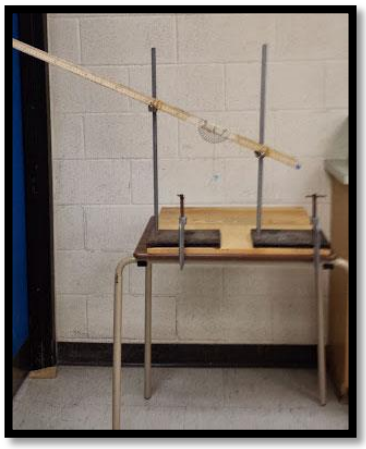
AMAZING PROJECTILE MOTION COMPETITION

BACKGROUND



First there was Aristotle – "objects continue in a straight path, and then suddenly plop out of the air." Galileo theorizes, "the horizontal and vertical components of the velocity are independent of one another, thus projectiles follow the path of a Parabola."

The present; can your team win the *Amazing Projectile Competition* by accurately calculating and launching a projectile onto a target?

THE PROBLEM

You (or your team) must launch a projectile (washer connected to an elastic) at some angle from a launcher (meter stick inclined at some angle) and hit a target a given distance away. Being successful at this will require some preliminary calibrations and experiments, as well as, deriving equations based on theoretical considerations.

CALCULATIONS and CALIBRATIONS

Some preliminary calculations and calibrations are required before the launch day if you are going to be successful.

DETERMINING "MUZZLE" VELOCITY

In order to be eligible for the competition you must calibrate your launcher. You must determine the "muzzle" velocity of the apparatus as a function of the stretch of the elastic. The "muzzle" velocity of an object shot vertically into the air, given that the spring is pulled back a fixed distance (*e.g.* 14 cm). The following equation will help you.

$\Delta d_y = v_{1y}\Delta t + \frac{1}{2}a\Delta t^2$, launching the projectile vertically and measuring the time to go up and come back down to the same height → $\Delta d_y = 0$ and $v_{1y} = v_m$ (muzzle velocity).

Therefore, $0 = v_m\Delta t + \frac{1}{2}a\Delta t^2 = \Delta t(v_m + \frac{1}{2}a\Delta t)$. Solve for v_m.

Determine the "muzzle" velocity as a function of elastic stretch, Δs. Do a number of trials to find the average and try many different stretch distances. *Be careful that you don't over stretch the elastic or else your launcher will experience non-linear behavior.* **Plot the "muzzle" velocity on the y-axis and stretch on the x-axis**. This is your calibration curve for your launcher.

ANNOTATED DERIVATION

Provide an annotated derivation for

1. an equation for Δs, the stretch, as a function of range, Δd_x, and θ.
2. an annotated derivation for the maximum height, $\Delta d_{y,max}$, as a function of Δs and θ.
3. an annotated derivation for the range, Δd_x, of the launched projectile as a function of the elastic stretch, Δs, and θ.

An annotated derivation is a derivation in which each step is fully justified with a clear written explanation.

THE COMPETITION

1. You get three launches. After each launch the angle, θ, is changed by the teacher, but the range, Δd_x, will stay the same.
2. Using your equation for the stretch, Δs, as a function of angle and range, you will determine the stretch required to hit the target.
    a. Your Δs equation must be entered into ***Wolfram Alpha*** [http://www.wolframalpha.com] and be ready on your phone for the launch day so you can do the calculations quickly.
    b. You can also use a ***QR Code*** barcode to save the Wolfram Alpha equation as a 2-dimensional barcode which you can then scan and get to your equation on the launch day. [http://qrcode.kaywa.com/]
3. The theoretical maximum height and distance are also calculated and evaluated for each launch.
4. See marking rubric for scoring.

On the competition day the following materials must be handed in.

1. ***Type written report*** – with full justification (justified left and right)
    a) Title page; including Title, Name(s), Course Code, teacher, due date
    b) Introduction, problem
    c) Data tables for determination of "muzzle" velocity, plus calibration graph, include table and figure captions. Include the derivation for how the muzzle velocity was found using Δt. See front of sheet.
    d) Annotated derivations for the three main equations – using equation editor.
    e) One sample calculation for each of the derived equations – using equation editor
    f) Launch day calculation pages at the end of the report in the appendix; must be present on the day of the launch as blank pages attached to the document.
2. ***Marking Rubric*** – do not staple it to the report

The Amazing Projectile Competition - Marking Rubric

[hand this rubric in with your report on the competition day. Do not staple it to the report! Also, keep this rubric sheet as a record of correspondence between your team and the teacher.]

NAME(S): _____ _____

Category	Level 0/1	Level 2	Level 3	Level 4
Title page	Missing	Missing 2 items	Missing 1 item	Well done
Introduction	Missing either the introduction or the problem definition	Missing some key components in the intro and problem definition	Introduction and problem clearly defined and well written	Extremely clear, very well written introduction and outline of the problem
Data tables	Missing more than 2 items or not included.	Missing 2 items of importance	Missing one item of importance	Complete and accurate with all labels, units and trials
Graph(s)	Missing two or more pieces of information, missing or inaccurate	Missing two pieces of information or very inaccurate	Missing one piece of information, or slightly inaccurate	Complete, accurate, title, label, line of best fit, equation of line, units, etc.
Annotated derivation #1 [stretch]	Derivation is incorrect, and or annotation is very unclear or missing.	Derivation correct. Annotation is unclear. Missing 2 key points.	Derivation correct. Annotation is slightly unclear, missing a key point.	Well annotated, correct, well presented, variables are clear and defined.
Annotated derivation #2 [max height]	Same as above	Same as above	Same as above	Same as above
Annotated derivation #3 [range]	Same as above	Same as above	Same as above	Same as above
Sample Calculations	Missing 2 or more calculations – or none at all.	Missing one calculation	Clear, correct, units missing or steps missing	Clear, correct, units included.
Performance [0-3] → rescaled out of 4				
Calculations (launch day)	Launch day calculations not completed	NA	NA	Stretch calculations completed and accurate
Style, grammar, spelling and report layout [Overall Impression]	Very difficult to read, due to grammar and spelling or style was very sloppy.	Not very well written. Many grammar or spelling mistakes	Well written, very few grammar and no more than 1 spelling mistake. Good style.	Well written, Very few grammar and no spelling mistakes. Excellent style.

TOTAL: /40

NOTES: