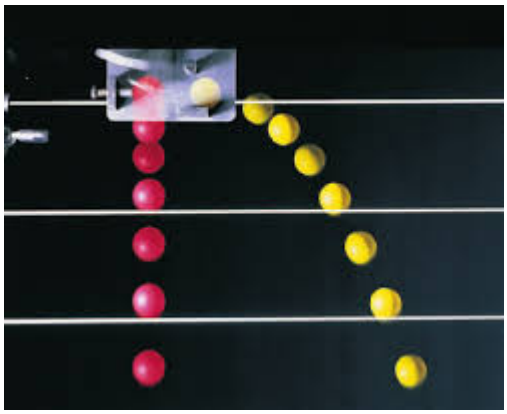
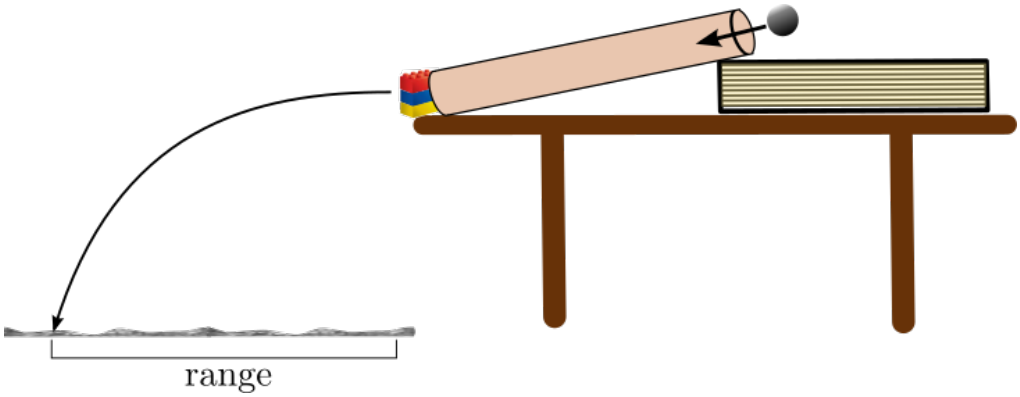
Gravity and Projectiles



- **Gravity** is a force that pulls all objects towards the center of the Earth.
- Gravity makes all objects fall at the same rate, regardless of how heavy they are.
- A **projectile** is an object that is both flying forward and falling, with only gravity pulling on it
- The horizontal and vertical motion of a projectile are described separately.
- **Time of flight:** how long the projectile flies before hitting the ground.
- **Projectile range:** how far the projectile goes horizontally before hitting ground.

Part 1: Lego Ballistics



1. Cut a sheet of aluminum foil at least 2 feet long. Place it next to the edge of a table. Tape it down so that it doesn't move. Warning: if you have wooden or tile floors, you may want to put a towel beneath the foil to protect the floor!

2. Make a mark right below the edge of the table.

3. Make a ramp from a paper-towel tube by placing a 1 in. thick book under one end.

4. Connect three Lego blocks into a stack. Place the stack right on the edge of the table. Point the opening of the paper towel tube at the stack.

5. Roll a marble from the top end of the tube. It should hit the Lego stack and knock it to the floor. Do a trial run to make sure it lands on the foil, and adjust your aim if needed.

