Introduction to Engineering Lab Manual

Introduction

Welcome to the Introduction to Engineering Interactive Lab Kit! Ahead of us is a set of 12 unique, hands-on experiments and activities that each demonstrate an individual discipline of engineering and show how all these types of engineers work together to solve complex problems. But, before we get into that, what exactly is it that we're doing? Let's set the scene with another question: Have you ever seen a live alligator before?

With an estimated population of 1.3 million across the state of Florida alone, no body of water seems safe from potential occupancy. However, searching with the intention of finding one in the wild is harder said than done. If you were to try to spot a live alligator on the University of Florida campus, (yes, they do roam the campus in addition to the students!) your best bet would be on the shoreline of Lake Alice.

Lake Alice is a nature reserve in the heart of the UF campus, designed to be a safe haven for all sorts of wildlife. However, upon visiting the lake, there is not much wildlife to be seen. Because most of the wildlife is far beyond the shore, tracking the live alligator population feels like an impossible task.

Luckily for us as engineers, our knack is solving impossible tasks! What if we were to build a pier that spans into the heart of Lake Alice, allowing for better observation of the natural ecosystem? We would first need an Environmental Engineer to ensure that the construction/usage of said pier does not damage the natural ecosystem. Having a Civil Engineer would be helpful for designing the pier structure, and a Mechanical Engineer could give insight into the parts manufacturing. With so many parts, an Industrial Engineer would be the best fit to manage the assembly process. A Chemical Engineer should determine the effects of the water on the support legs of the pier, and a Materials Engineer would then find a material that can withstand the possible corrosion. If the goal is to attract cold-blooded reptiles such as alligators to the pier to be observed, an array of heated lamps would be designed by an Electrical Engineer, put together by a Computer Engineer, and programmed by a Computer Science Engineer. After installation, it wouldn't hurt to have a Biomedical Engineer and Biological Engineer ensure that the light is not harmful to humans or reptiles, and after all of that you may have to scrap the entire project if the Nuclear Engineer determines that the heart of Lake Alice is too radioactive for humans from the nuclear power plant on campus!

Okay, yes, some of the examples provided may have been a bit of a stretch, and it may be against UF's policies regarding Lake Alice to build something of this vision, however we can still explore some fun, interdisciplinary engineering concepts in support of this endeavor. With that, let's dive into the kit!

Lab 1

Part A – Unboxing and Assembly (Mechanical Engineering)

Upon opening your Introduction to Engineering Interactive Lab Kit the first thing you will see is a components checklist ensuring that all the parts required for all the activities have successfully made it into the box. Do not discard this document; unfolding it reveals a return checklist for you to fill out when you are completed with all the included activities. Removing the top piece of protective foam will reveal the individual pieces of the kit, most of which are 3D printed.

3D Printing is a fantastic additive manufacturing technique that allows for inexpensive autonomous fabrication of very intricate parts. Think of 3D printing as building a sand castle with very thin layers of sand; every constructed layer needs hardened and dried before the next layer can be added. As you remove the 3D printed parts from the box, look very closely at the individual parts and see if you can see the layer lines.

After removing all the pieces from the foam, please reference the “Introduction to Engineering Lab Kit Assembly Guide” for instructions to fully assemble the core of the kit. At this time, you do not need to plug anything in or take anything out of the plastic bags. As you proceed with the assembly, see if you can identify the 5 different types of fits utilized by this kit (note, there are many, many more types of fits than just this!): threaded fits, slotted fits, friction fits, free fits, and swivel fits.

Procedure

1.) Reference the “Introduction to Engineering Lab Kit Assembly Guide” document for assembly instructions.

2.) Take a picture of your fully assembled lab kit and insert it into Lab 1 Part A in your Lab Journal.

Part B – Assembly Efficiency (Industrial Engineering)

