Strength of Materials WRE201 & WRE202

Chapter 4: Shear and moment in beams, part 2

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What is beam?

A beam is a bar subject to forces or couples that lie in a plane containing the longitudinal section of the bar. According to determinacy, a beam may be determinate or indeterminate.

Statically Determinate Beams

Statically determinate beams are those beams in which the reactions of the supports may be determined using the equations of static equilibrium. The beams shown below are examples of statically determinate beams.

They may be:

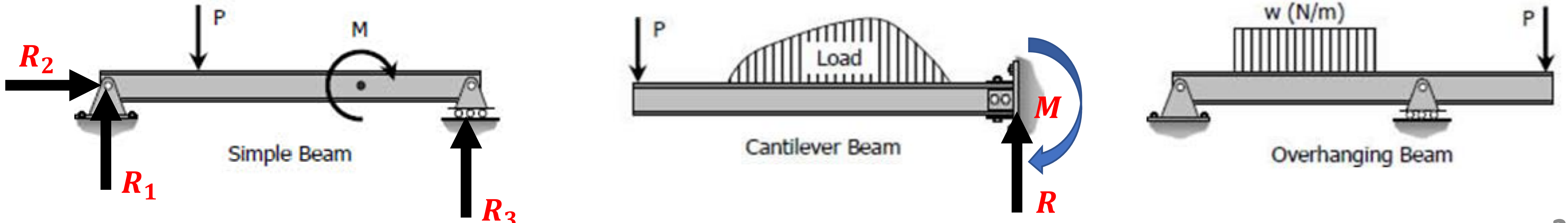


Fig. 1 . *Type of Statically determinate beams*

Statically Indeterminate Beams

If the number of reactions exerted upon a beam exceeds the number of equations in static equilibrium, the beam is said to be statically indeterminate. In order to solve the reactions of the beam, the static equations must be supplemented by equations based upon the elastic deformations of the beam.

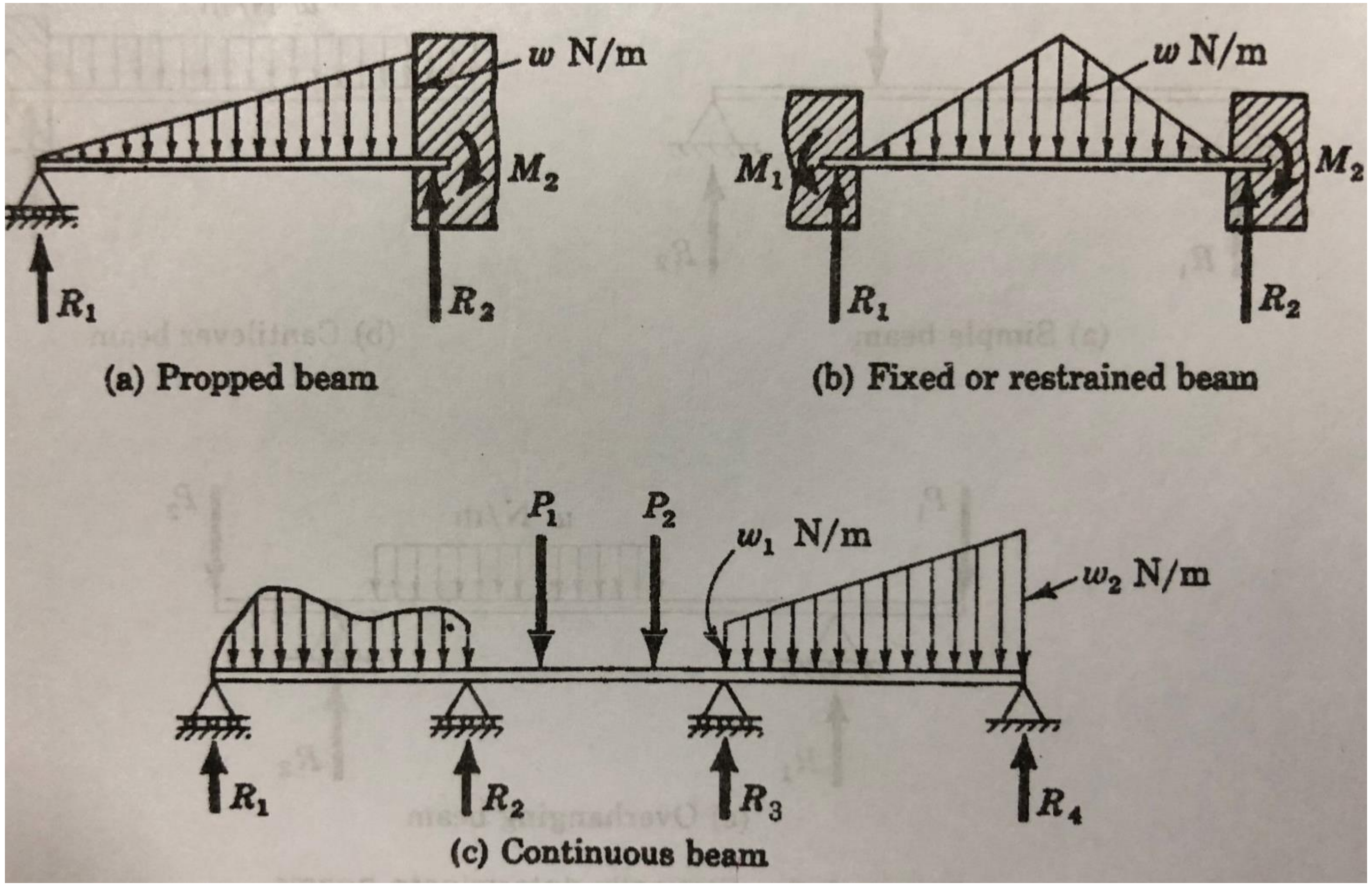


Fig. 2 . ***Statically indeterminate beams***

The degree of indeterminacy is taken as the difference between the umber of reactions to the number of equations in static equilibrium that can be applied. In the case of the propped beam shown, there are three reactions R_1, R_2, and M and only two equations ($\Sigma M = 0$ and $\Sigma Fv = 0$) can be applied, thus the beam is indeterminate to the first degree (3 - 2 = 1).

