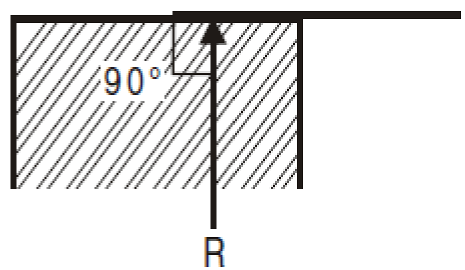
Asst. Prof. Yastuti Rao Guatam
Mechanical Engineering Department
UIET, CSJM Univ. Kanpur

# Beams

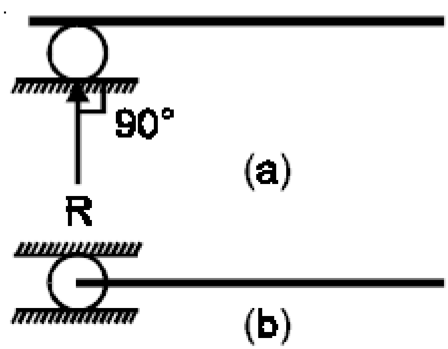
A beam may be defined as a structural element which has one dimension considerably larger than the other two dimensions, namely breadth and depth, and is supported at few points. The distance between two adjacent supports is called span. It is usually loaded normal to its axis. The applied loads make every cross-section to face bending and shearing. The load finally get transferred to supports.

# TYPES OF SUPPORTS

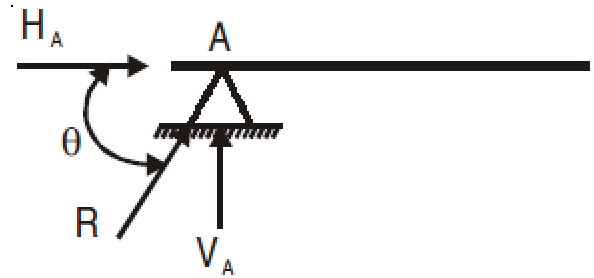
**Simple Support:** If the beam rests simply on a support it is called a simple support. In such case the reaction at the support is at right angles to the support and the beam is free to move in the direction of its axis and also it is free to rotate about the support



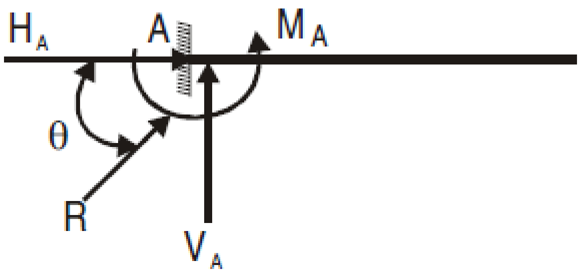

**Roller Support:** In this case, beam end is supported on rollers. In such cases, reaction is normal to the support since rollers can be treated as frictionless. Many mechanical components are having roller supports which roll between guides. In such cases, reaction will be normal to the guides, in both the direction. At roller support beam is free to move along the support. It can rotate about the support also



**Hinged Support:** At a hinged end, a beam cannot move in any direction. However, it can rotate about the support




**Fixed Support:** At such supports, the beam end is not free to translate or rotate. Translation is prevented by developing support reaction in any required direction.



# TYPES OF BEAMS

**Simply Supported Beam:** When both end of a beam are simply supported it is called simply supported beam
Such a beam can support load in the direction normal to its axis.

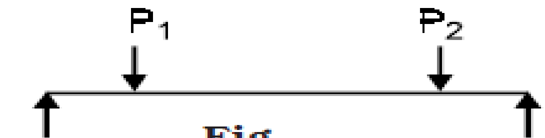



Fig.

**Beam with One End Hinged and the Other on Rollers:** If one end of a beam is hinged and other end is on rollers, the beam can resist load in any direction

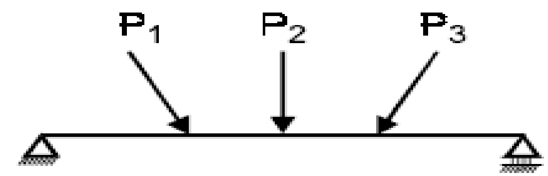



Fig.

**Over-hanging Beam:** If a beam is projecting beyond the support. It is called an over-hanging beam
The overhang may be only on one side as in Fig. (*a*) or may be on both sides as in Fig. (*b*).

