Physics

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PHYS204

Introduction

An introduction to Physics, focusing on various base concepts including forces, motion, energy, waves, and sound.

Part 1

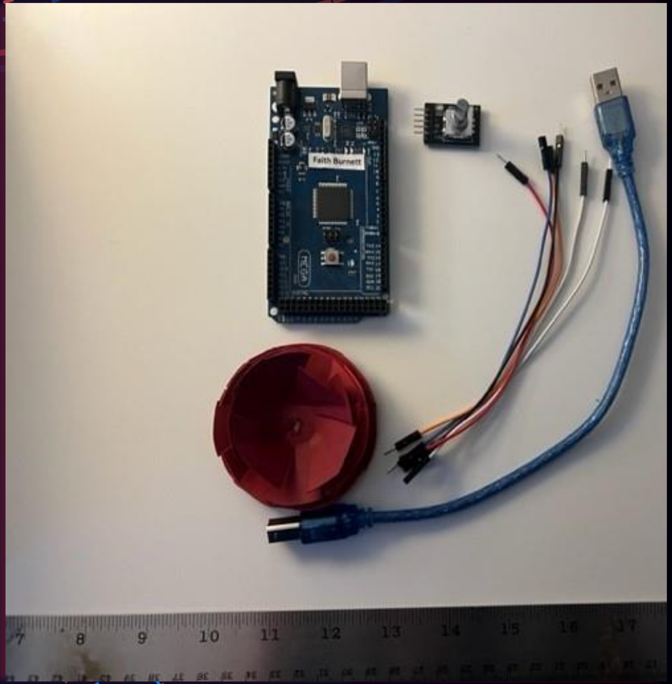
- Materials list
- Software requirements

Materials

- 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

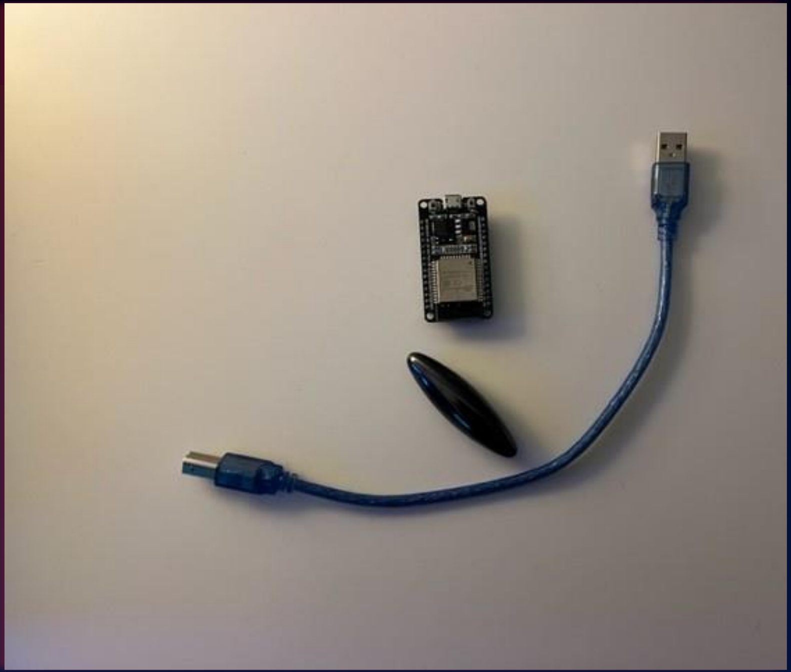
Materials cont.

- 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



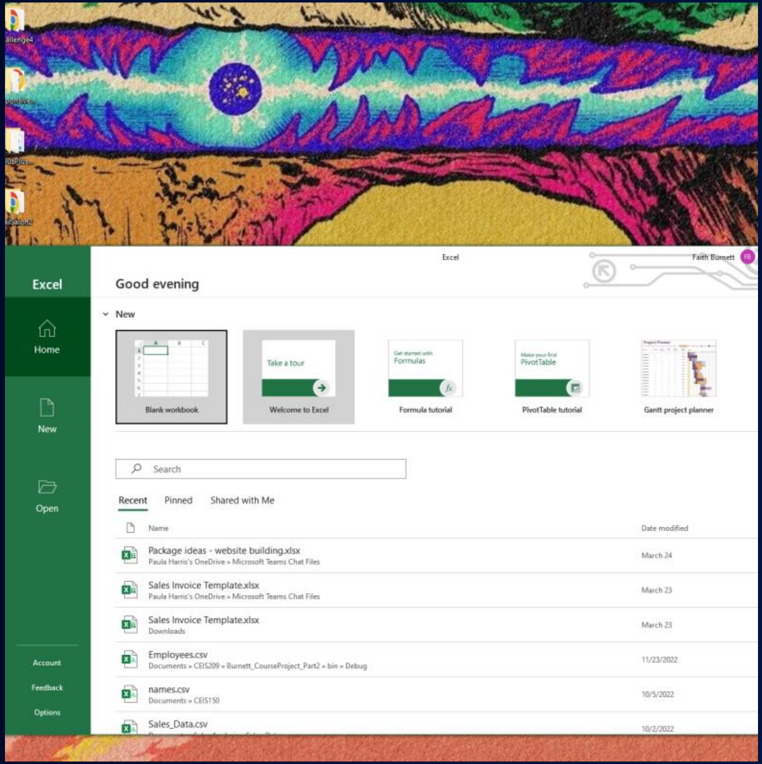
Materials cont.

