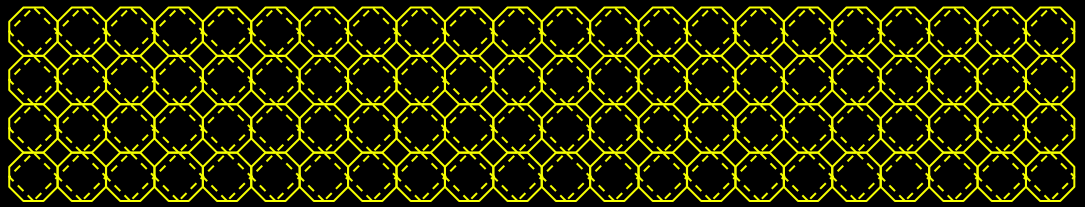
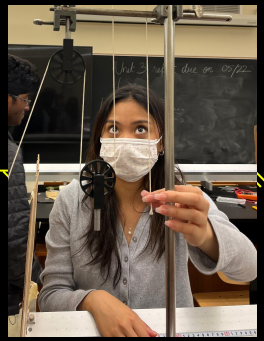
ADDING MULTIPLE STATIC PULLEYS TO A SIMPLE PULLEY SYSTEM



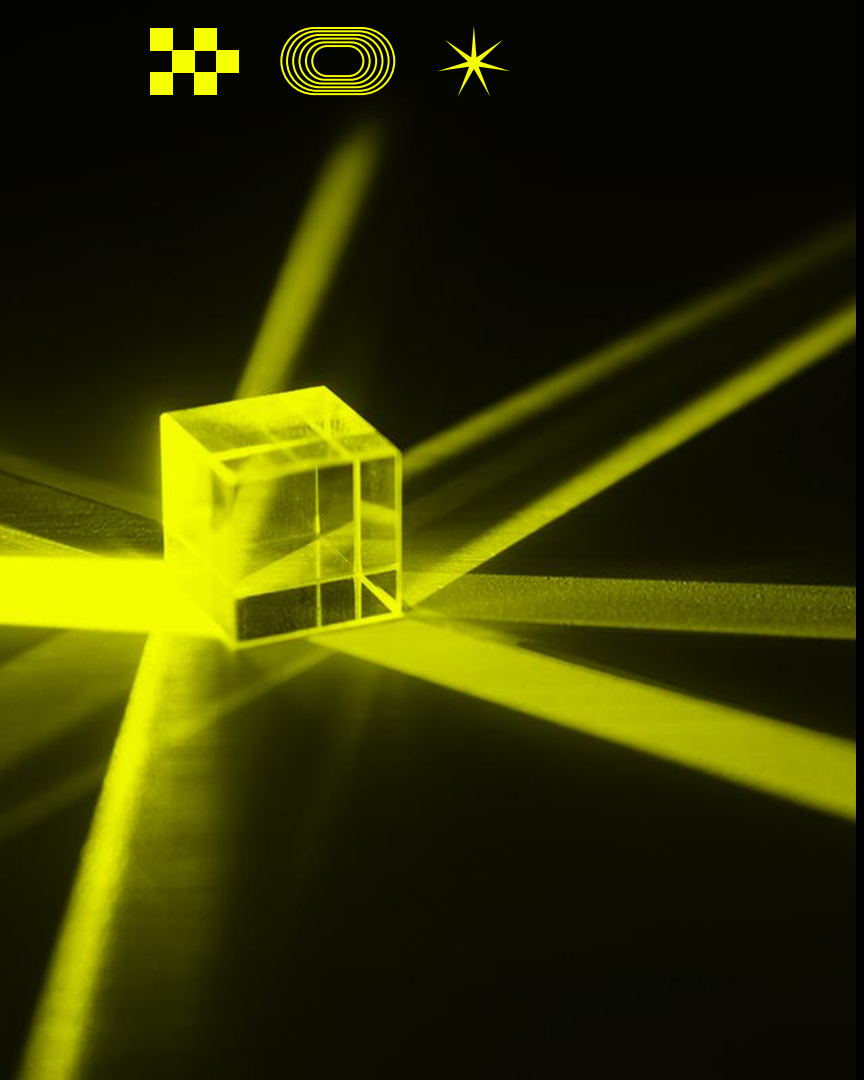
PHYSICS 4AL, Team 5

UCLA

TEAM



Lana Lim - EE Faraz Murshed - CS Aaron Zhao - CS



MOTIVATION

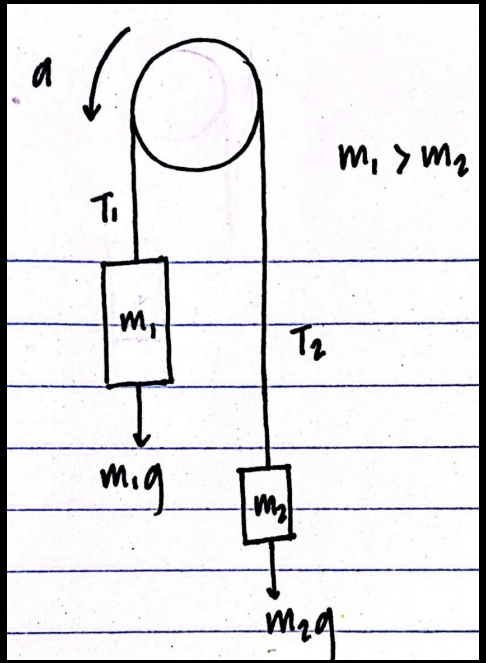
- Study of simple machines
- Physics Laboratory for Scientists and Engineers: MECHANICS!!!
