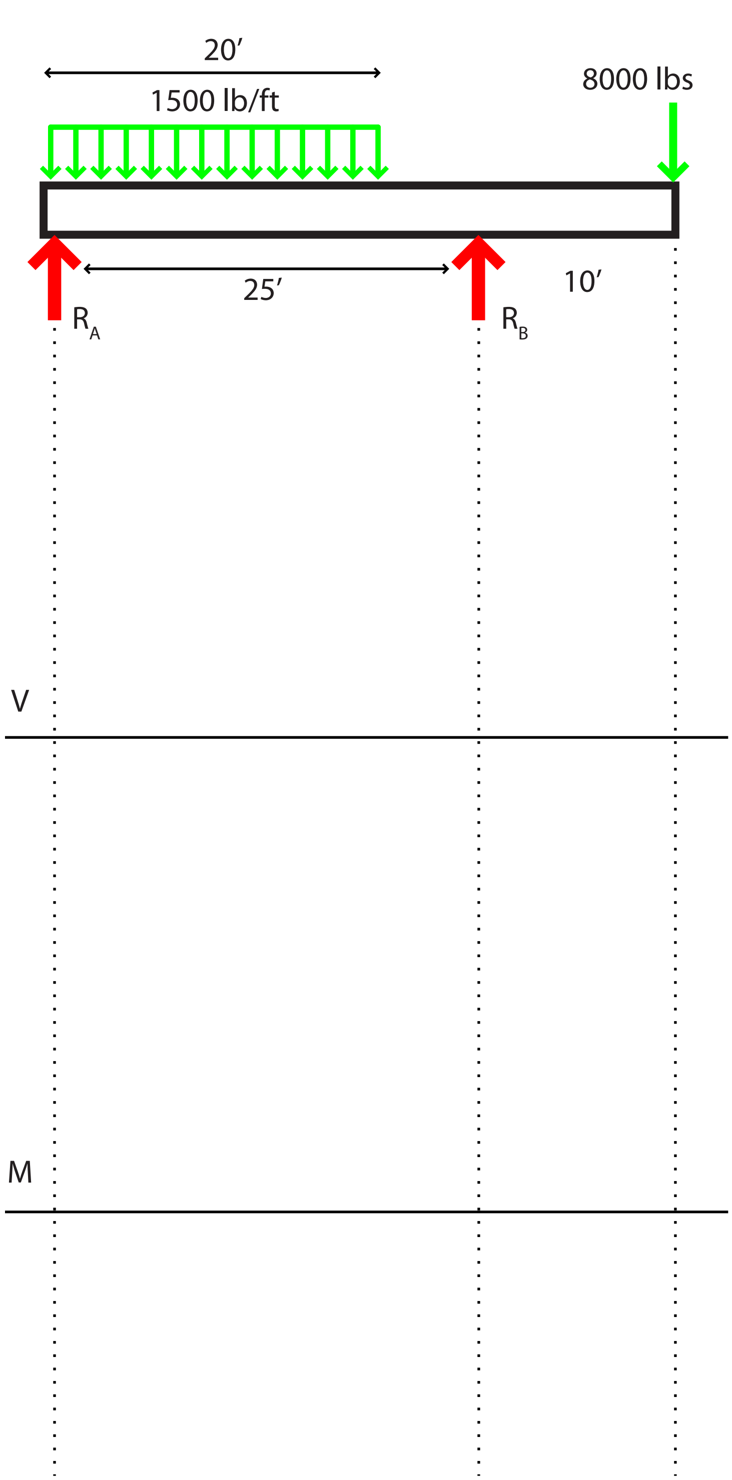
Structural Steel Design

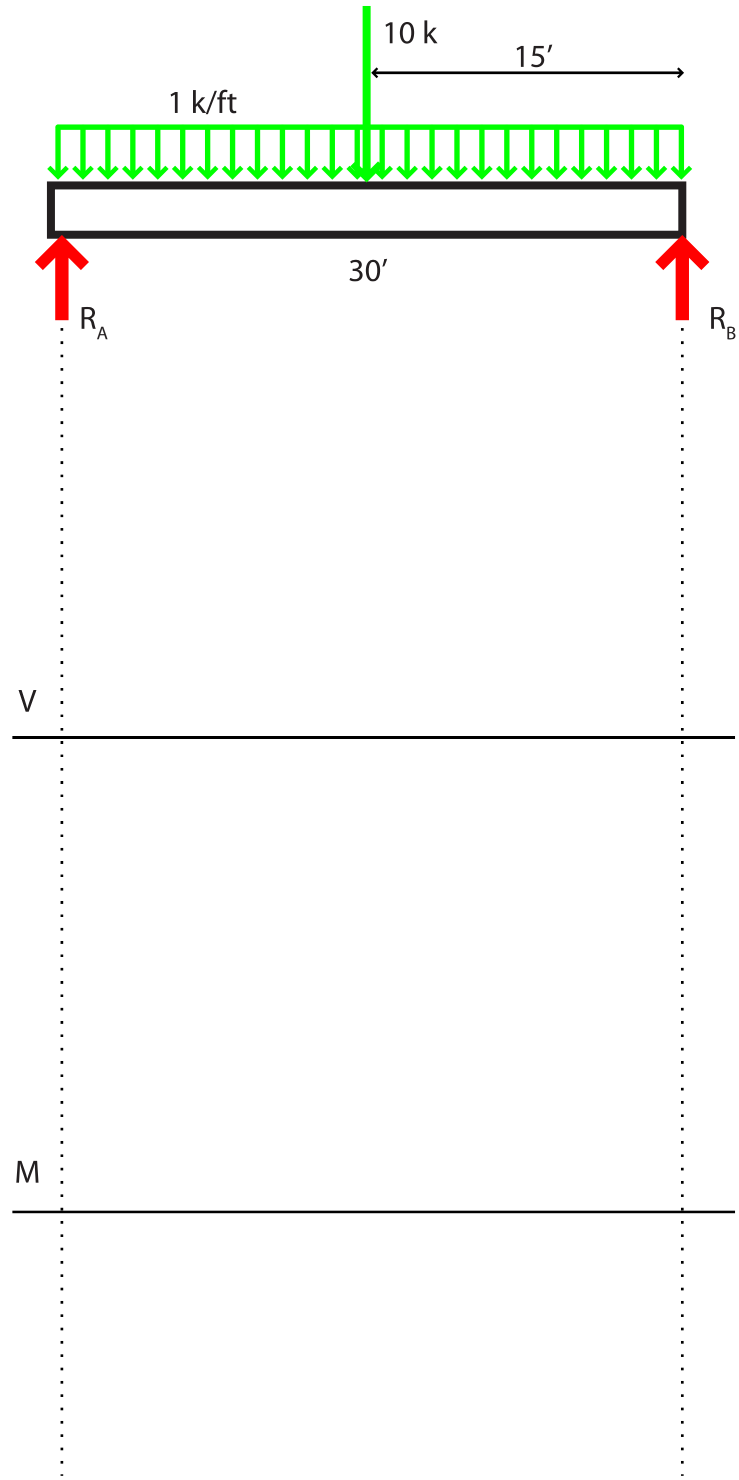
NAME

Quizzam Module 1 : Statics

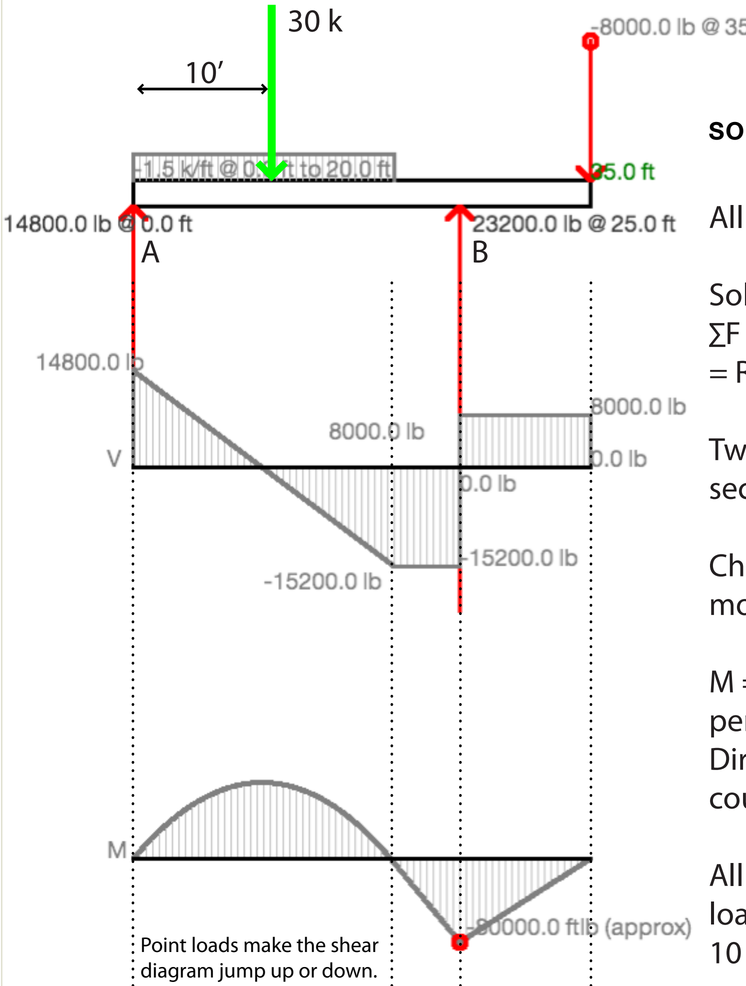
Draw shear and moment diagrams for the following loading conditions. Note the reactions. Calculate the maximum amount of internal bending moment.



