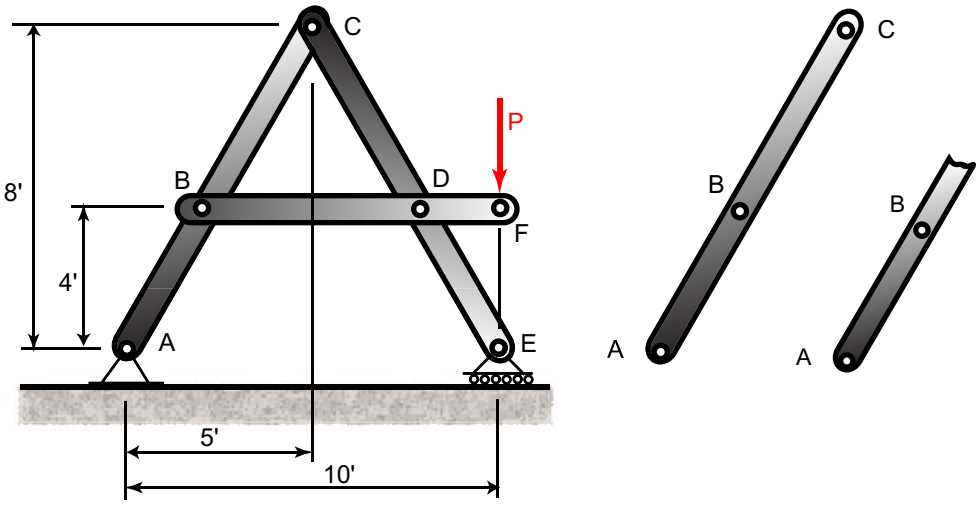
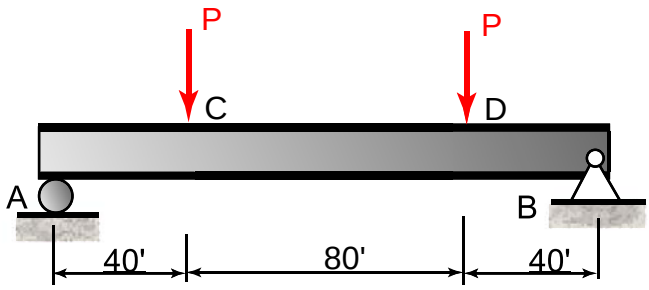
Chapter 5
Analysis and Design of Beams for Bending

INTRODUCTION

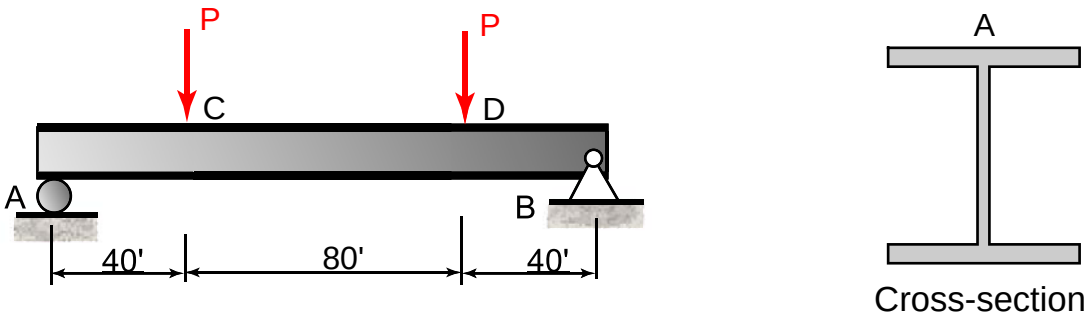
Internal Forces in Members



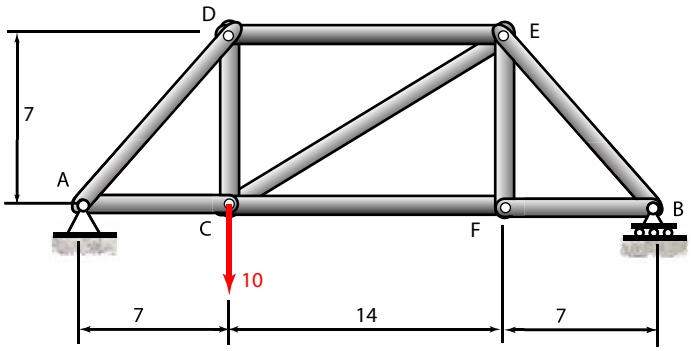
Shear and Bending-Moment Diagrams

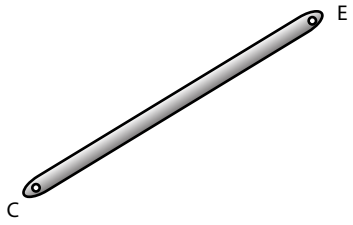


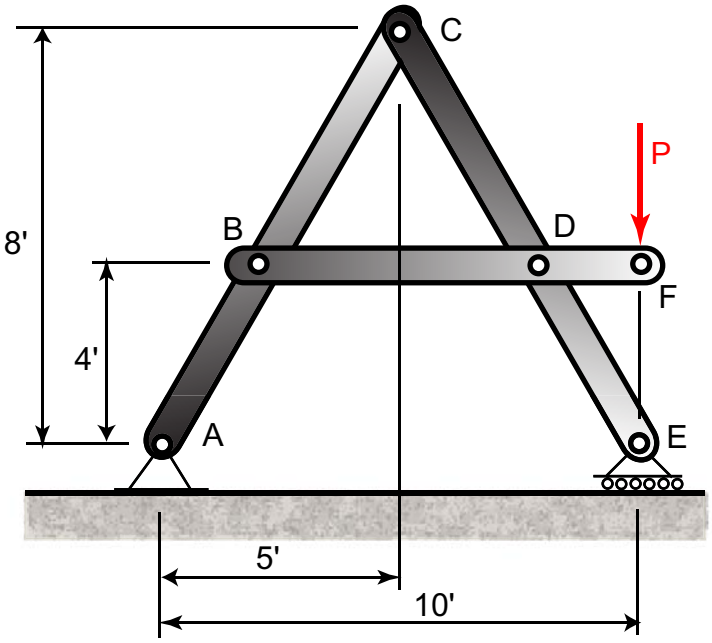
Design of Prismatic Beams for Bending

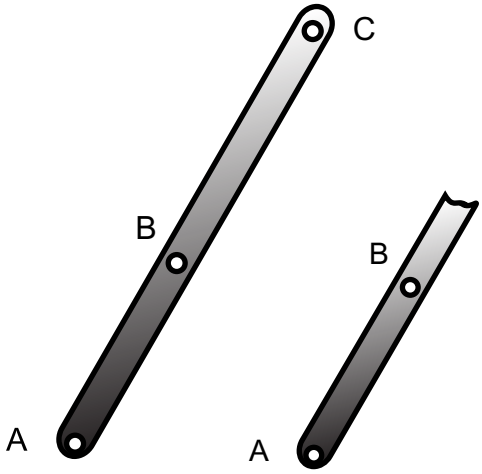


INTERNAL FORCES IN MEMBERS



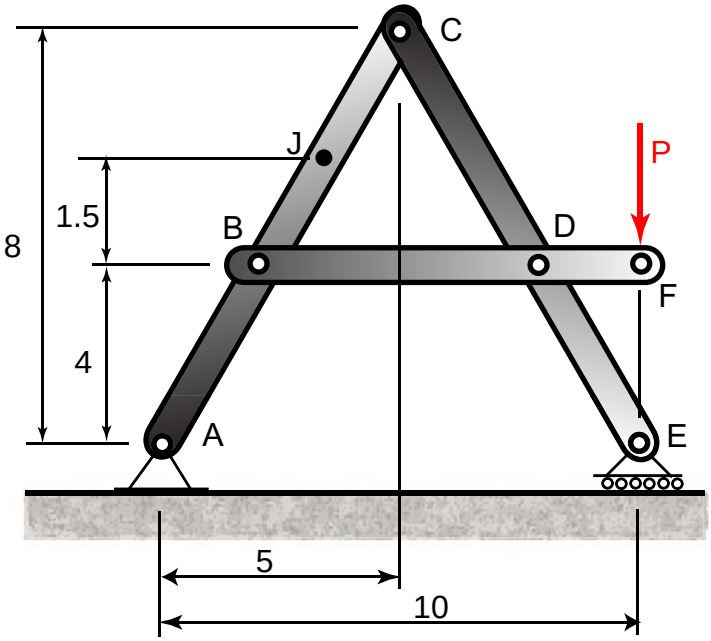


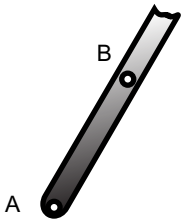




Example

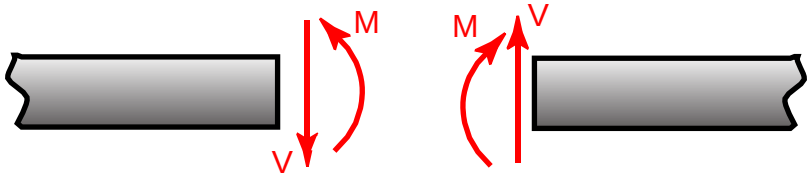
Determine the internal forces at point J. P= 5000 lb.
Units: Lb, ft.



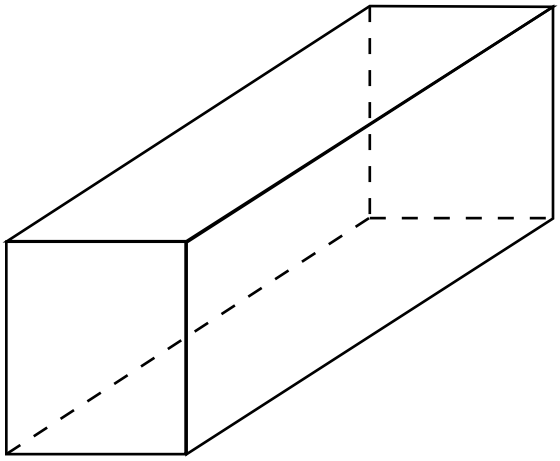


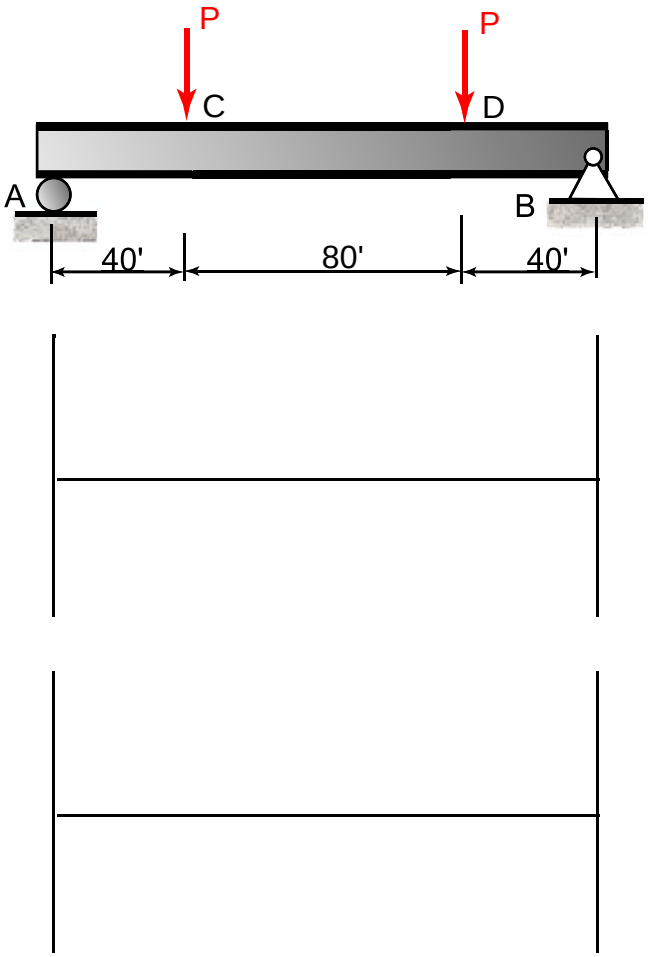
Shear and Bending Moment Diagrams

Sign Convention



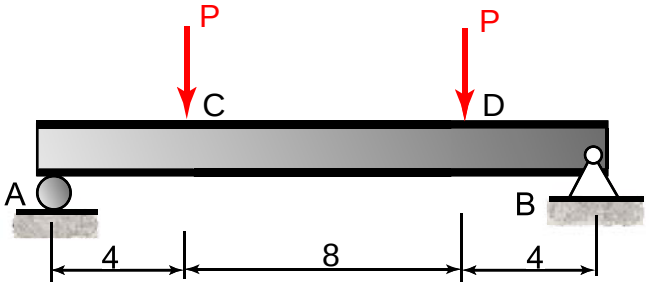
Why do we Need to Draw Shear and Bending Diagrams?



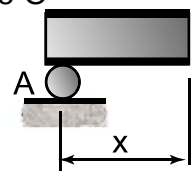
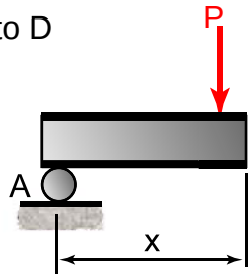
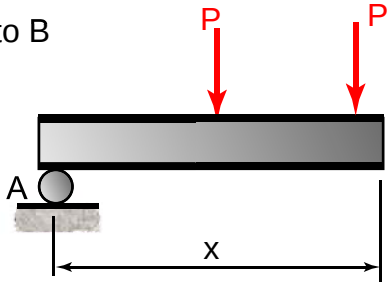


Example

Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: Lb, ft.

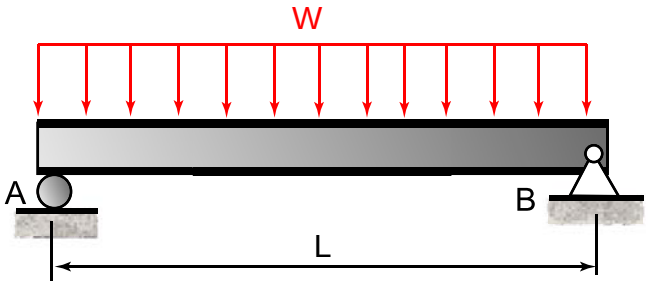


Support Reactions

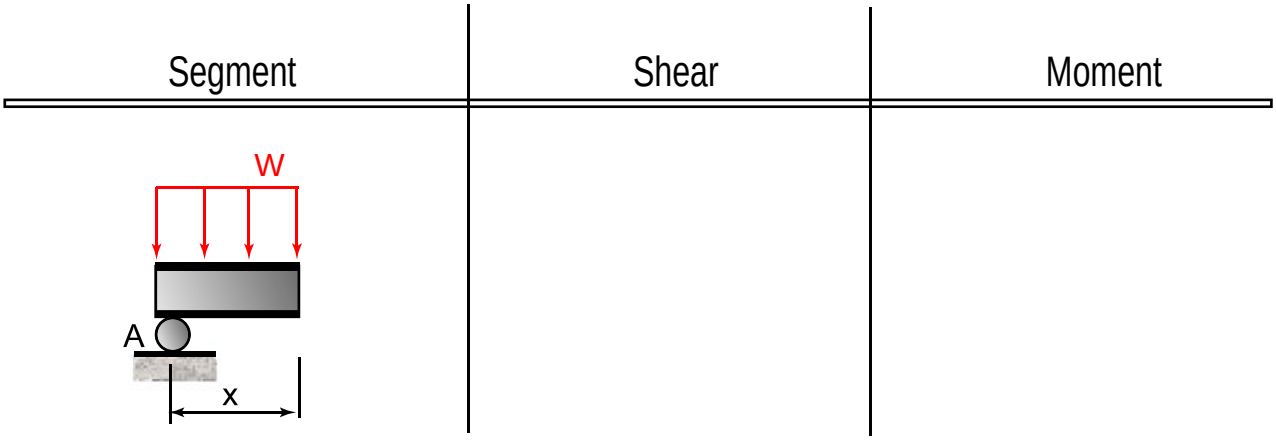
Segment	Shear	Moment
A to C 		
C to D 		
D to B 		

