Catapult Lab

A catapult is a device designed to launch a projectile some distance. Catapults and trebuchets were popular medieval weapons of mass destruction. They allowed warriors to launch projectiles and burning materials into castles, across rivers, etc.

This lab uses a relatively decent toy to measure the effect of angle and force on the vertical and horizontal components of motion. The motion is pretty much the same for each event which makes it a fun activity that produces results that you can replicate over and over again.

To the left, you see an image of the toy. A foam cat (projectile) is placed on the launching mechanism and another foam cat is dropped on the platform. The platform moves and ejects the original cat at an angle so that it has a vertical and horizontal components of motion that form a resultant velocity vector.

There are two levers that you can adjust. The orange lever adjusts the throw angle. The green lever adjusts the force of the throw. We can't measure the force of the throw, but you can estimate the throw angle with a protractor.

Materials:

3 meter sticks 1 catapult toy at least 2 foam cats 1 ruler

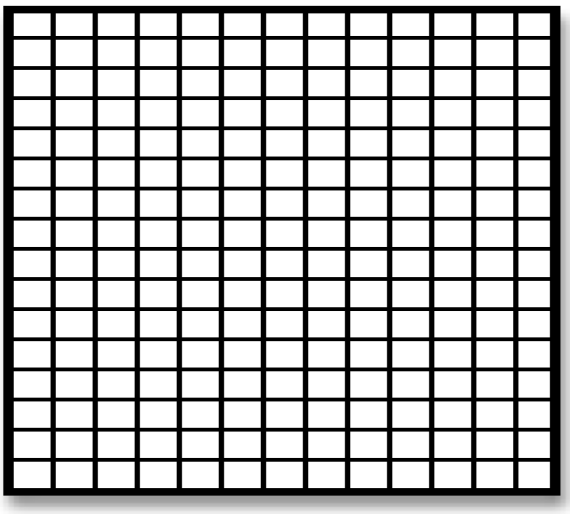
Note: It is easy for the foam cats to disappear. Please keep track of them. They are impossible to replace.

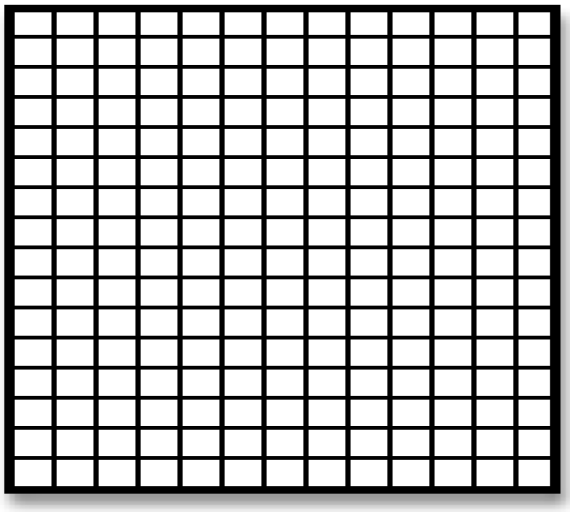
Part 1: Force

1) Set up the catapult on the floor. It is useful to use a bit of masking tape to keep it in place. Each launch causes it to rotate ever so slightly.
2) Lay two meter sticks end to end so that the zero mark of the first one is at the sitting position of cat. This will allow you to measure the horizontal distance.
3) Set the green lever to the 1st position. Green = Force. Set the angle lever to 1 and leave it there for this part.
4) Launch the cat by dropping a second cat onto the platform and make a note of where it is horizontally when the vertical distance is highest. This is a practice run. Have a partner put a vertical meter stick at this position. They will need to make note of the maximum height or apex for each trial.
5) Measure the horizontal distance to where the cat hits the floor, not where it rolls. Measure the height. Repeat two more times and average your data.
6) Set the green lever to the second position and repeat steps 4-5.
7) Do this for all the green lever settings.
8) Make a graph of the green lever value to the height and another of the green lever value to the horizontal distance.

