Solution.

1. A simply supported W12 x 53 steel beam has a uniform live load of 3 kip/ft and a span of 20 ft. Calculate the beam deflection due to: (A) The uniform live load and (B) The dead load.
   $E = 29 \times 10^3$ ksi

Solution.

$$w = 3\ \text{kip/ft}\left(\frac{\text{ft}}{12\text{in}}\right) = 0.25\ \text{kip/in}$$

$$L = 20\ \text{ft}\left(\frac{12\text{in}}{\text{ft}}\right) = 240\ \text{in.}$$

Table A-1(a)

W12 x 53

$I = 425\ \text{in.}^4$

$E = 29\,000$ ksi

Table 16-1, case 7

$$\delta_{MAX} = \frac{5wL^4}{384EI}$$

A. Live Load

$$\delta_{MAX} = \frac{5(0.25\ \text{kip/in})(240\ \text{in.})^4}{384\left(29\,000\ \frac{\text{kip}}{\text{in}^2}\right)(425\ \text{in.}^4)} = 0.88\ \text{in.}$$

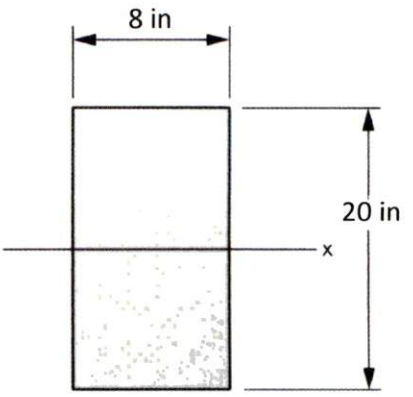
B. Dead Load (Beam Weight)

$$\delta_{MAX} = \frac{5(53\ \text{lb/ft})\left(\frac{\text{kip}}{1000\ \text{lb}}\right)\left(\frac{\text{ft}}{12\text{in}}\right)(240\ \text{in})^4}{384\left(29\,000\ \frac{\text{kip}}{\text{in}^2}\right)(425\ \text{in}^4)} = 0.015\ \text{in.}$$

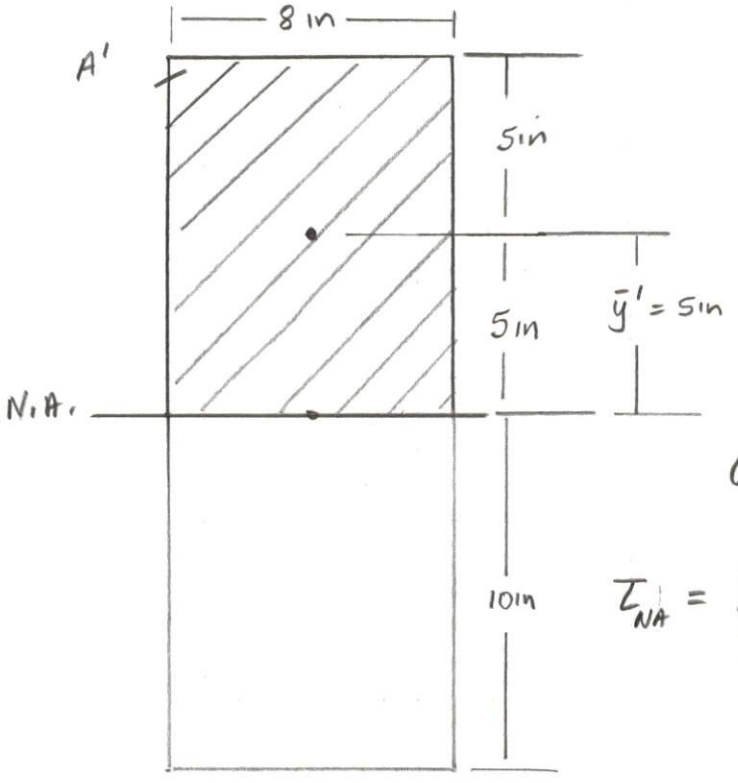
2. The shear force on the beam shown is 30 kips. Calculate the shear stress for the beam shown at:
   a. The neutral axis
   b. 2 in. away from the neutral axis
   c. 4 in away from the neutral axis
   d. at the outside surface.

