

BME Design-Fall 2020 - Brittany Glaeser Complete Notebook

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Team contact Information

Brittany Glaeser - Sep 13, 2020, 11:15 AM CDT

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Project description

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 12:15 PM CDT

Course Number: BME 400

Project Name: Teaching Model for Ventilation and Perfusion Mismatching

Short Name: V/P Teaching Model

Project description/problem statement:

During medical school, students are taught about the importance of ventilation-perfusion (V/Q) mismatching and the effects it has on the body. Oftentimes, the students have difficulty understanding that a high V/Q ratio leads to dead space ventilation or wasted ventilation and that a low V/Q can lead to hypoxemia, which is a condition where there is a low oxygen concentration in the blood. A model representing the mechanisms underlying V/Q mismatching would help students understand this concept.

About the client:

Dr. Chris Green is a retired pediatric pulmonologist and continues to teach lectures at UW-Madison School of Medicine. During his lectures, he discusses ventilation-perfusion mismatching and understands that the concept is difficult for some students to comprehend. Therefore, he has requested a physical model to use in his classroom to help with teaching the students the concept of ventilation-perfusion mismatching.



9/9/20 Client Meeting

Brittany Glaeser - Sep 09, 2020, 8:14 PM CDT

Title: First Client Meeting

Date: 9/9/20

Content by: Kaitlin

Present: Team + Client

Goals: To discuss any questions the team has with the client to better understand the project

Content:

What aspects or ideas from the model mentioned in the project description would he like us to model/replicate in our design?

Inversely, what doesn't he like about that model that he wants us to change?

- The design is messy with the water aspect and would require too much work to set up
-

Is there a specific age group that the model and research should be oriented around? (Curious as it was mentioned that he works in pediatrics)

- The model is for teaching med. students about V/Q mismatching so the direction of research is not important

What kind of budget does he want us to stick to?

- Has leftover money, \$1000, most have spent 100 to 300 bucks
- He is going to clarify on how to buy things and confirm with his department

Does this need to interface with any other equipment, or should it stand on its own?

- Stand on own

How portable should this be/what kind of size and weight is he thinking of? (any specific size or weight restrictions)

- Bigger the size of his fist
- 180 med students, room holds 225, model up 6x8 two feet deep, set up so everyone can see? Too big? Build tabletop size, 1.5-2 feet wide with camera on it

What in particular do students have trouble understanding? (he mentioned high V/Q ratios not leading to hypoxemia and leading to dead space ventilation)

- is that just because all of the extra ventilation is not helping perfusion but not hurting it?

What sort of ratios and ranges does he want the model to be able to mimic?

- Range from dead space to shunt
- Mentioned maybe buttons with about 5 settings or a dial to slowly increase/decrease ratios

Does he envision this as something that only the instructor uses to demonstrate, or would the students interact with it to learn? (aka how user friendly does this need to be)

How long of a time period would it be used for at once?

Does he want this for a purely learning tool or does he envision some sort of commercial viability he would want to pursue?

- Students to observe

Is there anything about ventilation/perfusion mismatch that he thinks are very important to this project/main ideas that we need to research

Does this model need to mimic any specific clinical conditions? (emphesema, pneumonia)

Would it be more beneficial to model a close up view of an alveoli in the lung and what happens specifically when the ratio of ventilation to perfusion changes, a system of alveoli and how a V/Q mismatch affects the system, or a whole diagram of the lung and how hypoxemia occurs? Should we include options for specific clinical applications like causes (pnemonia, COPD, PE, fibrosis, pulmonary hypertension, asthma...) and how to treat (100% O2)

- Not whole lung, single compartment lung, airway with alveolus at the end (not anatomically perfect, easy to build), one blood vessel
- Could also model a healthy V/Q ratio

Overview: medical students used to use West's textbook

- Trachea into bronchi branch points into alveoli
- Moving lots of wasted air in and out but no blood flow is dead space (infinity)
- 1 mL air to mL of blood 1:1, healthy ratio, most of lung
- Perfusion but no ventilation, blocked bronchus for example, lung tries to adjust, but called shunt
- Hard for medical students to grasp; hard to teach well
- Suggested dye in the airway pretended to be oxygen, colors fluid to indicate oxygenation of blood, dye and a pump but would be very messy, reservoirs, set speed
 - Instead could use LEDs to turn up or down voltage to show
 - Venous blood is darker red, arterial blood is bright red
 - bluish/bluish red, depict air coming in, color coming out indicates oxygenation
 - Ideally have a controller to show students dead space ventilation output, high V/Q ratio what do you, low V/Q what do you get, shunt output
 - Venous blood has oxygenation (mixed) 75% at rest
 - Show difference in oxygenation dead space, close to dead space, normal, low v/q, shunting
 - Slider or dial to show spectrum
 - Less desired having five switches
- If it doesn't work, we should learn a lot

He will send paper to us w/ more info

-he has lots more if we want it

Pedagogic: promoting better teaching

Get him advisors info

Pediatric pulmonology is his specialty

Hypoxemia low blood oxygen levels in the blood

- High v_q
 - Dead space ventilation
 - hyperventilation
 - Blood clot, no gas exchange taking place into blood
 - Pulmonary embolism
- Low v_q
 - shunting

Couple of weeks to meet again

Conclusions/action items:

After the client meeting, the team has a better understanding as to what the client is looking for in the design. The next steps would be to think of ideas to model the mixing of blood with O₂ similar to the diagram he referred to which used water. The client mentioned using LEDs to model this. The team can also begin more research on V/Q mismatching and how it can lead to hypoxemia.



9/24/20 Client Meeting

Brittany Glaeser - Sep 25, 2020, 2:32 PM CDT

Title: Client Meeting

Date: 9/24/20

Content by: Britt

Present: Team + Client

Goals: To understand our clients take on our design ideas

Content:

- Beads
 - Could flow beads through a closed liquid system
 - Use the same color beads and use volume to represent amount of flow
- LED
 - Use brightness
 - Shade of colors
 - Oxygen color and oxygen flow
 - O₂ and CO₂ would add to the design
- He likes the idea of having a physical model because many people learn in different ways
 - He has looked into having someone create an online model, and it have been proven to be difficult, but he would like a physical model for class purposes
- The LEDs seem to be the best option
- Scatter light in a tube
 - He used the idea of glass to scatter the light
 - Clear plastics could also be used to do this

Conclusions/action items:

After meeting with the client, we all decided the best way to model V/Q ratios would be through the use of LEDs. We will begin finalizing the LED more and also think of ways that would could scatter the light so that the LEDs are less noticable.



10/14/20 Client Meeting

Brittany Glaeser - Oct 15, 2020, 11:00 AM CDT

Title: Client Meeting

Date: 10/14/20

Content by: Britt

Present: Team + Client

Goals: Discuss parts needed for fabrication

Content:

- Client is okay with us ordering multiple different components and testing each of them to see what we all prefer
- Order all the parts at once so they come at once and can begin testing them all right away
- The design will be used with a document camera most likely
 - This is slightly different than our previous assumption of a projector
 - This could potentially change if our design is used from a top down view vs. a front view
 - Could make a design to allow for both
- Ideally the design will be bigger than a shoe box
 - Not sure if this is too big, will have to double check and get back to us
- From our design presentation, he is okay with the design weighing more than 15 lbs
 - With the components we plan on using, it probably wouldn't get this heavy but we can change this in our PDS incase we decide later to use different materials
- Most of the time, V/Q is taught with a single alveolus, mainly because each alveolus has a different V/Q ratio so for our design he would like to see only the one alveolus
 - This could potentially be changed in future semesters to show a more complicated model
- Talked about shape of the overall base design
 - Doesn't really have a preference
 - Can look into fibonacci numbers to determine an aesthetically pleasing design, but this is not necessary

Conclusions/action items:

The team will go ahead and order some materials to begin testing. This will include the LED strip with the silicone cover and maybe smaller LED strips. The team will also modify our solidworks design so that it only has one alveolus.



11/30/20 Client Meeting

Brittany Glaeser - Nov 30, 2020, 12:00 PM CST

Title: Client Meeting

Date: 11/30/20

Content by: Britt

Present: Team + Client

Goals: Discuss the progress from the semester

Content:

- The client would like to know if he can attend our presentation or see other presentations
- We would be continuing this project in the spring
- Talked about potentially changing the color of the alveolus to better represent O₂ entering and leaving
- He liked the idea of how we changed the ideas so that you can either increase/decrease ventilation or perfusion - not just changing the ratios
 - You can achieve the same ratios different ways
 - Ex. Same ratio by increasing ventilation or decreasing perfusion
- Next semesters work
 - Diffuser or circular LED
 - Survey Testing
 - Display and buttons into circuit
 - Implement LEDs
 - Clean up circuit/base

Conclusions/action items:

Finish up the semester and begin brainstorming for next semester



9/11/20 Discussion of Initial Client Meeting and Overall Project

Brittany Glaeser - Sep 11, 2020, 2:00 PM CDT

Title: Advisor Meeting

Date: 9/11/20

Content by: Britt

Present: Team + Advisor

Goals: Discuss what has been accomplished for the project and what will need to be done for the semester

Content:

- Physical aspect of model
 - Lung + capillaries
 - Can 3D print at makerspace (pickup)
- Electronics aspect of model
 - LEDs, motor, microcontroller, etc.
 - Model oxygen flow and blood flow
- Can split into to team for the physical and electronics aspect
- Can easily do small scale models at home
 - Should have all the necessary tools
- PDS is due next Friday
 - Rough draft ideas included in lab archives
- Problem statement should be included in lab archives

Conclusions/action items:

The team discussed the client meeting and the ideas the client was looking for in our model. Further research will be conducted for V/Q mismatching in order to come up with some future design ideas to present to the class. Also, the team will begin creating the PDS with information provided from the client meeting and will work out any details as we move along with the project.



9/18/20 Discussion of PDS

Brittany Glaeser - Sep 18, 2020, 2:22 PM CDT

Title: Advisor Meeting

Date: 9/18/20

Content by: Britt

Present: Team

Goals: Discuss model ideas and PDS

Content:

- 6x8 feet is very large
 - Talk over again with client
- Why a physical model?
 - Easier for students to learn with a physical interactive model
- Would be good to start with a small scale model for this semester
 - Could use plumbing tubes from homedepot
 - Transparent
 - Easier than 3D printing for a small scale model
- A display with ratios
- Microsoft teams works better to share screen

Conclusions/action items:

The next steps would be to do more research so we can determine how we want to model V/Q mismatching. By the next advisor meeting it would be good to have a few sketches and a few solidworks drawings of some designs. It would also be beneficial to create have an outline of our presentation slides with some information to go over.



9/25/2020 - Discussion of Preliminary Designs

KAITLIN LACY - Oct 06, 2020, 8:13 PM CDT

Title: Discussion of Preliminary Designs Advisor Meeting

Date: 9/25/2020

Content by: Kaitlin Lacy

Present: Entire Team

Goals: Discuss initial designs and get feedback in order to proceed for preliminary presentation.

Content:

-possibility to not have actual visible LEDs but rather put them inside a tube to diffuse the light

-Initial designs were presented, but even the ones that will not be chosen need to have enough details to understand how they would work

-decided to add a second design matrix that focuses on the different presentation of the LED models

Conclusions/action items:

Create a second design matrix with the variations of the LED design. Add more details to the bead design in order to properly conclude that the LED should still be chosen. Prepare for the preliminary presentation.



10/9/2020 Discussion of Presentation and Materials

Brittany Glaeser - Oct 09, 2020, 2:02 PM CDT

Title: Presentation and Material Discussion

Date: 10/9/20

Content by: Britt

Present: Team

Goals: Talk about the materials we wanna use and order

Content:

- We plan on moving forward with 3D printing
 - Start with a small design to determine whether or not we like it before printing a larger scaled design
 - For the semester, it would be better to have a smaller more perfected design than a larger nonperfected design
- We could split up the LED work into categories like capillary flow and O₂ and CO₂ flow
 - We should all order LEDs so we can work on the coding on our own
- Adafruit neopixels are a good choice for this design
 - Many different options and ideas can be coded for them

Conclusions/action items:

For next weeks discussion:

We would like to have met with the client and ordered the LEDs

Update the 3D design to incorporate purchased LEDs and create a small model of the design

Share my (britt) previous code with the team as an overview/basics for the team



10/16/20 - Discussion of Ordering Parts

Brittany Glaeser - Oct 16, 2020, 1:59 PM CDT

Title: Discussion of parts of ordering

Date: 10/16/20

Content by: Britt

Present: Team

Goals: Discuss the plans for the next week and the parts we would like to order

Content:

- Mentioned the critiques from the client
 - One Alveolus
 - Size is being changed to fit under document camera
- May need to use a stand to stand up the design
 - This would need to shown in lab archives
- Will be 3D printing in the makerspace
- Client is okay with us ordering multiple
 - Cheaper to order longer and break apart to distribute to the team members
- Should comment code more

Conclusions/action items:

Agenda for next week:

3D printing progress (file sent to makerspace ideally, discuss new design)

Discuss what was orders (Order parts by monday and hopefully by friday we have some LEDs to run code with)

By show and tell (Have a small version of 3D print, and 4 LED design that each of us can do)



10/26/20 Discussion on ordered parts and printing

Brittany Glaeser - Oct 23, 2020, 2:55 PM CDT

Title: Discussed LED ideas and concerns and printing

Date: 10/26/20

Content by: Britt

Present: Team

Goals: To discuss the teams progress on parts

Content:

- Discussed a potential of a battery pack to power LEDs
 - Silicone LEDs would require external supply between 9-12V
- Need to figure out how to solder wires onto the LEDs
 - Where do we plan on doing this?
- Will need to order the connectors for the LEDs as they did not come with them
- Discussed having multiple 3D printed designs for each of us
- Should send a side by side of the solidworks and the printed design to the client
- As a team, should decide on an end objective for the flow lighting so that we are all working towards the same goal when doing the coding
- Working on much of this design this semester will give us the opportunity to collect more data for research paper in 402
- Show and Tell
 - Base photo printed (labeled)
 - LED flow representation - each have our own parts completed

Conclusions/action items:

- Work on show and tell presentation and all work on coding for the LEDs
- Pick up base design



11/13/20 - Discussion of Testing Protocol

Brittany Glaeser - Nov 17, 2020, 3:24 PM CST

Title: Testing Protocol

Date: 11/3/20

Content by: Britt

Present: Team

Goals: To determine the next steps for the project

Content:

- First thing we need to accomplish is testing protocol
 - Related to PDS
 - Verification and/or validation
- Control group?
- What do we want to get out of testing
- Ideas:
 - Survey of understanding before and after the use of the device
 - Med students and normal people?
 - Do they learn from our device?
 - Doc come
 - Will it appear well on a doc cam?
 - Shape, size, color, brightness, cover for LEDs (circular)
 - Is the design user oriented?
- Can reserve space in ECB for testing with a doc cam
- Can also do zoom test
 - This is applicable now since classes are online
 - Will colors and brightness show up well enough?
- Will also need to discuss buttons for the design and how we want the LEDs to flow

Conclusions/action items:

The team will meet to determine a testing protocol, but before testing is done, we will need to come up with ideas for a cover for the circular LEDs and need to have the color, flow, and different settings for the LEDs in order to test which will work better.



11/21/20 - Discussion of Testing

Brittany Glaeser - Nov 21, 2020, 6:27 PM CST

Title: Testing Protocols

Date: 11/21/20

Content by: Britt

Present: Team

Goals: Discuss further testing protocols

Content:

- We plan on testing on Monday
- Verification Testing: PDS
 - Weight, model ratios correctly
 - Hypothesis -> clear differentiation
- Quantification Testing
 - Intensity Measure
 - Pictures with different intensity
 - Intensity profile, image J
 - Statistics
 - How we perceive with our eyes
 - What difference of intensity is good
 - Threshold value for eyes
 - Value difference can change for each person
 - Colorblind
 - Different eye sensitivity
 - Use pic without a doc cam do see difference with the filters of doc cam + camera
 - How many can perceive the difference intensity
 - Quantification and observation
- Size with the doc cam
 - Good size if we had to zoom in on it, will the color still be okay
 - Visual observation
- Meet during thanksgiving week

Conclusions/action items:

We plan on testing this coming monday in the blue room ECB. We will continue research as a team to discuss how we can use image J to calculate intensity and what statistical values can be concluded. We as a team need to find time during thanksgiving break to discuss testing results. the team also plans up on finishing the coding for the LEDs and printing a new base for the design.



11/30/20 - Discussion of prelim report and future work

KAITLIN LACY - Dec 08, 2020, 5:58 PM CST

Title: Final Advisor Meeting

Date: 11/30/20

Content by: Britt

Present: Team

Goals: Discuss future work and prelim report

Content:

- We need references in our report for the online simulation and all photos used
 - Not in the abstract
- We need to include in our report a reasoning why understanding V/Q ratios is important and how it can impact the students if they don't fully understand this concept
- Research how many med students are colorblind
 - Is this population large enough to consider with our design?
- Report needs more math/engineering equations
- Add an acknowledgements in reports
- ROUGH DRAFT OF FINAL BY MONDAY
- Email Professor Radwin to ask for anthropometric data relating to intensity differences perceived by the eye
- For Testing:
 - Report the amount of intensity change
 - Is the change enough?
 - Errors could be how the image is process on the phone/doc cam altering the output
 - May not be a linear process
 - Use example images with known data from other research to test our protocol
- We plan on extending out testing into next semester

Conclusions/action items:

Work on finishing testing to add into our final poster presentation. Also, work on the final report so we can have that done by Monday so it can be reviewed. Do some more research on colorblind doctors to determine this this should be considered in our design.



11/4/2020 - LED Discussion

Brittany Glaeser - Nov 04, 2020, 11:01 PM CST

Title: LED Team Meeting

Date: 11/4/2020

Content by: Britt

Present: Kaitlin, Jenna, Britt

Goals: Distribute LEDs and determine semester goals

Content:

- We decided that the end of semester goal would be to have a final prototype by thanksgiving break to give us time for poster and deliverables after break
- We have decided to break the silicone strip we have into 4 chunks so that everyone can work on them
 - We will try and break them into even number of LEDs so that we can share code with each other
 - We may need to buy more silicone caps for the ends of the LEDs to hide open circuits to give a cleaner look
- We also decided to cut our PCA strip in half to give to two different people to work on for more ideas
 - Ideally won't actually use this in our design but if we can code it, it can give us some ideas for future work
- Those who don't have the PCA strip halves, will work on the circular LEDs for the alveolus design
 - We have two different sizes of these
 - We still plan on order more so everyone can have on and maybe order one size larger to see what looks better within the base design
- We will need to order two more power cords for Zoe and Kaitlin so that are able to work on the silicone LEDs
- We also plan on creating a pocket in the back of the base design to house the microcontrollers
- By next Friday (11/13) the team plans on having researched buttons that can be used for the design to model the different V/Q ratios
 - By the end of the semester we would like to have some buttons added to the circuit - even if not quite included into the base of the design yet
 - Once we have button ideas, we would like to meet with the client to discuss the buttons as well as the progress of the coding for the LEDs
- For testing the design, we would like to use our base design with LEDs on a document camera within a classroom to see how they appear on camera
 - This could be challenging as many places are closed
- We also want to test our design with actual people, to see whether or not they can see a noticeable difference in the V/Q ratios

Conclusions/action items:

Continue to work on coding the LEDs

I (britt) will split the LEDs and solder and wires to them and distribute them to the team so everyone can work on coding

Look in buttons for the design

Begin looking into changing the base model to incorporate the microcontroller into the back of the design



11/11/20 - Meeting with Remington

Brittany Glaeser - Nov 17, 2020, 3:28 PM CST

Title: Meeting with Remington

Date: 11/11/20

Content by: Britt

Present: Britt, Zoe, Jenna, Remington

Goals: Determine his thoughts for the classroom

Content:

- Dimness would likely be more noticeable for the design
- Need to think about how we can integrate this into lecture
 - He will send us some lecture material to see how the material is taught
 - Still would like to use 5 different settings
- Blue to red vs. solid color
- The hardest aspect about learning this in class is that it is visually hard to picture
 - Especially dead space and permeability
- He can send out design to other med students come testing to see their thoughts on the design

Conclusions/action items:

Continue working on the design since he believes it is a good start. Start thinking of testing and how we can incorporate the other med students.