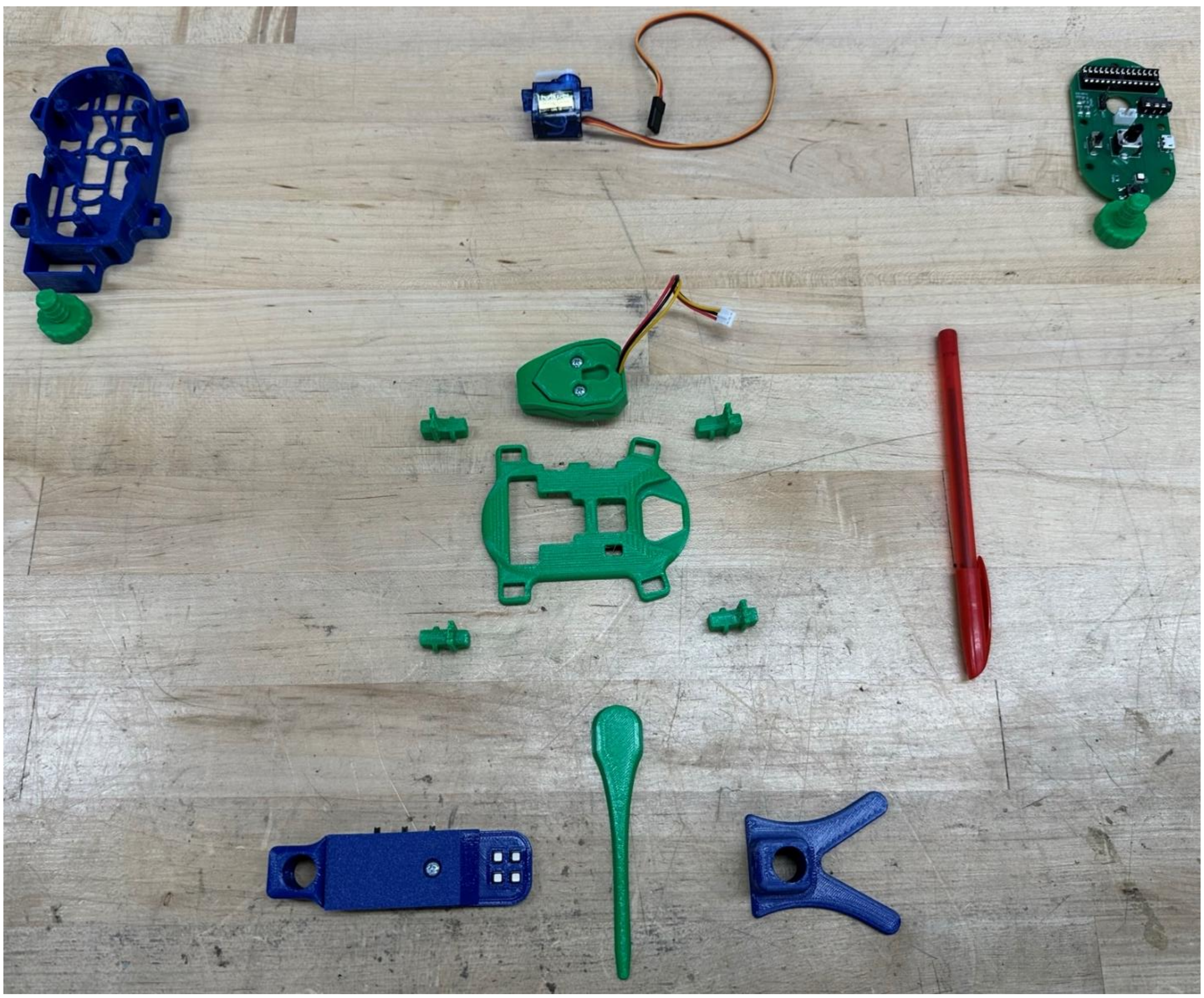
Now that you have your lab kit assembled from Lab 1 Part A, we are going to do what any good engineer would do and completely take it apart again. After spending the time learning how to put it together initially, how fast do you think you could put it back together again? Is there anything that you could think of that could possibly help or hinder the speed at which you could fully reassemble the kit start to finish? Are there any steps in the provided assembly guide that feel inefficient and could be optimized?

One thing that we can explore is the concept of workspace efficiency. Intuitively, it would be sensible to conclude that if you started the assembly process by scattering the individual parts far across your room that it would drastically hinder your assembly speed. That said, how far to the limits can we push this concept? Even if all the parts are on a table directly in front of you, it may result in a more efficient assembly time to group pieces that go together near each other, and even start with them facing a specific direction.

This may feel obvious, but on a larger scale the answer may not be so obvious. There may exist hidden bottlenecks lurking all throughout large companies' workflows that go unnoticed for years, costing them valuable time and resources. Even in this small-scale example, if you as the assembler can save 10 seconds of time simply by changing the starting orientation, imagine how that scales to the near 600 students that take Introduction to Engineering in a Fall semester at the University of Florida; if you were to single handedly assemble all the kits back-to-back, this small time save would save you 6000 seconds, or just over an hour and a half!

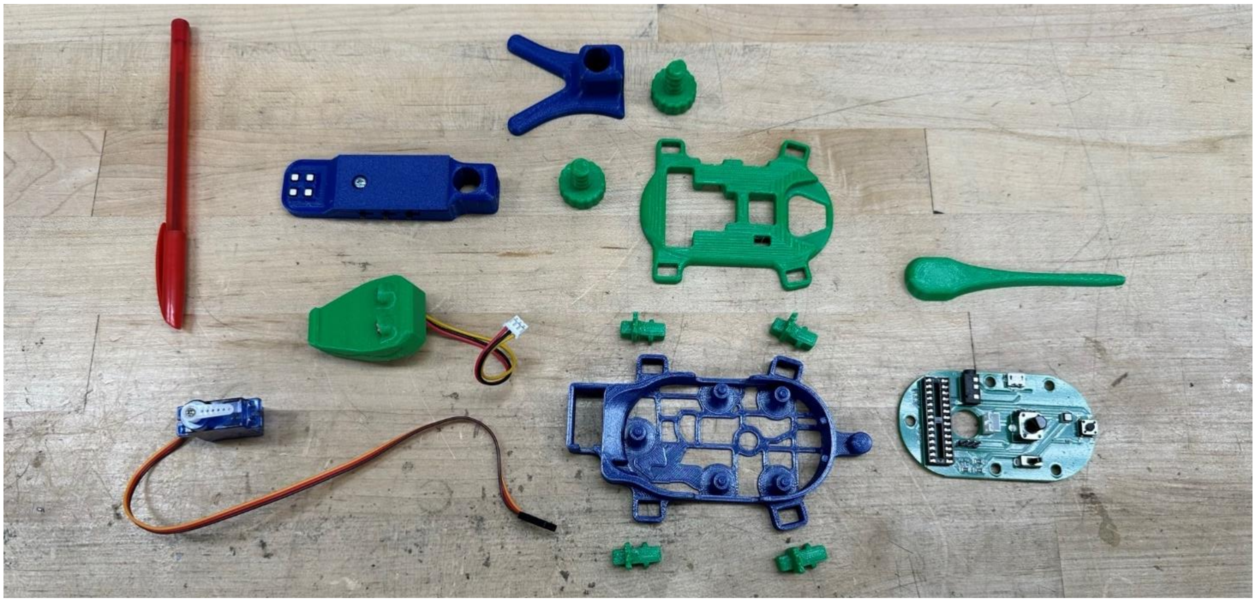
Procedure

1.) Completely disassemble your lab kit, and place the individual pieces in front of you with the following position and orientation:



