OBSERVING VARIOUS LAWS OF PHYSICS VIA PRINCIPLE OF TECHNOLOGY

A Science Project at DeVry University

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PHYS204

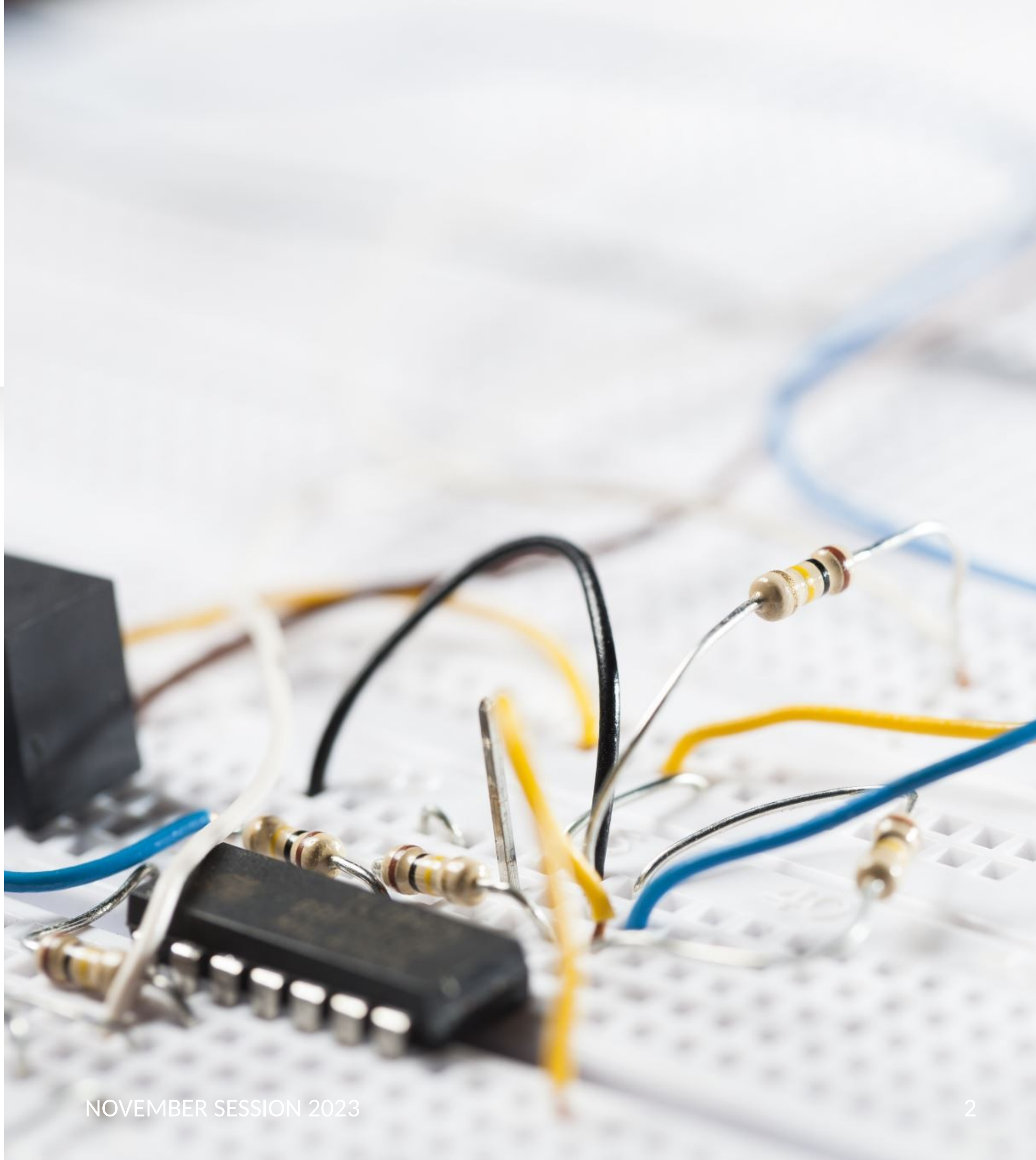
NOVEMBER SESSION 2023

WHATS TO COME

- Procedures:
  1. Observe & Measure Gravitational Acceleration of a Free-Falling Object Via an Ultrasonic Sensor, In the process of this I had to calibrate the sensor.
  2. Observe & Measure the Conservation of Energy of a Free-Falling Object.
  3. Observe & Measure the Relationship between Linear and Rotational Motion Via a Rotary Encoder.
  4. Demonstration & observation of the Hall Effect.

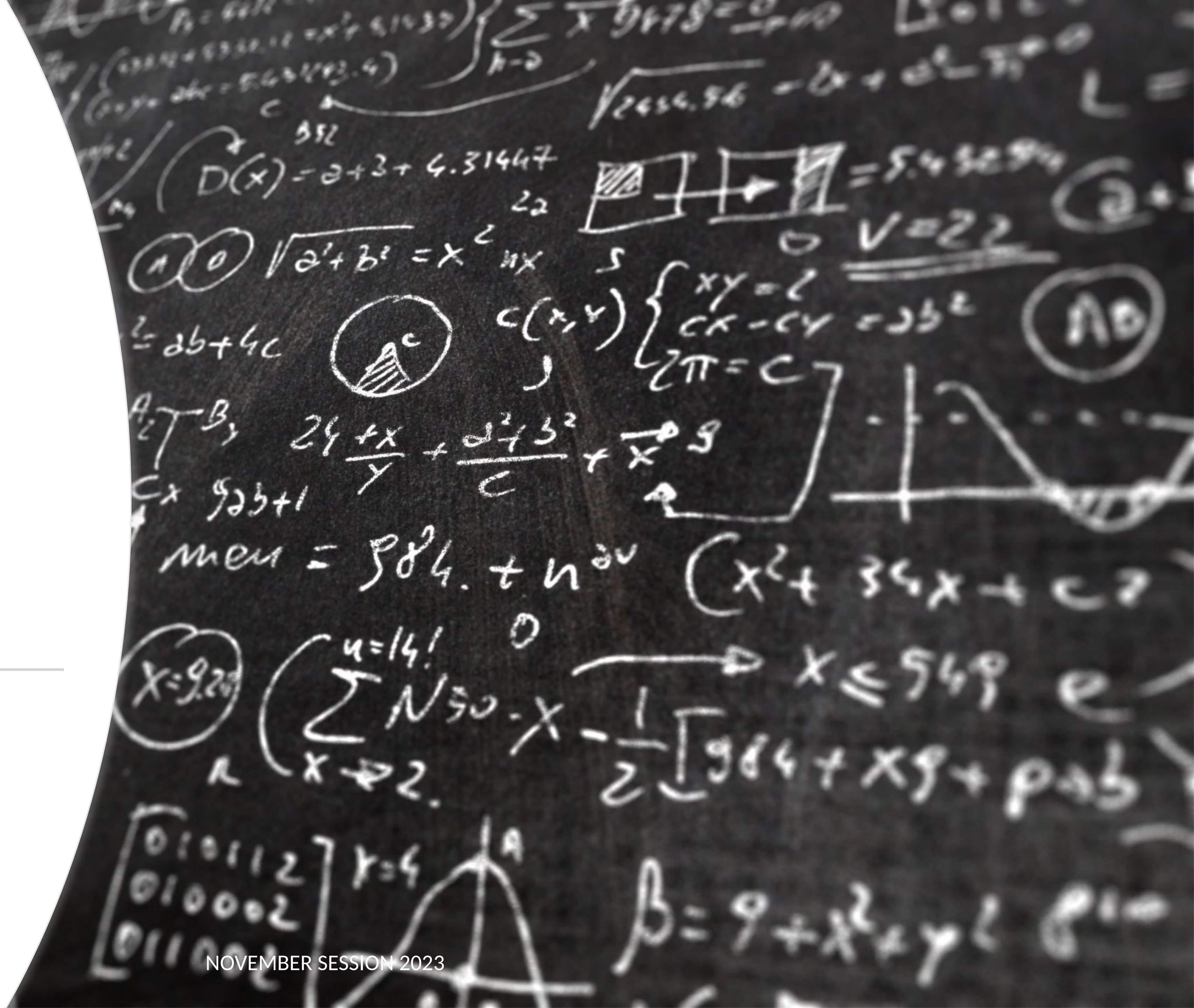
- Objectives:
  1. Procedures 1 and 2 will be verifying the principle of the Conservation of energy which states : energy in a closed system remains constant. Energy is not created or destroyed but merely changes forms.
  2. Procedure 3 will be investigating the relationship between rotational and linear motion.
  3. Procedure 4 will be Measuring the Strength and Sign of a Magnetic Field Via a Hall Sensor embedded on a esp32 Board.

I will be levraging an Arduino kit ot perform these procedures. Including A megaboard, esp32 board, Ultrasonic sensor, Rotary Encoder, and hall sensor.