   Sketch the shear distribution

Solution.



a. N.A.



$V = 30000\ lb$

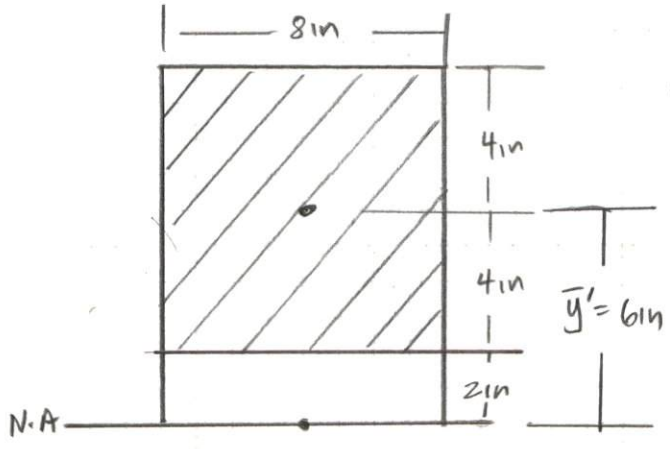
$I = \frac{bh^3}{12} = \frac{8in(20in)^3}{12} = 5333\ in.^4$

$Q = A'\bar{y}' = 8in(10in)(5in) = 400\ in^3$

$I_{NA} = \frac{VQ}{It} = \frac{30000lb(400in^3)}{5333\ in^4(8in)}$

$= 281\ psi$

b) 2in away from the N.A.

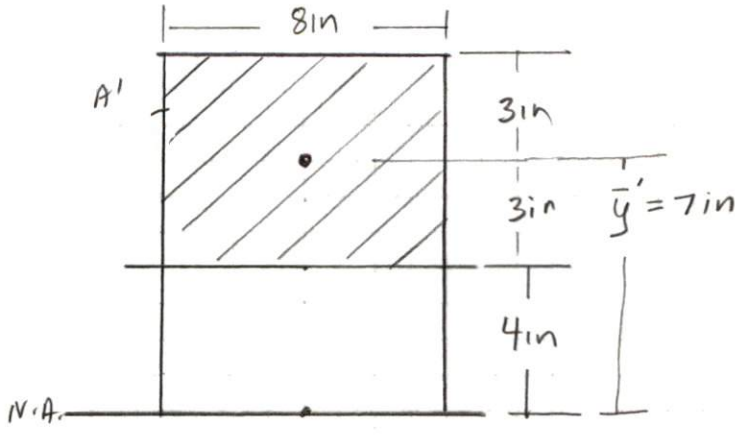


$Q = 8in(8in)(6in) = 384\ in^3$

$I = \frac{30000lb(384\ in^3)}{5333\ in^4(8in)}$

$= 270\ psi$

c) 4in away from the N.A.