2.) Start a stopwatch, and assemble the lab kit in the same manner as assembled in Lab 1 Part A. When complete, stop the stopwatch and record the time in Table 1 of Lab 1 Part B in your Lab Journal, in the cell titled "Scattered Layout Time".

3.) Again, completely disassemble your lab kit, and place the individual pieces in front of you with the following position and orientation:



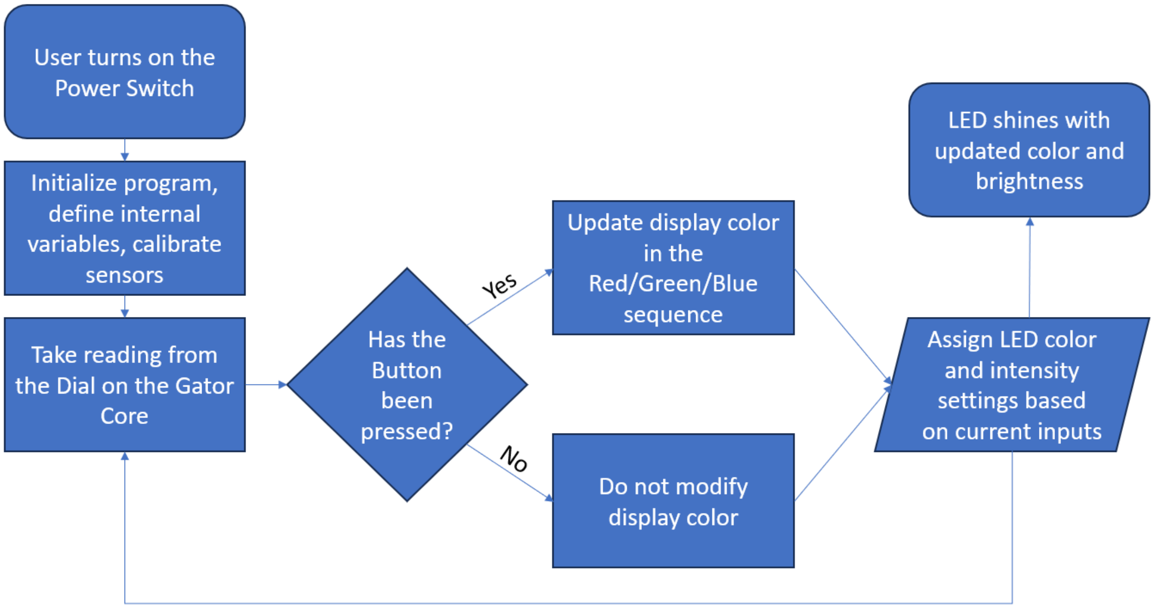
5.) Start a stopwatch, and assemble the lab kit in the same manner as assembled in Lab 1 Part A. When complete, stop the stopwatch and record the time in Table 1 of Lab 1 Part B in your Lab Journal, in the cell titled “Optimized Layout Time”.

Part C – Linking Hardware with Software (Computer Science Engineering)

Now that we fully understand what it takes to assemble the kit, it’s time to interact with it! In front of you stands a “live” mechatronic alligator representative of the alligators found on the UF Campus. In future labs we will observe the liveliness of this creature, but before we can get to that we must understand the link between hardware and software.

Hardware is any physical component that you as the user can interact with, whether that means providing user input information (through a button or dial) or more simply installing and swapping (like a microchip or passive electronics). The Gator Core has four main interactive hardware components, three of which we will discover the functionality of in this lab – the Power Switch, the Dial, the Button, and the THRM Temperature Sensor. The RGB Lamp has three main interactive hardware components that we will discover in future labs: three switches that each control a red, blue, and green light. The Gator Core also has a wide variety of non-interactive components that allow for specific function and capability, such as the microcontroller (the large rectangular chip) and a number of resistors, capacitors, and diodes.

Software is the coded information stored on the microcontroller that internally automatically processes the data coming in from the hardware to perform specific actions. Throughout the course of this lab and other lab activities, you will be presented with various flowcharts detailing how the software is processing information from the hardware. In this lab, you will be controlling the brightness and color of the onboard LED near the right side of the Gator Core. Let’s look at the code flowchart!



Procedure

1.) With the Servo Cable and Gator Head Cable coming up through the Gator Core, plug them into their respective pins as documented in the last section of the “Introduction to Engineering Lab Kit Assembly Guide”.

2.) Ensure that the Power Switch on the Gator Core is turned OFF (Left), the Dial on the Gator Core is turned all the way down (Clockwise), and the three switches on the RGB Lamp are turned off (Right).

3.) Plug each end of the stereo cable into its respective port on the back of the RGB Lamp and the back of the Gator Core, pushing each firmly until it clicks.

4.) Plug the Mirco-USB end of the USB cable into the back of the Gator Core and the other end into any compatible phone charger or computer USB port, pushing each firmly until it clicks.