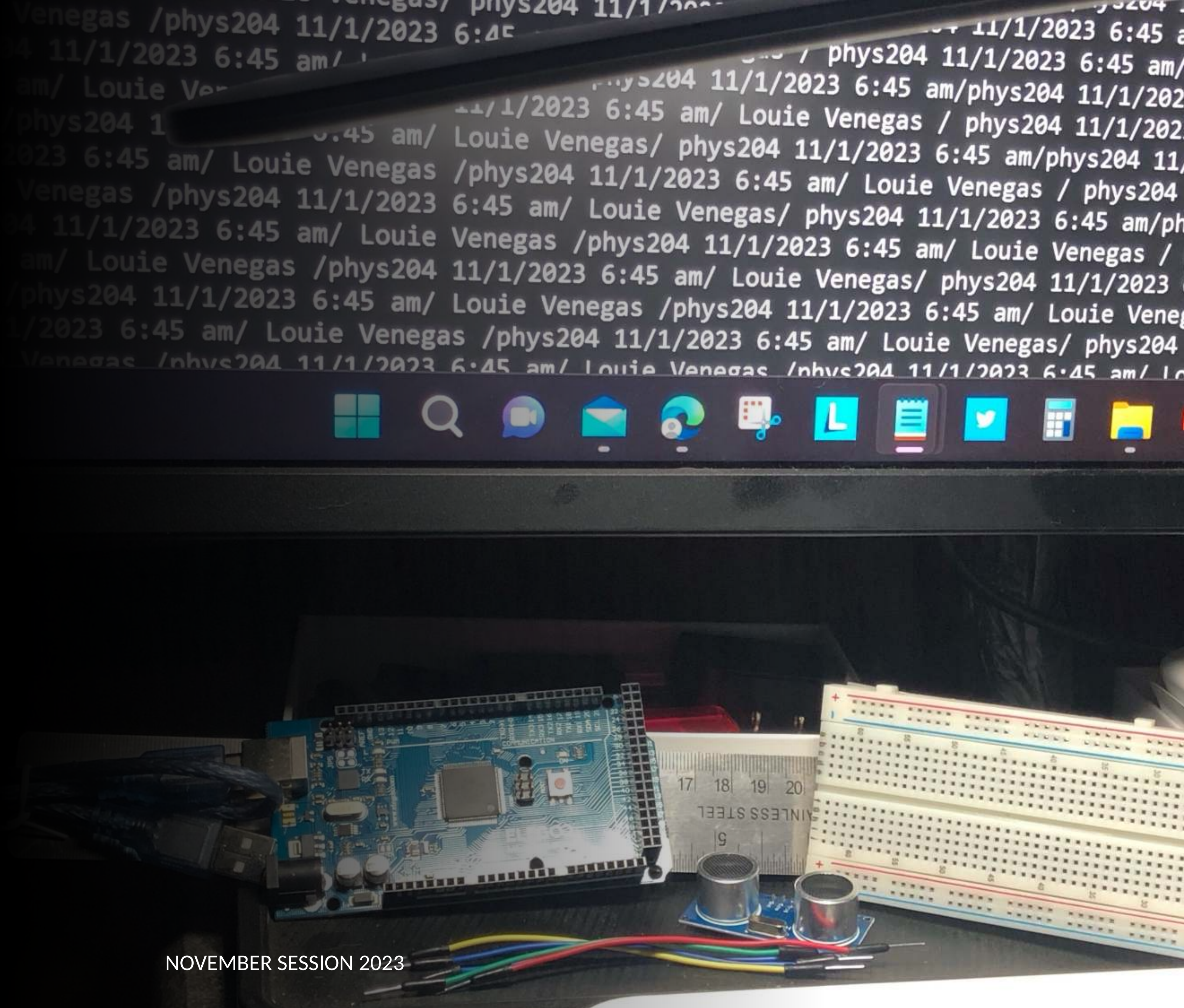
Inventory

Inventory of Parts and Software



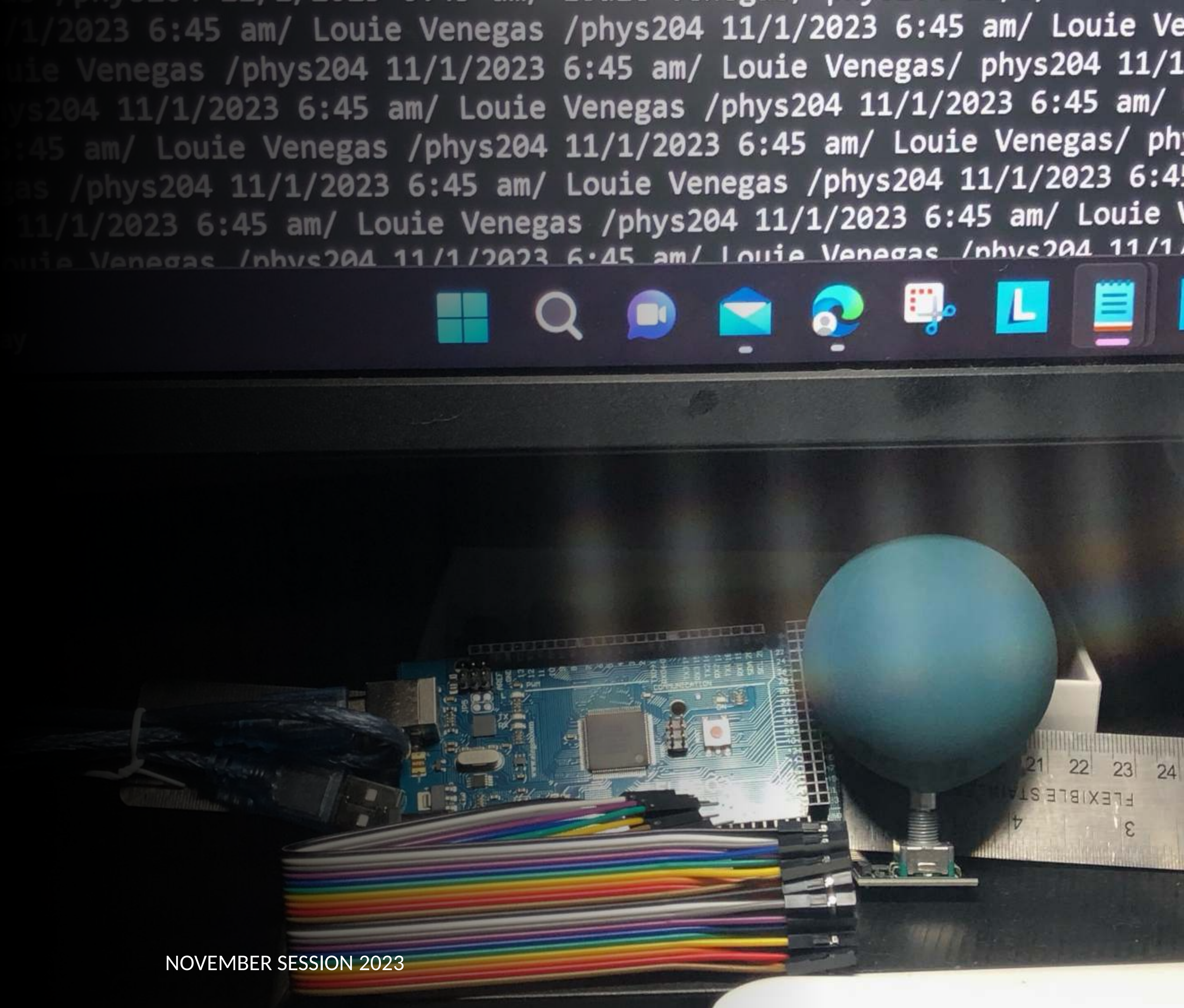
Materials List (Picture)

- 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
- Please include a note with your name on it next to parts.



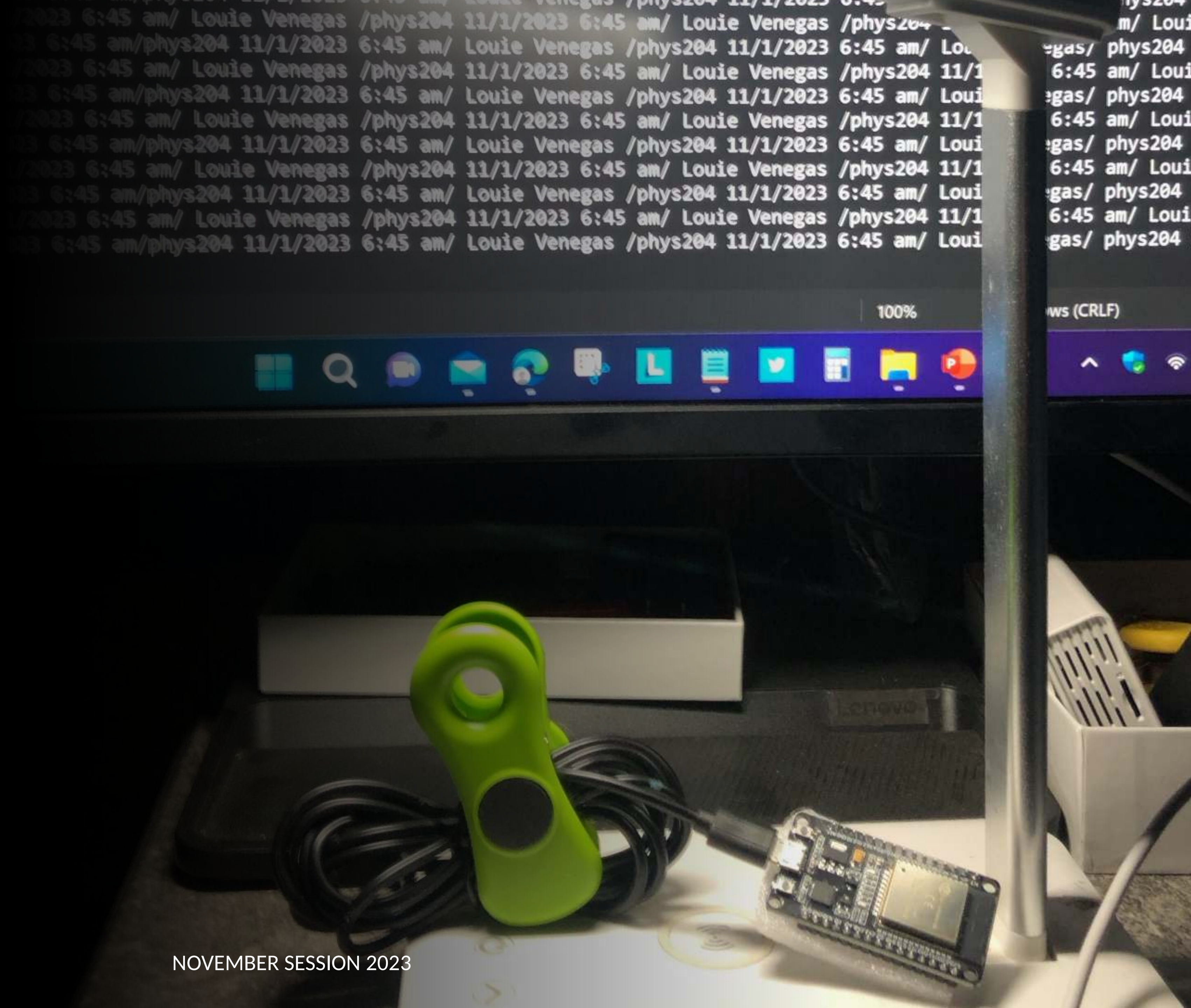
Materials List (Picture)

- 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
- Please include a note with your name on it next to parts.



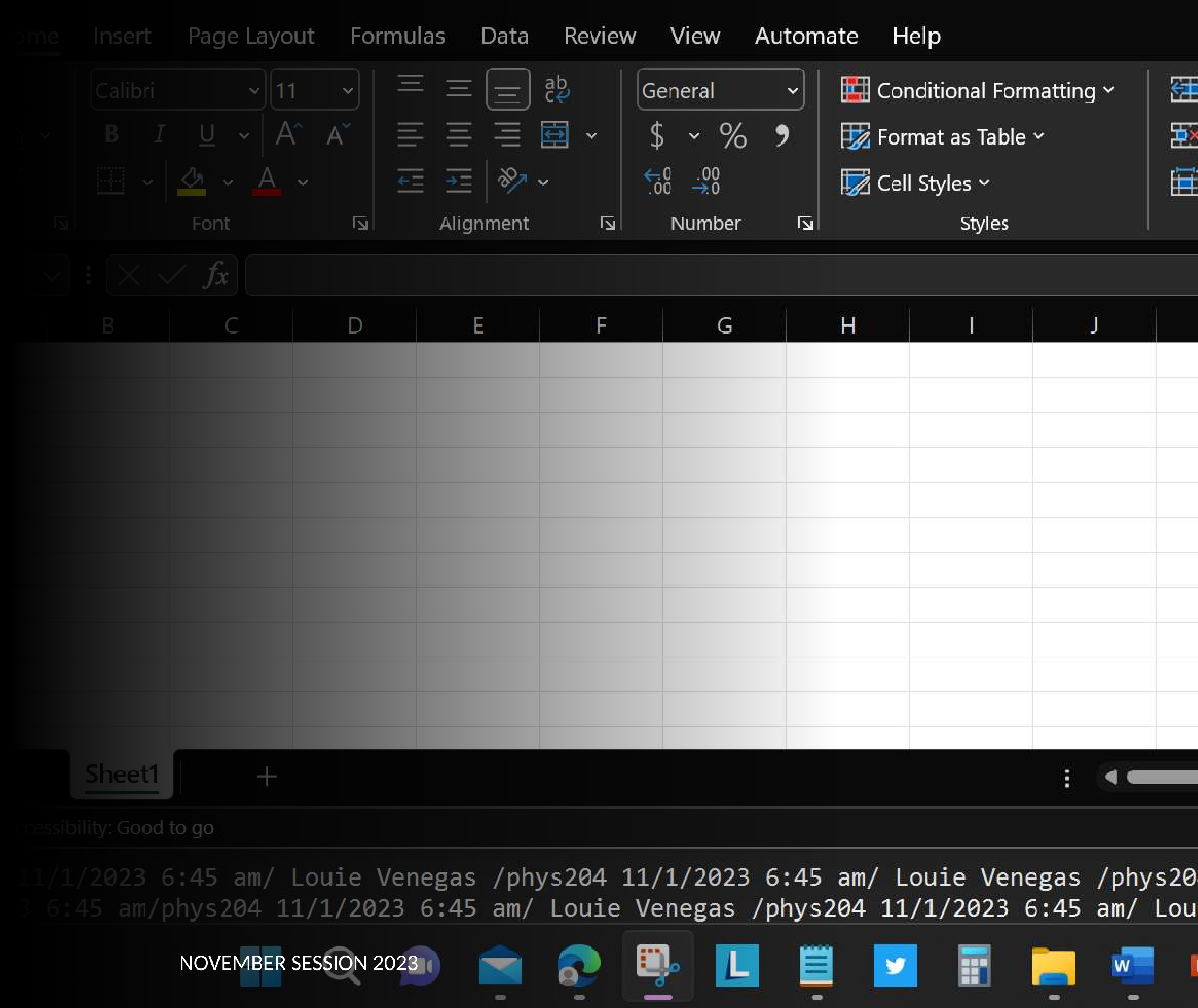
Materials List (Picture)

