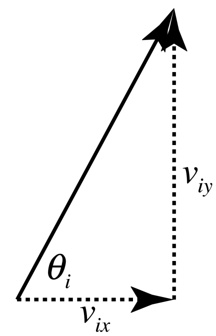
Flipping Physics Lecture Notes:
Nerd-A-Pult #2 – Another Projectile Motion Problem

The Nerd-A-Pult can be purchased at www.marshmallowcatapults.com



Example Problem: A ball is launched from the Nerd-A-Pult with an initial speed of 3.25 m/s at an angle of 61.7° above the horizontal. If the basket is 8.7 cm above the ball vertically, where should the basket be placed horizontally relative to the ball so the ball lands in the basket?

The initial velocity is the same as before, so we end up with the same components in the x and y directions.

$$\sin\theta = \frac{O}{H} \Rightarrow \sin\theta_i = \frac{v_{iy}}{v_i} \Rightarrow v_{iy} = v_i \sin\theta_i = (3.25)\sin(61.7°) = 2.86155\frac{m}{s}$$

$$\cos\theta = \frac{A}{H} \Rightarrow \cos\theta_i = \frac{v_{ix}}{v_i} \Rightarrow v_{ix} = v_i \cos\theta_i = (3.25)\cos(61.7) = 1.54079\frac{m}{s}$$

Now we can list our x & y direction knowns.

x-direction: $v_{ix} = v_x = 1.54079\frac{m}{s},\ \Delta x = ?$

y-direction: $\Delta y = 8.7cm \times \frac{1m}{100cm} = 0.087m;\ a_y = -9.81\frac{m}{s^2}$ (remember $g_{Earth} = +9.81\frac{m}{s^2}$)

We know 1 variable in x-direction and 3 variables in the y-direction, so we should start with the y-direction and find the change in time there. We would need to know 2 variables to start in the x-direction.

y-direction: We can solve for Δt in two ways (1) directly, using the quadratic formula, or (2) we can solve for v_{fy} first and then Δt. For completeness sake, I will show both. FYI: In my experience, more students make mistakes when trying to use the quadratic formula then when solving for v_{fy} first.

(1) $\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2 \Rightarrow 0.087 = 2.86155\Delta t + \frac{1}{2}(-9.81)\Delta t^2 \Rightarrow -4.905\Delta t^2 + 2.86155\Delta t - 0.087 = 0$

$$\Delta t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2.86155 \pm \sqrt{2.86155^2 - 4(-4.905)(-0.087)}}{(2)(-4.905)} = \frac{-2.86155 \pm 2.54588}{-9.81}$$

$$\Delta t = 0.291697 \pm 0.259519 = 0.551216\ or\ 0.0321784\sec \Rightarrow 0.55122\sec$$

(The time clearly isn't as small as ~3/100ths of a second & for the quadratic formula $a\Delta t^2 + b\Delta t + c = 0$)

(2) $v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y \Rightarrow v_{fy} = \sqrt{v_{iy}^2 + 2a_y\Delta y} = \sqrt{(2.86155)^2 + (2)(-9.81)(0.087)} = \pm 2.54588\frac{m}{s} = -2.54588\frac{m}{s}$

Please be smarter than your calculator and, anytime you take the square root, remember that the solution can be positive or negative. We know v_{fy} is negative, because we know the ball is going down.

$$v_{fy} = v_{iy} + a_y\Delta t \Rightarrow v_{fy} - v_{iy} = a_y\Delta t \Rightarrow \Delta t = \frac{v_{fy} - v_{iy}}{a_y} = \frac{(-2.54588 - 2.86155)}{-9.81} = 0.55122\sec$$

Notice that there is no confusion over which time to pick when you don't use the quadratic formula.

Now that we know the change in time, we can switch to the x-direction:

$$v_x = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = v_x\Delta t = (1.54079)(0.55122) = 0.849314m \times \frac{100cm}{1m} = 84.9314cm \approx \boxed{85cm}$$