5.) Switch the Power Switch on the Gator Core to the ON position (Right). The LED on the right end of the Gator Core should flash white three times. If it does not, check your USB connection. If the problem continues to persist, repackage the kit and contact your course instructor.

6.) Slowly turn the Dial on the Gator Core to the Left (Counter-Clockwise) and observe the result.

7.) Turn the Dial on the Gator Core all the way back down to the Right (Clockwise), and quickly press and release the Button on the right end of the Gator Core a single time.

8.) Continue to repeat Steps 5 and 6 for all available options.

9.) What happens if you do not turn the dial all the way back down to the Right (Clockwise) before pressing the button? Use your intuition, in combination with the flowchart presented in the informational section for this lab, to create the color Purple (100% Red, 100% Blue, 0% Green). Take a picture of your lab kit shining with the color Purple and insert it into Lab 1 Part C of your Lab Journal.

10.) Turn OFF the Power Switch on the Gator Core by moving it to the Left.

Lab 2

Part A – Discovering Density (Chemical Engineering)

Have you ever wondered why very salty bodies of water such as the Dead Sea cause objects to float, whereas in freshwater the same objects would normally sink? This is a result of the density of the saltwater solution being so great that the resulting upward buoyancy force is greater than the force of gravity pulling the object down. So then, if an important part of chemistry is understanding the intrinsic properties of fluids and solutions, an important part of chemical engineering is to look at ways we can use such properties to accomplish specific goals of relevance. If the goal is to make specific objects float, is it possible to add enough salt to fresh water to achieve that goal?

Not only is it possible, but we will observe exactly that in this lab! Because we can control how much salt we add to a known quantity of water, we can very meticulously control the density of a salt water solution between the values of freshwater and fully saturated saltwater. Included in your lab kit is a Plastic Vial containing a PLA Sediment, the density of which is very specifically crafted to be near 1.17g/cm^3, which will sink in tap water. Assuming a liquid volume of 4mL in the Plastic Vial, a tap water density of 1g/cm^3, and a salt density of 2.16g/cm^3, how many grams of salt would we need to add into the Plastic Vial to get our PLA Sediment to float? We can use the following equation to find out.

Constants

Density of Salt = D_s = 2.16 g/cm^3

Density of PLA Sediment = D_o = 1.17 g/cm^3

Initial volume of freshwater = V_w = 4mL

Initial mass of freshwater = M_w = 4g

Unknowns

Final mass of saltwater solution, M_{sw}

Final volume of saltwater solution, V_{sw}

Final density of saltwater solution, D_{sw}

Volume of salt required, V_s

Mass of salt required, M_s (only interest)

Problem

To achieve floatation, we need to add a mass of salt (M_s) to the water such that the density of the saltwater (D_{sw}) is greater than D_o.

Equation

$D_{sw} > D_o$

Using $D = \frac{M}{V}$: $\frac{M_{sw}}{V_{sw}} > D_o$

Splitting saltwater into water + salt: $\frac{M_s + M_w}{V_s + V_w} > D_o$

Using $V = \frac{M}{D}$: $\frac{M_s + M_w}{\frac{M_s}{D_s} + V_w} > D_o$

Simplifying: $M_s + M_w > D_o\left(\frac{M_s}{D_s} + V_w\right)$

$M_s + M_w > D_o\frac{M_s}{D_s} + D_o V_w$

Move M_s terms to one side: $M_s - D_o\frac{M_s}{D_s} > D_o V_w - M_w$

Factor out M_s: $M_s\left(1 - \frac{D_o}{D_s}\right) > D_o V_w - M_w$

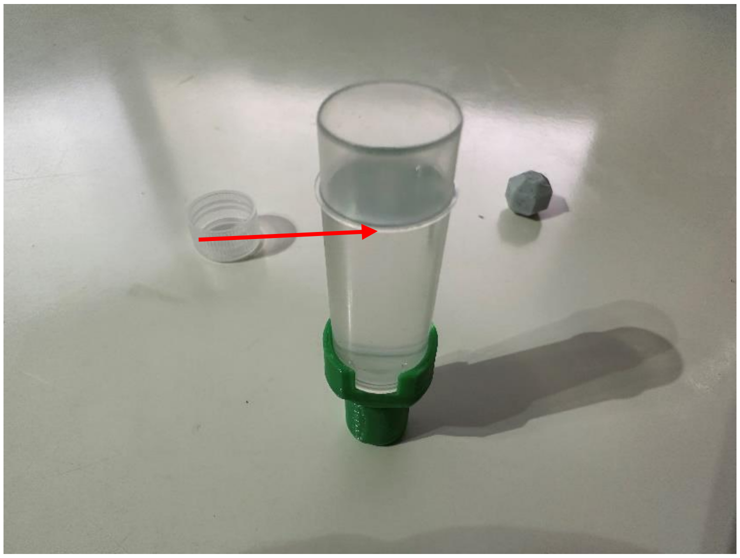
Final Equation

$$M_s = \frac{D_o V_w - M_w}{1 - \frac{D_o}{D_s}}$$

Procedure

1.) Calculate the mass of salt required (in grams) to increase the density of 4mL of water such that it can cause PLA to float using the Final Equation and constants noted above. Note this number in Lab 2 Part A of your Lab Journal.

2.) Fill the empty Plastic Vial with 4mL of water (up to the fill line).



3.) Place the PLA Sediment into the 4mL of water in the Plastic Vial and observe the result.