- ESP32 microprocessor
- Micro-USB cable
- Magnet
- Please include a note with your name on it next to parts.



Required Software (screenshot)

- Microsoft Excel installed and running on my computer

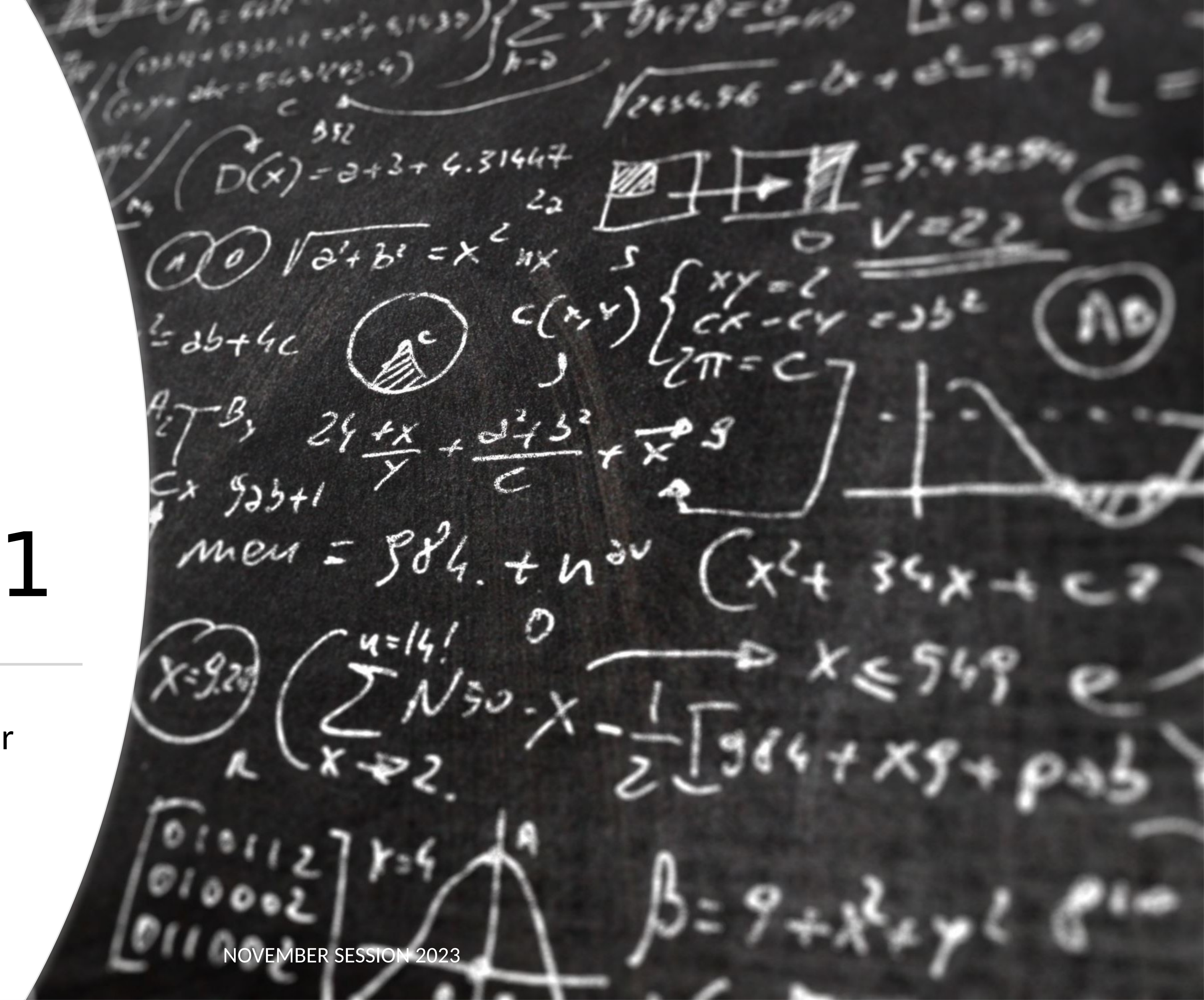


Required Software (screenshot)

- Arduino IDE installed and running on my computer.

Procedure 1

Precision of the Ultrasonic Sensor

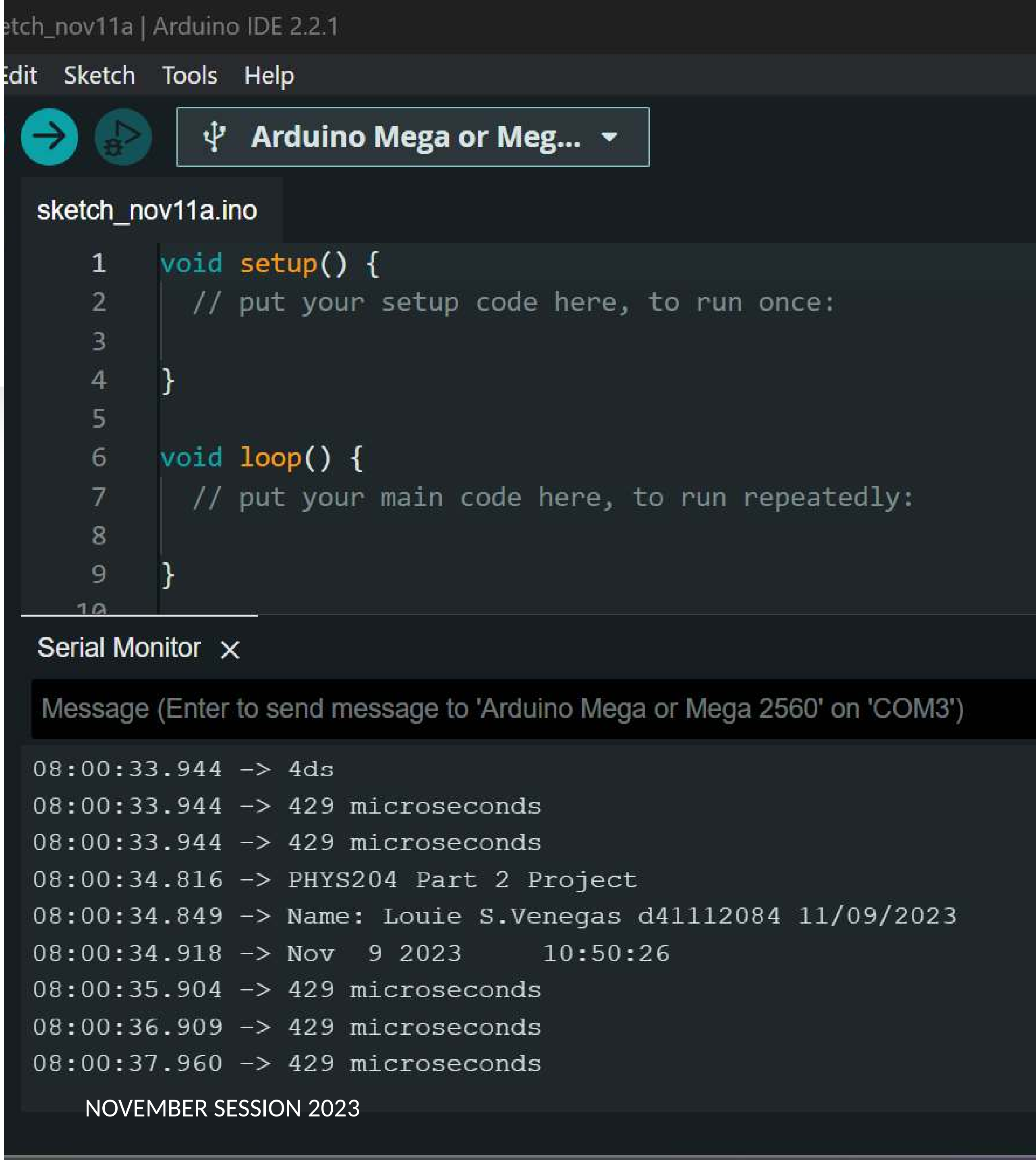


Experimental Set-up (Picture)

- 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 from the Ultrasonic sensor.