2020/09/20 - Design Matrix Ideas

Brittany Glaeser - Oct 07, 2020, 10:02 AM CDT

Title: Design Matrix Criteria

Date: 9/20/20

Content by: Britt

Present: Team

Goals: Determine the criteria for the design Matrix

Content:

- Because this design is going to be used as a teaching model in a classroom setting Effectiveness would be most important.
 - This would only be how well the design can show V/Q mismatching
 - How noticeable the differences are in ratios
 - The size of the device, if it can be seen in a lecture hall with 180 people (by the use of a projector)
- The device needs to be easy to set up and clean up for the professor
 - This category should also include how easy it would be for the user to change the ratios (buttons, dye, etc.)
 - Also ability to store the device, the smaller and lighter the device is the easier it would be to store
- Fabrication is important as we do have some limitations
 - Online models would be very difficult for us as we have limited knowledge with that kind of computer programming
 - How many moving parts are involved
- Viability
 - The device will likely be used in different semesters and the rest of the time will sit in storage
 - How fast the parts are likely to degrade or fall apart (LEDs would last longer than a water pump)
 - This would also depend on the parts chosen that would fall in our budget and other constraints
- The budget is large so this is less of a concern but important to consider

Conclusions/action items:

Next the team will evaluate each of the designs for the design criteria for the Model that will be used.

After further discussing the design with the advisor, we will create another design matrix that will show how we plan on incorporating the LEDs into our design (The LED model scored the highest in most categories).



2020/09/24 - Initial SolidWorks of Alveoli

KAITLIN LACY - Oct 06, 2020, 8:20 PM CDT

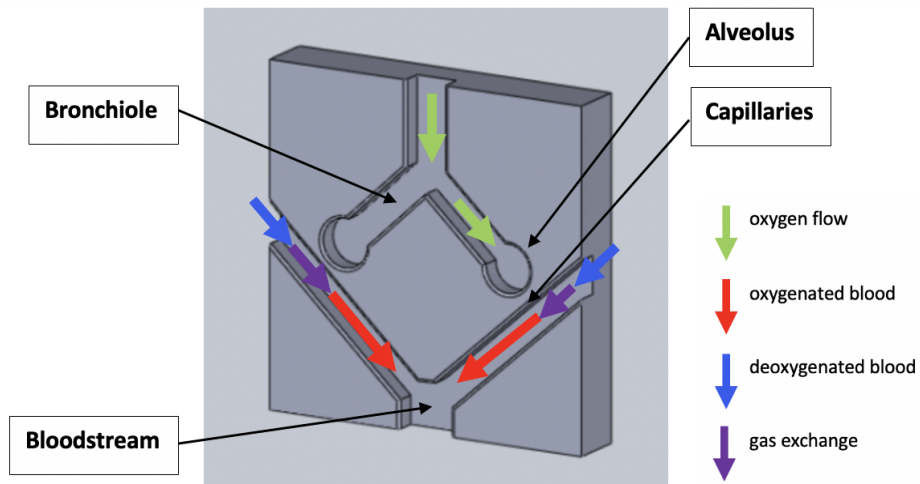
Title: Initial SolidWorks of Alveoli

Date: 9/24/2020

Content by: Kaitlin Lacy

Goals: Generate an initial idea of the layout of the alveoli and blood vessels in the model.

Content:



Conclusions/action items: Discuss dimensions and ways we can improve the model to show the passage of air and blood flow.



2020/10/16 - Single Alveolus SolidWorks

KAITLIN LACY - Oct 23, 2020, 12:33 PM CDT

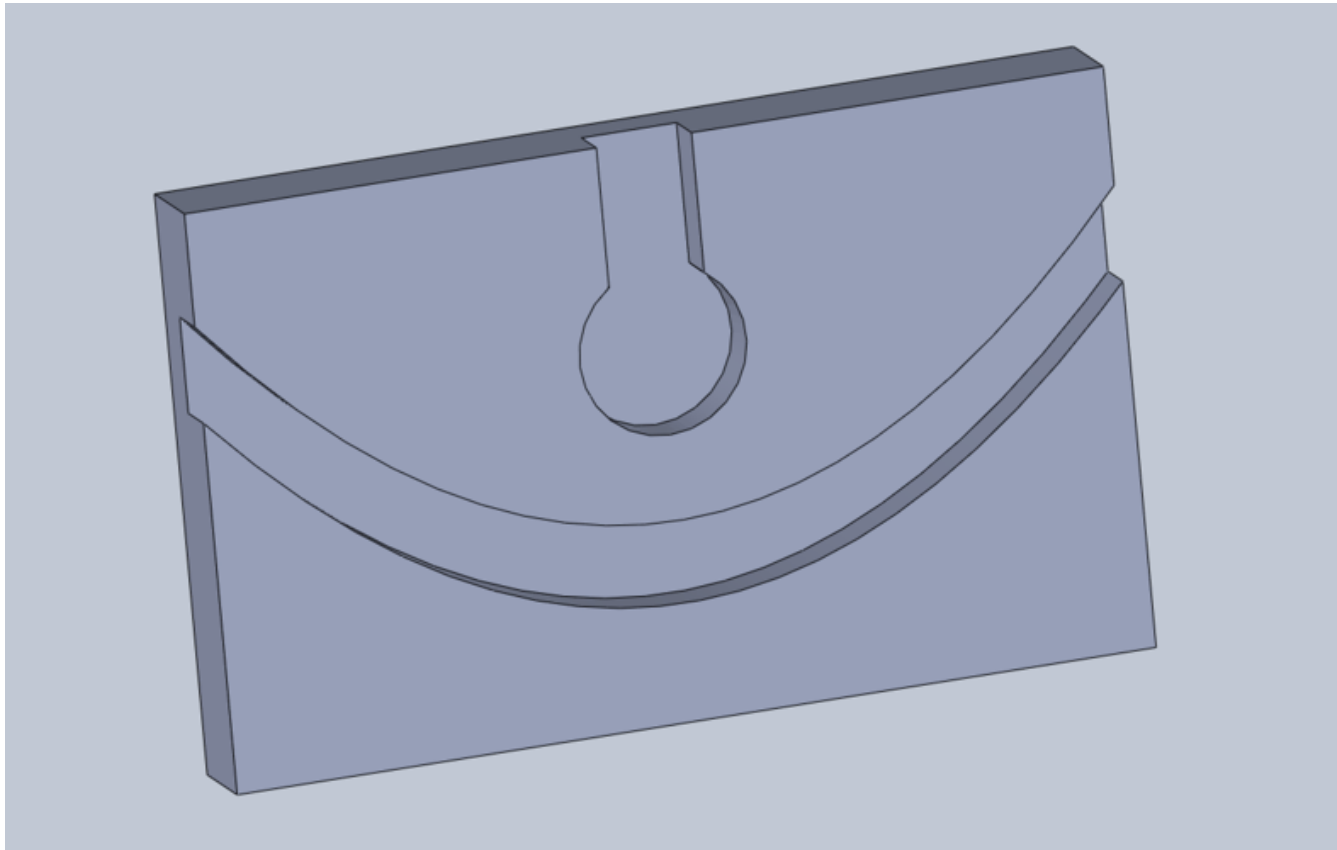
Title: Single Alveolus SolidWorks

Date: 10/16/2020

Content by: Kaitlin Lacy

Goals: Alter the SolidWorks design according to feedback from the client

Content:



Dr. Green suggested that we only make depict one alveolus as each alveolus can have a different V/Q ratio.

Conclusions/action items:

This depiction is too rectangular with too much capillary showing. A new design should be made that is more square and brings the capillary closer to the alveolus.



2020/10/21 - Updated Single Alveolus SolidWorks

KAITLIN LACY - Oct 23, 2020, 12:44 PM CDT

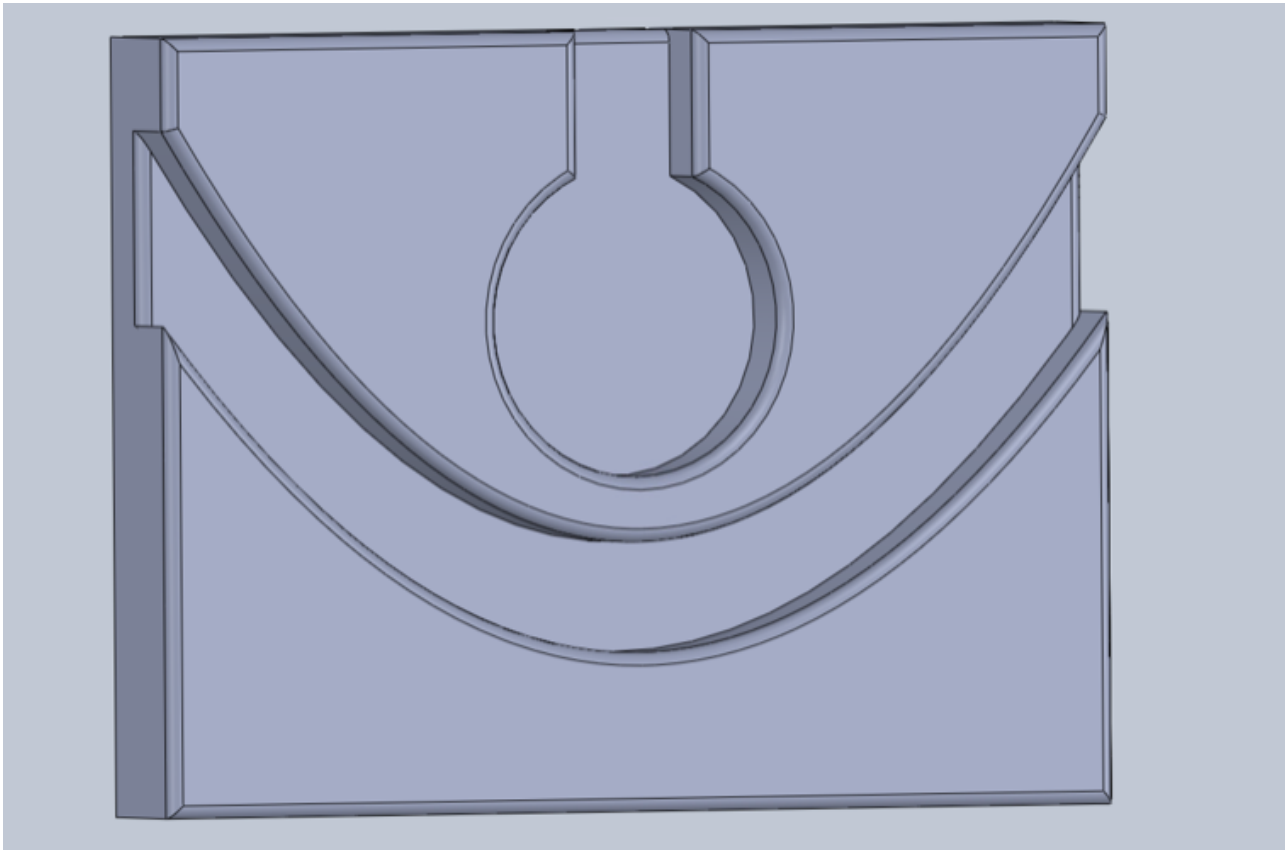
Title: Updated Single Alveolus SolidWorks

Date: 10/21/2020

Content by: Kaitlin Lacy

Goals: Update SolidWorks design based on team discussions.

Content:



The capillary was moved closer to the alveolus to better represent the possibility of gas exchange. The dimensions of the base were also altered to be more square (the height was reduced).

Conclusions/action items:

Show this design to the client to get more feedback. Update based on this and integration of the LED lights to it. Finalize dimensions of the actual final device we want to create.



Materials List

K

Title: Materials List

Date: 12/8/2020

Content by: Kaitlin Lacy and Jenna Eizadi


Goals: Record materials list and costs associated

Content:

Item	Description	Manufacturer	Part Number	Date	Quantity	C
Component 1	LED Strip with silicone	Adafruit	3869	10/18/2020	2	
Component 2	12 Circular LEDs	Adafruit	1643	10/18/2020	2	
Component 3	16 Circular LEDs	Adafruit	1463	10/18/2020	2	
Component 4	0.5 m LED Strip	Adafruit	3919	10/18/2020	1	
Component 5	12V DC Power Supply Adapter	Amazon		10/26/2020	3	
Component 6	JST Pin Female and Male Connector Plug	Amazon		10/26/2020	4	
Component 7	Breadboard-Friendly DC Power Supply Mount	Amazon		10/26/2020	1	
Component 8	JST 3 Pin Female and Male Connector Plug	Amazon		10/30/2020	1	

Conclusions/action items:

Continue to update as more materials are ordered.

 **Silicone LED circuit**

Brittany Glaeser - Nov 04, 2020, 10:28 PM CST

Title: Silicone LED Circuit**Date:** 11/4/20**Content by:** Britt**Present:** Britt**Goals:** Understand the circuit requirements for silicone LEDs**Content:**

The Silicone LED strip is powered with the wall plug shown below. This supplies 12V and ~1.5 mA to the circuit.



Figure 1. Wall plug

The wall plug then gets plugged into a barrel jack connector (for the time being a breadboard connector was used with a breadboard for testing purposes). The barrel jack connector can be seen in figure 2. The furthest pin from the opening is the V+ pin and the pin closest to the opening is the GND pin. The pin along the side is used for stabilizing the connector in the breadboard.



Figure 2. Barrel Jack Connector

The red wire from the LEDs was then connected to the breadboard in the same row as the V+ of the barrel connector and the black wire from the LEDs were then connected to the breadboard in the same row as the GND of the GND pin of the barrel connector.

IMPORTANT: A wire was connected from the GND row of the breadboard to the Arduino GND!!! If this is not done, the code will not work as expected and LEDs will blink in various forms!!!!

Lastly, the green pin of the LEDs were connected directly to the Arduino (I used pin 9).

The Arduino was powered by the USB cord to a laptop.

Conclusions/action items:

The next step would be to modify the circuit so that there are less open wires and gives it a more clean look. Also potentially using a microcontroller or PCB board may make the circuit more stable that will be durable for many uses.

Final LED Circuit

Brittany Glaeser - Dec 07, 2020, 1:22 AM CST

Title: Final Circuit Design

Date: 12/6/2020

Content by: Britt

Present: Britt

Goals: List the final design and steps for fabrication

Content:

Shown in Figure 1 is the overall design for the circuit.

The Arduino Uno microcontroller is power by a 5V supply via USB.

The circular LEDs had wires soldered to the VIN, DIN, and GND pins holes. The VIN was connected to the 5V on the arduino, the DIN was connected directly to the Digital 8 pin on the Arduino, and the GND was directly connected to one of the GND on the Arduino.

The Silicone LEDs were powered by a 12V DC supply plugged into the wall and then plugged into a barrel jack located on a breadboard. The VIN from the LEDs were connected on the breadboard inline with the front pin of the barrel jack (can be seen in Silicone LED circuit in Fabrication Folder). The Back pin of the barrel jack was connected on the breadboard to the GND of the arduino AND to the GND of the silicone LED strip. This connection must share the same GND. The DIN on the Arduino was then connected directly to the Arudino Digital pin 9. The script uploaded to the Arduino can be found under 12/6/20 LED scrip in the Fabrication folder.

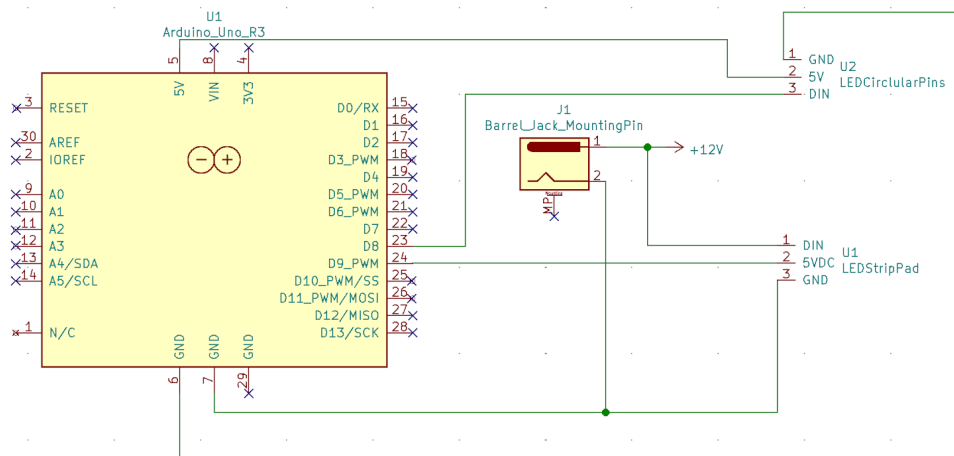


Figure 1. Circuit Schematic for Arduino Uno, External Supply, and LEDs

Conclusions/action items:

Build the circuit and add to the final report. In the next semester this will be updated with a new microcontroller and buttons and possibly a display for the ratios.



12/6/20 LED Script

Brittany Glaeser - Dec 07, 2020, 1:25 AM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

```
//This code currently has two settings (highQ to run lights and off)
```

```
//Ideally will have 5 different settings and will include the alveolus LEDs
```

```
#include <Adafruit_NeoPixel.h>
```

```
#include <elapsedMillis.h>
```

```
//Initializes variables used in Capillary code
```

```
elapsedMillis capillaryTime = 100;
```

```
int CAP_LED_NUMBER = 5;
```

```
int blue = 0;
```

```
int red = CAP_LED_NUMBER;
```

```
int pixelNumber = 0;
```

```
//Initializes variables used in Alveolus Code
```

```
int ALV_LED_NUMBER = 16;
```

```
elapsedMillis alvWaitTime;
```

```
elapsedMillis delayTime;
```

```
int position = 0;
```

```
int green = ALV_LED_NUMBER;
```

```
int yellow = 0;
```

```
int endposition = ALV_LED_NUMBER;
```

```
int endpositionoff = ALV_LED_NUMBER/2;
```

```
int brightness = 255;
```

```
int dim = 100;
```

```
int i = 0;
```

```
int j = ALV_LED_NUMBER/2;
```

```
int alvLightsDelay = 200;
```

```
bool fillAlveolus = true;
```

```
bool diffusedAlveolus = true;
```

```
//high,mid,low Q refers to the amount of perfusion
```

```
bool highQ = true;
```

```
bool midQ = false;
```

```
bool lowQ = false;
```

```
bool off = false;
```

```
String readCommand;
```

```
//high, mid, low P refers to amount of Ventilation
```

```
bool highV = true;
```

```
bool midV = false;
```

```
bool lowV = false;
```

```
bool alvOff = false;
```

```
Adafruit_NeoPixel capillaryLED(CAP_LED_NUMBER, 9, NEO_GRB + NEO_KHZ800);
```

```
Adafruit_NeoPixel alveolusLED(ALV_LED_NUMBER, 8, NEO_GRB + NEO_KHZ800);
```

```
//Sets up serial monitor and LED strip
```

```
void setup() {
```

```
  Serial.begin(9600);
```

```
  capillaryLED.begin();
```

```
  alveolusLED.begin();
```

```
}
```

```
void loop(){
```

```
  //When a command is recognized in serial monitor, it will read it and update booleans
```

```
  while(Serial.available()){
```

```
    //Variable containing serial input
```

```
    readCommand = Serial.read();
```

```
    //strcmp compares characters, when they characters are equal it will return 0
```

```
    //Character = 1 will run capillary LEDs
```

```
    //Character = 0 will turn off capillary LEDs
```

```
    if(readCommand == "1"){
```

```
      highQ = true;
```

```
      off = false;
```

```
      midQ = false;
```

```
      Serial.println("highQ");
```

```
    }
```

```
    else if(readCommand == "2"){
```

```
      highQ = false;
```

```
      off = false;
```

```
      midQ = true;
```

```
      Serial.println("midQ");
```

```
    }
```

```
    else if(readCommand == "3"){
```

```
      highQ = false;
```

```
      off = false;
```

```
      midQ = false;
```

```
      lowQ = true;
```

```
      Serial.println("lowQ");
```

```
    }
```

```
    else if(readCommand == "0"){
```

```
      off = true;
```

```
      highQ = false;
```

```
      midQ = false;
```

```
      lowQ = false;
```



```

}

// Letter values will change the ratios for the Alveolus LEDs
if(readCommand == 'A'){
  highV = true;
  midV = false;
  lowV = false;
  alvOff = false;
  brightness = 255;
  alvWaitTime = 200;
} else if(readCommand == 'B'){
  highV = false;
  midV = true;
  lowV = false;
  alvOff = false;
  brightness = 150;
  alvWaitTime = 300;
} else if(readCommand == 'C'){
  highV = false;
  midV = false;
  lowV = true;
  alvOff = false;
  brightness = 50;
  alvWaitTime = 400;
} else if(readCommand == 'D'){
  highV = false;
  midV = false;
  lowV = false;
  alvOff = true;
  brightness = 0;
}

}

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////

//Runs capillary LED code
if(highQ){
  if (capillaryTime > 250){
    red = CAP_LED_NUMBER * 4;
  }
  if(pixelNumber < CAP_LED_NUMBER){
    for(int i = 0; i < CAP_LED_NUMBER; i++){
      capillaryLED.setPixelColor(i, red, 0, blue);
      capillaryLED.show();
      red = red - 4;;
      blue++;
    }
    capillaryLED.setPixelColor(pixelNumber, 0, 0, 0);
    capillaryLED.show();
    pixelNumber++;
    capillaryTime = 0;
    red = CAP_LED_NUMBER * 4;
  }
}