M_{max} =



M_{max} =



SOLUTIONS

All of these problems have the same process.`

Solve for reactions.
∑F = Ra + Rb - (1.5 k/ft)(20 ft) - 8 k = Ra + Rb - 30 k - 8 k
= Ra + Rb - 38 k = 0

Two unknowns, Ra and Rb are present. We need a second equation: ∑M = 0.

Choose A as the point of rotation for moment. Sum the moments of each force from left to right.

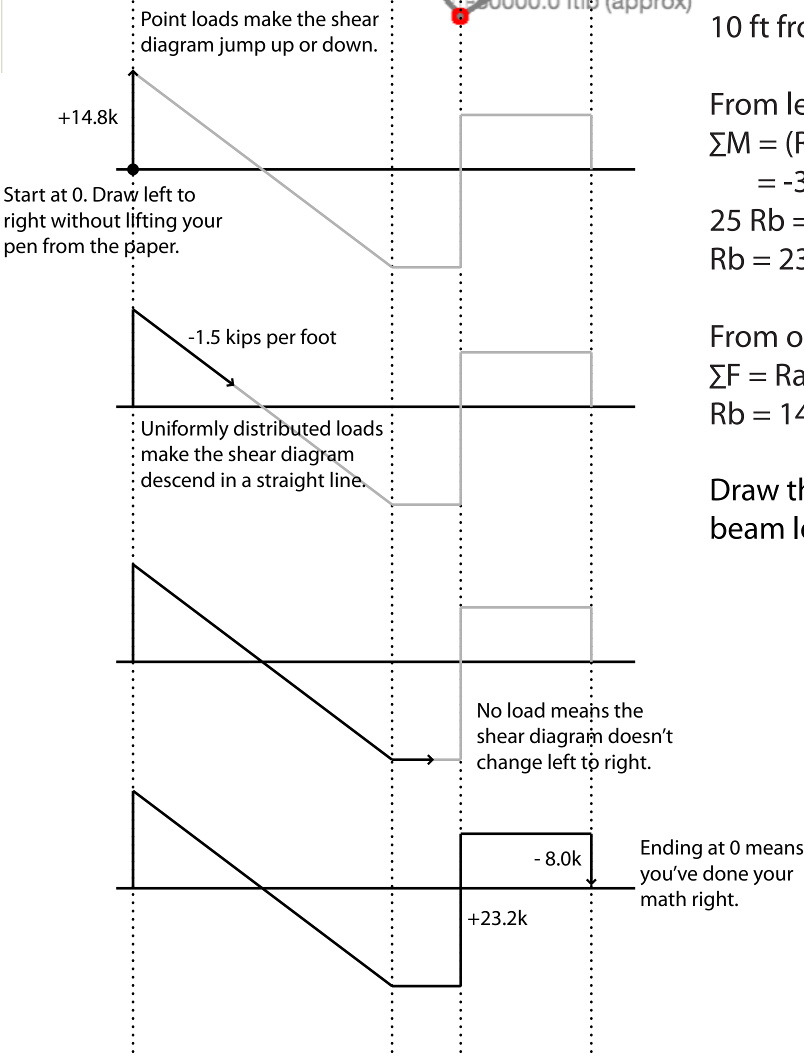
M = Fd, F = magnitude of force, d = moment arm, i.e. perpendicular distance from the point to the force.
Directions: negative (-) for clockwise, positive (+) for counterclockwise.