Example

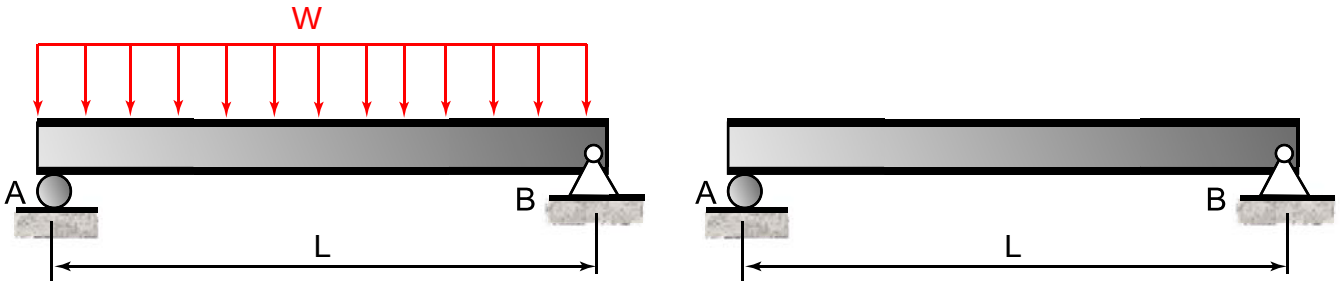
Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes.



Support Reactions

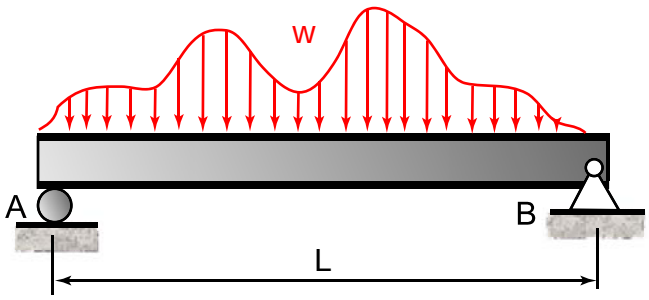


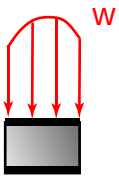
Caution:



When drawing FBDs, always use the original loading and not the equivalent.

RELATIONS AMONG LOAD, SHEAR, AND BENDING-MOMENT





$$\Delta V = -w\Delta x$$

The change in shear is equal to the area under the load curve.

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

The slope of the shear diagram is equal to the value of the w load.

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

The slope of the moment diagram is equal to the value of the shear.

$$\Delta M = V\Delta x$$

The change in moment is equal to the area under the shear curve.

Observations about the Shape of Shear/ Moment Diagrams

Shear Diagrams:

-Are a plot of forces (note the units).

-Discontinuities occur at concentrated forces.

Moment Diagrams:

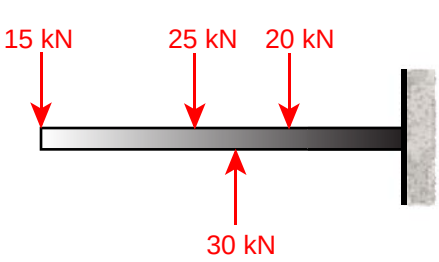
-Are a plot of moments (note the units).

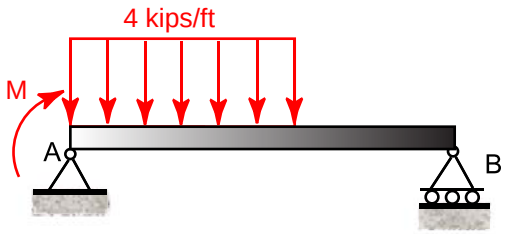
-Discontinuities occur at concentrated moments.

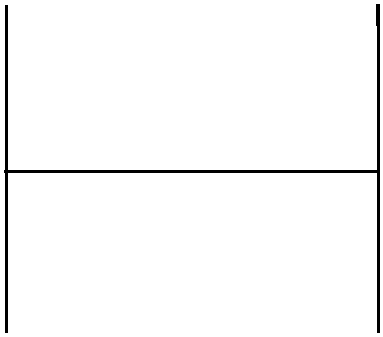
Miscellaneous:

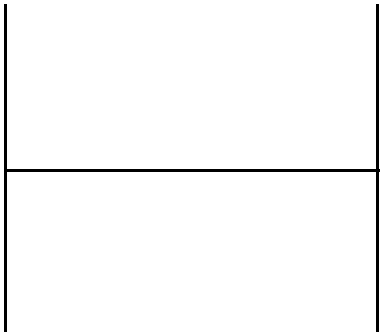
-Check your work by noting that you always start and end at zero.

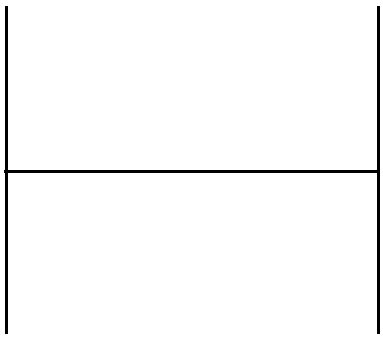
-Always use the original FBD and not the equivalent.

