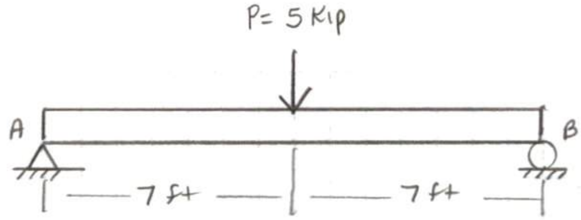
Solution,

CMGT 350 **Exam #3 [Practice #2]** **Fall 2020**

1. A simply supported standard wood joist is 14 ft long and supports a concentrated load at midspan of 5 kip. Select a size that will be adequate for both shear and bending if the allowable shear stress is 90 psi and the allowable bending stress is 1350 psi.

Solution.



Step 1.

$L = 14\ ft$

$P = 5\ kips$

$a = 7\ ft$

$\sigma_{allow} = 1350\ psi$

$\tau_{allow} = 90\ psi$

Step 2. Table 13-1, case 1

$$V_{MAX} = \frac{P}{2} = \frac{5\ kip}{2} = 2.5\ kip$$

$$M_{MAX} = \frac{PL}{4} = \frac{5\ kip(14 ft)}{4} = 17.5\ kip\cdot ft$$

Step 3.

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{17.5\ kip\cdot ft\left(\frac{12 in}{ft}\right)}{1.35\ ksi} = 155\ in^3$$

Step 4.

$$A_{req} = \frac{1.5\ V_{max}}{\tau_{allow}} = \frac{1.5(2.5\ kip)}{0.090\ ksi} = 41.7\ in^2$$

Step 5. Table A-6(a)

6 × 14 $A = 74.3\ in^2$ $S = 167\ in^3$ $wt = 20.6\ lb/ft$

Check,

$$M_{wt} = \frac{wL^2}{8} = \frac{20.6\ lb/ft\ (14 ft)^2}{8} = 504.7\ lb\cdot ft\left(\frac{kip}{1000\ lb}\right) = 0.5047\ kip\cdot ft$$

$$\frac{M_{wt}}{M_{MAX}} = \frac{0.5047\ kip\cdot ft}{17.5\ kip\cdot ft} = 0.029 = 2.9\%$$

$$\frac{Extra\ S}{S_{req}} = \frac{167 in^3 - 155 in^3}{155 in^3} = 0.077 = 7.7\% > 2.9\%$$ ✓ OK, bending

$$\frac{Extra\ A}{A_{req}} = \frac{74.3 in^2 - 41.7 in^2}{41.7 in^2} = 0.782 = 78.2\% > 2.9\%$$ ✓ OK, shear

Use, 6 × 14

2. Calculate the magnitude of uniform load needed to cause a 2x10 floor joist to deflect 0.50 in. The floor joist spans 16-ft and the modulus of Elasticity is 1.4 x 10^6 psi.

Solution.

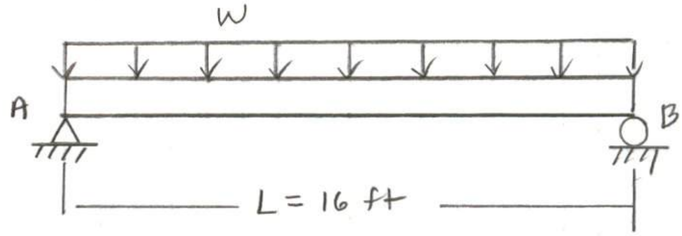


Table 16-1, case 7

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

$$W = \frac{384EI(0.50\text{in})}{5L^4}$$

Nominal 2 in × 10 in

Dressed 1.5 in × 9.25 in

$$I = \frac{bh^3}{12} = \frac{1.5\text{in}(9.25\text{in})^3}{12} = 98.9\text{ in}^4$$

OR, use Table A-6(a)

$$L = 16\text{ ft}\left(\frac{12\text{ in}}{\text{ft}}\right) = 192 \text{ in.}$$

$$E = 1.4 \times 10^6 \text{ psi}$$

$$W = \frac{384(1.4\times10^6\text{psi})(98.9\text{ in}^4)(0.5\text{in})}{5(192\text{in.})^4}$$

$$= \frac{26{,}584{,}320{,}000 \text{ lb}\cdot\text{in}^3}{6{,}794{,}772{,}480 \text{ in.}^4}$$