```

```
blue = 0;

}

else{

pixelNumber = 0;

}

}

}

if(midQ){

    if (capillaryTime > 350){

        red = CAP_LED_NUMBER *2;

if(pixelNumber < CAP_LED_NUMBER){

for(int i = 0; i < CAP_LED_NUMBER; i++){

    capillaryLED.setPixelColor(i, red, 0, blue);

    capillaryLED.show();

    red = red - 2;

    blue++;

}

capillaryLED.setPixelColor(pixelNumber, 0, 0, 0);

capillaryLED.show();

pixelNumber++;

capillaryTime = 0;

red = CAP_LED_NUMBER *2;

blue = 0;

}

else{

pixelNumber = 0;

}

}

}

if(lowQ){

    if (capillaryTime > 450){

if(pixelNumber < CAP_LED_NUMBER){

for(int i = 0; i < CAP_LED_NUMBER; i++){

    capillaryLED.setPixelColor(i, red, 0, blue);

    capillaryLED.show();

    red--;

    blue++;

}

capillaryLED.setPixelColor(pixelNumber, 0, 0, 0);

capillaryLED.show();

pixelNumber++;

capillaryTime = 0;

red = CAP_LED_NUMBER;

blue = 0;

}

else{

pixelNumber = 0;

}

}

}

}

//Turns off LEDs
```

```

if(off){

capillaryLED.clear();

capillaryLED.show();

}

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////

if(fillAlveolus){

// Turns LEDs on

//while ( i <= (ALV_LED_NUMBER/2)){

if(i <= (ALV_LED_NUMBER/2)){

//Sets each side of the Circular LED

alveolusLED.setPixelColor(i,0,green=brightness,0);

alveolusLED.setPixelColor(endposition, 0, green=brightness, 0);

//Turns on the LEDs

if (alvWaitTime > alvLightsDelay){

alveolusLED.show();

i++;

endposition--;

alvWaitTime=0;

if (i == (ALV_LED_NUMBER/2)+1) //The +1 allows the bottom light to turn on otherwise it entered this if statement too early

fillAlveolus = false;

i++; // for some reason its entering this loop twice so I'm trying this to stop that

}

}

}

}

if(!fillAlveolus){

//Turns Alveolus yellow

if(diffusedAlveolus){

// dimming all of the lights to show that oxygen has diffused out of the alveolus and slightly changing the color

for (int x=0; x<=ALV_LED_NUMBER; x++){

alveolusLED.setPixelColor(x,yellow=dim,green=dim+2,0);

alveolusLED.show();

}

diffusedAlveolus = false;

delayTime = 0;

}

// Turns LEDs off

//delayTime pauses at yellow for a second

if ( j >= 1 && delayTime > 1000){

alveolusLED.setPixelColor(j,0,0,0);

alveolusLED.setPixelColor(endpositionoff, 0, 0, 0);

if (alvWaitTime > alvLightsDelay){

alveolusLED.show();

j--;

endpositionoff++;

alvWaitTime=0;

}

}

}

```

```
if (j==0){  
    fillAlveolus = true;  
    // Resets variables  
    i=0;  
    j = ALV_LED_NUMBER/2;  
    endpositionoff = ALV_LED_NUMBER/2;  
    endposition = ALV_LED_NUMBER;  
    diffusedAlveolus = true;  
}  
}  
}  
  
}  
if(alvOff){  
    for(int i = 0; i < ALV_LED_NUMBER; i++){  
        alveolusLED.setPixelColor(i, 0, 0, 0);  
        alveolusLED.show();  
    }  
}  
}
```

Conclusions/action items:

Continue to alter and test code.

Current issues.

When Alveolus is off, it will randomly flash yellow for a short period of time.

There is no delay from when the LEDs turn off and then turn back to green.

Ratios and brightness may need to be altered after further testing.



Testing for Average Intensity Protocol

KAITLIN LACY - Dec 08, 2020, 5:56 PM CST

Title: Protocol for Testing Average Intensity

Date: 12/3/2020

Content by: Kaitlin Lacy

Present: Kaitlin Lacy, Brittany Glaeser, Zoe Schmanski

Goals: Present the protocols used for obtaining and analyzing images for average intensity.

Content:

Protocol for obtaining pictures:

1. Set brightness to 10 for the alveolar LEDs (circular).
2. With lights on, take an image of the device itself, and the device as seen through the document camera on the screen.
3. With the light off, take an image of the device itself, and the device as seen through the document camera on the screen.
4. Repeat steps 1-3 with brightness levels of 25, 50, 100, 150, 200, and 255. (Make sure to note which pictures are from each intensity for easy identification later on.)
5. Repeat all previous steps for the capillary LEDs (strip with silicone covering).

ImageJ analysis: alveolus

1. Define Region of Interest (ROI) as the circular border of the indentation in the base.
2. Use the Analyze -> Measure tool to get a mean intensity level (out of 255). Maximum and minimum values will be available as well.

ImageJ analysis: capillary

1. Define Region of Interest (ROI) as the indentation in the base in which the silicone-encased LEDs sit.
2. Use the Analyze -> Measure tool to get a mean intensity level (out of 255).

Conclusions/action items:

The ImageJ analysis was compared to test images that come with ImageJ to verify that the protocol was accurate. Different areas for the ROI were highlighted in order to determine which would provide the most accurate data for analysis. Now, the data must be analyzed to determine the linearity.

Ventilation-Perfusion Mismatching

Brittany Glaeser - Sep 05, 2020, 3:51 PM CDT

Title: Ventilation-Perfusion Mismatching

Date: 9/5/20

Content by: Britt

Present: Britt

Goals: Understand ventilation-perfusion mismatching and how it affects oxygen in the blood

Content:

- Ventilation: Alveolar airflow
- Perfusion: Capillary Blood flow
- Ventilation / Perfusion ratio
 - Much have a correct proportion otherwise is termed mismatching/inequality
- Major effect of inequality is to decrease PO_2 of systemic arterial blood\
- In disease states, regional changes in lung compliance, airway resistance, and vascular resistance can cause marked ventilation-perfusion inequalities
 - Examples: ventilated alveoli with no blood supply at all (dead space) or blood flowing through an area with no ventilation due to collapsed aveoli
- Carbon dioxide elimination can be impaired by inequality
 - Small increases in arterial PCO_2 lead to increases in alveolar ventilation, which usually prevent further increases in arterial PCO_2
- There are some local homeostatic responses within the lungs that can help some cases of inequalities - these can be seen in figure 1.
 - Effects of vasoconstriction and bronchoconstriction are to supply less blood flow to poorly ventilated areas and thus diverting blood flow to well-ventilated areas and to redirect air away from diseased or damaged alveoli and toward healthy alveoli.

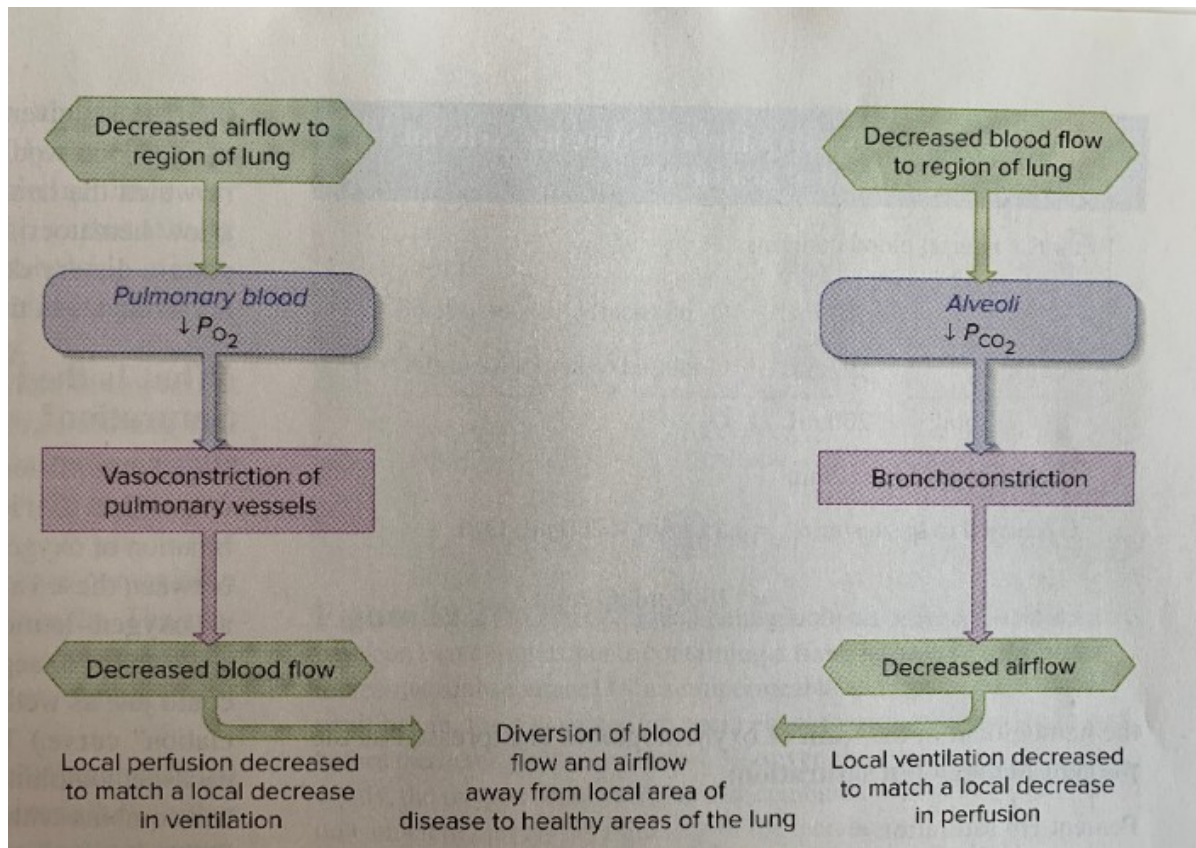


Figure 1: Local homeostatic responses to ventilation-perfusion mismatching [1]

Conclusions/action items:

The important thing to understand when making a model is what causes the events that are occurring. Ventilation-Perfusion mismatching is a common cause of hypoxia which our model will need to show. Mismatching can occur in a few different ways but some, such as decrease in PO₂ of systemic arterial blood, is the major cause. It is also good to know how our body responds to the mismatching and showing how a normal lung works could also be an important aspect to our model.

CITATION: [1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, *Vanders human physiology: the mechanisms of body function*, Fifteenth. New York: McGraw-Hill Education, 2019.

Lung Anatomy

Brittany Glaeser - Sep 12, 2020, 3:45 PM CDT

Title: Lung Anatomy

Date: 9/9/2020

Content by: Britt

Present: Britt

Goals: Understand the mechanics of the lung

Content:

- Dead Space is the volume of fresh air wasted in the conducting zone with each breath
 - The space below dead space is a mix of old and new air
 - The space below that is the old air for expiration
- With a high V/Q ratio, the dead space volume is higher than normal as the air is not mixing with the blood and will be expired
- Dead space is important to the aveolar ventilation
- Normal ventilation has 150 mL of dead space volume
- Aveolar Ventilation:
 - $AV = \text{respir. Rate} \times (\text{tidal vol} - \text{dead space})$

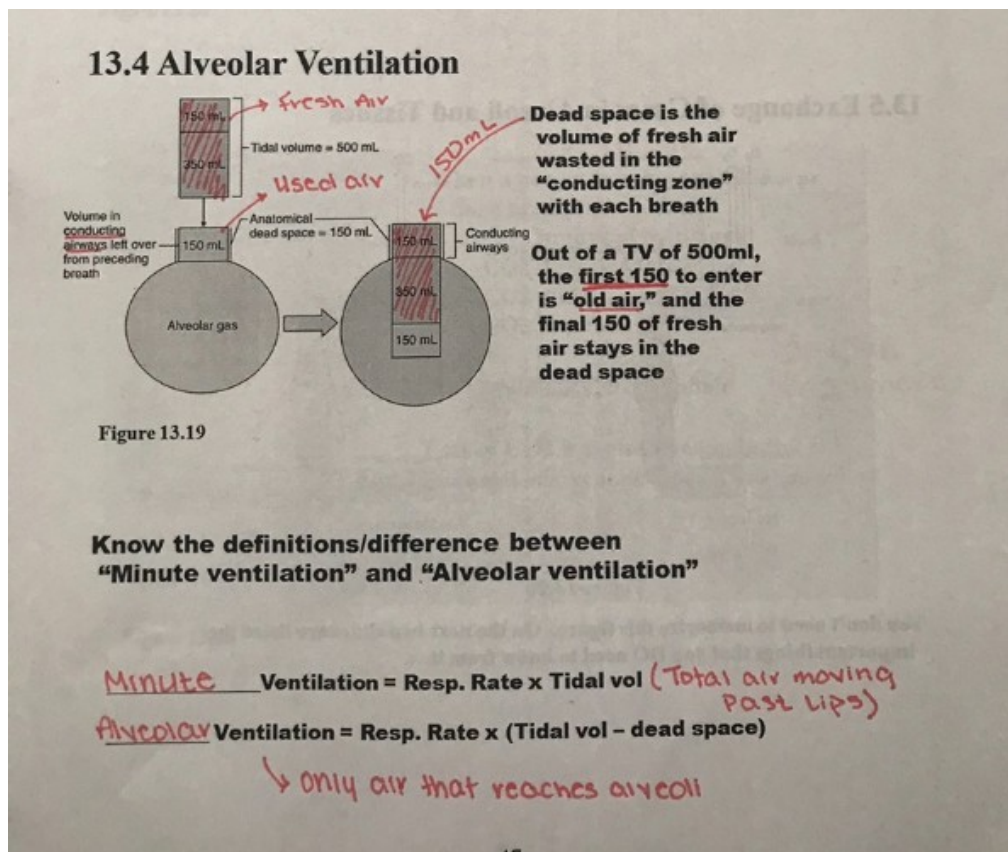


Figure 1: Process of aveolar ventilation and equations for ventilation

- The lung anatomy will not be modeled in our design but it important to understand as it contributes to ventilation/perfusion mismatching
- Air Flow: Mouth - larynx - trachea - bronchus - lung
- Diaphragm is used to change pressure to pull air into the lungs and then out of the lungs for expiration

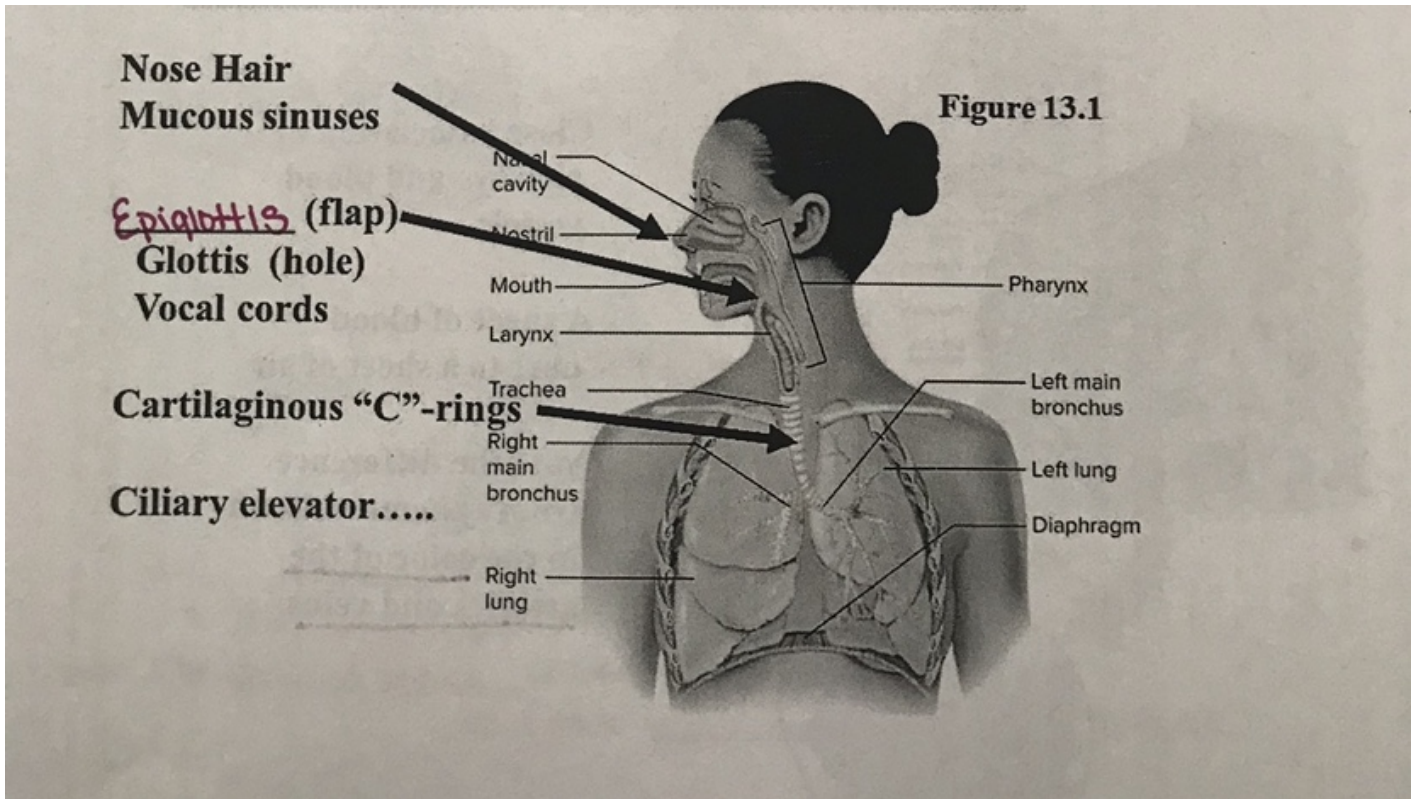


Figure 2: Lung Anatomy

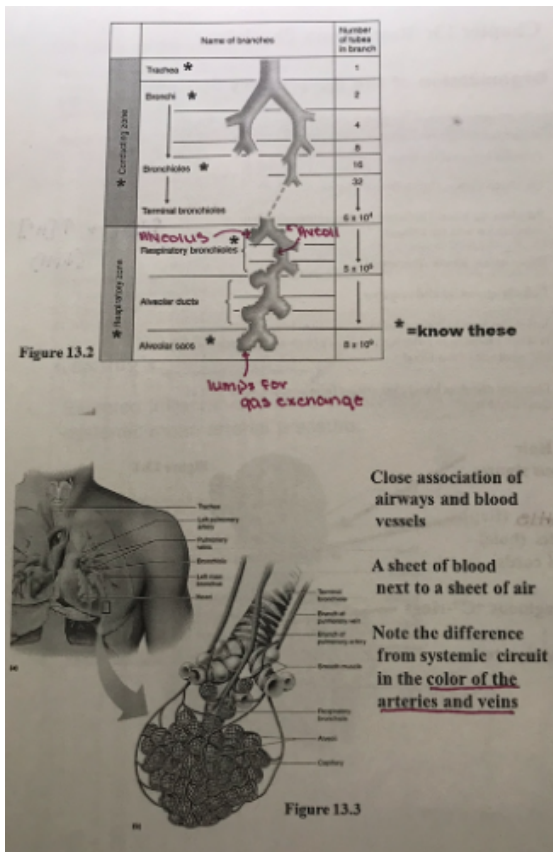


Figure 3: Aveoli Anatomy and lung hierarchy

- The capillaries surrounding the aveoli are the main aspect we will want to model in our design because this is the site of gas exchange
- The photo doesn't show the veins and the arteries (blue and red respectively), but that is something we will also want to show in our design
- Because the aveoli are so small in respect to the lung, it would not make sense to model the entire lung in our design
- The upper part of figure 3 shows the hierarchy of the parts of the lung from largest to smallest diameters

- Air flows through each of these to the aveolar sacs

Conclusions/action items:

By understanding lung anatomy, it will help to better understand ventilation/perfusion mismatching. From this we will decide how we want to model the lung, most likely the alveoli portion where gas exchange occurs. We would also have to model the flow of air through the lungs which was stated previously. We could also use the aveolar ventilation rate to determine the ratios of air in our model, or we could use it to show the output of our model. Will will have to determine these final ideas as a team.