$Q = 8in(6in)(7in) = 336\ in^3$

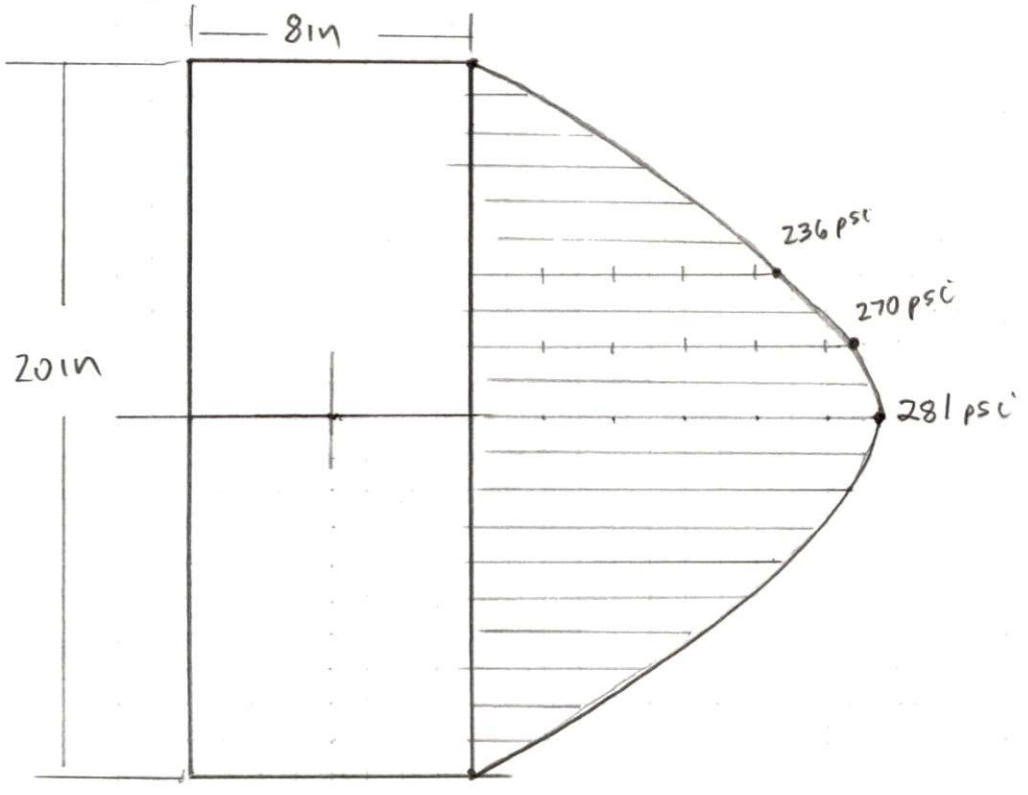
$$\tau = \frac{30{,}000\ lb\ (336\ in^3)}{5333\ in^4\ (8in)}$$