All uniformly distributed loads can be treated as point loads in the middle of the load. Thus, the load above is 10 ft from point A, and has a magnitude of 30 k.

From left to right:
∑M = (Ra * 0) - (30 k * 10 ft) + (Rb * 25 ft) - (8 k * 35 ft)
= -300 kft + 25 Rb - 280 kft = 0
25 Rb = 580 kft
Rb = 23.2 k

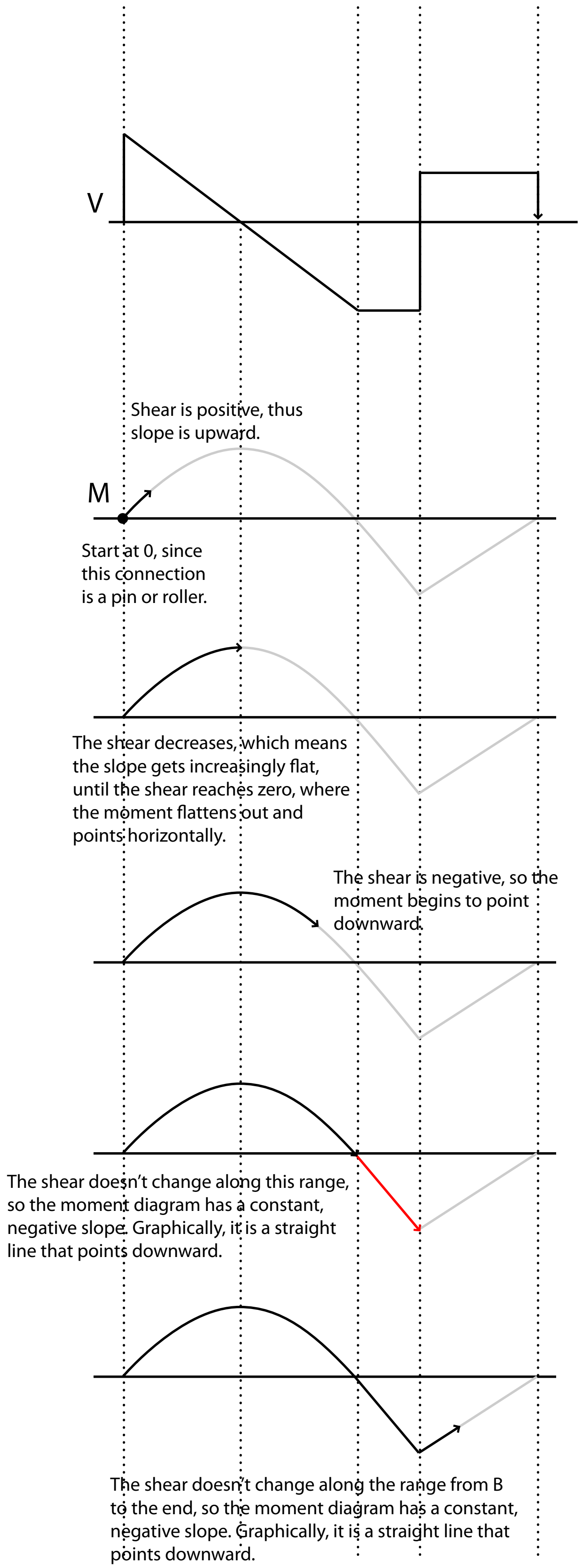
From our first equation, ∑F = 0, we have:
∑F = Ra + Rb - 38 k = 23.2 k + Rb - 38 k = 0
Rb = 14.8 k

Draw the shear diagram (series to the left). See the beam lectures for more rules and methods.



