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FACULTY OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering

MEPS102:Strength of Material

Lecture 19

Topic:Rule for drawing shear force and bending moment diagram

Instructor:

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Why?

- ✓When designing a beam, we usually need to know how the shear forces and bending moments vary throughout the length of the beam.
- ✓Of special importance are the maximum and minimum values of these quantities.
- ✓Information of this kind is usually provided by graphs in which the shear force and bending moment are plotted as ordinates and the distance x along the axis of the beam is plotted as the abscissa.
- ✓Such graphs are called shear-force and bending-moment diagrams.

Rules

- ✓ The ordinate on the distributed load curve ***(q)*** is equal to the negative of the slope on the shear diagram.

$$\frac{dV}{dx} = -q$$

- ✓ The difference in shear values between any two points on the shear diagram is equal to the (-) area under the distributed load curve between those same two points

$$V_B - V_A = \int_A^B dV = -\int_A^B q\,dx \;= -(area\ of\ loading\ diagram\ between\ A\ and\ B)$$

- ✓ *This equation is valid **only when distributed loads** act on the beam between points 'A' and 'B', but **not** when a **concentrated load** is acting between point 'A' and 'B'*

- ✓ The ordinate on the shear diagram (***V***) is equal to the slope on the bending moment diagram

$$\frac{dM}{dx} = V$$

Rules

- ✓ The difference in values between any two points on the moment diagram is equal to the area under the shear diagram between those same two points

$$M_B - M_A = \int_A^B dM = \int_A^B V\,dx$$
$$= (area\ of\ shear\ force\ diagram\ between\ A\ and\ B)$$

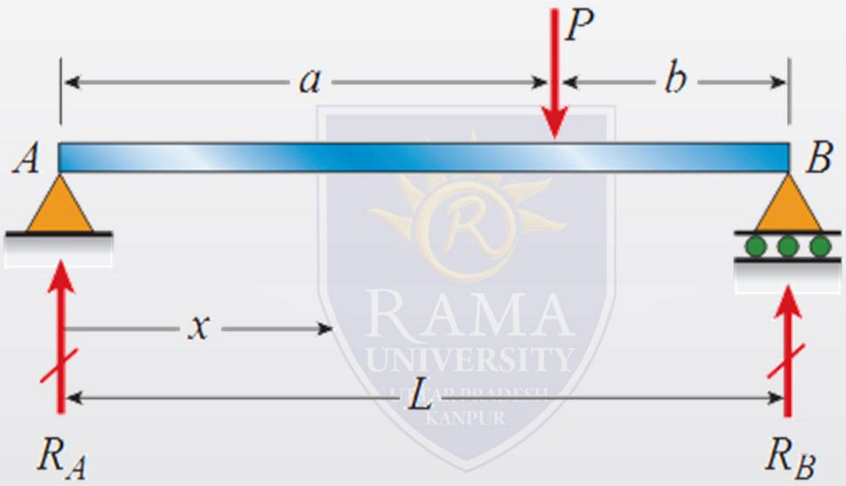
- ✓ *This equation is **valid even when concentrated loads** act on the beam between points 'A' and 'B', but **not** when a **couple** is acting between point 'A' and 'B'*
  - ✓ At those points at which the shear curve crosses the reference axis ***(i.e., V=0)***, the value of the moment on the moment diagram is a local maximum or minimum.
  - ✓ The ordinate on the axial force diagram ***(N)*** is equal to zero at an axial force release; the ordinate on the shear diagram ***(V)*** is zero at a shear release; and the ordinate on the moment diagram ***(M)*** is zero at a moment release.

Rules

- If the bending moments at both ends of a beam are zero, as is usually the case with a simple beam, then the area of the shear-force diagram between the ends of the beam must be zero provided ***no couples*** act on the beam
- The maximum positive and negative bending moments in a beam may occur at the following places
  - A cross section where a concentrated load is applied and the shear force changes sign
  - A cross section where the shear force equals zero
  - A point of support where a vertical reaction is present, and
  - A cross section where a couple is applied.