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	429	4.29× 10-4 s	372.96
2	7	.14	419	4.19× 10-4 s	334.13
3	6	.12	322	3.22× 10-4 s	372.67
4	5	.10	222	2.22× 10-4 s	450.45
5	4	.08	257	2.57× 10-4 s	311.28

Data Analysis

- Average velocity from table

Answer: 368.30 m/s
units

- Percent difference where

Answer: 7.38 %
units

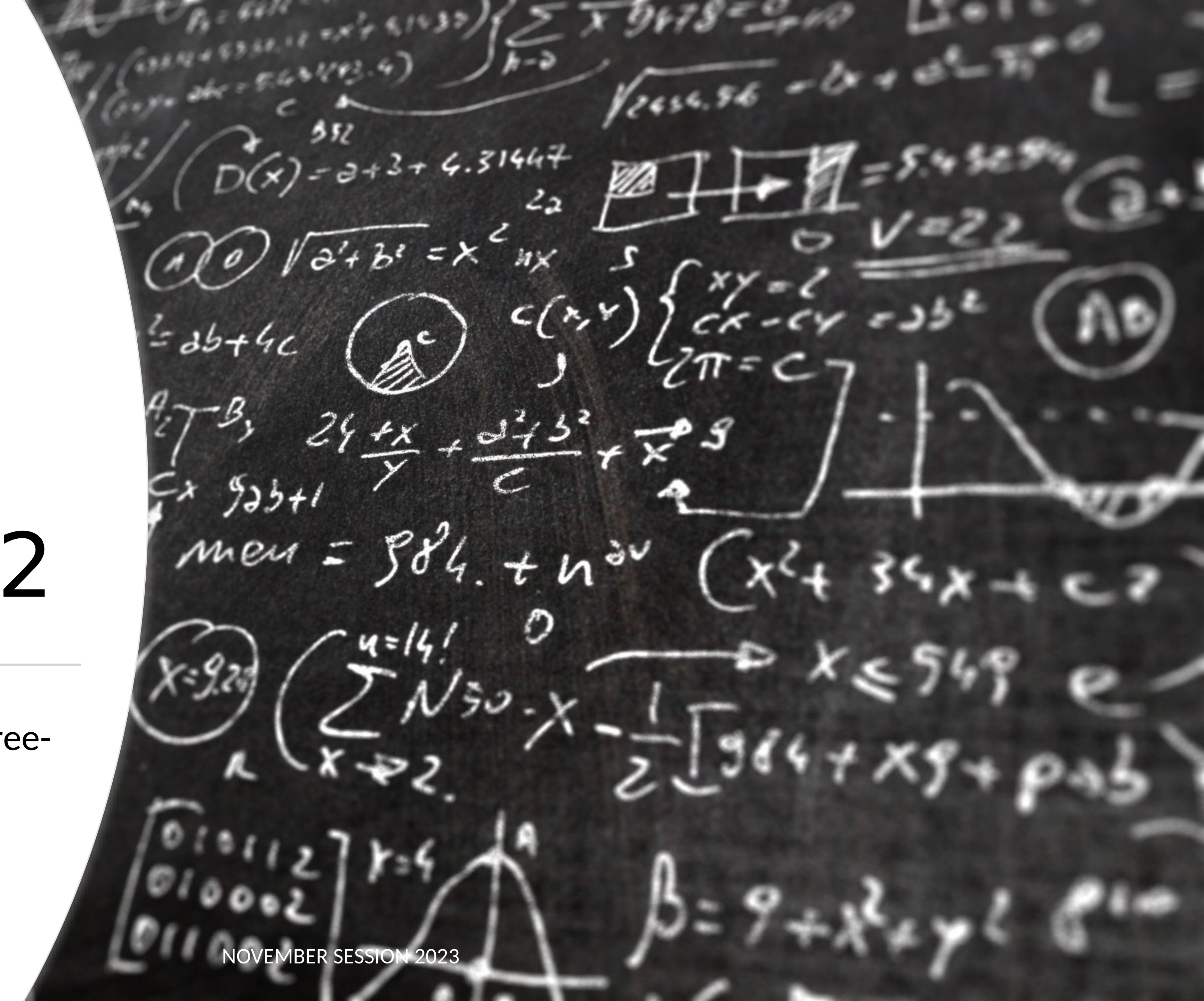
Conclusions

- Discuss the results and comment on the source of errors.
  - Answer: I had to run the test twice because the first round I was using a obstacle that had a curve. My end answer was over 20 percent. Once I changed the obstacle to a flat box I had a more accurate result.

- What is the dependence of temperature, humidity, and atmospheric pressure on the speed of sound? How does it affect the results?
  - Answer: I do now that in vacuum sound does not exist at least not the way it does down here in the gravity well. The denser the pressure of atmosphere the faster sound can travel. Although a highly humid atmosphere may cause sound to slow or be muffled. I would say on such a small experiment these variables are not part of my equation.

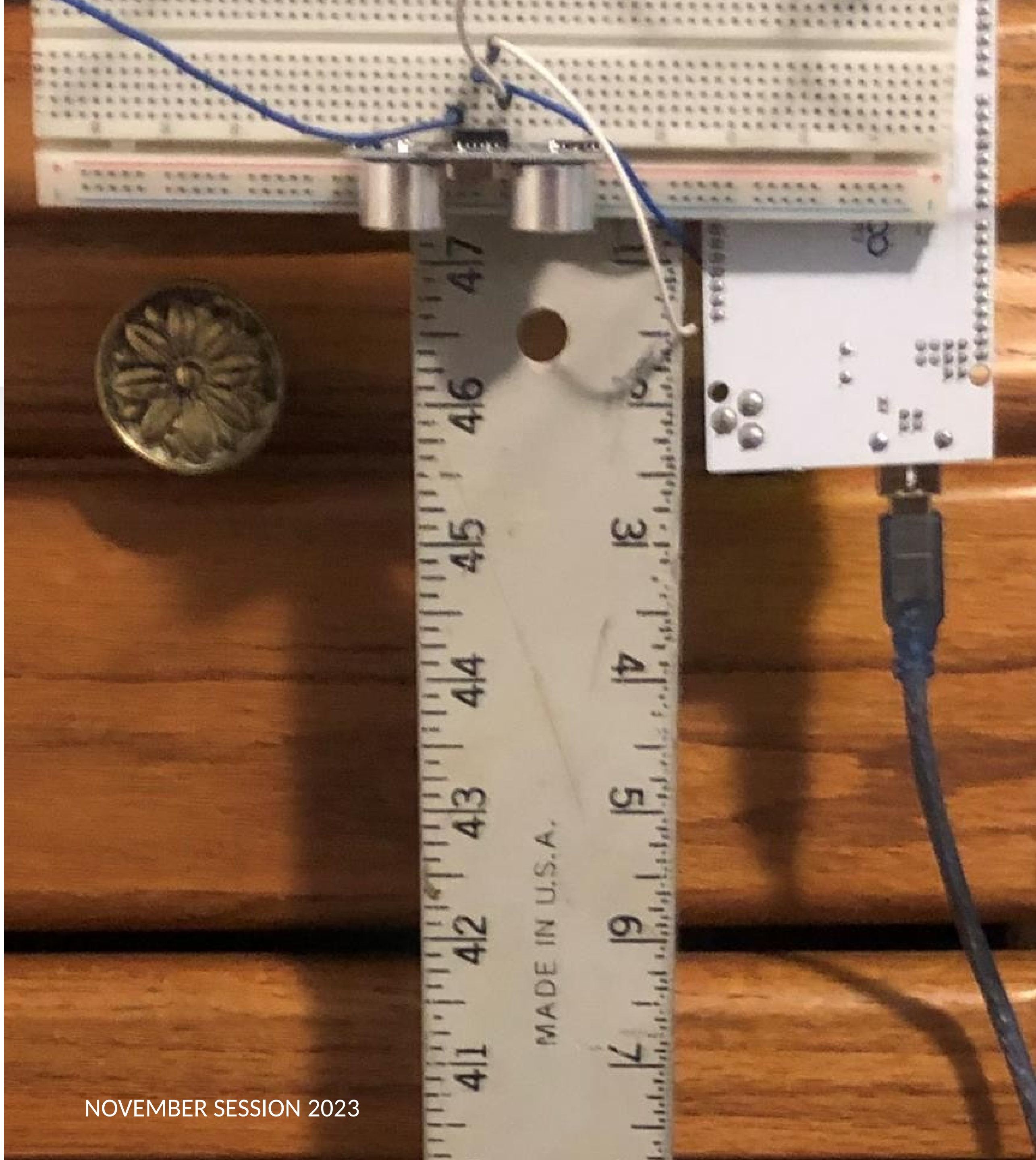
Procedure 2

Gravitational Acceleration of a Free-Falling Object



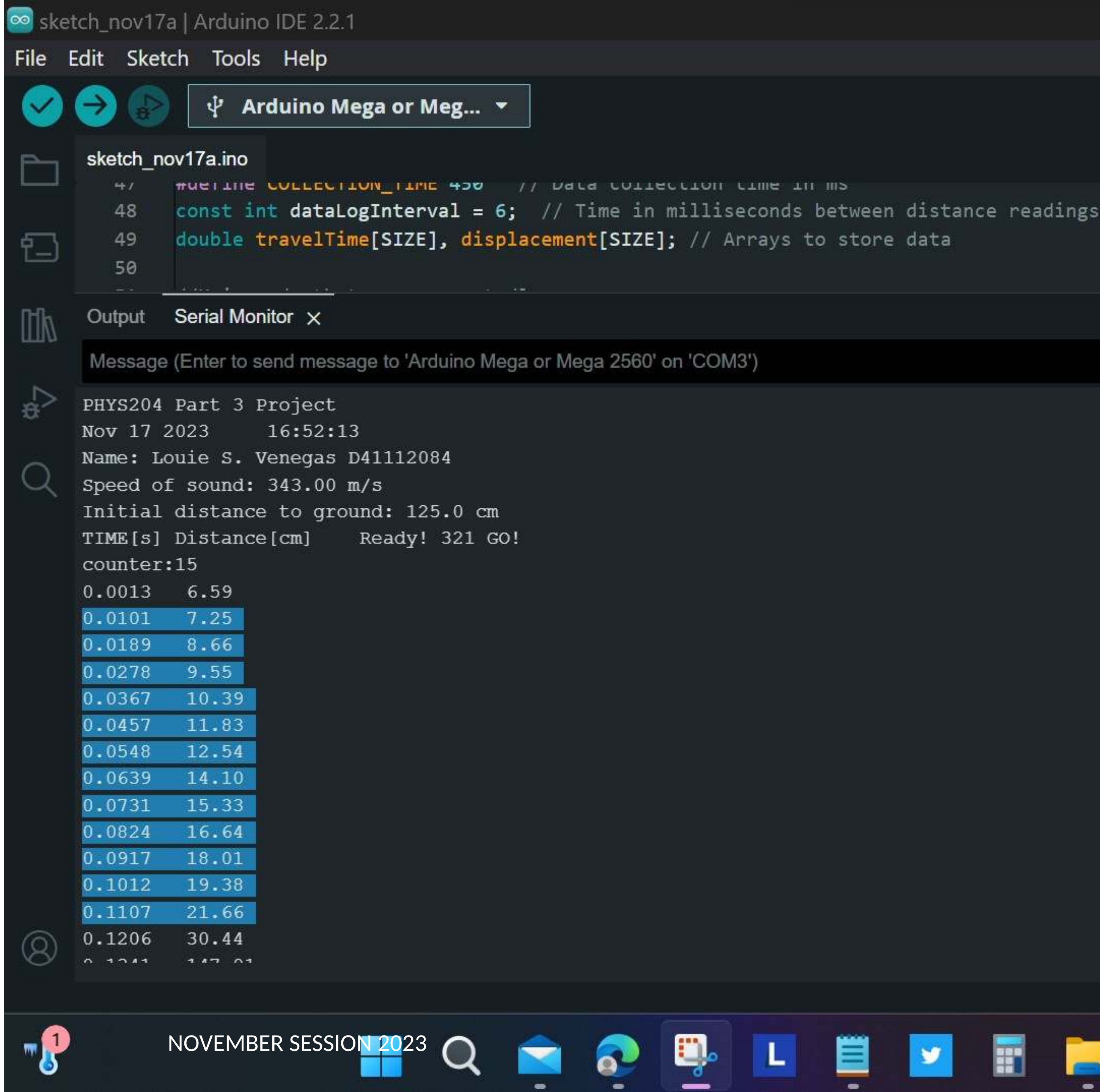
Experimental Set-up (Picture)

- 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)

- Includes screenshot of raw data showing the start of the fall and end of the fall of one trial.
- **Includes my name displayed in the serial monitor.**



