1. Problem 7-4
2. Problem 7-10. Neglect the requirement about the reliability. Compute the applied force so that the component has an infinite fatigue life.
3. Problem 7-12.
(7-4) **AisI 1137 cold-drawn**  \( S_{ut} = 734 \text{ MPa} \\

(a) **Endurance limit of a laboratory specimen:**

\[
S'_e = 0.504 \times (734) = 370 \text{ MPa}
\]

Surface finish factor \( a = 4.51 \text{ MPa}, \quad b = -0.265 \)

\[
K_a = a \cdot S_{ut} = 4.51 \times 734 = 0.785
\]

\[
S'_e = K_a \cdot S'_e = 0.785 \times 370 = 291 \text{ MPa}
\]

(b) \[
S_f = a \cdot N^b \quad N = 130 \cdot 10^3 \text{ cycles}
\]

\[
a = \left( \frac{0.9 \times S_{ut}}{S_e} \right)^2 = \left( \frac{0.9 \times 734}{291} \right)^2 = 1500 \text{ MPa}
\]

\[
b = -\frac{1}{3} \log \frac{0.9S_{ut}}{S_e} = -\frac{1}{3} \log \frac{0.9 \times 734}{291} = -0.119
\]

\[
S_f = 1500 \cdot \left(130 \cdot 10^3\right)^{-0.119} = 369.5 \text{ MPa}
\]
Monotonic (static) stress concentration factor:

\[ \frac{D}{d} = \frac{30}{20} = 1.5 \]
\[ \frac{r}{d} = \frac{1}{12} = 0.05 \]

\( k_t = 2.4 \)

The axial stress is given by the bending moment. The question is which point is critical, A or B? It can be observed that at A, the moment arm is only \( \frac{125}{75} = 1.67 \) times greater than at point B. But at B the stress concentration is 2.4, which means that the stress at B is larger than the stress at A. In addition, the cross-sectional area at B is smaller than the cross-section at A. In conclusion, B is the critical location with the largest stress.

\[ S_e' = 0.504 \times 1090 = 549 \text{ MPa} \]
\[ K_a = a \cdot \text{Sup}^b = 1.58 \cdot (1090)^{-0.085} = 0.872 \]

\[ d_e = 0.808 \sqrt{20.10} = 11.43 \text{ mm} \]

\[ K_b = \left( \frac{11.43}{7.62} \right)^{-0.1133} = 0.955 \]

Fig. 5-16 \rightarrow \varphi = 0.85 \]

\[ K_f = 1 + 0.85(K_t-1) = 1 + 0.85(2.4-1) = 2.19 \]

\[ K_e = \frac{1}{K_f} = 0.457 \]

\[ S_e = K_a \cdot K_b \cdot K_e \cdot S_e' = 0.872 \cdot 0.955 \cdot 0.457 \cdot 549 = 209 \text{ MPa} \]

\[ G = \frac{M \cdot y}{I} = \frac{(F \cdot 75) \cdot 10}{10 \cdot 20^3} = \frac{F \cdot 75 \cdot 12}{20^3} = 0.113F \]

(we put dimensions in mm, stress in MPa, thus the force will be in N)

\[ S_e = 0.113F \Rightarrow F = \frac{S_e}{0.113} = \frac{209}{0.113} = 1850 \text{ N} \]
\[ S_{ut} = 89 \text{ ksi}, \text{ ground finish}, \quad n = 1720 \text{ rev/min} \]

\[ F_1 = 2000 \text{ lb} \quad F_2 = 3000 \text{ lb} \]

\[ R_A = 2333 \text{ lb} \quad R_B = 2667 \text{ lb} \]

The critical location is at the center shoulder

\[ M = 2333 \cdot 10.5 - 2000 \cdot 2.5 = 19500 \text{ lb in} \]

\[ S_e' = 0.504 (89) = 44.856 \text{ ksi} \]

\[ K_a = a \cdot S_{ut} = 1.34 \cdot (89) = 0.915 \]

\[ K_b = \left( \frac{d}{0.3} \right)^{-0.1133} = \left( \frac{1.625}{0.3} \right)^{-0.1133} = 0.826 \]

\[ K_c = K_d = 1 \]

\[ \frac{D}{d} = \frac{1.875}{1.625} = 1.154 \quad \text{Table A-15-9} \]

\[ \frac{r}{d} = \frac{0.0625}{1.625} = 0.03846 \]

\[ K_t = 2.1 \]
Fig. 5-16 \Rightarrow g = 0.78

\[ K_f = 1 + 2(K_t - 1) = 1 + 0.78(2.1 - 1) = 1.86 \]

\[ K_e = \frac{1}{K_f} = \frac{1}{1.86} = 0.538 \]

\[ S_e = K_a K_b K_c K_d K_e \quad S_e' = 0.915(0.826)(0.538) \cdot 44.856 = 18.2 \text{ ksi} \]

\[ G = \frac{M_y}{I} = \frac{32M}{\pi d^3} = \frac{32 \cdot 19500}{\pi (1.625)^3} = 46.29 \text{ ksi} \]

\[ \sigma = S_f \]

\[ S_f = a \cdot N^b \]

\[ a = \frac{(0.9 \cdot S_{ut})^2}{S_e} = \frac{(0.9 \cdot 89)^2}{18.2} = 352.5 \text{ ksi} \]

\[ b = -\frac{1}{3} \log \frac{0.9 \cdot S_{ut}}{S_e} = -\frac{1}{3} \log \frac{0.9 \cdot 89}{18.2} = -0.2145 \]

\[ N = \left(\frac{S_f}{a}\right)^{\frac{1}{b}} = \left(\frac{46.29}{352.5}\right)^{-0.2145} = 12,893 \text{ cycles} \]

\[ \text{Life} \quad t = \frac{12,893}{1720} = 7.5 \text{ min} \]