The Accelerometer

Do you ever wonder how your smartphone detects if it's in portrait or landscape mode? Or how your Wii Remote detects when it moves suddenly? Or how if you tilt your phone while playing a game, you can affect some action on screen?

The device responsible for that is the ***accelerometer***.

Acceleration

Before we understand an *accelerometer*, we have to understand *acceleration*... given the names they are probably related.

What is acceleration?

If you have a car that *accelerates* from 0 to 100 km/h in 10 seconds. The *acceleration* is the *change* in velocity (or speed) over time. So that equals 100/10, or 10 km/h per second. Every second, we increase our speed by an additional 10 km per hour. So we *accelerate* at 10 km/h per second.

If you were in a car, you could measure this with a stopwatch. If you start the stopwatch when you start driving, after a few seconds, look at the speed, and you would be able to calculate the *acceleration*, by dividing the speed after at the end by how many seconds have elapsed.

This requires you to wait, however, what if we're lazy and we want the answer *now* instead of waiting? To do this, we can use Newtown's Second Law of Motion, which is simply:

$$\text{Force} = \text{mass} \times \text{acceleration}$$

or

$$F = ma$$

Sound familiar? We can rearrange that equation (remember that algebra thing... yeah, we're going there):

$$a = \frac{F}{m}$$

What does that equation mean? The acceleration (a), is the amount of force (F) required to move each unit of mass (m). If we know a **mass** and can measure the **force**, we can calculate the **acceleration**.

Measuring Force

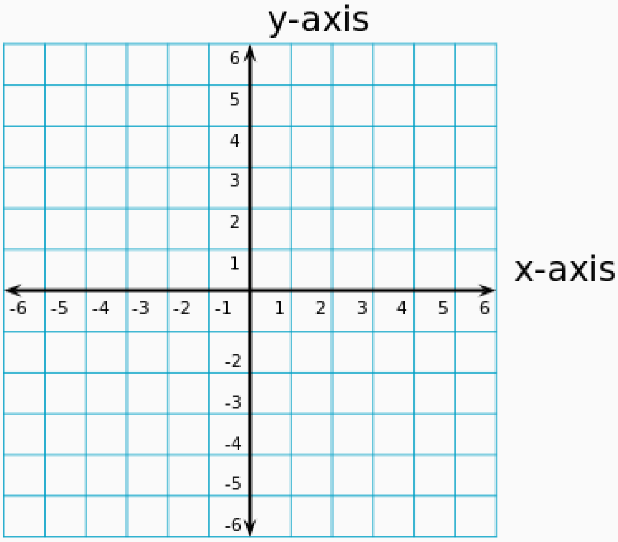
How do we even do that? Imagine we have a ball (which has a mass that we know), and attach it to a spring inside an enclosed container. If we pick up the container and move it upwards (shown below), the spring will either stretch or compress to change its length.

The length the spring change is proportional to the amount of force being placed on the ball. So we can measure how far the spring moves, then we know the **force**, we also know the **mass**, so we can calculate the **acceleration**.

Axes

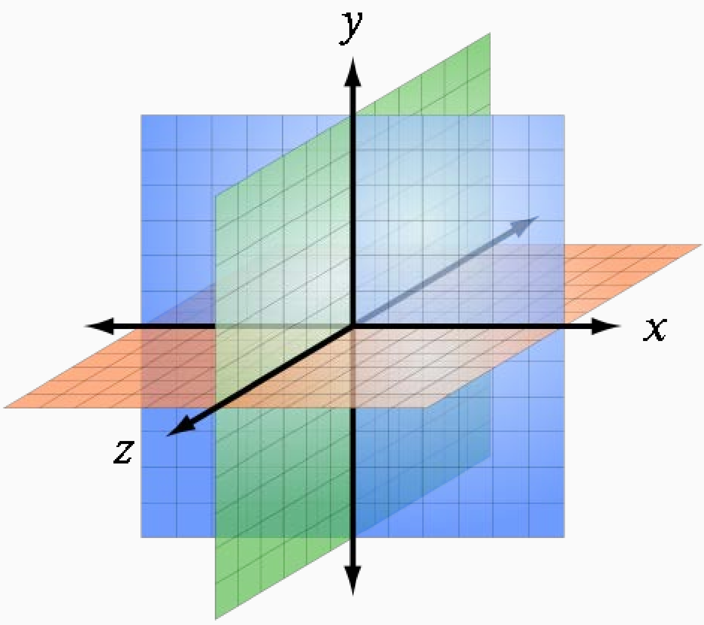
Our accelerometer doesn't just tell us the force in one direction, it tells us the force is *three* different directions. So instead of the one spring-ball-container, we get *three* spring-ball-containers, and place them in the directions we want to measure. We refer to each of these three different directions (we have to give them a name - so we can refer to them) as the *x, y* and *z* direction.

Remember how we draw axes on plots in maths class?