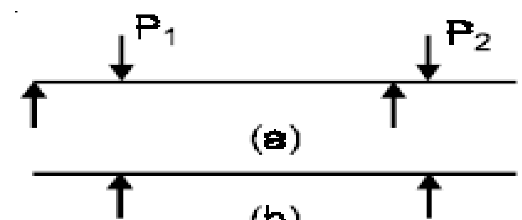



Fig.

**Cantilever Beam:** If a beam is fixed at one end and is free at the other end, it is called cantilever beam

Fig.

**Propped Cantilever:** It is a beam with one end fixed and the other end simply supported (Fig.

Fig.

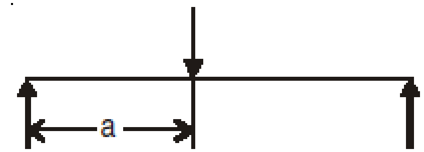
**Both Ends Hinged:** In these beams both ends will be having hinged supports (Fig.

Fig.

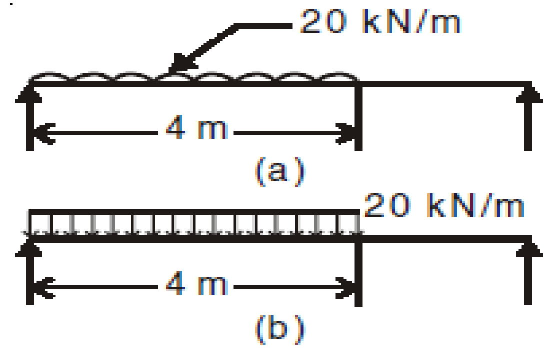
**Continuous Beam:** A beam is said to be continuous, if it is supported at more than two points

# TYPES OF LOADING

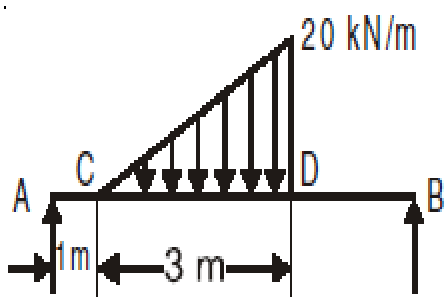
**Concentrated Loads:** If a load is acting on a beam over a very small length, it is approximated as acting at the mid point of that length and is represented by an arrow as shown in Fig



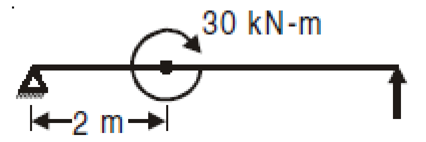

**Uniformly Distributed Load (UDL):** Over considerably long distance such load has got uniform intensity. It is represented as shown in Fig.



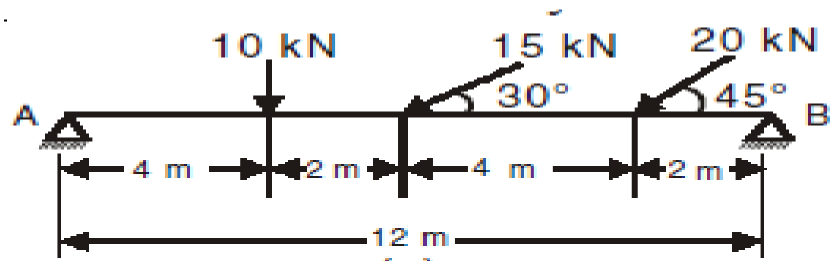

**Uniformly Varying Load:** The load shown in Fig. varies uniformly from *C* to *D.*
Its intensity is zero at *C* and is 20 kN/m at *D.* In the load diagram, the ordinate represents the load intensity and the abscissa represents the position of load on
the beam.



