
PHYS204
Applied Physics
Final Course Project
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DeVry University
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Introduction

This presentation covers several fascinating areas of physics. It teaches the physical principles behind the workings of the universe and teaches the solution process of complex logical problems.

This course project is based on the scientific method and is divided into six parts.

It covers precision, free-fall motion, conservation of energy, rotation motion, and Hall effect. The tools used, objectives, and conclusions for each part of the project are shown throughout presentation.

The presentation concludes with Challenges, Career Skills obtained, and a Conclusion.

PHYS204
Project Part 1

MATERIAL LIST

(Inventory of Parts and Software)

In this part of the project, the materials list and required software is presented. The materials list is a vital component this lab report. It provides a clear description of exactly what will be used to conduct the experiments.

Materials List (Picture)

Arduino Mega 2560

Ultrasonic sensor HC-SR04

Male to Male Wires

Breadboard

USB cable to connect Arduino

Ruler or tape measurer

Object to act as obstacle and/or undergo free-fall

Materials List (Picture)

Arduino Mega 2560

Rotary Encoder Part KY-040

Male to Female Wires

USB cable to connect Arduino

Object to attach onto rotary encoder

Ruler or tape measurer

Materials List (Picture)

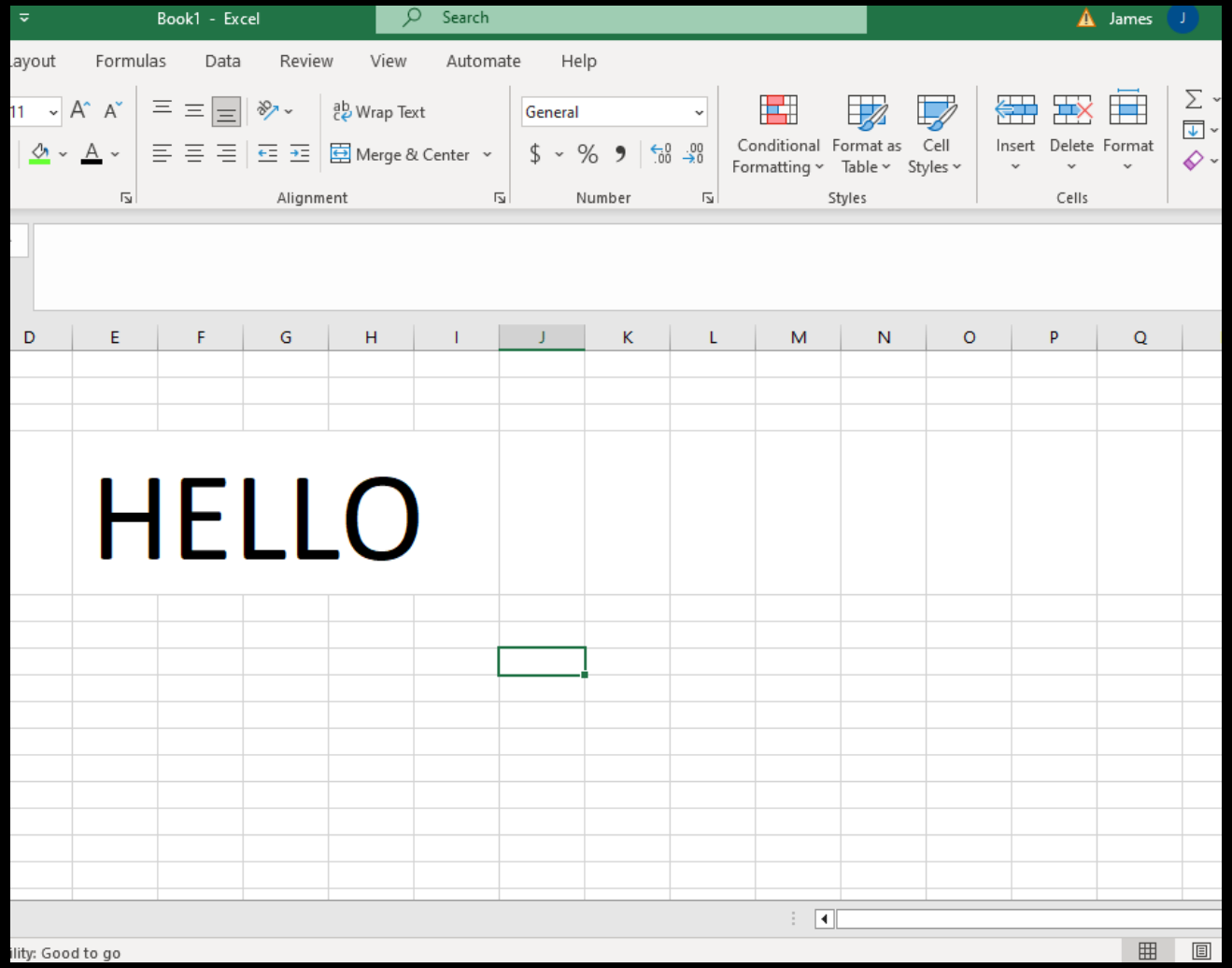
ESP32 microprocessor

Micro-USB cable

Magnet

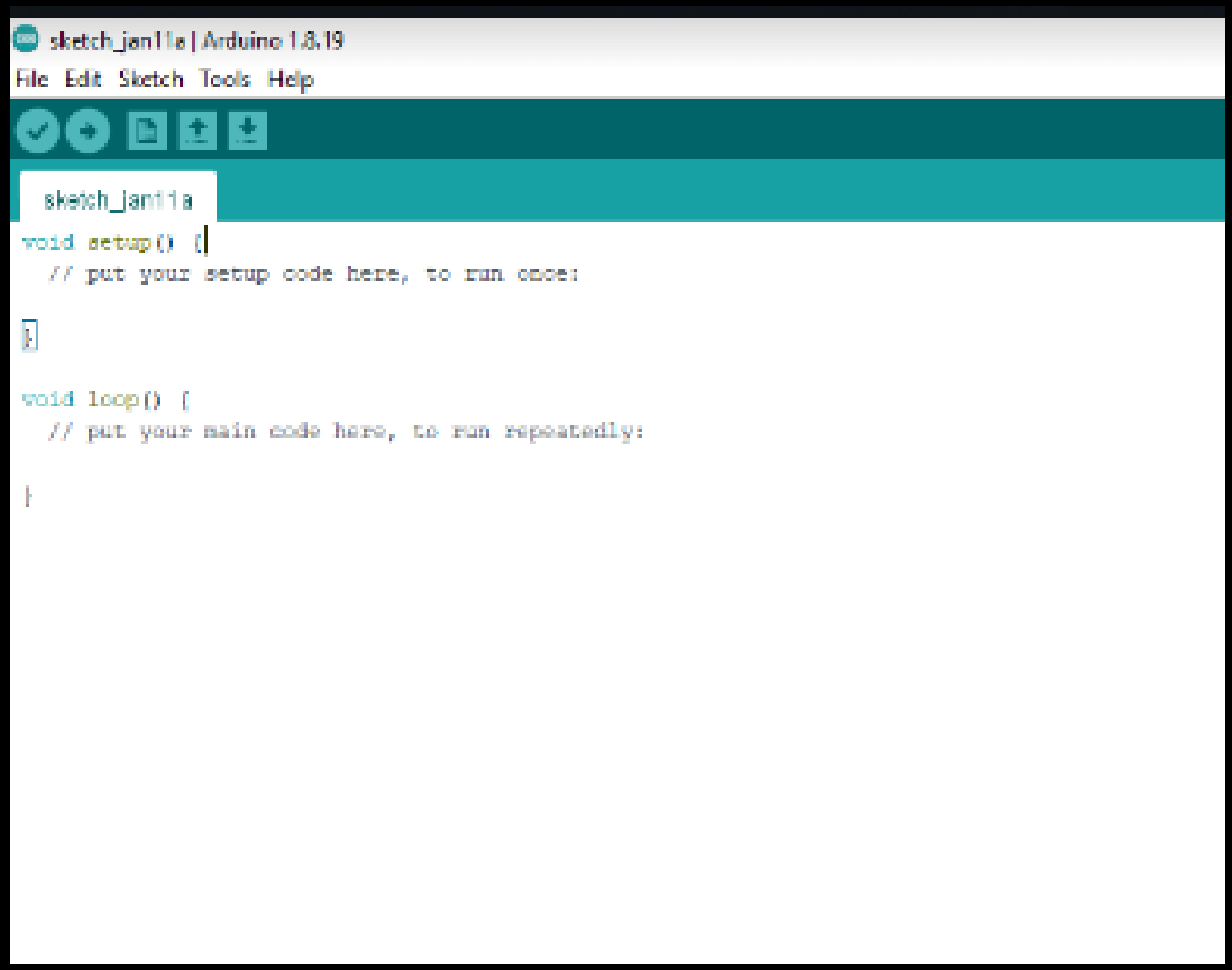
Required Software (screenshot)

Microsoft Excel installed and running on your computer



Required Software (screenshot)

Arduino IDE installed and running on your computer



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Project Part 2

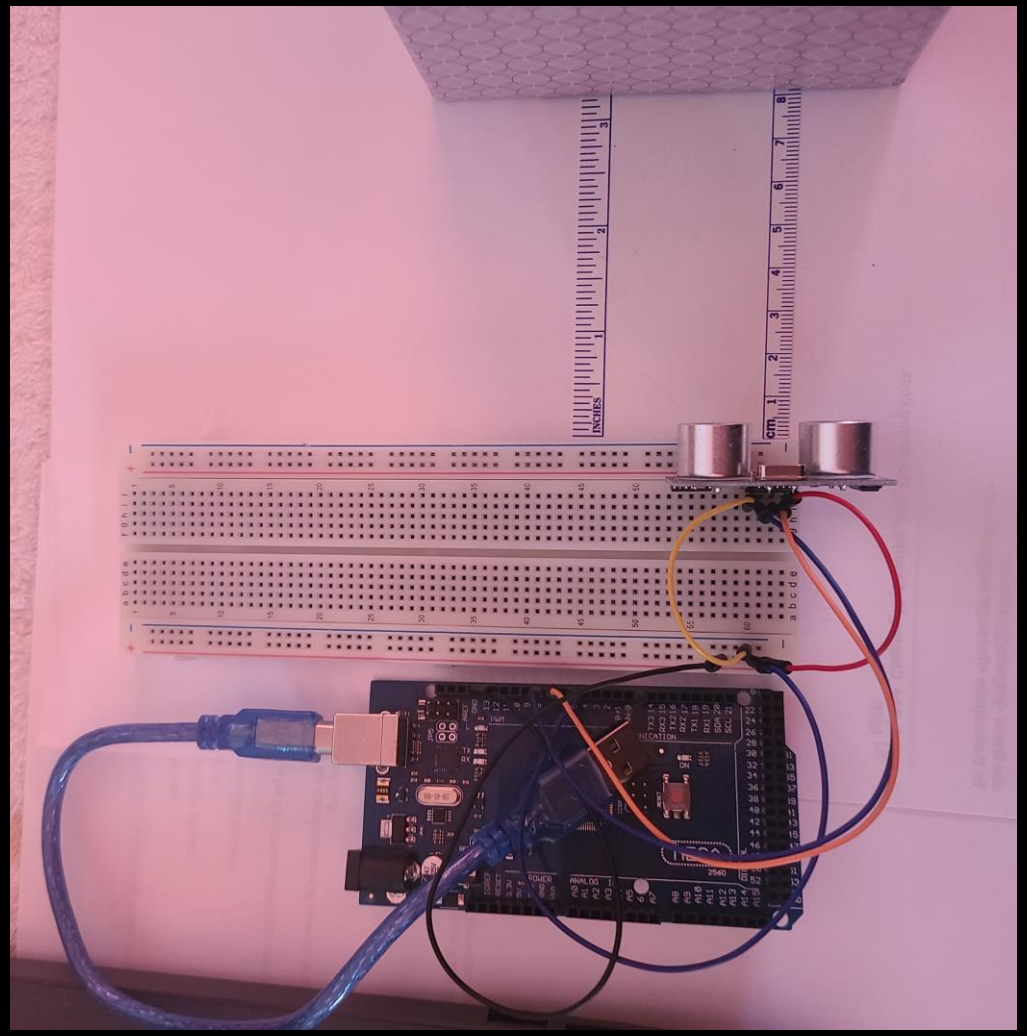
PRECISION OF ULTRASONIC SENSOR

The ultrasonic sensor is an electronic device with two transducers that are used to detect an object within its range. Determining the precision of the data gathering sensor is essential in experiments as sensors often drift over time and give incorrect readings.

