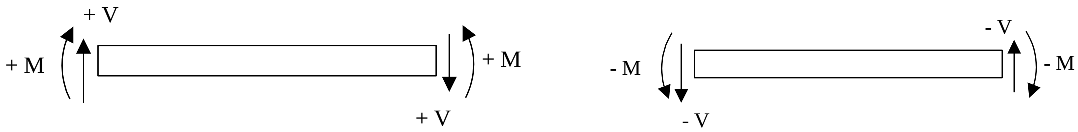
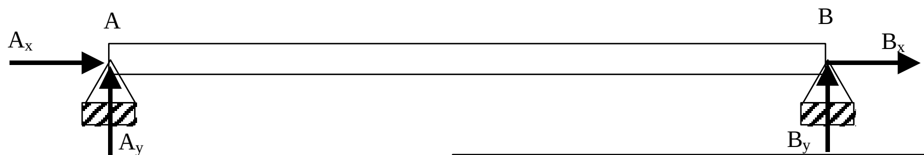
Some Guidelines for Constructing Shear Force and Bending Moment Diagrams

SIGN CONVENTIONS

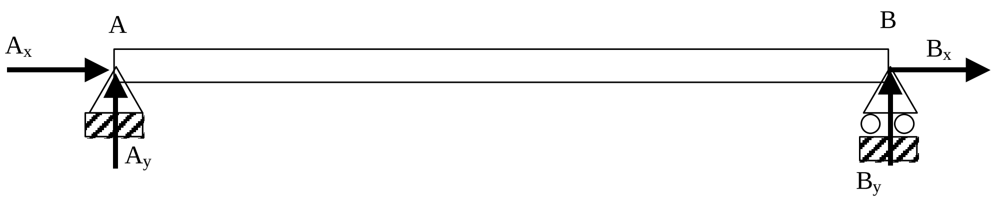


BOUNDARY CONDITIONS



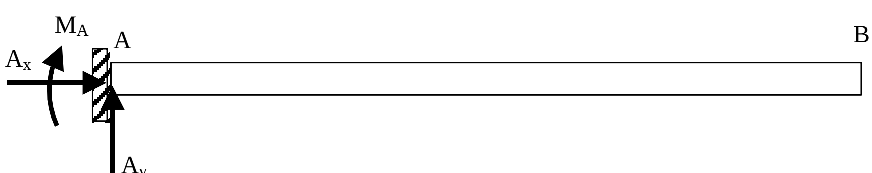
Pinned LEFT End:
Reaction force, A_x is unknown.
Reaction force, A_y is unknown.
V (shear force) = A_y (reaction force)
M = 0 (unless there is an applied moment at this point)
Deflection, y = 0
Slope, θ is unknown

Pinned Right End:
Reaction force, B_x is unknown.
Reaction force, B_y is unknown.
V (shear force) **= -B_y** (reaction force)
M = 0 (unless there is an applied moment at this point)
Deflection, y = 0
Slope, θ is unknown



Pinned LEFT End:
Reaction force, A_x is unknown.
Reaction force, A_y is unknown.
V (shear force) = A_y (reaction force)
M = 0 (unless there is an applied moment at this point)
Deflection, y = 0
Slope, θ is unknown

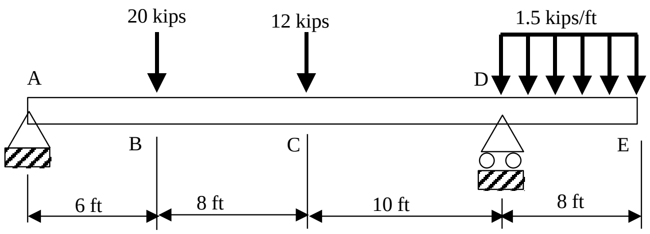
Roller Support at Right End:
Reaction force, B_x =0.
Reaction force, B_y is unknown.
V (shear force) **= -B_y** (reaction force)
M = 0 (unless there is an applied moment at this point)
Deflection, y = 0
Slope, θ is unknown

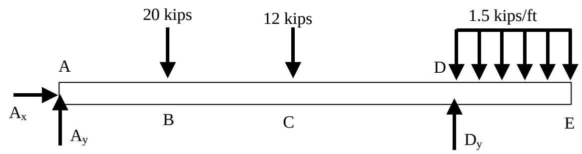


Clamped End:
Reaction force, A_x is unknown.
Reaction force, A_y is unknown.
Reaction moment, M_A is unknown
V (internal shear force) = A_y (reaction force)
M (internal bending moment) = M_A
Deflection, y = 0
Slope, θ = 0

