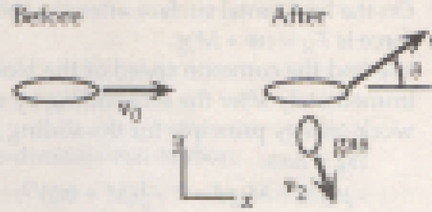
13. If M is the initial mass of the rocket and m_2 is the mass of the expelled gases, the final mass of the rocket is $m_1 = M - m_2$. Because the gas is expelled perpendicular to the rocket in the rocket's frame, it will still have the initial forward velocity, so the velocity of the rocket in the original direction will not change. We find the perpendicular component of the rocket's velocity after firing from



$v_{1\perp} = v_0 \tan\theta = (115 \text{ m/s}) \tan 35° = 80.5 \text{ m/s}.$

Using the coordinate system shown, for momentum conservation in the perpendicular direction we have

$0 + 0 = m_1 v_{1\perp} - m_2 v_{2\perp}$, or

$(M - m_2)v_{1\perp} = m_2 v_{2\perp}$;

$(3180 \text{ kg} - m_2)(80.5 \text{ m/s}) = m_2(1750 \text{ m/s})$, which gives $m_2 =$ **140 kg.**

14. We find the average force on the ball from

$F = \Delta p/\Delta t = (\Delta mv/\Delta t) = [(0.0600 \text{ kg/s})(65.0 \text{ m/s}) - 0]/(0.0300 \text{ s}) =$ **130 N.**

Because the weight of a 60-kg person is ≈ 600 N, this force is **not large enough.**

15. We find the average force on the ball from

$F = \Delta p/\Delta t = m\,\Delta v/\Delta t = (0.145 \text{ kg})[(52.0 \text{ m/s}) - (-39.0 \text{ m/s})]/(1.00 \times 10^{-3} \text{ s}) =$ **1.32×10^4 N.**

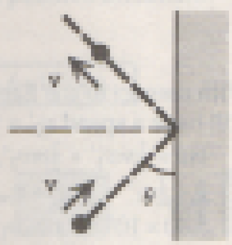
16. (*a*) We find the impulse on the ball from

Impulse $= \Delta p = m\,\Delta v = (0.045 \text{ kg})(45 \text{ m/s} - 0) =$ **2.0 N·s.**

(*b*) The average force is

$F = \text{Impulse}/\Delta t = (2.0 \text{ N·s})/(5.0 \times 10^{-3} \text{ s}) =$ **4.0×10^2 N.**

17. The momentum parallel to the wall does not change, therefore the impulse will be perpendicular to the wall. With the positive direction toward the wall, we find the impulse on the ball from



Impulse $= \Delta p_\perp = m\,\Delta v_\perp = m[(-v \sin\theta) - (v \sin\theta)]$

$= -2mv \sin\theta = 2(0.060 \text{ kg})(25 \text{ m/s}) \sin 45° = -2.1 \text{ N·s}.$

The impulse on the wall is in the opposite direction: **2.1 N·s.**

18. (*a*) With the positive direction in the direction of the fullback (East), the momentum is

$p = m_{\text{fullback}} v_{\text{fullback}} = (115 \text{ kg})(4.0 \text{ m/s}) =$ **4.6×10^2 kg·m/s (East).**

(*b*) We find the impulse on the fullback from

$\text{Impulse}_{\text{fullback}} = \Delta p_{\text{fullback}}$

$= 0 - 4.6 \times 10^2 \text{ kg·m/s} =$ **-4.6×10^2 kg·m/s (West).**

(*c*) We find the impulse on the tackler from

$\text{Impulse}_{\text{tackler}} = -\text{Impulse}_{\text{fullback}} =$ **$+4.6 \times 10^2$ kg·m/s (East).**

(*d*) We find the average force on the tackler from

$F_{\text{tackler}} = \text{Impulse}_{\text{tackler}}/\Delta t = (+4.6 \times 10^2 \text{ kg·m/s})/(0.75 \text{ s}) =$ **6.1×10^2 N (East).**