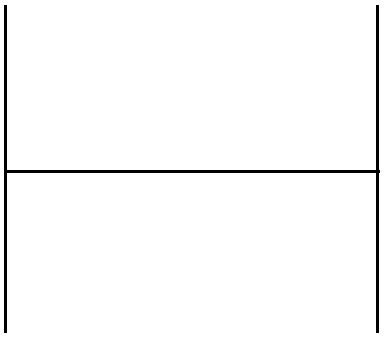






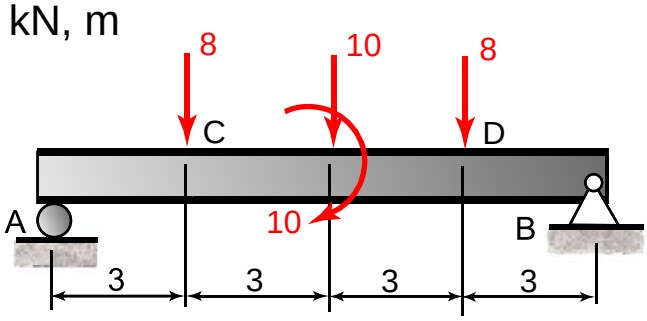




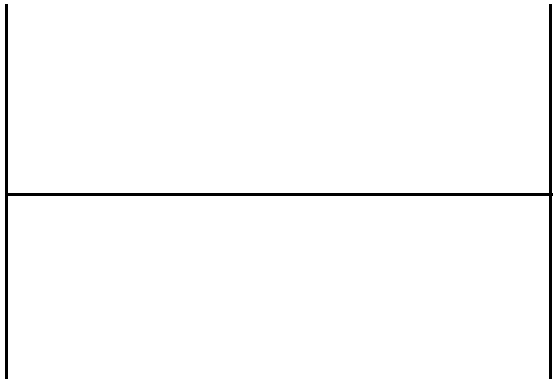


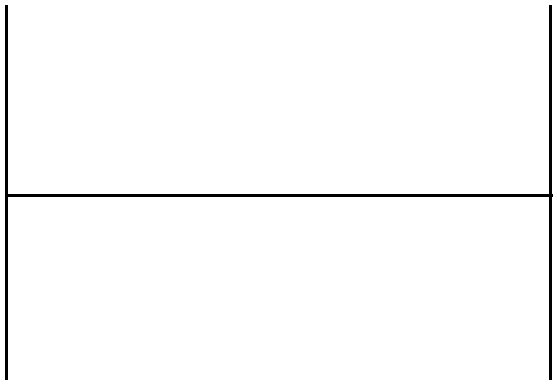
Example

Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: kN, m



Support Reactions





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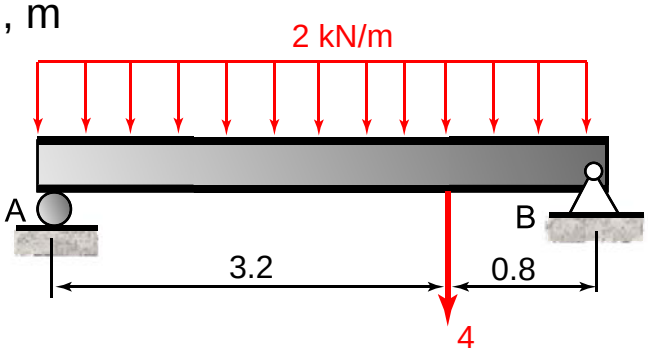
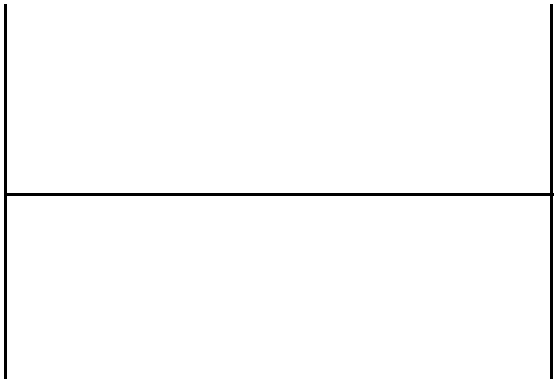
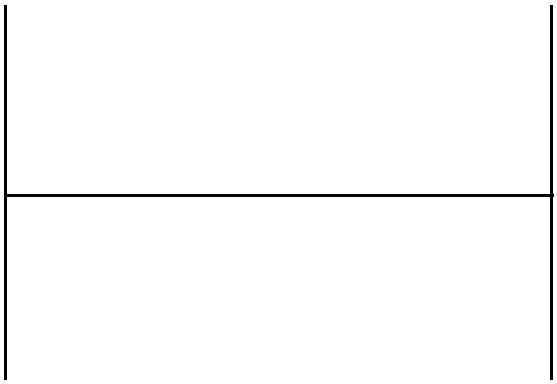


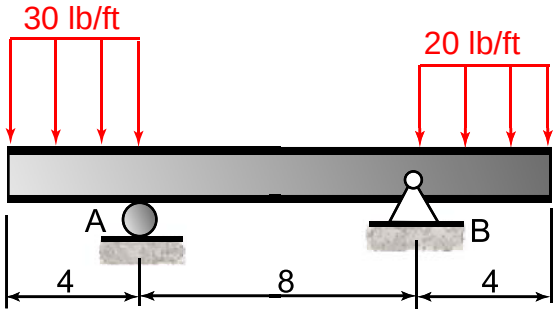
Support Reactions





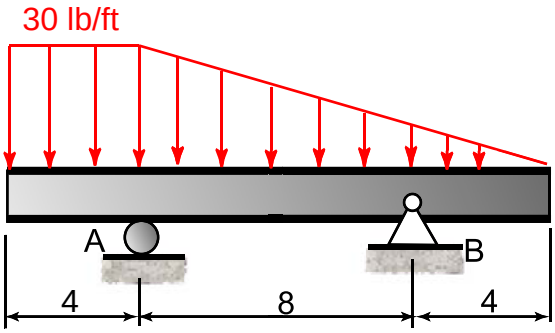
Example

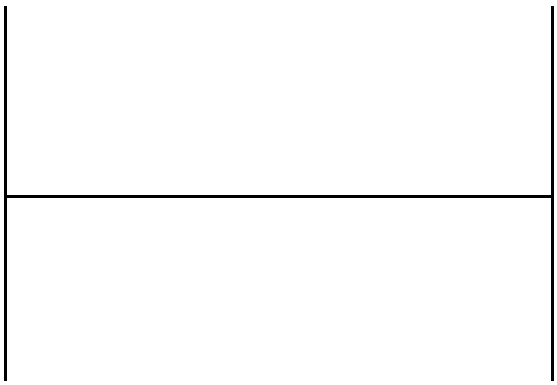
Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: Lb, ft.

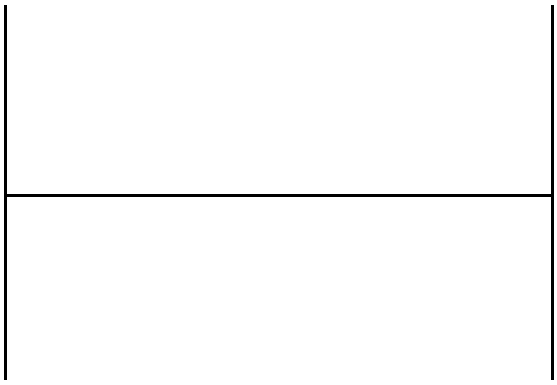


Example

Sketch the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: Lb, ft.

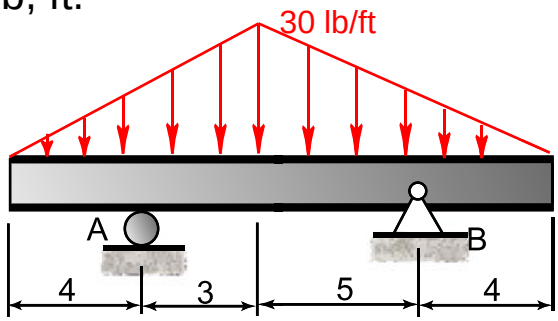






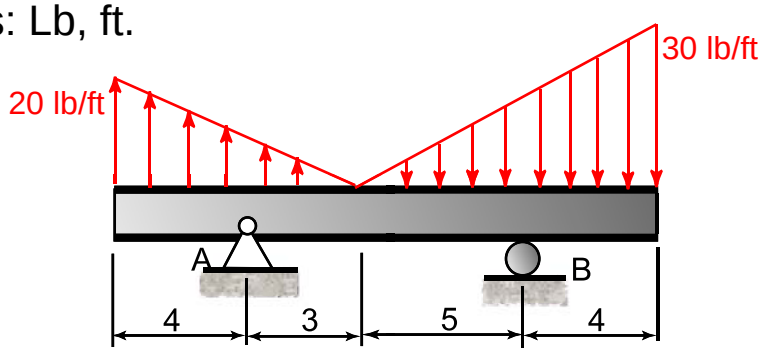
Example

Sketch the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: Lb, ft.



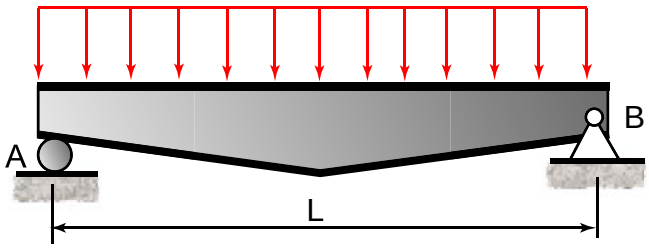
Example

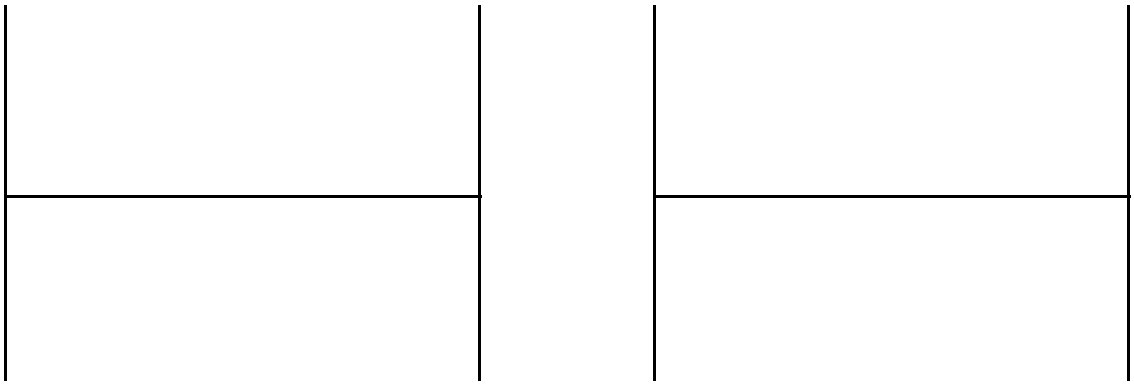
Sketch the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. Units: Lb, ft.



