As per Lami's ...

$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

8.3 Support and Support Reaction :

Support *is defined as the structure which tends to maintain equilibrium of the body.*

While maintaining equilibrium under the action of applied forces or self weight of the body the support exerts a force or moment on the body known as ***"support reaction".***

- When a particular displacement of the body is prevented corresponding reaction will develop.
- If the linear displacement is prevented, support will offer a reaction force and if the angular displacement or rotation of the body is prevented, support will offer a reaction moment.

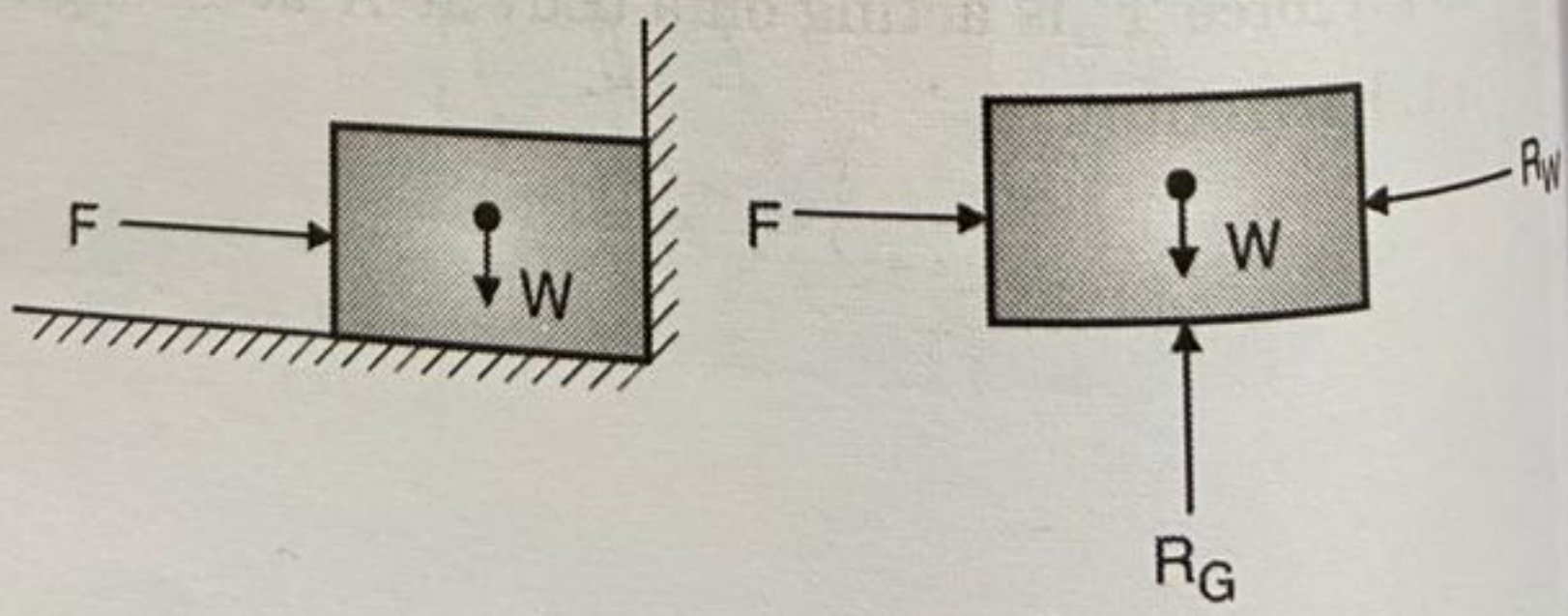


Fig. 8.3.1

Because of weight, W body will have vertical downward displacement which is prevented by the ground surface by offering a support reaction R_G in the opposite direction.

Similarly, applied force 'F' will cause displacement of the body towards right which is prevented by vertical wall by offering a reaction force R_W in the opposite direction.