$= 236\ psi$

d) at outside surface

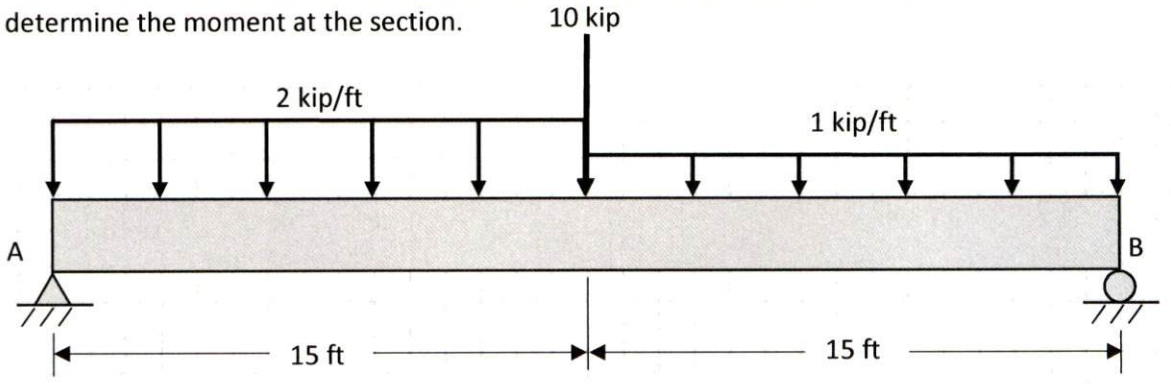
$A = 0$ $\quad \tau = 0$

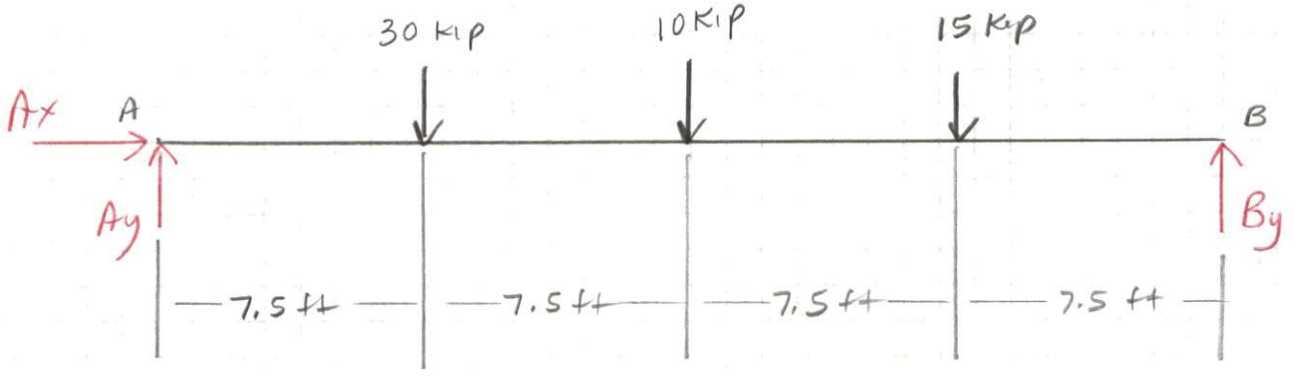
Sketch



3. Draw the shear force and bending moment diagram for the beam shown. Locate the section with zero shear force and determine the moment at the section.

Solution.