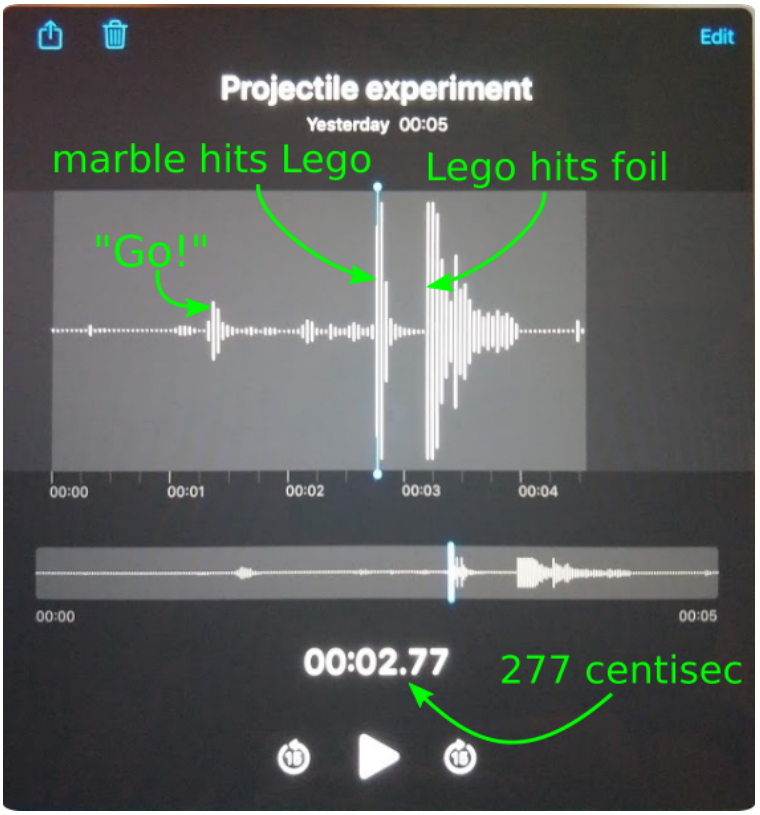
6. Make a mark on the foil at the place where the Lego first hits the floor.

How far <u>horizontally</u> from the edge of the table did the Lego piece land? (Measure the distance between your two marks):

Range of Lego: _____ in

7. To measure the time of flight, we will use the "Voice Memos" app on your school tablet. Place the iPad on the table right next to where the marble will hit the Lego.

8. Hit the red circle to start recording. Say "Go!" as you release the marble. Keep recording until the Lego hits the foil on the floor. Then hit pause.



9. Play back your recording. The wave-forms show how loud the recorded sound is at each time. Find the peaks that correspond to the marble hitting the Lego and the Lego hitting the foil.

10. Move the recording so that the blue line matches the peak when the marble hit the Lego. The white number on the bottom tells you precisely the time when this happened.

If you ignore the ":" and the decimal point, you get a time in "centiseconds" (a centisecond is one-hundredth of a second). Record that number below. Then find the peak for the Lego hitting the floor and record that.

Time when marble hit Lego: _____ centiseconds

Time when Lego hit floor: _____ centiseconds

11. Calculate the **time of flight** for the Lego. Get this by subtracting the time it was hit by the marble from the time it hit the floor.

Lego time of flight: _____ centiseconds

12. Now make a prediction:
What will happen if you make the ramp steeper by adding a second book beneath it?

The range of the Lego should: (circle one)
increase decrease stay about the same

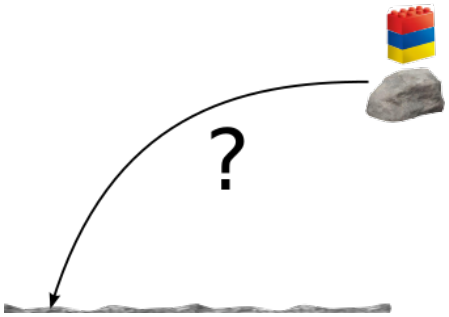
The time of flight should: (circle one)
increase decrease stay about the same

13. Repeat the measurements above and find out if your predictions were right!

Range of Lego, with steeper ramp: _____ inches

Time of flight of Lego with steeper ramp: _____ centiseconds

Part 2: Launching Rocks



1. Compare your Lego and your rock, in terms of **size**.
Which one is bigger in volume (size)?:
Lego rock about the same

2. Compare your Lego and rock in terms of **weight**. If you're not sure which is heavier: Hold a ruler exactly in the middle. Place the rock on one end and the Lego on the other. Relax your hold on the ruler. It will topple towards the heavier object.

Which one is heavier?: Lego rock about the same

2. Make a prediction. If we replace the Lego with a rock in our experiment,

What will happen to the range?
The rock will fly: Farther less far about the same

What will happen to the time of flight?
The time of flight for the rock will be: longer shorter about the same

3. Do the measurements and find out!
Range of rock: _____ inches

Time of flight for rock: _____ centiseconds