Worksheet ~~2A~~ 3A
Introduction to Design/Analysis

1. *Design.* A circular bar must be designed to resist a centric axial load of 100 kips. The bar has a constant cross-section. The Factor of Safety is 1.75 with respect to the failure stress. The material is A36 steel with a failure normal stress of 36 ksi.

Determine the minimum diameter.

Actual ≤ Allowable

$$\sigma_{act} \le \sigma_{all}$$

$$\frac{100\text{ kips}}{A_t} \le \frac{\sigma_{fail}}{FS}$$

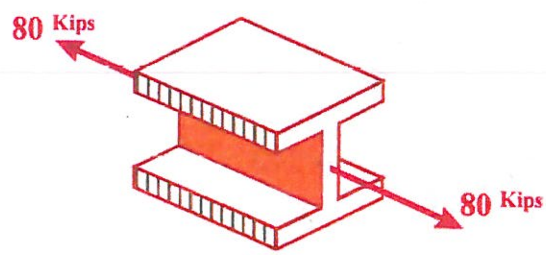
$$A_t = \frac{\pi d^2}{4}$$

$$d^2 \ge \frac{(4)(100\text{ kips})(FS)}{(\sigma_{fail})(\pi)}$$

$$d^2 \ge \frac{(4)(100)(1.75)}{(36)(\pi)}$$

$$d \ge 2.49\text{ inches}$$

2. *Analysis.* A W 6x12 wide flange section is being used as a tension member in a bridge truss. The section has a cross-sectional area of 3.35 in^2 and is made of A36 steel. The member is subjected to a tension force of 80 kips. If the minimum factor of safety is 1.67, is the design adequate?



Actual ≤ Allowable

$$\sigma_{act} \le \sigma_{all}$$

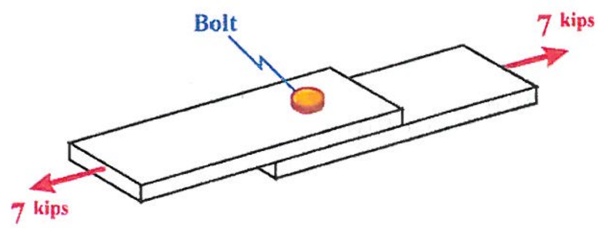
$$\frac{80\text{ kips}}{3.35\text{ in}^2} \le \frac{36\text{ ksi}}{1.67}$$

$$23.88 \not\le 21.55$$

Not adequate
actual > allowable

3B
Worksheet ~~2B~~
Introduction to Design/Analysis

The steel lap joint is held together by one bolt. The failure shear stress is 30 ksi. Determine the required bolt diameter to the nearest 1/4" using a factor of safety of 2.5. What is the actual factor of safety for the bolt you chose?



Determine bolt diameter (design)

Actual ≤ Allowable

$$\tau_{act} \le \tau_{all}$$

$$\frac{7\text{ kips}}{A_t} \le \frac{\tau_{fail}}{FS}$$

$$A_t \ge \frac{(7\text{ kips})(2.5)}{(30\text{ ksi})}$$

$$A_t = \frac{\pi d^2}{4}$$

$$d \ge \sqrt{\frac{(4)(7)(2.5)}{\pi(30)}}$$

$$= 0.862$$

"nearest ¼ in" → $\underline{d = 1.00''}$

Actual FS (analysis)

$$\text{Actual FS} = \frac{\text{Failure level}}{\text{Actual level}} = \frac{\tau_{fail}}{\tau_{act}}$$

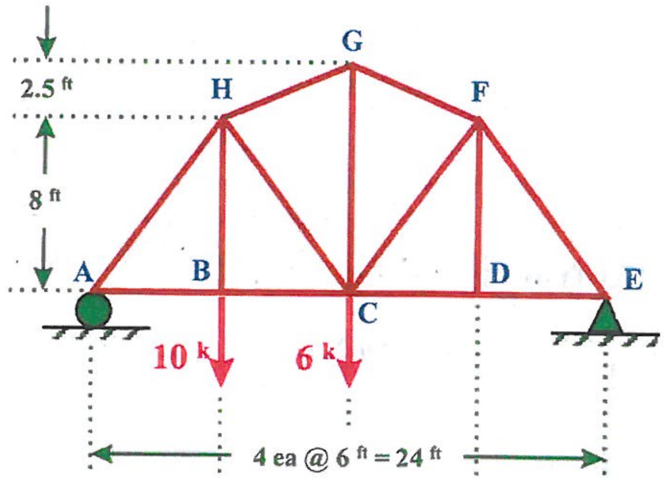
$$FS = \frac{(30\text{ ksi})}{(V/A_t)} = \frac{(30\text{ ksi})}{\left(7\text{kips}/\frac{\pi(1)^2}{4}\right)} = \frac{30}{8.913}$$

$$\underline{FS = 3.37}$$

Worksheet ~~2C~~
Design of a Truss Member

1. The 4 bay truss below is made of 2014-T6 aluminum ($\sigma_y = 58$ ksi). The truss members have a circular cross section. Circular bars are available in all sizes up to 3" diameter in 1/4" increments. Using a factor of safety of 2.0 with respect to the yield stress, design member CD of the truss.

2. What is the actual factor of safety after design with respect to the proportional limit stress?



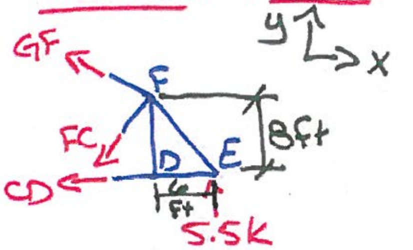
1) Design CD

External Forces

$$\circlearrowleft \sum M_A = 0 = 10(6) + 6(12) - E_y(24)$$

$$E_y = 5.5\,k \uparrow$$

Internal Forces



$$\circlearrowleft \sum M_F = 0 = CD(8) - 5.5(6)$$

$$CD = 4.125\,k\ (T)$$

Stress

Actual ≤ Allowable

$$\sigma_{act} \le \sigma_{all}$$

$$\frac{P}{A_t} \le \frac{\sigma_{fail}}{FS}$$

$$d \ge \sqrt{\frac{(4)(4.125)(2)}{\pi(58)}}$$

$$\ge .426$$

1/4" increments

$d = 0.5"$

2) Actual FS

$$FS = \frac{\sigma_{fail}}{\sigma_{act}}$$

$$FS = \frac{(58\ ksi)}{\left(4.125 \Big/ \frac{\pi(.5)^2}{4}\right)} = 2.76$$