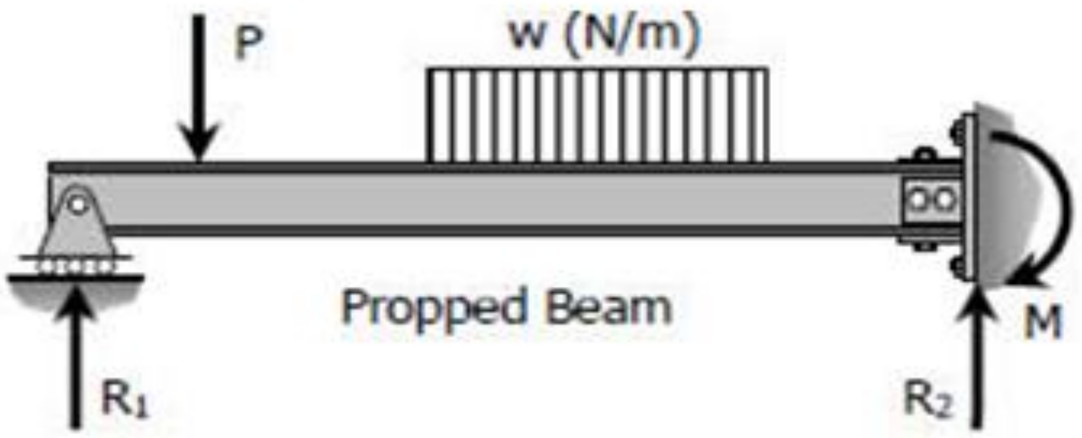


Fig. 3 . ***Statically indeterminate beam***

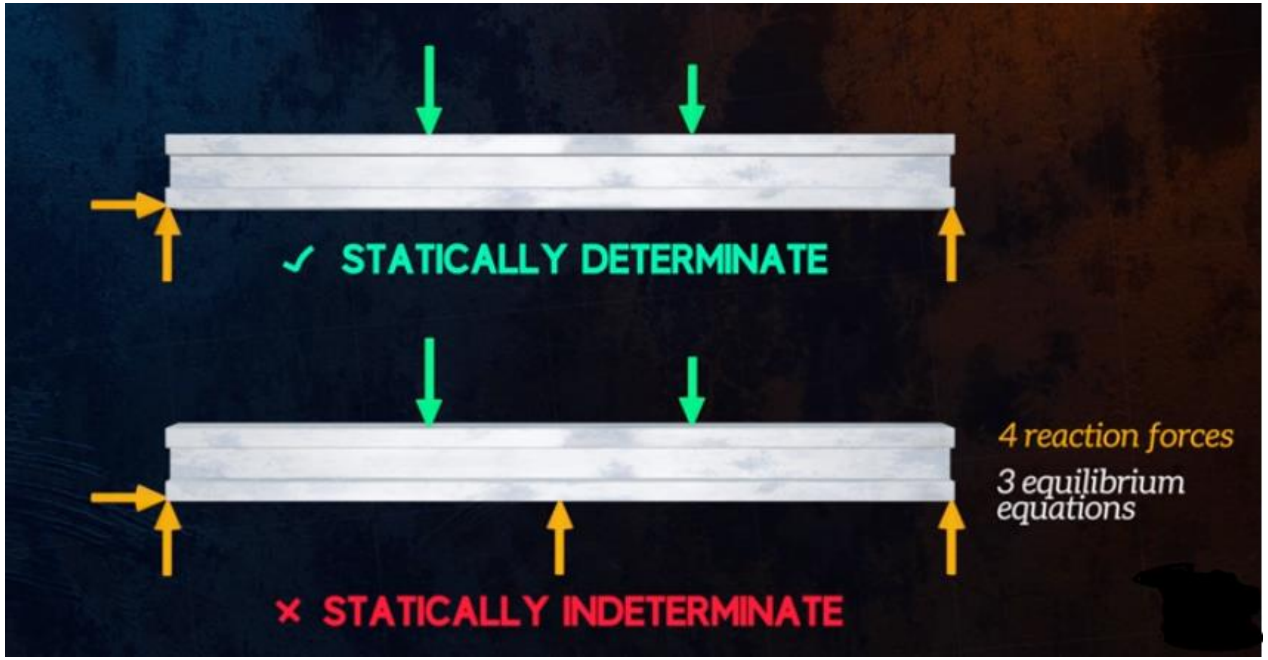


Fig. 4 . ***Statically determinate & indeterminate beams***

Types of Loading

Loads applied to the beam may consist of a concentrated load (load applied at a point), uniform load, uniformly varying load, or an applied couple or moment (**Fig. 5**).