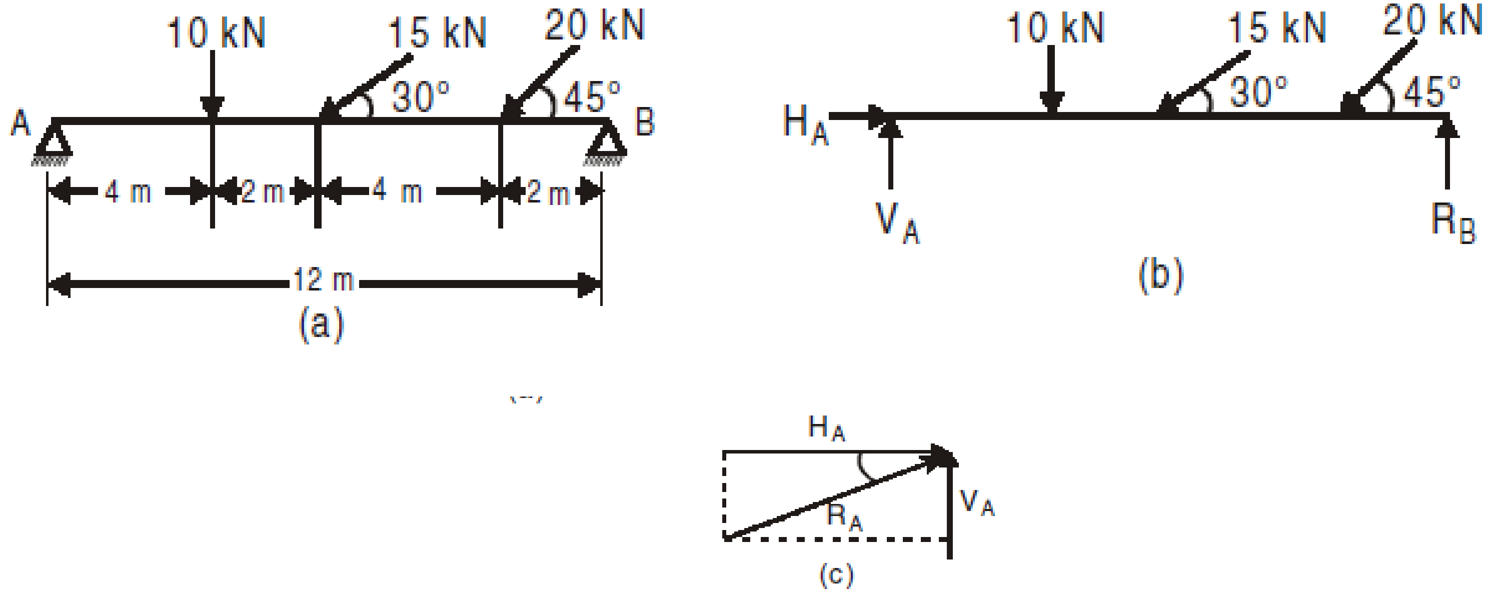
**External Moment:** A beam may be subjected to external moment at certain points.



*The beam AB of span 12 m shown in Fig. 9.17 (a) is hinged at A and is on rollers at B. Determine the reactions at A and B for the loading shown in the Figure*




(a)




Now, $\Sigma H = 0$, gives

$$H_A - 15 \cos 30° - 20 \cos 45° = 0$$

$$H_A = 27.1325 \text{ kN}$$

$$\Sigma M_A = 0, \text{ gives}$$

$$R_B \times 12 - 10 \times 4 - 15 \sin 30° \times 6 - 20 \sin 45° \times 10 = 0$$

$$\mathbf{R_B = 18.8684 \ kN.}$$

$$\Sigma V = 0, \text{ gives}$$

$$V_A + 18.8684 - 10 - 15 \sin 30° - 20 \sin 45° = 0$$

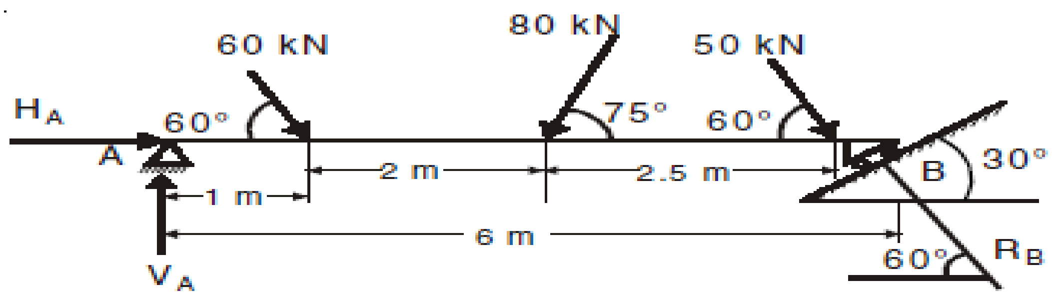
$\therefore$ $$V_A = 12.7737 \text{ kN}$$

$\therefore$ $$R_A = \sqrt{H_A^2 + V_A^2} = \sqrt{27.1325^2 + 12.7737^2}$$

*i.e.*, $$\mathbf{R_A = 29.989 \ kN.}$$

and $$\boldsymbol{\alpha} = \tan^{-1}\frac{(12.7737)}{(27.1325)} = \mathbf{25.21°.}$$