4.) Each included packet of salt is roughly 0.5g of salt. Open a number of these packets such that the total salt is nearly equivalent to the required salt based on your calculation. Add this amount of salt to the 4mL of water in the Plastic Vial containing the PLA Sediment and shake well.

5.) Take a picture of the result and insert it into Lab 2 Part A of your Lab Journal.

6.) Hold on to the salt water, it will be required in Lab 2 Part B.

Part B – Osmotic Pressure (Environmental Engineering)

In Lab 2 Part A, we took perfectly consumable tap water and added table salt to it, effectively making it unfit for human consumption. Is it possible to now extract the salt from the solution to leave behind the fresh water?

The answer is: Yes in principle, No in practice. Unfortunately, this is a very difficult problem; you can't simply filter the salt out from the solution, as fully dissolved salt crystals are near the same size as water molecules. In theory, you could boil the water off (leaving the salt behind) and collect and cool the water vapor back into fresh water. However, this process requires an inefficient amount of energy for the yield, making it an economically unviable process. If there was an easy way, the world would not have a freshwater shortage issue. So then, the question becomes: surely there must be something useful we can do with saltwater; what can it be used for?

In this lab we will demonstrate the phenomenon of Osmotic Pressure. It turns out that if you separate a body of saltwater from freshwater solely by a semi-permeable membrane, the system will slowly attempt to reach equilibrium by allowing freshwater across the membrane to dilute the saltwater. Cleverly, if we fix the volume of the saltwater container, we can artificially create a pressure as the freshwater attempts to dilute the saltwater solution, otherwise known as Osmotic Pressure. This small but "free" generation of force can be largely upscaled, even to the scale of an Osmotic Power Plant. To demonstrate this concept in this lab, we will be using the saltwater from Lab 2 Part A and a piece of Dialysis Tubing included in your kit. The first 5 steps of the experiment setup can be difficult, so here is a video showing the process: https://youtu.be/aV2pAnp986Q

Procedure

1.) Remove the dialysis tubing from the small zipped bag. While dry, it looks flat.

2.) Run under a consistent, low-pressure stream of water. Gently work the tube under the stream of water until it opens.

3.) Remove the nut from the end of one of the two included Screw Clips. Place the end of the Dialysis tubing into the open section of the Screw Clip, and then reattach the nut, locking the clip in place.

4.) Holding open the tube, deposit the salt water collected in Lab 2 Part A into the tube (ignoring the PLA Sediment).

5.) Attach the second included Screw Clip to the remaining free end of the Dialysis Tube, locking the salt water inside. Take a picture and insert into Lab 2 Part B of your Lab Journal

6.) Submerge into a cup of fresh/tap water and let sit undisturbed for 45 minutes. Remove the Dialysis Tube from the cup of fresh/tap water and take a picture to observe results. Insert this picture into Lab 2 Part B of your Lab Journal and add a brief discussion of your observations. If you choose to complete the optional activity below, hold onto your swelled Dialysis Tube. If not, you may remove it from the clips and discard it.

Optional Activity

A.) Unfold the included Lab Paper to reveal a centimeter ruler noted for use in Lab 2. Stand the paper up such that the ruler is oriented vertically.

B.) Very carefully remove one of the Screw Clips from the Dialysis Tube such that the salt water inside does not spill out.

C.) Open the Plastic Vial, and empty as much salt water as possible from the Dialysis Tube back into the Plastic Vial as possible. Reattach the screw clip to the Dialysis Tube to secure remaining salt water. (It may be beneficial to empty the contents of the Dialysis Tube into a small cup and then pour it back into the vial from there). If any of the saltwater is lost during either Step B or C, the experiment results will be invalid. In theory, the Dialysis Tube can be rinsed out and used again to collect a new sample, but as this is an optional activity, do not feel pressured to do so.

D.) Using the centimeter ruler in your Lab Paper, measure the height of salt water present in the Plastic Vial. The Plastic Vial can be inserted into the RGB Lamp Stand temporarily for ease of measuring. Record this height of salt water, and then discard the salt water in the Plastic Vial.

E.) Repeating Steps 8-10, record the height of the salt water remaining in the Dialysis Tube. After all salt water has been measured, remove the Dialysis Tube completely from both Screw Clips and discard the Dialysis Tube. Add the two measurements to calculate a total height and compare this to the initial starting height of 2.8cm from the initial 4mL of saltwater. Document your findings in your discussion in Lab 2 Part B of your Lab Journal.

Part C – Glass Transition Temperature (Materials Engineering)

We've done quite a bit in this lab with the intrinsic properties of liquids, but we can also observe some inherent material properties of solids. Included in your kit is not one but two 3D printed tails, one labeled "1" and the other labeled "2" (labels are imprinted on the bottom-side of each tail). Both are indeed 3D printed, so what's the difference?

Although both are 3D printed, they are printed out of different types of plastic. The most common type of plastic used for 3D printing is a material called Polylactic Acid, or PLA. This material is very cheap, rigid, has a low melting point (relatively speaking), and is biodegradable as it is a derivative of corn. Another very common 3D printing material is Polyethylene Terephthalate Glycol, or PET-G. This material has higher durability and a slightly higher melting point than PLA and is also recyclable. So then, which tail is made of which material? How could we find out?