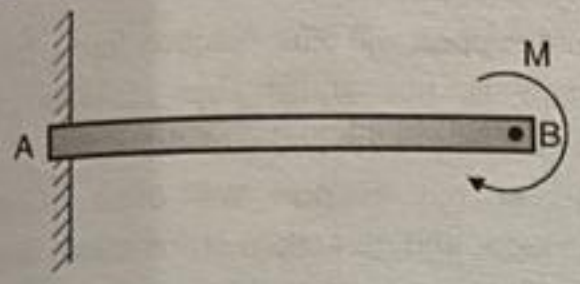


Fig. 8.3.2

Let a clockwise moment 'M' is applied to member 'AB' which tends to rotate the member in CW direction. To maintain equilibrium support at 'A' will offer reaction moment (M_R) in ACW direction i.e. opposite to the direction of rotation.

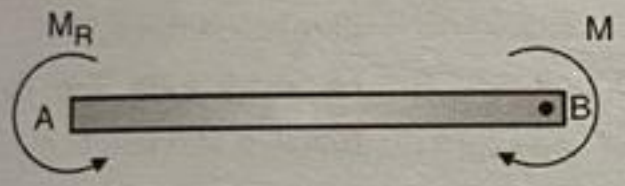


Fig. 8.3.3

8.4 Types of Supports

In engineering, basically three types of supports are used :

(i) Simple support
  a) Sliding b) Roller
(ii) Hinge or pin support
(iii) Fixed support

(i) **Simple supports :** Simple support is the support in which there is no link or connection between the body and the support.

There are two types of simple support :

a) **Sliding support :** If the body rests against a surface whether it is horizontal, vertical or inclined, then it is known as sliding support.

b) **Roller support :** If the body rolls over the surface instead of sliding then it is known as roller support.

Sliding or roller support will prevent the displacement in the direction perpendicular to the plane of surface. Hence sliding or roller support always offer reaction normal to the plane of surface.

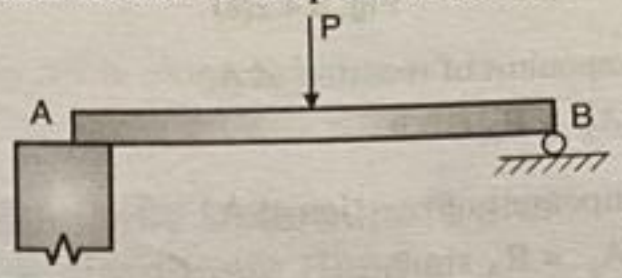


Fig. 8.4.1(a)

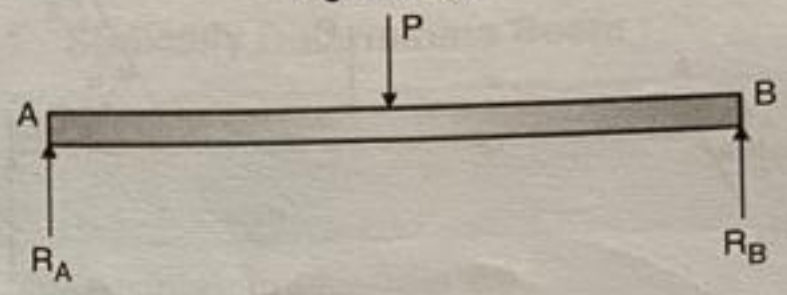


Fig. 8.4.1(b)

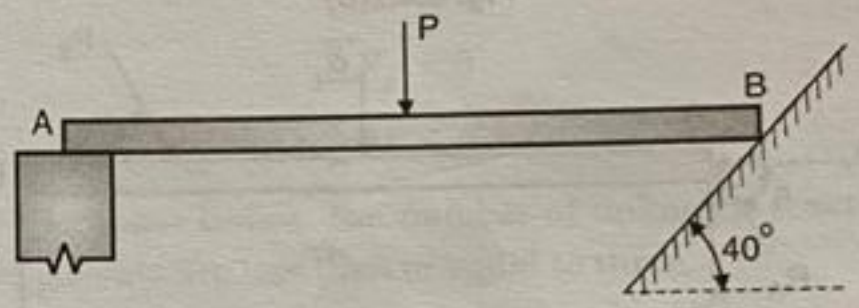


Fig. 8.4.1(c)

