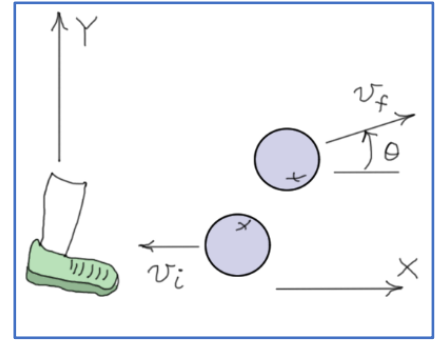


ME 2580 Example #24: (Impulse & Momentum)

Given: $v_i = 5$ (ft/s), $v_f = 10$ (ft/s), $\theta = 30$ (deg)

$\Delta t = 0.01$ (sec), $W_B = 0.5$ (lb)

Find: a) average force exerted by the player on the ball
 b) maximum force exerted by the player on the ball assuming a triangular force profile



Solution: (using the *principle of impulse & momentum*)

a) $\boxed{\vec{L}_1 + \vec{L}_{1 \rightarrow 2} = \vec{L}_2}$ with $\boxed{\vec{L}_1 = -\left(\frac{W_B}{g}\right)v_i \hat{i}}$ and $\boxed{\vec{L}_2 = \left(\frac{W_B}{g}\right)v_f (\cos(\theta)\hat{i} + \sin(\theta)\hat{j})}$

X direction: $\boxed{-\left(\frac{W_B}{g}\right)v_i + (F_x)_{\text{avg}} \Delta t = \left(\frac{W_B}{g}\right)v_f \cos(\theta)}$

$\Rightarrow \boxed{(F_x)_{\text{avg}} = \left(\frac{W_B}{g \Delta t}\right)(v_i + v_f \cos(\theta)) \approx 21.2116 \approx 21.2 \text{ (lb)}}$

Y direction: $\boxed{0 + (F_y)_{\text{avg}} \Delta t = \left(\frac{W_B}{g}\right)v_f \sin(\theta)}$

$\Rightarrow \boxed{(F_y)_{\text{avg}} = \left(\frac{W_B}{g \Delta t}\right)v_f \sin(\theta) \approx 7.76398 \approx 7.76 \text{ (lb)}}$

$\left. \begin{array}{l} \\ \\ \end{array} \right\} \boxed{|\vec{F}_{\text{avg}}| \approx 22.6 \text{ (lb)}}$

Note: In the above calculation, we *neglected* the impulse of the *weight force* of the ball. If we include the weight force in our calculation, the equation in the Y direction becomes:

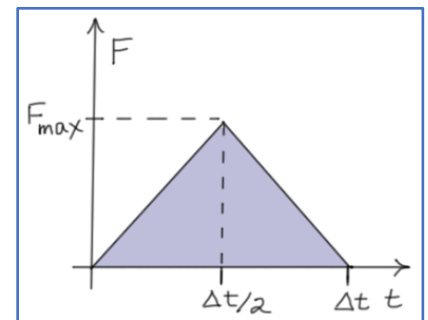
Y direction: $\boxed{\left((F_y)_{\text{avg}} - W_B\right) \Delta t = \left(\frac{W_B}{g}\right)v_f \sin(\theta)}$

$\Rightarrow \boxed{(F_y)_{\text{avg}} = \left(\frac{W_B}{g \Delta t}\right)v_f \sin(\theta) + W_B \approx 8.26 \text{ (lb)}}$

$\left. \begin{array}{l} \\ \\ \end{array} \right\} \boxed{|\vec{F}_{\text{avg}}| \approx 22.8 \text{ (lb)}}$

b) If the force profile is assumed to be *triangular*, the *maximum* force can be calculated. In this case, the impulse of the force is

$\boxed{\int_0^{\Delta t} F dt = \frac{1}{2}(\Delta t) F_{\text{max}}}$



Ignoring the effect of the weight force gives

$\boxed{(F_x)_{\text{max}} = \left(\frac{2W_B}{g \Delta t}\right)(v_i + v_f \cos(\theta)) \approx 42.4 \text{ (lb)}}$

$\boxed{(F_y)_{\text{max}} = \left(\frac{2W_B}{g \Delta t}\right)v_f \sin(\theta) \approx 15.5 \text{ (lb)}}$

$\left. \begin{array}{l} \\ \\ \end{array} \right\} \boxed{|\vec{F}_{\text{max}}| \approx 45.2 \text{ (lb)}}$

Using this approach, the *maximum force* is found to be *twice* the *average force*.