Experimental Set-up (Picture)

Materials List:

- Mega 2560 Board
- Ultrasonic sensor HC-SR04
- Male to Male Wires
- Breadboard
- Ruler or tape measurer
- Large and flat object to act as obstacle

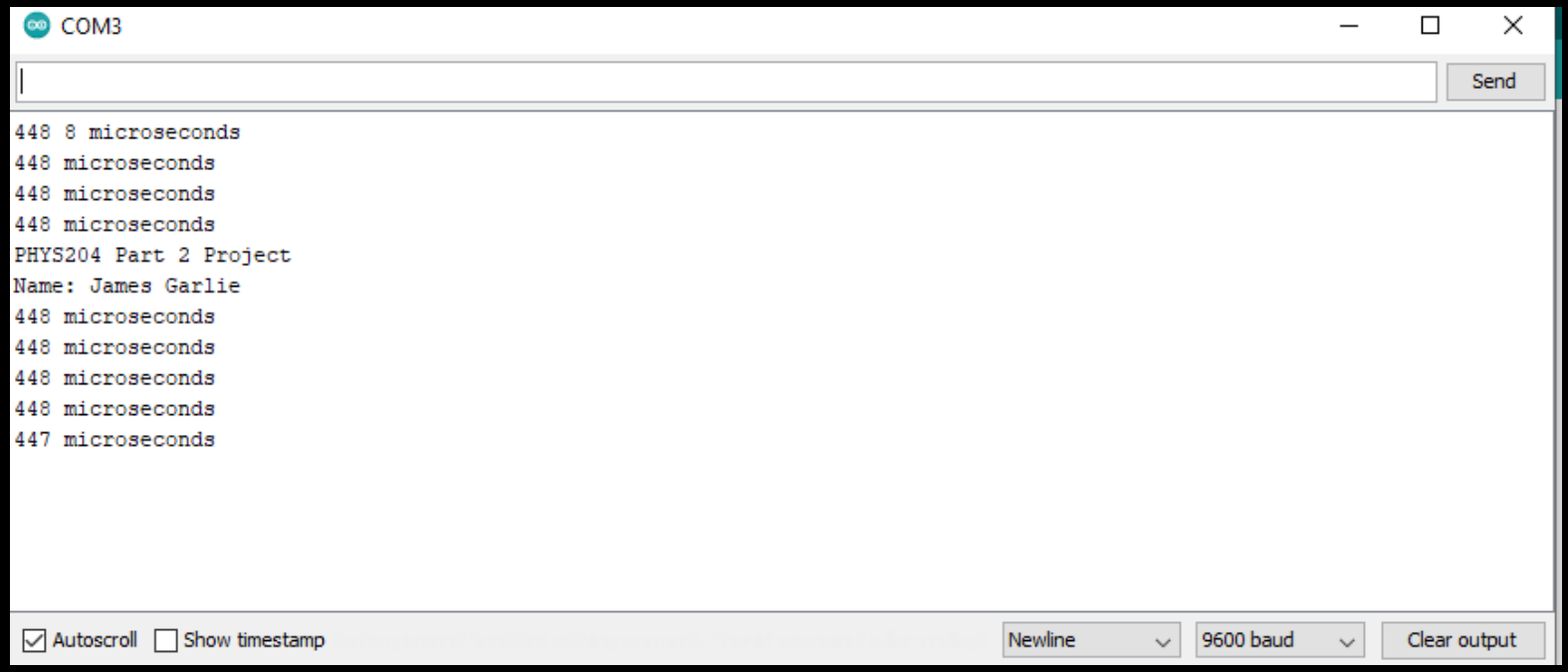


Raw Data (Screenshot)

Screenshot of Serial Monitor from Arduino IDE showing raw data.

Must include your name displayed in the serial monitor.

Make sure “show timestamp” is NOT selected.



Data Collection

Trial	Ruler Distance (cm)	Total Roundtrip Distance (m)	Time from Serial Monitor (microseconds)	Roundtrip time (s)	Velocity = distance/time (m/s)
1	8	.16	438	4.3E-4	365
2	9	.18	493	4.9E-4	365
3	10	.20	653	6.5E-4	306
4	11	.22	690	6.9E-4	319
5	12	.24	701	7.0E-4	342

Data Analysis

- Average velocity from table

$$v_{avg} = \frac{v_1 + v_2 + v_3 + v_4 + v_5}{5}$$

Answer: _____ _____ *units*

- Percent difference where $v_{sound} = 343\ m/s$

$$Percent\ difference = \frac{|v_{avg} - v_{sound}|}{v_{sound}} \times 100$$

Answer: _____ _____ *units*

Conclusions

- Discuss the results and comment on the source of errors.
  - Answer: The only errors I had were due to installing the power wire to slot 5 on one side versus the V5 on the other side.

- What is the dependence of temperature, humidity, and atmospheric pressure on the speed of sound? How does it affect the results?
  - Answer: In my case because it is very dry where I live, my measurement showed a negative 1.16%. I suspect in a more humid environment it would be a greater percentage difference.

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Project Part 3

FREE FALL MOTION

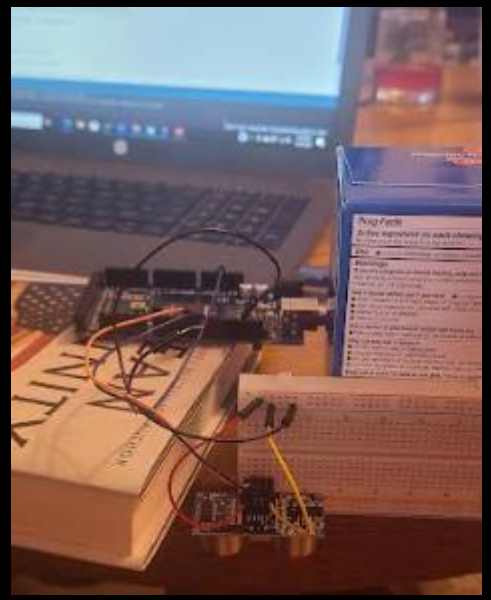
(Gravitational Acceleration of a Free-Falling Object)

Now that the precision of the ultrasonic sensor has been determined, the sensor is used to determine the gravitational acceleration of a free-falling object. This data will be used in the next part to investigate the conservation of energy during the fall.

