Team 1967

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Calculations for 2012 FRC Game Robot Rumble

Instructions: Change only the items described by comments in red.
All other values and plots will be updated automatically

Shot Exit Velocity Calculation for a given launch height, distance from the hoop, and basket height

Givens & Constants

$\pi = 3.142$ Mathcad Constant Values

$g = 9.807 \frac{m}{s^2}$

Goal Heights: Defining the height of the game baskets

$h_{goal} := \begin{bmatrix} 28 \\ 61 \\ 98 \end{bmatrix} \cdot in$

$low := 0$

$mid := 1$

$high := 2$

Shot Parameters

Launch Height: $h_0 := 36\ in$

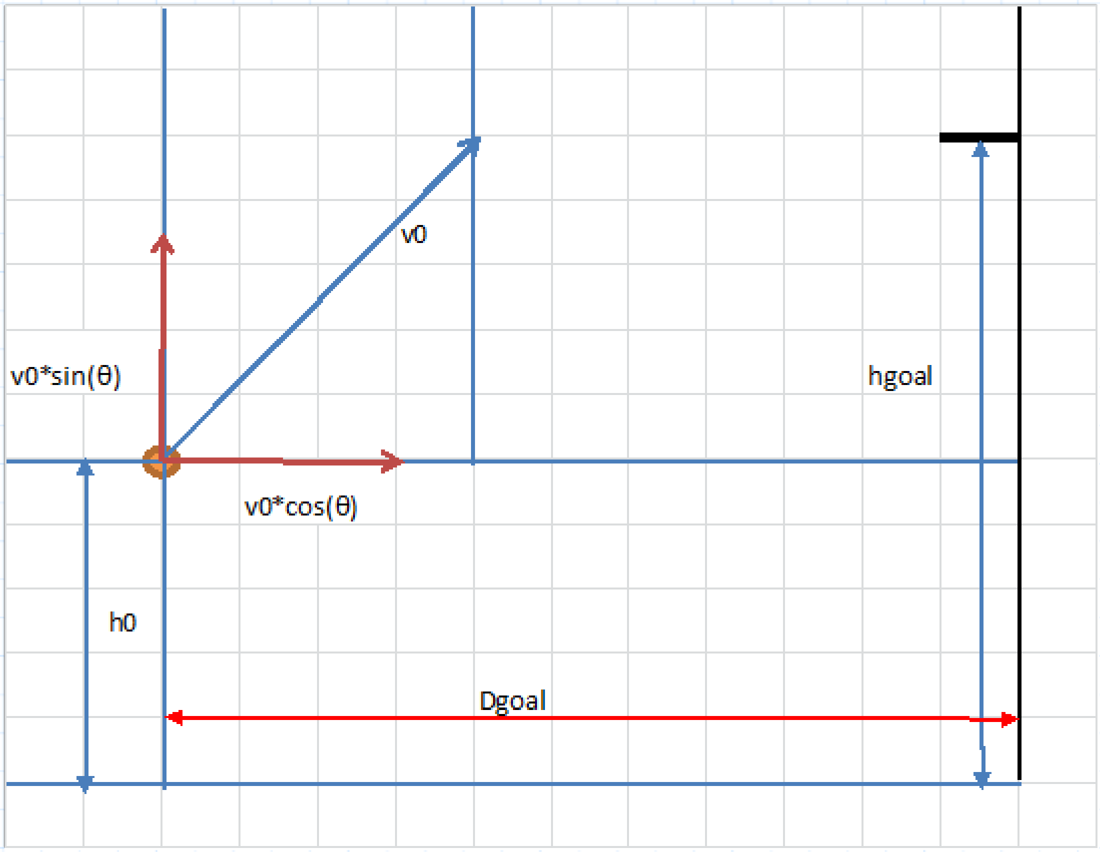
Launch Angle: $\Theta_0 := 45\ deg$

Shot Distance: $D_{goal} := 15\ ft$

Target Selection: $Target := 0$ Low = 0, Middle = 1, High = 2

$h_{goal_{Target}} = 2.333\ ft$

Calculation of the Initial Velocity Required to Reach the Basket



$$v_x = v_0 \cdot cos\left(\Theta_0\right) \qquad v_y = v_0 \cdot sin\left(\Theta_0\right)$$