- ESP32 microprocessor
- Micro-USB cable
- Magnet



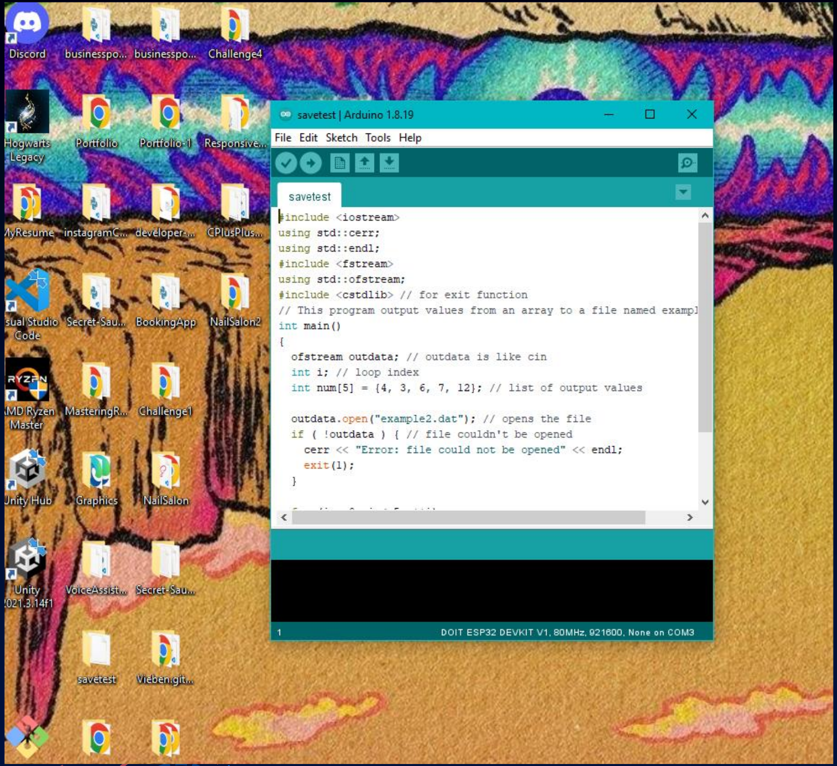
Software

- Microsoft Excel installed and running



Software cont.

