areas: we converted all "cm" into "m".

$A_1 = (0.9m \times 0.35m) = 0.315m^2$

$A_2 = (0.35m \times 0.65m) = 0.2275m^2$.

$A_3 = (0.15m \times 0.65m) = 0.0975m^2$.

Now centre points from origin.

$y_1 = 0.9/2 = 0.45m$.

$y_2 = 0.9/2 = 0.45m$.

$y_3 = 0.9/2 = 0.45m$

$z_1 = 0.35/2 = 0.175m$

$z_2 = 0.35 + (0.65/2) = 0.675m$.

$z_3 = 0.35 + 0.65 + (0.15/2) = 1.075m$.

Now finding centroid:

$$y_c = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3} = \frac{(0.315 \times 0.45) + (0.2275 \times 0.45) + (0.0975 \times 0.45)}{0.315 + 0.2275 + 0.0975}.$$

$$y_c = \frac{0.14175 + 0.102375 + 0.043875}{0.64}.$$

$$y_c = \frac{0.288}{0.64}$$

$$\boxed{y_c = 0.45m}.$$

Now z_c:

$$z_c = \frac{A_1z_1 + A_2z_2 + A_3z_3}{A_1 + A_2 + A_3} = \frac{(0.315 \times 0.175) + (0.2275 \times 0.675) + (0.0975 \times 1.075)}{0.315 + 0.2275 + 0.0975}$$

next page

$$Z_c = \frac{0.055125 + 0.1535625 + 0.1048125}{0.64}$$

$$Z_c = \frac{0.4183125}{0.64}$$

$$\boxed{Z_c = 0.65 m.}$$

Qno4) Part b). For mid area (65cm x 35cm) only find the moment of Inertia, Radius of Gyration and Section Moduli.

Sol:-

For inertia.

We know that, we have a formula.

$$I_y = \frac{b \cdot h^3}{12}.$$

$$I_y = \frac{35 \times (65)^3}{12} = \frac{35 \times 274625}{12}$$

$I_y = 800989.6 cm^4 \rightarrow$ in meters $= \boxed{8009.9 m^4}$

Now;

$$I_x = \frac{b^3 h}{12}.$$

$$I_x = \frac{(35)^3 \times (65)}{12} = \frac{42875 \times 65}{12}$$

$I_x = 232239.6 cm^4$ or $\rightarrow \boxed{2322.4 m^4}$.

next page.

Now radius of gyration:

we know.

$$r_y = \sqrt{\frac{I_y}{A}}.$$

Area = 0.65 × 0.35

= 22.75

$$r_y = \sqrt{\frac{8009.9}{22.75}}$$

$$r_y = \sqrt{352.08}$$

$$\boxed{r_y = 18.76}.$$

Now;

$$r_x = \sqrt{\frac{I_x}{A}}$$

$$r_x = \sqrt{\frac{2322.4}{22.75}}$$

$$r_x = \sqrt{102.08}$$

$$\boxed{r_x = 10.10}.$$

Now Section Moduli:

For rectangle we know.

$$c = \frac{1}{2}h \Rightarrow \frac{0.65}{2} = 0.325$$

$$I = 8009.9.$$

Now;

$$Z_e = \frac{I}{c} \Rightarrow \frac{1}{6}bh^2.$$

$$Z_e = \frac{0.35 \times (0.65)^2}{6} = \frac{0.35 \times 0.4225}{6}$$

$$\boxed{Z_e = 0.0246}.$$

$$Z_p = \frac{1}{4} bh^2$$

$$= \frac{0.35 \times (0.65)^2}{4}$$

$$Z_p = \frac{0.35 \times 0.4225}{4}$$

$$\boxed{Z_p = 0.0369}.$$

Now:

$$f = \frac{Z_p}{Z_e} = \frac{0.0369}{0.0246}$$

$$\boxed{f = 1.5} \text{ Ans.}$$

Qno5) Explain work, energy and power in detail along practical example from daily life.

Ans) Work:

The application of a force through certain distance is known as work.

OR:

Work is said to be done when a force is applied to an object moves that object.

Mathematically:

Work = Force x Distance Travelled in direction of force.

When calculating the work done by a force acting at an angle then we use:

$$W = Fs\cos\theta.$$

Unit:

Work unit is joule.

★ **Energy:**

Energy is the measure of the ability of an object or a system to do work.

OR:

We can also define energy as the capacity to do work.

Unit:

The unit of energy is joule and is denoted by J. As we all know that energy cannot be created or destroyed, it can only be changed from one form to another. e.g:

When a ball is thrown vertically upward, its Kinetic energy is converted to gravitational potential energy.

★ **Power:**

Power is the rate at which work is done or the rate at which energy is transferred.

★ **Mathematically:**

$$\text{Power} = \frac{\text{Work done}}{\text{Time Taken}}$$

Unit:

Power is measured in watts.

★ **Theoretical examples:** of ~~Work, Energy and Power~~

- Water can produce electricity. Water falls from the sky, converting potential energy to Kinetic Energy. This energy is then is then used to rotate the turbine of the generator. In this process, the P.E of water in a dam can be turned into K.E which can then become electricity.

- When rubbing both our hands together the K.E is converted into heat energy.
- In wind turbines the K.E of the wind rotates the turbine which is converted into electrical energy.

THE END.