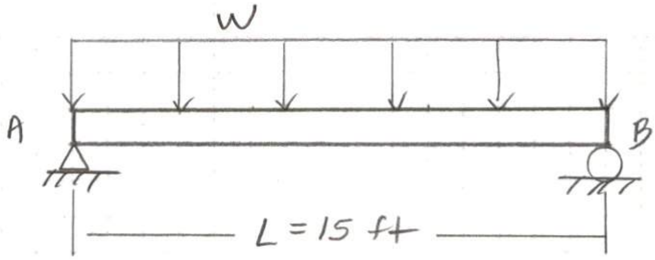
Show all work for full credit. You may work with ONE other person.

Due: December 4, 2020 @ 11:59 PM

2. A 6 x 14 Douglas fir beam of rectangular cross section is used in a 15-ft simple span. Determine the maximum allowable uniform load w applied to the entire span that the beam can carry if the allowable flexural stress is 1200 psi, the allowable shear stress is 100 psi, and the allowable deflection is L/360.



$L = 15\ ft \left(\frac{12\ in}{ft}\right) = 180\ in.$

$\sigma_{allow} = 1200\ psi$

$\tau_{allow} = 100\ psi$

$\delta_{allow} = \frac{L}{360} = \frac{180\ in}{360} = 0.50\ in$

Table A-6(a)

6x14 $I = 1128\ in.^4$

$S = 167\ in.^3$

$A = 74.3\ in^2$

Table A-7(a)

Douglas Fir $E = 1.9 \times 10^3\ ksi$

Flexural Stress

Table 13-1, case 4

$M_{MAX} = \frac{wL^2}{8} = S\,\sigma_{allow}$

$w = \frac{8\,S\,\sigma_{allow}}{L^2} = \frac{8(167\ in^3)(1200\ lb/in^2)}{(180\ in)^2} = 49.5\ lb/in$

Deflection

Table 16-1, case 7

$\delta_{MAX} = \frac{5wL^4}{384EI} = 0.50\ in$

$w = \frac{384EI(0.5\ in)}{5L^4} = \frac{384(1900\,000\ psi)(1128\ in^4)(0.5\ in)}{5(180\ in)^4} = 78.4\ lb/in$

Step 3.

$W_{MAX} = 49.5 \text{ lb/in}$ (Flexural stress σ_{MAX})

$W_{MAX} = 78.4 \text{ lb/in}$ (Deflection δ_{MAX})

∴ Flexural stress Governs

and

$$W_{MAX} = 49.5 \text{ lb/in} \left(\frac{12 \text{ in}}{\text{ft}}\right) = 594 \text{ lb/ft}$$

Step 4. Check Shear

Table 13-1, case 4 $w = 594 \text{ lb/ft}$

$$V_{MAX} = \frac{wL}{2} = \frac{594 \text{ lb/ft} (15 \text{ ft})}{2} = 4{,}455 \text{ lb}$$

For Rectangular Section

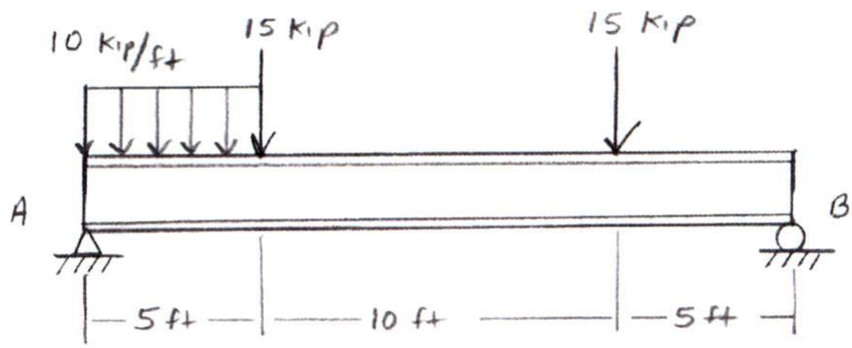
$$\tau_{MAX} = \frac{1.5 V_{MAX}}{A} = \frac{1.5(4455 \text{ lb})}{74.3 \text{ in}^2} = 90 \text{ psi}$$