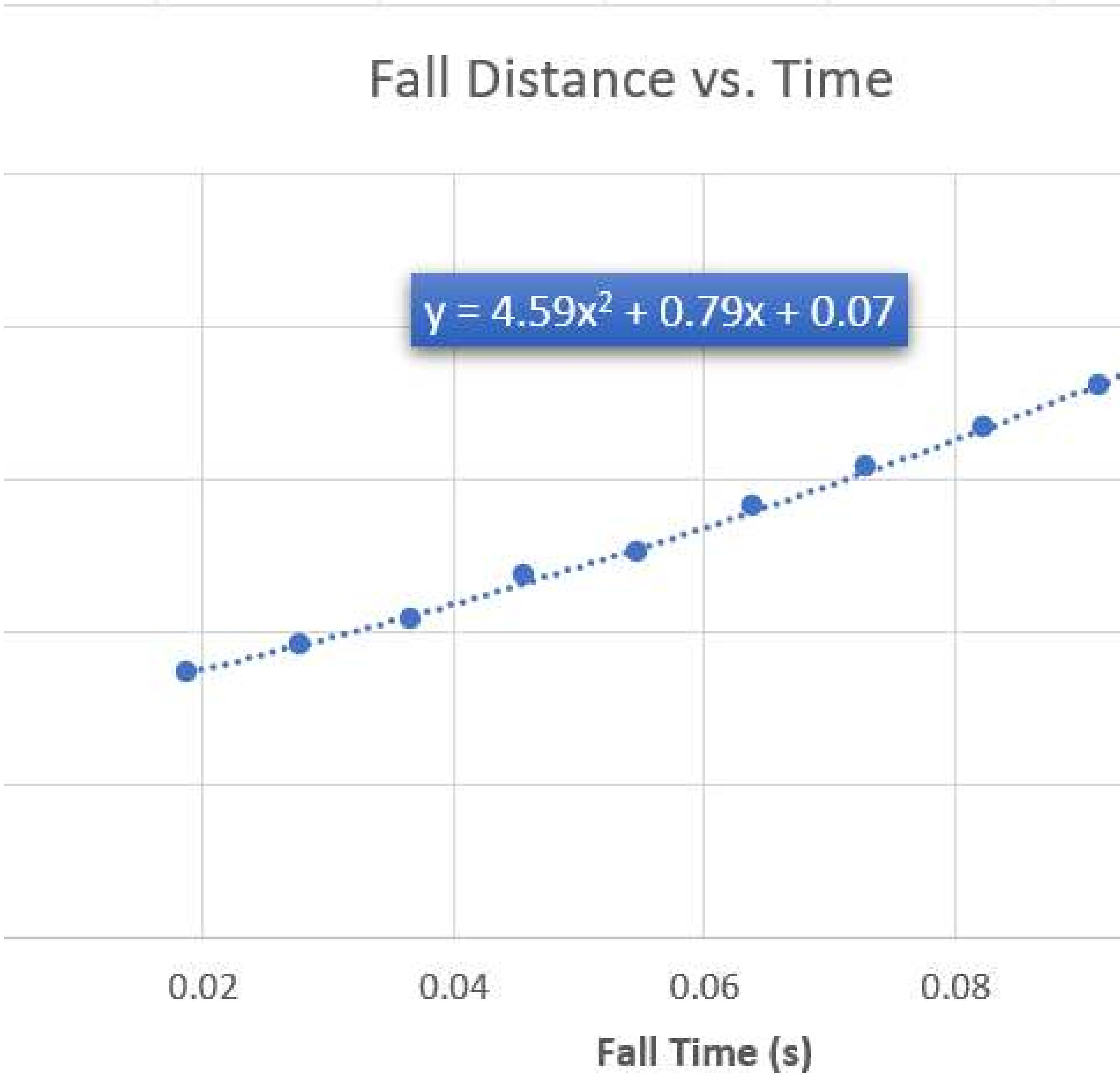
Excel Table (Screenshot)

- This shows my iPhone being dropped from 125 cm high.
- This is the data that includes the time of the time and distance of the objects as it falls.

	A	B	C
1	Time (s)	Distance (cm)	Distance (m)
2	0.0189	8.66	0.0866
3	0.0278	9.55	0.0955
4	0.0367	10.39	0.1039
5	0.0457	11.83	0.1183
6	0.0548	12.54	0.1254
7	0.0639	14.1	0.141
8	0.0731	15.33	0.1533
9	0.0824	16.64	0.1664
10	0.0917	18.01	0.1801
11	0.1012	19.38	0.1938
12	0.1107	21.66	0.2166
13			

Excel Graph (Screenshot)

- the fall distance as a function of time.
- **Confirms that most data points fall along the curve fitting.**
- **The x^2 coefficient is 4.59**



Trial	x^2 coefficient value from curve fitting	Acceleration (m/s^2) = 2* (x^2 coefficient)
1	4.59	9.18
2	3.36	6.72
3	6.66	13.32
4	6.66	13.32
5	5.37	10.74

Data Collection

Data Analysis

Average acceleration from table

Answer: 10.76 m/s^2
units

Percent difference with

Answer: 9.80 %
units

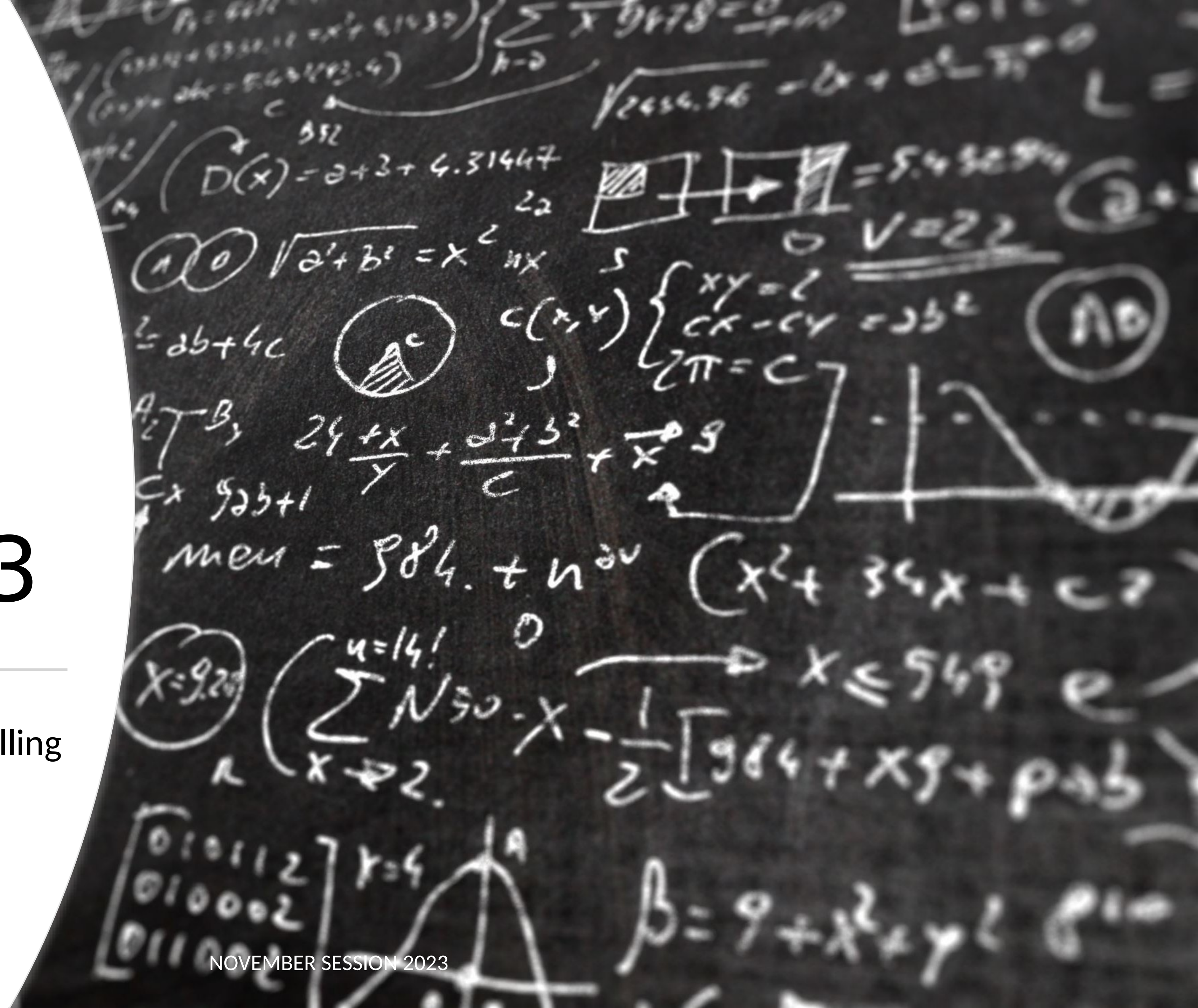
Conclusions

I find it rather intriguing that I come with 9.80 as my average. The process was very straightforward and it proved the constant acceleration of gravity. I struggled with finding a suitable object that would give me reliable and consistent results within the given parameters. I also struggled with preventing the object from coming to close to the square I was using.

I concluded that so long as my object fell without doing a 360 in the air I had consistent results. Of course this is a very controlled environment.

Procedure 3

Conservation of Energy of a Free-Falling Object



Excel Table (Screenshot)

•Includes 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	0.0367	10.15	0.1015	0.20	0.00	0.0000	0.3844	0.3844
3	0.0456	10.86	0.1086	0.19	0.80	0.0636	0.3704	0.4341
4	0.0546	11.82	0.1182	0.18	1.07	0.1138	0.3516	0.4654
5	0.0637	13.02	0.1302	0.17	1.06	0.1130	0.3281	0.4411
6	0.0728	13.86	0.1386	0.16	1.10	0.1216	0.3116	0.4333
7	0.082	15.57	0.1557	0.14	1.37	0.1873	0.2781	0.4654
8	0.0913	17	0.1700	0.13	1.44	0.2079	0.2501	0.4580
9	0.1007	18.54	0.1854	0.11	1.68	0.2814	0.2199	0.5013
10	0.1102	19.69	0.1969	0.10	1.46	0.2135	0.1974	0.4108
11	0.1197	21.75	0.2175	0.08	1.67	0.2797	0.1570	0.4367
12	0.1294	23.43	0.2343	0.06	1.70	0.2903	0.1241	0.4144
13	0.1392	25.4	0.2540	0.04	1.97	0.3877	0.0855	0.4731
14	0.1491	27.66	0.2766	0.02	2.01	0.4041	0.0412	0.4453
15	0.1591	29.76	0.2976	0.00	2.13	0.4542	0.0000	0.4542