- Come up with unique configurations of a pulley-system

INTRODUCTION

A simple pulley system

$$F = ma$$

$$a = \frac{F_{net}}{m_{tot}} \Rightarrow a = \frac{m_1 g - m_2 g}{m_1 + m_2} \Rightarrow a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

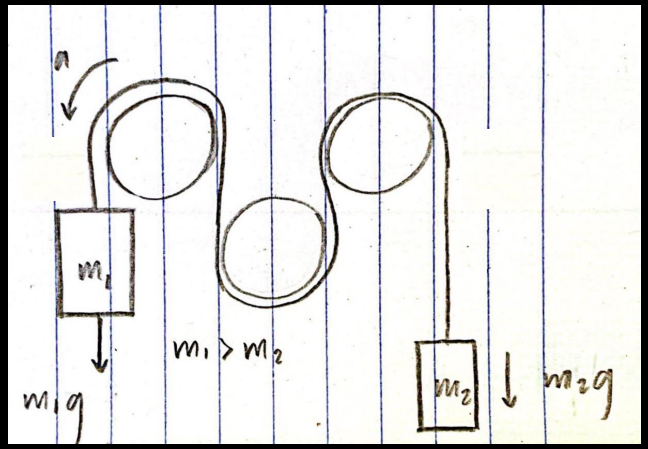


INTRODUCTION

A 3-static pulley system?

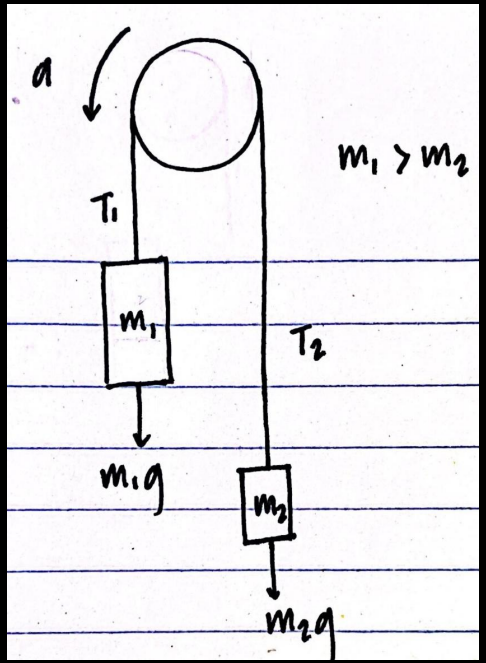
Same thing!

