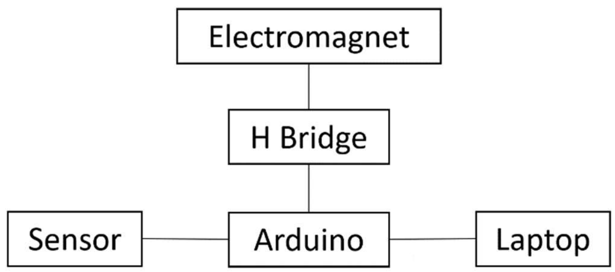
CPAC 3: Use of Free Fall to measure acceleration due to gravity g.

Apparatus:

For this experiment I used Experiment equipment I had made. I had found a video online detailing how a similar equipment could be made; bit.ly/2TEWcsV. My experiment is similar to this but I have used a electromagnet to get a consistent release of the ball bearing. The equipment works as follows: The electromagnet is placed at a known height and magnetized and the ball bearing is offered to it. At the push of a button on the laptop the electromagnet is demagnetized, the ball bearing is released and a microcontroller takes a reading of the time since the program has started in milliseconds. Once the ball has made contact with the bottom sensor, which is essentially a push-to-make switch, a second time is taken. The first time is subtracted from the second to get the time the ball was falling. This value is outputted to the screen of the Laptop.

Circuit Diagram:

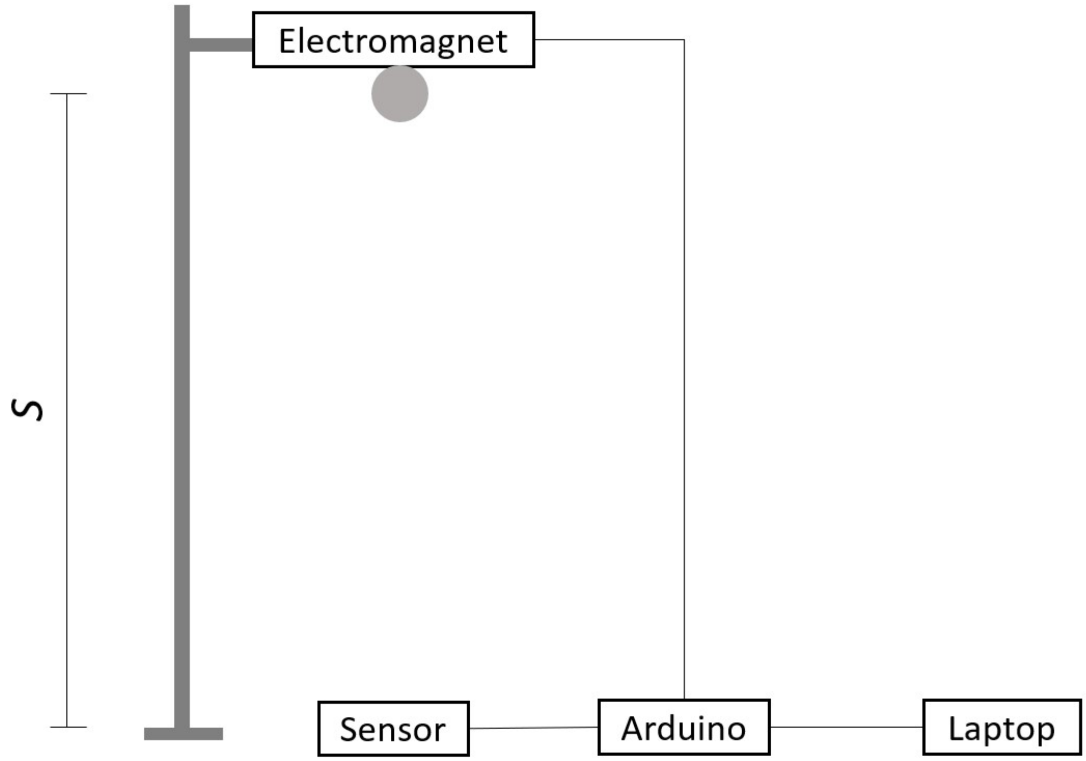


The Electromagnet works with the current flowing either way so the H bridge isn't necessary but it can handle a higher current and voltage than the Arduino so in this case its acting more like a driver board for the Electromagnet. Also the connection between the Arduino and the laptop carries power and a serial connection.

Code:

```
Timer §
//The Pin Numbers of the Hardware
const int Sensor = 5;
const int ElectromagnetPlus = 7;
const int ElectromagnetMinus = 8;

//Variables of the Program
bool flag = false;
bool newData = false;
bool restart = false;
int time1 = 0;
int time2 = 0;
int timefinal = 0;
char serial1 = "";

//Setting up all the things
void setup() {
        Serial.begin(9600);                     //Start Serial Interface
        pinMode(Sensor, INPUT);                 //Set Sensor as input
        pinMode(ElectromagnetPlus, OUTPUT);     //Set the wires to the H Bridge up as Inputs
        pinMode(ElectromagnetMinus, OUTPUT);
        Serial.print("I have Started Good\n");  //An Indicator to the user that the Setup is Complete
}

void loop() {
        ArmElectromagnet();           //Arms Electromagnet
        while (Serial.available())    //Checks for a input from the Serial interface (from the lapatop)
        {
        Serial.print("Launching\n");
        time1 = millis();             //Takes a reading of the time since the program has started
        digitalWrite(ElectromagnetPlus,LOW);  //Disenguages Electromagnet
        Serial.print("Electromagnet Disengaged\n");
        while (true)                 //Runs consistantly until the loop is broken out of
        {
          if (digitalRead(Sensor) == HIGH)   //If the Sensor is closed
          {
            time2 = millis();                //takes a second reading of the time
            Serial.print("Sensor has been read as HIGH\n");
            break;                           //Loop broken out of
          }
        }
        timefinal = time2 - time1;           //Works out the time the ball was in the air
        Serial.print("The time taken was :");
        Serial.println(timefinal);
        }
}

void ArmElectromagnet(){
        digitalWrite(ElectromagnetPlus,HIGH);   //Setting one of the wires to positive
        digitalWrite(ElectromagnetMinus,LOW);   //Setting the other to negative
        }
```

