RAMA UNIVERSITY

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FACULTY OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering

MEPS102:Strength of Material

Lecture 17

Topic:17. Introduction to beam, Shear Force and Bending Moment

Instructor:

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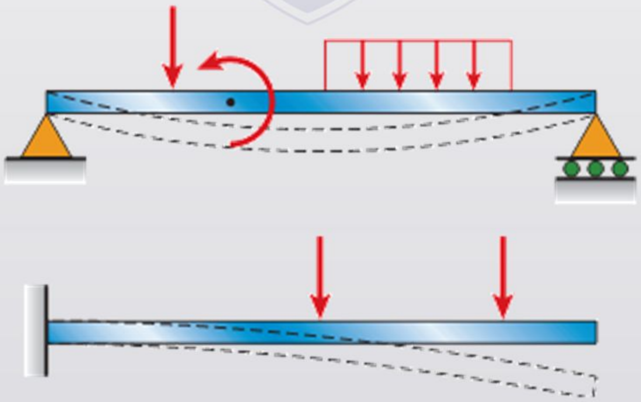
Beam

✓ Structural members subjected to lateral loads, that is, forces or moments having their vectors perpendicular to the axis of the bar.

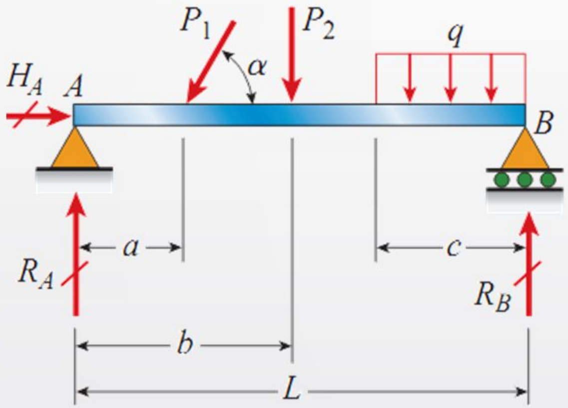
✓ Classified as planar structures because they lie in a single plane. If all loads act in that same plane, and if all deflections (shown by the dashed lines) occur in that plane, then we refer to that plane as the plane of bending.

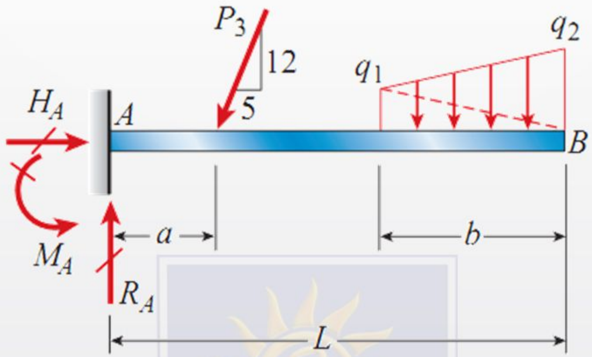


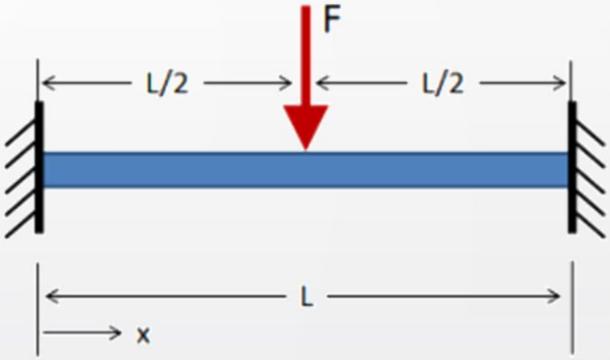
Types of Beams, Loads, and Reactions

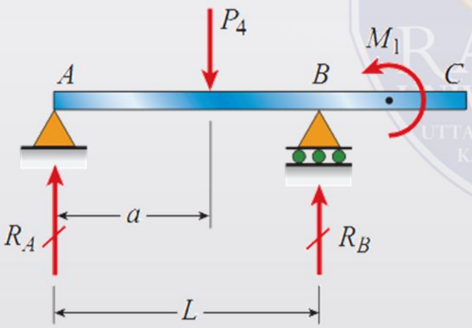
1. Simply supported – a beam supported on the ends which are free to rotate and have no moment resistance.
2. Cantilever – a projecting beam fixed only at one end.
    1. Fixed – a beam supported on both ends and restrained from rotation. (Double cantilever)
3. Over hanging – a simple beam extending beyond its support on one end.
    1. Double overhanging – a simple beam with both ends extending beyond its supports on both ends.
4. Continuous – a beam extending over more than two supports.

