

Elementary Dynamics Example #17: (Newton's Laws, Radial & Transverse Components)

Given: $W = 250$ (lb) (man and bucket)

$r = 30$ (ft), $\dot{r} = 2$ (ft/s) (constant)

$\theta = 40$ (deg), $\dot{\theta} = 10$ (deg/s) (constant)

Find: $\vec{F}$ the force applied to the bucket at B

Solution:

Kinematics:

$$\begin{aligned}\vec{a}_B &= (\ddot{r} - r\dot{\theta}^2)\vec{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\vec{e}_\theta \\ &= -30\left(\frac{10\pi}{180}\right)^2 \vec{e}_r + 2(2)\left(\frac{10\pi}{180}\right)\vec{e}_\theta\end{aligned}$$

$$\Rightarrow \boxed{\vec{a}_B = -0.91385 \vec{e}_r + 0.69813 \vec{e}_\theta}$$

Kinetics:

$$\nearrow \sum F = F_r - W \sin(\theta) = \left(\frac{W}{g}\right)a_r$$

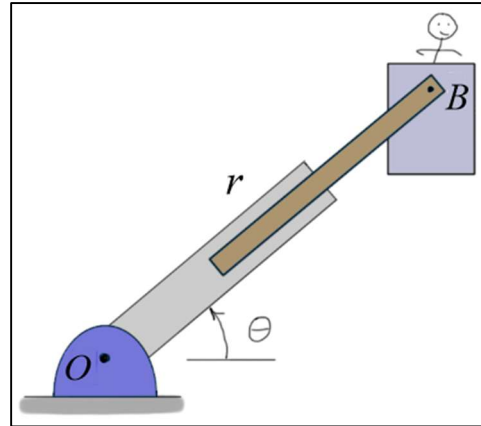
$$\Rightarrow F_r = W \sin(\theta) + \left(\frac{W}{g}\right)a_r \approx 153.60 \approx 154 \text{ (lb)}$$

$$\nwarrow \sum F = F_\theta - W \cos(\theta) = \left(\frac{W}{g}\right)a_\theta$$

$$\Rightarrow F_\theta = W \cos(\theta) + \left(\frac{W}{g}\right)a_\theta \approx 196.93 \approx 197 \text{ (lb)}$$

Note:

$$\boxed{|\vec{F}| = \sqrt{F_r^2 + F_\theta^2} \approx 249.75 \approx 250 \text{ (lb)}} \text{ (acceleration is small)}$$



Free body diagram