$$= 3.91 \text{ lb/in} \times \frac{12\text{ in}}{\text{ft}}$$

$$= 46.9 \text{ lb/ft}$$

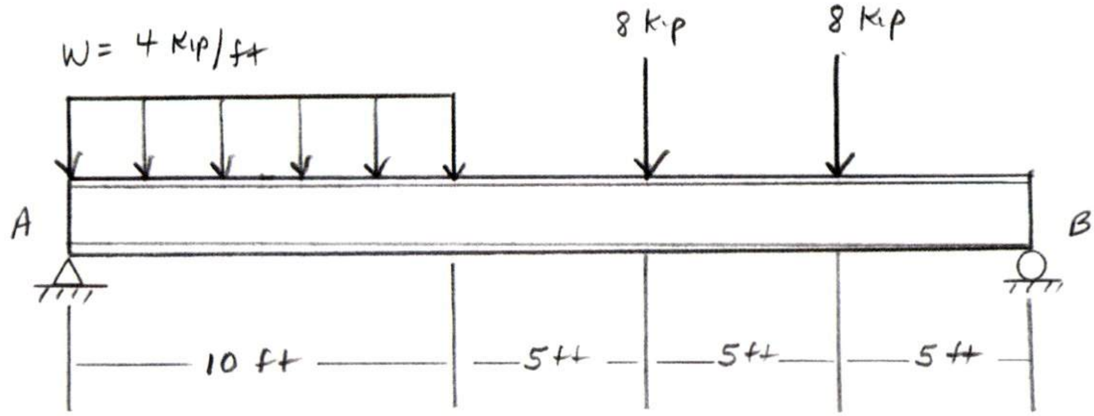
2X10

wt = 3.85 lb/ft

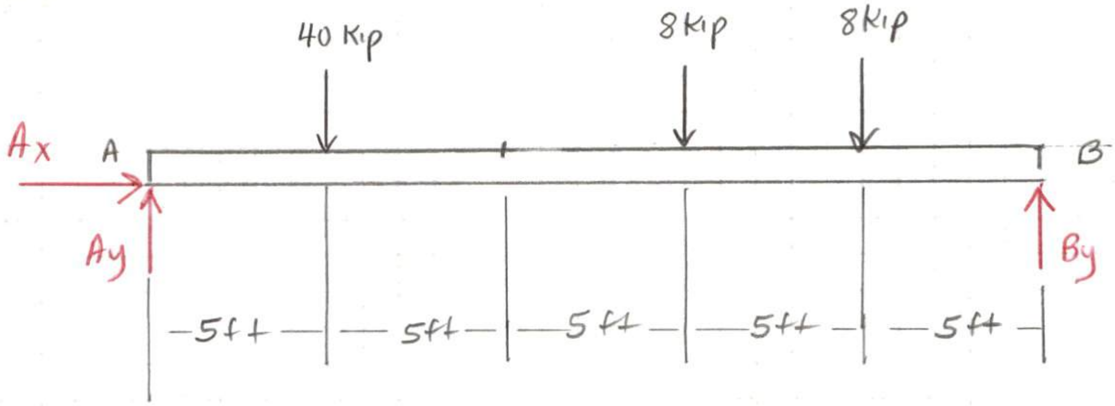
$$W_{allow} = 46.9 \text{ lb/ft} - 3.85 \text{ lb/ft}$$

$$\boxed{W_{allow} = 43 \text{ lb/ft}}$$

3. Solve for the reactions at the supports and sketch the shear and moment diagrams. Locate the section(s) where the shear force is zero and determine the moment at the section(s).



Solution.