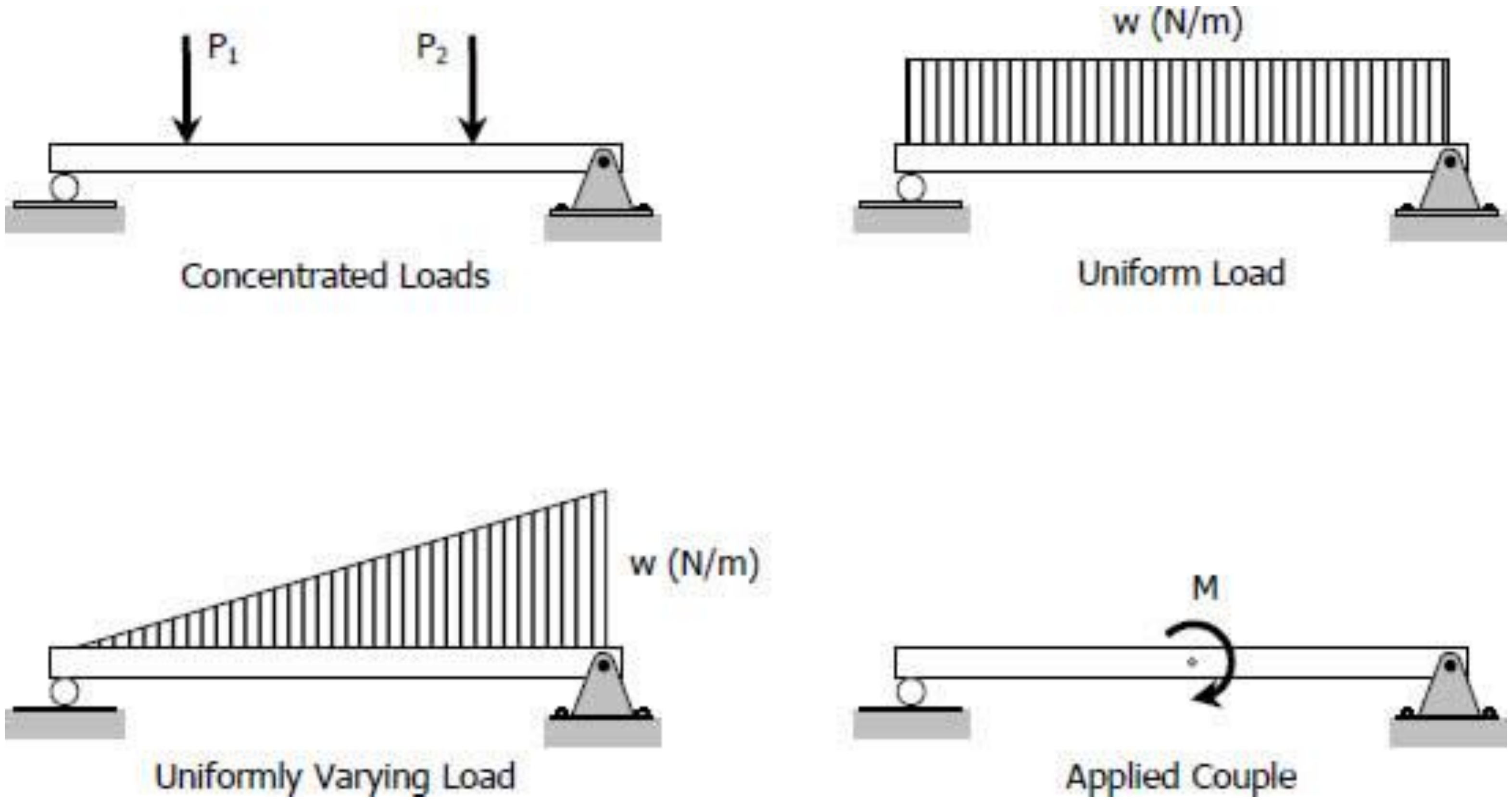


Fig. 5 . ***Types of Loading***

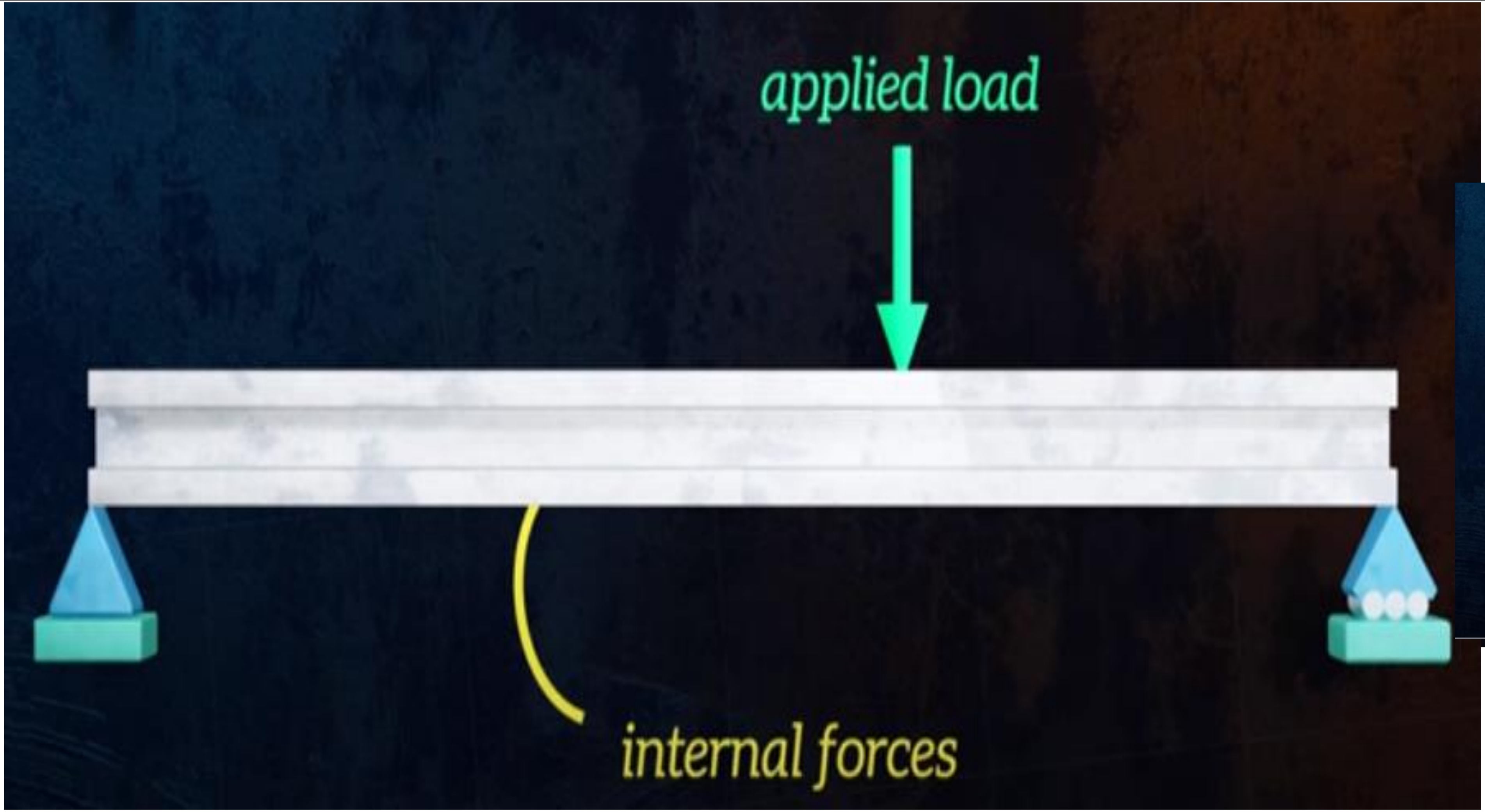
