Answer on Question #50492, Physics / Mechanics | Kinematics | Dynamics

A ball is hit with 20 m/s velocity creating an angle of 30 degree. It is dropped after some time. 6 s after dropping, one fielder took the ball and threw it. At that moment a batsman achieves 1 run and started running for the 2nd run. After 3 s from throwing time, the ball hits the stump. To complete 1 run a batsman need minimum 6 s. Will the batsman got run out?

Solution:

First, determine the horizontal and vertical components of the initial velocity. We begin by looking at the motion in the y direction. We have the following.

$$v_{0y} = v_0 \sin\theta = \left(20\frac{m}{s}\right) \cdot (\sin 30°) = 20 \cdot 0.5 = 10\ m/s$$

$$v_{0x} = v_0 \cos\theta = \left(20\frac{m}{s}\right) \cdot (\cos 30°) = 20 \cdot 0.866 = 17.321\ m/s$$

$$a = g = -9.81\ \frac{m}{s^2}$$

Now we have to determine the time it took to land.

$$y = v_{0y}t - \frac{1}{2}gt^2$$

Since $y = 0$ at the end of flight we have:

$$0 = \left(10\frac{m}{s}\right)t - \frac{1}{2}(9.81\ \frac{m}{s^2})t^2$$

We solve the obtained equation for t.

$$\left(\left(10\frac{m}{s}\right) - \frac{1}{2}\left(9.81\ \frac{m}{s^2}\right)t\right)t = 0$$

Simplify the equation.

$$\left(10\frac{m}{s}\right) - \frac{1}{2}\left(9.81\ \frac{m}{s^2}\right)t = 0$$

$$\left(10\frac{m}{s}\right) - 4.905\frac{m}{s^2}t = 0$$

Then we can find the time of the ball in air.

$$4.905\frac{m}{s^2}t = 10\frac{m}{s}$$

Divide both sides by 4.905.

$$t = \frac{10\frac{m}{s}}{4.905\frac{m}{s^2}}$$

$$t = 2.039\ \text{s}$$

Now we can find the distance the ball travels before it hits the ground if we assume that the one fielder will not try to catch the ball.

$$x = v_x t$$

Substitute into the formula the find values.

$$x = 17.321\ \text{m/s} \cdot 2.039\ \text{s}$$

$$x = 35.313\ \text{m}$$

This mean the ball will travel 35.313 m.

Now we can determine the total time including the time of the ball in air and the time after dropping the ball.

$$t_{\text{total time}} = 2.039\ \text{s} + 6\ s = 8.039\ s$$

Thus, the total time since the ball was dropped and after dropping is equal to 8.04s. According to the condition of the task to complete 1 run a batsman need minimum 6 s, at 8.04s a batsman achieves 1 run, thus, we can conclude that the batsman got run out.