- Arduino IDE installed and running



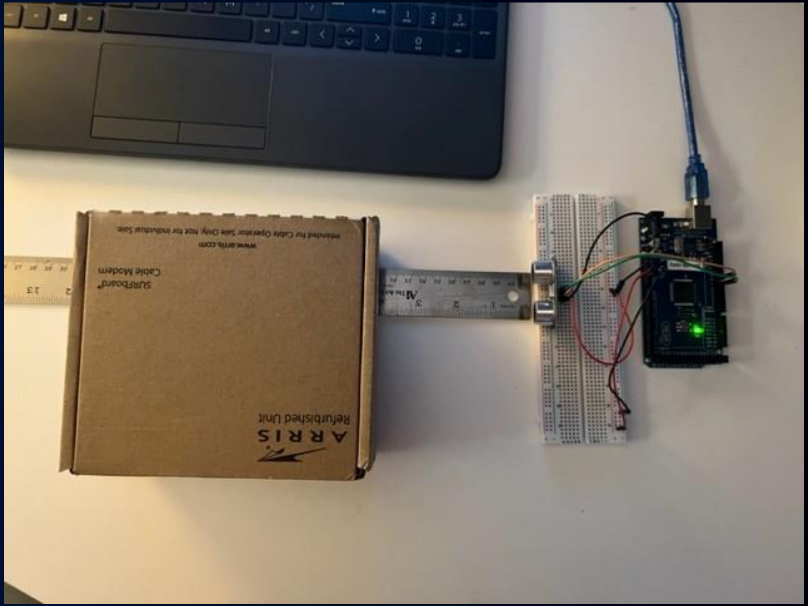
Part 2

Precision of the Ultrasonic Sensor

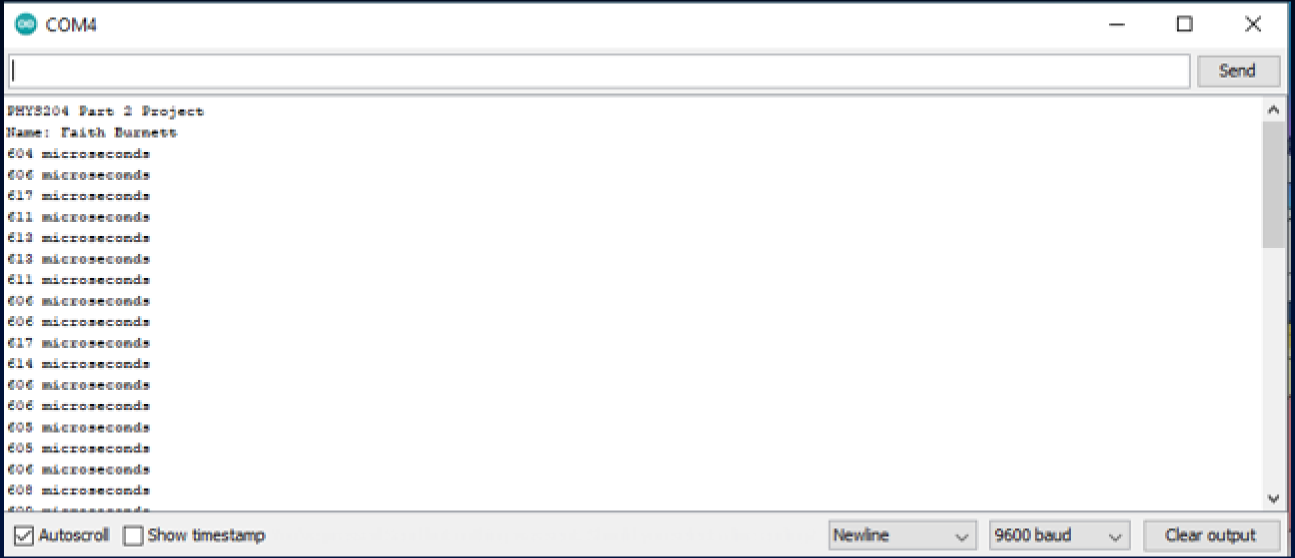
- Experimental setup
- Materials list
- Data collection
- Analysis
- Conclusions

Experimental Setup & Materials

- 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


COM4
Send
PHYS204 Part 2 Project
Name: Faith Burnett
604 microseconds
606 microseconds
617 microseconds
611 microseconds
612 microseconds
613 microseconds
611 microseconds
606 microseconds
606 microseconds
617 microseconds
614 microseconds
606 microseconds
606 microseconds
605 microseconds
605 microseconds
606 microseconds
608 microseconds
Autoscroll
Show timestamp
Newline
9600 baud
Clear output

Data Collection

Trial	Ruler Distance (cm)	Total Roundtrip Distance (m)	Time from Serial Monitor (microseconds)	Roundtrip time (s)	Velocity = distance/time (m/s)
1	10.16	0.2032	617	617E-4	329.34
2	19.05	0.381	1064	1.064E-3	358.08
3	25.4	0.508	1435	1.435E-3	354.01
4	31.75	0.635	1804	1.804E-3	281.60
5	35.56	0.7112	2009	2.009E-3	252.86

Analysis

- Average velocity from table

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

Answer: 315.18 m/s

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

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

Answer: 8.11 m/s

Conclusions

- Discuss the results and comment on the source of errors.

Answer: As for result I can see an increase in time the further the distance which was as expected. The velocity however fluctuated despite the object remaining perfectly still. One of the sources I can see would be the inconsistency of time, which could be attributed to the temperature in my home.

- What is the dependence of temperature, humidity, and atmospheric pressure on the speed of sound?

Answer: Sound travels faster in warmer temperatures than in cold, according to Iowa State University, “The speed of sound in room temperature air is 346 m/s” and freezing temperature is 331 m/s. Humidity causes the air to become less dense which increases the speed of sound. Atmospheric pressure plays no roll in the speed of sound.

Resources

https://www.nde-ed.org/Physics/Sound/tempandspeed.xhtml
https://www.discovery.com/science/Sound-Carries-Farther-Cold-Days
https://howthingsfly.si.edu/ask-an-explainer/does-sound-velocity-depend-pressure