1. *Find the reactions at supports A and B in the beam AB shown in Fig.*



(a)

$$\sum M_A = 0 \text{ gives}$$

$$R_B \sin 60° \times 6 - 60 \sin 60° \times 1 - 80 \times \sin 75° \times 3 - 50 \times \sin 60° \times 5.5 = 0$$

$$\therefore \quad \mathbf{R_B = 100.4475 \text{ kN.}}$$

$$\sum H = 0, \text{ gives}$$

$$H_A + 60 \cos 60° - 80 \cos 75° + 50 \cos 60° - R_B \cos 60° = 0$$

$$H_A = -60 \cos 60° + 80 \cos 75° - 50 \cos 60° + 100.4475 \cos 60°$$

$$= 15.9293 \text{ kN}$$

$$\sum V = 0, \text{ gives}$$

$$V_A + R_B \sin 60° - 60 \sin 60° - 80 \sin 75° - 50 \sin 60° = 0$$

$$V_A = -100.4475 \sin 60° + 60 \sin 60° + 80 \sin 75° + 50 \sin 60°$$

$$= 85.5468 \text{ kN}$$

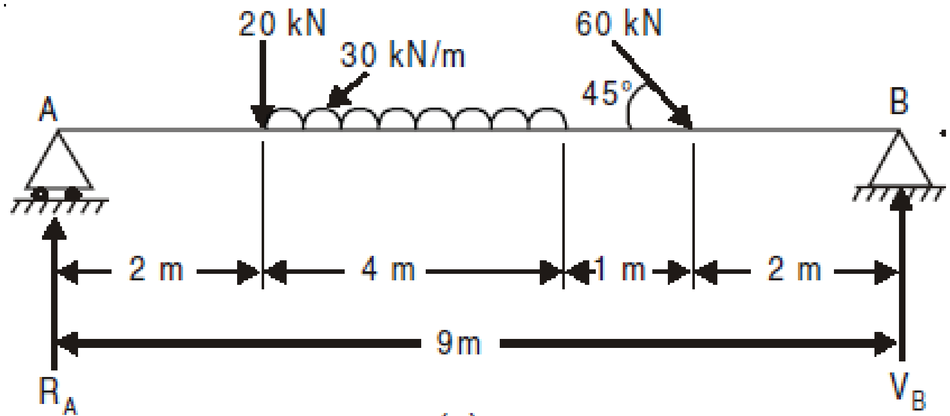
$$\therefore \quad R_A = \sqrt{15.9293^2 + 85.5468^2}$$

$$\mathbf{R_A = 87.0172 \text{ kN.}}$$

$$\alpha = \tan^{-1} \frac{85.5468}{15.9293}$$

$\boldsymbol{\alpha} = \mathbf{79.45°}$, as shown in Fig. 9.18(*b*).

*2. Find the reactions at supports A and B of the loaded beam shown in Fig*



(a)