Experimental Set-up (Picture)

Materials List:

- Mega 2560 Board
- Ultrasonic sensor HC-SR04
- Male to Male Wires
- Breadboard
- Large and flat object that is not susceptible to air resistance to undergo free fall motion

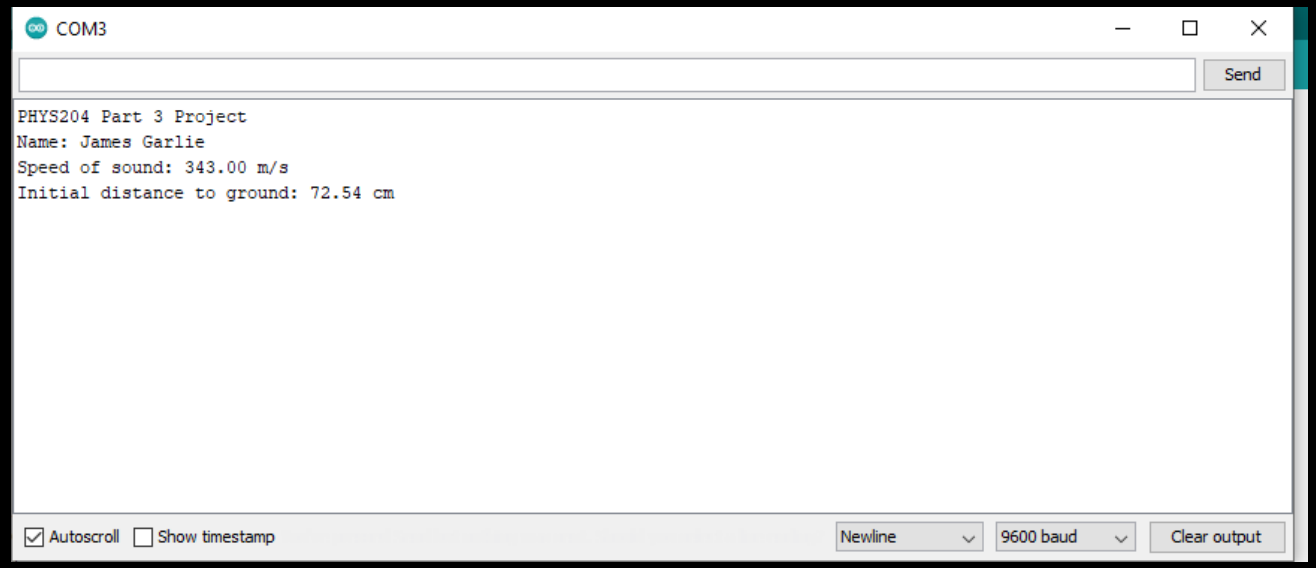


Serial Monitor (Screenshot)

Include screenshot of raw data showing the start of the fall and end of the fall of one trial.

Must include your name displayed in the serial monitor.

Make sure “show timestamp” is NOT selected.



Excel Table (Screenshot)

Include all values in the Excel table for a single trial showing the fall distance in centimeters and meters as a function of time

Be sure your drop your drop is long enough to experience free-fall.

A good drop is from a height of a table or countertop.

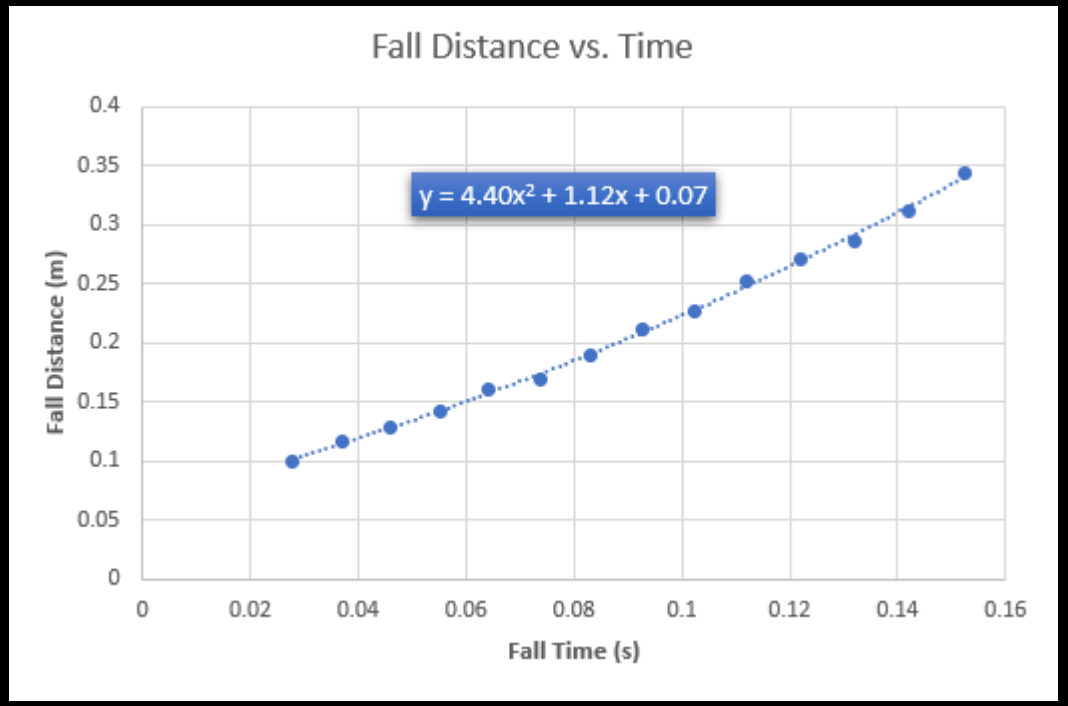
	A	B	C
1	Time (s)	Distance (cm)	Distance (m)
2	0.1317	28.66	0.2866
3	0.1418	30.89	0.3089
4	0.152	33.27	0.3327
5	0.1624	36.26	0.3626
6	0.173	38.54	0.3854
7	0.1837	41.33	0.4133
8	0.1945	43.84	0.4384
9	0.2055	46.84	0.4684
10	0.2167	50.13	0.5013
11	0.2281	53.58	0.5358
12	0.2397	57.97	0.5797
13	0.2516	61.47	0.6147
14	0.2637	67.16	0.6716
15	0.2754	47.44	0.4744
16	0.2872	68.53	0.6853

Excel Graph (Screenshot)

Include Excel graph for a single trial showing the fall distance as a function of time.

Confirm that most data points fall along the curve fitting.

The x^2 coefficient should be between 2.5 and 7.5 such that its yields an acceleration value between 5 m/s^2 and 15 m/s^2



Data Collection

Trial	x^2 coefficient value from curve fitting	Acceleration (m/s^2) = 2* (x^2 coefficient)
1	5.31	10.62
2	5.85	11.70
3	6.03	12.06
4	3.82	7.64
5	4.40	8.80

Data Analysis

- Average acceleration from table

$$a_{avg} = \frac{a_1 + a_2 + a_3 + a_4 + a_5}{5}$$

Answer: _____ _____
units

- Percent difference with $g = 9.8\ m/s^2$

$$Percent\ difference\ = \frac{|a_{avg} - g|}{g} \times 100$$

Answer: _____ _____
units

Conclusions

- Discuss the results and comment on the source of errors.
  - *Answer: The results from my experiment were relatively close to gravity or 9.8 m/s^2. The average was 10.02 m/s^2 which showed a difference of 4.08%. Some sources of errors were the humidity in the room, the starting distance between the sensor and the item that was dropped, and the speed in which I let go of the item that was dropped.*
- How much variation is there from trial to trial? What does this indicate about the uncertainty of the result?
  - Answer: *The minimum difference between trials was 0.36 m/s^2 and the maximum difference was 4.36 m/s^2. This indicates to me that errors play an important factor in the results of the experiment.*

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Project Part 4

CONSERVATION OF ENERGY

(Conservation of Energy of a Free-Falling Object)

In this part of the project, the free-fall data is used to observe the transformation of potential energy into kinetic energy. The total mechanical energy gives insight into the conservation of energy.