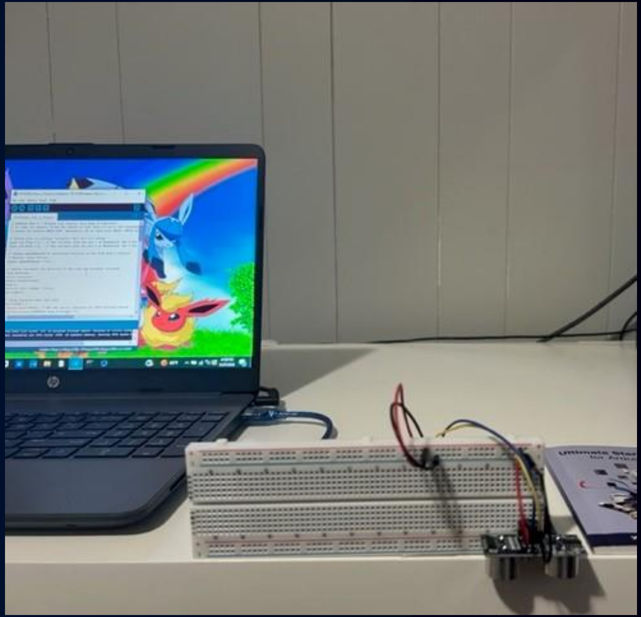
Part 3

Gravitational Acceleration of a Free-Falling Object

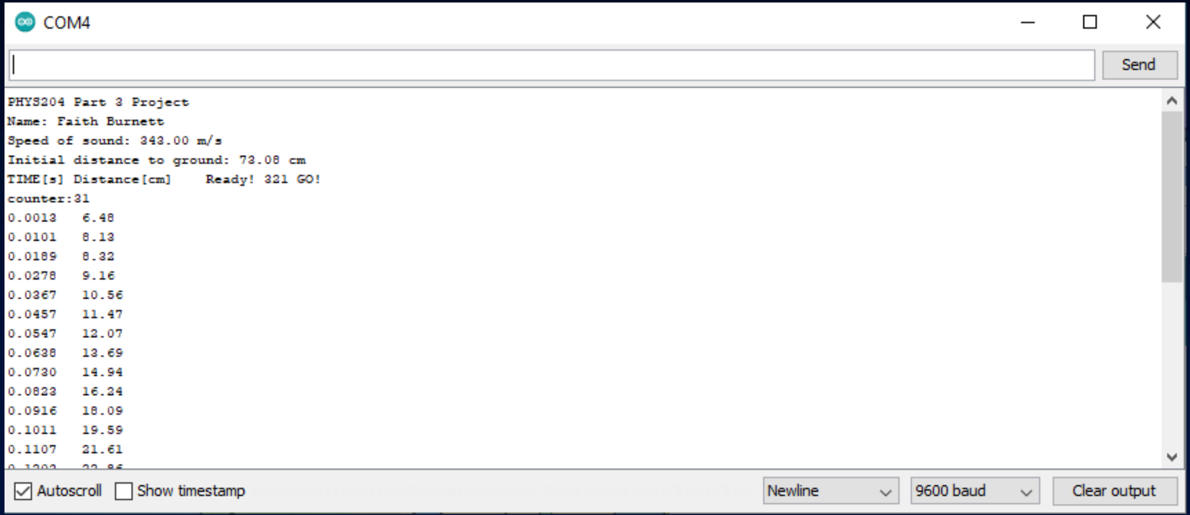
- Experimental setup
- Materials list
- Excel table & graph
- Data collection
- Analysis
- Conclusions

Experimental Setup & Materials

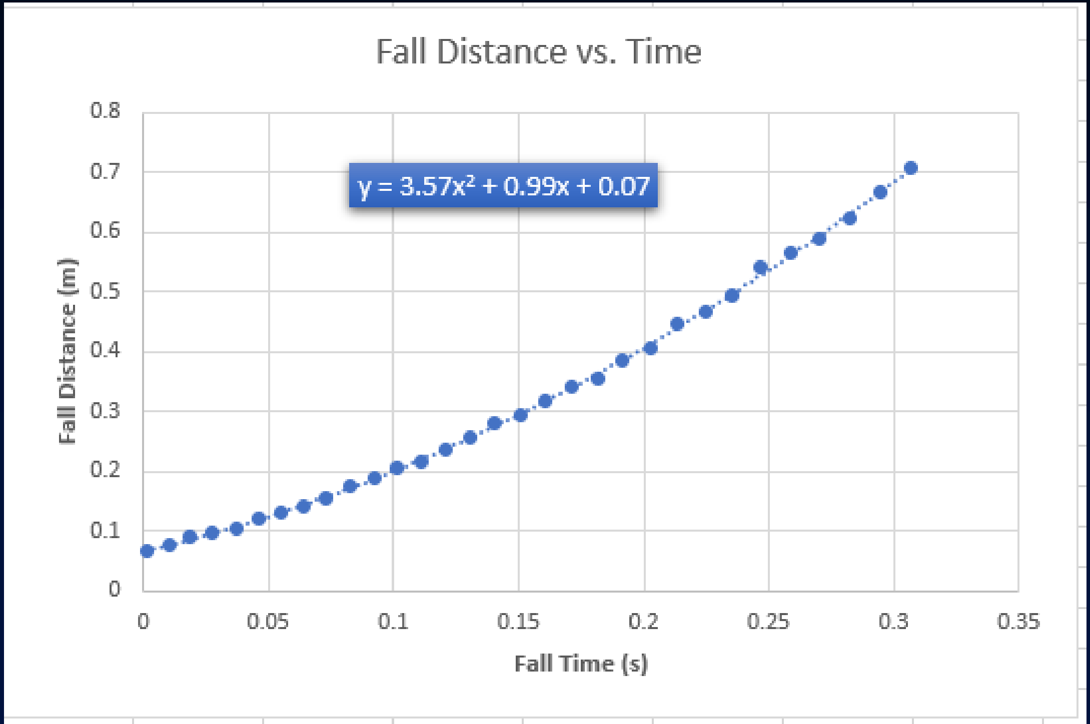
- Mega 2560 board
- Ultrasonic sensor HC-SR04
- Male to male wires
- Breadboard
- Large and flat object that is not susceptible to air resistance to undergo free fall motion



