(The notes from class 3 and the project proposal/idea are written after the images of the setup from Project 5)

Setup

The setup of Project 5 from the Arduino book is more complex than the previous ones. Namely, the potentiometer required a greater force to secure it to the board and establish a flow of current. This needed to be methodically done in order to prevent damage to the Arduino board. The potentiometer provides analog input and can therefore control various mechanisms. In the case of this setup, that mechanism is the motion of the servo motor's arm.

Further on, the servo motor, that is present in the Starter Kit lacked the header pins that were required to establish the connection. However, the setup was a success when the so-called "female connectors" were manually wired up to the Arduino board with separate wires. Moreover, another technical aspect of the motor made the overall experiment more difficult. As presented in the image provided below, the wires, which in the manual are supposed to be ordered differently (first the power cable - red, then the ground - black, and finally the white which is the control line that receives information from the Arduino), had a switched order. Namely, the white and red wires had a different position than the one expected. Instead of attempting to change their order, to prevent any damage, the wires that manually connected the servo motor to the conductor board were arranged properly, as advised by the Arduino book.

Project and Code

As done with previous projects, the code was written manually. However, since there are not a lot of variables that can undergo change, the only modifiable one is the 'delay'. Hereby, if the 'delay' variable is set to 1, the servo motor almost instantly reacts to the input provided by the potentiometer. Furthermore, by increasing the delay, the reaction time increases, thus the servo motor requires more time to respond to the given command.

Data Collected

To collect organized data, the "delay" value was set to 3000, hereby one data point is provided every 3 seconds. However, this data is provided by the movement of the servo motor and currently, it does not have any experimental purpose.

Data in Excel

Historical Data

Time	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10
04:27.3	potVal: 1023	angle: 179								
04:30.3	potVal: 0	angle: 0								
04:33.3	potVal: 0	angle: 0								
04:36.3	potVal: 248	angle: 43								
04:39.3	potVal: 424	angle: 74								
04:42.3	potVal: 617	angle: 107								
04:45.4	potVal: 767	angle: 134								
04:48.4	potVal: 978	angle: 171								
04:51.4	potVal: 1023	angle: 179								
04:54.4	potVal: 1023	angle: 179								
04:57.4	potVal: 713	angle: 124								
05:00.4	potVal: 496	angle: 86								
05:03.4	potVal: 248	angle: 43								
05:06.4	potVal: 0	angle: 0								
05:09.4	potVal: 0	angle: 0								

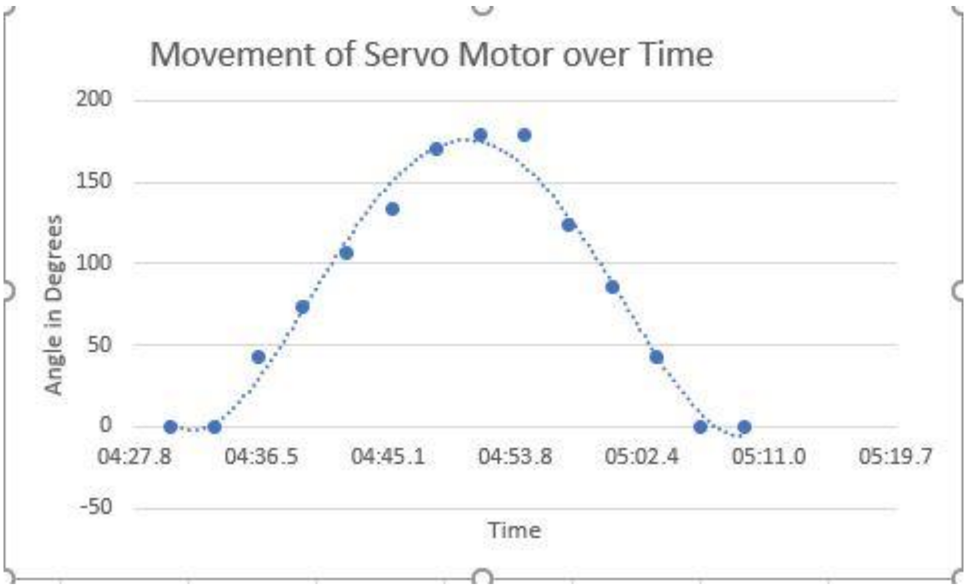
Newest

Raw data in a table (generated through Excel's Data Streamer and then converted into coma separated data points)