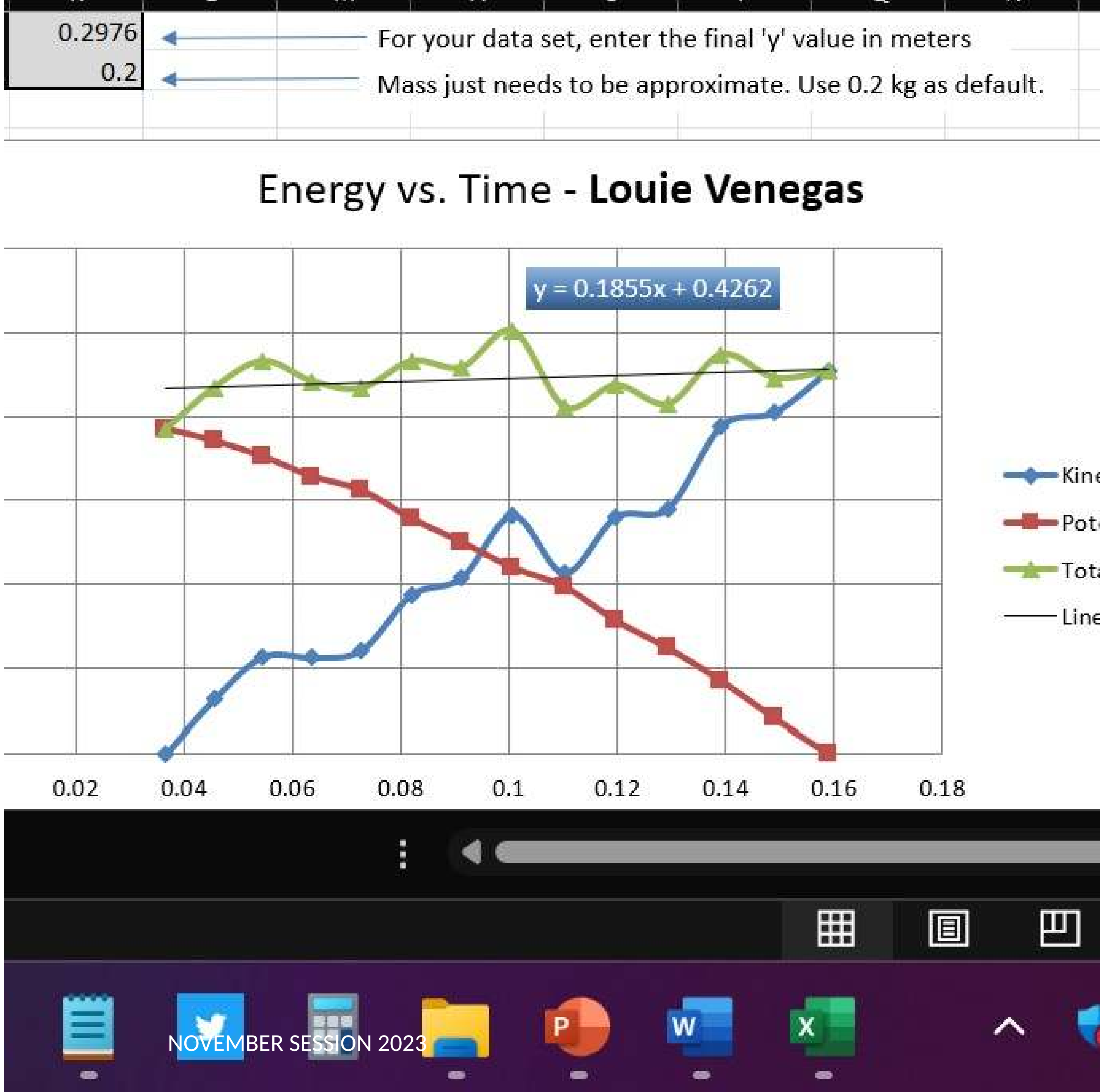
Conservation of Energy

Ready Scroll Lock Accessibility: Investigate

32°F Partly cloudy

Excel Graph (Screenshot)

- Includes 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.
- Notice my name in the graph…



Data Analysis

- Theoretical value of final velocity

.2976-.1015= 0.1961m
units

=1.96m/s
units

- Final velocity from experimental data (or largest velocity)

= 2.13 m/s
units

- Percent difference

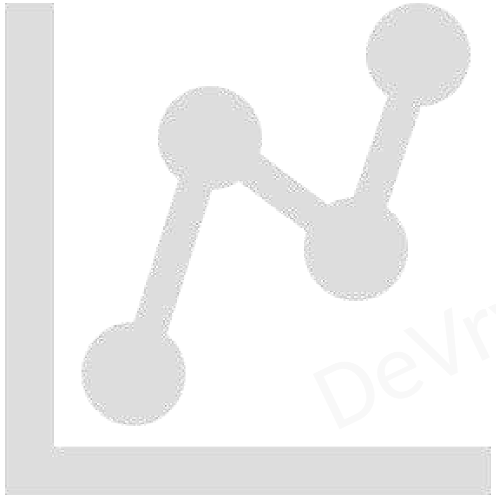
Answer: 7.98 %
units

Conclusions

The table on slide x is a graphical depiction of an items free fall describing it in two key terms kinetic and potential energy. Notice kinetic energy ends when it hits total energy. That moment coincides with when my phone hit the floor.

It should be noted that Kinetic Energy K is lowest when potential U is highest, and that potential energy U is lowest when kinetic energy K is highest. We see equilibrium between kinetic energy and potential energy when the lines cross. I believe that the kinetic energy is rising because of gravitational acceleration while potential is falling for two reason's. One would be friction with the air and two would be the item was turning around in the air as it was falling.

Conclusions

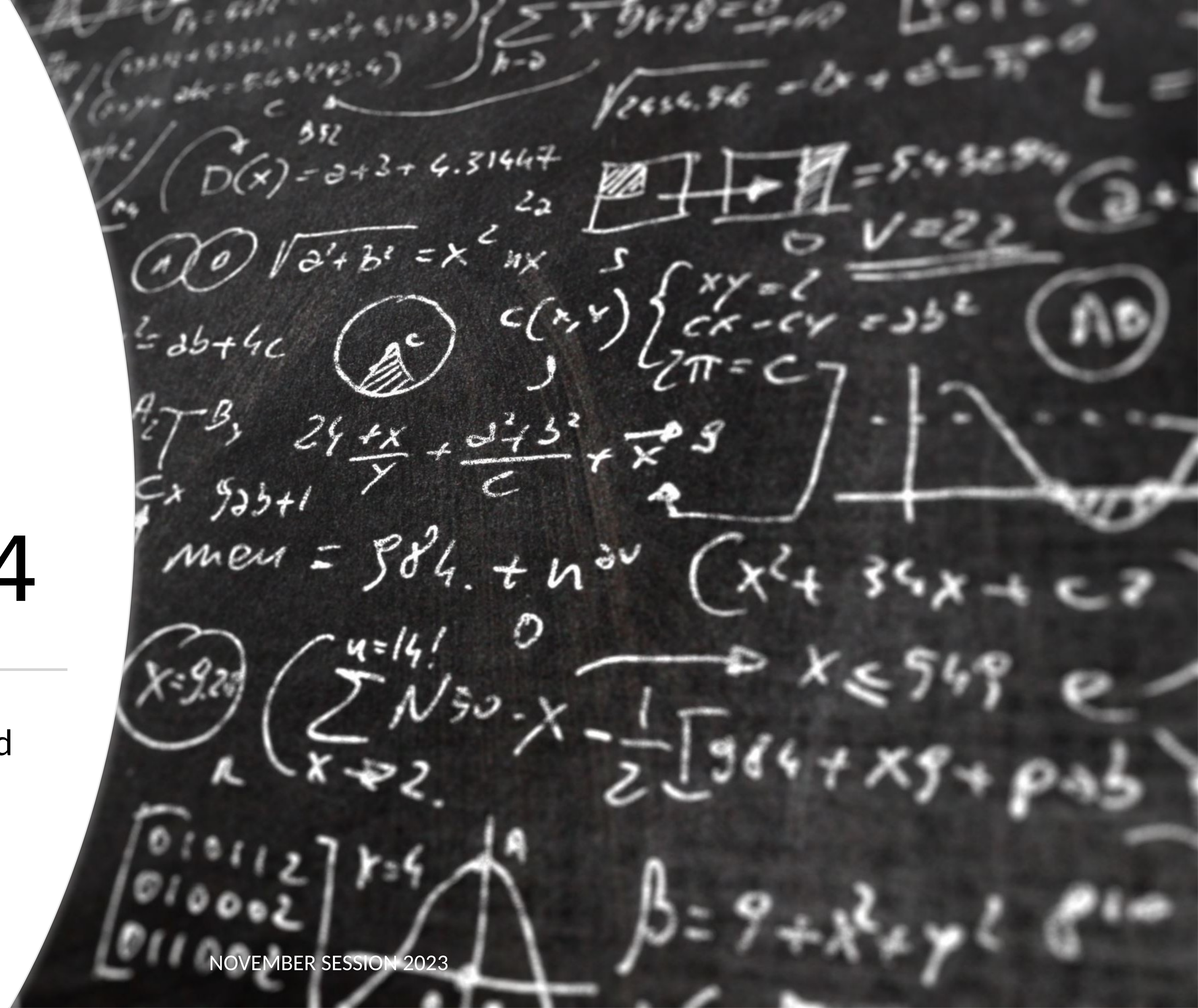


- What is the trend of the best fit line for the total energy E in your data? If the data is accurate, the total mechanical energy should decrease slightly. Why is that?
  - Answer:

  My best fit line is trending up ever so slight. The total energy line goew up then trends back down. This is due to friction from the air and rotation in the object.

Procedure 4

Relationship between Linear and Rotational Motion



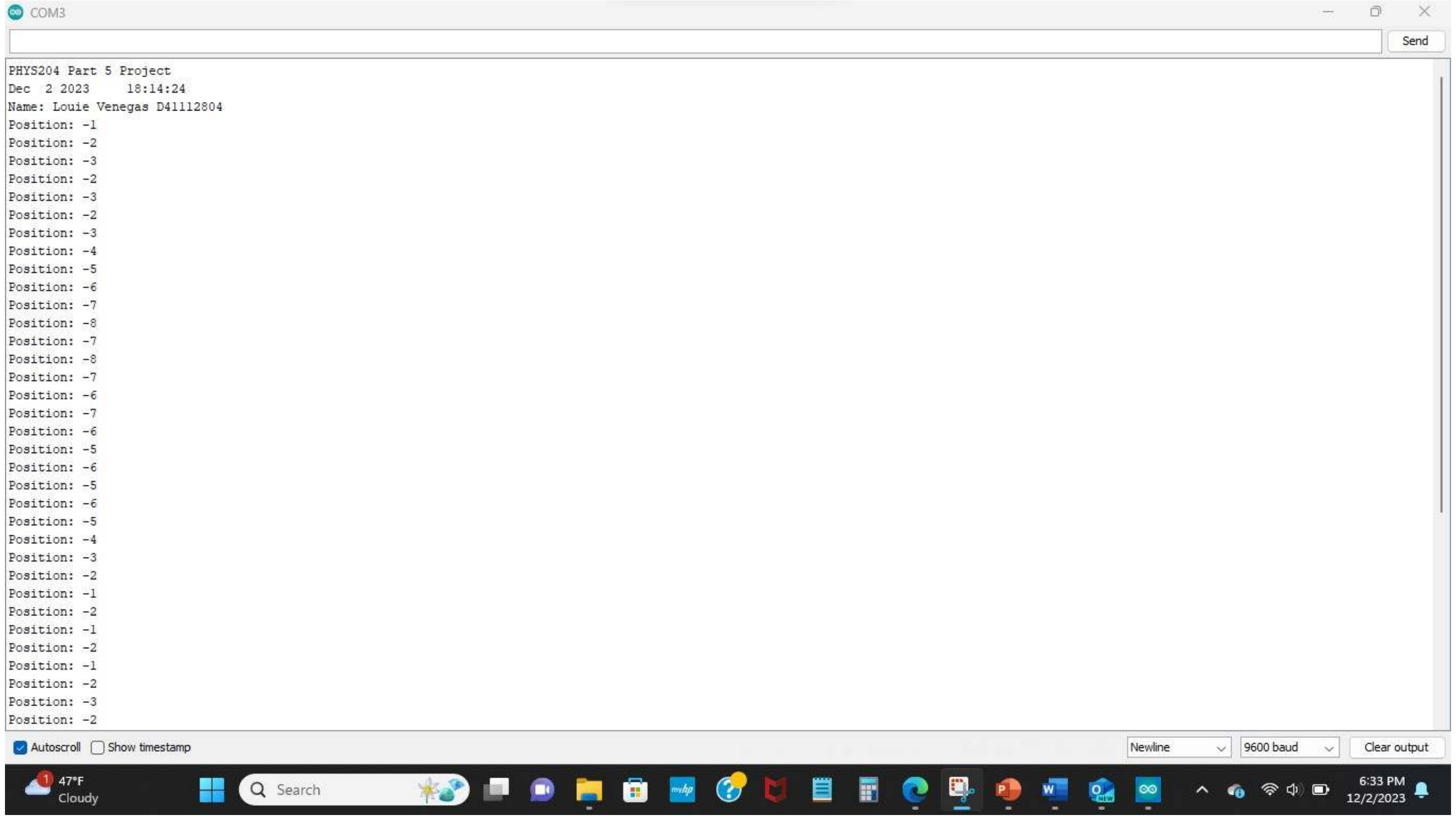
Experimental Set-up (Picture)

- 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

- Please include a note with your name on it next to experimental set-up.