$$\sum M_B = 0, \text{ gives}$$

$$R_A \times 9 - 20 \times 7 - 30 \times 4 \times 5 - 60 \sin 45° \times 2 = 0$$

$$\mathbf{R_A = 91.6503 \text{ kN.}}$$

$$\sum H_A = 0, \text{ gives}$$

$$H_B - 60 \cos 45° = 0$$

$$\mathbf{H_B = 42.4264 \text{ kN.}}$$

$$\sum V_A = 0$$

$$91.6503 + V_B - 20 - 30 \times 4 - 60 \sin 45° = 0$$

$$\mathbf{V_B = 90.7761 \text{ kN.}}$$

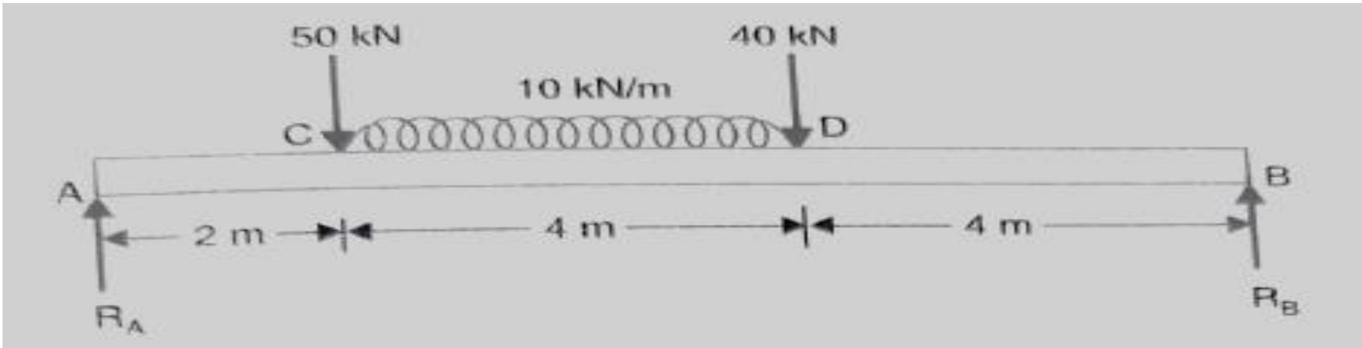
$$R_B = \sqrt{42.4264^2 + 90.7761^2}$$

$$\mathbf{R_B = 100.2013 \text{ kN.}}$$

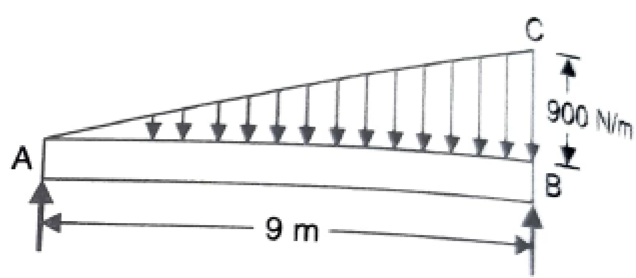
$$\alpha = \tan^{-1} \frac{90.7761}{42.4264}$$

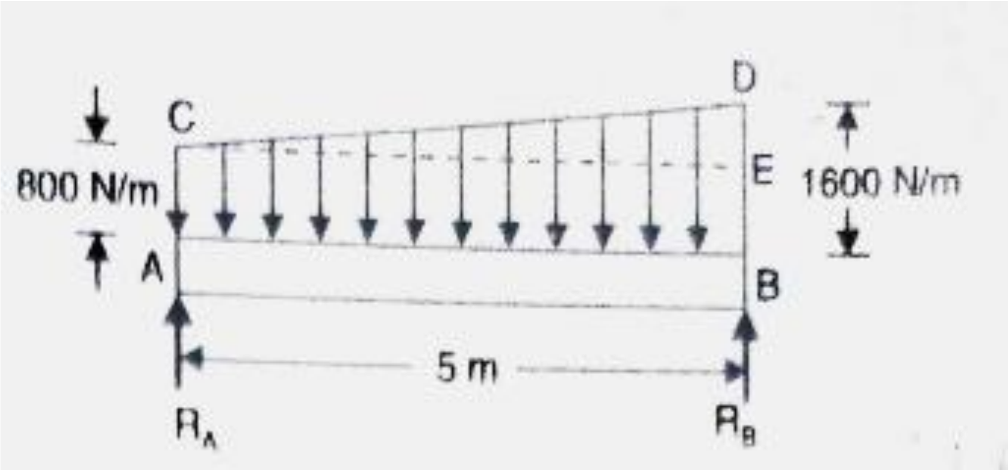
$\boldsymbol{\alpha} = \mathbf{64.95°}$, as shown in Fig. 9.19(*b*).

A simply supported beam of length 10 m, carries the uniformly distributed load and two point loads as shown in Fig.. Calculate the reactions $R_A$, and $R_B$

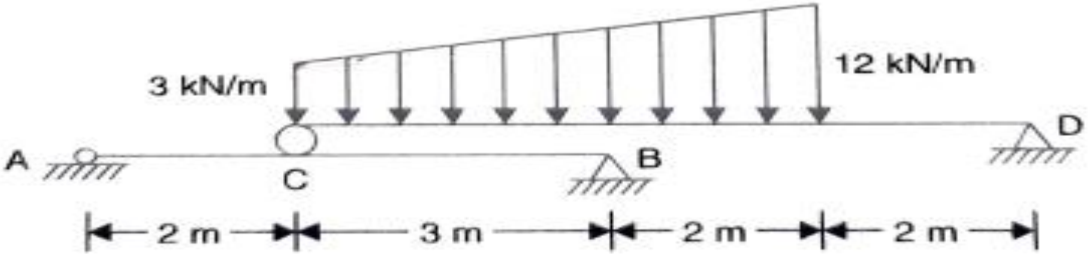



A simply supported beam of span 9 m carries a uniformly from zero at end A to 900 Nm at end B. Calculate the reactions at the two ends of support .