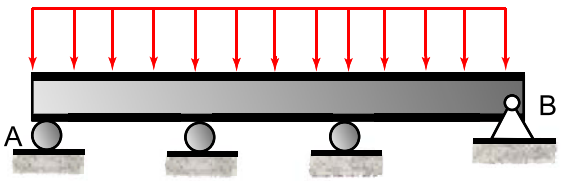
Example

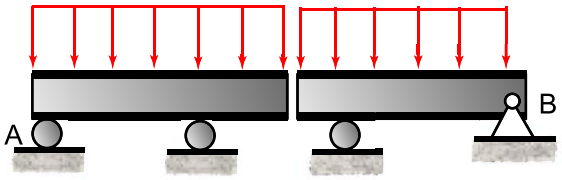
Here is an example of how the shape of the girder reflects the shear and bending diagrams.

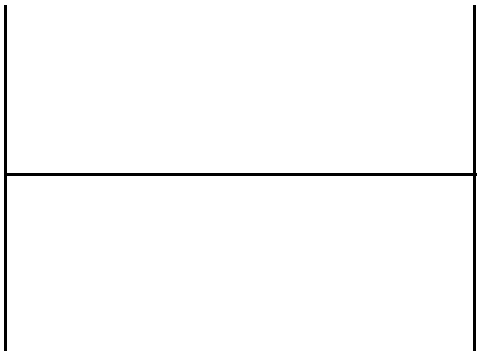


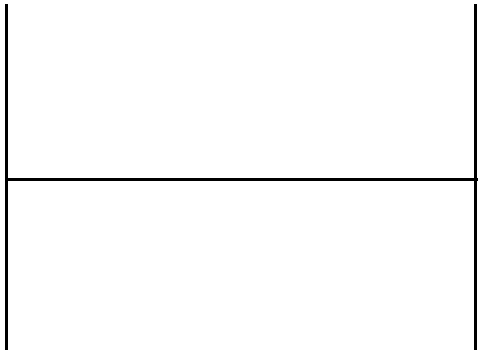


So why did they put that gap in the bridge?





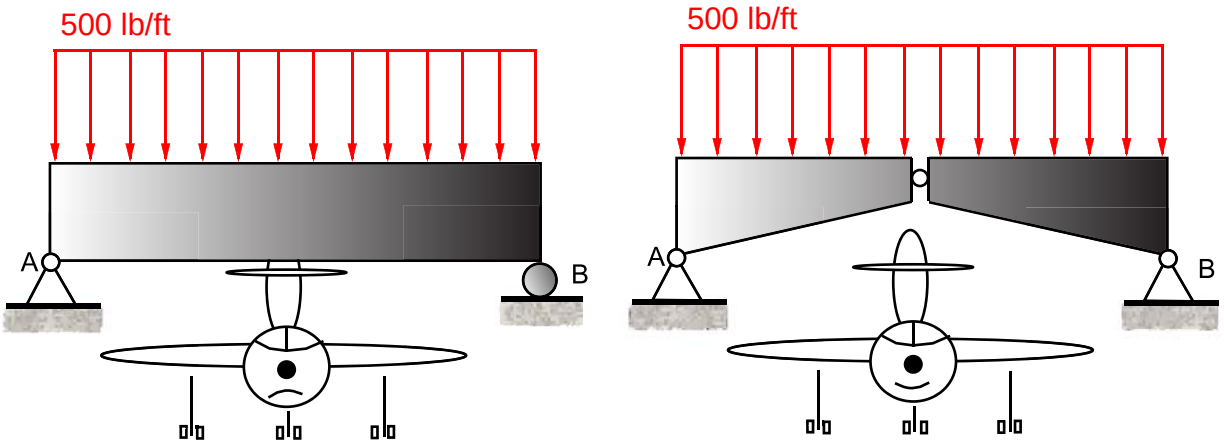


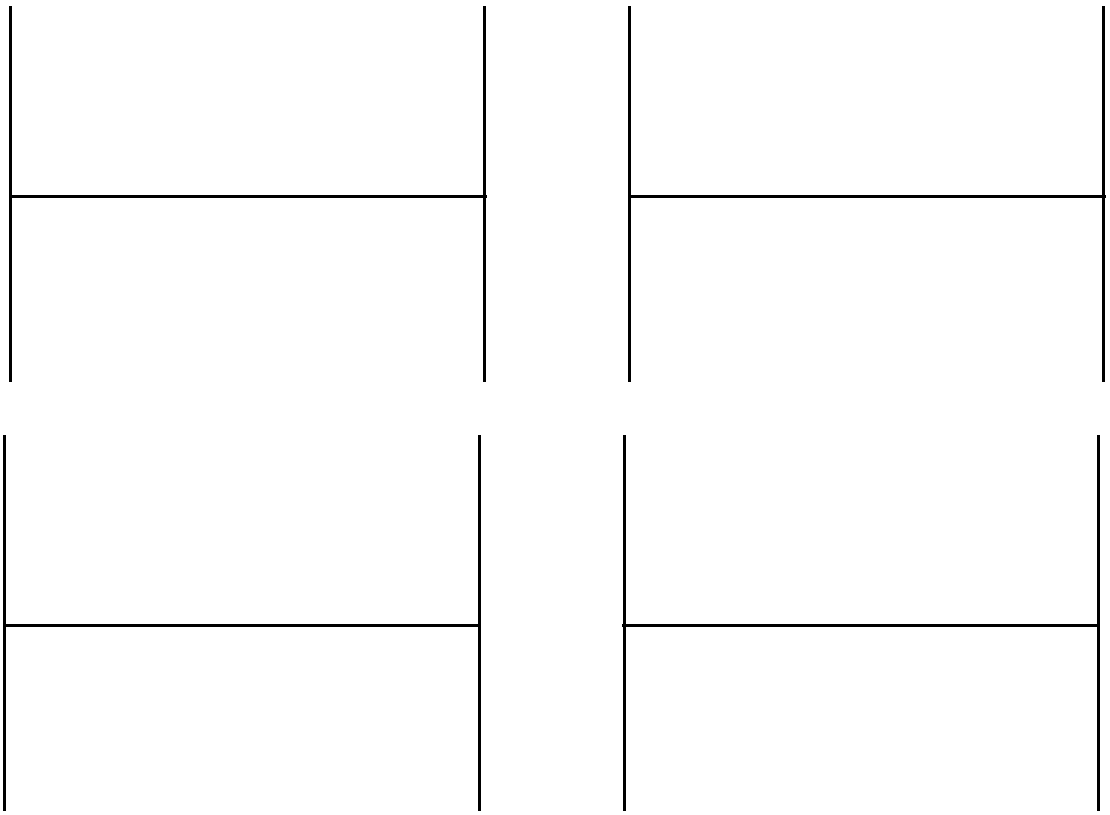


Pins

Example

Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. The addition of the internal pin at the center of the beam allows additional head room because rather than the moment being a maximum in the center it becomes zero. This design is used at Wings Air West in SLO. Total span= 75 ft.