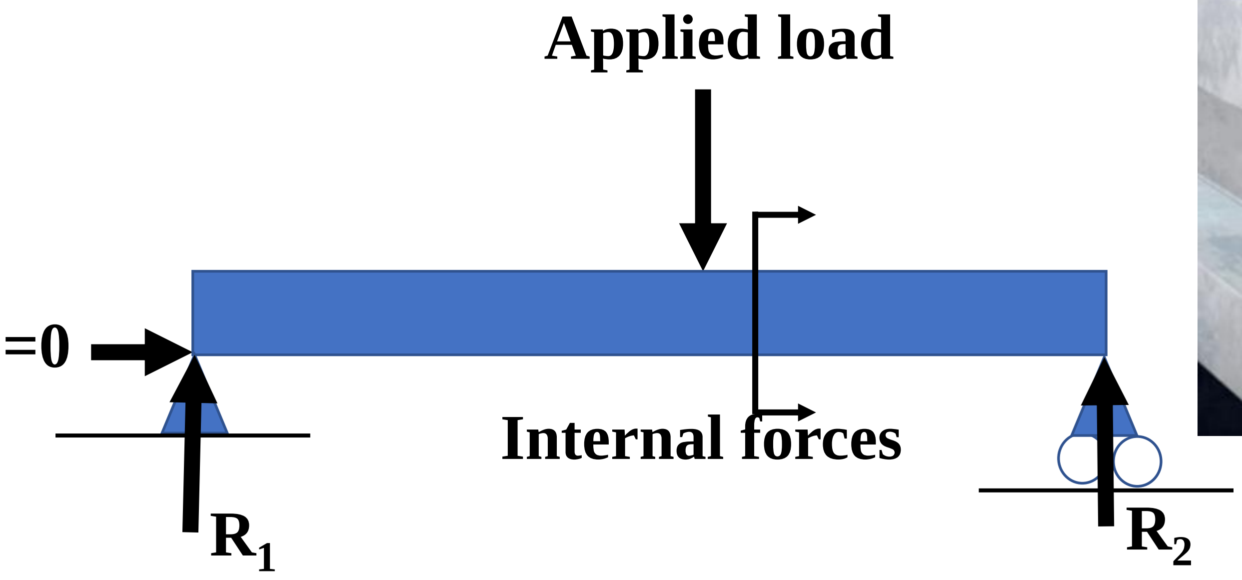
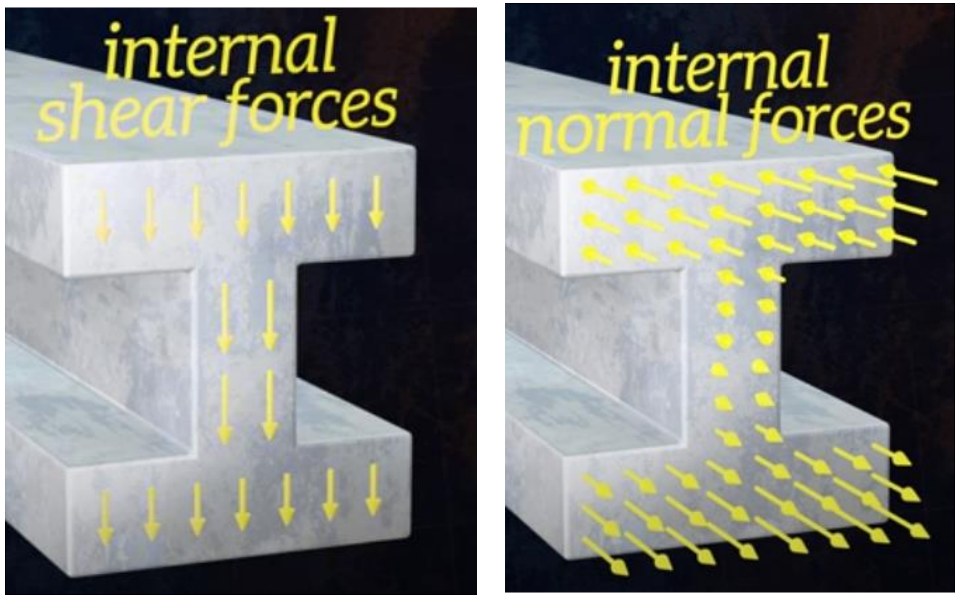