Procedure for Point Load

✓ Consider the following simply supported beam

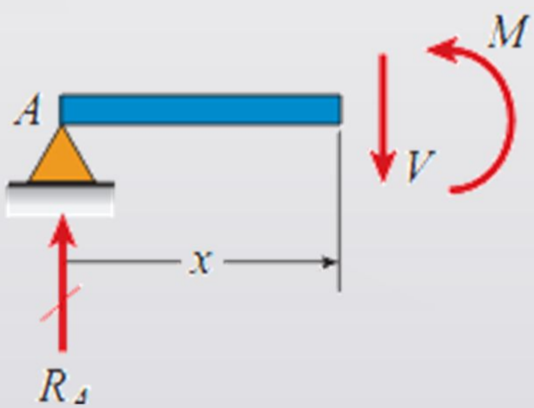


✓ Considering the entire beam as a free body and determine the reactions of the beam from equilibrium; the results are

$$R_A = \frac{Pb}{L} \qquad R_B = \frac{Pa}{L}$$

Procedure for Point Load

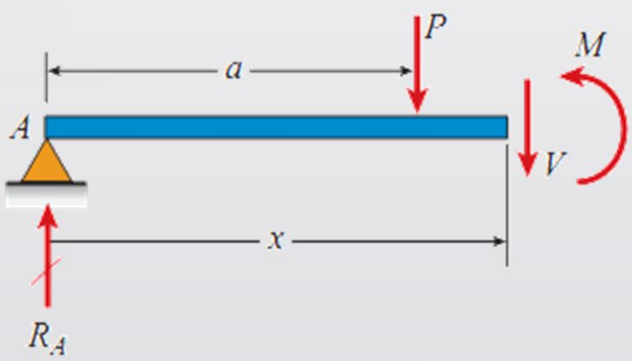
- ✓ We now cut through the beam at a cross section to the left of the load P and at distance x from the support at A.
- ✓ Then we draw a free-body diagram of the left-hand part of the beam
- ✓ From the equations of equilibrium for this free body, we obtain the shear force V and bending moment M at distance x from the support
- ✓ These expressions are valid only for the part of the beam to the left of the load P



$$V = R_A = \frac{Pb}{L} \qquad M = R_A x = \frac{Pbx}{L} \qquad (0 < x < a)$$

Procedure for Point Load

- ✓ Next, we cut through the beam to the right of the load P (that is, in the region a<x<L) and again draw a free-body diagram of the left-hand part of the beam
- ✓ From the equations of equilibrium for this free body, we obtain the following expressions for the shear force and bending moment



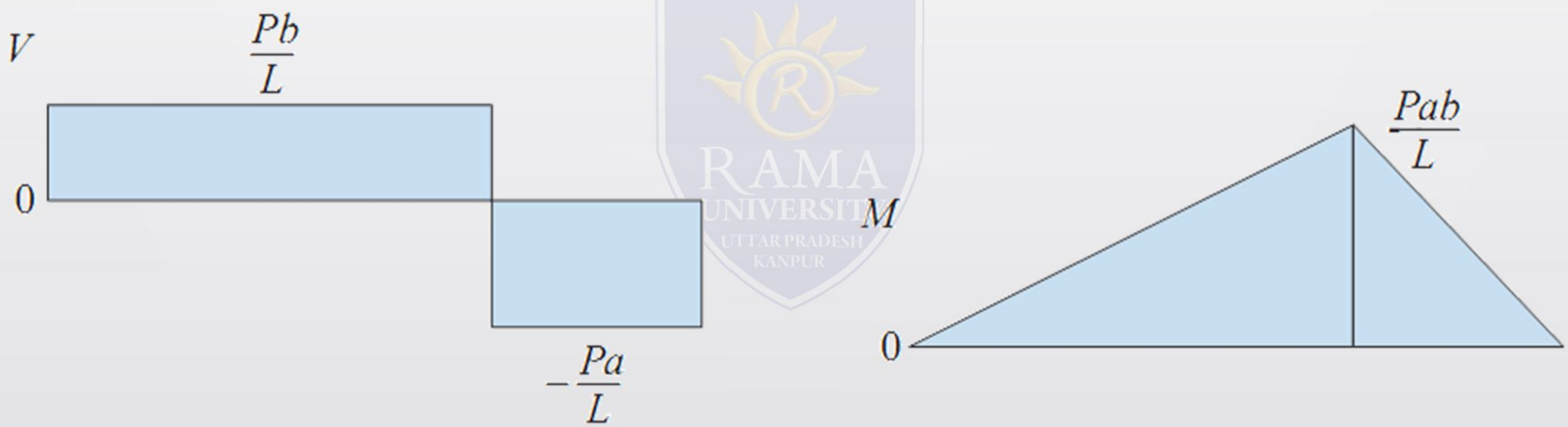
$$V = R_A - P = \frac{Pb}{L} - P = -\frac{Pa}{L} \qquad (a < x < L)$$

$$M = R_A x - P(x-a) = \frac{Pbx}{L} - P(x-a)$$

$$= \frac{Pa}{L}(L-x) \qquad (a < x < L)$$

Shear force and Bending Moment Diagram

✓ The equations for the shear forces and bending moments are plotted.