$$a = \frac{F_{net}}{m_{tot}} \Rightarrow a = \frac{m_1 g - m_2 g}{m_1 + m_2} \Rightarrow a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$



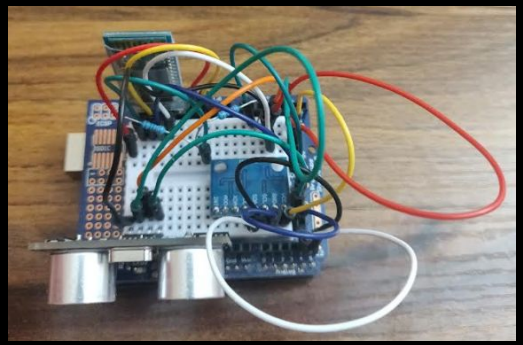
HYPOTHESIS

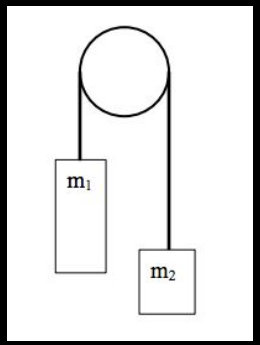
Two blocks of mass m1 and m2 are hanging off a simple pulley as shown. Suppose m1 > m2. m1's acceleration will be the same if we add two additional static pulleys to the experimental design. The static pulleys act as directional changes of the string's path and do not contribute to the object's equations for motion.