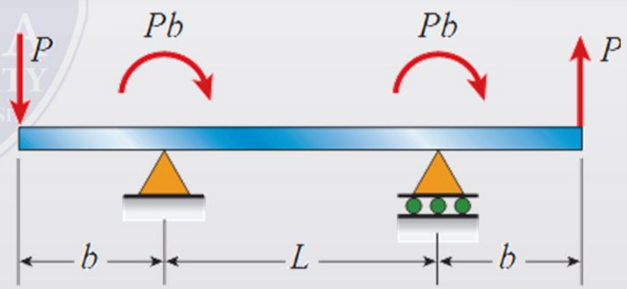
Types of Beams, Loads, and Reactions

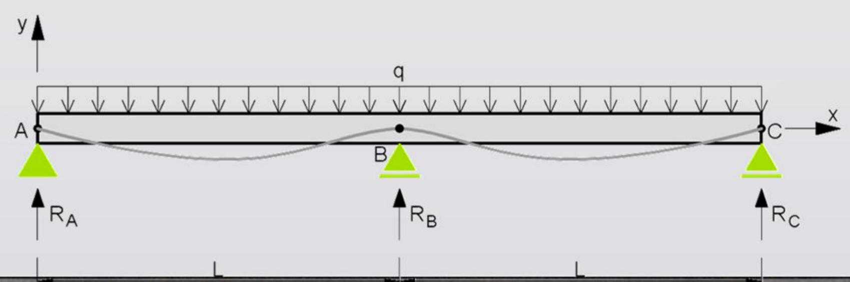




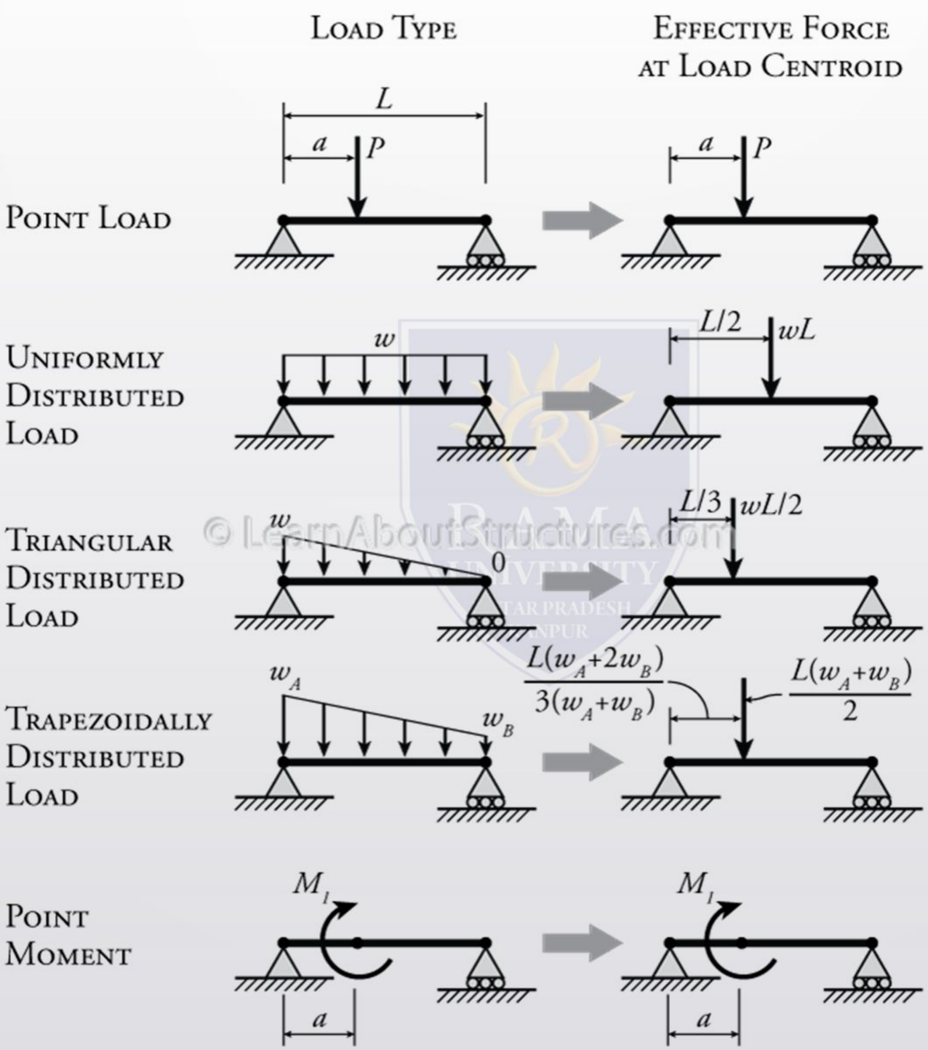






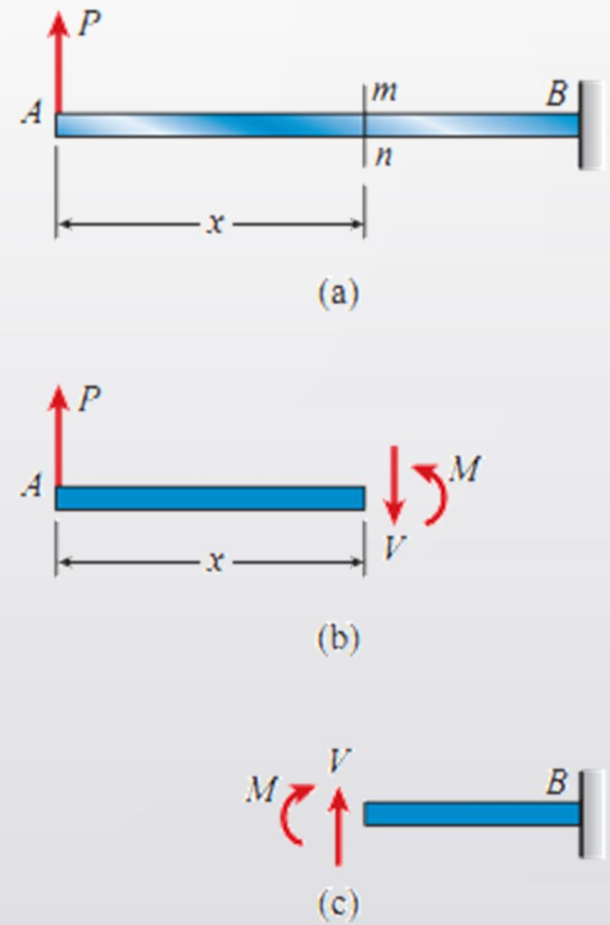


Types of Load



Shear Force and Bending Moment

✓ When a beam is loaded by forces or couples, stresses and strains are created throughout the interior of the beam. To determine these stresses and strains, we first must find the internal forces and internal couples that act on cross sections of the beam



- ✓ As an illustration of how these internal quantities are found, consider a cantilever beam AB loaded by a force P at its free end. We cut through the beam at a cross section mn located at distance x from the free end and isolate the left-hand part of the beam as a free body. The free body is held in equilibrium by the force P and by the stresses that act over the cut cross section. These stresses represent the action of the right-hand part of the beam on the left-hand part. At this stage of our discussion we do not know the distribution of the stresses acting over the cross section; all we know is that the resultant of these stresses must be such as to maintain equilibrium of the free body.