Raw Data


COM4
Send
PHYS204 Part 3 Project
Name: Faith Burnett
Speed of sound: 343.00 m/s
Initial distance to ground: 73.08 cm
TIME[s] Distance[cm]   Ready! 321 GO!
counter:31
0.0013   6.48
0.0101   8.13
0.0189   8.32
0.0278   9.16
0.0367   10.56
0.0457   11.47
0.0547   12.07
0.0638   13.69
0.0730   14.94
0.0823   16.24
0.0916   18.09
0.1011   19.59
0.1107   21.61
Autoscroll
Show timestamp
Newline
9600 baud
Clear output

Excel Table & Graph



Time (s)	Distance (cm	Distance (m)
0.0013	6.59	0.0659
0.0101	7.67	0.0767
0.0189	9.02	0.0902
0.0278	9.93	0.0993
0.0368	10.36	0.1036
0.0458	12.31	0.1231
0.0549	13.03	0.1303
0.064	14.22	0.1422
0.0732	15.59	0.1559
0.0826	17.44	0.1744
0.092	18.92	0.1892
0.1015	20.53	0.2053
0.1111	21.68	0.2168
0.1207	23.56	0.2356
0.1305	25.79	0.2579
0.1405	28.23	0.2823
0.1505	29.58	0.2958
0.1606	31.83	0.3183
0.1709	34.06	0.3406
0.1813	35.67	0.3567
0.1918	38.64	0.3864
0.2025	40.8	0.408
0.2133	44.59	0.4459
0.2244	46.7	0.467
0.2355	49.31	0.4931
0.2469	54.31	0.5431
0.2585	56.47	0.5647
0.2702	58.84	0.5884
0.2821	62.43	0.6243
0.2943	66.71	0.6671
0.3066	70.71	0.7071

Data Collection

Trial	x^2 coefficient value from curve fitting	Acceleration (m/s^2) = 2* (x^2 coefficient)
1	3.57	7.14
2	5.08	10.16
3	5.83	11.66
4	4.60	9.2
5	4.58	9.16

Analysis

- Average acceleration from table

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

Answer: 9.464 m/s^2

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

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

Answer: 90.15 m/s^2

Conclusions

- Discuss the results and comment on the source of errors.

Answer: The distance from sensor to floor was slightly different each time which no doubt made inaccuracies. Also the height from which I dropped it could have been slightly different each drop.

- How much variation is there from trial to trial? What does this indicate about the uncertainty of the result?

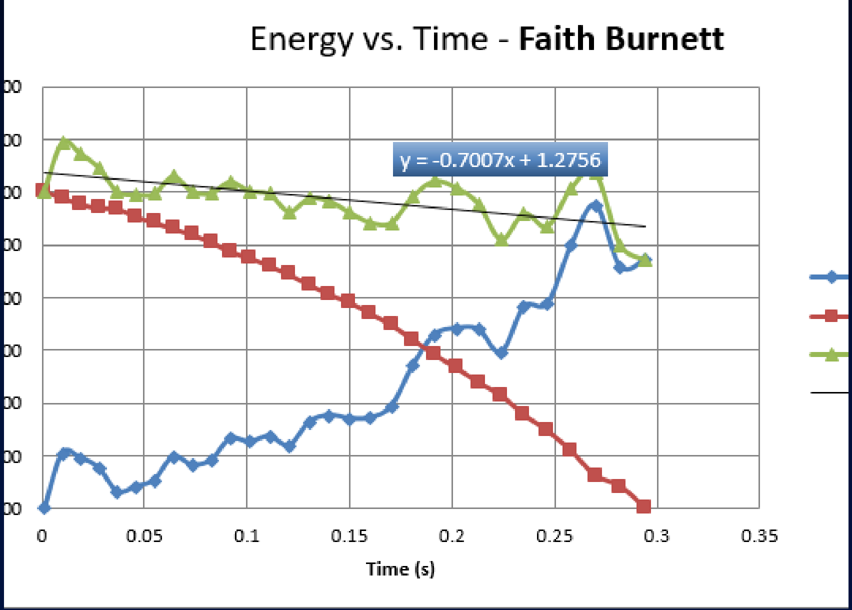
Answer: Some drops were relatively close but they all were within a few cm difference. I believe that indicates that without the same variables each drop the results will be inconsistent and won’t provide the most precise outcome.