Free End:
V (shear force) **=** 0 (unless there is an applied point force at this end)
M = 0 (unless there is an applied moment at this point)
Deflection, y is unknown
Slope, θ is unknown

Example:
Draw the shear force and bending moment diagram for the following beam:





Step 1: Find the reaction forces at A and D.
Draw F.B.D.:

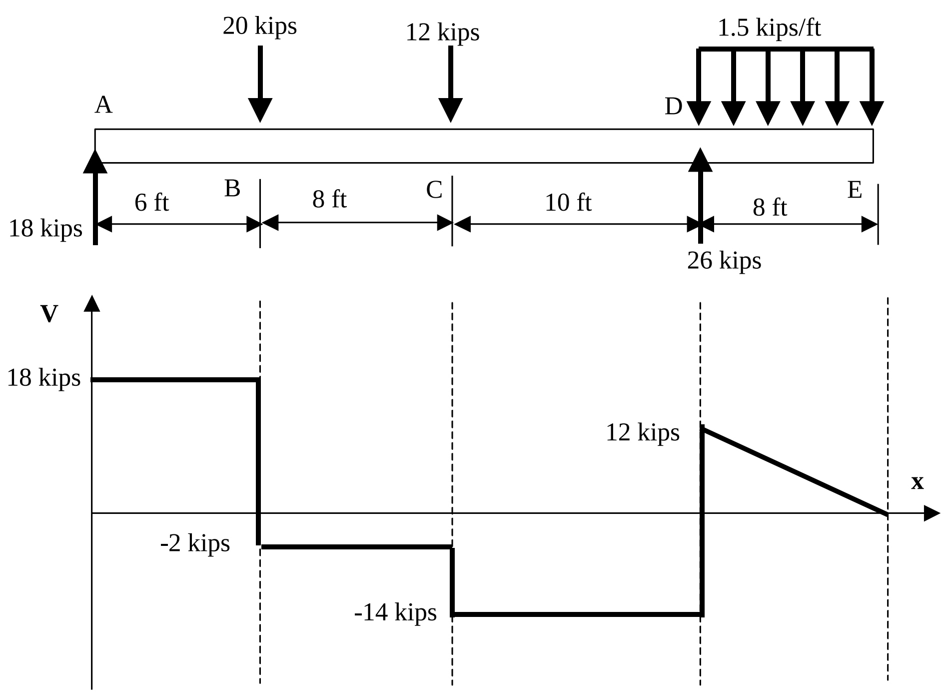
$\sum F_x = 0$, $\mathbf{A_x = 0}$

$\sum M_A = 0$, $(20 \text{ kips})(6 \text{ ft}) + (12 \text{ kips})(14 \text{ ft}) + (1.5 \text{ kips/ft})(8 \text{ ft})(28\text{ft}) - (D_y)(24 \text{ ft}) = 0$