Each of these plastics have specific inherent glass transition temperatures. Hilariously, that doesn't mean the temperature that they will turn into glass; glass transition temperature refers to the temperature at which a material will lose its inherent rigidity and become flexible. PLA has a transition temperature of roughly 60 degrees Celsius, and for PET-G its nearly 85 degrees Celsius. If we can heat a medium of water to somewhere in this range and subject each tail to the heated water, we should be able to observe which one deforms and which one remains rigid!

Procedure

1.) Safely prepare a cup of water to a very hot, near-boiling temperature.

2.) Submerge the bottom (the thin end) of Gator Tail #1 (denoted on the bottom of the tail) into the hot water and hold for 20 seconds.

3.) Remove the tail from the water and quickly (without burning yourself!) attempt to gently bend the tail in a direction of your choosing.

4.) Repeat steps 1-3 for Gator Tail #2.

5.) Observe the changes and document your findings within Lab 2 Part C of your Lab Journal. Take a picture of the tails side by side and insert into Lab 2 Part C of your Lab Journal.

Lab 3

Part A – Cold-Blooded (Biological Engineering)

We've heard time and time again that reptiles are "cold-blooded", and mammals are "warm blooded". That said, what does this mean from a functional perspective? Biologically speaking, cold-blooded animals cannot regulate their internal bodily functions and processes the same way that mammals do. For example, the average healthy human body temperature will very consistently fall around 98.6 degrees Fahrenheit, regardless of who, when, or where you take someone's temperature. Conversely, reptiles such as alligators heavily rely on sunlight and cool water for heat and cooling respectively, and their body temperature drastically changes with their surrounding environment.

Additionally, this notion of external temperature influence also applies to the heart rate of alligators. When subjected to warm environments, the heart rate of an alligator has been observed to directly increase in comparison to cold environments where the heart rate directly decreases. In this lab, we will observe how changing the environment can manipulate the internal processes of reptiles such as our alligator. Moreover, reptiles (specifically alligators) make for excellent nuclear waste biomarkers. Although it is certainly not healthy, they can survive in very toxic bodies of water. We will also observe the bio-toxic effects of radioactivity on alligators' internal processes in this lab. More information on this can be found here: https://www.youtube.com/watch?v=SZUUh9EqwVs

Procedure

1.) Turn ON the Power Switch on the Gator Core by moving it to the Right. The LED on the right end of the Gator Core should flash white three times. Press and hold the Button on the right end of the Gator Core until the LED on the right end of the Gator Core again flashes white three times, and then release the Button. The LED should at this point begin pulsing with a pure green light.

2.) Begin a stopwatch (or a timer set for 30 seconds). Begin counting pulses, keeping an eye on the stopwatch. Stop counting pulses after 30 seconds have elapsed.

3.) Multiply the number of pulses counted by 2 to generate a heart rate with units of Beats Per Minute (BPM). Document this value in the "No Light" cell in Table 2 within Lab 3 Part A of your Lab Journal.

4.) Move the furthest left switch on the RGB Lamp to the left, exposing the alligator to a warm red light. Repeat steps 3-4, documenting this value in the "Heated (Red) Light" cell in Table 2. When complete, turn off the red light on the RGB Lamp.

5.) Repeat steps 2-4 for the remaining single Cold (Blue) Light and Toxic (Green) Light.

6.) Turn off all RGB Lamp lights.

Part B – Biometric Observation (Biomedical Engineering)

In Lab 3 Part A we observed how external light-based temperatures can influence the heart rate of cold-blooded reptiles. Another fun way of influencing the internal processes of our alligator is through heat transfer from direct contact! As mentioned in Lab 1 Part C, the THRM Temperature Sensor on the right end of the Gator Core can detect a physical change in temperature when touched, which will ultimately influence the heart rate of the alligator.

A significant part of Biomedical Engineering is uniting the human body with technology, often observed in the specific context of health and medicine. This lab will observe how the effects of various increase the alligator's heart rate upon contact, as well as measuring your own heart rate. If you do not know how to take your heart rate, this is a fantastic potentially life saving skill to develop. https://www.wikihow.com/Check-Your-Pulse

Procedure

1.) Relax for 5 minutes to approach a steady relaxed heart rate.

2.) Place your right index finger on the small black component labeled "THRM" near the right end of the Gator Core. The pulsing LED should change color to cyan. Wait 30 seconds for the pulsing LED to stabilize.

3.) Repeat steps 2-3 from Lab 3 Part A and document the observed gator heart rate in BPM into the cell labeled "Control" in Table 3 within Lab 3 Part B of your Lab Journal. After completion, wait at least 1 minute for the THRM sensor to return to ambient temperature. This should cause the pulsing light to turn back from cyan to green, however if it does not after 1 minute, it is still okay to continue.

4.) Complete Activity 1: Brainstorm. Set a timer for 1 minute, and in that one minute, write the first word that comes to your mind that beings with the letter "A". Continue writing single words in alphabetical order. If you complete "Z" before time runs out, restart with "A" until the timer expires. Immediately after completion of Activity 1, repeat Steps 2-3, and document the observed gator heart rate in BPM into the cell labeled "After Activity 1" in Table 3 within Lab 3 Part B of your Lab Journal.

5.) Complete Activity 2: Human Benchmark. Visit https://humanbenchmark.com/ and scroll down to see the 8 available activities. Complete each activity in succession. Immediately after completion, repeat steps 2-3, and document the observed gator heart rate in BPM into the cell labeled "After Activity 2" in Table 3 within Lab 3 Part B of your Lab Journal.