CITATION: Physiology Class Notes



Title: Mechanism of Hypoxemia

Date: 9/9/2020

Content by: Britt

Present: Britt

Goals: To understand the disorder, hypoxemia, and how the body responds to the disorder

Content:

- Hypoxemia: decrease in the partial pressure of oxygen in the blood
- Hypoxemia can be caused by different mechanisms
 - V/Q mismatching
 - right-to-left shunt (abnormal communication between right and left sides of systemic and pulmonary vessels)
 - Diffusion impairment
 - Hypoventilation
 - Low inspired PO₂
- V/Q mismatch is the most common cause
- Normal V/Q level is 0.8 (ventilation / Perfusion)
- Ventilation is responsible for gas exchange, the apical region with high ratio has low alveolar CO₂ and high oxygen content and the basal region has low alveolar oxygen and high CO₂
 - Only low V/Q ratio produces hypoxemia by decreasing the alveolar oxygen level and subsequently arterial oxygen level
- Body Compensatory Mechanism: the body will try to restrict perfusion in areas of the lungs with reduce ventilation
 - Done by Hypoxic pulmonary vasoconstriction (HPV)
 - Diverts blood to well-ventilated lung regions
 - Chronic HPV causes vascular structural remodeling and subsequent development of sustained pulmonary hypertension
- Common causes of mismatching
 - Asthma, COPD, bronchiectasis, cystic fibrosis, interstitial lung disease, pulmonary hypertension
 - Mismatch can be easily corrected by supplemental oxygen therapy

Conclusions/action items:

This article was a little more detailed into how hypoxemia can occur and related it to how it can cause other disorders such as hypoxia. This is important to understand why this disorder should be acknowledged. This article also mentioned how the body compensates for the changes in oxygen levels which related to the chart show on the page "ventilation-perfusion mismatching". An important thing to note is that V/Q mismatching is not the only cause of Hypoxemia, but it is the most common.

CITATION: Sarkar, M., Niranjana, N. and Banyal, P., 2017. Mechanisms of hypoxemia. *Lung India*, 34(1), p.47.



Color Blindness in the Medical Field

Brittany Glaeser - Dec 06, 2020, 11:54 PM CST

Title:

Date: 12/5/20

Content by: Britt

Present: Britt

Goals: Determine the importance of accounting for color blind individuals in our design

Content:

- This paper states that at least 8% of all males in the population are affected by color blindness and less than 1% of females
- This research was done in the UK but seems to have similar results as the US as far as overall population - it was difficult to find research on the US
- Color blindness can affect the skills of a doctor such as determining one's skin color, examining blood, over-viewing scans, looking at bruises and rashes
- Because this population is relatively small, the few skills that are lacking can be overcome due to many others in the workforce that are able to help
- Overall found that there was 8% of the medical profession that are colorblind (this includes all types) for males and less than 1% of females
- It is known that it is an x-linked recessive trait and is why it is more common in males as they only carry one x chromosome

Conclusions/action items:

Even though this population is small, it is still important to consider for their understanding and ability to provide the correct treatment plans. Many are still able to see hues of different colors and therefore brightness can be altered also, the speed at which the lights change can also indicate an increase or decrease in ventilation or perfusion.

CITATION: J. Anthony and B. Spalding, "Colour vision deficiency in the medical profession," *British Journal of General Practice*, June-1999. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1313448/pdf/10562750.pdf> [Accessed: 05-Dec-2020].



Water Model

Brittany Glaeser - Sep 12, 2020, 4:11 PM CDT

Title: Ventilation Perfusion Water Model**Date:** 9/12/20**Content by:** Britt**Present:** Britt**Goals:** To understand some existing design ideas**Content:**

This model was given to the team from the client. The idea is that the water running through the bottom represents the blood and the powdered dye represents the intake of oxygen. When ventilation is increased, there would be more dye and the blood would become a darker color, becoming more oxygenated. The model shows that the concentration of dye is affected by the flow of the water and the flow of the dye being poured (ventilation). The stirrer on the bottom represented the diffusion occurring between the capillaries and the aveoli.

After discussing with our client, we decided that this model may not be the best representation of V/Q mismatching. It would be difficult to show different ratios. This design could also be messy and difficult to set up for class.

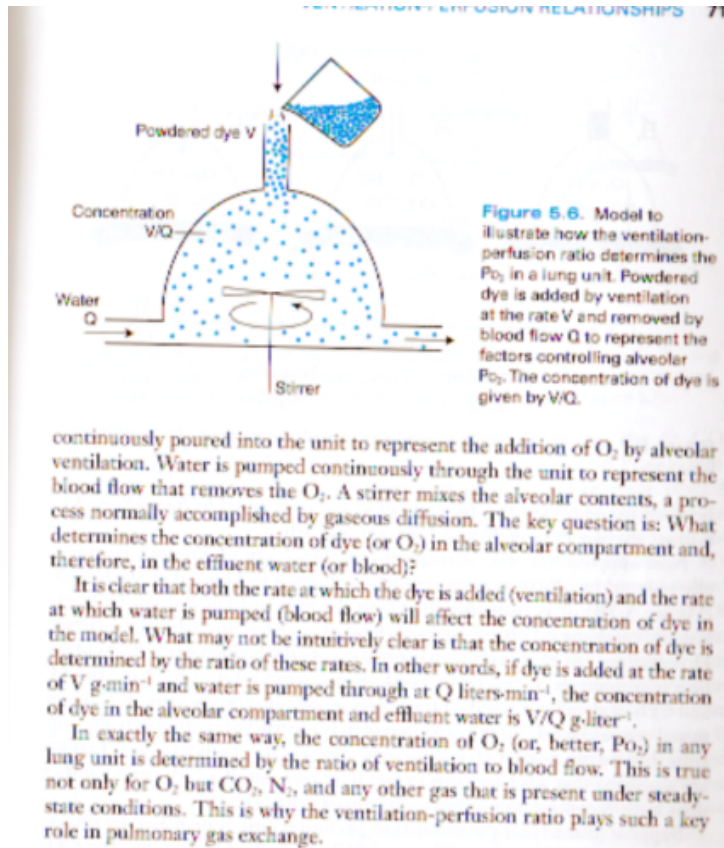


Figure 1: Water model for ventilation and perfusion with description

Conclusions/action items:

The team is going to focus our ideas around this main concept of this design. We plan on eliminating the water aspect and using more electrical components such as LEDs. It would be beneficial to include some way of easily changing the V/Q ratios in the model without having to clean the device before the next use. We would also like to incorporate different colors to represent oxygen, deoxygenated blood, and oxygenated blood.

CITATION: Photo provided by client

Multi-Scale Computational Model

Brittany Glaeser - Oct 05, 2020, 11:36 AM CDT

Title: Multi-scale Computation Model of V/Q matching

Date: 10/4/20

Content by: Britt

Present: Britt

Goals: To find other competing designs for V/Q mismatching

Content:

- This study plans on using a computer model of the hemodynamics and gas exchange for V/Q matching
- The model serves as an in-silico (online/computer) platform to test and refine hypotheses regarding the contributions of vasoregulatory mechanisms
 - They are using their model for more research purposes rather than teaching like our model would be used for
- For an accurate model, they used a series of ordinary and partial differential equations
- Would model the whole lung vascular network model
 - Geometry is generated by a space-filling algorithm and is tested by comparing anatomical predications to existing literature
 - Mechanics are tested by comparing the model predictions to macro-scale pressure-flow relationships and pulmonary artery pressure waveforms
- From using their simulated model, they could determine that more homogenous blood flow distributions increase the bulk oxygen content entering the systemic circuit
- The model of the computer design can be seen in figure 1
- This design is far more complicated that we could model on a computer, but the idea of using a simplified online model may be more achievable, but we require much more programming knowledge

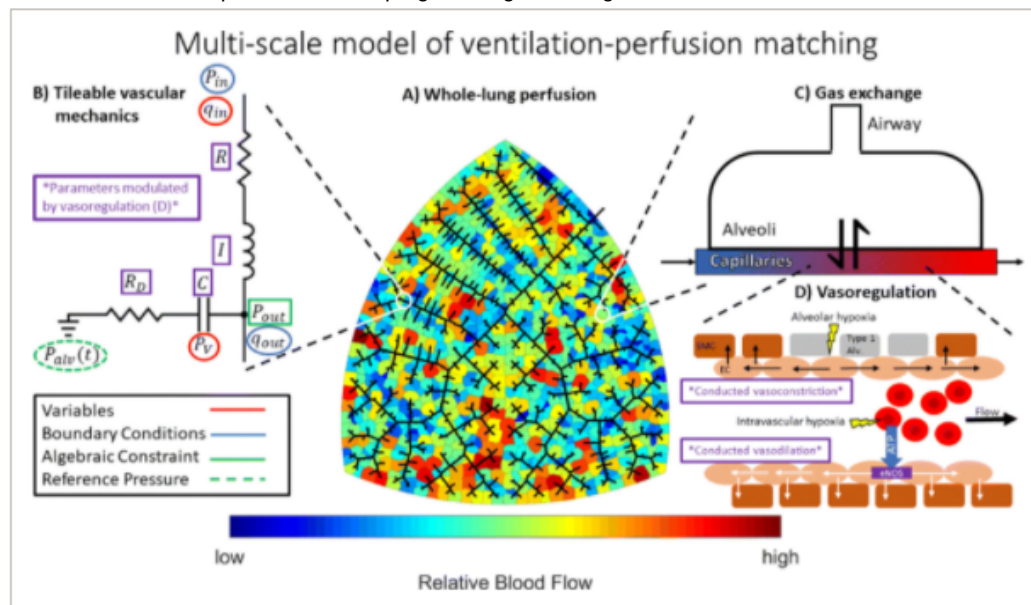


Figure 1: Online model of V/Q ratios

Conclusions/action items:

This model is used more for research purposes and helping to create a better understanding of V/Q mismatching. This model specifically, models the entire lung, where we ideally would like to model our design on the micro-level (alveolar level). We would also like to better model the flow of blood and gas through the design, where this uses more shades of colors to model flow (we would like to do this as well as using moving pieces whether it be LED movement or water flow). There don't seem to be many resources or patents with other models for V/A models, which would be good for our design if we later decide to go further with this project.

Power existing LEDs

Brittany Glaeser - Oct 29, 2020, 12:26 PM CDT

Title: Powering the LEDs that we have ordered

Date: 10/24/20

Content by: Britt

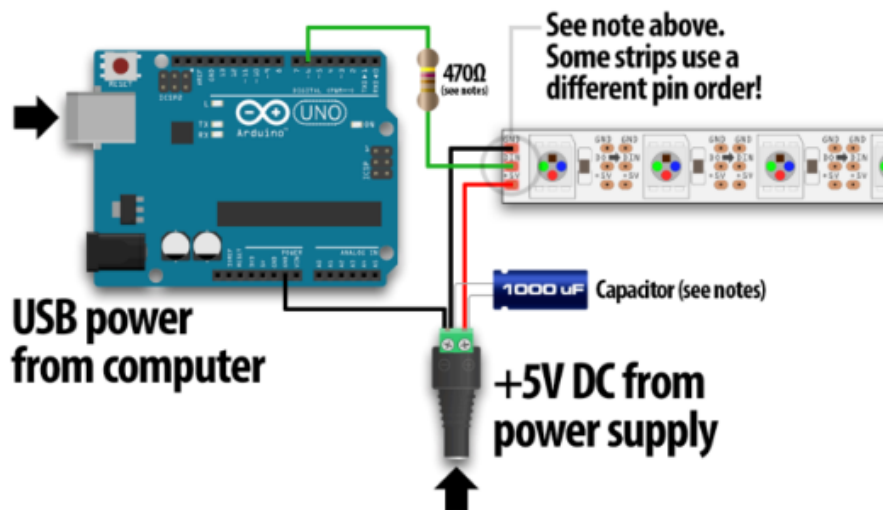
Present: Britt

Goals: Determine how we will need to power our LEDs

Content:

The information obtained was from adafruit's website [1]

- Circular LEDs
 - These should be relatively simple. They already have a resistor before the DIN pad so for these all that needs to be added is the wiring to the arduino
- Normal LED strip
 - These will need to have power cords
 - They should be able to use the power supply from the arduino with a resistor (470 ohm) before the DIN
 - If there is dimness in the strip an external power supply may need to be used
 - Depending on how these LEDs were shipped, we may need to order some of the JST connectors that are on the expense list already
 - Recommended that less than 1m is used for the strips (ours is less than 0.5 ft so this should not be a problem)
- Silicone LED strip
 - This will need to be powered with an external source to receive a voltage of 9-12 V
 - Kaitlin mentioned using a 9V battery
 - Future ideas for a quick solution can be found under design ideas folder named 9/12V Solution for Neopixel Strip
 - Because this is using an external power supply, it is recommended that a capacitor is placed between the +/- terminals (seen in figure 1)



⚠ When connecting NeoPixels to any LIVE power source or microcontroller, ALWAYS CONNECT GROUND (-) BEFORE ANYTHING ELSE. Conversely, disconnect ground last when separating.

⚠ When using a DC power supply, or an especially large battery, we recommend adding a large capacitor (1000 μF, 6.3V or higher) across the + and - terminals. This prevents the initial onrush of current from damaging the pixels. See the photo on the next page for an example.

Figure 1: External power supply and capacitor [1]

There is potential for future work with this design. Including a battery back would allow the design to be more portable.

Conclusions/action items:

Powering the design can start off simply so we can begin coding the LEDs. As we move forward with the design, we can add different power supplies so a cleaner circuit that would be more appealing to the user. We would also want to decide which LEDs we are using to finalize the final circuit. For the ideas, a few things will need to be ordered.

CITATION: [1] Adafruit Learning System. 2020. *Adafruit Neopixel Überguide*. [online] Available at: <<https://learn.adafruit.com/adafruit-neopixel-uberguide/powering-neopixels>>



Remodeling LED design strips

Brittany Glaeser - Oct 15, 2020, 11:46 AM CDT

Title: Adafruit LED strips remodeling

Date: 10/14/20

Content by: Britt

Present: Britt

Goals: Finding ways to connect/change LED strips

Content:

<https://learn.adafruit.com/florabrella/assemble-umbrella-circuit>

The website pasted above shows how the LED strips from adafruit can be cut and modified to different lengths. The strips they used are similar to the 0.5m length ones we looked into ordering. Apparently, on the plastic portion there are cut lines marked between the LEDs where you can cut through the plastic. Then the LEDs would have to be desoldered to meet the desired length. They then used to wires to solder the 5V, DIN/DOOUT, and GND pads together to complete a circuit. (I have done something similar to this before so I would know how to code these). This would allow us to get a proper size for the neopixels in our design. I am unsure whether all the designs would work this way, the silicone ones mentioned they would be easy to cut, so I would assume that those could be modified. The circular ring of LEDs would not be able to be changed, but there are many options for sizing, so the base model may have to be modified to fit this if we choose to use it.

Conclusions/action items:

The team can use this as an example for how we want to integrate our LEDs into the model, the next step would be to order the LEDs so we can play around with the sizing. It would be assumed that the LEDs can be resoldered together, but may not give a clean finish for the plastic part if we end up changing the overall design. With this in mind, it may be beneficial to order an LED strip with no covering and finding a cheap diffuser for ourselves so if changes are made, we can continue to use the same LEDs.

After further looking into the strips, it looks that when they sell strips less than 5m, they are cut from the 5m reel, so therefore, any of their neopixels sizes can be changed. From this, it was also important to see that they only have one connector, or potentially none, so we may need to order multiple connectors.



Image J Testing

Brittany Glaeser - Nov 22, 2020, 7:32 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

<https://www.unige.ch/medecine/bioimaging/files/1914/1208/6000/Quantification.pdf>

Conclusions/action items:

Title: Connectors to Silicone LEDs

Date: 12/5/20

Content by: Britt

Present: Britt

Goals: Determine better ways to connect the silicone LEDs to wires so they don't fall off

Content:

These are the type of connectors that come on most of Adafruit's LEDs, we had ordered some originally but they were the wrong size. If we can find the right size, we would likely be able to use these are a better connected to the silicone LEDs once we cut them. We would likely need solder paste and a heat gun to get these onto the LEDs since they would be very difficult to solder with a soldering iron.

Currently, we just soldered wires onto the LEDs and we had many issues where it was too loose and they fell apart easily. This is obviously an issue and we finalize our final design and we would not want the design to fall apart while in use. On Adafruit's page, there is a link to the JST website where there are many connectors listed, this may be somewhere to look if we are unable to find the correct size elsewhere.

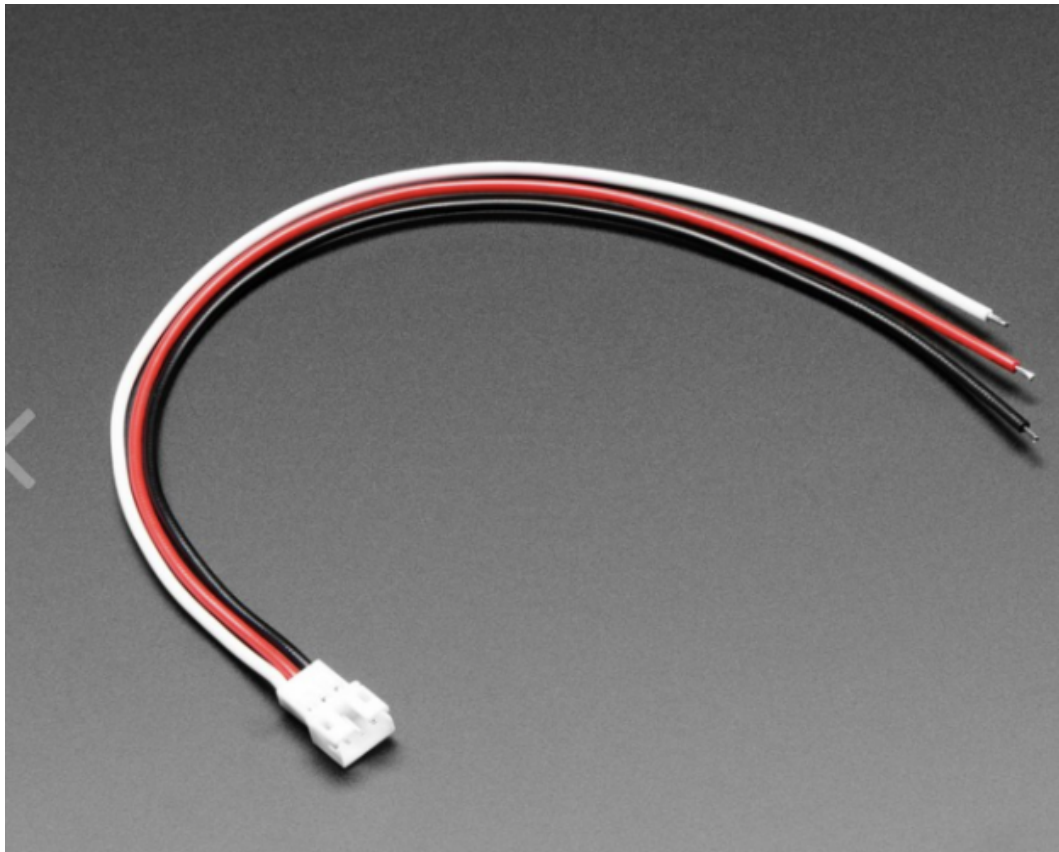


Figure 1: JST PH 3 Pin Connector for LEDs (200 mm) [1]

Conclusions/action items:

Find a connector that would fit our silicone LEDs and test them with our circuit.