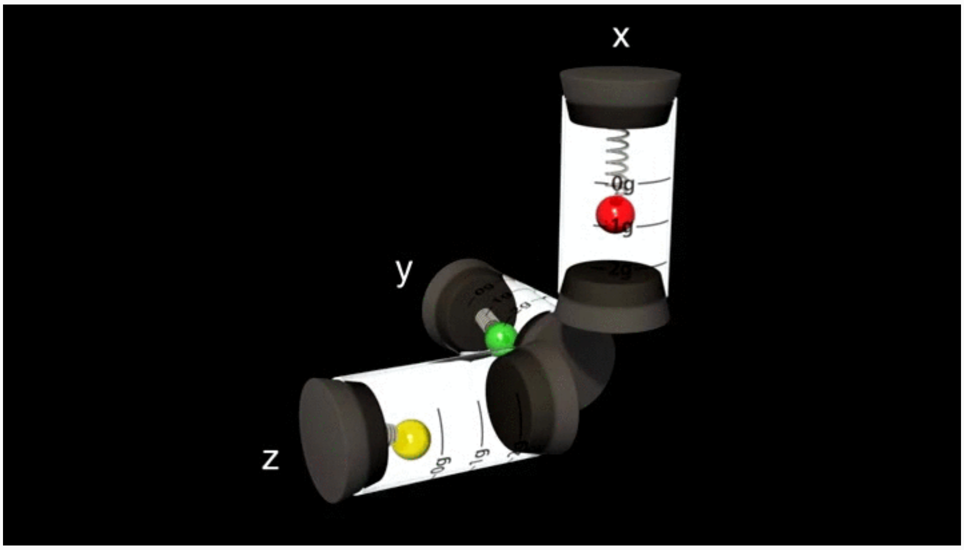
So the *x-axis* goes to the left and right, the *y-axis* goes up and down, but what about the *z-axis*? The z-axis comes out of your computer monitor. So you are looking down the z-axis, right now.

If we want to represent the three axes in 3-dimensions (3D), we can draw them like so:



Using the spring-ball-container representation, we point them in the three different directions, *x, y,* and *z*, to measure the force in each axis:

When we rotate the accelerometer, we can detect the force on each axis.



Now the spring-ball-container isn't exactly the form which the accelerometer takes.
It's a little complicated, and beyond the scope of this course to learn that type of thing, but if you really want to know then this youtube video explains how we can make this spring-like mechanism on a silicon chip.
Reference:

- https://www.youtube.com/watch?v=KZVgKu6v808
- https://commons.wikimedia.org/wiki/File:3D_coordinate_system.svg
- https://commons.wikimedia.org/wiki/File:2D_Cartesian_Coordinates.PNG

Accelerometer Values

So what does the accelerometer actually give us anyway? It does this stuff like 'detect falling', and 'detect orientation'. But how does it actually do that? Well, the accelerometer gives us *values,* and *you* (yes, you), have to read those values and ***interpret*** them to detect all of these things.

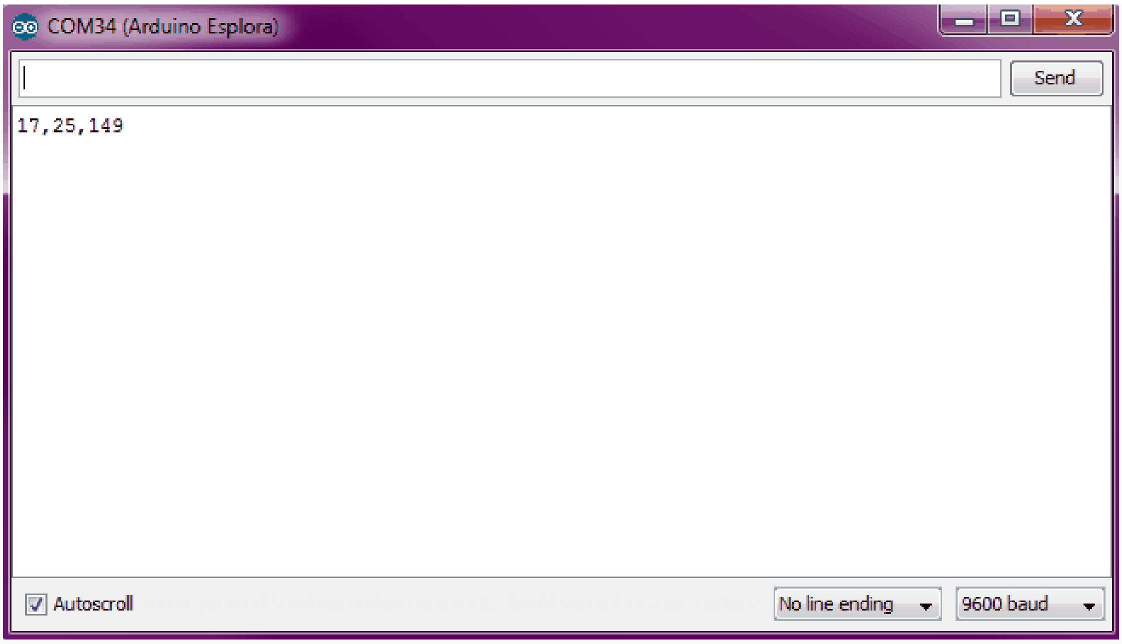
So let's write a program that reads from the accelerometer, and prints it to the **Serial Monitor**, so we can actually see what it gives us.

```
#include <Esplora.h>

void setup() {
  Serial.begin(9600);
}

void loop() {
  int xAxis = Esplora.readAccelerometer(X_AXIS);
  Serial.print(xAxis);
  Serial.print(',');
  Serial.println();
  delay(500);
}
```

Activity

Your task is to *hack* the above program, so it prints the x, y, and z axes to the serial monitor on the one line, with a comma in between each value. Make sure you print a newline at the end. Then you can look and see what values the accelerometer gives us.

It should look something like this:



When you're happy with it, change the *delay* to be 5 ms, so that it sends us the data really fast.