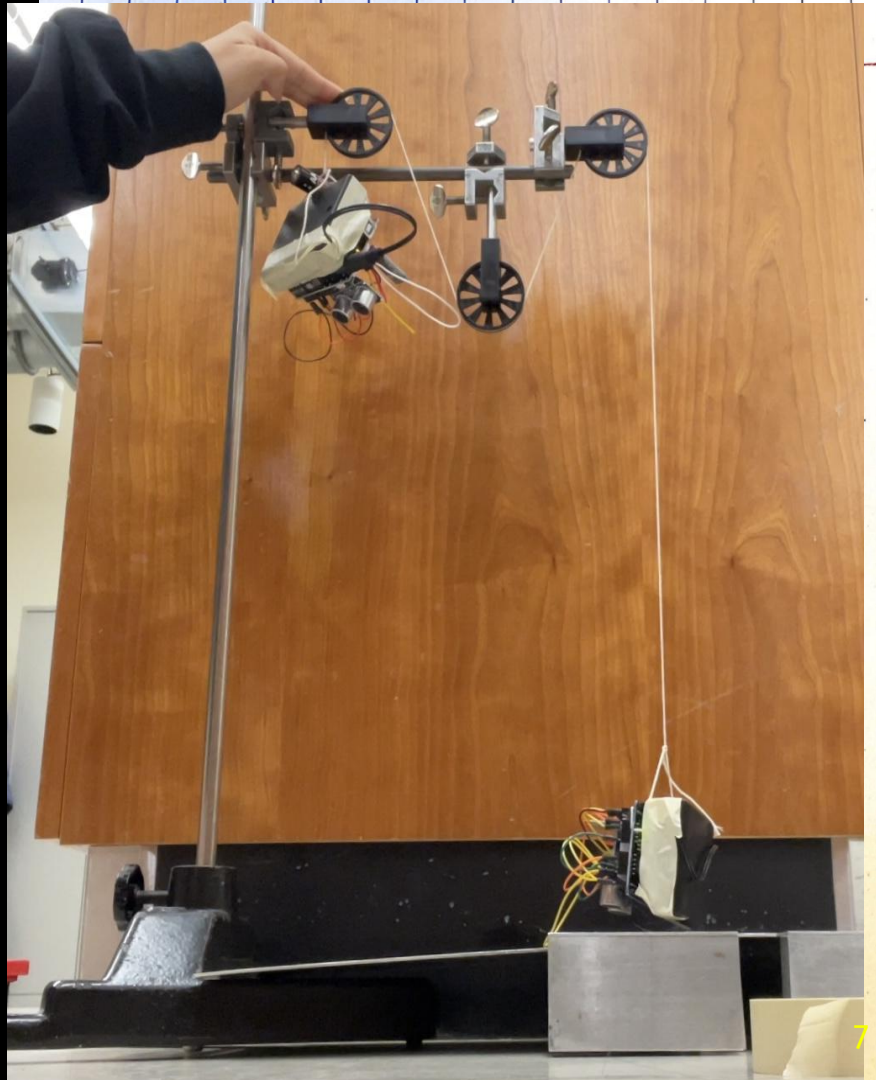


EXPERIMENTAL SETUP

- Pulley systems
- Arduino setup with accelerometer and ultrasound sensor







DATA ANALYSIS PROCEDURE

- For each trial, store 5 column Arduino data in csv file
  - Fields: Time, Displacement, X-axis Acceleration, Y-axis Acceleration, Z-axis Acceleration
- Plot and analyze ultrasound displacement data
- Calibrate Arduino accelerometer
- Plot, compute, and analyze accelerometer data

DATA COLLECTION

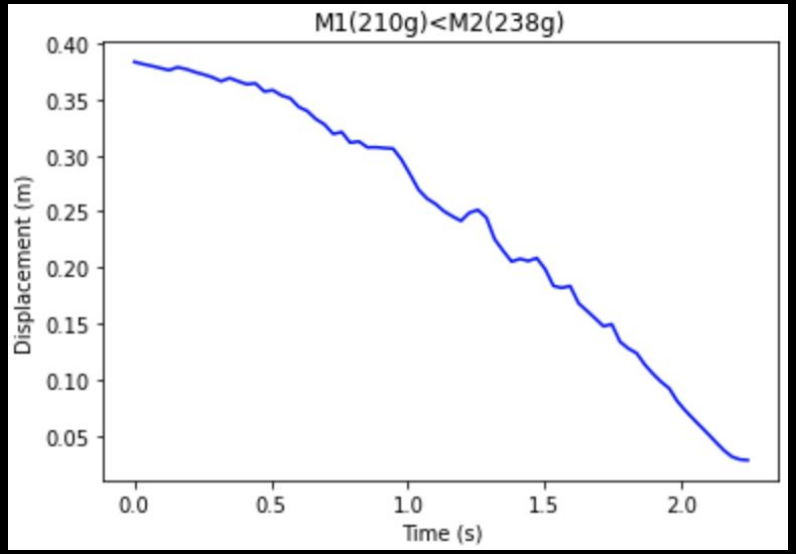
```
int16_t ax, ay, az;

float duration, cm;

void setup() {

  #if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
  Wire.begin();
#elif I2CDEV_IMPLEMENTATION == I2CDEV_BUILTIN_FASTWIRE
  Fastwire::setup(400, true);
#endif
  Serial.begin(9600);

  mySerial.begin(9600);
  delay(10);

  accel.initialize();
  //Serial.println("Hello, SerialA ready");


  // The trigger pin will output an ultrasonic
  // signal from the speaker
  pinMode(trigPin, OUTPUT);

  // The echo pin will receive the reflected signal
  // and input it back to the IDE
  pinMode(echoPin, INPUT);
  pinMode(10, INPUT);
  pinMode(11, OUTPUT);
  Serial.println("Hello, Serial ready");
  mySerial.println("Hello, SoftwareSerial ready");

}
```