potVal: 0	angle: 0
potVal: 71	angle: 12
potVal: 344	angle: 60
potVal: 517	angle: 90
potVal: 637	angle: 111
potVal: 798	angle: 139
potVal: 1023	angle: 179
potVal: 1023	angle: 179
potVal: 898	angle: 157
potVal: 558	angle: 97
potVal: 351	angle: 61
potVal: 0	angle: 0

In the data above represents the position of the servo motor. As presented above, it is recorded as an angle of movement of the motor 'arm'. To further analyze the table, the data point begins at 0 degrees, which is the stationary and beginning position. As the potentiometer is moved, the servo motor's pointer rotates slowly until reaching 179 degrees. Afterward, as the rotation reverses, the pointer is returned to its starting point at 0 degrees.

Graph from Data



Here the dots are the data points and the line is a best fit. Based on the information about the physical system, it is discernible that from time 4:27 to 4:53 the motor was running in the clockwise direction. Afterwards, as the parabola changes direction, the motor arm began spinning slowly in the opposite direction. The data points are not fully on the best fit line since the potentiometer was controlled manually by hand, hereby yielding changes of angle that do not occur at the same intervals of time. However, the overall motion of the motor is discernible, as previously discussed.

The following graph portrays the relationship between the PortVal and angle. As expected, the values have a linear relationship, meaning that the graphed line has a constant slope. The usage of this graph is to determine is there is an error in the data that is being reported. Namely, if the PortVal and Angle reading do not have a linear relationship, then there is an issue with the received data or its interpretation by the computer.

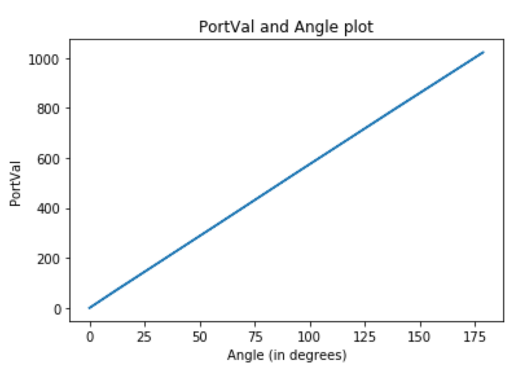


Image of the setup

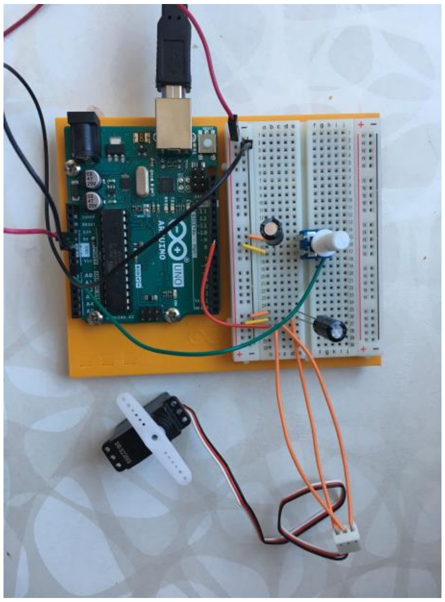
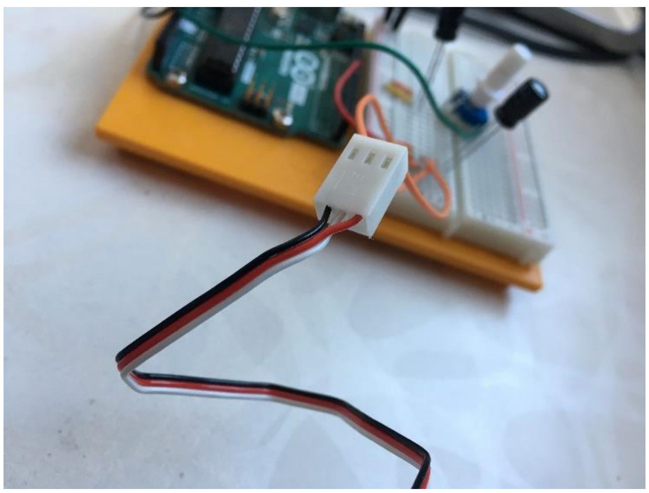