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* = 6 cm ______ ______ *units*
- Object radius: *r* = 3 cm ______ ______ *units*
- Number of pulses for one revolution: *x* = 40 ______
- Resolution =

.0157 ______ Radians\pulses ______ *units*

Data Analysis

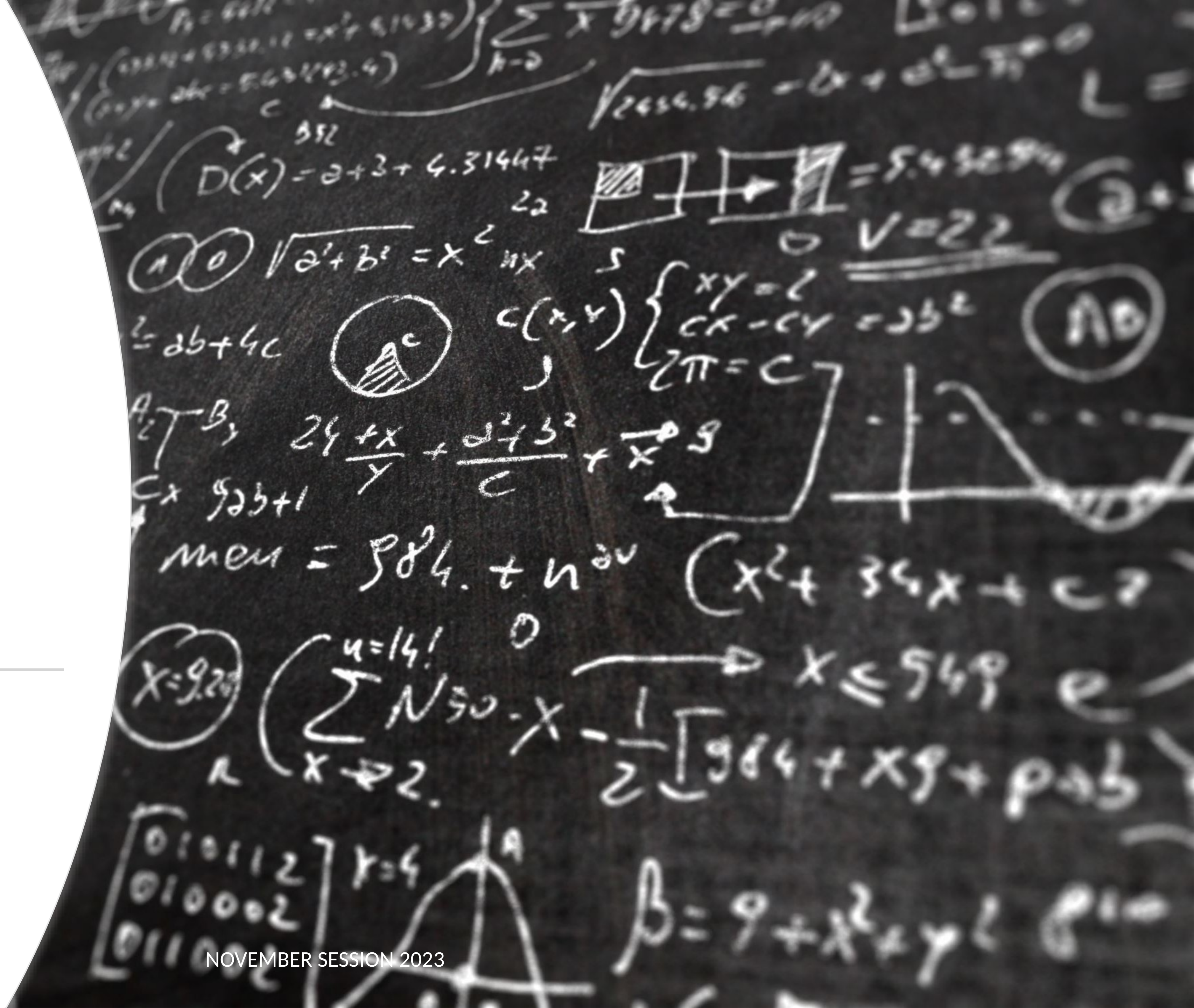
Trial	Number of pulses *N*	Encoder distance *r N*	Measured distance with ruler	Percent difference
1	64	28.8	28	2.86
2	13	6.3	8	15.87
3	19	8.55	10	14.5
4	22	9.99	12	16.75
5	30	13.5	15	10

Conclusions

- Discuss the results and comment on the sources of error.
  - Answer: I had an average of approx. 12% I feel like this amount of error was too wide and should’ve been closer to 5 percent. I believe that the issue I am having by producing so much error is the precision with which I am rolling. Perhaps I'm not rolling it in a straight line, or the surface is not completely round.
  - What are some applications of this measuring technique? Could this measuring system be used to measure surfaces that are not flat?
  - Answer: Two uses for rotary encoders and this measuring technique that interest me would be Industrial automation and robotics. Industrial automation this technique is used to control equipment's and know their positions such as conveyer belts and with robotics it detects the position of the joints and actuators,