Part 4

Conservation of Energy of a Free-Falling Object

- Excel table & graph
- Analysis
- Conclusions

Excel Table & Graph



t (s)	*y* (cm)	y (m)	h (m)	*v* (m/s)	*K* (J)	*U* (J)	*E* (J)
0.0014	6.89	0.0689	0.62	0.00	0.0000	1.2054	1.2054
0.0101	8.15	0.0815	0.60	1.45	0.2098	1.1807	1.3905
0.019	9.38	0.0938	0.59	1.38	0.1910	1.1566	1.3476
0.0279	10.17	0.1017	0.58	1.24	0.1532	1.1411	1.2943
0.0369	10.29	0.1029	0.58	0.80	0.0638	1.1388	1.2025
0.0459	11.83	0.1183	0.57	0.91	0.0830	1.1086	1.1915
0.0549	12.97	0.1297	0.55	1.04	0.1075	1.0862	1.1938
0.0641	14.1	0.1410	0.54	1.40	0.1962	1.0641	1.2603
0.0733	15.35	0.1535	0.53	1.28	0.1650	1.0396	1.2046
0.0826	16.72	0.1672	0.52	1.35	0.1833	1.0127	1.1960
0.0919	18.62	0.1862	0.50	1.63	0.2644	0.9755	1.2398
0.1014	19.81	0.1981	0.49	1.59	0.2519	0.9522	1.2041
0.111	21.42	0.2142	0.47	1.65	0.2739	0.9206	1.1945
0.1206	23.05	0.2305	0.45	1.54	0.2383	0.8887	1.1269
0.1304	25.06	0.2506	0.43	1.81	0.3277	0.8493	1.1770
0.1402	26.91	0.2691	0.41	1.88	0.3535	0.8130	1.1665
0.1502	28.52	0.2852	0.40	1.85	0.3415	0.7815	1.1230
0.1603	30.61	0.3061	0.38	1.86	0.3445	0.7405	1.0850
0.1705	32.88	0.3288	0.36	1.97	0.3882	0.6960	1.0842
0.1809	35.67	0.3567	0.33	2.33	0.5424	0.6413	1.1837
0.1914	38.59	0.3859	0.30	2.57	0.6584	0.5841	1.2425
0.2021	41.14	0.4114	0.27	2.61	0.6833	0.5341	1.2174
0.2129	44.01	0.4401	0.24	2.61	0.6793	0.4778	1.1571
0.2239	46.49	0.4649	0.22	2.43	0.5909	0.4292	1.0201
0.2351	50.27	0.5027	0.18	2.77	0.7654	0.3552	1.1206
0.2465	53.37	0.5337	0.15	2.79	0.7760	0.2944	1.0704
0.2581	57.3	0.5730	0.11	3.16	0.9991	0.2174	1.2164
0.2699	62.07	0.6207	0.06	3.39	1.1498	0.1239	1.2736
0.282	64.11	0.6411	0.04	3.03	0.9153	0.0839	0.9992
0.2942	68.39	0.6839	0.00	3.07	0.9437	0.0000	0.9437

Analysis

- Theoretical value of final velocity

  $h = y_{final} - y_{initial} =$ 0.615 m

  $v_f = \sqrt{2gh} =$ 3.47 m/s

- Final velocity from experimental data (or largest velocity)

  $v_{experimental} =$ 3.07 m/s

- Percent difference

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

  Answer: 12 m/s

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: The potential energy starts at 0 and increases through the drop kinetic energy starts off at it’s maximum and ends on 0.

- 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: It is decreasing I would imagine because the kinetic energy is decreasing and it’s apart of the total energy.