Image of Servo Motor (wrong wiring)



Notes from Class 3

Throughout the class, ideas were shared about the upcoming research papers and ways to record data were discussed. The least complicated and most efficient way of collecting data was through the Data Streamer on Excel, since it automatically converts the data points into any file format. Another useful method of data collection is through Python. To exemplify, the code for Project 3 data collection is the following:

import serial
import time

```
ser = serial. Serial('COM3', 500, timeout=1)
try:
        start=time.perf_counter()
while 1:
        line = ser.readline()
        print(line)
        file=open("try.txt", mode='a')
        file.write('/n')
        file.write(str(line))
        end=time.perf_counter()
        timepassed=end-start
        print(f"{timepassed: .2f}")
except KeyboardInterrupt
        ser.close()
```

Personal Project Idea: Measuring the Planck's Constant Using the Activation Voltage on LEDs

The following idea is not fully developed and may undergo change. Additionally, the procedure is just hypothetical and is still not fully thought through.

Procedure of experiment:

Knowing that E, which is the energy of a photon, is equal to f(frequency)x h(Planck's constant) there is a possibility to calculate this value using differently colored LEDs. To elaborate, the Planck's constant is equal to E/f, and since f=wavelength/speed of light, hereby h= (energy of the photon x wavelength) / speed of light.

By manipulating the equations in this manner, the experiment can be fully carried out. Initially, the Energy of the photons will be measured. To begin, the fact that to produce a photon an LED must be supplied with enough electrical energy (measured in volts) must be considered. The voltage that allows an LED to produce a photon will be called Activation Voltage. By observing the spectrum of visible light, one can deduce that the red LEDs will have a lower activation voltage than the blue ones. Hereby, to measure the energy of the photon, low amount of voltage will be supplied, where this supply will be carefully increased until the Activation Voltage is reached. To reduce error, this will be repeated and the data will be collected.

For the second step of this experiment, the wavelength of each LED will be measured. To do this a diffraction grating will be used. Further, the light from the LEDs will be projected onto a surface blank surface from the same distance. In addition, the distance from the diffraction grading and the surface need to be recorded. To determine the wavelength a few steps are required:

First, the distance from the center point of the projection on the surface must be measured. By doing an inverse tangent function of
(distance to center of projection)/(distance from surface to the diffraction grating), a value for the angle of the photon can be determined.

Second, the distance between the lines of the diffraction grating should be known. By knowing this distance, the wavelength can be calculated using the following method:
(distance between lined of dg) x sin(angle gotten with previous calculation) = wavelength

Finally, before calculating, the voltage needs to be changed into Energy or Jules. To determine the energy, the voltage must be multiplied by the elementary charge constant which is considered to be approximately 1.602x10^-19.

And, hopefully, after all of this is done and the calculations are made, a value close to 6.023x10^-34 Js.

Feedback:

Zhixiu Zhu
"I appreciate your method of collecting data and sorting them into a excel file. Also, the description of the Arduino is very detailed. The experiment you conducted and the curve fit of the data you plotted is very scientific. For the session 3 description part, you may include more ideas of what other students proposed. This may help you comprehend the lesson more and also refine your own experiment."

Based on this feedback, next assignment I will make a more detailed note about the discussions that were carried out in class.

Tianrui Wu
"Your work is outstanding. Your summary was written in the comprehensive description and it demonstrates that you went through a detailed analysis of the project. I am very impressed with your thorough description of the setup, which displayed your professionalism and high observation skills. However, the use of

formatted charts would be better compared to screenshots, which are harder to read. Otherwise, your work would be excellent."

Based on this feedback I will attempt to provide the data as formatted graphs rather than screenshots.