Motion 4 - Forces

The two most famous equations of physics are $F = ma$ and $E = mc^2$. Today we learn about $F = ma$, also known as, Newton's 2nd Law of Motion.

Newton's 3 laws describe how objects move.

1st Law - Inertia - says objects won't change their motion for no reason.

2nd Law - Forces - gives the equation when an object WILL change their motion.

3rd Law - Equal and opposite - states what happens when two objects run into each other.

Newton's 2nd Law

Most people know Newton's 2nd Law as 'force equals mass times acceleration', $F = ma$. That is only partially correct. As you blossom into adulthood, you are now old enough to learn that 'the sum of all forces equals mass times acceleration',

$$\sum F = ma$$

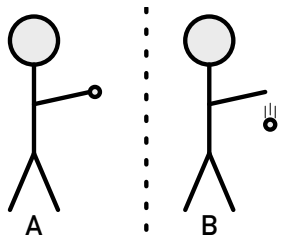
is much more correct. The symbol $\sum$ means 'sum of all', or, 'add all together'.

Looking at the equation there are only 3 parts; sum of all forces, mass, and acceleration. Mass is almost always constant, so the only two parts that need examined are the sum of all forces and acceleration.

Sum of all Forces

Sum of all forces can be explained by the difference in the two pictures at the right. In picture A, the ball is not moving BECAUSE the sum of all the forces is zero. The hand is holding the ball with enough force to oppose gravity, canceling out the force of gravity.

In picture B, the ball is falling, because the only force acting on the ball is gravity, and with no other force acting on it, it falls.



Acceleration

Acceleration is a change in motion, and most easily understood comparing when something is accelerating, and when something is not.

Something IS NOT Accelerating if:

- Moving at a constant speed
- Not moving at all

Something IS Accelerating if:

- Speeding up
- Slowing down
- Turning a corner

Activity

The most common force is gravity. It is so common that you cannot fathom (imagine) a world without gravity. Gravity pulls everything together, but since the earth is so much bigger than everything else around, we experience gravity as a downward pull. In fact, we define 'down' as the direction gravity pulls us!

As you have just learned, where there is a force, there is also an acceleration. You have also just learned that you can measure the acceleration by collecting time and distance data. Putting those together you will measure the acceleration of gravity!

Setup - Procedure

- Each member of your group should pick a different object to drop. Note, they cannot be too heavy or you will break things or too light because air resistance will play a part.
- Record a video of each team member dropping their object.
  - Keep the camera still
  - Have a meter stick in the background for calibrating the video
  - **Note;** if you have an iPhone or a phone capable of taking high speed, or slow motion footage, you should use it for this activity. Ask permission to use your phone so you don't get in trouble.
- Each group member should process their own video using the *Tracker* application.

Questions for Labbook

Make sure you have correctly labeled axis on your sketches.

- Sketch the following plots for your dropped object:

X-axis vs **Y-axis**
t vs y
t vs vy (velocity-y)
t vs ay (acceleration-y)

- Sketch the plot of each group members time vs ay (acceleration-y) plot into your notebook.
- Compare your results for the acceleration due to gravity (the y-acceleration plots) with your group-mates.

Cleanup

- Fill out and turn in the form indicating your chosen objects and that you each did your own work for your group.
- Return the flash drive with the 'Tracker' app.
- Return your chosen objects to their proper place.