$$x_d = v_x \cdot t \qquad y_d = \frac{-1}{2} \cdot g \cdot t^2 + v_y \cdot t + h_0$$

$$t = \frac{x_d}{v_x}$$

substitute into

$$y_d = \frac{-1}{2} \cdot g \cdot \left(\frac{x_d}{v_x}\right)^2 + v_y \cdot \frac{x_d}{v_x} + h_0$$

$$y_d = \frac{-g \cdot {x_d}^2}{2 \cdot {v_x}^2} + x_d \cdot \frac{v_y}{v_x} + h_0$$

In the Hidden Area a lot of Algebra Happens

Formula for Desired Initial Velocity

$$v_o = \sqrt{\frac{-g \cdot {x_d}^2}{2 \cdot cos\left(\Theta_0\right)^2 \cdot \left(y_d - x_d \cdot tan\left(\Theta_0\right) - h_0\right)}}$$

Formula Expressed in Terms of Worksheet Parameters:

$$Vel := \sqrt{\frac{-g \cdot D_{goal}^{2}}{2 \cdot \cos\left(\Theta_0\right)^{2} \cdot \left(h_{goal_{Target}} - D_{goal} \cdot \tan\left(\Theta_0\right) - h_0\right)}} = 21.496 \ \frac{ft}{s}$$

$D_{goal} = 15\ ft$ $\Theta_0 = 45\ deg$ $Target = 0$

$h_0 = 36\ in$ $h_{goal_{Target}} = 2.333\ ft$

Index vector for Creating a Plot with a Standard Increment

$$index := \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{bmatrix}$$

Note: This vector is used to generate all remaining data vectors and plots.

Calulating the ball trajectory over time

$V_x := Vel \cdot \cos\left(\Theta_0\right) = 15.2\ \frac{ft}{s}$ $V_y := Vel \cdot \sin\left(\Theta_0\right) = 15.2\ \frac{ft}{s}$

$$\Delta t := \frac{D_{goal}}{V_x} \cdot \frac{1}{\text{length}\left(index\right) - 1} = 0.09\ s$$

Note:
time, *distance*, and *height* are vectors. Open the Hidden Area below the definitions to view the data.

