**Parametric Equations Lab**

**Learning Outcomes**

Upon completion student will experience application of parametric equations and their utility in modeling a real world problem.

**Objective & Background**

We want to develop our understanding of parametric equations by studying the flight of a projectile. The projectile, called a “rocket” because of its look, is really just a ballistic missile. This is because it behaves like a falling body after the initial impulse of velocity. Note: By definition, a *rocket* has a propulsion system and is therefore not a falling body, while a *ballistic missile* is a falling body that is also moving laterally. For example: a ball tossed from one person to another is a ballistic missile. Since this involves motion in two dimensions, where each is a function of time, then we will map this two dimension motion on a two dimension graph with time imbedded (i.e. time is not an axis on the graph) as a parameter. The X-coordinate of the rocket’s position will be a rectilinear function of time, . Visualize this as the noon-time shadow of the rocket on the ground being recorded as a map on the X-axis. Similarly, the Y-coordinate of the rocket’s position will be a separate rectilinear function of time, . Visualize this as the late-evening shadow of the rocket on a vertical wall being recorded as a map on the Y-axis. We will set up our coordinate system so that the initial X-coordinate is , then based on the picture below the parametric functions are given in the box at right.

The flight path is described by:





Where the initial velocity vector is:



And the initial height is

Actual Flight Path













See launch pad detail below right

Launch Pad Detail

Launch Angle





Labeled Wedge Angle



**Equipment Setup**

Mount the rocket launch tube to the launch pad by inserting the four bolts from the hinged side of the board through to the other side and placing the launch tube on the exposed end of the bolts, then attaching the wing nuts to secure the tube in place. The two nails are for securing the launch pad in position on the ground [hint: what does this mean about the initial height?]. There are several wedges to provide different launch angles. Each time the rocket is to be launched, you must first snap a grommet onto the launch tube then slide the rocket onto the tube/grommet. Be sure the rocket is seated firmly into place. Attaching a pressurized air source to the launch tube provides the impulse of initial velocity. When the air pressure overcomes the friction of the grommet, it forcefully discharges, taking the rocket with it. CAUTION: stay out of the way! The grommet should stay seated inside the rocket during flight and must be punched out before attempting another launch. Occasionally the grommet will come loose during flight or at impact, so keep watch for these, we don’t want to lose the grommets.

**Field Assignment**

Start with the “low” grommet, and do the following:

1) Choose and record the wedge angle, 

2) Record the grommet size

3) Launch the rocket and record the distance,  from launch pad to impact point

4) Repeat steps 1 - 3 for three more launches and average the distances.

If time allows repeat steps 1 - 4 for the “med”, “high”, “super” grommets at various angles.

**Lab Assignment**

For each set of flight distance data that was recorded and averaged:

1) Determine the launch angle, , which is related to the wedge angle .

2) Calculate the flight time, 

3) Calculate the initial velocity, 

4) Calculate the maximum height, 

**Expected Results**

Type a lab report that includes:

1) The objective and description of how it will be achieved.

2) A table of measured data and calculated values (include one sample calculation for each type).

3) An analysis of the position functions (why no  in the X, why cosine in X but sine in Y, etc.).

4) Any conclusions you can make by comparing/contrasting across grommets and launch angles.

5) Rewrite the parametric functions as .

6) As a bonus, prove mathematically that complementary launch angles with the same initial velocity will produce the same impact distance (though different flight times)

7) A summary of your experience.