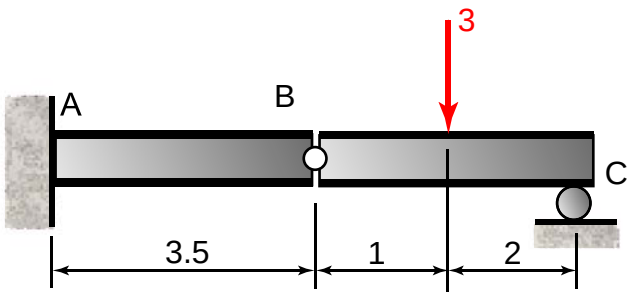


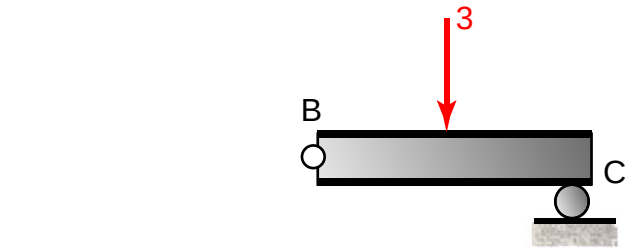


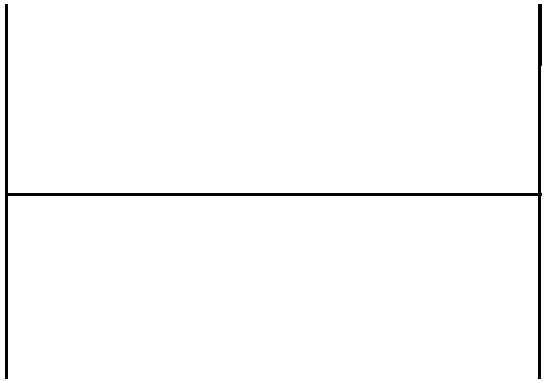
Example

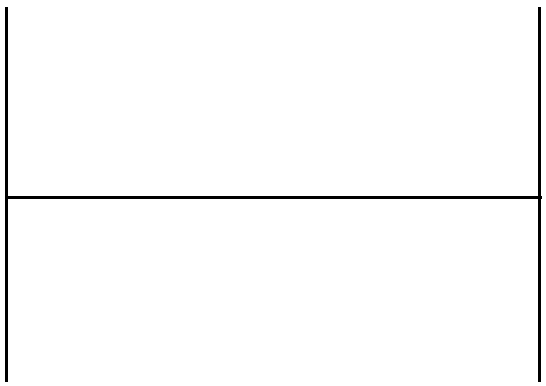
Draw the shear and bending-moment diagrams for the beam and loading shown. Label all points of change, maximums and minimums, and the axes. This example demonstrates that with the addition of an internal pin we get an additional equation, otherwise we would have too many unknowns.

Support Reactions





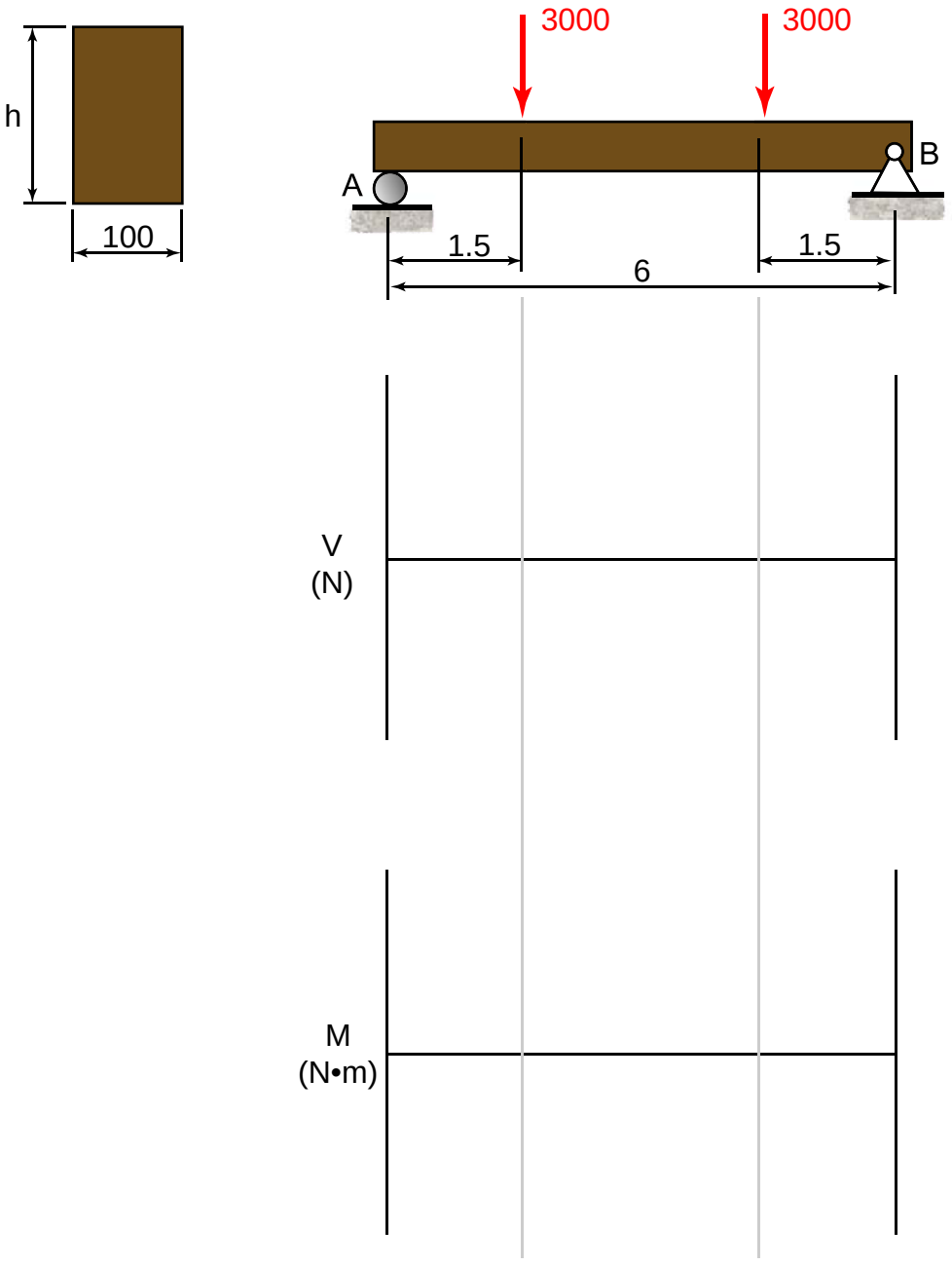




DESIGN OF PRISMATIC BEAMS FOR BENDING

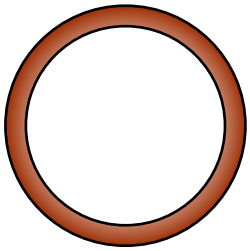
Example

Design the cross section's minimum height of the beam, knowing that the grade of wood used has an allowable bending stress of 12 MPa. Units: N, m.

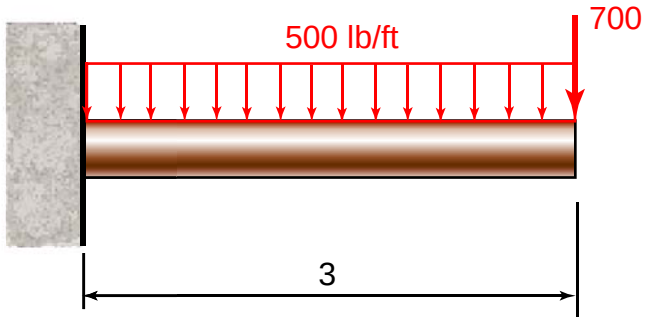


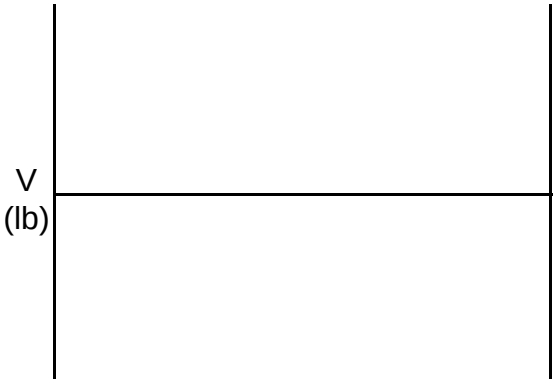
Example

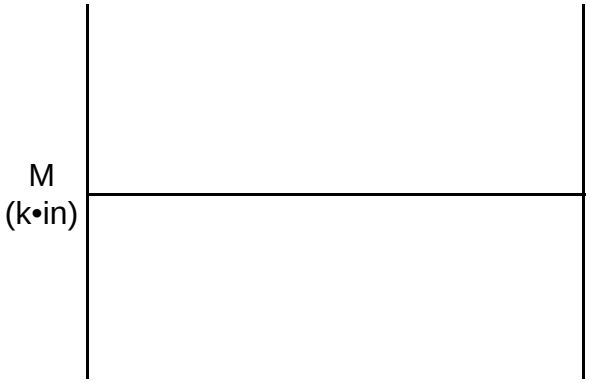
Knowing that the grade of copper used has an allowable bending stress of 15 ksi, determine the minimum wall thickness for the 6" diameter pipe. Units: lb, ft.