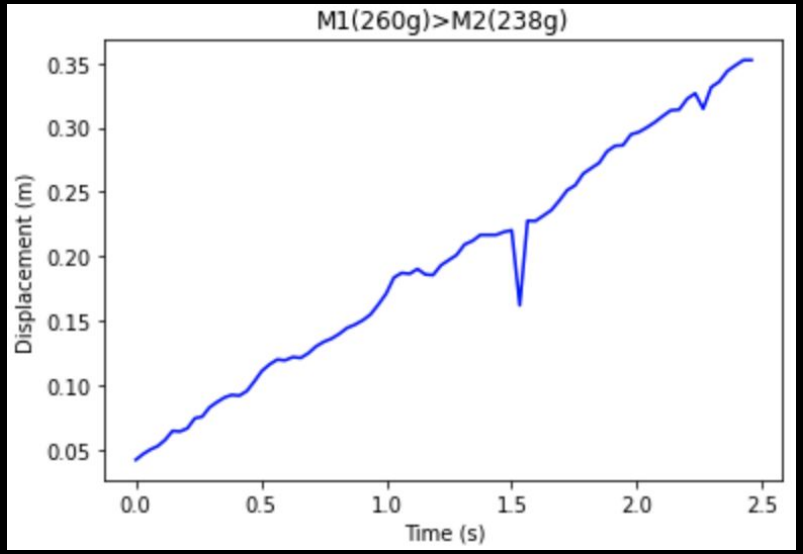
```
void loop() {
  // put your main code here, to run repeatedly:
  // Define the duration beetween transmitted and
  // recieved

  //------- UltraSound -------
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH); //Send pulse
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH); // Recieve pulse
  cm = (duration/2)*0.0343;
  delay(1);

  accel.getAcceleration(&ax, &ay, &az);
  mySerial.print(millis());
  mySerial.print(',');
  mySerial.print(cm);
  mySerial.print(',');
  mySerial.print(ax);
  mySerial.print(',');
  mySerial.print(ay);
  mySerial.print(',');
  mySerial.println(az);

  delay(2); // Delay in between samples

}
```

Arduino Code

- Measure acceleration data using MEMS accelerometer
- Record x, y, z axis acceleration data

