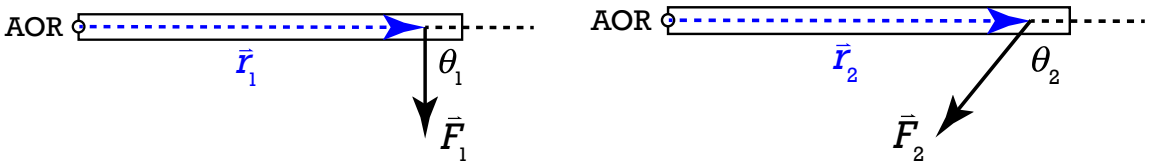
Flipping Physics Lecture Notes:

An Introductory Torque Wrench Problem

Example: To tighten a lag bolt, a 29 N force is applied at a 90° angle to a wrench 0.18 m from the center of a lag bolt. If the angle between the wrench and the force is changed to 50°, what magnitude force is necessary to tighten the bolt with the same torque? (assume both angles have 2 significant digits.)



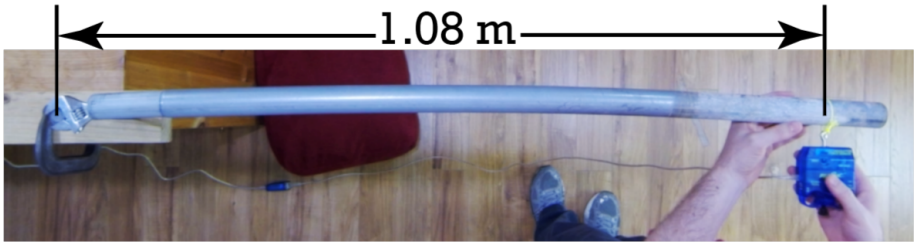
Knowns: $r_1 = 0.18m = r_2; F_1 = 29N; \theta_1 = 90°; \theta_2 = 180° - 50° = 130°; \tau_1 = \tau_2; F_2 = ?$

$\vec{\tau} = \vec{r}\vec{F}\sin\theta \Rightarrow \tau = rF\sin\theta\ (magnitude)$

$\tau_1 = r_1F_1\sin\theta_1 = (0.18)(29)\sin 90 = 5.22N \cdot m$ (This is the torque applied by the original force.)

$$\tau_1 = \tau_2 = r_2F_2\sin\theta_2 \Rightarrow F_2 = \frac{\tau_1}{r_2\sin\theta_2} = \frac{5.22}{(0.18)\sin(130)} = 37.8568 \approx \boxed{38N}$$

Part B) If a pipe is fitted to the wrench which increases the distance between the lag bolt and where the force is applied to 1.08 meters, what would the minimum magnitude force necessary be to cause the same torque as before?



Minimum force means the angle needs to be 90° because $\sin 90 = 1$.
Any other force would result in a larger force necessary to produce the same torque.

$$\vec{\tau}_1 = \vec{\tau}_3 \Rightarrow \vec{F}_3 = \frac{\vec{\tau}_1}{\vec{r}_3\sin\theta_3} = \frac{5.22}{(1.08)\sin 90} = 4.8\overline{3} \approx \boxed{4.8N}$$