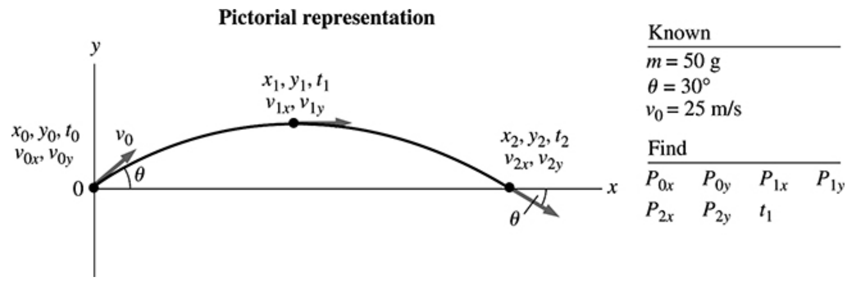
9.25. Model: Model the ball as a particle. We will also use constant-acceleration kinematic equations.



Solve: **(a)** The momentum just after throwing is

$$p_{0x} = p_0 \cos 30° = mv_0 \cos 30° = (0.050 \text{ kg})(25 \text{ m/s})\cos 30° = 1.083 \text{ kg m/s}$$

$$p_{0y} = p_0 \sin 30° = mv_0 \sin 30° = (0.050 \text{ kg})(25 \text{ m/s})\sin 30° = 0.625 \text{ kg m/s}$$

The momentum just after throwing is (1.08, 0.63) kg m/s.
The momentum at the top is

$$p_{1x} = mv_{1x} = mv_{0x} = 1.08 \text{ kg m/s} \quad p_{1y} = mv_{1y} = 0 \text{ kg m/s}$$

Just before hitting the ground, the momentum is

$$p_{2x} = mv_{2x} = mv_{0x} = 1.08 \text{ kg m/s} \quad p_{2y} = mv_{2y} = -mv_{0y} = -0.63 \text{ kg m/s}$$

(b) p_x is constant because no forces act on the ball in the x-direction. Mathematically,

$$F_x = \frac{dp_x}{dt} = 0 \text{ N} \Rightarrow p_x = \text{ constant}$$

(c) The change in the y-component of the momentum during the ball's flight is

$$\Delta p_y = -0.625 \text{ kg m/s} - 0.625 \text{ kg m/s} = -1.250 \text{ kg m/s}$$

From kinematics, the time to reach the top is obtained as follows:

$$v_{1y} = v_{0y} + a_y(t_1 - t_0) \Rightarrow t_1 = \frac{-v_{0y}}{a_y} = \frac{-(12.5 \text{ m/s})}{-9.8 \text{ m/s}^2} = 1.276 \text{ s}$$

The time of flight is thus $\Delta t = 2t_1 = 2(1.276 \text{ s}) = 2.552 \text{ s}$. Multiplying this time by $-mg$, the y-component of the weight, yields –1.25 kg m/s. This follows from the impulse-momentum theorem:

$$\Delta p_y = -mg\Delta t$$