1. A C-shaped clamping device, shown below, is to be made of 50 mm wide plate and is loaded by a force, \( F \), that fluctuates between 0 to 60 kN. What should be the thickness, \( b \), of the clamp in order to provide a factor of 4 for an infinite life at point, \( P \)?

Use a surface finish of 0.75 and a size factor of 0.87. The material (steel) has an ultimate strength of 0.5 GPa. The area moment of inertia is \( bh^3/12 \) where \( h \) is the width. Also, the maximum bending stress is \( My/I \). (35 pts.)
2. The hydraulic cylinder shown below is held together by four 3/8 inch diameter SAE grade 5 coarse bolts with a proof strength of 85kpsi. The tensile area is 0.078 square inches. They are tightened to a preload of 75% of the proof load. The stiffness of each bolt is 0.245 Mlb/in and the cylinder has a total stiffness of 10 Mlb/in. Will the bolts fail or will the joints separate first? Justify your answer. (Assume the end plates to be completely rigid.) (30 pts).

\[ n = \frac{S_p A_t - F_i}{C P} \]  
\[ n = \frac{F_i}{(1-c)P} \]

\[ F_i = 0.75 S_p A_t = \frac{497316}{0.75} \]

\[ C = \frac{k_b}{k_b + k_m} = \frac{0.245}{0.245 + 10} = 0.09 \]

\[ n = \frac{497316}{(1-0.09)P} \]

\[ n = 5465 \frac{P}{F} \]

--- Separation ---

\[ n = 5465 \frac{P}{F} \]  

\[ n > 1844 \frac{P}{F} \]

Larger \( n \) at same \( P \)

--- Bolt Failure ---

\[ nP = 6530 - 4973 \]

\[ n = 1844 \frac{P}{F} \]

\[ n > 1844 \frac{P}{F} \]

Small \( n \)

--- Separate before yield ---

\[ n = 5465 \frac{P}{F} \]
3. A nested two-spring arrangement is shown below. The outer spring has a wire diameter of 2mm and an outside diameter of 22mm. The inner spring has a 1.4mm wire diameter and a 15.4mm outside diameter. Both springs have 16 coils and are made of steel with a shear modulus of 80 GPa. Which spring sees the higher shear stress? (Note that both springs undergo identical deflections.) (35 pts)

\[ \frac{\tau_0}{\tau_i} = \frac{K_{50}F_0D_0}{\pi d_0^2} = \frac{K_{5i}F_iD_i}{\pi d_i^2} \]

\[ C_0 = \left( \frac{D}{d} \right)_0 = \left( \frac{22 - 2}{2} \right) = 10 \quad D_0 = 20 \]

\[ C_i = \left( \frac{D}{d} \right)_i = \left( \frac{15.4 - 1.4}{1.4} \right) = 10 \quad D_i = 14 \]

\[ K_{50} = \frac{2C + 1}{2C} \quad K_{5i} = K_{50} \]

\[ \frac{\tau_0}{\tau_i} = \frac{F_0D_0}{d_0^2} \cdot \frac{d_i^2}{F_iD_i} \]

\[ \frac{\tau_0}{\tau_i} = \frac{D_0}{d_0^2} \cdot \frac{d_i^2}{D_i} \cdot \frac{d_0^4 D_i^2}{d_i^4} \]

\[ = \frac{D_0 D_i^2}{d_0^2 d_i} = \frac{2(14)^2}{(20)^2(11.4)} \]

\[ \tau_0 = 2.7 \quad \tau_i = 1.5 \]

\[ \text{IF YOU ASSUME} \quad F_0 = F_i = F \]

\[ F_0 = k_0 \delta \quad F_i = k_i \delta \]

\[ \text{and} \quad \frac{F_0}{k_0} = \frac{F_i}{k_i} \quad \frac{F_0}{F_i} = \frac{k_0}{k_i} \]

\[ F_0 = \frac{d_0^4 C}{8 D_0^2 N} \quad F_i = \frac{d_i^4 C}{8 D_i^2 N} \]

\[ \frac{k_0}{k_i} \quad \text{higher spring} \]