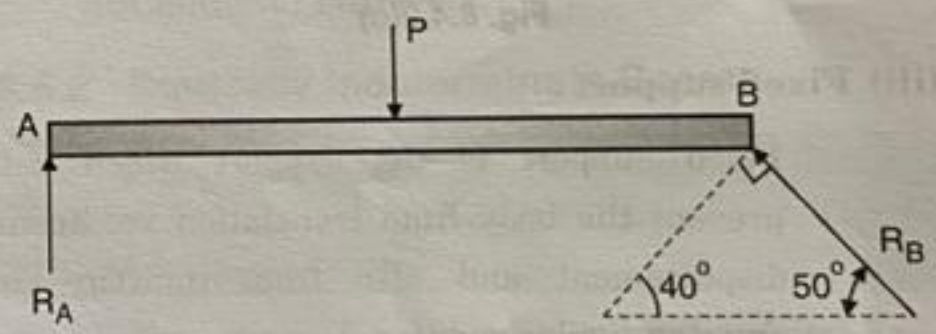


Fig. 8.4.1(d)

(ii) **Hinge or pin support :** Hinge support is the support where there is a link or connection between the body and the support, but it allows the rotation of the body.

Hinge support will prevent linear displacement and allows angular displacement.

∴ Hinge support will offer reaction force by preventing linear displacement but the reaction moment is zero.

The reaction force will have magnitude 'R' and direction 'θ'. It can be resolved in two reaction components R_x and R_y along horizontal and vertical directions.

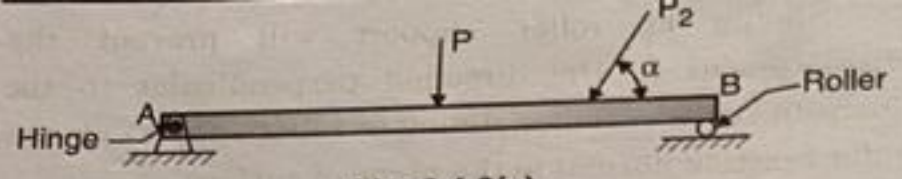


Fig. 8.4.2(a)

x-component of reaction at A,

$$A_x = R_A \cos\theta$$

y-component of reaction at A,

$$A_y = R_A \sin\theta$$

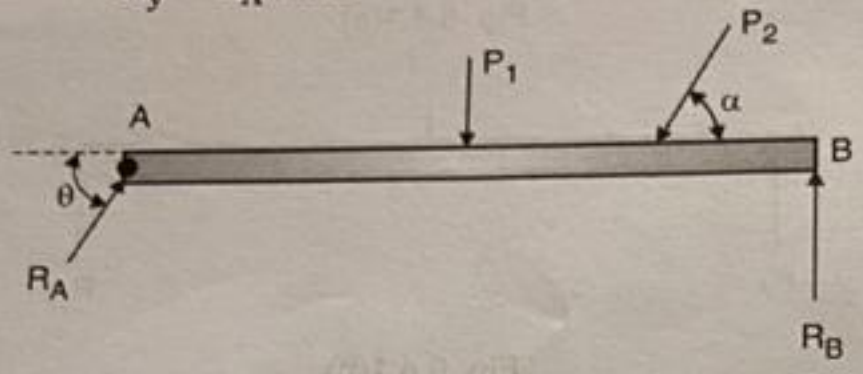


Fig. 8.4.2(b)