$\tau_{MAX} = 90 \text{ psi} < \tau_{allow} = 100 \text{ psi}$ ✓ ok, shear

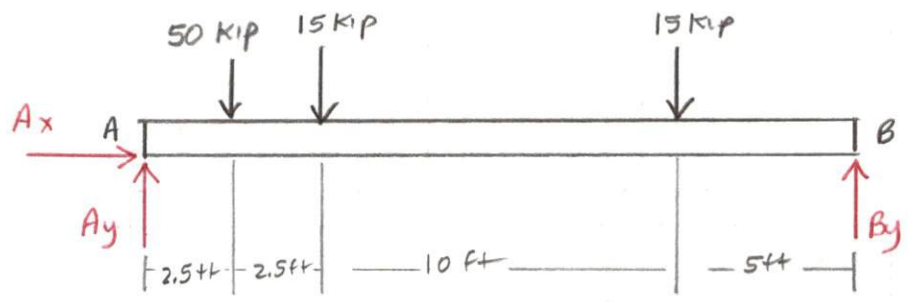
(Beam wt)

$$W_{allow} = 594 \text{ lb/ft} - 20.6 \text{ lb/ft}$$
$$= 573.4 \text{ lb/ft}$$

3. A simple beam has a span of 20-ft with the load shown. The beam is braced laterally throughout its length. Select the lightest W shape for A36 steel to carry the load.