Part 1: Data

Green Lever	Force				
	1	2	3	4	5
horizontal 1					
horizontal 2					
horizontal 3					
horizontal ave					
vertical 1					
vertical 2					
vertical 3					
vertical ave					



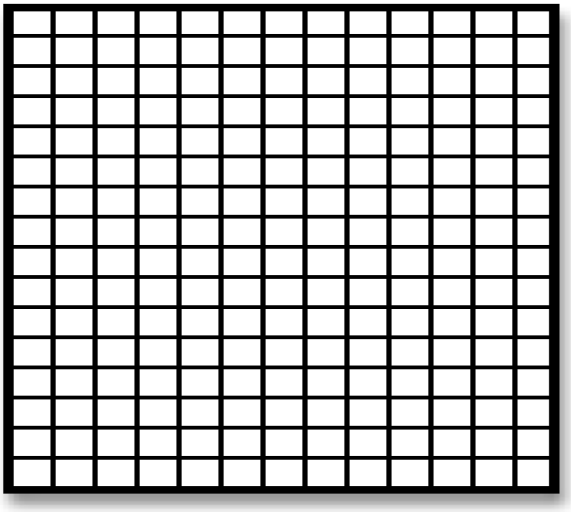


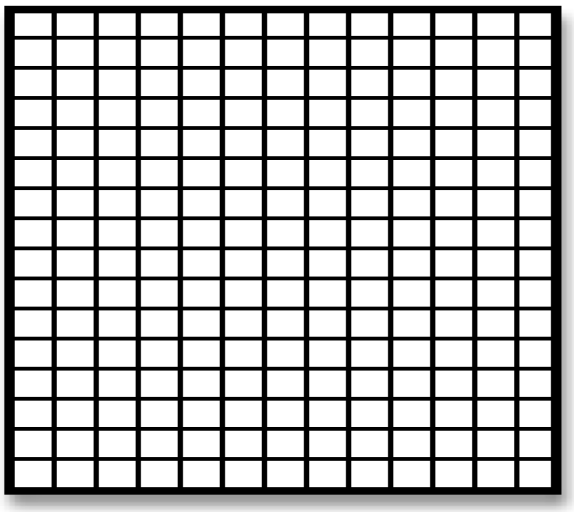
Part 2: Angle

1) Leave the catapult set up as before. Set the force lever to maximum and leave it there for this part of the lab. Set the orange lever to 1.
2) Place the ruler so that it follows the approximate launch angle. Use a protractor to measure this.
3) Launch a cat and measure the height and horizontal distance. Repeat two more times and average your values.
4) Change the orange lever to setting 2 and repeat steps 2-3.
5) Do this for all the orange lever settings.
6) Make a graph of the orange lever value to the height and another graph of the orange lever value to the horizontal distance.

Part 2: Data

Orange Lever	Angle 1	2	3	4	5
horizontal 1					
horizontal 2					
horizontal 3					
horizontal ave					
vertical 1					
vertical 2					
vertical 3					
vertical ave					





Data Analysis:

1) What is the shape of the graph for force to vertical height? What does it mean?

2) What is the shape of the graph for force to horizontal distance? What does it mean?

3) What is the shape of the graph of angle to vertical height? What does it mean? (This one might surprise you.)

4) What is the shape of the graph of angle to horizontal distance? What does it mean?

Conclusion:

Write a statement that explains the impact of force on height and horizontal distance:

Write a statement that explains the impact of throw angle on height and horizontal distance. Explain the odd shape of the graph clearly.

Use the vertical height to determine how long the cat was in the air for one force and one angle average data.
$t=\sqrt{2s_v}/g$

Use the time and $v_f = gt$ to determine the initial vertical component of motion for these two situations:

Use the horizontal distance and the time you calculated above to determine the horizontal velocity for these two instances using $s_h/t_{total} = v_h$

Finally, solve for the resultant velocity for these two instances using Pythagorean theorem.

Bonus: Set up 10 catapults and make a chain reaction where one cat sets off the next cat. If you get all 10, and your instructor sees it, you get bonus points. It is legal to videotape the event with your phone, if necessary. Rules: Each device must have a different combination of settings. Hint: tape the units in position.