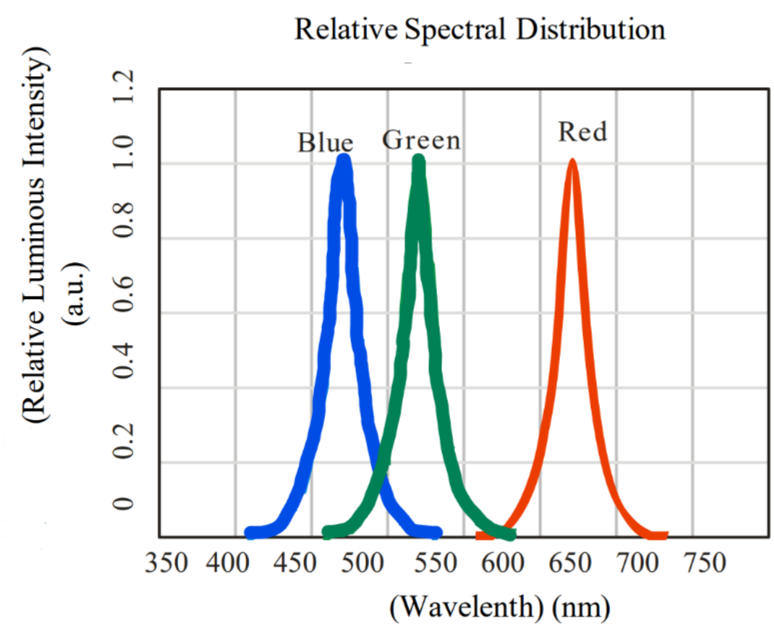
6.) Repeat steps 1-6, but instead of measuring the heart rate of the alligator, measure your own heart rate. Document these values in the appropriate cells in Table 4 in Lab 3 Part B.

Part C – Wavelengths and Reflection (Nuclear Engineering)

Unfortunately, a radioactive piece of Uranium was deemed too dangerous to include in your lab kit. That said, what exactly makes something labeled as "radioactive" dangerous? Radioactive waves, otherwise referred to as gamma-rays on the electromagnetic spectrum, are very similar in principle to any other wave on the spectrum, with one key difference: the wavelength. The wavelengths of gamma-rays are so incredibly small that the proportional amount of energy in each ray is massive. When a human cell attempts to absorb a gamma-ray, the cell simply cannot handle the degree of energy absorbed, often damaging or killing the cell. So, how can we safely demonstrate any aspect of Nuclear Engineering? If it is true that gamma-rays and visible light primarily differ by wavelength, we can observe the properties of various wavelengths of light within the visible region!

As an aside, how does the human eye differentiate different colors across the visible region of the electromagnetic spectrum? When white light hits an object, the "color" of that object (regulated by its material properties) determines what wavelengths of that white light will be absorbed and which will be reflected. Any reflected wavelengths bounce off the object and are absorbed by our eyes. For example, a "red" object appears red to us when exposed to white light because all other colors except red are absorbed by the object, the wavelength that we interpret as red is reflected, and that light is detected by our eyes and interpreted by our brain.

That begs the question: What if you were to shine pure blue light at a red object? Using the logic above, what color would you interpret that object to be? We can answer this question using the colored strips on our included Lab Paper, as well as the three colors from our RGB Lamp. For reference, here is a spectral peak graph of the colors in the RGB Lamp, denoting the specific wavelengths of each of the colored light sources.



Procedure

1.) Open your Lab Paper to the section noted for use in Lab 3, containing 3 uniquely colored trips of ink.

2.) Darken your ambient light environment as much as conveniently possible.

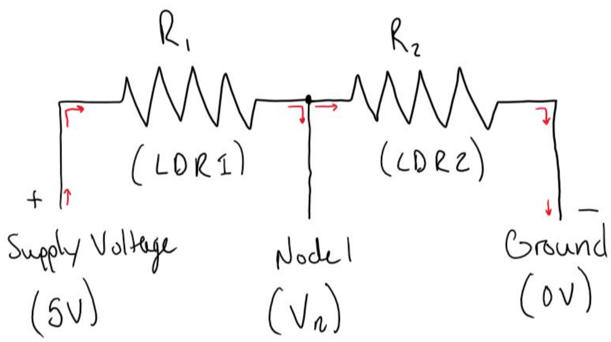
3.) Individually flip each of the switches on the RGB Lamp to expose the colored ink strips to either Red, Blue, or Green Light. Observe the perceived color of all the strips under each color of exposed light and explain your observations in the format of a brief discussion under Lab 3 Part C in your Lab Journal.

4.) What happens if you attempt to combine multiple switches on the RGB Lamp? Observe and document the results alongside your discussion.

Lab 4

Part A – Resistors in Series (Electrical Engineering)

In the upcoming lab, we will finally get to utilize the onboard solar tracking capabilities to bring our mechatronic alligator to life! Inferred from Lab 3 Part A, cold-blooded reptiles such as alligators are inclined to move towards warm heat sources when cold to increase their internal body temperature. Embedded in our mechatronic alligator's eyes are two light dependent resistors (LDR's, or photoresistors) that will electrically allow for the positional triangulation of a light source. Conventionally, the internal resistance of a LDR will decrease as it is exposed to higher concentrations of light. Drawn below is a labeled, simplified version of the electrical schematic for the eyes, as well as the governing equation for the Voltage measured between the two resistors wired in series.



The value measured at V_n will be defined as the difference in voltage between node 1 and Ground.

