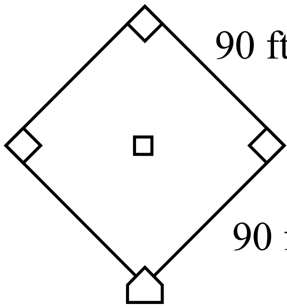
Chapter 2 Problem 46 †



Given

$t_{runner} = 3.4\ s$
$v_{pitcher} = 90\ mi/h$
$d_{pitcher} = 61\ ft$
$d_{bases} = 90\ ft$

Solution

Find the speed the catcher must throw the ball to put the runner out.

First we need everything in consistent units. In this case let's convert to meters for all distances.

$$d_{bases} = 90\ ft \left(\frac{0.3048\ m}{1\ ft} \right) = 27.4\ m$$

$$d_{pitcher} = 61\ ft \left(\frac{0.3048\ m}{1\ ft} \right) = 18.6\ m$$

The distance of the diagonal that the catcher must throw is

$$d_{catcher} = \sqrt{(27.4\ m)^2 + (27.4\ m)^2} = 38.7\ m$$

The velocity of the pitched ball is

$$v_{pitcher} = 90\ mi/h \left(\frac{1609\ m}{1\ mi} \right) \left(\frac{1\ h}{3600\ s} \right) = 40.2\ m/s$$

The time for the pitch to reach the catcher is

$$v = \frac{\Delta x}{\Delta t}$$

$$\Delta t = \frac{\Delta x}{v} = \frac{18.6\ m}{40.2\ m/s} = 0.463\ s$$

Time left for the catcher's throw to reach second base is

$$t_{catcher} = t_{runner} - t_{pitcher} - t_{rethrow} = 3.4\ s - 0.463\ s - 0.45\ s = 2.49\ s$$

The catcher's throw must be at a velocity of

$$v = \frac{d}{t} = \frac{38.7\ m}{2.49\ s} = 15.5\ m/s$$

†Problem from Essential University Physics, Wolfson

Converting to the original set of units

$$v = 15.5\ m/s\left(\frac{3600\ s}{1\ h}\right)\left(\frac{1\ mi}{1609\ m}\right) = 34.7\ mi/h$$

Rounding to 2 sig figs gives

$$v = 35\ mi/h$$