Determine the reactions at the supports A and B



FBD- Entire Beam

Equilibrium Equations

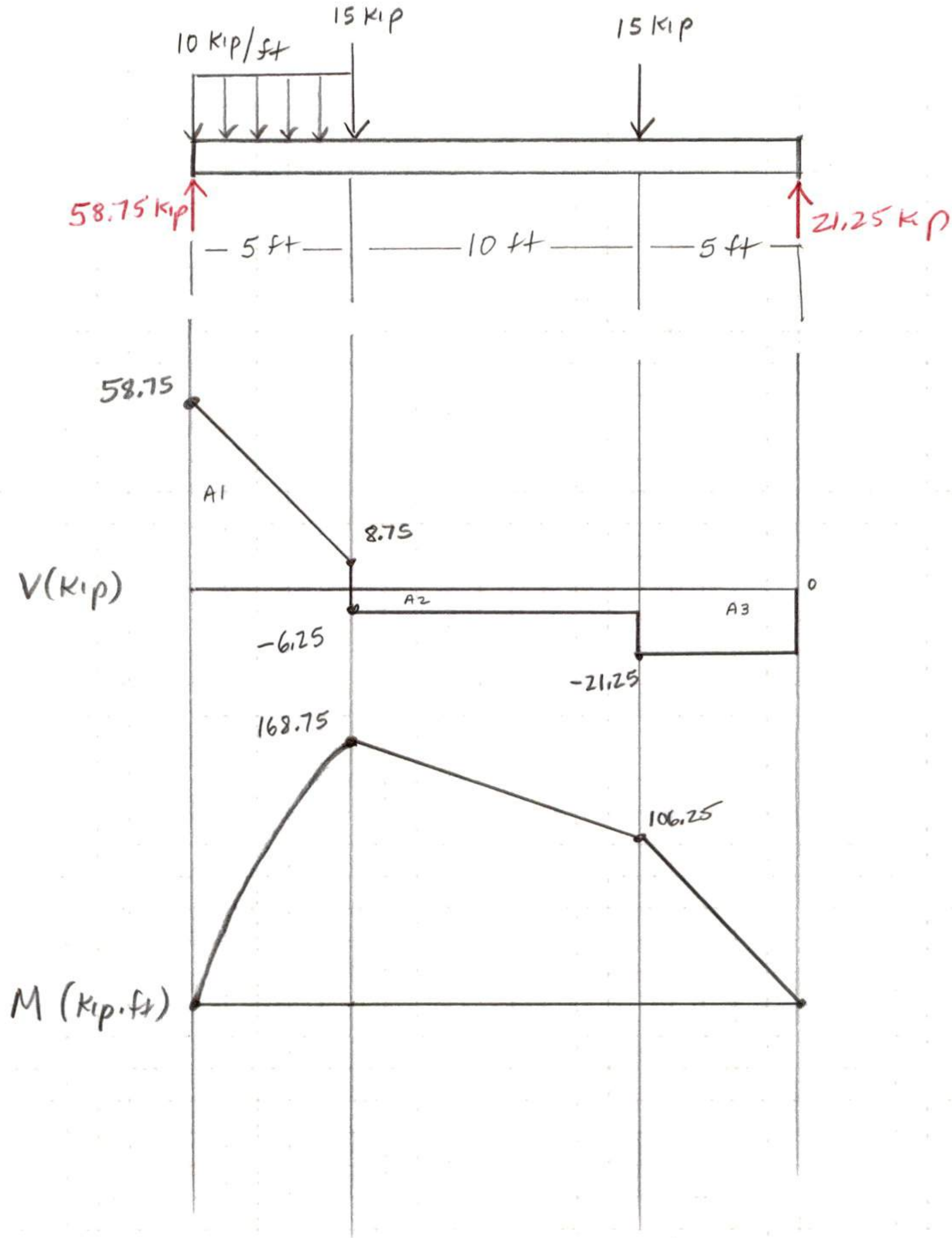
$[\Sigma F_x = 0]$ $\quad A_x = 0$

$+\circlearrowleft [\Sigma M_A = 0]$ $\quad -50\text{ kip}(2.5\text{ ft}) - 15\text{ kip}(5\text{ ft}) - 15\text{ kip}(15\text{ ft}) + B_y(20\text{ ft}) = 0$

$$B_y = \frac{425\text{ kip}\cdot\text{ft}}{20\text{ ft}} = 21.25\text{ kip} \uparrow$$

$[\Sigma F_y = 0]$ $\quad A_y - 50\text{ kip} - 15\text{ kip} - 15\text{ kip} + B_y = 0$

$$A_y = 80\text{ kip} - 21.25\text{ kip} = 58.75\text{ kip} \uparrow$$



$V_{MAX} = 58.75$ kip

$M_{MAX} = 168.75$ kip·ft

A1 $\quad 5\,ft\,(8.75) + \frac{1}{2}(5\,ft)(50) = 168.75$

A2 $\quad 10\,ft\,(-6.25) = -62.5$

A3 $\quad 5\,ft\,(-21.25) = -106.25$

Step 1.

A36 Steel

$\sigma_{allow} = 24$ ksi

$\tau_{allow} = 14.5$ ksi

Step 2.

$V_{MAX} = 58.75$ kip

$M_{MAX} = 168.75 \text{ kip}\cdot\text{ft} \left(\frac{12 \text{ in}}{\text{ft}}\right) = 2025 \text{ kip}\cdot\text{in}$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{2025 \text{ kip}\cdot\text{in}}{24 \text{ ksi}} = 84.375 \text{ in.}^3$$

Step 4. Table A-1(a)

W12×65	$S = 87.9 \text{ in}^3$
W14×61	$S = 92.2 \text{ in}^3$
W16×57	$S = 92.2 \text{ in}^3$
W18×50	$S = 88.9 \text{ in}^3$ (Lightest)

Select, W18×50

From Table 13-1, case 4

Beam Weight (wt)

$$M_{wt} = \frac{wL^2}{8} = \frac{50 \frac{\text{lb}}{\text{ft}} (20 \text{ ft})^2}{8} = 2500 \text{ lb}\cdot\text{ft}$$

$$\frac{M_{wt}}{M_{MAX}} = \frac{2.5 \text{ kip}\cdot\text{ft} \left(\frac{12 \text{ in}}{\text{ft}}\right)}{2025 \text{ kip}\cdot\text{in}} = 0.0148 = 1.5\%$$

$$\frac{\text{Extra } S}{S_{req}} = \frac{88.9 \text{ in}^3 - 84.375 \text{ in}^3}{84.375 \text{ in}^3} = 0.054 = 5.4\% > 1.5\%$$ ✓ ok, bendi

Step 5. Check Shear

W18×50

$d = 17.99$ in.

$t_w = 0.355$ in.

$$\tau_{avg} = \frac{V_{MAX}}{d\,t_w} = \frac{58.75 \text{ kip}}{17.99 \text{ in} (0.355 \text{ in})} = 9.2\% < \tau_{allow} = 14.5 \text{ ksi}$$ ✓ ok, shear

Use, W18×50