Equation

$$V_n = 5V \cdot \frac{R_2}{R_1 + R_2}$$

Procedure

1.) Return the Gator Core to the base state of Lab 3 such that the LED on the right side of the Gator Core is pulsing green.

2.) Turn the Dial on the Gator Core halfway between fully Counter-Clockwise and Clockwise. The flattened end should be facing away from you.

3.) Press and hold the Button near the right end of the Gator Core until the LED near the right end of the Gator Core flashes white three times, and then release the Button. Be advised that the Gator Head may momentarily move itself as it calibrates.

4.) Move the leftmost switch on the RGB Lamp to the left, exposing the Red warm light to the eyes of the Gator Head. Move the entire Gator assembly left and right beneath the RGB Lamp and observe the result. Document your observations in Lab 4 Part A of your Lab Journal as a brief discussion.

5.) Referencing the circuit schematic, answer the following questions in your brief discussion for Lab 4 Part A in your Lab Journal:

a) If R_1 decreases relative to R_2, what happens to the Voltage at Node 1?
b) If R_2 decreases relative to R_1, what happens to the Voltage at Node 1?

Part B – Proportionately Driven Systems (Computer Engineering)

As we continue to explore each independent field of engineering, you may be wondering – how much potential overlap exists between them? One of the most beautiful things about interdisciplinary projects is that the skillset of each engineer does not fully bind them to their niche specific tasks; it often takes a variety of diversified minds and perspectives to find the most eloquent solutions to complex problems. Although labeled as Computer Engineering, the contents of this specific activity have roots in other disciplines such as Mechanical, Electrical, and Computer Science Engineering.

We've discovered in the previous lab how we can influence the response of our mechatronic alligator with light, but is that all we have at our disposal? Total, we have three different ways of affecting the behavior of our alligator: the sensitivity dial, the color of light, and the distance of the light from the alligator's eyes. Each of these "input parameters" will have a different effect on the response of the system, and it is up to you to determine the cause and effect.

Procedure

1.) Ensure that the Gator Core is configured correctly to be in the same Lab 4 state used in the previous lab (see Lab 4 Part A Steps 1-3).

2.) Position the RGB Lamp on the stand as low as possible to the Gator Head without causing a collision.

3.) Move the leftmost switch on the RGB Lamp to the left, exposing the Red warm light to the eyes of the Gator Head.

4.) Turn the Dial on the Gator Core all the way to the Right (Clockwise) and observe the result as you attempt to move the alligator underneath the light source.

5.) Turn the Dial on the Gator Core halfway between fully clockwise and counter clockwise and observe the result as you attempt to move the alligator underneath the light source.

6.) Turn the Dial on the Gator Core all the way to the Left (Counter-Clockwise) and observe the result as you attempt to move the alligator underneath the light source.

7.) Reposition the RGB Lamp on the stand as high away from the Gator Head as possible while still positioning the RGB Lamp directly over the Gator Head. Now repeat Steps 3-7.

8.) Repeat Steps 2-7 three times total, except with each repetition, modify Step 3 to use pure cold blue light (middle switch only on the RGB Lamp) for the second repetition and pure toxic green light (rightmost switch only on the RGB Lamp) for the third repetition.

9.) Summarize your observations in a discussion in Lab 4 Part B in your Lab Journal.

10.) Slide the Power Switch on the Gator Core to the left to turn OFF the kit. We are finished with the mechatronics portion of the lab.

Part C – Functional Art (Civil Engineering)

Our final activity will leave you with yet another souvenir item: a piece of art! Artwork and drawings are very functionally important to engineers, as they allow for visual representation of complex ideas or objects. More specifically, learning how to draw like an engineer will allow you to draw 3-dimensional items on a 2-dimensional piece of paper, a technique of which is commonly referred to as orthographic drawing. To be able to fully visually represent a 3D object in 2D space, we will need to construct 4 unique perspectives: a Top View, a Side View, a Front View, and an Isometric View. The first three are very straight forward and intuitive, as they are meant to capture the planar projection of a 3D object from each cartesian direction (X, Y, and Z). The final view is less intuitive; an isometric view of an object is a planar projection of the object that in some capacity captures all the views together. More simply, it is a drawing of the object from looking at it diagonally such that the Top, Side, and Front views can all be seen at once. More educational information regarding orthographic engineering drawings can be found here - https://www.teachengineering.org/activities/view/cub_spatviz_lesson01_activity2

Procedure

1.) Select any item from the kit, any item around your room/space, any shape from either the website listed in the activity description, or any simplified 3-dimensional shape.

2.) Open your included Lab Paper and turn to the side containing 4 boxes titled “Top View”, “Side View”, “Front View”, and “Isometric View”.

3.) Place the item in front of you and observe the item from a pure aerial view (looking straight down at it) and in the box labeled “Top View”, attempt to draw exactly what you see. If it helps, you can take a picture of your item and reference the picture as you draw.

4.) Reposition the item such that you can only purely see the front of the item, and in the box labeled “Front View” attempt to draw exactly what you see. If it helps, you can take a picture of your item and reference the picture as you draw.

5.) Reposition the item such that you can only purely see the right side of the item, and in the box labeled “Side View” attempt to draw exactly what you see. If it helps, you can take a picture of your item and reference the picture as you draw.

6.) Using these three drawings, as well as observing your item, attempt to draw a 3-dimensional rendering of your item in the box labeled “Isometric View”.

7.) Take a picture of your work and insert the picture into Lab 4 Part C of your Lab Journal.