CITATION: [1] Industries, A., 2020. *JST PH 3-Pin Socket To Color Coded Cable - 200Mm*. [online] Adafruit.com. Available at: <<https://www.adafruit.com/product/4046>> [Accessed 2 December 2020].

Alveolus Colored idea

Brittany Glaeser - Sep 09, 2020, 9:10 PM CDT

Title: Alveolus Colored Idea

Date: 9/9/20

Content by: Britt

Present: Britt

Goals: To come up with design ideas for the alveolus to model V/Q mismatching

Content:

After the meeting with the client, I had a better understanding of what he wants to model in the design. In figure 1, it shows a model of the alveolus which we discussed would be the main part of the model, not the entire lung. The figure shows different colored blood representing the different levels of oxygenation. The idea of using different colors would be ideal for our model and we could use this using LEDs. In the figure, it shows purple as being the blood that is currently being mixed with the oxygen and the red as being oxygenated. We could easily model the how oxygenated the blood is by creating a spectrum of colors similar to the one in the figure.

One thing the figure doesn't show is the movement of air flow to the capillaries, so this is something we will have to add. Also a shunt, which could potentially be shown by LEDs not being lit or dimming the LEDs to show less ventilation is occurring while the brightness of the blood remains constant.

If LEDs were to be used, I have used Adafruit Neopixels that had a wide range of colors and brightness levels and were easy to program. There are also a wide array of LEDs that could be used for the project.

✕ Cross-section through an alveolus

Alveoli are the tiny air sacs at the end of the bronchioles, in which gas exchange occurs.

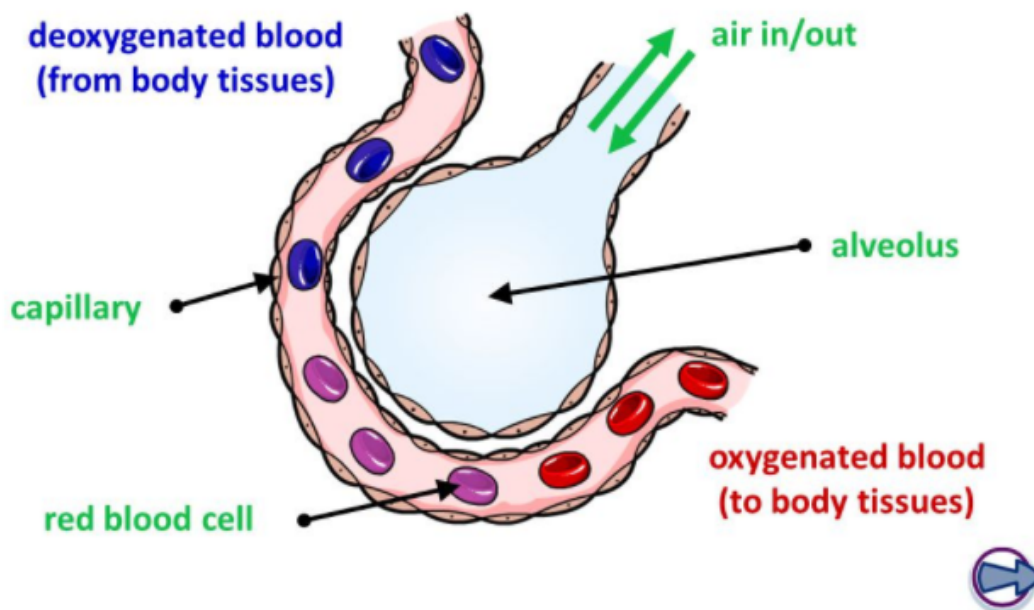


Figure 1: Cross-Section of the alveolus using different colors to represent oxygenated blood [1]

Conclusions/action items:

The next steps would be to further develop this model as potentially use it as a preliminary design for the design matrix.

CITATION: [1] Sarkar, M., Niranjana, N. and Banyal, P., 2017. Mechanisms of hypoxemia. *Lung India*, 34(1), p.47.



Brittany Glaeser - Sep 27, 2020, 4:29 PM CDT

Title: Aveolus LED design

Date: 9/20

Content by: Britt

Present: Britt

Goals: To present an LED idea

Content:

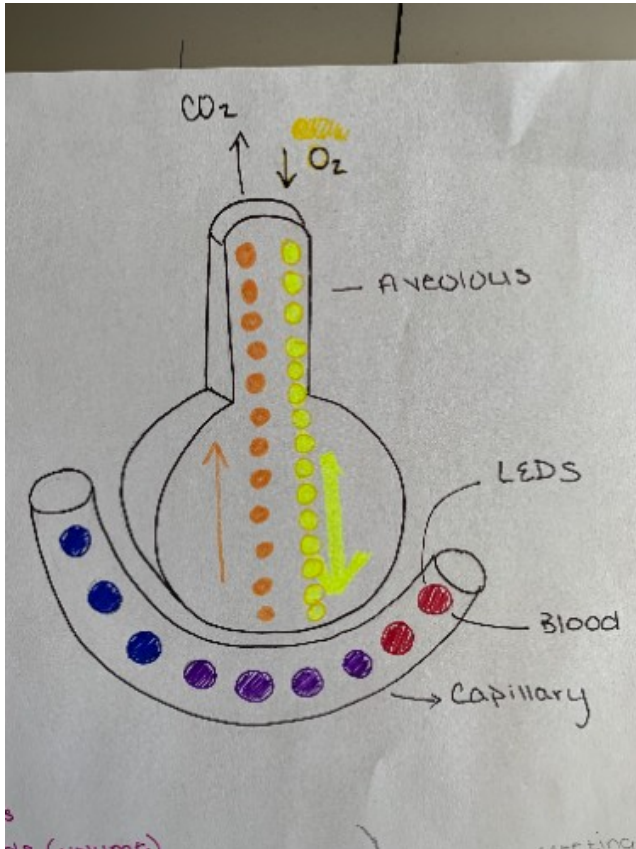


Figure 1: A single 3D aveolus with LEDs to represent oxygen and carbon dioxide as well as blood flow

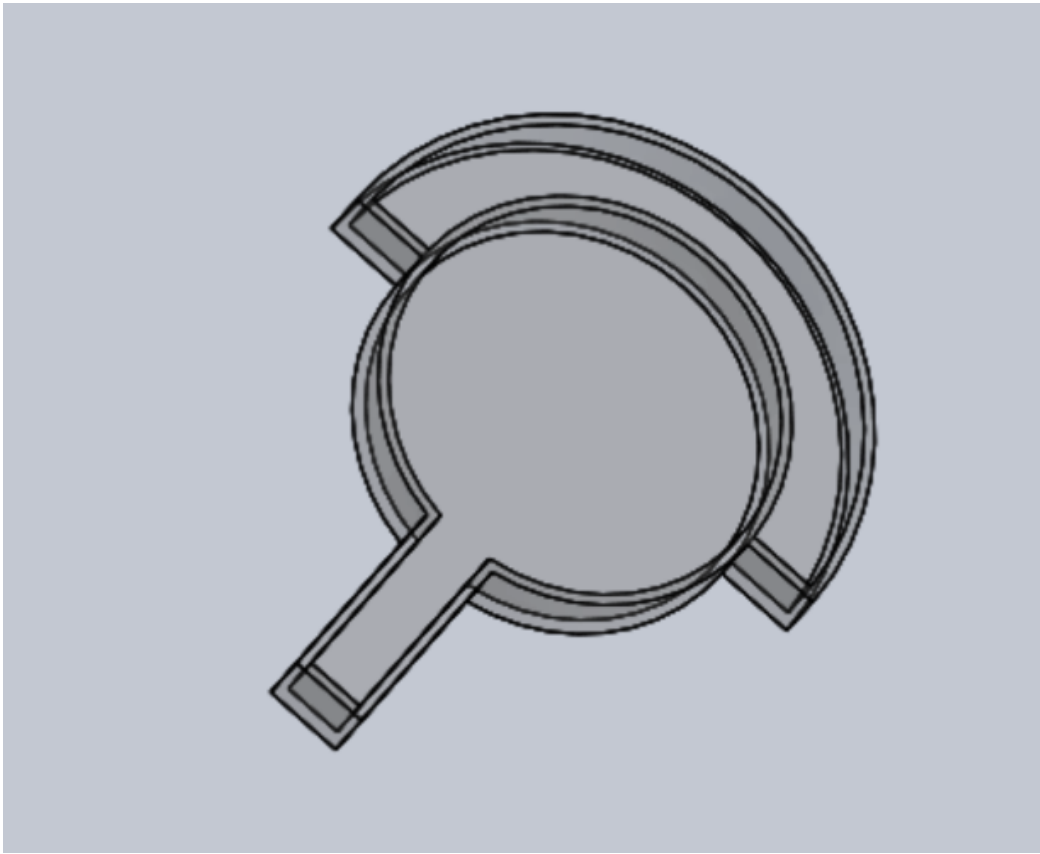


Figure 2: Solidworks drawing of alveolus design

The idea with this design was to use a single alveolus to model perfusion, even though it happens at more than one at a given time. The LEDs would be color coded to represent O₂, CO₂, deoxygenated blood and oxygenated blood. Ideally, both the brightness and the shade of color would change based on how much perfusion is occurring. The O₂ and CO₂ would also change based on how much ventilation is occurring. The LEDs would "move" to show the direction of flow through the capillary and show the CO₂ moving out and the O₂ moving into the alveolus.

The solidworks drawing is shown slightly differently than the drawing. I modeled this design as if it would be carved from a laser cutter machine. This idea came to me from user the laser cutter at work to encase my LEDs. The LEDs would be held within the carved middle sections of the design. The front of the design would actually be the back side of the drawing consisting of a flat surface. This would allow the light to diffuse through the plastic material (the plastic would have to be almost clear, but not clear enough that each individual LED can be seen).

Conclusions/action items:

To move forward with this design, it would be beneficial to create a CAD drawing to further explain my thought process. I would also begin looking into LEDs that could be used for this design (specifically RGB LEDs).



Brittany Glaeser - Sep 30, 2020, 11:58 AM CDT

Title: Diffused LEDs

Date: 9/29/20

Content by: Britt

Present: Britt

Goals: To come up with ideas for diffusing the light of LEDs so that the LEDs are less noticeable

Content:

<https://www.instructables.com/id/13-Ideas-for-Diffusing-LEDs/>


The website listed above has some really cool ideas for how to diffuse light through a bunch of different materials

- The one that first caught my eye is ping pong balls
 - Ping pong balls wouldn't not actually be ideal for this project but using a thin plastic cover around the LED capillaries would work
- In one of there other ideas, they used white 3D printed materials over the LEDs
 - This would be great for our project as it could give us a lot of options as to how we want the design to look
 - The only worry is that it may diffuse too much and color change or brightness shade would be less noticeable
- Crinoline tubing was also used in one
 - This may not be ideal as it is form fitting to the LED strip and the LED strip would still be seen through the design and won't have as clean as a look
- Laser-Cute Acrylics
 - This is similar to what I did in my lab that allowed the light to diffuse through and also provide some "holes" for the light to flow out of
 - This is a more complicated idea, but could also give us some more ideas for the design
 - Would only allow for a 2D like object as laser cutting won't allow 3D prints
- Glass
 - Our client mentioned using glass
 - This would be a lot harder as we would need outside help to do this
 - It would also increase the overall weight of our design but it gives it a nice clean finish

Conclusions/action items:

Using these ideas, it would probably be best to combine a few ideas or test a few of them out before making a decision on what would work best for our design. Using some form of plastic that we can design/shape ourselves would most likely be preferred as it will give us a design with the look we intend.

CITATION: Stern, B., 2020. *13 Ideas For Diffusing Leds*. [online] Instructables. [Accessed 30 September 2020].



Water Model Circuit

Brittany Glaeser - Oct 05, 2020, 11:49 AM CDT

Title: Water Model + Closed Circuit Design

Date: 10/1

Content by: Britt

Present: Britt

Goals: To combine the water idea with a full system for a design

Content:

The design seen in Figure 1 is also mentioned in the Competing design portion of my notebook. This model was given to us by the client as an example of what he was looking for. The model given was only a brief overview of what a model could look like using water and dye and an explanation in the book, but we would need to complete the design into a full physical model. To do this, we would need to use a close water circuit to circulate the water through the system to create flow. An idea of this system can be seen in Figure 2. This design would need to include a clean water reservoir to and a water pump to move the water through the system, it will also need a waste reservoir at the end to hold the water mixed with the dye. This will cause the design to become heavy and would require clean up and set up time. The design would have the similar ideas as the author suggested in his book, just with the incorporation of a water pump system.

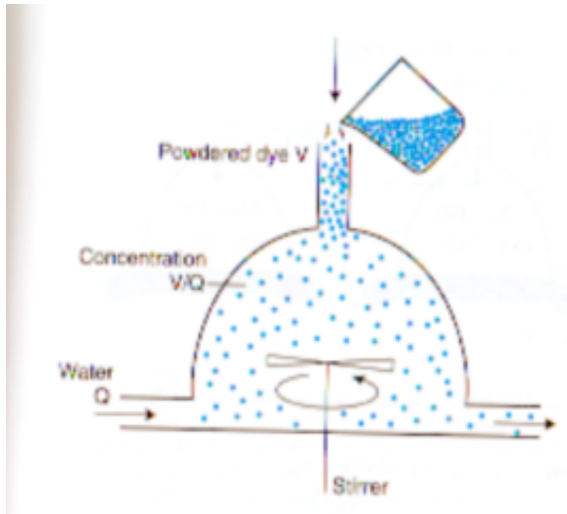


Figure 1: Initial water model from client using water and dye circulation [1]

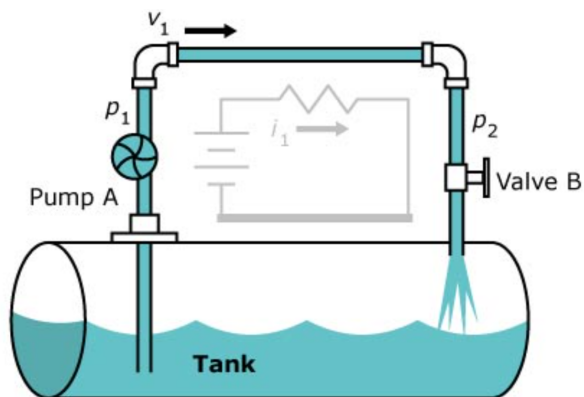


Figure 2: Closed water system [2]

Conclusions/action items:

This design, when added with a water pump system, is a viable design for our design matrix. This would require a lot of fabrication in order to create a water reservoir and pump system, but is doable. The dye for this design would only allow for one color, therefore, the ratios would only be shown by the dye and flow is simply shown by water through the system. If this were to be the design we chose from our design matrix, more

research would need to go into specific water pumps for this circuit (there seems to be many viable options, it would just be a matter of picking the right one for our design).

CITATION: [1] *West's Pulmonary Physiology, Tenth Edition*, John B. West and Andrew Luks, Wolters Kluwer, 2016, pp 70-71.

[2] Johnson, H., 2010. *Water Analogy*. [online] Sigcon.com.

9/12V Solution for Neopixel Strip

Brittany Glaeser - Oct 26, 2020, 2:26 AM CDT

Title: 12V Solution

Date: 10/26/20

Content by: Britt

Present: Britt

Goals: Find solution

Content:

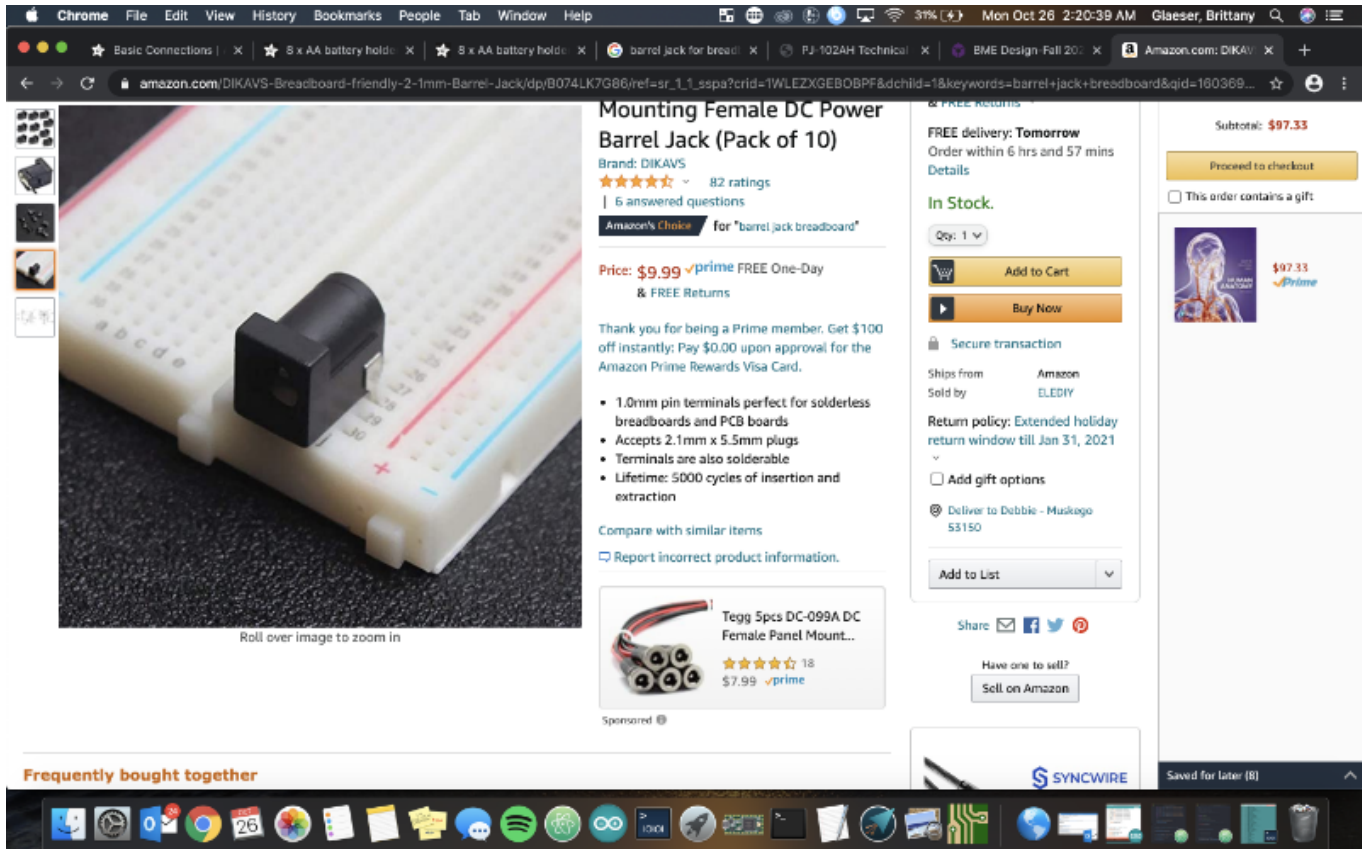


Figure 1. Barrel Jack Connector

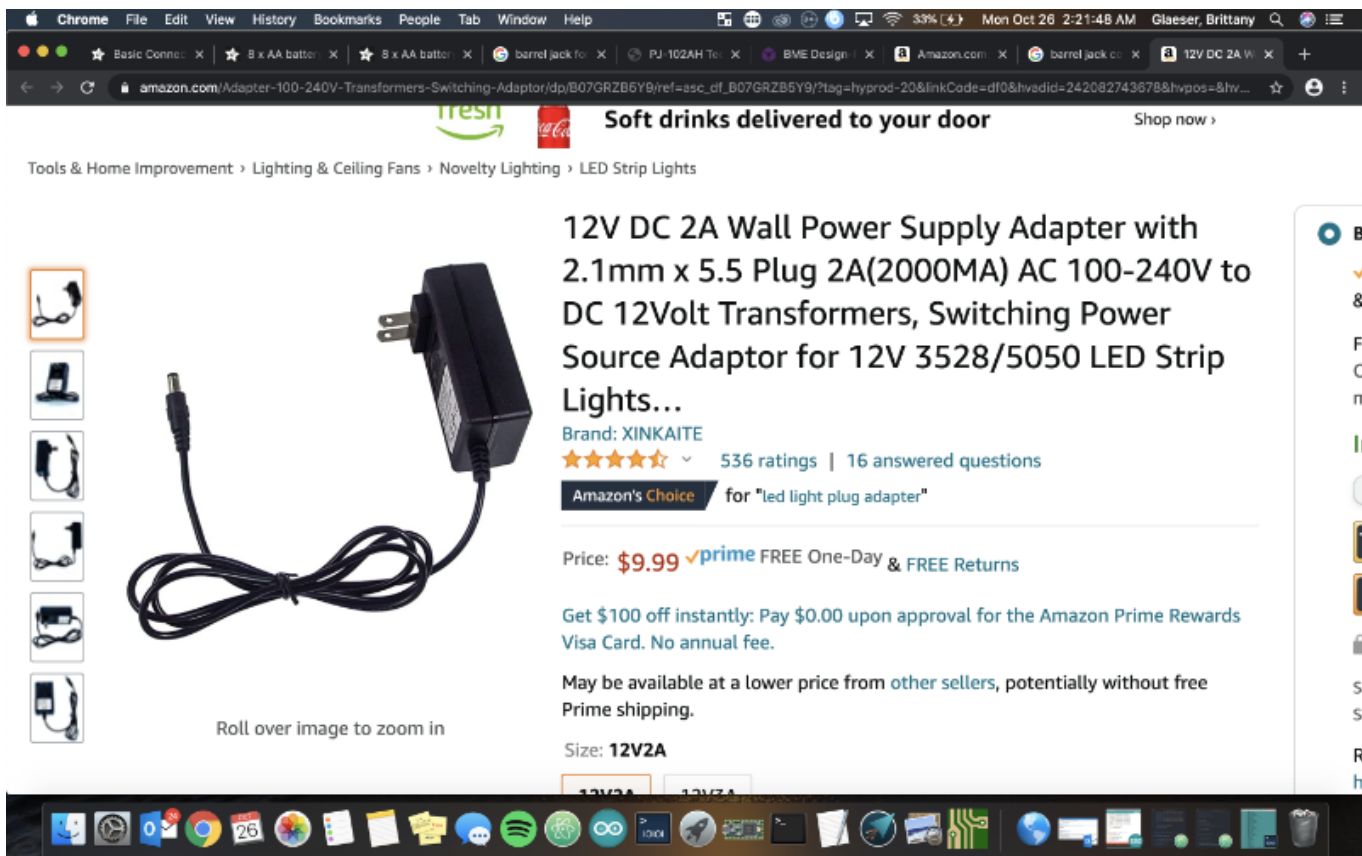


Figure 2. 12V DC power supply for LEDs

This plug (Figure 2) contains can supply up to 12V by plugging it into a simple wall outlet (I have one of these). The end can be plugged into a barrel jack connector (Figure 1) and amazon has some that are compatible with a breadboard (which we should all have). We can then add a 0.1uF capacitor across the power plug connector and the wires for the LED strip to the breadboard. This would allow for a quick solution to begin coding the LEDs. A better solution should be created for the final design.

Adafruit also sells battery packs that works with the barrel jack connector and has potential for the future design as it will make the device more portable.

Conclusions/action items:

Order as soon as possible to begin coding the LEDs.

Battery Pack for LEDs

Brittany Glaeser - Oct 29, 2020, 12:36 PM CDT

Title: Battery pack for portable design

Date: 10/29/20

Content by: Britt

Present: Britt

Goals: Determine if a portable would be beneficial

Content:

Part of the PDS was to have a portable design, to make our design more portable, it would require a portable power supply. The one shown in figure 1 would be able to provide 12V to the silicone LED strip using 8 AA batteries. We would still need another external battery pack to power the Arduino. It could be beneficial to find a design that could provide power for both the microcontroller and the LED strip. It could be even more beneficial to find a rechargeable battery pack.

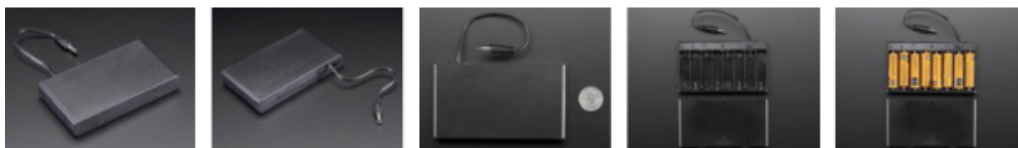


Figure 1. Battery pack that supplies 12V

This battery pack may not be the best option depending on how long the batteries last especially since they can discharge when in storage for long periods of time.

Conclusions/action items:

After looking into battery packs, the team would have to determine if it would be beneficial for the design to be slightly more portable. This could require additional cost for the future and additional set up time rather than using a simple wall plug that is used currently.

CITATION: Adafruit Learning System. 2020. *Adafruit Neopixel Überguide*. [online] Available at: <<https://www.adafruit.com/product/875#technical-details>>

Title: Buttons for design

Date: 11/17

Content by: Britt

Present: Britt

Goals: To decide how we should incorporate buttons for the different ratios

Content:

Buttons need to be incorporated into the design so the user can change the V/Q ratios easily. For this semester, it may be easiest to use buttons incorporated into the breadboard since our circuit will currently be used on that. Breadboard buttons seemed to be limited, so it would be best to use simple ones used from 201, that many of us already have to test with, and later incorporate our code to a newer button with a better circuit.



Figure 1. Example of the breadboard button from 201



Figure 2. Potential future buttons for the design

The buttons in Figure 2 are potential buttons that can be used in our design. These will be easy in our base design to give a clean flush look and should be easy incorporated into the circuit/code similar to that for the breadboard button.

Conclusions/action items:

Work with integrating the breadboard button into the circuit and work on the code. Then, next semester, look into the other buttons and other colors that we think would be best for our design. The buttons would need to be researched a little future to determine how they can be soldered and contained so there are no open wires. This can potentially be done by looking back at our 201 project which used a similar button to the ones in Figure 2.

Breadboard Button: <https://www.sparkfun.com/products/12993>

Black Button: <https://www.sparkfun.com/products/9339>

Silver Button: <https://www.sparkfun.com/products/11996>

Title: PCB Board for circuit design

Date: 12/1/20

Content by: Britt

Present: Britt

Goals: To find ways that will give a more clean look to our circuit

Content:

I have created PCB's in the past using KiCad and I think creating a board with microcontroller integrating and finding a way to attach the power supply mount and the microcontroller as well as the LEDs will help simplify our circuit with a few less cords and would be cleaner than a breadboard. This can also help make our circuit more stable so there is less of a chance our circuit will come apart.

In order to do this a new microcontroller will need to be found to be integrated into the board.

I have ordered boards through DigiKey before and shown in Figure 1 are the steps to order the boards. This process can take time so this would be something to implement early next semester to give us time for error and changes in the boards/circuit.

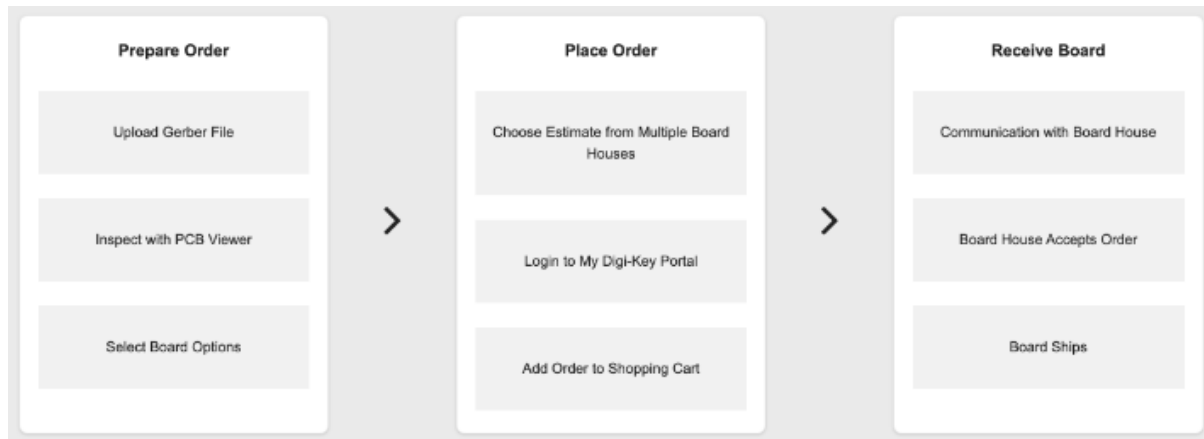


Figure 1. PCB steps for ordering [1]

Conclusions/action items:

Begin thinking of ways the layout could help simplify our circuit and talk with team to determine if this is the step we would want to take. We would also need to find a microcontroller and test the microcontroller with our circuit to make sure it would work before creating a PCB for it. This can be added to our future work portions of the presentation and final report.

CITATION: [1] "Getting Started," *Getting Started – PCB Builder* | DigiKey Electronics. [Online]. Available: <https://www.digikey.com/en/resources/design-tools/pcb-getting-started>. [Accessed: 05-Dec-2020].

Title: Microcontrollers

Date: 12/2/20

Content by: Britt

Present: Britt

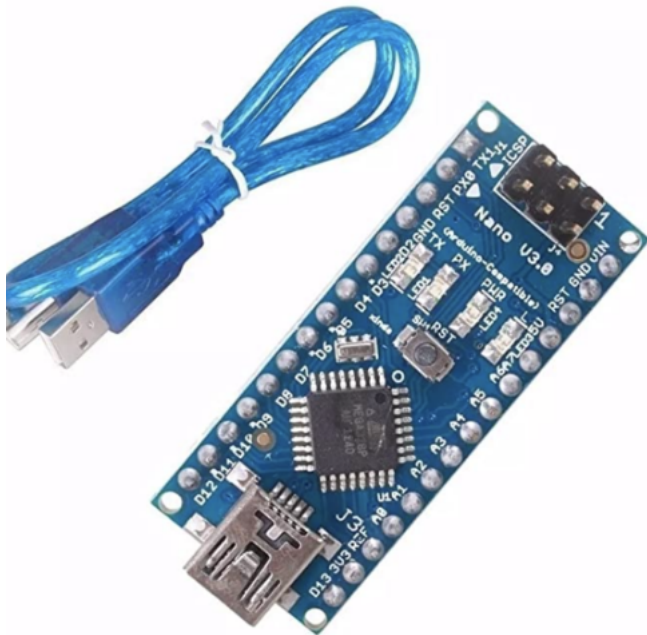
Goals: Brainstorm different microcontrollers that can be used in the design

Content:

Currently, the design uses an Arduino Uno which is bulky and doesn't have strong connection, also, if we choose to create a PCB for simplicity of a circuit, an Arduino Uno would not work. A few possible options are the Arduino Nano and the Teensy Microcontrollers. These are much smaller than the Uno and has pins that can be soldered onto a PCB. Both of these microcontrollers will be compatible with our code on the Arduino software. These microcontrollers have a larger processing capability, but these is not as an important factor for our design as it doesn't consist of many components.

The Arduino Uno cost less than the teensy which can be beneficial to lower the manufacturing cost of the design.

Teensy has multiple microcontrollers. The 4.0 is the newest model and is also the smallest with a higher memory and faster speeds.



Roll over image to zoom in

Figure 1. Arduino Uno Microcontroller [1]



Figure 2. Teensy 4.0 Microcontroller [2]

Conclusions/action items:

Discuss with the team what would be a better option for our design. Continue research of these possible microcontrollers to see what benefits they have over one another.

CITATION: [1] Amazon.com. 2020. [online] Available at: <https://www.amazon.com/ATmega328P-Microcontroller-Board-Cable-Arduino/dp/B00NLAMS9C/ref=asc_df_B00NLAMS9C/?tag=hyprod-20&linkCode=df0&hvadid=309776868400&hvpos=&hvnetw=g&hvrnd=10933307501965660581&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1015695&hvtargid=593018008274&th=1> [Accessed 5 December 2020].

[2] Amazon.com. 2020. [online] Available at: <https://www.amazon.com/Teensy-4-0-With-Pins/dp/B08259KDHY/ref=sr_1_3?dchild=1&keywords=teensy&qid=1607210092&s=electronics&sr=1> [Accessed 5 December 2020].



Original Capillary LED Code

Brittany Glaeser - Dec 08, 2020, 2:05 PM CST

Title: Original Capillary LED code

Date: Code was created early in the semester

Content by: Britt

Present: Britt

Goals: Begin Code

Content:

This is my original LED code that I had created using my neopixels powered by a teensy microcontroller. This creates a color gradient from blue to red. It also flashes off a single LEDs light to try and create what looks like flow.

ElapsedMillis was used in this code rather than a delay function so that the code is continuously running and a delay function does not stop the progression of the code. This is useful as I have used in other projects, so input from other functions like a serial monitor can be read in as soon as it is typed and a delay would delay the reading of the input.

There were also many versions of this as I played around testing it with different colors, speeds, and affects, but this was the base for the testing code.

```
#include <Adafruit_NeoPixel.h>
#include <elapsedMillis.h>

//Number of LEDs in my strip
int LED_NUMBER = 16;
//I use elapsedMillis rather than delay
elapsedMillis time;
//Starting position for the "off" LED
int position = 0;
//Red will begin at the end of the strip
int red = LED_NUMBER;
//Blue will begin at the beginning of the strip
int blue = 0;

//Initiating Neopixels
Adafruit_NeoPixel capillaryLED(LED_NUMBER, 29, NEO_GRB + NEO_KHZ800);

void setup(){
  capillaryLED.begin();

  //This will turn on every LED with the correct shade/color
  for(int i = 0; i < LED_NUMBER; i++){
    //Total = 16 = Red + blue

    capillaryLED.setPixelColor(i, red, 0, blue);
    capillaryLED.show();
    red--;
    blue++;
  }
  red = LED_NUMBER;
  blue = 0;
}

void loop() {
  //Sets time for the off LED
```

```
if (time > 100){
  //If it reaches end of the LED strip, it will start over from the beginning
  if(position < LED_NUMBER){
    //This will turn on every LED
    for(int i = 0; i < LED_NUMBER; i++){
      //Setting LED Colors (Position, red, green, blue)
      capillaryLED.setPixelColor(i, red, 0, blue);
      //Lighting up the LEDs
      capillaryLED.show();
      red--;
      blue++;
    }
    //Setting the single off LED for each run through
    capillaryLED.setPixelColor(position, 0, 0, 0);
    capillaryLED.show();
    position++;
    time = 0;
    red = LED_NUMBER;
    blue = 0;
  }
  else{
    position = 0;
  }
}
}
```

Conclusions/action items:

This code works for the teensy microcontroller, to change for the arduino uno, only the pin number for the neopixels will need to be changed. This also only allows for one ratio and further code will need to be created for more ratios.



2020/09/09 - Dead Space in Lungs

KAITLIN LACY - Sep 09, 2020, 12:40 PM CDT

Title: Lung Dead Space

Date: 9/9/2020

Content by: Kaitlin Lacy

Goals: Learn more about dead space in the lungs as it was mentioned in the description of our projects with medical students sometimes struggling to understand how high V/Q ratios lead to dead space ventilation.

Content:

-Dead space is the volume of air involved in ventilation that does not directly engage in gas exchange.

Anatomic dead space: air volume in the nose, trachea, and bronchi (conducting zone); 30% of normal tidal volume; approximately 150 mL

Physiologic/total dead space: sum of anatomic and alveolar dead space; volume in respiratory zone not involved in gas exchange (respiratory bronchioles, alveolar duct, alveolar sac, alveoli; negligible in healthy adults)

Ventilation: process in which air enters the lungs

Minute ventilation (VE) = tidal volume (VT) * respiratory rate (RR)

Alveolar ventilation (VA) = (VT - physiologic dead space (VD)) * RR

$VD = VT * [(PaCO_2 - PeCO_2) / PaCO_2]$

Amount of dead space increases when the alveoli have lost some functioning, decreased cardiac output, hypotension, pulmonary embolism, vasoconstriction

-increased by emphysema, pneumonia, acute respiratory distress syndrome

Conclusions/action items:

Dead space is a critical idea to this model, and these equations may be helpful for modeling ventilation in the lungs.

Work with the client to determine how dead space will be modeled in the device and the importance of it in the model.

S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.



2020/09/09 - Ventilation and Perfusion Overview

KAITLIN LACY - Sep 09, 2020, 1:09 PM CDT

Title: Ventilation and Perfusion Overview

Date: 09/09/2020

Content by: Kaitlin Lacy

Goals: Review the concepts of Ventilation and Perfusion in order to have an informed discussion with our client.

Content:

Gas exchange occurs between alveolar air and blood of pulmonary capillaries; alveoli must be ventilated and perfused adequately; in respiratory zone of the lungs (respiratory bronchioles, alveolar ducts, alveolar sacs, alveoli)

-alveoli are opened and closed by alveolar cusps which are smooth muscle projections

-operates through diffusion

-increases as surface area increases, alveolar pressure difference increases, solubility of gas increases, membrane thickness decreases

Alveolar septa separate adjacent alveoli, and these septum have capillaries and thin walls to permit gas exchange

DPPT surfactant lowers the alveolar surface tension

V/Q ratio measures matching of ventilation to perfusion

-varies within regions of the lung (ventilation greater at the base of lung than the apex due to gravity pulling blood down and the weight of the fluid in pleural cavity increases intrapleural pressure to a less negative value)

-high V/Q results in increased PO₂ and decreased PCO₂ (alveolar air matches the larger volume of air more than perfused blood)

Bronchial circulation drains into the pulmonary vein; PaO₂ drops slightly from 100 mmHg to 95 mmHg in this vein

Conclusions/action items:

Ventilation varies depending on the part of the lung, so inquire about whether this device needs to mimic a specific area of the lung, the lung as a whole, or just specific V/Q ratios set by the user.

K. A. Powers and A. S. Dhamoon, "Physiology, Pulmonary, Ventilation and Perfusion." Jan-2020.



2020/09/17 - Teaching Ventilation/Perfusion Relationships

KAITLIN LACY - Sep 18, 2020, 9:56 AM CDT

Title: Teaching Ventilation/Perfusion Relationships in the Lung

Date: 9/17/2020

Content by: Kaitlin Lacy

Goals: Learn more about how medical school professors teach this concept in order to get a better idea of how our model can fit into their teaching.

