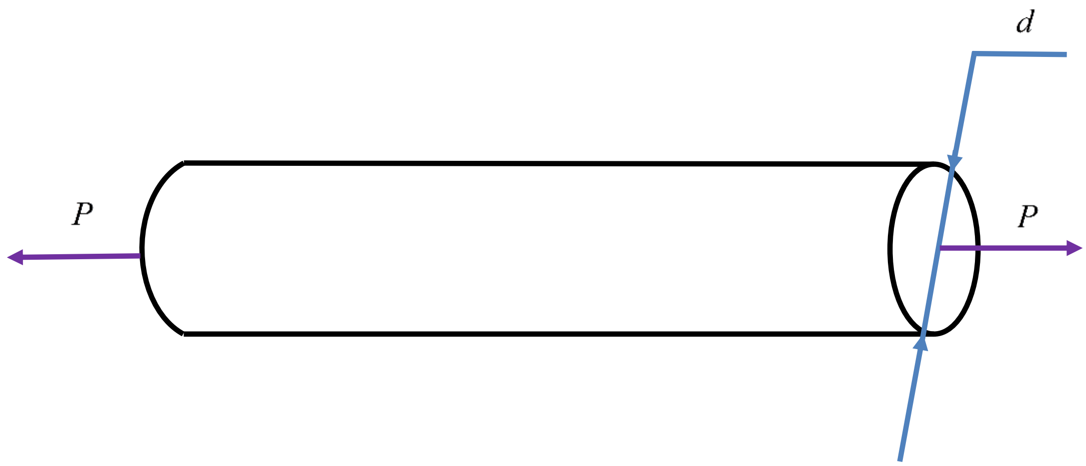
1. A solid circular rod is subjected to an axial force of $P = 2000\,\text{lbf}$. The yield stress of the rod is $S_y = 20\,\text{kpsi}$. The factor of safety is $n_s = 3.0$. a) What is the minimum diameter of the rod? Then select a preferred fractional diameter. b) If $P \sim N(2000, 300^2)\,\text{lbf}$, $S_y \sim N(20, 3^2)\,\text{kpsi}$, and P and S are independent, determine the probability of failure using Monte Carlo Simulation.



Solution

a) The cross-sectional area of the rod is

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

The tensile stress of the rod is

$$S = \frac{P}{A} = \frac{4P}{\pi d^2}$$

The tensile stress should be less than the allowable stress

$$S = \frac{4P}{\pi d^2} \le \frac{S_y}{n_s}$$

Solving for d yields

$$d \geq \sqrt{\frac{4Pn_s}{\pi S_y}} = \sqrt{\frac{4(2000)(3)}{\pi \times (20000)}} = 0.618 \text{ in}$$

Thus the minimum diameter of the rod is 0.618 in. **Ans.**

And the preferred fractional diameter could be chosen as $d_0 = \frac{5}{8}$ in = 0.625 in. **Ans.**

b) The limit-state function is the actual stress of the rod subtracted from the allowable maximum stress. Failure occurs when $Y < 0$.

$$Y = g(\mathbf{X}) = S_y - S = S_y - \frac{4P}{\pi d_0^2}$$

where $\mathbf{X} = (P, S_y)$, and d_0= 0.625 in is the preferred diameter.

Using Monte Carlo Simulation and 1e7 samples, the probability of failure is found to be $1.16(10^{-5})$.

Ans.