2008 IEEE Region 2 Student Activities Conference
Physics Problem
April 5, 2008

Physics Competition Preliminary Write Up

This problem will test a student's knowledge of elementary physics in the area of projectiles in motion. Your job will be to determine the launch angle of the projectile launcher. This will require you to use the equations below and some trigonometric identities. When you come to CAL 155, bring your problem all worked out and be ready to verify if you were correct. You will need to be able to prove your solution without the use of software (ex. Matlab, Excel, ect..)

X direction	**Y direction**
$v_{ox} = v_o \cos(\theta)$	$v_{oy} = v_o \sin(\theta)$
$x = v_{ox}t + \frac{at^2}{2}$	$y - y_1 = v_{oy}t - \frac{gt^2}{2}$
$v_x{}^2 = v_{ox}{}^2 + 2ax$	$v_y{}^2 = v_{oy}{}^2 - 2gy$
$v_x = v_{ox} + at$	$v_y = v_{oy} - gt$
$x = v_{xo}t$	$g = 9.81 m/s^2$

Hints

- $\sin\theta = \sqrt{1-\cos^2\theta}$
- You may want to use a substitution to make to problem easier to solve.

$$z = \cos^2\theta$$

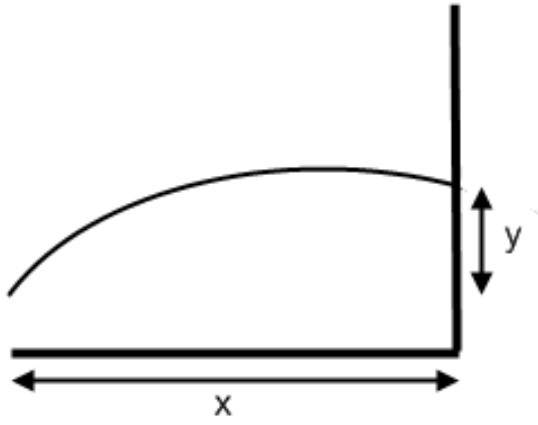
The Set Up

You will need to set the launch angle of the projectile launcher knowing that there will be a few parameters given to you. You will have 2 attempts at firing the launcher and the time for testing your solution will need to be between 1PM & 4PM.

$\Delta y = 0.76m$

$V_o = 6.1 m/s$

$x = 2.4m$



$$V_{ox} = \frac{x}{t} = V_o \cos\theta, t = \frac{x}{V_o \cos\theta}$$
$$V_{oy} = V_o \sin\theta$$

$$y = V_{oy} t - \frac{1}{2} g^2$$
$$\Delta y = \frac{(V_o \sin\theta)x}{V_o \cos\theta} - \frac{1}{2}(g)\left(\frac{x^2}{V_o^2 \cos^2\theta}\right)$$
$$\Delta y - x\frac{\sin\theta}{\cos\theta} = -\frac{1}{2}(g)\left(\frac{x^2}{V_o^2 \cos^2\theta}\right)$$
let
$$k = -\frac{gx^2}{2V_o^2}$$
$$\Delta y \cos^2\theta - x\sin\theta\cos\theta = k$$
$$\Delta y \cos^2\theta - x\cos\theta\sqrt{1-\cos^2\theta} = k$$
$$-x\cos\theta\sqrt{1-\cos^2\theta} = k - \Delta y\cos^2\theta$$
$$x^2\cos^2\theta(1-\cos^2\theta) = \Delta y^2\cos^4\theta - 2k\Delta y\cos^2\theta + k^2$$
let
$$z = \cos^2\theta$$
$$x^2 z - x^2 z^2 = \Delta y^2 z^2 - 2k\Delta y z + k^2$$
$$(-x^2 - \Delta y^2)z^2 + (x^2 + 2k\Delta y)z - k^2 = 0$$

Now_use_Quadratic_formula
$$z_{1,2} = \frac{(-x^2 - 2k\Delta y) \pm \sqrt{x^4 + 4k\Delta y x^2 + 4k^2\Delta y^2 - 4k^2x^2 - 4k^2\Delta y^2}}{-2x^2 - 2\Delta y^2}$$
$$= \frac{(-x^2 - 2k\Delta y) \pm \sqrt{x^4 + 4k\Delta y x^2 - 4k^2x^2}}{-2x^2 - 2\Delta y^2}$$

So…

$$z_1 = 0.16070146$$
$$z_2 = 0.56605573$$
$$\theta = \arccos\left(\sqrt{0.56605573}\right) = 41.2^o$$