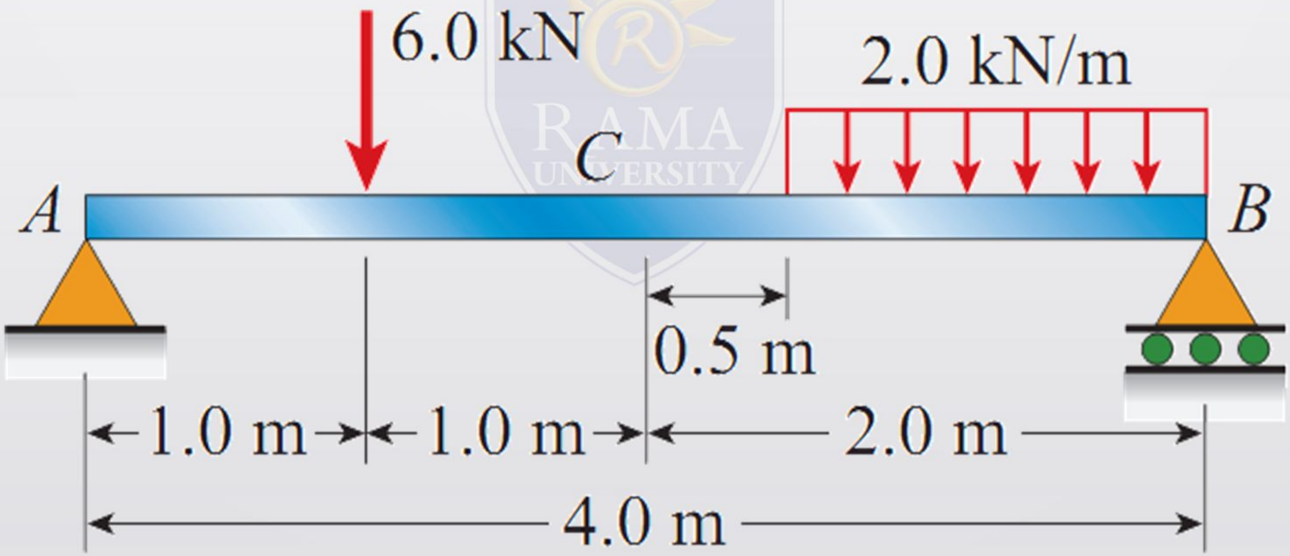


Observations

- ✓ From the first diagram we see that the shear force at end A of the beam (x = 0) is equal to the reaction R_A. Then it remains constant to the point of application of the load P. At that point, the shear force decreases abruptly by an amount equal to the load P. In the right-hand part of the beam, the shear force is again constant but equal numerically to the reaction at B
- ✓ As shown in the second diagram, the bending moment in the left-hand part of the beam increases linearly from zero at the support to Pab/L at the concentrated load (x = a). In the right-hand part, the bend-ing moment is again a linear function of x, varying from Pab/L at x = a to zero at the support (x = L). Thus, the maximum bending moment is