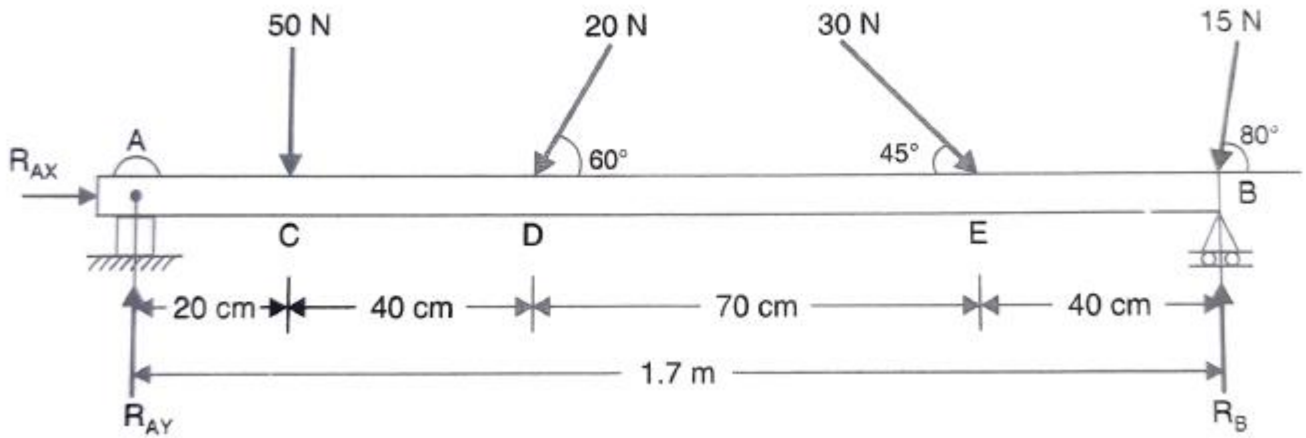


C
D
800 N/m
E
1600 N/m
A
B
5 m
$R_A$
$R_B$

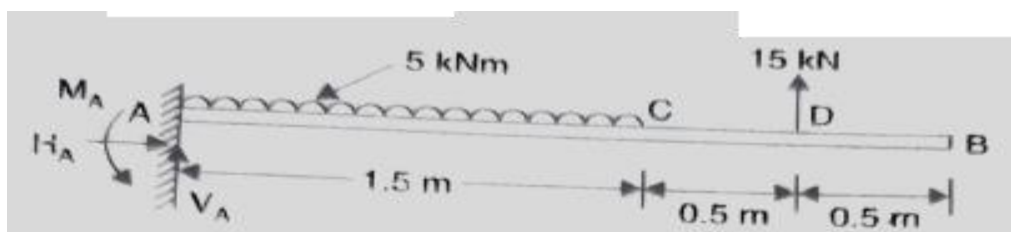



3 kN/m
12 kN/m
A
C
B
D
2 m
3 m
2 m
2 m

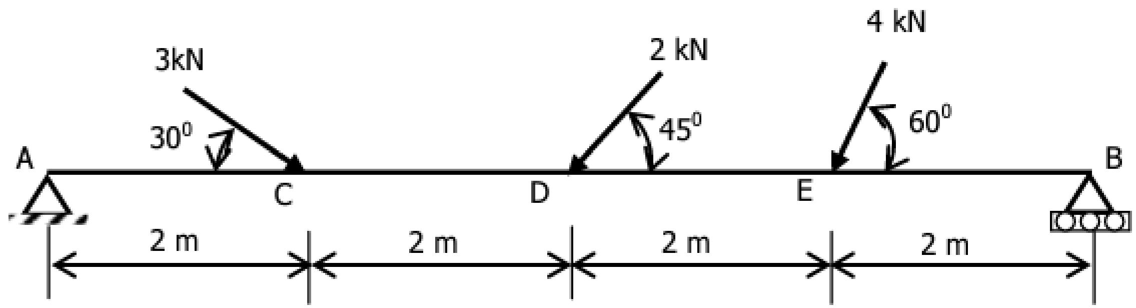
A beam AB 1.7 m long is loaded as shown in Fig.. Determine the reactions at A and B



