Physics Example From Knight – Friday Night Football

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CHAPTER 1

MOTION WITH CONSTANT ACCELERATION

1.1 Ex. 2.14 Friday Night Football

Given

Fred catches the football while standing on the goal line and he immediately starts running forward with an acceleration of $6\frac{ft}{s^2}$. At the moment that Fred catches the ball, Tommy is 20 yards away and is heading directly toward Fred with a steady speed of $15\frac{ft}{s}$. Neither player deviates from a straight-ahead path.

Find

Find where Tommy will tackle Fred.

Plan

Write equations of motion for Fred and Tommy, determine *when* they will be at the same location and use this time to find *where* the collision will occur. I'll use the same coordinate system for both Fred and Tommy with zero at the goal line and the positive direction coinciding with Fred's direction. Since the acceleration and velocity are provided with length dimensions in feet, I convert Tommy's initial position to feet.

Calculations

The equation for Fred's position:

$$x_F = \frac{1}{2}a_F t^2 + 0 \cdot t + 0$$

The equation for Tommy's position:

$$x_T = 0 \cdot t^2 + v_i t + 60$$

By setting these equal, we can solve for the time at which they will be at the same position.

$$\begin{aligned} \frac{1}{2}6t^2 &= -15t + 60 \\ 3t^2 + 15t - 60 &= 0 \end{aligned}$$

$$\begin{aligned} t^2 + 5t - 20 &= 0 \\ t^2 + 5t + \left(\frac{5}{2}\right)^2 &= 20 + \left(\frac{5}{2}\right)^2 \\ \left(t + \frac{5}{2}\right)^2 &= \frac{105}{4} \\ t &= \frac{-5 \pm \sqrt{105}}{2} \end{aligned}$$

Using only the positive time solution, we see that the collision occurs at

$$t = \frac{-5 + \sqrt{105}}{2}$$

or approximately at $t \approx 2.6s$.

We can substitute this value into either Fred's or Tommy's position equation to find out where the collision [presumably a tackle] occurs.

$$x_T = -15(2.6) + 60 = 20.6479 \approx 21 feet$$

or, right about the 7 yard line.

Solution

Tommy tackles Fred at the seven (7) yard line.