Cross-section

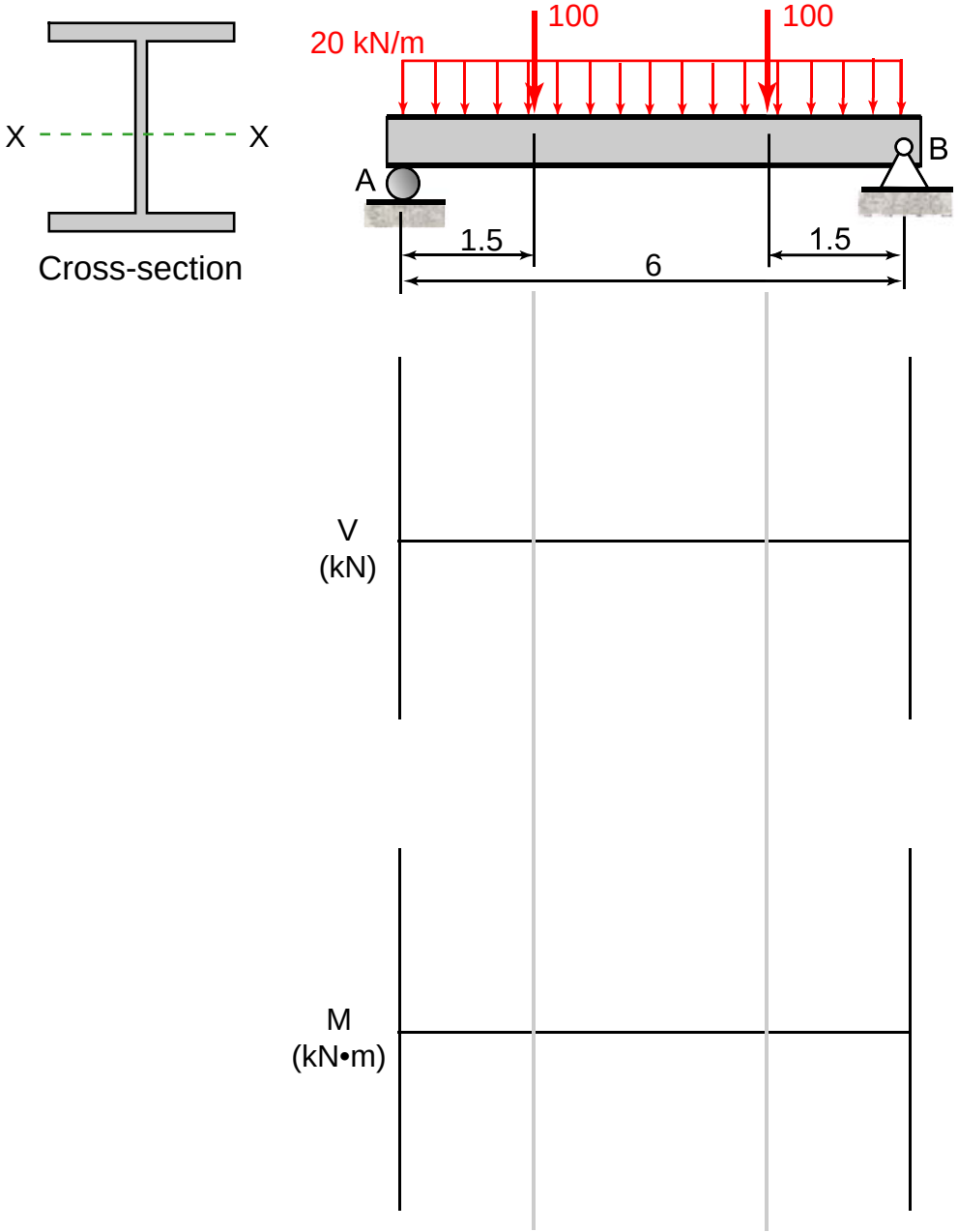






Example

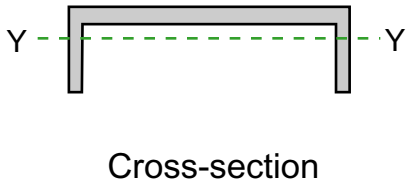
Knowing that the allowable bending stress for steel is 160 MPa, determine the most economical W410-shape to support the load. Units: kN, m.



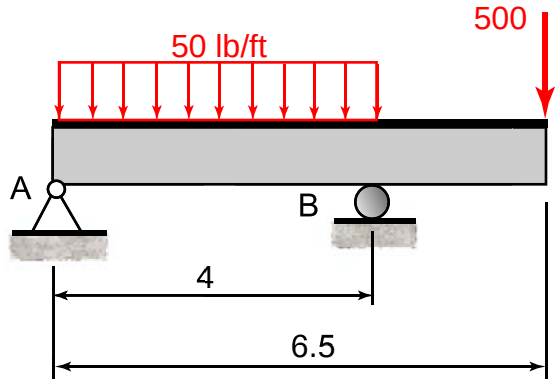
Example

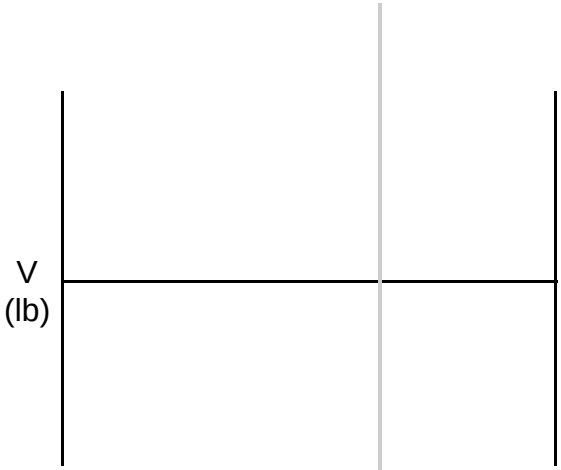
Knowing that the allowable bending stress for steel is 24 ksi, determine the most economical C7-shape to support the load.

Units: lb, ft.