$$\sum F_{\text{vert}} = 0 \qquad P - V = 0 \text{ or } V = P$$

$$\sum M = 0 \qquad M - Px = 0 \text{ or } M = Px$$

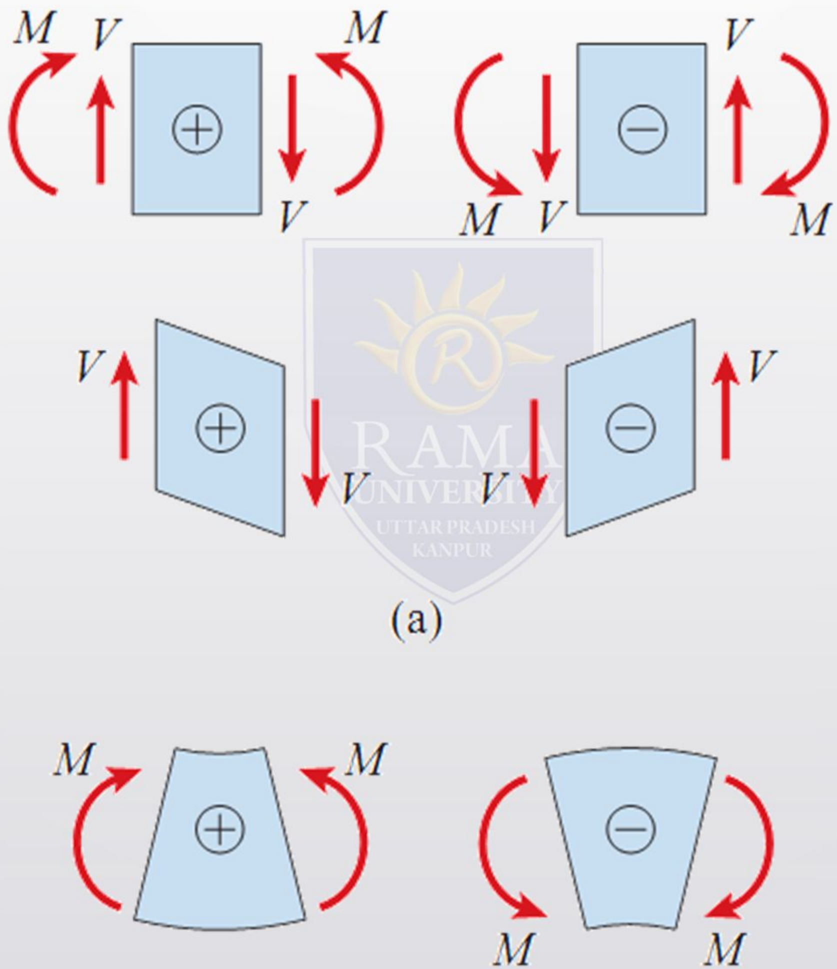
Shear Force and Bending Moment

- ✓ From statics, we know that the resultant of the stresses acting on the cross section can be reduced to a shear force V and a bending moment M. Because the load P is transverse to the axis of the beam, no axial force exists at the cross section. Both the shear force and the bending moment act in the plane of the beam, that is, the vector for the shear force lies in the plane of the figure and the vector for the moment is perpendicular to the plane of the figure
- ✓ Shear forces and bending moments, like axial forces in bars and internal torques in shafts, are the resultants of stresses distributed over the cross section. Therefore, these quantities are known collectively as ***stress resultants***