Excel Table (Screenshot)

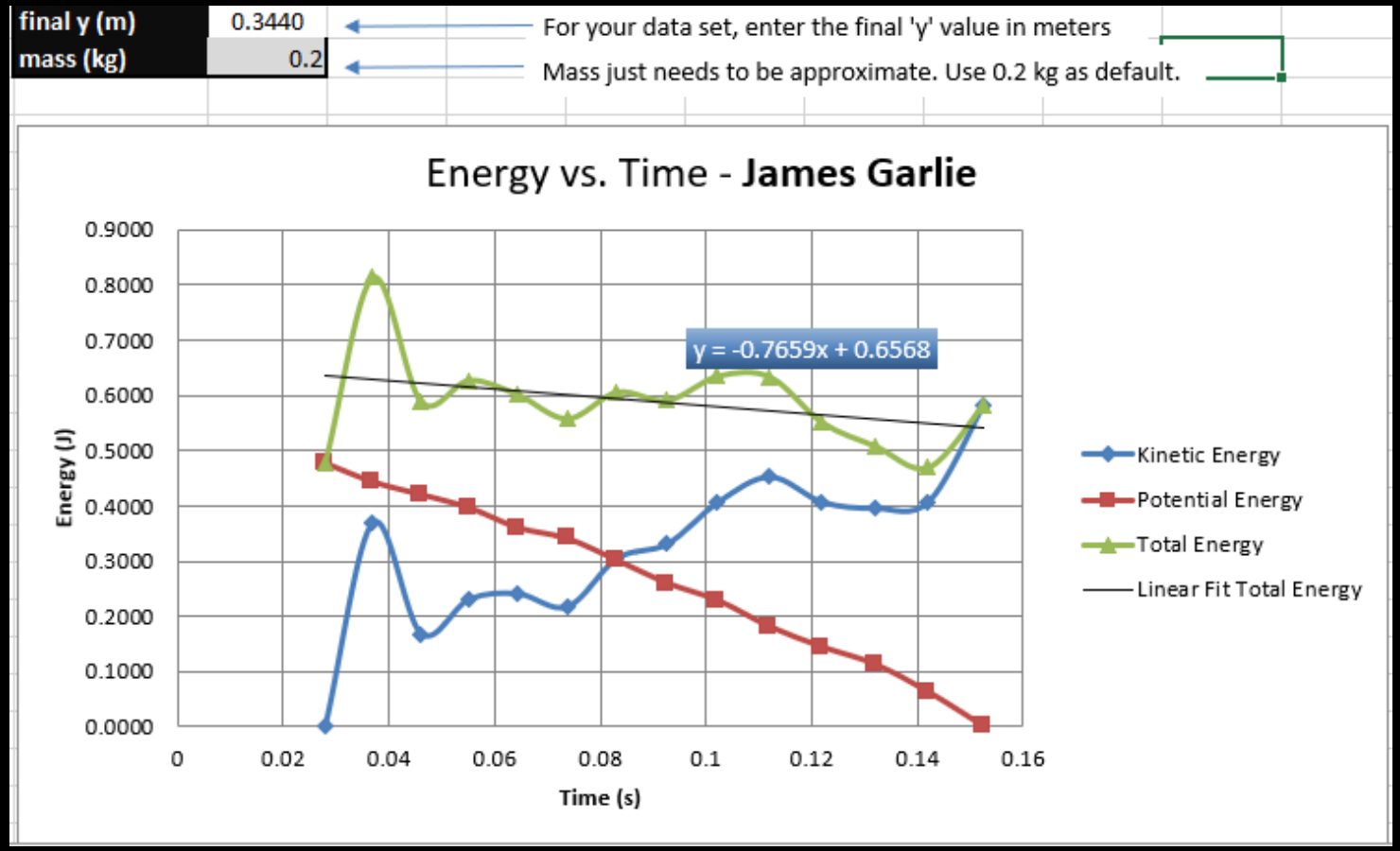
Include all values in the Excel table for a single trial showing the fall distance in centimeters and meters as a function of time with the values generated for kinetic energy K, potential energy U, and total mechanical energy E.

	A	B	C	D	E	F	G	H
1	*t* (s)	*y* (cm)	y (m)	h (m)	*v* (m/s)	*K* (J)	*U* (J)	*E* (J)
2	0.0279	10.02	0.1002	0.24	0.00	0.0000	0.4778	0.4778
3	0.0369	11.75	0.1175	0.23	1.92	0.3695	0.4439	0.8134
4	0.046	12.93	0.1293	0.21	1.30	0.1681	0.4208	0.5890
5	0.0551	14.15	0.1415	0.20	1.52	0.2305	0.3969	0.6274
6	0.0643	16	0.1600	0.18	1.55	0.2406	0.3606	0.6012
7	0.0737	17.01	0.1701	0.17	1.47	0.2170	0.3408	0.5578
8	0.0831	19.04	0.1904	0.15	1.75	0.3050	0.3011	0.6061
9	0.0926	21.15	0.2115	0.13	1.82	0.3312	0.2597	0.5909
10	0.1022	22.76	0.2276	0.12	2.02	0.4070	0.2281	0.6352
11	0.112	25.19	0.2519	0.09	2.13	0.4529	0.1805	0.6334
12	0.1219	27.06	0.2706	0.07	2.02	0.4069	0.1439	0.5507
13	0.1319	28.67	0.2867	0.06	1.99	0.3960	0.1123	0.5083
14	0.142	31.25	0.3125	0.03	2.02	0.4080	0.0617	0.4698
15	0.1523	34.4	0.3440	0.00	2.41	0.5830	0.0000	0.5830

Excel Graph (Screenshot)

Include Excel graph for a single trial showing the plots of the kinetic energy K, potential energy U, and total mechanical energy E as a function of time.

Must include your name in the title of the graph.