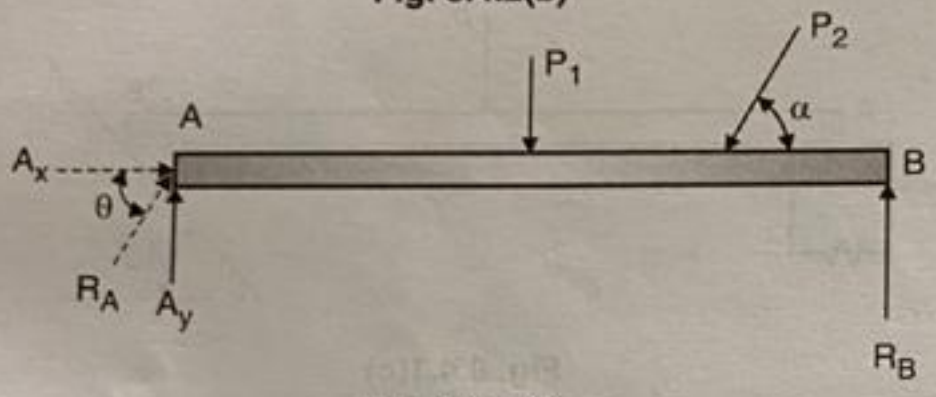


Fig. 8.4.2(c)

(iii) Fixed support :

- Fixed support is the support which will prevent the body from translation i.e. linear displacement and also from rotation i.e. angular displacement.
- Hence fixed support will offer reaction force and reaction moment.
- In fixed support, there is a rigid connection between the body and the support.

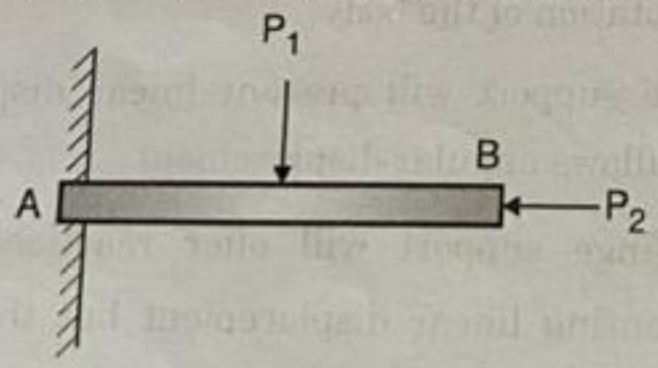


Fig. 8.4.3(a)

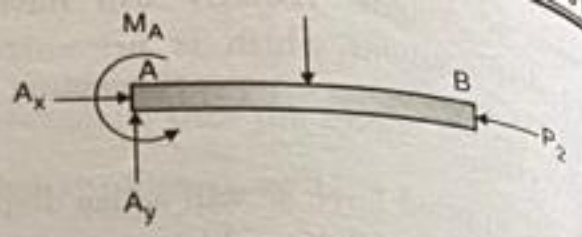


Fig. 8.4.3(b)

Important notes :

(i) Simple support will offer reaction force. Magnitude of reaction is not known but direction is always perpendicular to the plane of surface.

(ii) Hinge or pin support will offer reaction force. Magnitude and direction of reaction both are not known. It can be resolved into x and y components.

(iii) Fixed support will offer reaction force and reaction moment.

(iv) The number of unknowns at

Simple support : 1. i.e. magnitude of reaction

Hinge/pin support : 2. i.e. magnitude and direction of reaction or x and y components of reaction force

Fixed support : 3. i.e. magnitude and direction of reaction and reaction moment.

OR

x and y components of reaction force and reaction moment.

8.5 Beam

*A **beam** is defined as a structural member which is subjected to transverse loading. i.e. the load acting perpendicular to the longitudinal axis of the member.*

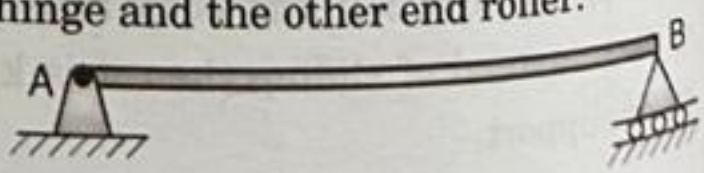
Due to applied loads, reactions will develop at the supports and the system of forces consisting of applied loads and reactions keep the beam of equilibrium.