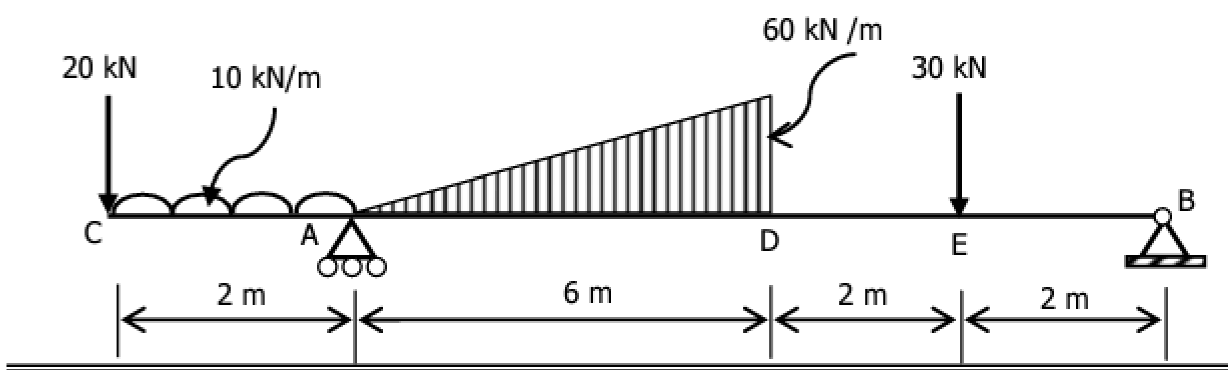

What force and moment is transmitted to the supporting wall at A in the given cantilever beam shown in Fig. ?



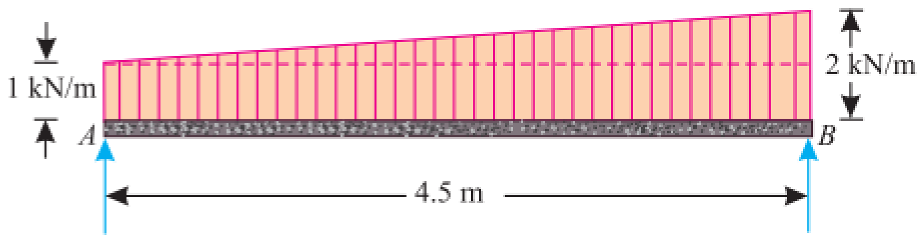
*Find the reactions at supports A and B of the loaded beam shown in Fig*



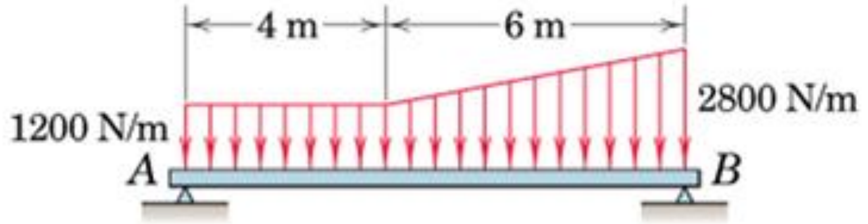

Find the support reactions for the beam loaded as shown in fig



A simply supported beam AB of span 4.5 m is loaded as shown in Fig



Determine the external reactions for the beam



We know that anticlockwise moment due to $R_B$ about $A$

$$= R_B \times l = R_B \times 4.5 = 4.5\ R_B \quad \text{kN-m} \qquad ..$$

and sum of clockwise moments due to uniformly varying load about $A$

$$= (1 \times 4.5 \times 2.25) + (2.25 \times 3) = 16.875 \quad \text{kN-m} \qquad ...$$

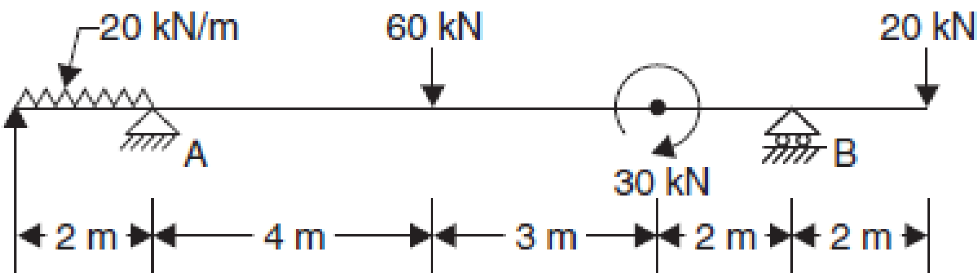
Now equating anticlockwise and clockwise moments given in (*i*) and (*ii*),

$$4.5\ R_B = 16.875$$

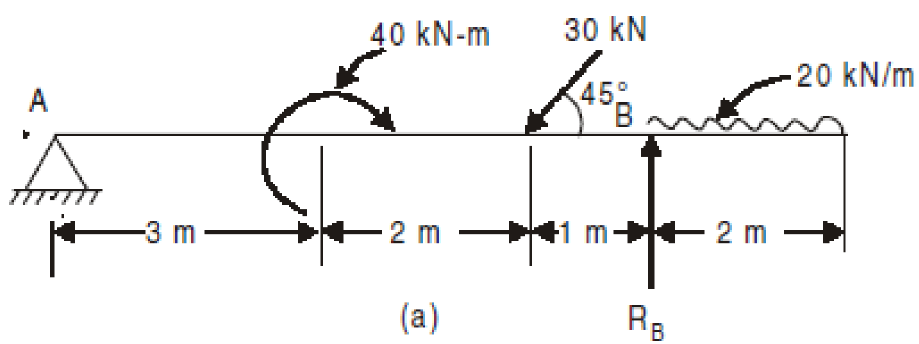
or $$R_B = \frac{16.875}{4.5} = 3.75 \text{ kN} \qquad \textbf{Ans.}$$