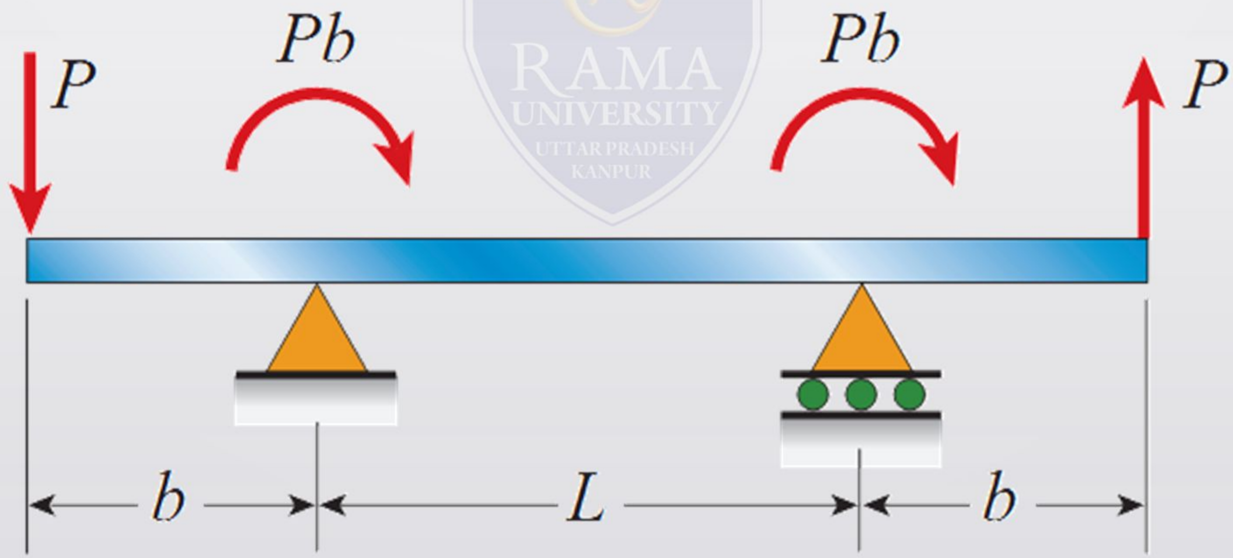
Questions

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.



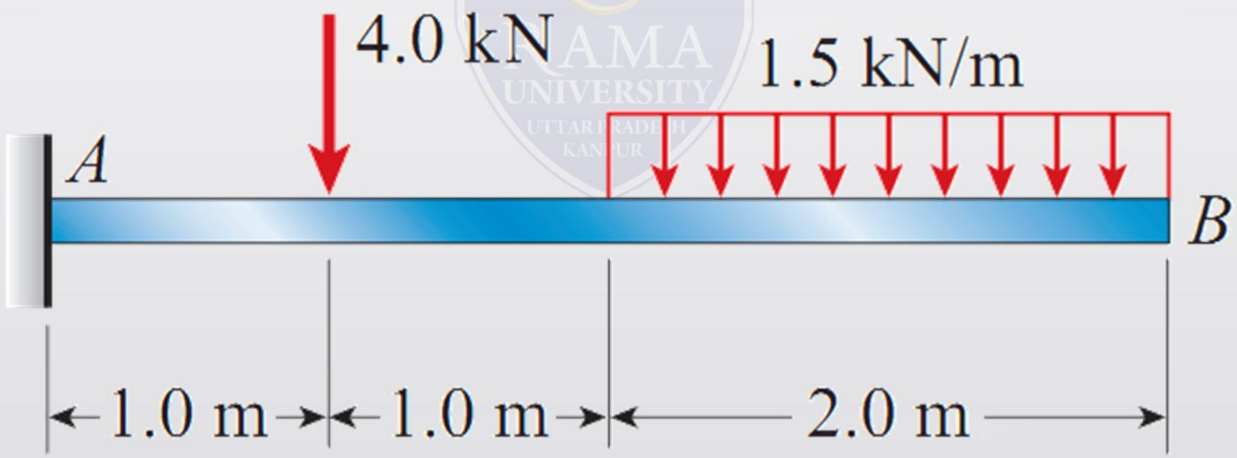
Questions

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.



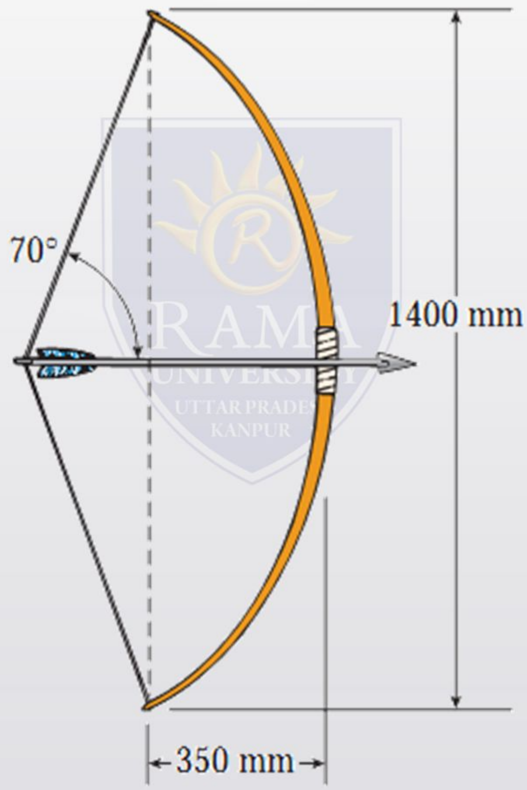
Questions

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

4.3-10 Under cruising conditions the distributed load acting on the wing of a small airplane has the idealized variation shown in the figure.

Calculate the shear force V and bending moment M at the inboard end of the wing.