Fig. 6 . *Simple beam*

Internal forces is developed within it to maintained equilibrium. These Internal forces have two components. We have internal shear force oriented in the vertical direction and, we have internal normal forces which is oriented along the axis of the beam.





Internal forces

Fig. 6 . ***Simple beam***

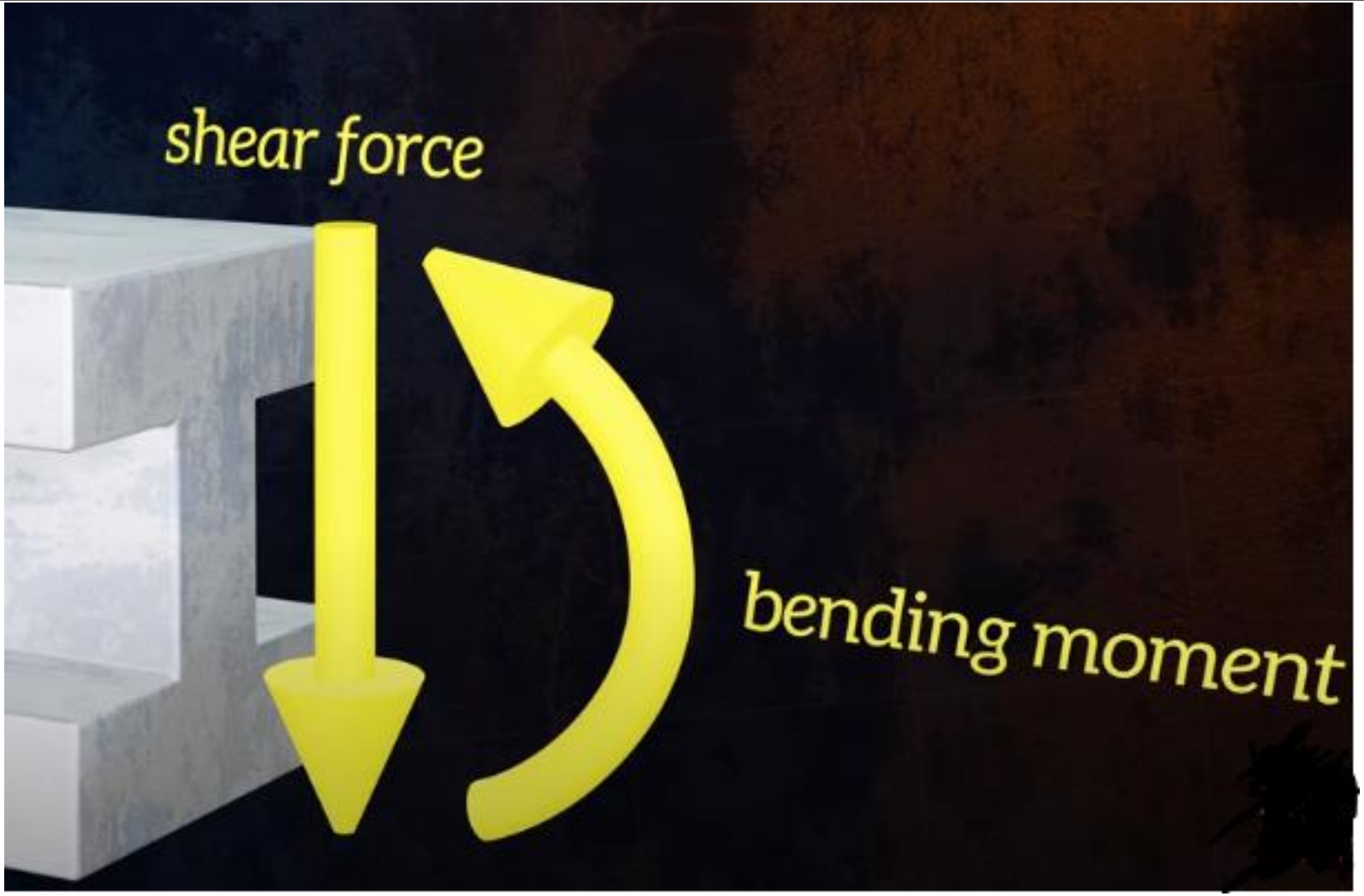


Fig. 7 . Internal forces in the beam

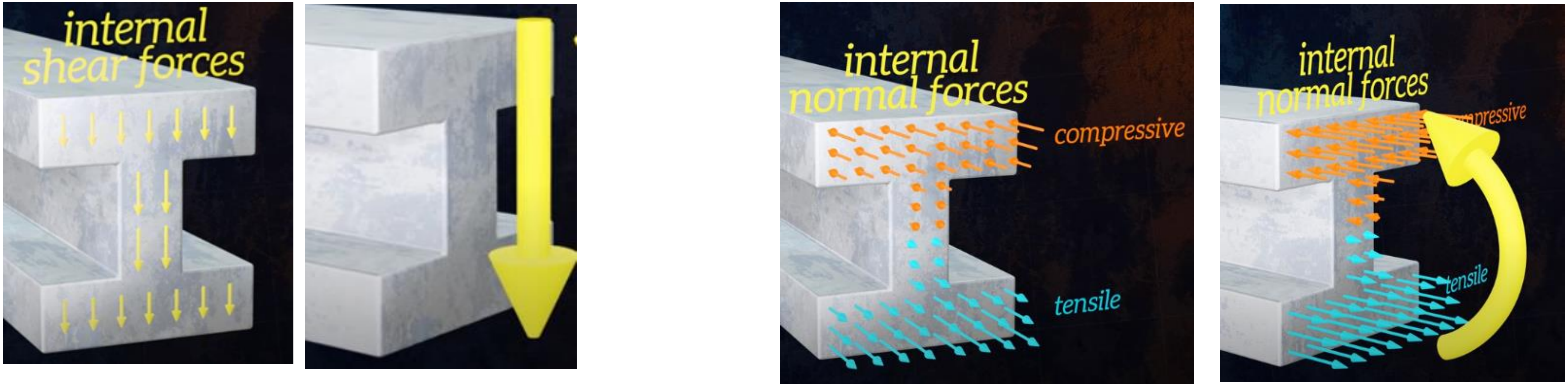
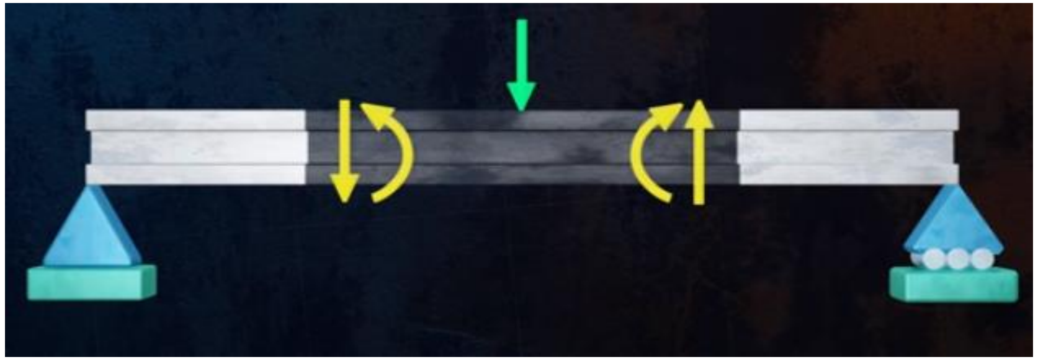
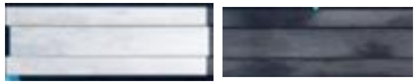


Fig. 8 . Sections of internal forces in the beam

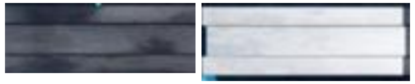
Sign Conventions:

Shear



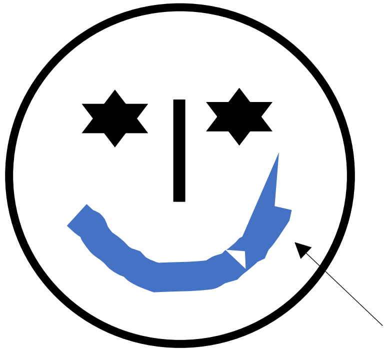


Positive shear



Negative shear

Moment



Smile face

Sad face

Slope of the shear diagram

$$\frac{dV}{dx} = -w \quad \xrightarrow{\text{INTEGRATE}} \quad V_2 - V_1 = -\int_{x_1}^{x_2} w\, dx$$

change in shear force between two points

area under the loading diagram between two points

Slope of the moment diagram

$$\frac{dM}{dx} = V \quad \xrightarrow{\text{INTEGRATE}} \quad M_2 - M_1 = \int_{x_1}^{x_2} V\, dx$$

change in bending moment between two points

area under the shear force diagram between two points

Load ⟶ shear ⟶ moment

Illustrative problem: *Simple beam*

1- A, B, and C are called change of load points.
2- Begin by computing the reactions. Applying Sum…..
3- +Shearing forces are plotted upward from the x-axis.
4- Locate the points of zero shear.