Diagram:

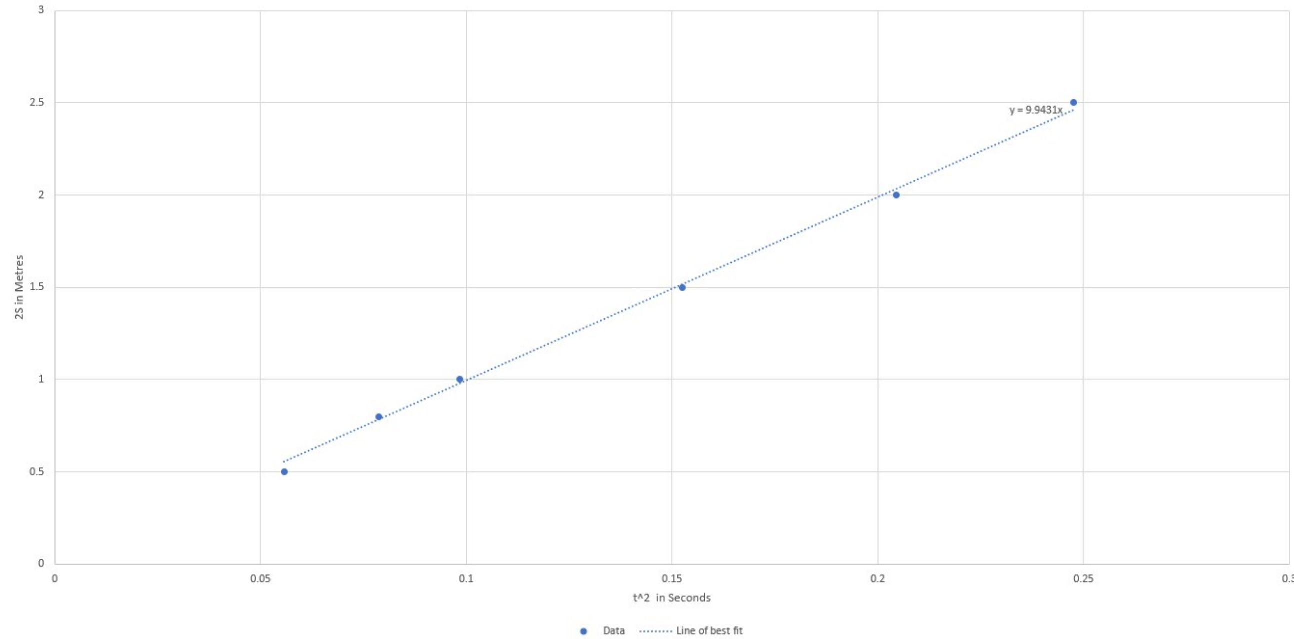


Method:

- Set up the apparatus as shown in the diagram.
- Set The height to the current height you are recording
- Start the Serial Connection on the laptop
- Offer the ball bearing up to the electromagnet
- Press enter on the laptop to release the ball bearing
- Record the result in milliseconds
- Repeat 3 times per height and for at least 6 different heights
- Work out the average time per height
- Put the time into the equation $a = 2S/t^2$ and $a = g$ = Gravitational Field Strength of Earth

Results:

Height in Metres	Time 1 in Milliseconds	Time 2 in Milliseconds	Time 3 in Milliseconds	Average	Value of G		Average Value of G
0.25	236	236	236	0.236	8.977305372		9.8323569
0.5	315	313	313	0.313666667	10.16396738		in m/s
0.75	392	389	391	0.390666667	9.828303183		
1	453	451	453	0.452333333	9.774910953		
1.25	497	498	498	0.497666667	10.09399076		
0.4	280	282	280	0.280666667	10.15566376		



Conclusion:

When simply taking the averages of the values of g per height I find g to be 9.83 to 2 d.p. but when I find the gradient of the graph of $2S$ against t^2 I find g to be 9.93 to 2 d.p. . Considering that the standard acceleration of gravity is 9.81 to 2 d.p. (according to bit.ly/2jUMezH), these results are reasonably accurate considering the limitations of the equipment and the environment. Things to consider: I assumed air resistance to be negligible, The Arduino takes time between the instruction to drop the ball and to take a time reading but this time is 1/16 millionths of a second so is also negligible also there's a small delay between the electromagnet being sent a instruction to turn off and it actually turning off.