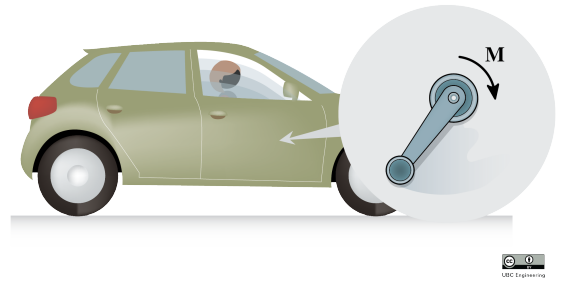


22-R-WE-JL-51

The crank to roll a car window up and down must be turned clockwise a total of 7 revolutions to completely open the window. You have decided that it requires too much work though, and instead built a motor to apply a clockwise moment $M = 0.4\theta^2 + 9 \text{ N}\cdot\text{m}$.

You do a test run with it and it works perfectly! What is the total work U_M done on the crank?



Solution

The work of a couple moment U_M is found by integrating

$$U_M = \int_{\theta_0}^{\theta_f} M d\theta$$

So using $\theta_0 = 0$ and $\theta_f = 2\pi(7) = 14\pi \text{ [rad]}$, we can integrate the applied moment M and solve for the work done.

$$U_M = \int_0^{14\pi} 0.4\theta^2 + 9 d\theta$$

$$U_M = \left. \frac{0.4}{3}\theta^3 + 9\theta \right|_0^{14\pi}$$

$$U_M = \frac{0.4}{3}(14\pi)^3 + 9(14\pi) = 11740 \text{ [J]}$$