The nature of reaction depends on the type of supports.

8.5.1 Types of beams

Depending on the type of supports, beams are classified into the following types :

(i) **Simply supported beam :** One end is supported by hinge and the other end roller.



(ii) **Cantilever beam :** One end of the beam is fixed and the other end free.

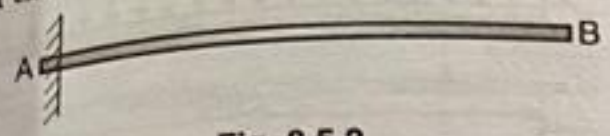


Fig. 8.5.2

(iii) **Fixed beam :** Both ends of the beam are fixed.

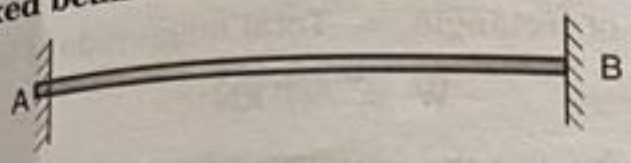


Fig. 8.5.3

(iv) **Propped cantilever :** One end of the beam is fixed and the other end is simply supported.

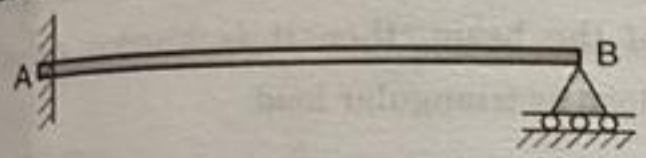


Fig. 8.5.4

(v) **Overhanging beam :** Beam is having projection beyond the support.

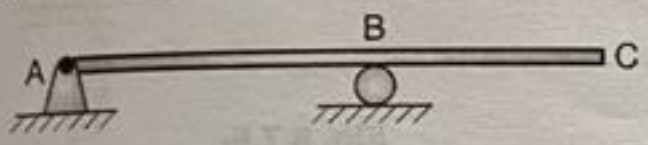


Fig. 8.5.5 : Singly overhanging beam
(Having projection on one side)

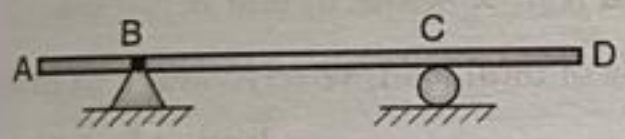


Fig. 8.5.6 : Doubly overhanging beam

(Having projection on both sides)

(vi) **Continuous beam** : Beam supported by more than two supports.

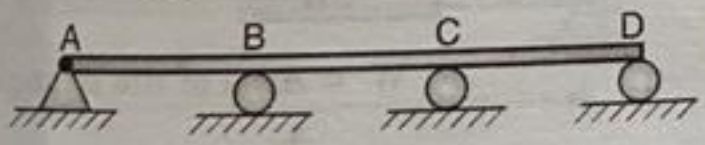


Fig. 8.5.7

(vii) **Compound beam :** It is the combination of two simple beams.

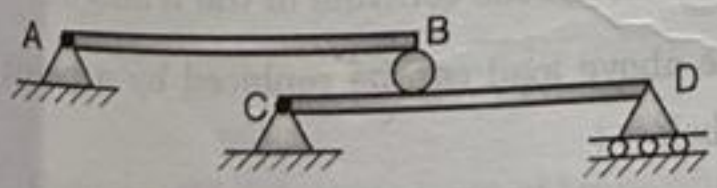


Fig. 8.5.8

Beam AB rests on beam CD.

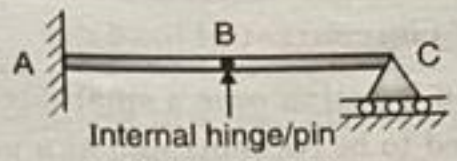


Fig. 8.5.9

Beam AB is connected to beam BC by an internal hinge.

