Answer on Question #46719-Physics-Other

A basketball player shot a ball. It left his hand at a height of $h_i = 2.05\ m$ above the court at an angle of $\alpha = 40$ degrees relative to horizontal, what initial speed did the ball have if it hit "nothing but net" at the basket $x_f = 4.50\ m$ away? Assume the rim is $h_f = 3.05$ m above the court.

Solution

The vertical equation of motion:

$$h = h_i + v_0 \sin\alpha\, t - \frac{gt^2}{2}.$$

The horizontal equation of motion:

$$x = v_0 \cos\alpha\, t.$$

The final coordinates are

$$h_f = h_i + v_0 \sin\alpha\, t_f - \frac{gt_f^2}{2};\ x_f = v_0 \cos\alpha\, t_f.$$

We have

$$t_f = \frac{x_f}{v_0 \cos\alpha}.$$

Then

$$h_f = h_i + v_0 \sin\alpha \left(\frac{x_f}{v_0 \cos\alpha}\right) - \frac{g\left(\frac{x_f}{v_0 \cos\alpha}\right)^2}{2} \to h_f - h_i = x_f \tan\alpha - \frac{gx_f^2}{2v_0^2 \cos^2\alpha}.$$

The initial speed of the ball is

$$v_0 = \frac{x_f}{\cos\alpha}\sqrt{\frac{g}{2(x_f \tan\alpha - h_f + h_i)}} = \frac{4.50}{\cos 40}\sqrt{\frac{9.81}{2(4.50 \tan 40 - 3.05 + 2.05)}} = 7.81\frac{m}{s}.$$

Answer: $7.81\frac{m}{s}$.