and $$R_A = [1 \times 4.5] + \left[4.5 \times \frac{0+1}{2}\right] - 3.75 = 3.0 \text{ kN} \qquad \textbf{Ans.}$$

*Find the reactions at supports A and B of the beam shown in Fig*




*Determine the reactions at A and B of the overhanging beam shown in Fig*




(a)

$$\Sigma M_A = 0, \text{ gives}$$

$$-20 \times 2 \times 1 + 60 \times 4 + 30 + 20 \times 11 - V_B \times 9 = 0$$

$$\mathbf{V_B = 50 \text{ kN.}}$$

$$\Sigma V = 0, \text{ gives}$$

$$-20 \times 2 + V_A - 60 + V_B - 20 = 0$$

$$V_A = 120 - V_B = 120 - 50$$

$$\mathbf{V_A = 70 \text{ kN.}}$$

***Solution:***

$$\Sigma M_A = 0$$

$$R_B \times 6 - 40 - 30 \sin 45° \times 5 - 20 \times 2 \times 7 = 0$$

$$\mathbf{R_B = 71.0110 \text{ kN.}}$$

$$\Sigma H = 0$$

$$H_A = 30 \cos 45° = 21.2132 \text{ kN}$$

$$\Sigma V = 0$$

$$V_A - 30 \sin 45° + R_B - 20 \times 2 = 0$$

$$V_A = 30 \sin 45° - R_B + 40$$

$$V_A = -9.7978$$

(Negative sign show that the assumed direction of $V_A$ is wrong. In other words, $V_A$ is a vertically downwards).

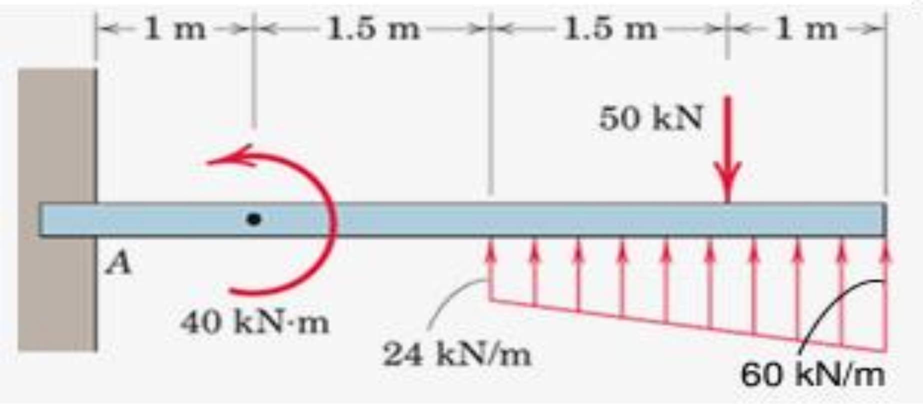
$$R_A = \sqrt{V_A^2 + H_A^2}$$

$$\mathbf{R_A = 23.3666 \text{ kN.}}$$

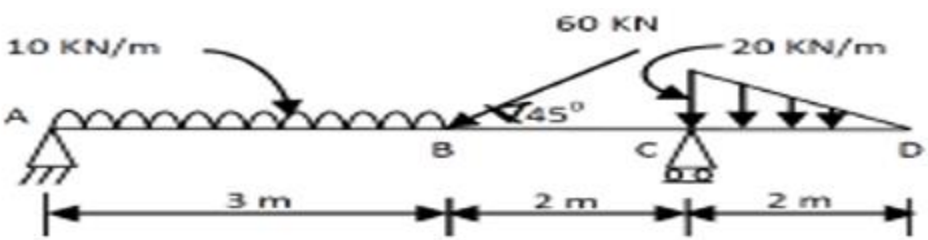
$$\alpha = \tan^{-1} \frac{V_A}{H_A}$$

$\boldsymbol{\alpha}$ = **24.79°**, as shown in Fig. 9.24(b).

Determine the external reactions for the beam




Calculate reactions at support due to applied load on the beam as shown in Figure



$A_y$ = -55 kN Downwards