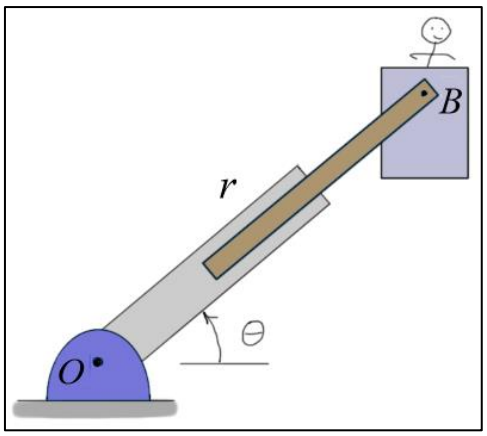
Elementary Dynamics Example #17: (Newton's Laws, Radial & Transverse Components)

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: $\underset{\sim}{F}$ the force applied to the bucket at B



Solution:

Kinematics:

$$\underset{\sim}{a}_B = \left(\ddot{r} - r\dot{\theta}^2\right)\underset{\sim}{e}_r + \left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right)\underset{\sim}{e}_\theta$$

$$= -30\left(\frac{10\pi}{180}\right)^2 \underset{\sim}{e}_r + 2(2)\left(\frac{10\pi}{180}\right)\underset{\sim}{e}_\theta$$

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

Kinetics:

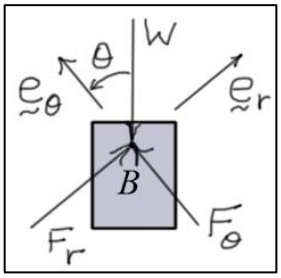
$$\nearrow \sum F = F_r - W\sin(\theta) = \left(\frac{W}{g}\right)a_r$$

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

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

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

Free body diagram



Note:

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