A ball is thrown at an unknown speed and angle off a building 20.0m high.
Someone observes the ball to be traveling at a speed of 30.0 m/s and in a direction 50.0 degrees below the horizontal just before striking the ground.

a) What is the initial velocity of the ball (magnitude and direction)?

b) How much time did it spend in the air?

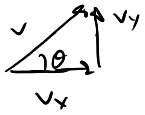
c) How far horizontally did it travel?

a) $v_{yf}^2 = v_{y0}^2 + 2a_y\Delta y \rightarrow$ $v_{y0} = \sqrt{v_{fy}^2 - 2a_y\Delta y} = \sqrt{(30\frac{m}{s}\sin(50)) - 2(-9.81\frac{m}{s^2})(-20m)}$

$= 11.56\ m/s$

$v_{0x} = v_{fx} = 30\frac{m}{s}\cos(50) = 19.28\frac{m}{s}$

(no acceleration in x-direction)



$v = \sqrt{(11.56\frac{m}{s})^2 + (19.28\frac{m}{s})^2} = \boxed{22.48\frac{m}{s}}$

$\theta = \tan^{-1}\left(\frac{11.56\frac{m}{s}}{19.28\frac{m}{s}}\right) = \boxed{30.94^\circ}$

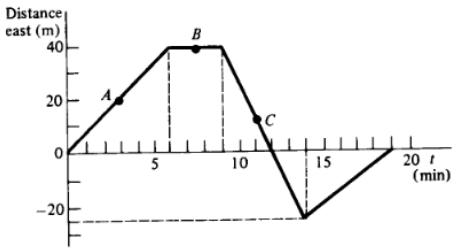
b) $v_{fy} = v_{oy} + at \rightarrow t = \frac{v_{fy} - v_{oy}}{a_y} = \frac{-30\frac{m}{s}\sin(50) - 11.56\frac{m}{s}}{-9.81\frac{m}{s^2}} = \boxed{4.23s}$

Could've also solved as a quadratic with $\Delta y = v_{oy}t + \frac{1}{2}at^2$

c) $\Delta x = vt = (19.28\frac{m}{s})(4.23s) = \boxed{81.55m}$

3.39 A girl walks along an east–west street, and a graph of her displacement from home is shown in Fig. 3-4. Find her average velocity for the whole time interval shown as well as her instantaneous velocity at points *A*, *B*, and *C*.

from 3,000 Solved Problems in Physics



$v_{avg} = \frac{\text{displacement}}{t} = 0$

A: $\frac{40m}{6\ min} = 6.67\ m/min$

B: $0\ m/min$

C: $\frac{-65m}{5\ min} = -13\ m/min$ East

from 3,000 solved problems in physics

3.44 A ball is thrown vertically upward with a velocity of 20 m/s from the top of a tower having a height of 50 m, Fig. 3-7. On its return it misses the tower and finally strikes the ground. **(*a*)** What time t_1 elapses from the instant the ball was thrown until it passes the edge of the tower? What velocity v_1 does it have at this time? **(*b*)** What total time t_2 is required for the ball to reach the ground? With what velocity v_2 does it strike the ground?

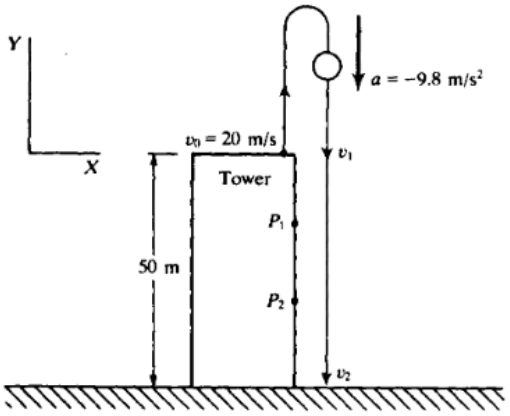


Fig. 3-7

$V_0 = 20 m/s$ a) $t_1 = ?$

$h = 50m$ $\Delta y = V_0 t + \frac{1}{2} a t^2$

$0 = V_0 t + \frac{1}{2} a t^2$

$0 = V_0 + \frac{1}{2} a t$

$t = \frac{-2V_0}{a} = \frac{-2(20 m/s)}{-9.81 m/s^2} = \boxed{4.08 s}$

$\boxed{V = -20 m/s}$

b) time to ground?

$\Delta y = V_1 t + \frac{1}{2} a t^2$

$\frac{1}{2} a t^2 + V_1 t - \Delta y = 0$ $\quad a = \frac{1}{2} a = \frac{1}{2}(9.81) = 4.905 \frac{m}{s^2}$

$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-20) \pm \sqrt{(-20)^2 - 4(-4.9)(50)}}{2(-4.905)}$ $\quad b = V_1 = -20 m/s$

$c = -\Delta y = +50 m$

$= 1.75 s, -5.83 s$ $\quad t_2 = 1.75 + 4.08 s = \boxed{5.83 s}$

$V_2 = -20 \frac{m}{s} - (9.81 \frac{m}{s^2})(1.75 s) = \boxed{-37.16 m/s}$