$\sum F_x = 0;$ ⟶ $A_x = 0$

$\sum M_c = 0 \curvearrowleft_{+};\ A_y \times 4 - 12 \times 2 = 0$ ⟶ $A_y = 6\ kN \uparrow$

$\sum F_y = 0;\ 6 - 12 + C_y = 0$ ⟶ $C_y = 6\ kN \uparrow$

$M_A = 0 \quad , M_B = M_A + Area_1$

$Area_1 = +\ 6\ kN \times \quad = +12\ kN.\ m$

$Area_2 = -\ 6\ kN \times \quad = -12\ kN.\ m$

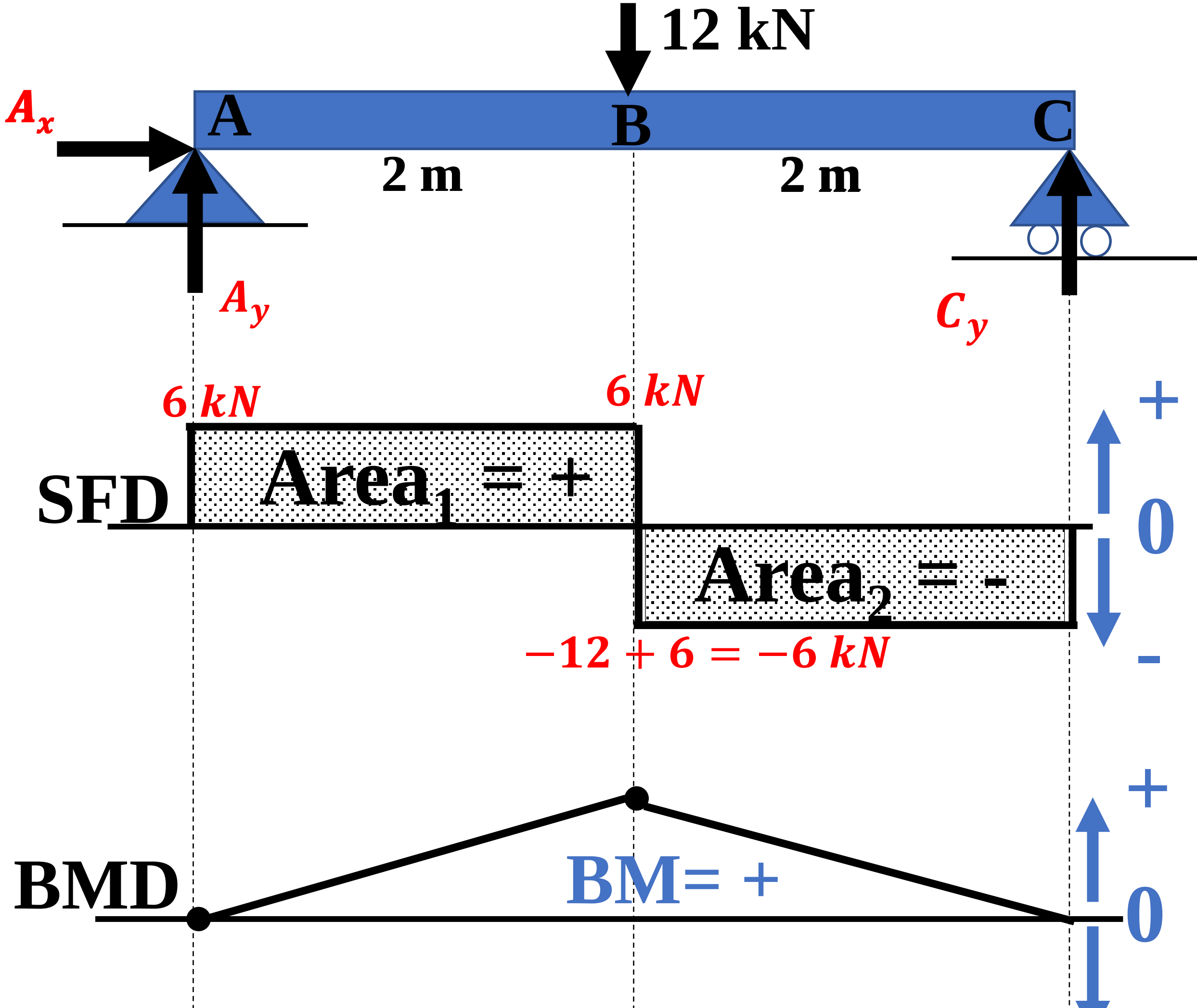


Fig. 9 . SFD & BMD

Illustrative problem: *Simple beam*

1- A and B are called change of load points.
2- Begin by computing the reactions. Applying Sum.....
3- +Shearing forces are plotted upward from the x-axis.
4- Locate the points of zero shear.

$\sum F_x = 0;$ → $A_x = 0$

$\sum M_B = 0 \curvearrowright_+;\ A_y \times 4 - 48 \times 2 = 0$ → $A_y = 24\ kN \uparrow$