8.6 Statically Determinate and Indeterminate Beams

8.6.1 Statically Determinate Beam :

A beam which can be analysed using three equations of equilibrium is known as ***statically determinate beam.***

The equilibrium equations are :

$$\sum F_x = 0,$$

$$\sum F_y = 0$$

and $$\sum M = 0$$

In these beams, the number of unknown reaction components are less than or equal to three.

E.g. (i) Simply supported beam

(ii) Cantilever beam, etc.

8.6.2 Statically Indeterminate Beam :

The beam which cannot be analysed using 3 equations of equilibrium is called ***statically indeterminate beam.***

In this type of beam, the number of unknown reaction components are more than three equilibrium equations.

E.g. (i) Fixed beam

(ii) Propped cantilever

(iii) continuous beam, etc.

8.7 Types of Loads

Beam is subjected to the following types of loads:

(i) Point or concentrated load

(ii) Uniformly Distributed Load (UDL)

(iii) Uniformly Varying Load (UVL)

(iv) Variation is nonlinear

Δ ABD is an isosceles triangle.

From Δ BCD,

$$\cos\alpha = \left(\frac{2.25}{3}\right)$$

$$\therefore \quad \alpha = 41.41°$$

$$\beta = 90° - \alpha = 90° - 41.41° = 48.59°$$

Step 2 : FBD of member AB :

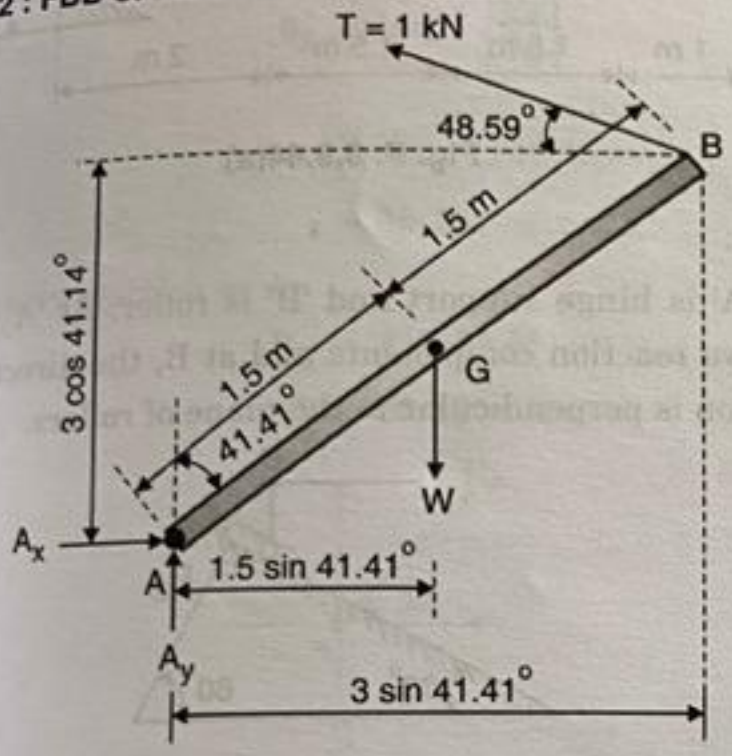


Fig. P. 8.10.41(c)

ep 3 : Equilibrium equations :

r equilibrium of member AB,

king moments at 'A'

$$\Sigma M_A = 0$$

$' \times 1.5 \sin 41.41° + 1 \times \cos 48.59° \times 3 \cos 41.41°$

$\sin 48.59° \times 3 \sin 41.41° = 0$

$$\therefore \quad \mathbf{W = 3\ Kn}$$

e weight of the bar, **W = 3 kN** **...Ans.**

Type 4 : Equilibrium of Beams

8.9.42 : Find the support reactions at hing 'A' and roller or the beam shown in Fig. P. 8.9.42(a)