Sign Conventions

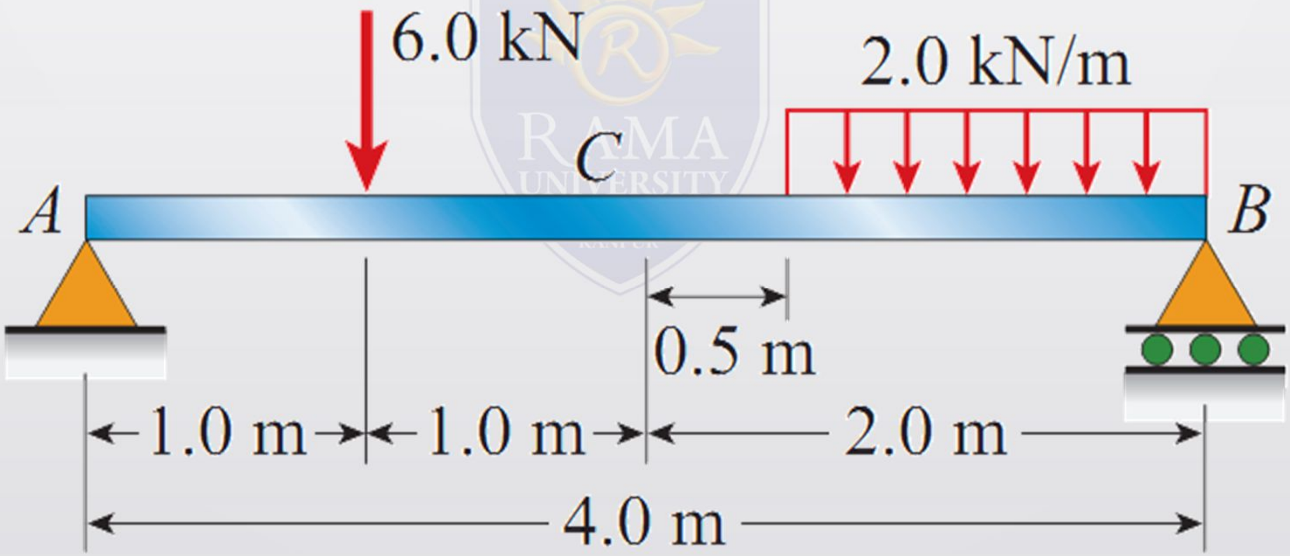
- ✓ Sign conventions for stress resultants are called ***deformation sign conventions*** because they are based upon how the material is deformed.
- ✓ A positive shear force acts clockwise against the material and a negative shear force acts counterclockwise against the material. Also, a positive bending moment compresses the upper part of the beam and a negative bending moment compresses the lower part. When writing equations ***of equilibrium, we use static sign conventions,*** in which forces are positive or negative according to their directions along the coordinate axes.
- ✓ Suppose that we are summing forces in the vertical direction and that the y axis is positive upward. Then the ***load P is given a positive sign*** in the equation of equilibrium because it acts upward. However, the ***shear force V (which is a positive shear force) is given a negative sign*** because it acts downward (that is, in the negative direction of the y axis)

Sign Conventions



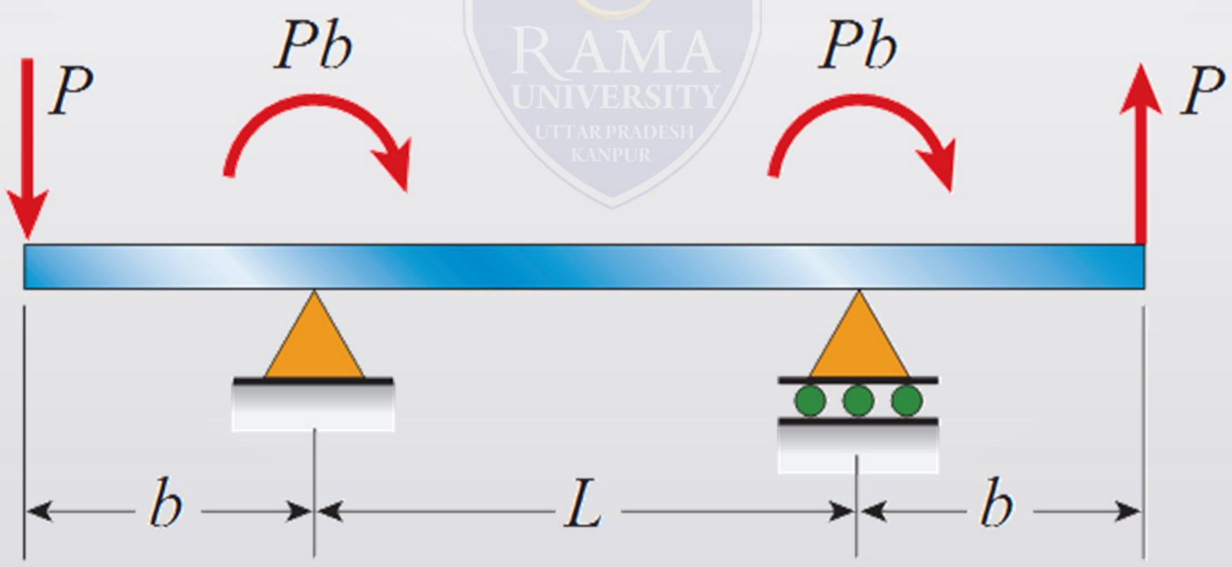
Questions

4.3-2 Determine the shear force V and bending moment M at the midpoint C of the simple beam AB shown in the figure.