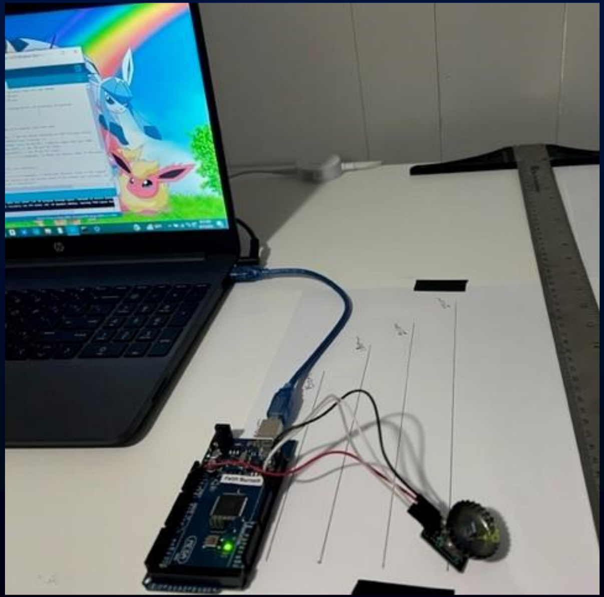
Part 5

Relationship between Linear and Rotational Motion

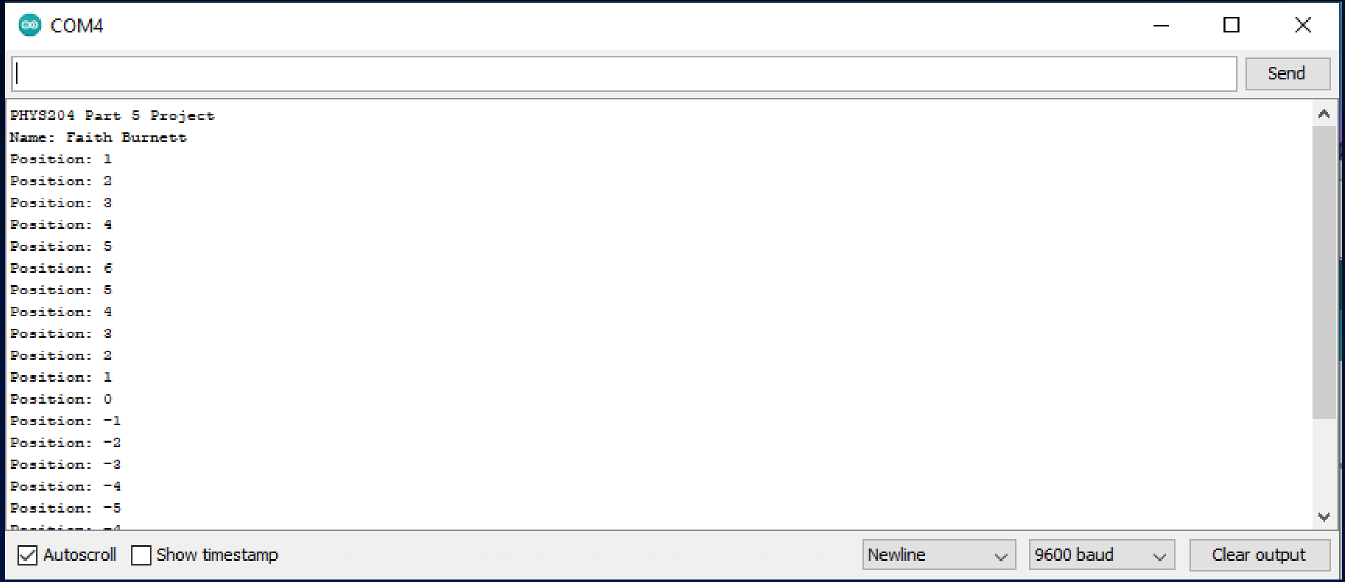
- Experimental setup
- Materials list
- Data collection
- Analysis
- Conclusions

Experimental Setup & Materials

- Mega 2560 board
- Rotary encoder Part KY-040
- Male to female wires
- Object to attach onto rotary encoder
- Ruler or tape measurer



Raw Data


COM4
Send
PHYS204 Part 5 Project
Name: Faith Burnett
Position: 1
Position: 2
Position: 3
Position: 4
Position: 5
Position: 6
Position: 5
Position: 4
Position: 3
Position: 2
Position: 1
Position: 0
Position: -1
Position: -2
Position: -3
Position: -4
Position: -5
Autoscroll
Show timestamp
Newline
9600 baud
Clear output

Data Collection

Trial	Number of pulses N	Encoder distance $r \cdot Resolution \cdot N$	Measured distance with ruler	Percent difference
1	33	0.0876m/s	0.1m	12.4
2	48	0.1274m/s	0.15m	15.1
3	54	0.1433 m/s	0.18m	20.4
4	63	0.1672m/s	0.21m	20.4
5	69	0.1831m/s	0.24m	23.7

Analysis

- Object diameter: d = 0.0254 m
- Object radius: r = 0.0127 m
- Number of pulses for one revolution: x = 30
- Resolution = $\left(\frac{1}{x}\,\frac{Revolution}{pulses}\right) * \left(\frac{2 * \pi\ radians}{1\ Revolution}\right)$ = 0.209

Conclusions

- Discuss the results and comment on the sources of error.

Answer: As expected when the distance grows the number of revolutions increases and the time it takes increases. The pace at which the object is rolling is not exact, I can see that throwing off the measurements.

- What are some applications of this measuring technique? Could this measuring system be used to measure surfaces that are not flat?

Answer: This is used for things like conveyor belts, bottle filling, cutting equipment, and robotic joints. And I would think that other terrain would need a different formula. My reasoning is that distance traveled is the same but the time will differ. If you hit an incline the time it takes increases and on a decline time will shorten.

Resources

https://www.variohm.com/news-media/technical-blog-archive/rotary-encoder-applications