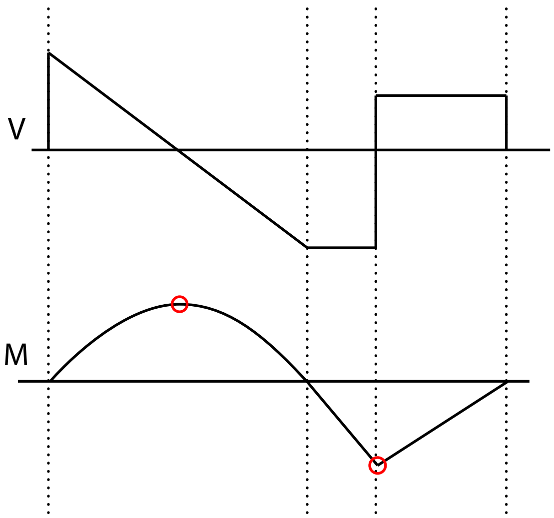
Given the shear diagram, **draw the moment diagram**. The value of the shear diagram is the slope (rise/run) of the moment diagram.

Positive shear means upward slope. ↗
Negative shear means downward slope. ↘
0 shear means no slope. ⟶



We have to end at zero. We know the moment diagram is negative at point B because we have an upward slope (positive shear) that must end at zero. The only way to end at zero with an upward slope is to start in the negative range (at point B).

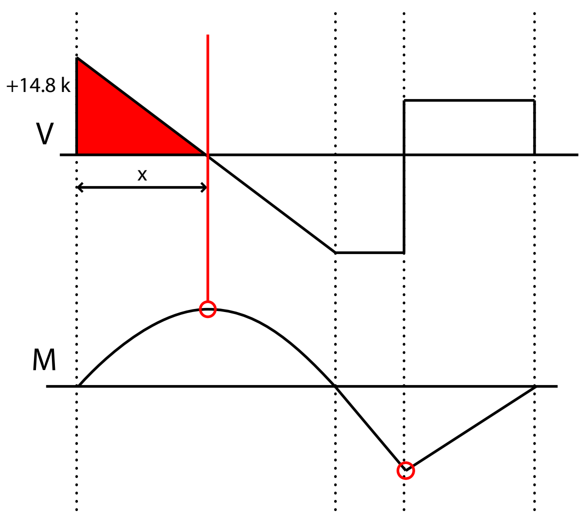
Calculating maximum moment.



There are two candidates for the "maximum internal bending moment." We have to calculate both of them and take the larger magnitude.

If we take a candidate point and draw a line up to the shear diagram, we can get the value for the moment by calculating the area under the shear diagram to the *left or right* of the line.

Candidate 1. This one is trickier one. We need the equation for the area of a triangle and for a line (since we don't know the distance x below).



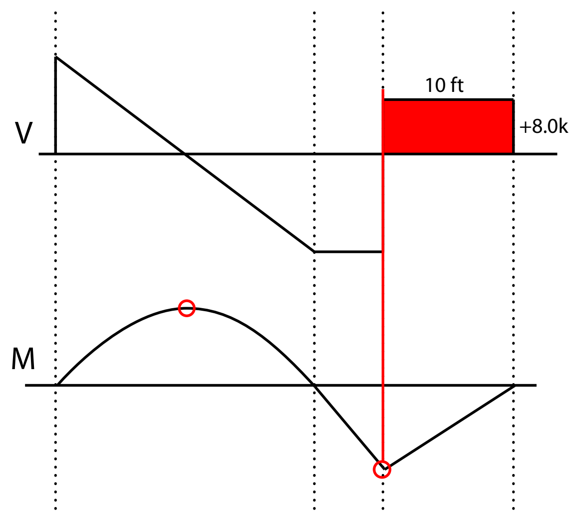
y = mx + b
To solve for x, we need to evaluate this line equation. In this case, the slope of the shear diagram's line is the value of the uniformly continuous load that caused it. Thus m = -1.5 k/ft. b is the intersection of the line with the y-axis. (b = 14.8 k)

y = mx + b
0 = (-1.5 k/ft) x + 14.8 k
x = (-14.8 k) / (-1.5 k/ft) = 9.866667 ft

Now calculate the area of the triangle.