$\mathbf{D_y = 26 \text{ kips}}$

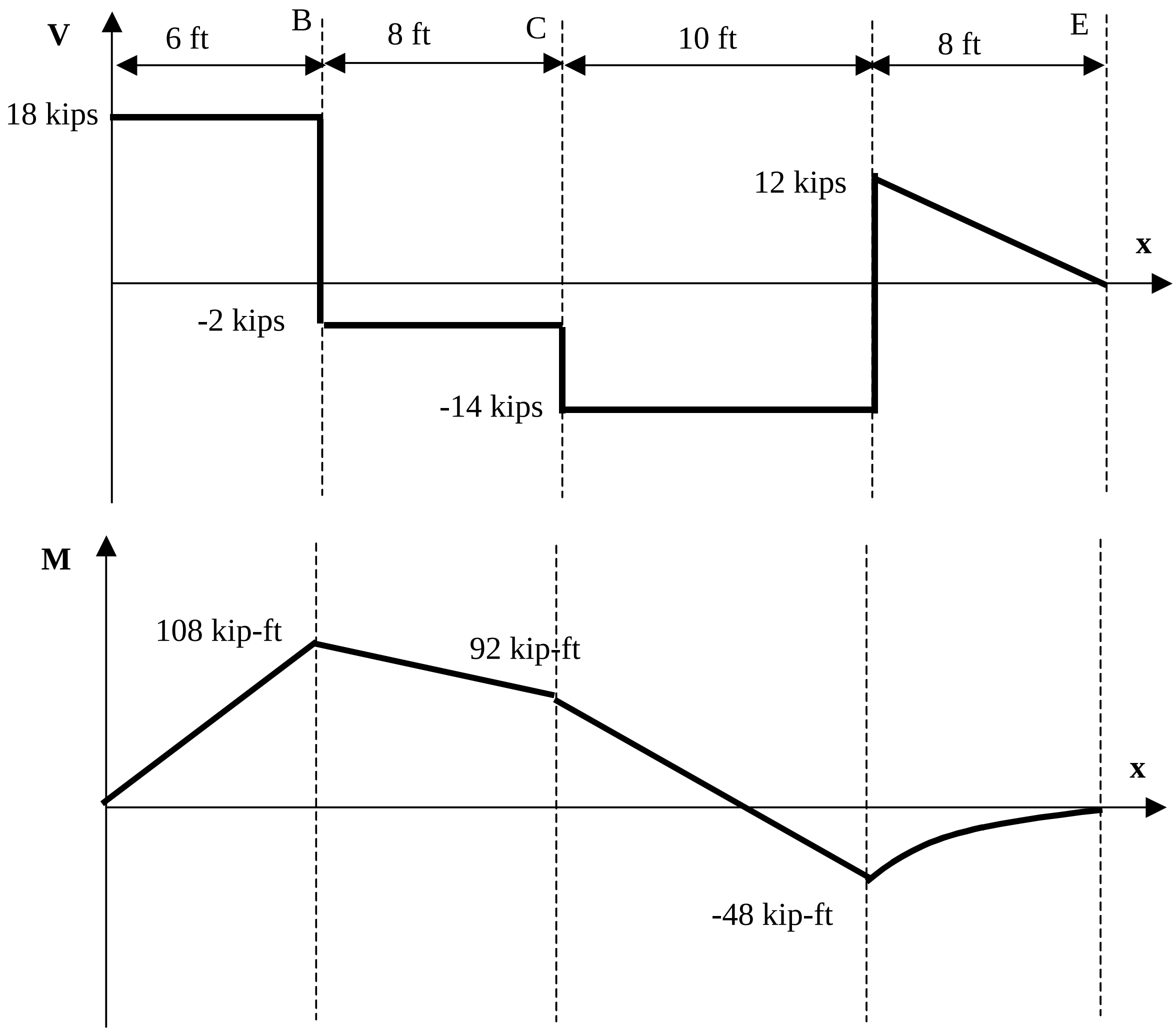
$\sum F_y = 0$, $A_y + D_y - 20 \text{ kips} - 12 \text{ kips} - (1.5 \text{ kips/ft})(8 \text{ ft}) = 0$, $\mathbf{A_y = 18 \text{ kips}}$

Construction of the shear force diagram



a) $V = A_y = 18$ kips at point A.
b) The shear force is constant until there is another load applied at B.
c) The shear force decreases by 20 kips to –2 kips at B because of the applied 20 kip force in the negative y direction.
d) The shear force is constant until there is another load applied at C.
e) The shear force decreases by 12 kips to –14 kips at C because of the applied 12 kip force in the negative y direction.
f) The shear force is constant until there is another load applied at D.
g) The shear force increases by 26 kips to 12 kips at D because of the 26 kip reaction force in the positive y direction.
h) The shear force decreases linearly from D to E because there is a constant applied load in the negative y-direction.
i) The change in shear force from D to E is equal to the area under the load curve between D and E, -12 kips, [$A_{DE} = (-1.5 \text{ kips/ft})(8 \text{ ft}) = -12$ kips]
j) The shear force at E = 0 as expected by inspection of the boundary conditions.

Construction of the Bending Moment diagram



a) M = 0 at point A because it is a pinned end with no applied bending moment.
b) $M_B = M_a$ + (the area under the shear force diagram between A and B.)
c) M_B = 0 + (18 kips)(6 ft) = 108 kip-ft
d) $M_C = M_B$ + (the area under the shear force diagram between B and C.)
e) M_C = 108 kip-ft - (2 kips)(8 ft) = 92 kip-ft
f) $M_D = M_C$ + (the area under the shear force diagram between C and D.)
g) M_D = 92 kip-ft - (14 kips)(10 ft) = -48 kip-ft
h) $M_E = M_D$ + (the area under the shear force diagram between D and E.)
i) M_E = -48 kip-ft + $^1/_2$ (12 kips)(8 ft) = 0 kip-ft (as expected)