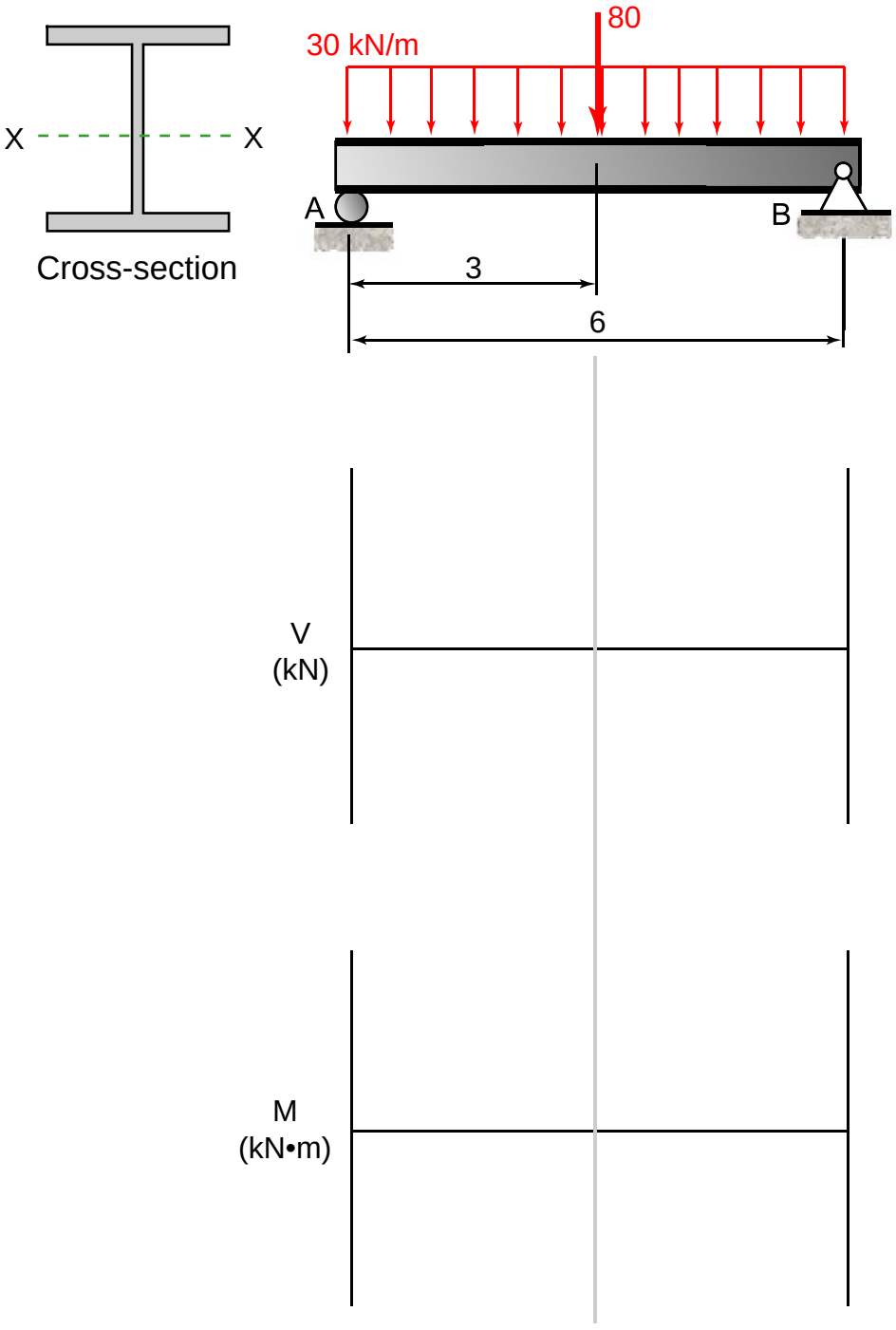
Cross-section





Example

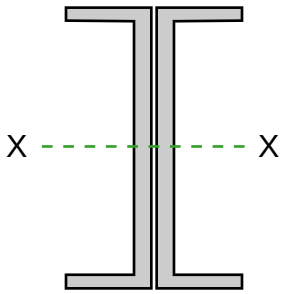
Knowing that the allowable bending stress for steel is 160 MPa, determine the most economical W310-shape to support the load. Units: kN, m.



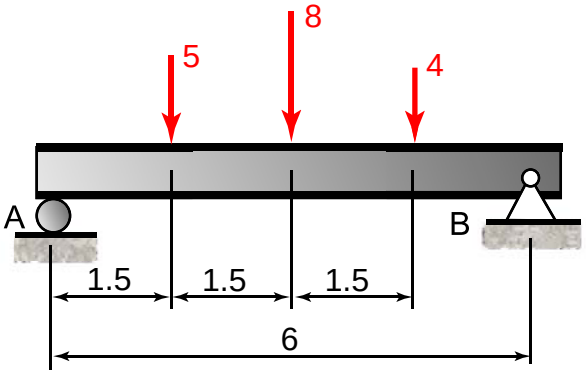
Example

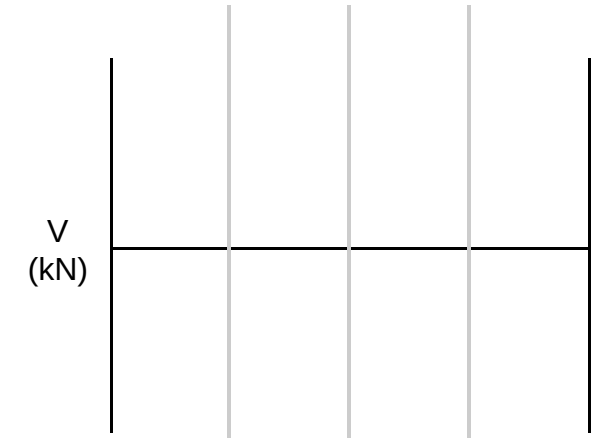
Two rolled-steel C150 channels are welded back to back. Knowing that the allowable bending stress for steel is 160 MPa, determine the most economical channels to support the load.

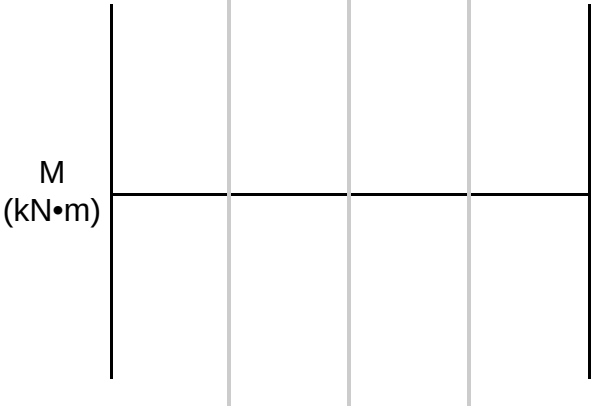
Units: kN, m.



Cross-section

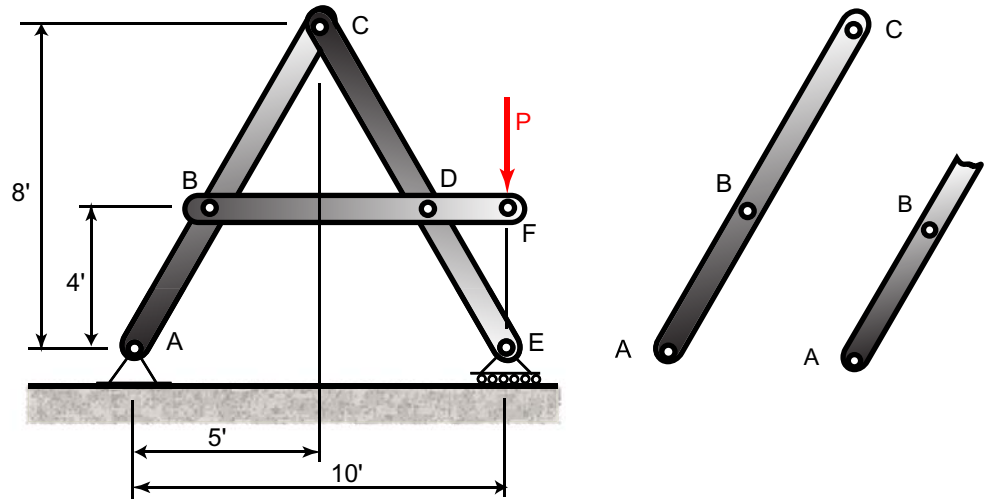




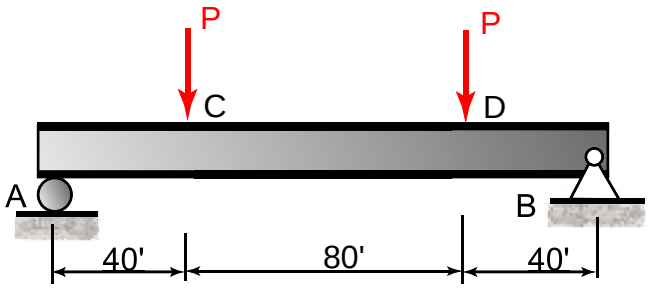


SUMMARY

Internal Forces in Members



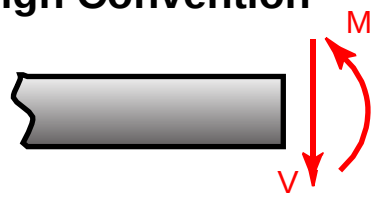
Shear and Bending-Moment Diagrams



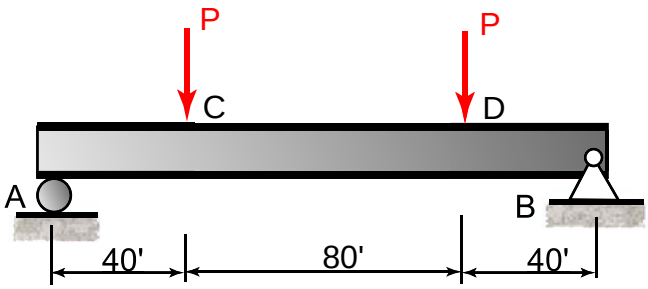
$$\Delta V = -w\Delta x$$

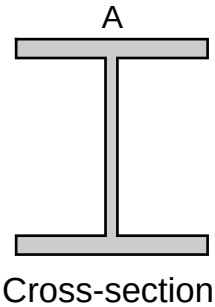
$$\Delta M = V\Delta x$$

Sign Convention



Design of Prismatic Beams for Bending





Cross-section