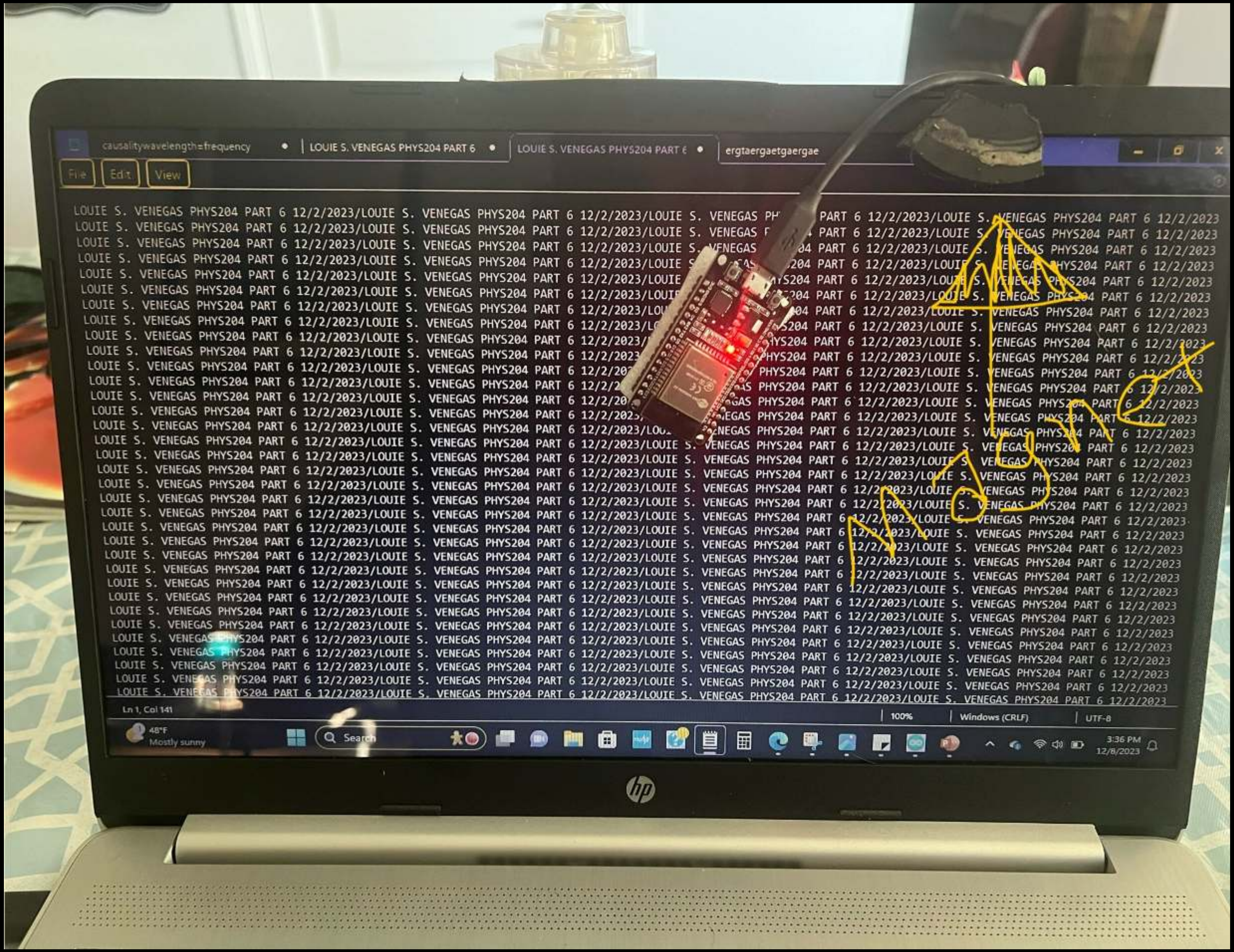
Part 6

The Hall Effect



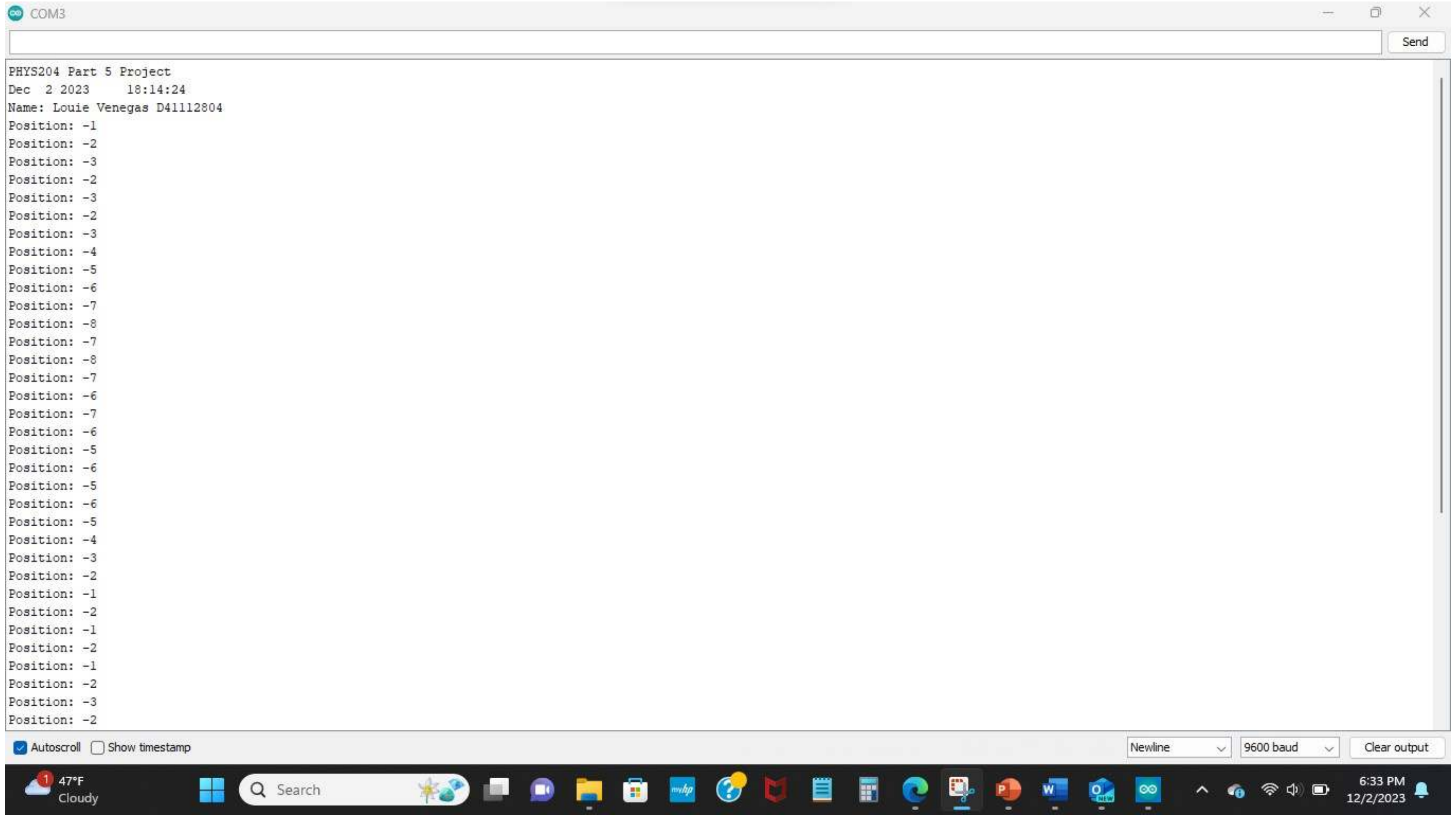
experimental setup

- Micro usb
- ESP32
- Laptop
- magnet



Raw Data (Screenshot)

- Screenshot of Serial Monitor from Arduino IDE showing raw data.
- **Must include your name displayed in the serial monitor.**



COM4

Send

```
1
ets Jul 29 2019 12:21:46

rst:0x1 (POWERON_RESET),boot:0x13 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0xee
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:1
load:0x3fff0030,len:1184
load:0x40078000,len:13260
load:0x40080400,len:3028
entry 0x400805e4
PHYS204 Part 6 Project
Name: Louie Venegas D41112084
1
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```

A screen shot of

Raw data

This screen shot is of the serial monitor from the Arduino IDE(Integrated Development Environment). Notice my name and date in the printed text before the data begins its transmission. The data is transmitted when I hold a magnet near the ESP32’s Hall sensor.

Autoscroll Show timestamp Newline 115200 baud Clear output

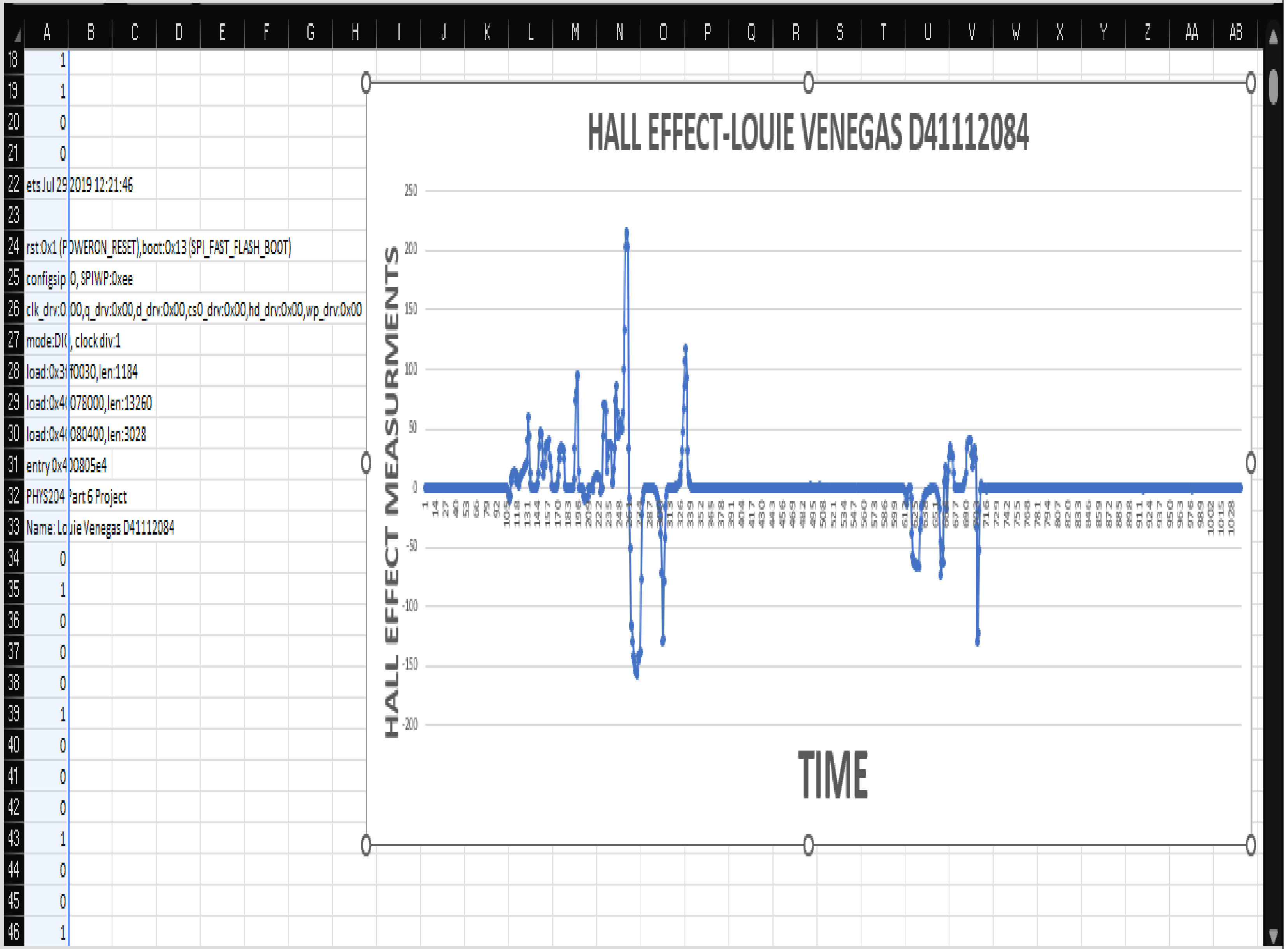
A screenshot

of

an excel graph

showing the hall effect

I took the raw data to Microsoft excel and pasted it into a blank notebook. I then took that data and put it into a scatter line chart. As you can see excel took the raw data and turned it into something tangible and easy to understand.



Conclusion

The Hall Effect… It is important to note that this phenomenon was first discovered by one Edwin Hall in 1879 during the pursuit of his doctoral degree at Johns Hopkins University. The Hall Effect occurs when you place a magnet near a conductor carrying a current. When this happens the electrons within the conductor are pulled towards the magnet or pushed depending on the polarity. In response to the accumulation of electrons near the magnetic field it creates a voltage difference between the two sides of the conductor. This deference is known as the Hall Voltage. The discovery of the Hall Effect led to the creation of the Hall Sensors. It is a hall sensor embedded in my esp32 board that I used for this experiment.

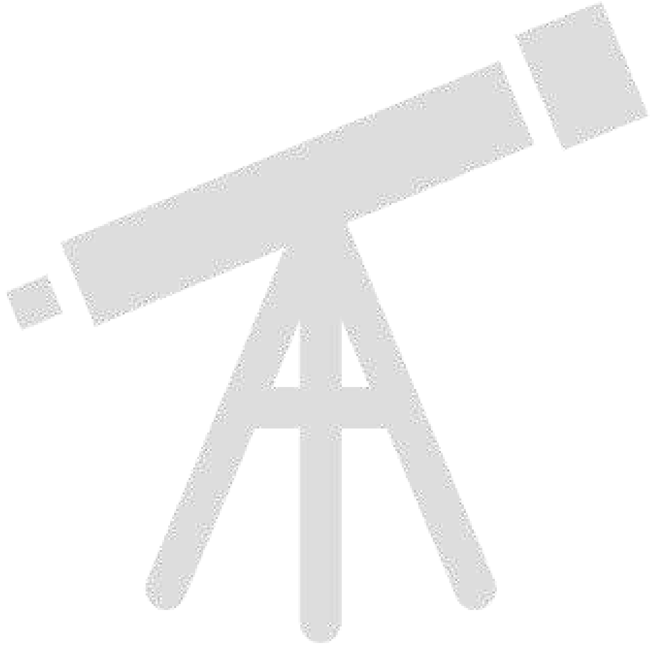
I started by connecting my esp32 board to my windows pc and flashing the microprocessor with the code required to perform the task I needed using the Arduino IDE. Then after successfully programing the board I used the Arduino serial port to collect data from the sensor embedded on the board. Utilizing a magnet form an old speaker I triggered the hall sensor on the board several time form both poles. From the chart on the excel graph its easy to see when I moved the magnet in close to the board.

This process is used in many various applications. From sensing current to sensing if a door is shut. Did you know that the keyboard I'm typing on right now uses a hall sensor in the shift button?

References

1. 1. Bing. (2023, December 9). Re: I need some help understanding the hall effect [Online forum comment]. https://www.bing.com/
2. 2. Hall effect. (2021). In Wikipedia, https://en.wikipedia.org/wiki/Hall_effect
3. 3. Hall effect. (2021). In ScienceDirect, https://testbook.com/physics/hall-effect
4. 4. Hall effect. (2021). In Encyclopædia Britannica, https://www.britannica.com/science/Hall-effect

Conclusion



Throughout the course of this project, I tested several principles of physics and found that the universe is still working. I tested these principles via technology and classically accepted physics equations. Using various mathematical constants. The procedures were challenging at time because of various variable interacting with my components. Through critically thinking about the problem, I was able to figure out how to get appropriate results. The skills acquired throughout this course will most likely be principles used frequently throughout the course of my future career as a software engineer. Especially if Into automation of any kind.