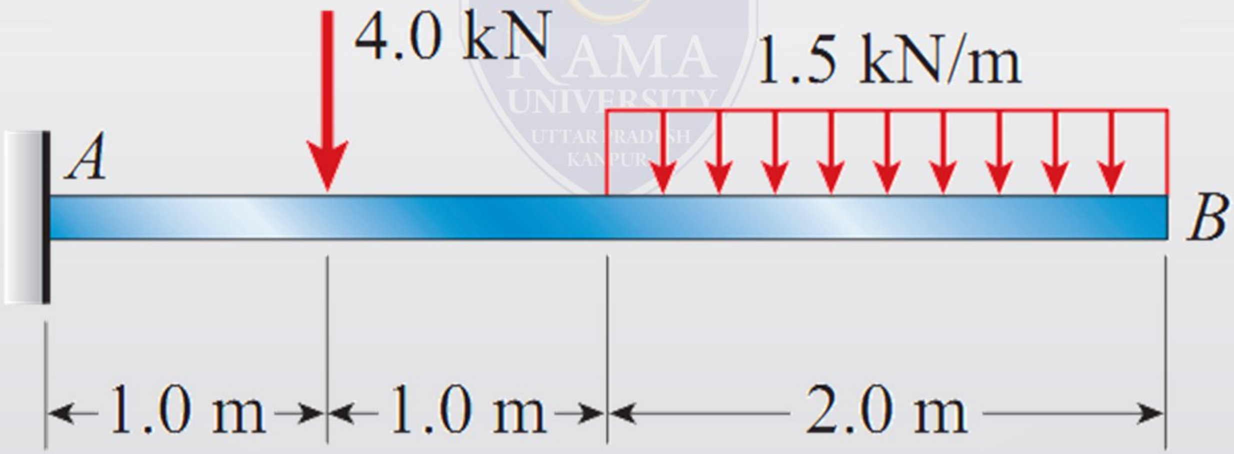
Questions

4.3-3 Determine the shear force V and bending moment M at the midpoint of the beam with overhangs (see figure). Note that one load acts downward and the other upward, and clockwise moments Pb are applied at each support.



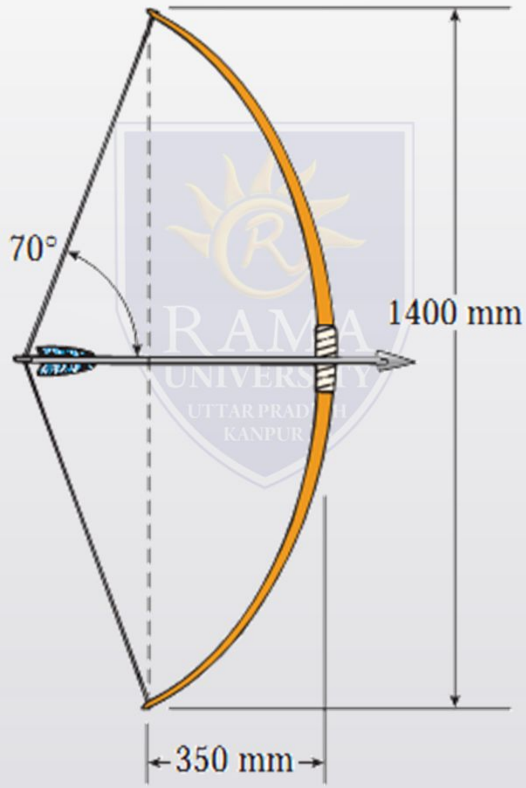
Questions

4.3-4 Calculate the shear force V and bending moment M at a cross section located 0.5 m from the fixed support of the cantilever beam AB shown in the figure.



Questions

4.3-8 At full draw, an archer applies a pull of 130 N to the bowstring of the bow shown in the figure. Determine the bending moment at the midpoint of the bow.



Questions

4.3-9 A curved bar *ABC* is subjected to loads in the form of two equal and opposite forces *P*, as shown in the figure. The axis of the bar forms a semicircle of radius *r*.

Determine the axial force *N*, shear force *V*, and bending moment *M* acting at a cross section defined by the angle θ.