Data Analysis

- Theoretical value of final velocity

$h = y_{final} - y_{initial} =$ _____ _____ *units*

$v_f = \sqrt{2gh} =$ _____ _____ *units*

- Final velocity from experimental data (or largest velocity)

$v_{experimental} =$ _____ _____ *units*

- Percent difference

$$Percent\ difference\ = \frac{|v_f - v_{experimental}|}{v_f} \times 100$$

Answer: _____ _____ *units*

Conclusions

- Discuss the key characteristics of the plot. Consider the points when potential energy U is maximum, U is minimum, kinetic energy K is maximum, K is minimum and when U and K are the same value. What is the significance of these points?
  - Answer: *Starting out the PE is highest, and KE is the lowest. This was when I first let go of the item I dropped. At the end, KE is the highest and PE is the lowest. When KE and PE are the same values, that is the equilibrium point. That is when the lines on the graph intersect.*

Reference: Course video and Dr. Waksmanski

Conclusions

- What is the trend of the best fit line for the total energy E in your data? If the data is accurate, the total mechanical energy should decrease slightly. Why is that?
  - Answer: *Total energy is decreasing due to air resistance. In situations where there is a great deal of humidity, I suspect that produces more air resistance. If the air or humidity is dry and low, I suspect there is less air resistance. Other factors might include air flow and the item turning.*

Reference: Course video and Dr. Waksmanski

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Project Part 5

CIRCULAR MOTION WITH ROTARY ENCODER

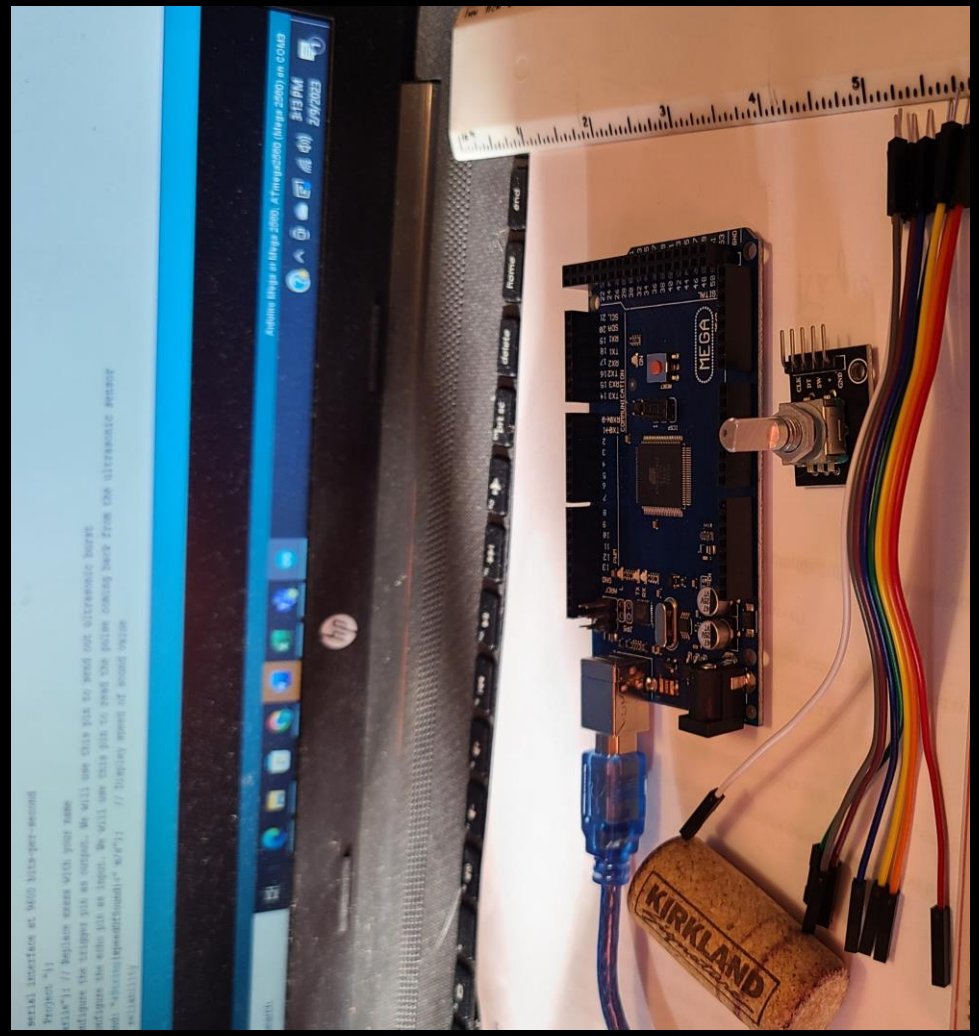
(Relationship between Linear and Rotational Motion)

In this part of the course project, we apply what we have learned about circular motion to observe the relationship between radial displacement and linear displacement using the rotary encoder.

Experimental Set-up (Picture)

Materials List:

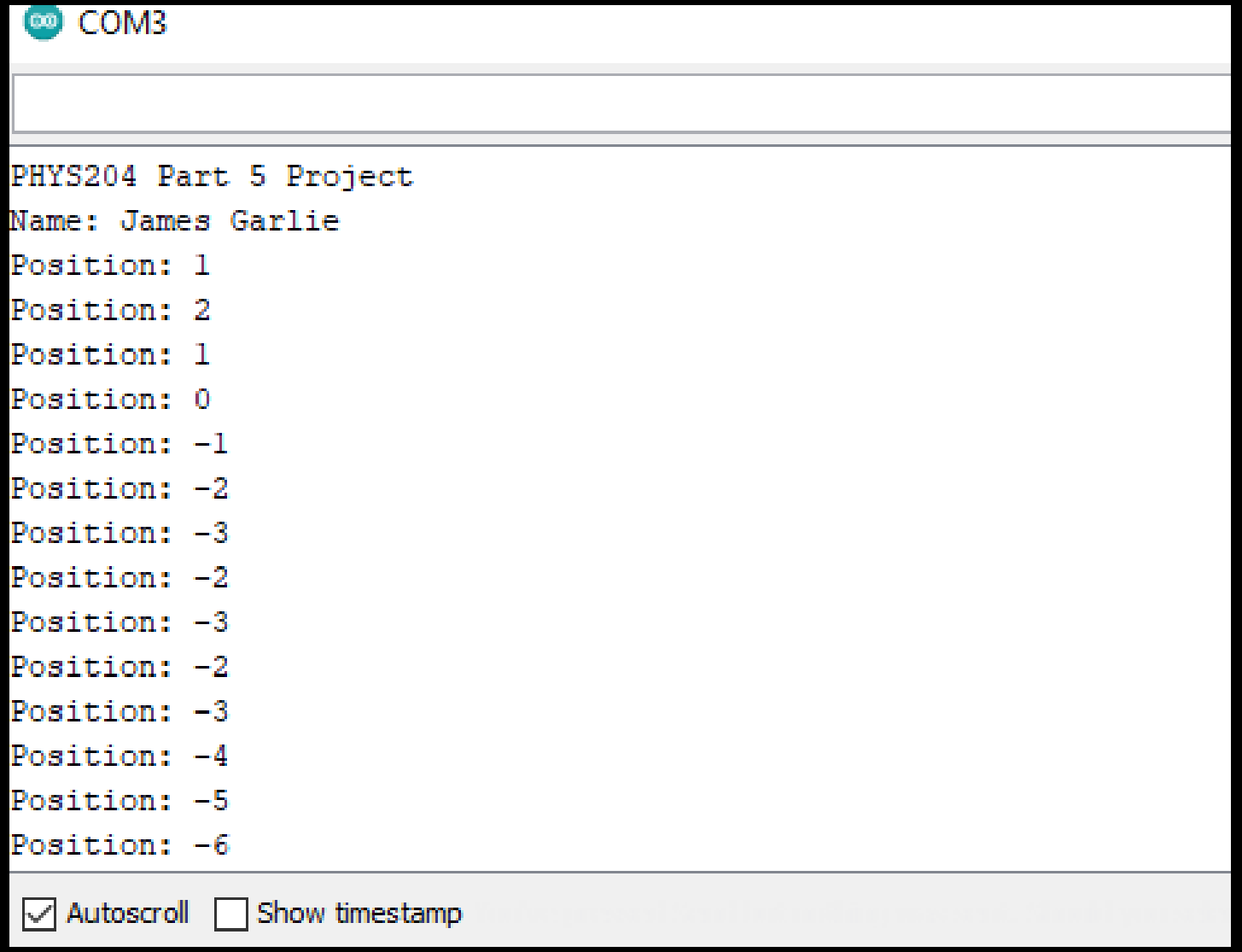
- Mega 2560 Board
- Rotary Encoder Part KY-040
- Male to Female Wires
- Object to attach onto rotary encoder (e.g. cork, bottle cap, ball)
- Ruler or tape measurer



Raw Data (Screenshot)

Screenshot of Serial Monitor from Arduino IDE showing raw data.

Must include your name displayed in the serial monitor.



Data Collection

- Object diameter: *d* = _____ _____ *units*
- Object radius: *r* = _____ _____ *units*
- Number of pulses for one revolution: *x* = 40
- Resolution = $\left(\frac{1}{x}\ \frac{Revolution}{pulses}\right) \cdot \left(\frac{2 \cdot \pi\ radians}{1\ Revolution}\right) =$ _____ _____ *units* /pulse

Data Analysis

Trial	Number of pulses N	Encoder distance $r \cdot Resolution \cdot N$	Measured distance with ruler	Percent difference
1	56	9.7	10	3
2	67	11.6	12	3.3
3	78	13.5	14	3.6
4	90	15.5	16	3.1
5	101	17.4	18	3.3

Conclusions

- Discuss the results and comment on the sources of error.
  - Answer: *My results so that I am off by 3.1% to 3.6%. I believe this is due to slippage/traction and not holding the item I chose tight enough to the surface.*

- What are some applications of this measuring technique? Could this measuring system be used to measure surfaces that are not flat?
  - Answer: *Yes, this measuring technique could be used for surfaces that are not flat. An application and an example would be a vehicle going up and down a hill. A person could measure the distance by the revolutions per tire.*

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Project Part 6

HALL EFFECT

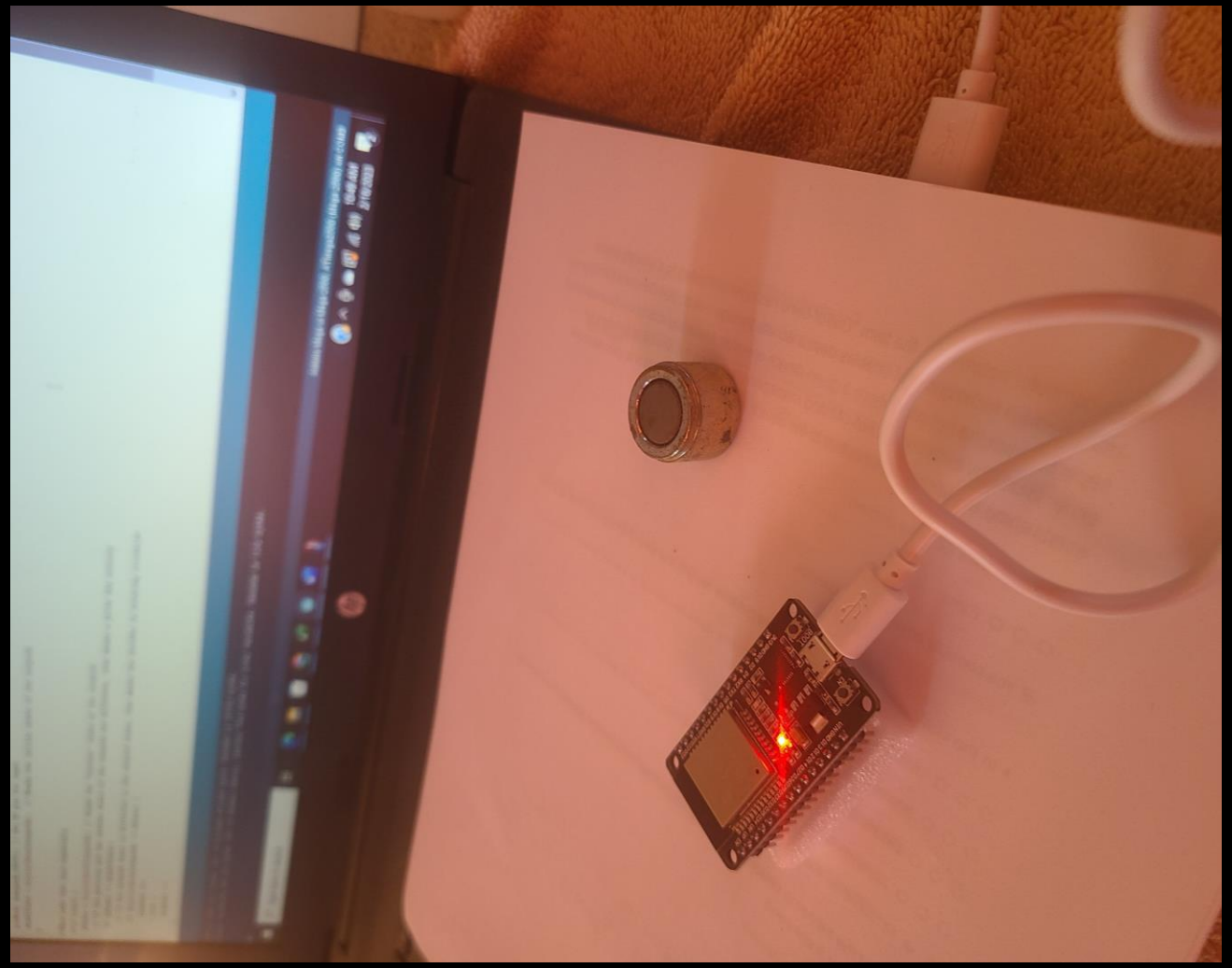
(Observing the Hall Effect)

In this part of the course project, we investigate the hall effect by using the ESP32 microcontroller to measure the proportional voltage under the effect of a magnetic field. The hall effect sensor is located behind the metal lid of the ESP32 chip. The measurements from the sensor can increase or become negative depending on the magnet pole facing the sensor.