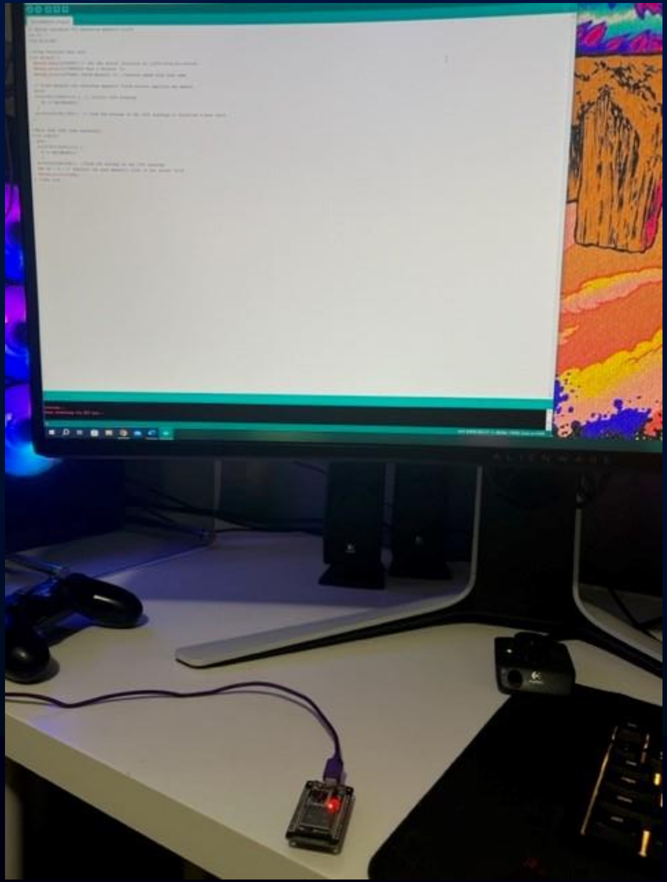
Part 6

Observing the Hall Effect

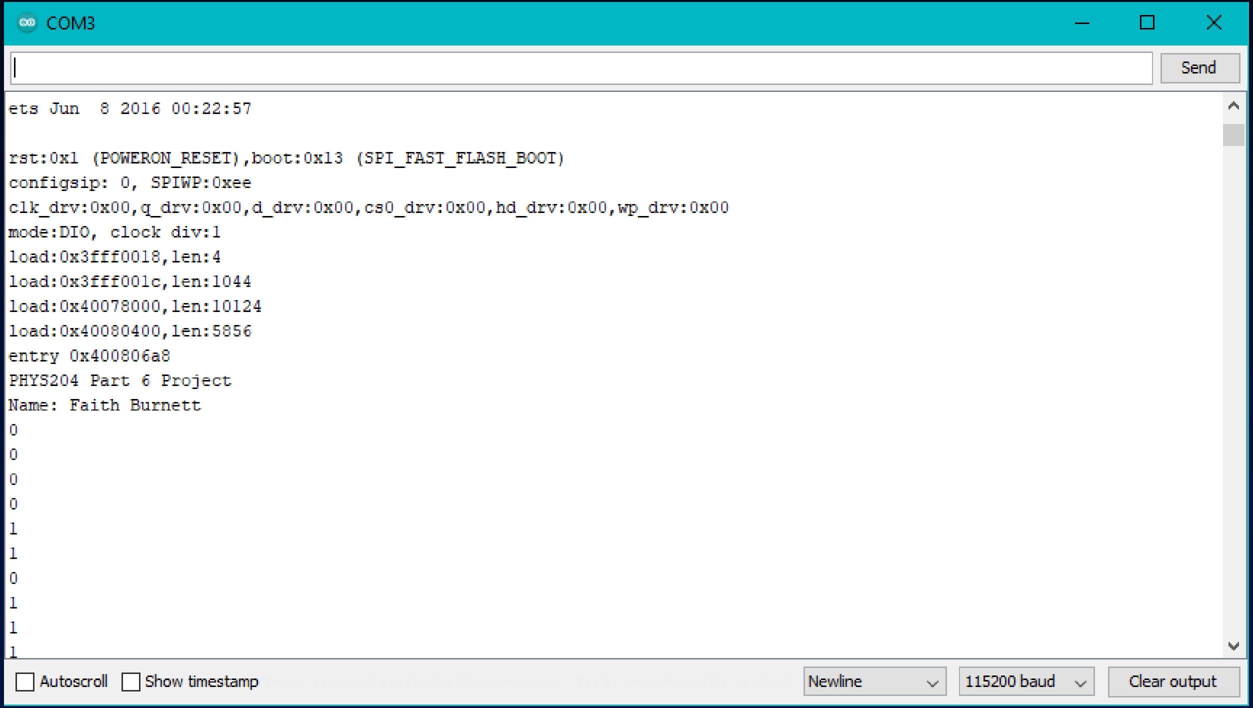
- Experimental setup
- Materials list
- Excel graph
- Conclusions

Experimental Setup & Materials

- ESP32 microprocessor
- Micro-USB cable
- Magnet



Raw Data


COM3
Send
ets Jun 8 2016 00:22:57
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:0x3fff0018,len:4
load:0x3fff001c,len:1044
load:0x40078000,len:10124
load:0x40080400,len:5856
entry 0x400806a8
PHYS204 Part 6 Project
Name: Faith Burnett
0
0
0
0
1
1
0
1
1
1
Autoscroll
Show timestamp
Newline
115200 baud
Clear output

Excel Graph


HALL EFFECT BY FAITH BURNETT
100
50
0
-50
-100
-150
-200
-250
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
171
181
191
201
211
221
231
241
251
261
271
281
291
301
311
321
331
341
351
361
371

Conclusions

- Discuss the results and comment on the sources of error.

Answer: My desk is full of electronics so that could possibly interfere with an accurate measurement.

- Describe how the Hall sensor works. What are some applications for the Hall effect sensor?

Answer: It is used to detect strength and direction of magnetic fields by converting magnetic information into electrical signals via circuits. Some important uses for this sensor are anti-lock brakes, in automobiles to detect position, and internal combustion engines.

Resources

https://www.electronics-tutorials.ws/electromagnetism/hall-effect.html
https://uk.rs-online.com/web/content/discovery/ideas-and-advice/hall-effect-sensors-guide

Challenges

- Retaining formulas
- Making sure measurements were as accurate as possible

Skills

- Describing the effects of forces
- Understanding the Laws of Conservation of Energy
- Applying concepts of circular motion and Newton’s Laws of Motion

THANKS!

Does anyone have any questions?

faithburnett@outlook.com