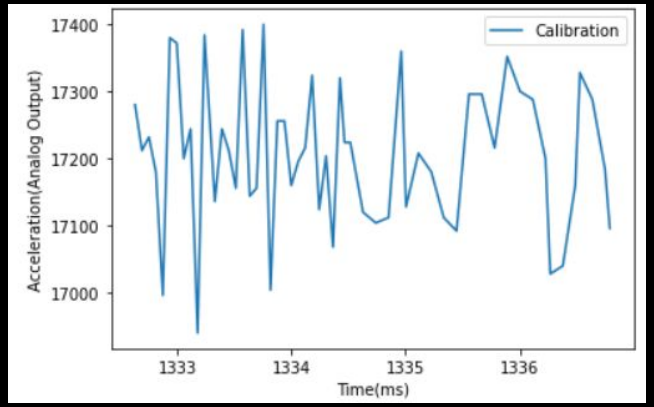
ULTRASOUND DATA

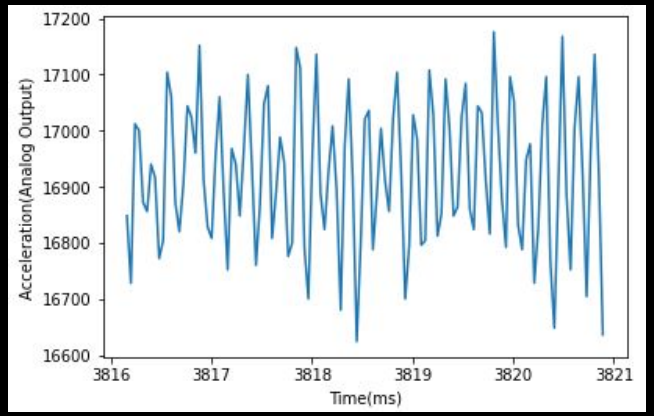


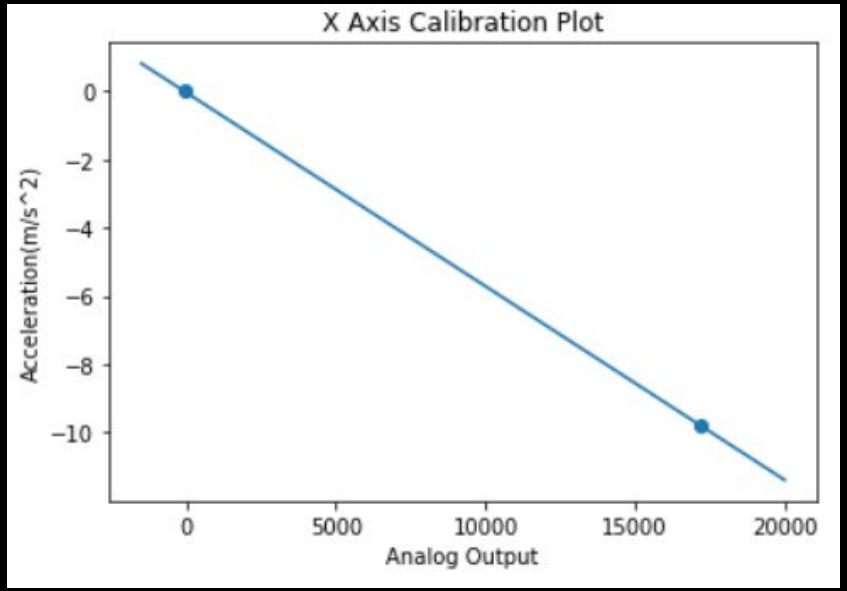


*Graphs are from the perspective of M2

CALIBRATION PROCESS





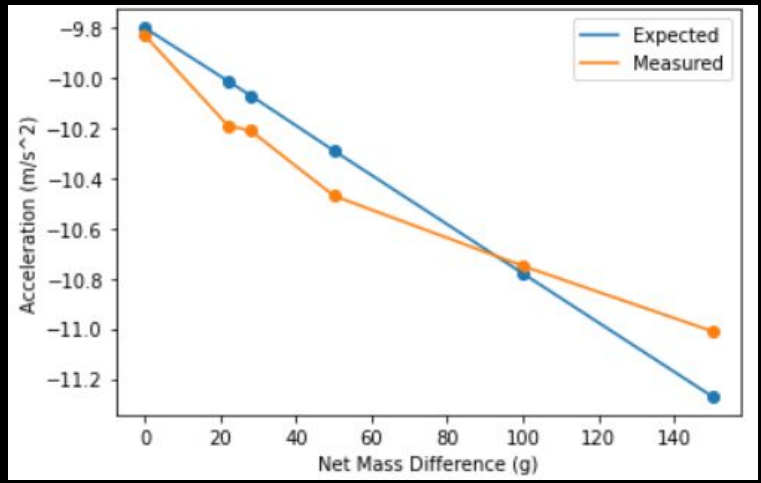


RESULTS

```
def calibrate(x1,y1,x2,y2):
  slope = (y2-y1)/(x2-x1)
  intercept = y1 - slope*x1
  return slope,intercept
```

```
def relativeAccel(totalAccel):
  return totalAccel + 9.81
```

```
calibAccel = relativeAccel(slope*xAccel + inter)
cMean = np.mean(calibAccel)
cStd = np.std(calibAccel)
print("Mean: " , cMean, "StD: ", cStd)
```



Mass Difference (g)	0g (equilibrium)	22g (one 50g weight, one battery)	28g (one batter)	50g	100g	150g
Expected Acceleration (m/s^2	-9.8	-10.012	-10.07	-10.29	-10.78	-11.27
Measured Acceleration (m/s^2)	-9.83	-10.19	-10.21	-10.47	-10.75	-11.01

SIGNIFICANCE

- Friction between rope and pulley. Static friction keeps the rope from slipping over the surface and makes the pulley rotate when the rope is pulled.

- Friction between the pulley and the axle. Results in a torque opposing the movement.

- Additional static pulleys in a system does not affect equations of motion.

CONCLUSION/FUTURE PROSPECTS

- Acceleration measured followed expected behavior with the constraints given
- Improve the integrity of the Arduino setup
- Reduce friction: low-friction pulleys, smaller angle of string

ACKNOWLEDGEMENTS & REFERENCES

Professor Ni Ni
TA Mianzhi Zhou

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- Ni, Ni. “Lab 3A: Vertical Mass and Spring.” PHYSICS 4AL: Physics Laboratory for Scientists and Engineers: Mechanics.
- Ling, Samuel J., et al. University Physics: Volume 1. OpenStax, Rice University, 2017.