Content:

-bathtub analogy: level of water represents level of O₂ in alveolus (P_AO₂), ventilation is like water pouring into the tub, O₂ leaving through blood flow is like water leaving the tub like a drain

-level of Co₂ has inverse relationship

-high V/Q ratio will produce increased P_AO₂ and decreased alveolar PCO₂, low V/Q will decrease PAO₂ and increase PCO₂

Oxygen consumption = Ventilation(fraction of inspired oxygen*fraction of alveolar O₂)

PAO₂=inspired PO₂ - (VO₂/VA)(barometric pressure-47mmHg)

PACO₂ low when V/Q is high and vice versa (marker of hypoventilation)

Decrease in the inspired O₂ (like high altitude) will lead to hypoxemia unless minute ventilation increases (Fraction of inspired oxygen does not change with altitude) (from decreasing barometric pressure)

-shunt is where V/Q=0 and dead space is where V/Q = infinity

-students must understand gas partial pressures, contents of blood, and shape of hemoglobin dissociation curve

Heterogeneity of V/Q Distributions:

-should not be difference between PO₂ in postveolar capillaries and PaO₂

-low V/Q regions will cause PO₂ to be lower in the capillary arterial blood than average alveolar value

-alveolar to arterial difference = delta(A-aO₂), widened with V/Q mismatch

-hypoventilation and low pressure of inspired oxygen have normal difference

-shunt is fourth cause of hypoxemia

-fraction of shunt = $Q_s/Q_t = (C_{cO_2} - C_{aO_2}) / (C_{cO_2} - C_{vO_2})$

-different than low V/Q as its hypoxemia does not improve with increased P_IO₂ as shunted blood does not come in contact with alveoli

-clinical example of diagnosing a narcotic overdose (normal delta(A-aO₂)) versus asthma (widened delta(A-aO₂))

Conclusions/action items:

The equations presented in this article will most likely be very useful in designing the model in order to create an accurate representation of V/Q ratios. This is a challenging concept and the reading raised several questions for me. Meeting with the client to ask questions about this article would help to really solidify the idea of V/Q mismatching.

Glenny, R., 2008. Teaching ventilation/perfusion relationships in the lung. *Advances in Physiology Education*, 32(3), pp.192-195.



09/17/2020 - Hemoglobin Dissociation Curve

KAITLIN LACY - Sep 18, 2020, 10:10 AM CDT

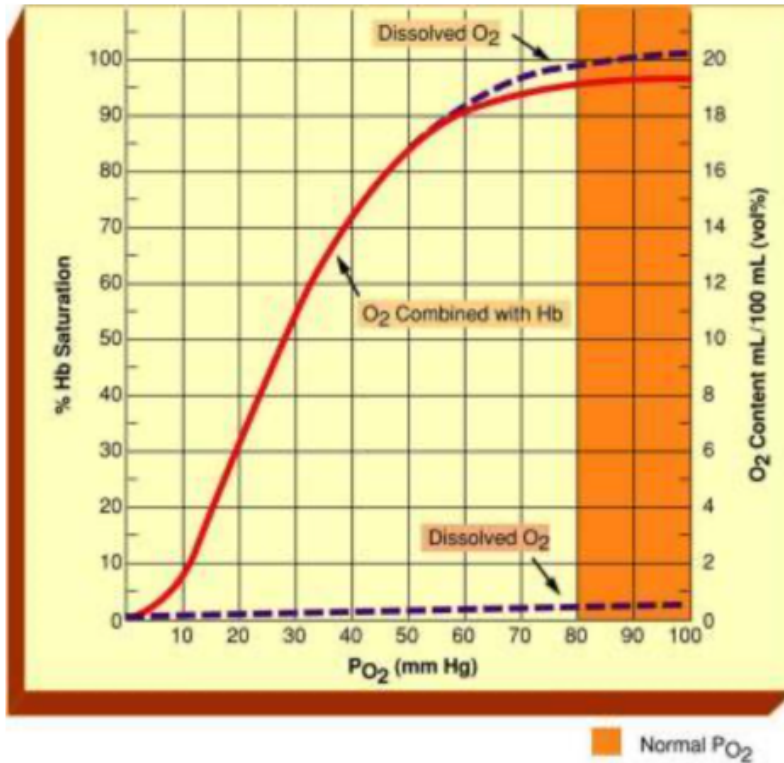
Title: Kaitlin Lacy

Date: 09/17/2020

Content by: Kaitlin Lacy

Goals: Remember the important parts of the hemoglobin dissociation curve as it was referenced in previous articles

Content:



The partial pressure of oxygen can decrease from 100 to 60 mmHg and hemoglobin will remain about 90% saturated with oxygen. However, decreasing below 60 mmHg causes a rapid decrease in amount of O₂ bound to hemoglobin. Physiologically this is important to allow proper oxygenation of the tissues. Once the blood reaches areas with lower partial pressures of oxygen, this indicates an area in need of oxygen, and the hemoglobin lets go of the oxygen rather easily.

Conclusions/action items:

Knowing some of the values from the figure above will be useful in creating an accurate representation of the transfer of oxygen from the alveoli to the blood.

Oxygen Dissociation Curve, 2010. [Online]. Available:

https://media.lanec.edu/users/driscolln/RT127/Softchalk/Oxygen_transport_softchalk/Oxygen_Transport_Lesson4.html. [Accessed: 17-Sep-2020].



Measuring Brightness Using ImageJ

KAITLIN LACY - Dec 08, 2020, 4:59 PM CST

Title: Measuring Intensity Using ImageJ

Date: 11/28/2020

Content by: Kaitlin Lacy

Goals: Learn about how to measure intensity using ImageJ in order to analyze the images obtained from testing.

Content:

Hovering the cursor over any pixel in the image will give the intensity of the Red, Green, and Blue colors at that point. However, to get the average intensity over a defined area, this area must be enclosed as a Region of Interest (ROI) using one of the drawing tools. Or, a threshold can be set to a certain level, and then the average intensity will be pulled from those areas.

During the actual analysis, I ran into issues with getting inconsistent numbers compared to the trend we were expecting. Playing around with the threshold areas as suggested in this source showed that the LEDs themselves were the areas of maximum intensity. However, I realized that all of the minimum and maximum were very close, and thus the measurement was greatly impacted by the accuracy of which I drew the ROI. I then expanded the ROI to the indentations in the base model as this would allow me to more consistently highlight the same area for analysis.

Conclusions/action items:

Continue researching the best way to complete these measurements. Research how these measurements compare to the perception of the human eye.

C. Labno, "Basic Intensity Quantification with ImageJ," *Bioimaging at Universite de Geneve*. [Online]. Available: <https://www.unige.ch/medecine/bioimaging/files/1914/1208/6000/Quantification.pdf>. [Accessed: 29-Nov-2020].



2020/09/18 - Beads and Water Pump

KAITLIN LACY - Sep 18, 2020, 9:51 AM CDT

Title: Bead Idea

Date: 9/18/2020

Content by: Kaitlin Lacy

Goals: Brainstorm new ideas for representing V/Q mismatch

Content:

Originally, our client shared West's proposed model for representing V/Q mismatch which utilized dye and water. The color of the water leaving the lung would show the oxygenation of the blood. However, he thought the dye and water would be too messy and require too much effort on the part of the lecturer to set up and reset in between showing the different magnitudes of mismatch. One way to resolve some of these problems would be to use colored beads instead of dye. If there was some way to cycle the beads and water back through to be reused, there would be no need for reservoirs to collect the water and would eliminate some of the mess. Some other material other than beads could be used as well. I'm thinking of something like a lava lamp where the color remains separate from the water (as opposed to dye) and does not need to be reloaded like water and dye would. If there would be some way to utilize that process, the idea of using water (or another liquid) would not need to be abandoned like the dye idea.

Conclusions/action items:

Since our client already has thought of several reasons for abandoning the water/dye model since he proposed the device, it would need to be modified in order to be viable. Cycling the water repeatedly through the model and using beads could be a way to prevent issues related to reloading and mess that the pump model had. Discuss this model with the group at the next meeting when we discuss ideas for design matrix.



2020/09/30 - Updated Beads Design

KAITLIN LACY - Oct 07, 2020, 12:27 PM CDT

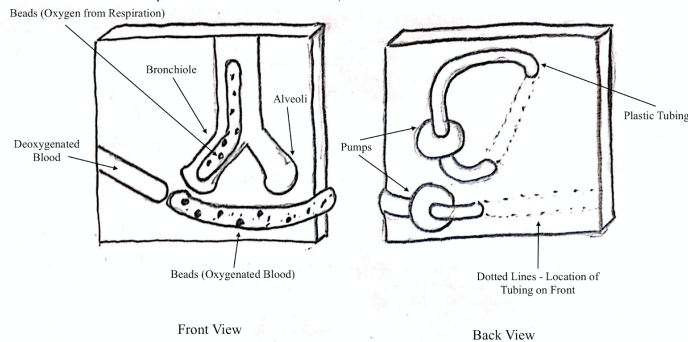
Title: Updated Beads Design

Date: 9/30/2020

Content by: Kaitlin Lacy

Goals: Fill in the details about how exactly the beads design will work and come up with a sketch of the design.

Content:



Water pumps are used to simulate the flow of air and blood while circulating beads show the oxygenation of the blood and the flow of air in the lungs. The circulation of these beads can be controlled through pinching the tubes at the back of the device. However, this would require more effort on the part of the user, and would not be as ideal as some of the other designs. This device could be designed to be more interactive where the ventilation and perfusion rates are adjusted and the V/Q ratio is displayed somehow.

Conclusions/action items:

Discuss this design in the preliminary presentation, and adjust the design as necessary. Discuss with team to decide whether or not this device could be made more user friendly.



2020/11/18 - Coverings for Alveolus Lights

Title: Coverings for Alveolus Lights

Date: 11/18/2020

Content by: Kaitlin Lacy

Goals: Brainstorm coverings and materials to diffuse the alveolar LED lights

Content:

A silicone covering like the one already integrated on the strip of LEDs could work to diffuse the light. Possibly something like the one found here:

https://www.grainger.com/product/56GT73?gclid=Cj0KCQiA5bz-BRD-ARIsABjT4nhHHyfJi21hL6UI2axS3hmESAbXS9h_M40hVYu1TuagdsbuAMKvM-YaAsCGEALw_wcB&cm_mmc=PPC:+GYaAsCGEALw_wcB:G:s&s_kwcid=AL!2966!3!281698275774!!!g!471564520201!&gclid=N:N:PS:Paid:GGL:CSM-2295:4P7A1P:20501231

Or:

https://www.amazon.com/500x500mm-Thicknes-Silicone-Transparent-Resistant/dp/B07HQVR92Y/ref=sr_1_1_sspa?dchild=1&keywords=silicone+sheet+translucent&qid=1607466490&sr=8-1&spons&pssc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExWU1QSE9aWFI4WENlJmVuY3J5cHRlZElkPUEwMTI5MDMzMINSV0FMWWTNGNkxaWSZlbnNyeXB0ZWRRBZEikPUEwMTk0MDg

Would need to be translucent to hide the LED but allow the light to shine through and white to not interfere with any of the colors.

Potentially, we could use a shrink film material laid on top as this would be similar to the silicone:

https://www.amazon.com/Grafix-Shrink-Film-Matte-Sheets/dp/B002J8VN0W/ref=sr_1_4?dchild=1&keywords=shrinky+dink+paper&qid=1607466585&sr=8-4

If we wanted more of a domed material, we could find a bouncy ball or other circular object with translucent material, and we could cut it in half and hollow it out to place on top.

Conclusions/action items:

Continue searching for materials like this. I may have some at home that I could bring for testing purposes. We could also check the room with all of the old materials for ideas and to try things



2020/11/20 - Code for Oxygen Entering Alveolus

KAITLIN LACY - Nov 20, 2020, 1:22 PM CST

Title: Code for Oxygen Entering Alveolus

Date: 11/20/2020

Content by: Kaitlin Lacy

Goals: Record work on code

Content:

```
#include <Adafruit_NeoPixel.h>
#include <elapsedMillis.h>

//Number of LEDS in my strip
int LED_NUMBER = 12;
//I use elapsedMillis rather than delay
elapsedMillis time;
elapsedMillis time1;
//Starting position for the "off" LED
int position = 0;
//Red will begin at the end of the strip
int green = LED_NUMBER;
//Blue will begin at the beginning of the strip
int blue = 0;
int yellow = 0;

//Initiating Neopixels
Adafruit_NeoPixel capillaryLED(LED_NUMBER, 9, NEO_GRB + NEO_KHZ800);

void setup(){
  capillaryLED.begin();

  //This will turn on every LED with the correct shade/color
  //for(int i = 0; i < LED_NUMBER; i++){
    //Total = 12 = Red + blue

    //capillaryLED.setPixelColor(i, yellow, green, 0);
    //capillaryLED.show();
    //red--;
    //green--;
    //blue++;
    //yellow++;

  //red = LED_NUMBER;
  //blue = 0;
}
int i=0;
int endposition = LED_NUMBER;
void loop() {
  //Sets time for the off LED
  if (time > 100){
    //If it reaches end of the LED strip, it will start over from the beginning
    while ( i < (LED_NUMBER/2)){
      capillaryLED.setPixelColor(i,yellow,green,0);
      capillaryLED.setPixelColor(endposition, yellow, green, 0);
      if (time1 > 100){
        capillaryLED.show();
      }
    }
  }
}
```

```
    i++;  
    endposition--;  
    time1=0;  
  }  
}  
}
```

Conclusions/action items:

Add to code to show movement of oxygen out of alveolus. Work on making the whole process repeat, and then apply this to the five different ratios.



2020/11/22 - Improved Code for Alveolus

KAITLIN LACY - Dec 08, 2020, 5:08 PM CST

Title: Improved Code for Alveolus LEDs

Date: 11/22/2020

Content by: Kaitlin Lacy

Goals: Write code that shows movement of oxygen in and out of the alveolus of the design.

Content:

```
#include <Adafruit_NeoPixel.h>
#include <elapsedMillis.h>

//Number of LEDS in my strip
int LED_NUMBER = 12;
elapsedMillis time;
elapsedMillis time1;

//Starting position for the "off" LED
int position = 0;
int green = LED_NUMBER;
int blue = 0;
int yellow = 0;
int j = LED_NUMBER/2;
int k = 0;
int endpositionoff = LED_NUMBER/2;
int i=0;
int endposition = LED_NUMBER;
int time_delay = 250;
int brightness = 255;
int dim = 100;
//Initiating Neopixels
Adafruit_NeoPixel capillaryLED(LED_NUMBER, 9, NEO_GRB + NEO_KHZ800);

void setup(){
  capillaryLED.begin();
  Serial.begin(9600);
}

void loop() {
  //Sets time for the off LED
  while (time>100){
    if (k==0){ // Turns LEDs on
      while ( i <= (LED_NUMBER/2)){
        capillaryLED.setPixelColor(i,yellow,green=brightness,0);
        capillaryLED.setPixelColor(endposition, 0, green=10, 0);
        if (time1 > 100){
          capillaryLED.show();
          i++;
          endposition--;
          time1=0;
          delay(time_delay);
        }
        if (i == (LED_NUMBER/2)+1){ //The +1 allows the bottom light to turn on otherwise it entered this if statement too early
          k=1;
          i++; // for some reason its entering this loop twice so I'm trying this to stop that
        }
      }
    }
  }
}
```

```

    }
  }
}

for (int x=0; x<=LED_NUMBER; x++){ // dimming all of the lights to show that oxygen has diffused out of the alveolus and slightly changing the
color
  capillaryLED.setPixelColor(x,yellow=dim,green=dim+2,0);
  capillaryLED.show();
}
delay(1000); // Pause before turning off lights
if (k==1){ // Turns LEDs off

  while ( j >= 1){
    //capillaryLED.clear();
    capillaryLED.setPixelColor(j,0,0,0);
    capillaryLED.setPixelColor(endpositionoff, 0, 0, 0);
    if (time1 > 100){
      capillaryLED.show();
      j--;
      endpositionoff++;
      time1=0;
      delay(time_delay);
    }
    if (j==0){
      k=0;
    }
  }
}

}

// Resets variables
i=0;
j = LED_NUMBER/2;
endpositionoff = LED_NUMBER/2;
endposition = LED_NUMBER;
delay(1000); // Pause before turning lights back on
}
}

```

Conclusions/action items:

This code sets the color of the alveolus, and turns the LEDs on from both sides from top to bottom. The LEDs then dim and turn a yellow-green to show the diffusion of oxygen out of the alveolus. Then, the lights turn off from bottom to top on sequentially on each side.

Future work for this includes testing the code with the capillary LEDs plugged into the same Arduino to make sure that the Arduino can run both at the same time. The buttons need to be selected and integrated into the code. I also need to add more comments explaining how each section of the code works.



2020/09/10 - Ventilation/Perfusion

ZOE SCHMANSKI - Oct 06, 2020, 7:56 PM CDT

Title: Ventilation/Perfusion Ratio Matching

Date: 9/10/2020

Content by: Zoe

Present: n/a

Goals: Further my understanding of V/Q ratios and what happens when they vary

Content:

V - Ventilation, air we breath in

- oxygen goes into the alveoli
 - small sacs at the end of the bronchioles (smallest air tubes)
- carbon dioxide exits

Q - perfusion, blood flow

- deoxygenated blood from your heart goes to the pulmonary capillaries (tiny blood vessels)
- oxygen is absorbed
 - through the alveoli
- carbon dioxide exits your blood
 - through the alveoli

V/Q ratio

- amount of air that reaches your alveoli divided by the amount of blood flow in the capillaries in your lungs
- 4 liters of air
- 5 liters of blood
- Anything other than a 1:1 ratio is a mismatch

Normal --> 1:1 ratio

Measuring V/Q.

- using test called pulmonary ventilation/perfusion scan
- involves a series of two scans
 1. measure how air flows through the lungs
 2. show where blood is flowing in your lungs
- involves an injection of radioactive substance that gathers in areas of abnormal airflow and blood flow
 - images taken in scanner to show these areas

Notation

\dot{V}_A/\dot{Q} with the "A" as a subscript.

V dot is measured in liter per minute and Q dot in liters per minute.

The "A" signifies alveolar.

So Vdot subscript A is alveolar ventilation in L/min. Obviously one could use mL/sec the point is that both are flows.

Treatment

- oxygen therapy
- oral steroids
- antibiotics
- pulmonary rehabilitation
- blood thinners
- surgery

Conclusions/action items:

Consider when developing designs for the teaching model.