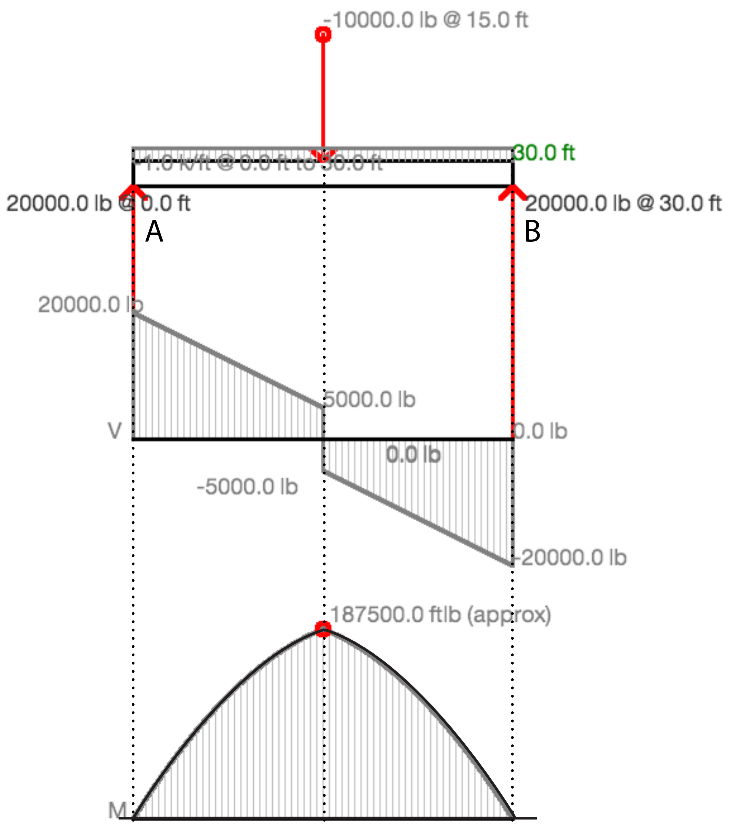
$$A_{\Delta} = \frac{1}{2} bh = \frac{1}{2} (9.86667 \text{ ft})(14.8 \text{ k}) = \mathbf{73 \text{ k ft}}$$

Candidate 1. This is the easiest to calculate. Just calculate the area of the red rectangle.



M1 = 10 ft * 8.0k = **80 k ft**

Since this is the larger magnitude, this is the correct answer.