Experimental Set-up (Picture)

Materials List:

- ESP32 microprocessor
- Micro-USB cable
- Magnet



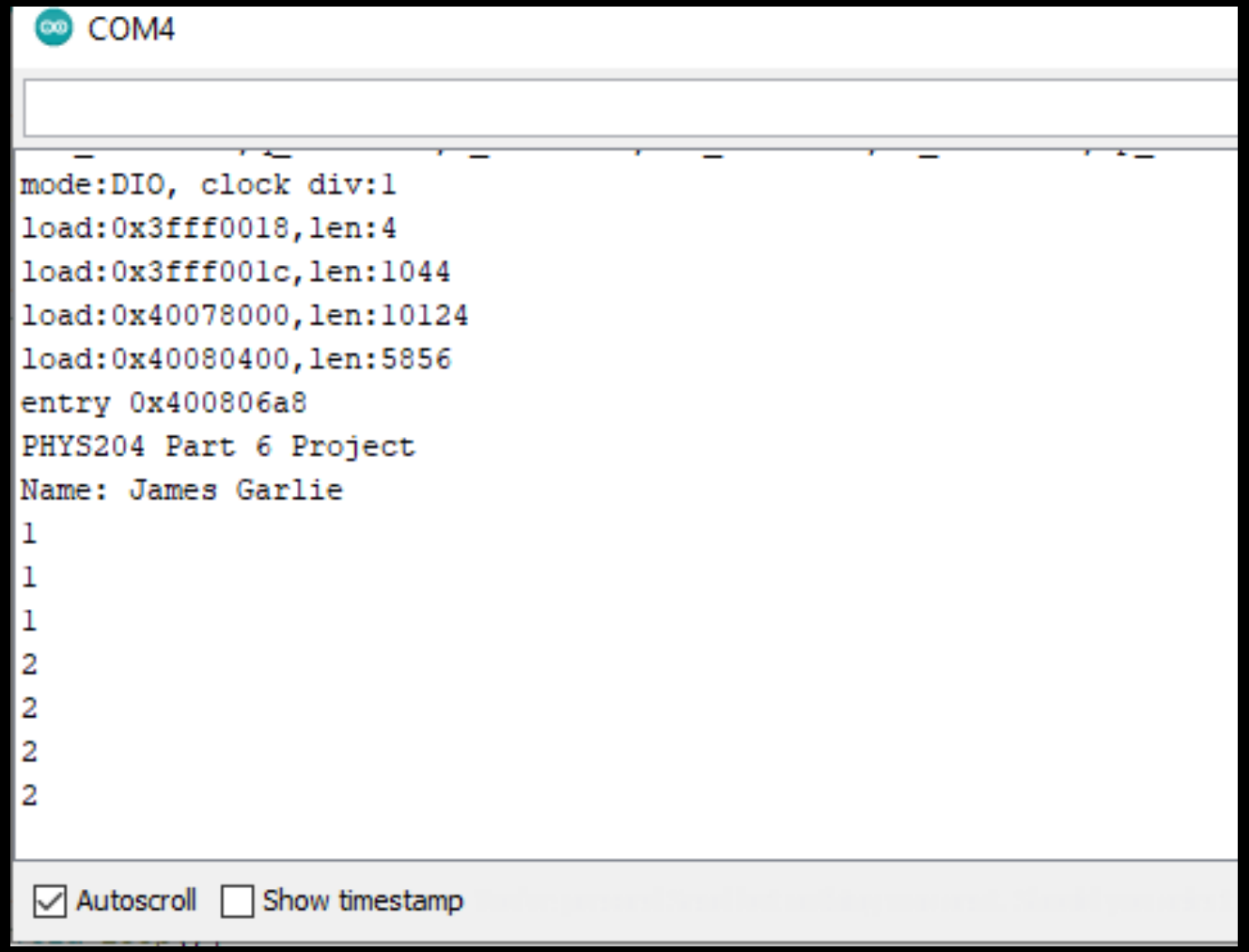
Raw Data (Screenshot)

Screenshot of Serial Monitor from Arduino IDE showing raw data.

Must include your name displayed in the Serial Monitor.

Press EN button to display name.

Unselect “Autoscroll” and scroll all the way up.



Excel Graph (Screenshot)

Include Excel graph for a single trial of data plotted as a function of time.

Must include your name in the title of the graph.

Conclusions

- Discuss the results and comment on the sources of error.
  - Answer: *My results ranged from a -4 to +5 which seemed low compared to other examples I have seen. A source of the error may have been the low powered magnet I used.*

- Describe how the Hall sensor works. What are some applications for the Hall effect sensor?
  - Answer: *They work by measuring the changing voltage when the device is placed in a magnetic field.*
  - *Some applications include Wheel speed sensors – RPM, Crankshaft & Camshaft sensors and MEMS Compasses.*

  Reference:

  https://www.electronics-tutorials.ws/electromagnetism/hall-effect.html

Challenges

- The project encompasses various sensors and requires hardware knowledge.
- Learning additional mathematic formulas and calculations.
- The free fall motion reveals that the object drifts and requires smallet time increments.

Career Skills

- The development process of the project includes critical thinking, hardware setup, and programming.
- Project encompasses the several aspects of the IoT and prepare for a future career in technology.
- What competencies will help you gain the opportunities to advance your career?

Conclusion

- Physics helps us understand the universe at scales ranging from subatomic to cosmological.
- Experiments play a key role in the development of physics and also in the growth of understanding for anyone approaching physics concepts.
- Reading and talking about physical ideas is useful; however, there is o substitute for hands-on experience with the phenomia.
- This course project utilized everyday household items and simple experiments to gain a better understanding of the world around us through the laws of physics.
- I feel that physics and this project will be a tremdous help to me in the future.