FBD- Entire Beam

Equilibrium Equations

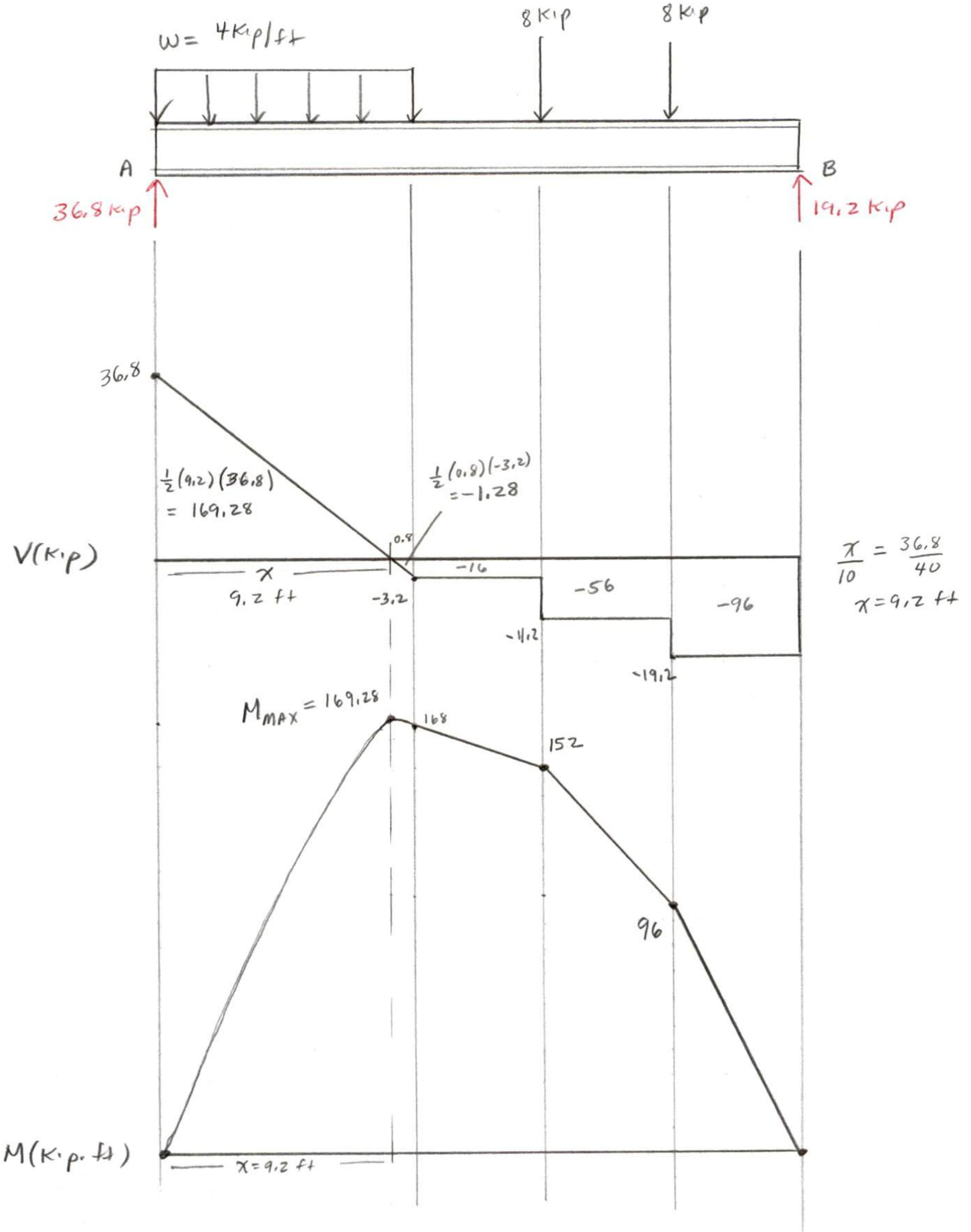
$[\Sigma F_x = 0]$ $A_x = 0$

$+\circlearrowleft\ [\Sigma M_A = 0]$ $-40\text{ kip}(5\text{ ft}) - 8\text{ kip}(15\text{ ft}) - 8\text{ kip}(20\text{ ft}) + B_y(25\text{ ft}) = 0$

$$B_y = \frac{480\text{ Kip}\cdot\text{ft}}{25\text{ ft}} = 19.2\text{ Kip} \uparrow$$

$[\Sigma F_y = 0]$ $A_y - 40\text{ Kip} - 8\text{ Kip} - 8\text{ Kip} + B_y = 0$

$$A_y = 56\text{ Kip} - 19.2\text{ Kip} = 36.8\text{ Kip} \uparrow$$



w = 4 kip/ft
8 kip
8 kip
A
B
36.8 kip
19.2 kip
V(kip)
36.8
½(9.2)(36.8)
= 169.28
½(0.8)(-3.2)
= -1.28
0.8
x
9.2 ft
-3.2
-16
-56
-11.2
-96
-19.2
x/10 = 36.8/40
x = 9.2 ft
M(kip·ft)
M_MAX = 169.28
168
152
96
x = 9.2 ft

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.

A36 Steel

$\sigma_{MAX} = 24$ ksi

$\tau_{allow} = 14.5$ ksi

$V_{MAX} = 36.8$ kip

$M_{MAX} = 169.28$ kip·ft

$$S_{req} = \frac{M_{MAX}}{\sigma_{allow}} = \frac{169.28 \text{ kip·ft} \left(\frac{12 \text{ in}}{\text{ft}}\right)}{24 \text{ kip/in}^2} = 84.64 \text{ in}^3$$

Table A-1(a)

W10 × 77	$S = 85.9$ in^3	
W12 × 65	$S = 87.9$ in^3	
W14 × 61	$S = 92.2$ in^3	
W16 × 57	$S = 92.2$ in^3	
W18 × 50	$S = 88.9$ in^3	Lightest
W21 × 50	$S = 94.5$ in^3	

Check Shear Stress

W18 × 50

$d = 17.99$ in.

$t_w = 0.355$ in.

$$\tau_{AVG} = \frac{V_{MAX}}{d t_w} = \frac{36.8 \text{ kip}}{17.99 \text{ in} (0.355 \text{ in})} = 5.8 \text{ ksi} < \tau_{allow} = 14.5 \text{ ksi}$$

OK ✓ Shear

Use, W18 × 50