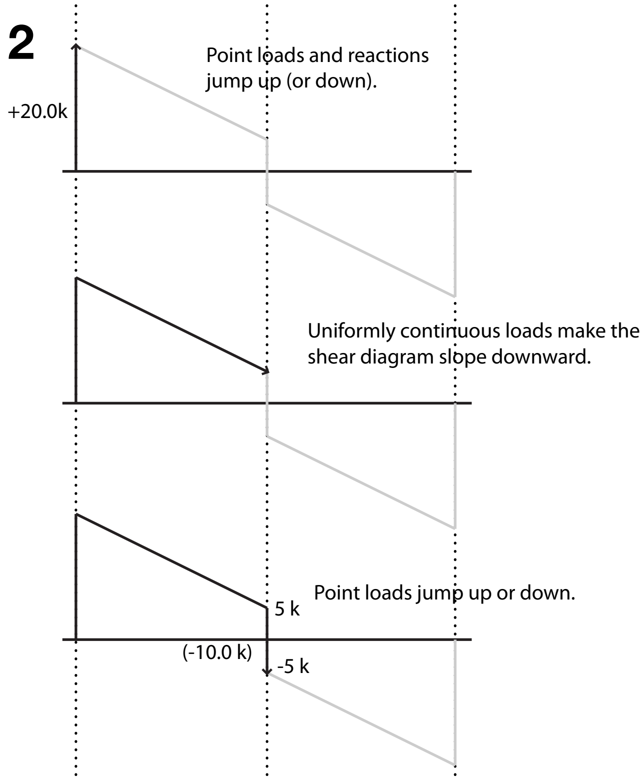
PROBLEM 2

1 Solve for reactions.

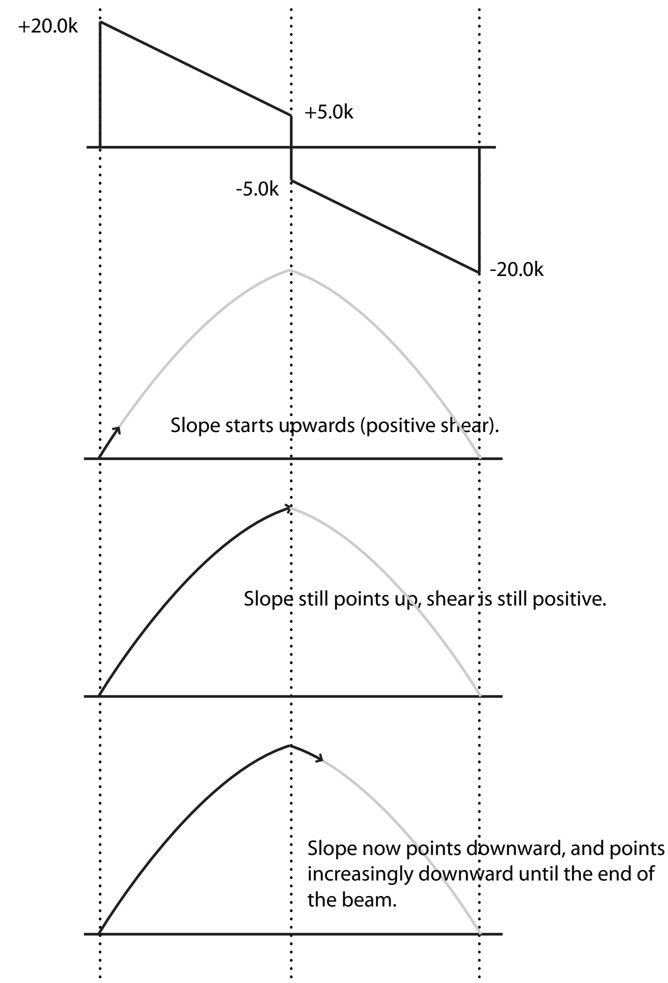
Ra and Rb are the same because of symmetry. So we just add up all the loads and divide by 2.

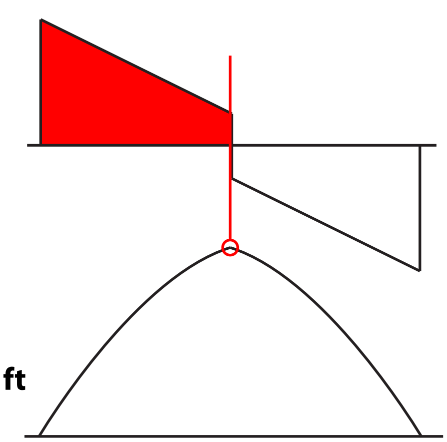
Ra = Rb = (10 k + 1.0 k/ft * 30 ft) / 2
= (10 k + 30 k) / 2
= 40 k / 2 = 20 k

2

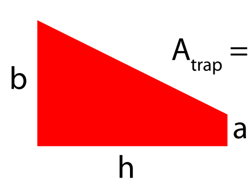


3 Given the shear diagram, draw the moment diagram.





4 There is only one candidate for greatest moment. Calculate the area of the associated trapezoid to get the maximum moment.



$$A_{trap} = \frac{1}{2}(a+b)h = \frac{1}{2}(5k + 20k)(15\ ft)$$

$$= 375\ k\ ft / 2 = \mathbf{187.5\ k\ ft}$$