SPPU : Nov. 08, 8 Marks

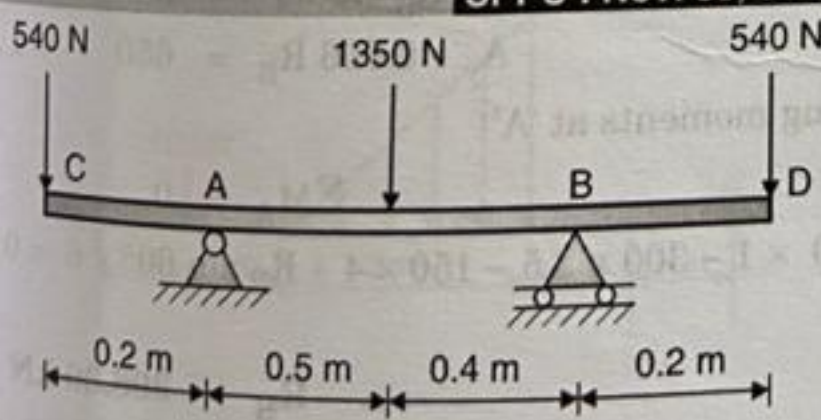


Fig. P. 8.9.42(a)

Soln. :

Hinge support 'A' will have two reaction components horizontal and vertical where as at roller support B, the reaction is normal to the plane of rollers.

FBD of beam

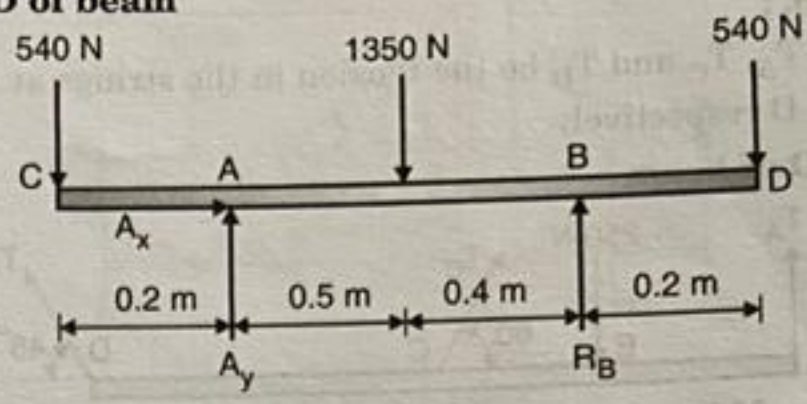


Fig. P. 8.9.42(b)

For equilibrium of beam;

$$\Sigma F_x = 0$$

$$A_x = 0 \qquad \ldots (1)$$

$$\Sigma F_y = 0$$

$$-540 + A_y - 1350 + R_B - 540 = 0$$

$$A_y + R_B = 2430 \qquad \ldots (2)$$

Taking moments at 'A'

$$\Sigma M_A = 0$$

$$540 \times 0.2 - 1350 \times 0.5 + R_B \times 0.9 - 540 \times 1.1 = 0 \quad \ldots (3)$$

$$\therefore \quad \mathbf{R_B = 1290\ N \uparrow}$$

From Eq^n (2),

$$A_y + 1290 = 2430$$

$$\therefore \quad \mathbf{A_y = 1140\ N \uparrow}$$

Support reaction at A,

$$R_A = \sqrt{A_x^2 + A_y^2} = A_y \qquad (\because A_x = 0)$$

(i) Reaction at A, $\mathbf{R_A = A_y = 1140\ N \uparrow}$ **...Ans.**

(ii) Reaction at B, $\mathbf{R_B = 1290\ N \uparrow}$ **...Ans.**

Ex. 8.9.43 : A light beam ABCD carries a load 250 N at B as shown in Fig. P. 8.9.43(a) It is supported by three strings at A, C and D. Determine tension in the strings.

SPPU : May 07, 8 Marks