$\sum F_y = 0;\ 24 - 48 + B_y = 0$ → $B_y = 24\ kN \uparrow$

$M_A = 0$, $M_C = M_A + Area_1$

$Area_1 = +24\ kN \times \quad \times \frac{1}{2} = +24\ kN.m$

$Area_2 = -24\ kN \times \quad \times \frac{1}{2} = -24\ kN.m$

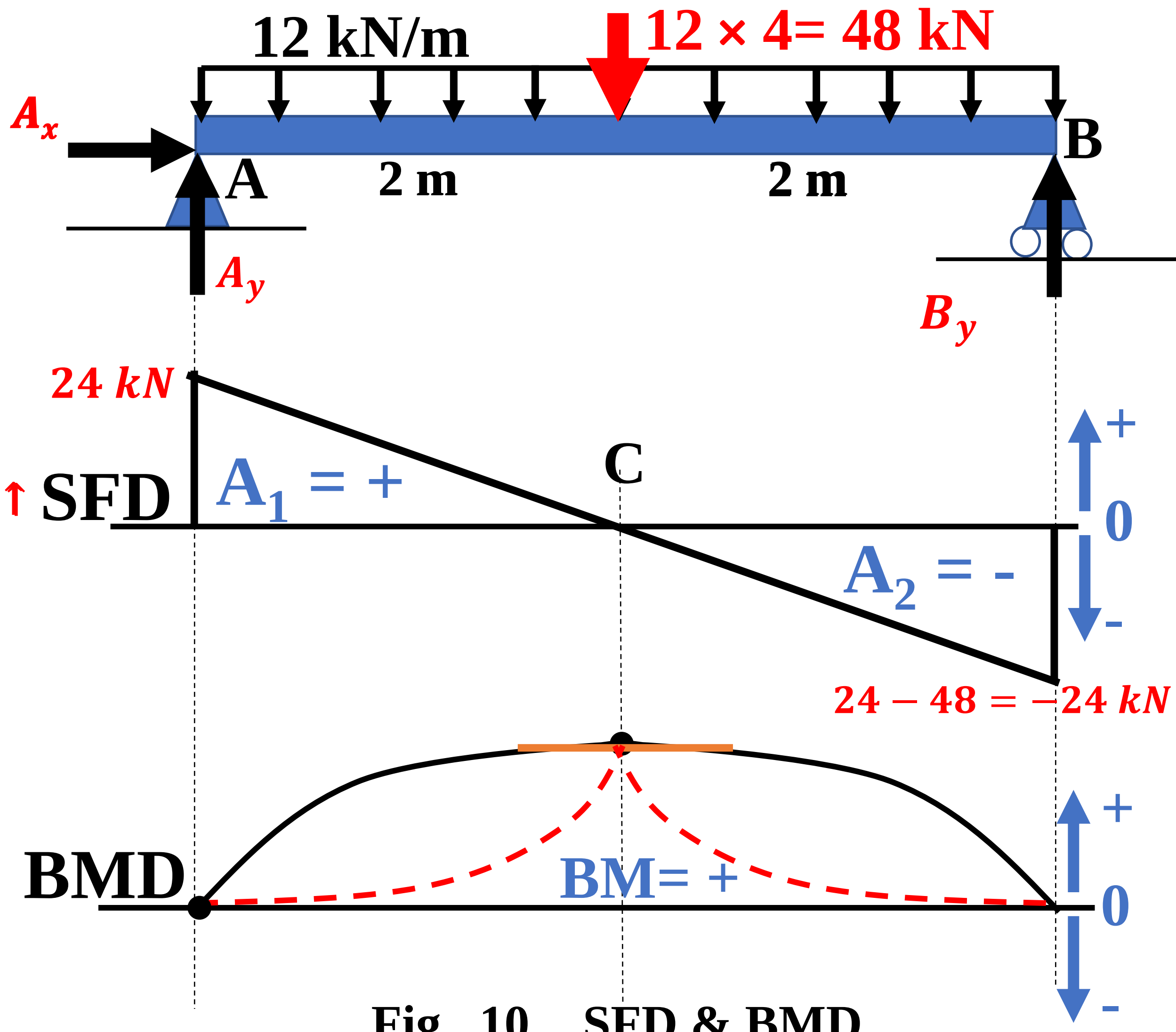


Fig. 10 . SFD & BMD

Illustrative problem: Overhanging beam

Beam loaded as shown in **Fig. 11.** Sketch shear and bending moment diagrams for the beam.

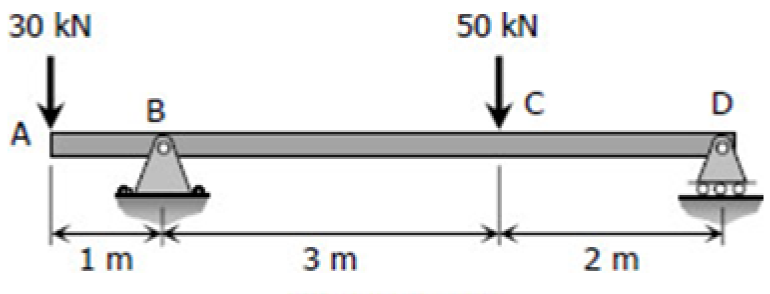
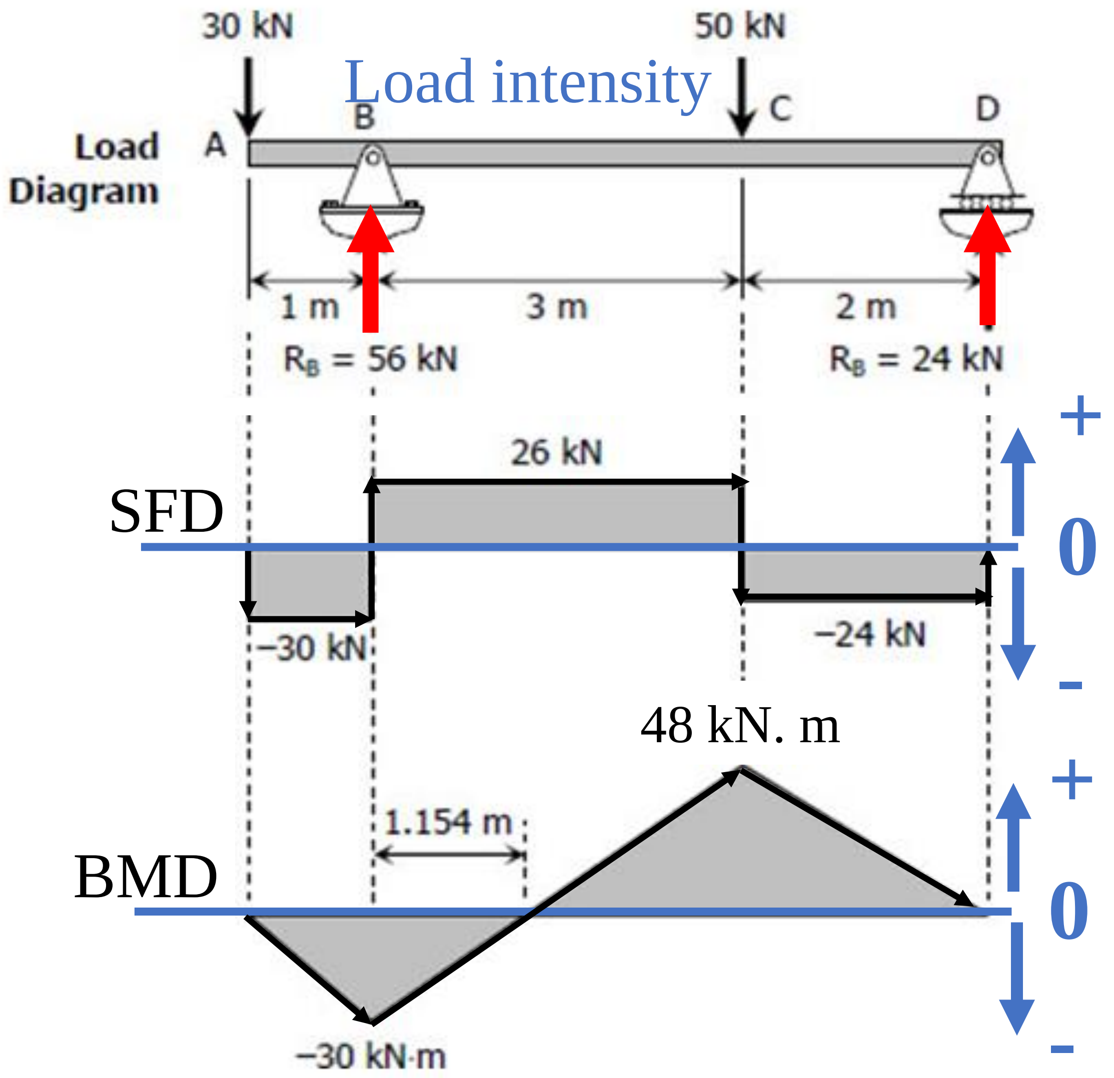