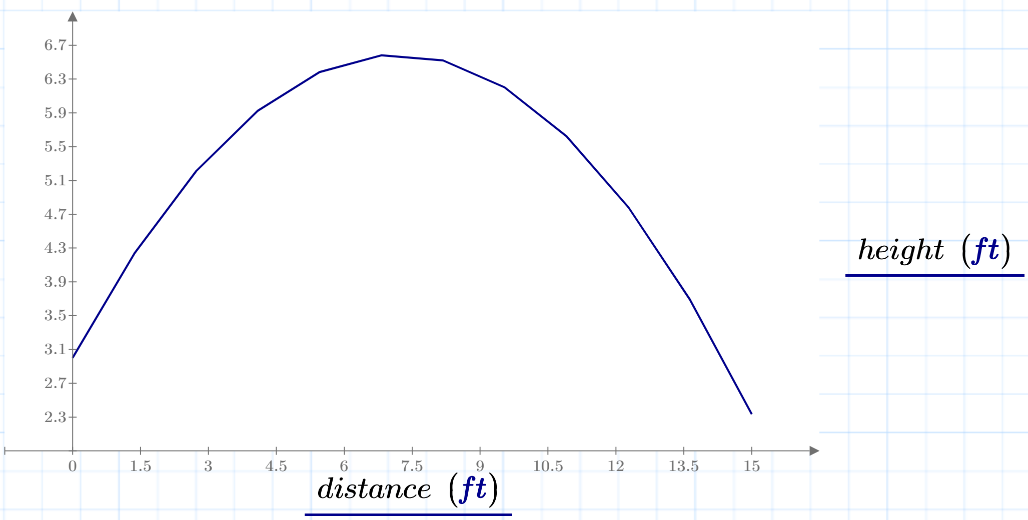
$$time := (index - 1) \cdot \Delta t$$

$$distance := time \cdot V_x$$

$$height := time \cdot V_y - \left(\frac{g}{2}\right) \cdot time^2 + h_0$$

Plot of ball trajectory: Distance from Robot vs. Height

$D_{goal} = 15\ ft$ $\Theta_0 = 45\ deg$ $h_0 = 0.914\ m$



Calculation of the Scoring Angle of the Ball

$$ScoringAngle := \text{atan}\left(\frac{height(\text{length}(index) - 1) - height(\text{length}(index) - 2)}{distance(\text{length}(index) - 1) - distance(\text{length}(index) - 2)}\right)$$

$$ScoringAngle = -44.826\ deg$$

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Calculating the needed shooting velocity as a function of the distance to the hoop

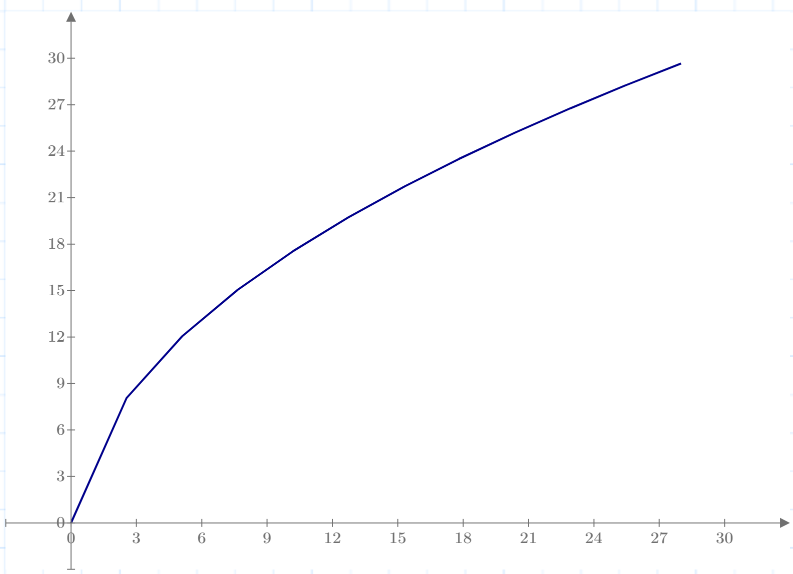
$maxShootingRange := 28\ ft$ Adjust maximum shooting range if desired

$$deltaRange := \frac{maxShootingRange}{\text{length}(index) - 1} = 2.545\ ft$$

$$Dist2Hoop := (index - 1) \cdot deltaRange$$

$$Vel\_d2h := \overrightarrow{\sqrt{\frac{-g \cdot Dist2Hoop^2}{2 \cdot \cos(\Theta_0)^2 \cdot \left(h_{goal_{Target}} - Dist2Hoop \cdot \tan(\Theta_0) - h_0\right)}}}$$

Desired Velocity vs. Distance from Goal for Launch Angle $\Theta_0 = 45\ deg$



$Vel\_d2h\ \left(\frac{ft}{s}\right)$

$Dist2Hoop\ (ft)$

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Calculation of the launch velocity needed for different launch angles

Shot Parameters

$maxAngle := 80\ deg$ Adjust the angle range if desired

$minAngle := 10\ deg$

$$deltaAngle := \frac{maxAngle - minAngle}{\text{length}(index) - 1} = 6.364\ deg$$

$$Angle := (index - 1) \cdot deltaAngle + minAngle$$

$$Vel\_Angle := \overrightarrow{\sqrt{\frac{-g \cdot D_{goal}^{\ 2}}{2 \cdot \cos(Angle)^2 \cdot \left(h_{goal_{Target}} - D_{goal} \cdot \tan(Angle) - h_0\right)}}}$$

Plot of the launch velocity vs. launch angle for a constant distance to the hoop

$D_{goal} = 15\ ft$