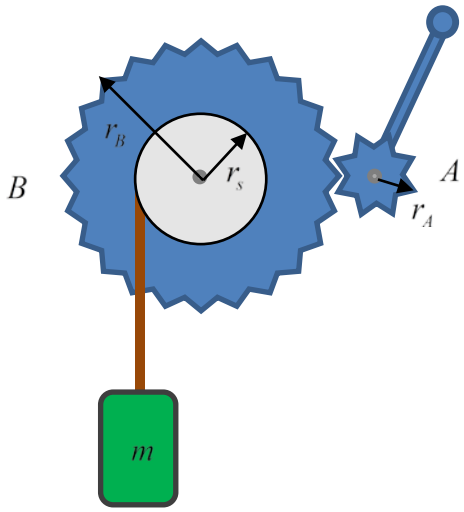
4-3. A crank device consists of two gears, and the radiuses of gear *A* and gear *B* are $r_A = 0.2$ m and $r_B = 1$ m, respectively. A spool is connected to gear *B*, and due to manufacturing precision, the radius of the spool follows a normal distribution $r_s \sim N(0.4, 0.02^2)$ m. If the weight is $m = 20$ kg, find how much work is required to rotate the crank ten full revolutions.



Solution:

$$r_A\theta_A = r_B\theta_B$$

$$\theta_A = 10 \text{ rev.} = 20\pi$$

$$\theta_B = \frac{\theta_A r_A}{r_B} = \frac{20\pi r_A}{r_B}$$

$$s = \theta_B r_s$$

$$U = mgs = \frac{20mg\pi r_A r_s}{r_B}$$

$$\mu_U = \frac{20mg\pi r_A \mu_{r_s}}{r_B} = 986.21 \text{ J}$$

$$\sigma_U = \frac{20mg\pi r_A \sigma_{r_s}}{r_B} = 49.31 \text{ J}$$

Therefore, $U \sim N(986.21, 49.31^2)$ J. **Ans.**