Fig. 11 .Illustrative problem

$$\sum F_x = 0: \rightarrow No\ horizontal\ forces;$$

$$\sum M_D = 0: \rightarrow R_B = 56\ kN$$

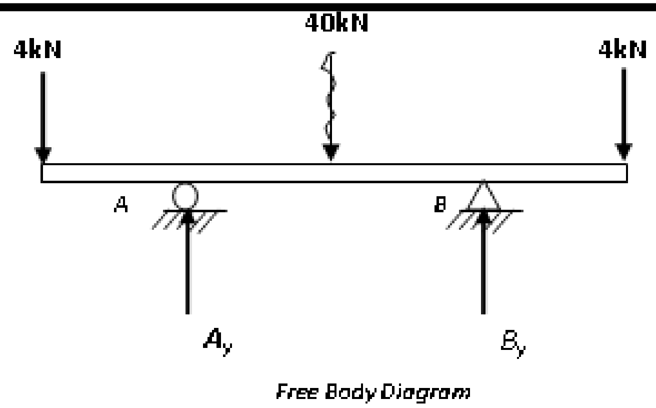
$$\sum F_y = 0: \rightarrow R_D = 24\ kN$$

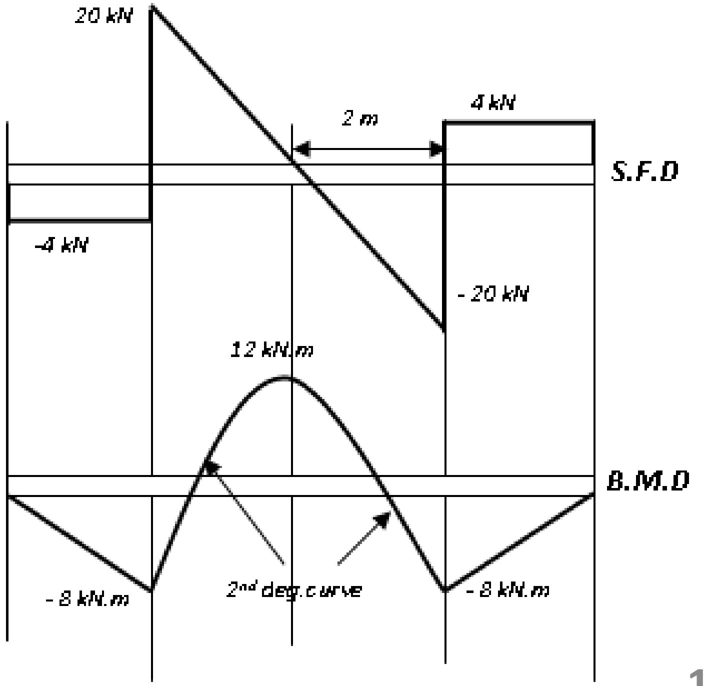


Go to pages 130-136. Strength of Materials, 3rd edition by F. L, Singer and A. Pytel

Illustrative problem : Overhanging beam

Overhanging beam with both ends extending beyond the supports loaded as shown in **Fig. 12.** Sketch shear and bending moment diagrams for the beam.





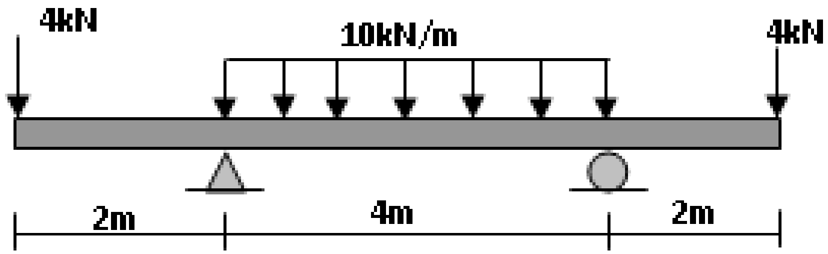


Fig. 12 .Illustrative problem

Self study/independent study

Homework: Beam loaded as shown in **Fig. 13.** Sketch shear and bending moment diagrams for the beam.

Applied load

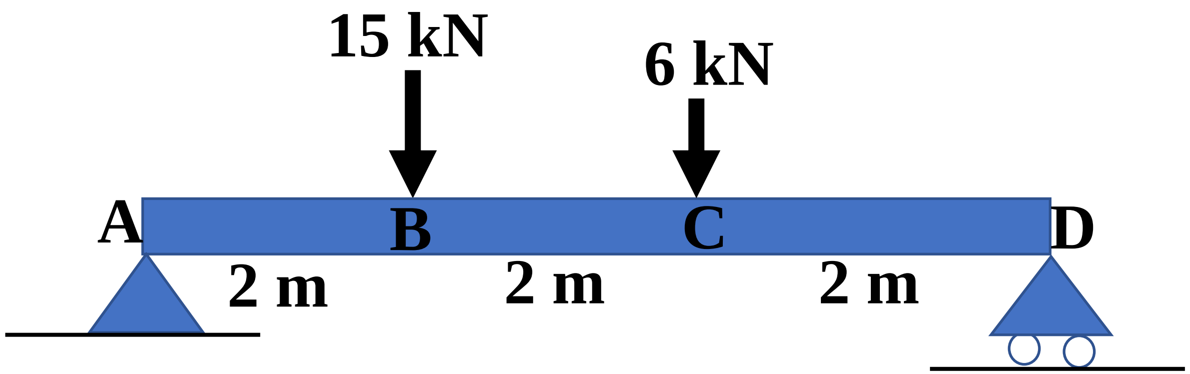


Fig. 13 . ***Simple beam***

Is required homework in classwork for Shear and moment, part 2 on Google Classroom platform

for your kind attention and further action.

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