FBD- Entire Beam

Equilibrium Equations

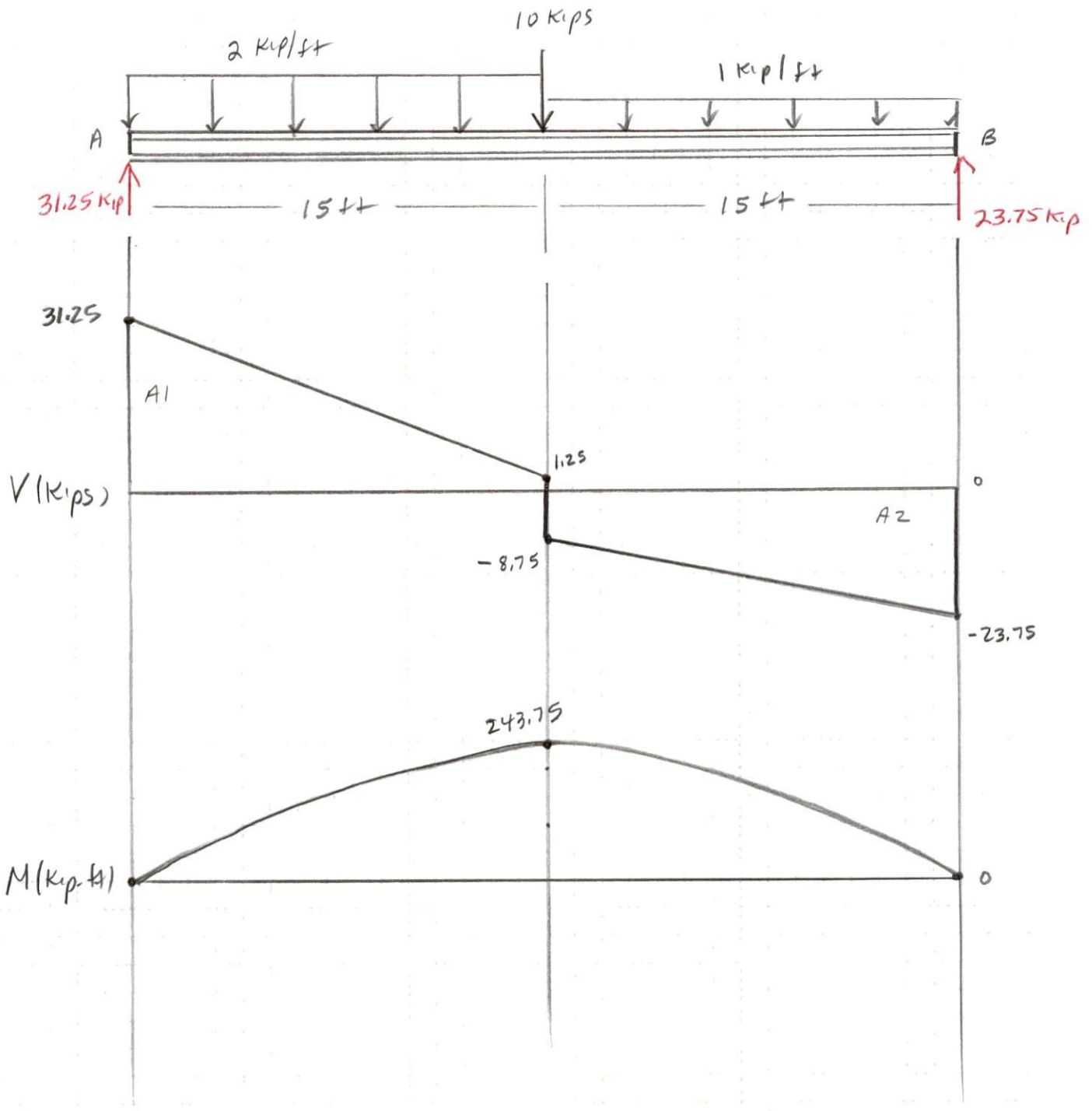
$[\Sigma F_x = 0]$ $\quad A_x = 0$

$+\circlearrowleft [\Sigma M_A = 0]$ $\quad -30\,\text{Kip}(7.5\,\text{ft}) - 10\,\text{Kip}(15\,\text{ft}) - 15\,\text{Kip}(22.5\,\text{ft}) + B_y(30\,\text{ft}) = 0$

$$B_y = \frac{712.5\ \text{Kip}\cdot\text{ft}}{30\,\text{ft}} = 23.75\ \text{Kip}\ \uparrow$$

$[\Sigma F_y = 0]$ $\quad A_y - 30\,\text{Kip} - 10\,\text{Kip} - 15\,\text{Kip} + B_y = 0$

$$A_y = 55\ \text{Kip} - 23.75\ \text{Kip} = 31.25\ \text{Kip}\ \uparrow$$



A1 $1.25(15) + \frac{1}{2}(15)(30) = 243.75$ kip·ft

A2 $8.75(15) + \frac{1}{2}(15)(15) = -243.75$

4. Select the lightest wide-flange steel section for the beam and load in problem 3. Use A36 steel and assume the beam is supported laterally for its entire length. The weight of the beam is already included in the uniform load.

Solution.

Step 1.

A36 steel

$\sigma_{allow} = 24$ ksi

$\tau_{allow} = 14.5$ ksi

Step 2.

$V_{MAX} = 31.25$ kip

$M_{MAX} = 243.75 \text{ kip.ft} \left(\frac{12 \text{ in}}{\text{ft}}\right) = 2925 \text{ kip.in}$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{2925 \text{ kip.in}}{24 \text{ ksi}} = 121.875 \text{ in}^3$$

Step 4.

Table A-1(a)

W 21 x 62 $S = 127 \text{ in}^3$ (Lightest)

W 14 x 82 $S = 123 \text{ in}^3$

Select, W 21 x 62

Step 5.

W 21 x 62

$d = 20.99$ in

$t_w = 0.400$ in

$$\tau_{avg} = \frac{V_{MAX}}{d t_w} = \frac{31.25 \text{ kip}}{(20.99 \text{ in})(0.400 \text{ in})}$$

$= 3.7$ ksi $< \tau_{allow} = 14.5$ ksi

✓ ok, so lean

Use, W 21 x 62