<https://www.healthline.com/health/v-q-mismatch#what-it-means>



2020/09/10 - V/Q Mismatching

ZOE SCHMANSKI - Oct 06, 2020, 7:56 PM CDT

Title: V/Q ratio mismatching

Date: 09/10/2020

Content by: Zoe

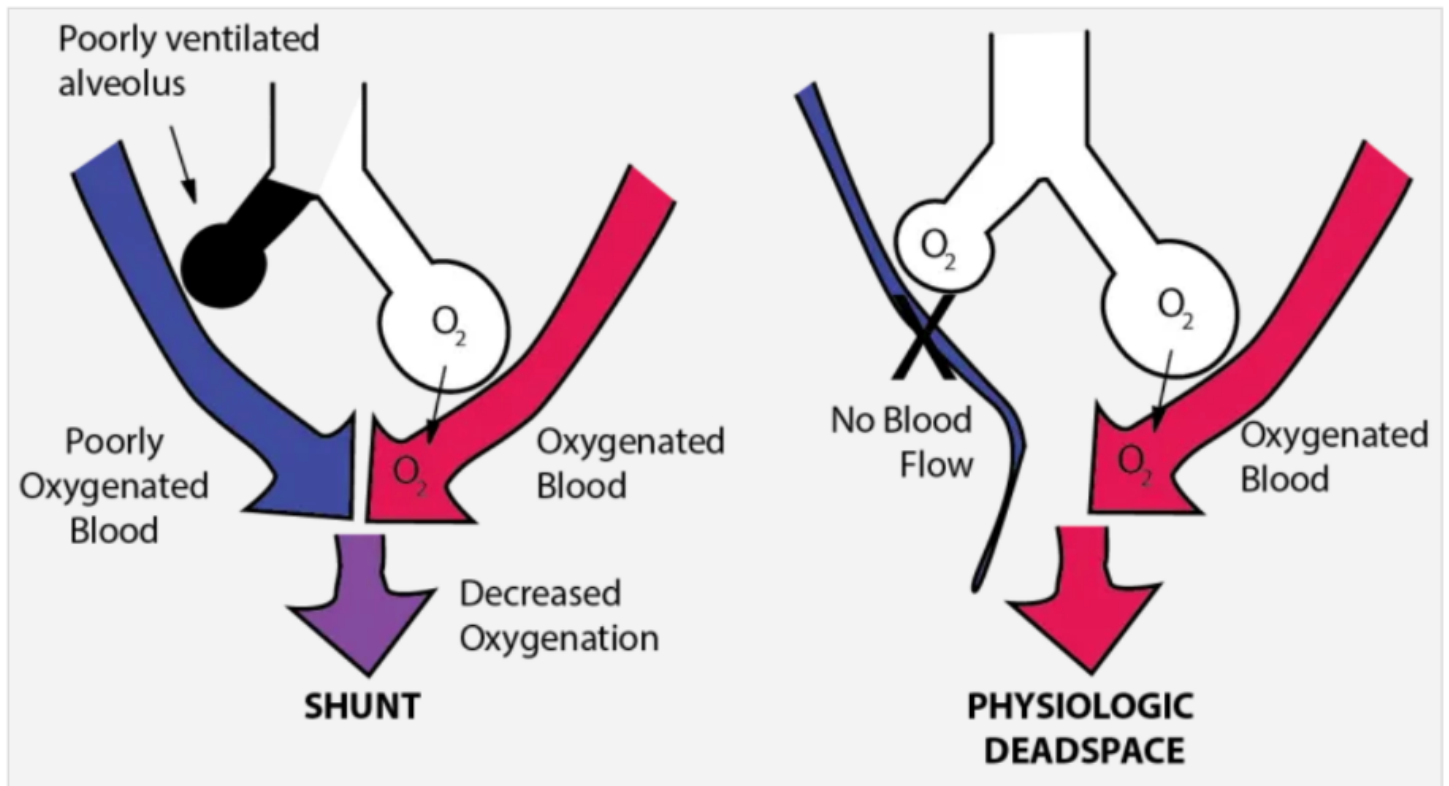
Present: n/a

Goals: Understand the outcomes of different V/Q ratio mismatches

Content:

Any V/Q ratio that differs from 1:1 is a mismatch

1. High V/Q ratio (> 1)
 - low blood oxygen level
 - dead space ventilation
 - ventilation of poorly perfused alveoli
 - alveoli are ventilated, but not perfused
 - hyperventilation
 - blood clot, no gas exchange taking place into blood
 - pulmonary embolism
2. Low V/Q ratio (< 1)
 - decreased oxygenation of blood
 - due to poorly ventilated alveoli
 - blood doesn't pick up enough oxygen
 - this poorly oxygenated blood mixes with other blood at the heart and lowers the blood oxygen level
 - causes hypoxemia
 - Shunting
 - perfusion of poorly ventilated alveoli
 - alveoli are perfused, but not ventilated



V/Q Mismatch Causes

- Chronic Obstructive Pulmonary Disease (COPD)
 - obstructs airflow in your lungs

- emphysema
- chronic bronchitis
- Asthma
- Pneumonia
 - lung infection
- Pulmonary edema
 - lung congestion
- pulmonary embolism
 - blood clot in lungs

Conclusions/action items:

Consider when developing designs for the teaching model.

<https://airwayjedi.com/2017/01/06/ventilation-perfusion-mismatch/>



Title: Teaching Ventilation/Perfusion in the Lungs

Date: 9/12/2020

Content by: Zoe

Present: n/a

Goals: Published work sent to us by Dr. Green used for teaching topic in medical school to better understand ventilation/perfusion

Content:

Concept

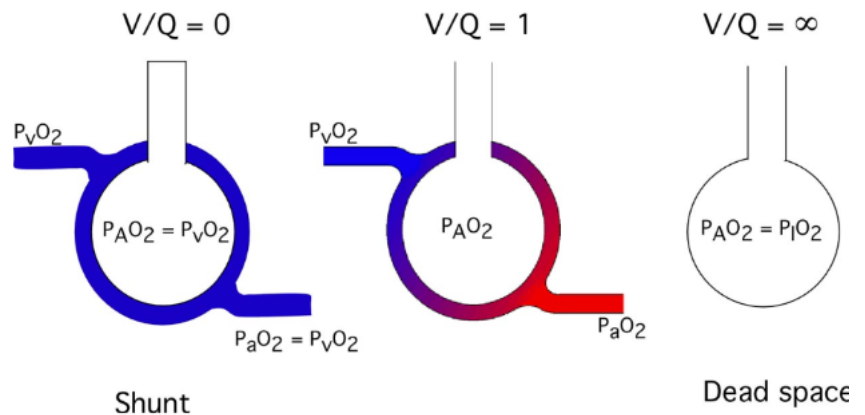
- one of the hardest topics for medical students to understand
- key building blocks for understanding pathophysiology in the lung
- hypoventilation - low V/Q
 - increased P_aCO_2
 - decreased P_aO_2
- hyperventilation - high V/Q
 - increased P_aO_2
 - decreased P_aCO_2
- lung is more complicated than the simplified model of the alveolus to blood exchange
 - asymmetries in the airway
 - vascular geometries
 - differences in ventilation/perfusion between the top and bottom of the lung

hypoxemia - P_aO_2 less than normal for subject's age, 5 causes

1. Low P_iO_2 if not enough compensatory ventilation
2. Decrease in V_a (hypoventilation)

** V/Q mismatches contribute to gas exchange inefficiencies, but only low V/Q ratios cause hypoxemia

Fig. 5. Three different lung regions with ventilation-to-perfusion ratios (V/Q ratios) of 0 (left), 1 (middle), and ∞ (right). The expected P_{O_2} s are shown for each region. $P_{V_{O_2}}$, venous P_{O_2} .



Equations

P_aO_2 - alveolar O_2

P_iO_2 - inspired oxygen

P_b - barometric pressure

V_a - ventilation

Notation

V_A/Q with the "A" as a subscript.

V dot is measured in liter per minute and Q dot in liters per minute.

The "A" signifies alveolar.

So V dot subscript A is alveolar ventilation in L/min. Obviously one could use mL/sec. the point is that both are flows.

Teaching keys

1. build from simple to complex
2. use simplified analogies to allow students to visualize the relationship between regional ventilation and perfusion
3. integrate the concepts of alveolar-arterial O_2 differences



2020/12/01 - Relation of Brightness and Intensity

ZOE SCHMANSKI - Dec 01, 2020, 3:27 PM CST

Title: Relation of Brightness and Intensity

Date: 12/1/2020

Content by: Zoe

Present: n/a

Goals: Understand the human capabilities of perceiving brightness and intensity for the LED portion of the teaching model

Content:

Brightness grows as a power function of luminance

Light adaptation reduces the brightness of a given luminance

The enhancement of brightness is at about 50 msec (Broca-Sulzer effect)

The maximum enhancement shifts to a lower duration as the intensity is increased

Below about 10msec in the dark adapted eye the product of duration and intensity is constant for a given brightness (Bloch's law)

The maximum intensity at durations between 162 to 35 msec as the intensity was raised by about 10 dB

Increase by a factor of 10 lux = increase by factor of 10 db illuminance (<https://www.translatorscafe.com/unit-converter/en/illumination/?redir=teaser>)

Conclusions/action items:

Journal (from Prof R. in ISyE) - Relation of brightness to duration and luminance under light and dark adaptation

ZOE SCHMANSKI - Dec 01, 2020, 3:28 PM CST

Reference: Vukobratovic, D. (1971). The perception of light and color.

RELATION OF BRIGHTNESS TO DURATION AND LUMINANCE UNDER LIGHT- AND DARK-ADAPTATION

J. S. ABBAS and A. S. STAVANS
Laboratory of Psychophysics, Harvard University, Cambridge, Massachusetts
Original Article (1961)

Abstract—These experiments determined how the brightness of a brief flash grows with duration and intensity under light- and dark-adaptation. Observers viewed electronic flashes of a color similar to that of natural daylight over a wide range of intensities. They also noted the change in brightness of the flash with time. The resulting data show that the brightness grows as a power function of the flash intensity. The maximum intensity at a given duration is lower under light than under dark adaptation. Below about 10 msec in the dark-adapted eye the product of duration and intensity is constant for a given brightness (Bloch's law). The maximum enhancement of brightness is at about 50 msec and shifts to a lower duration as the intensity is increased. The present study sought to determine experimentally how brightness depends upon duration and luminance when the eyes are dark-adapted and light-adapted. Observers noted the luminance of a flash in one eye to make it appear equal in brightness to a flash of a different duration that had been presented to the other eye.

APPARATUS AND PROCEDURE

The apparatus was a modification of that used by SPRACKMAN (1960). It consisted of an electronic system that controlled the sequence and the flash duration of two "glow modulators", each in a separate optical system.

Light sources. The glow modulator (Sylvania type R113C) has a small hollow cathode which, when the tube is activated, appears as a fairly uniform disk of light about 2.5 mm in diameter. A current of 25 mA produces a luminance of about 111 cd/m² or 10⁻⁴ L. (The decibel reference level, close to the absolute threshold, will be used to express all except

1-s2.0-0042698964900112-main.pdf(824.1 KB) - download



2020/09/10 - John West Pedagogic Model

ZOE SCHMANSKI - Sep 10, 2020, 11:02 AM CDT

Title: Pedagogic Model by John West

Date: 09/10/2020

Content by: Zoe

Present: n/a

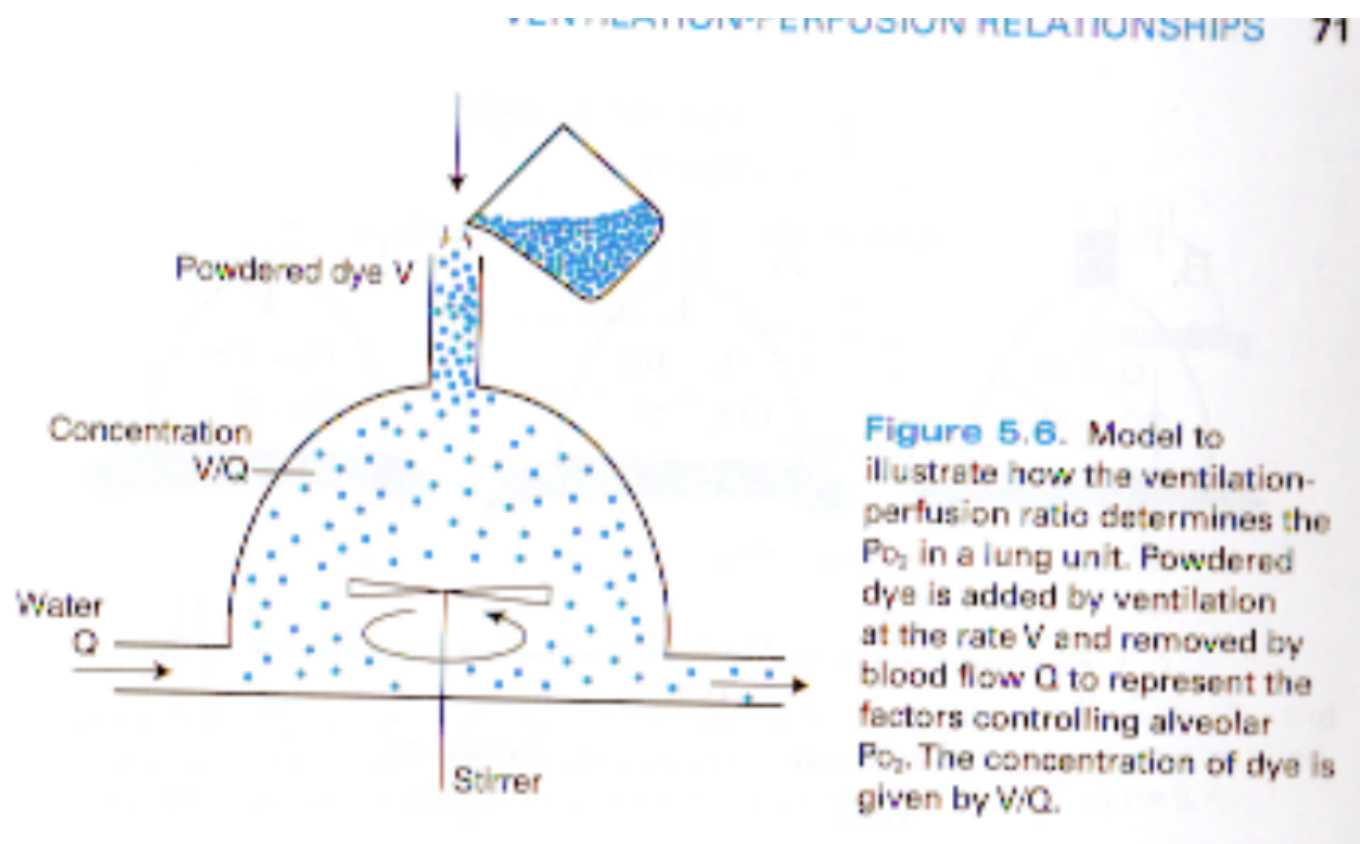
Goals: Learn about the teaching model created by John West published in the textbook *Respiratory Physiology*

Content:

Dye is used to represent the oxygen levels in the alveoli and blood during exchange

Dye is added at the rate of oxygenation to show concentration in water

The concentration of the dye in water(blood) is the V/Q ratio



Conclusions/action items:

West, John. *Respiratory Physiology: The Essentials*. 9th Edition. 2012



2020/09/24 - Design 1 with LEDs

ZOE SCHMANSKI - Oct 06, 2020, 7:57 PM CDT

Title: Design 1: V/Q model with LEDs

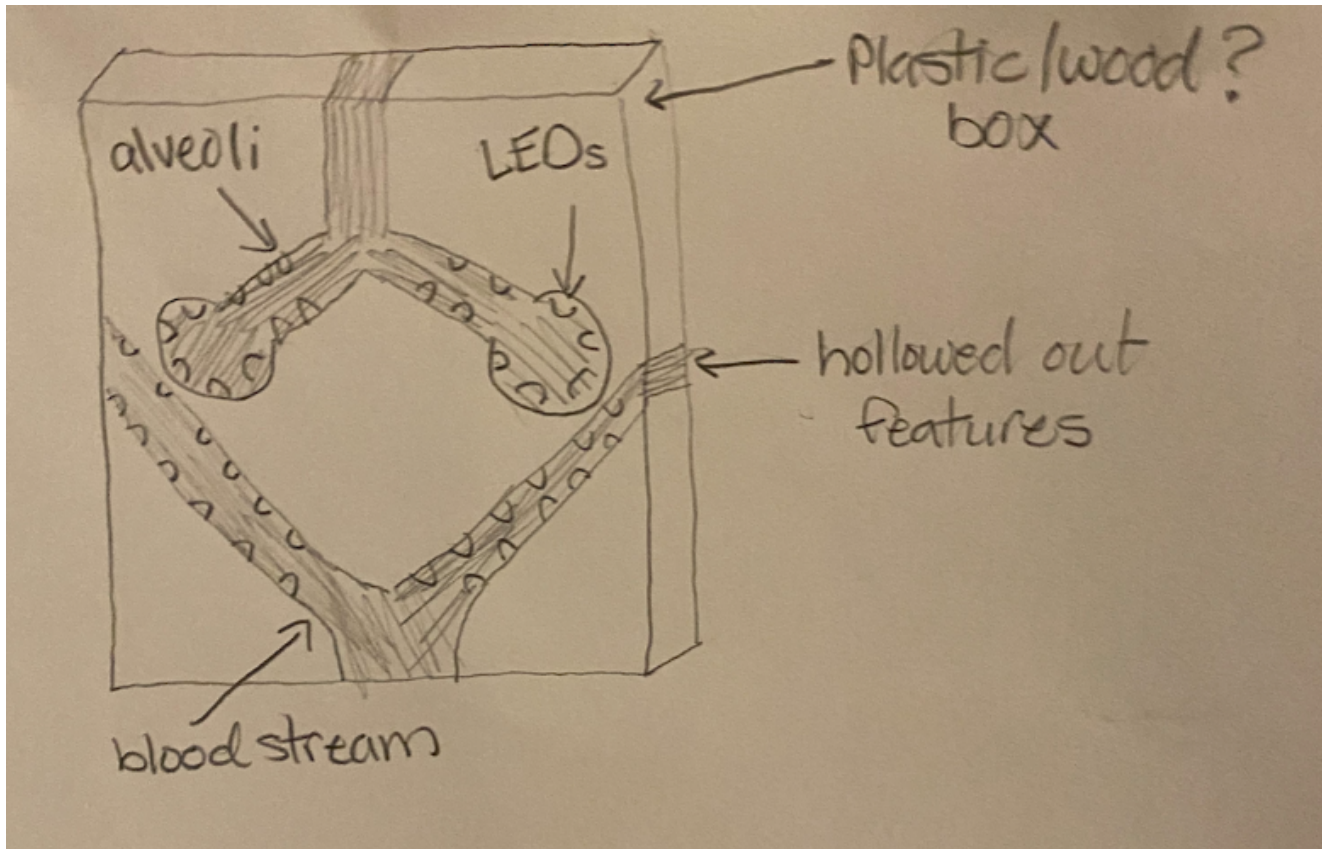
Date: 9/24/2020

Content by: Zoe

Present: n/a

Goals: Provide sketches of initial design idea

Content:



Conclusions/action items:

Bring to team meeting as an initial design idea.



2020/10/04 - Light Diffusing Plastics

ZOE SCHMANSKI - Oct 04, 2020, 7:30 PM CDT

Title: Light Diffusing Plastics

Date: 10/4/2020

Content by: Zoe

Present: n/a

Goals: Research on possible plastics to use for the base model

Content:

LEDs can be difficult because they create "hot spots" of focused light that distract from the visual appeal

Solutions

- special grades of acrylic sheet, polycarbonate sheet and polycarbonate film engineered to diffuse hot spots of light

Acrylic

- superior optical properties
- highest light transmission

Polycarbonate

- tougher/ more durable material
- high temperature resistance
- can be cold formed

Conclusions/action items:

We can use these ideas for possible materials for the base model.

[https://www.curbellplastics.com/Research-Solutions/Industry-](https://www.curbellplastics.com/Research-Solutions/Industry-Solutions/Markets/Lighting#:~:text=Which%20plastics%20are%20the%20best,excellent%20LED%20light%20diffusing%20characteristics.)

[Solutions/Markets/Lighting#:~:text=Which%20plastics%20are%20the%20best,excellent%20LED%20light%20diffusing%20characteristics.](https://www.curbellplastics.com/Research-Solutions/Industry-Solutions/Markets/Lighting#:~:text=Which%20plastics%20are%20the%20best,excellent%20LED%20light%20diffusing%20characteristics.)



2020/10/06 - Types of LED Diffusers

ZOE SCHMANSKI - Oct 06, 2020, 7:54 PM CDT

Title: Different Types of LED Diffusers

Date: 10/06/2020

Content by: Zoe

Present: n/a

Goals: Document different types of LED diffusers for possible use in the model

Content:

Solutions

- UV stabilized polycarbonate **diffusers**.
- Tempered glass **diffusers**.
- PMMA optical **diffusers**.
- 3D three-sided **diffusers**.
- Anti-glare **diffusers**.
- Transparent **diffusers** (DT)
- Opaque **diffusers** (DO)
- Satin **diffusers** (DS)

Purpose of Using Diffusers

- Eliminates invisible hot spots
- Very good light-scattering
- Applicable in very flat, homogeneously illuminated light elements
- Diffusion breaks straight beams of light from the source, scattering them in different directions and producing a glow, rather than a sharp beam, which is soothing to the eyes.
- Diffusers mimic the soft natural light from the sun (diffused naturally by clouds and the atmosphere), eliminate harsh shadows, offer larger expanses of continuous illumination, and improve aesthetics and occupant comfort.

Applications for LED Diffusers

- Lenses
- Buttons
- Switches
- Knobs
- LED backlit signage
- Channel lettering
- Architectural accent lighting
- LED light bulb lenses

Good website: <https://www.electronicshobby.com/important-sectors/leds-led-lighting/led-diffusers-look/>

Conclusions/action items:

Consider these options when deciding what LEDs and diffusers to order for the model.



2020/10/08 - Flow Design

ZOE SCHMANSKI - Oct 09, 2020, 1:51 PM CDT

Title: Flow final model

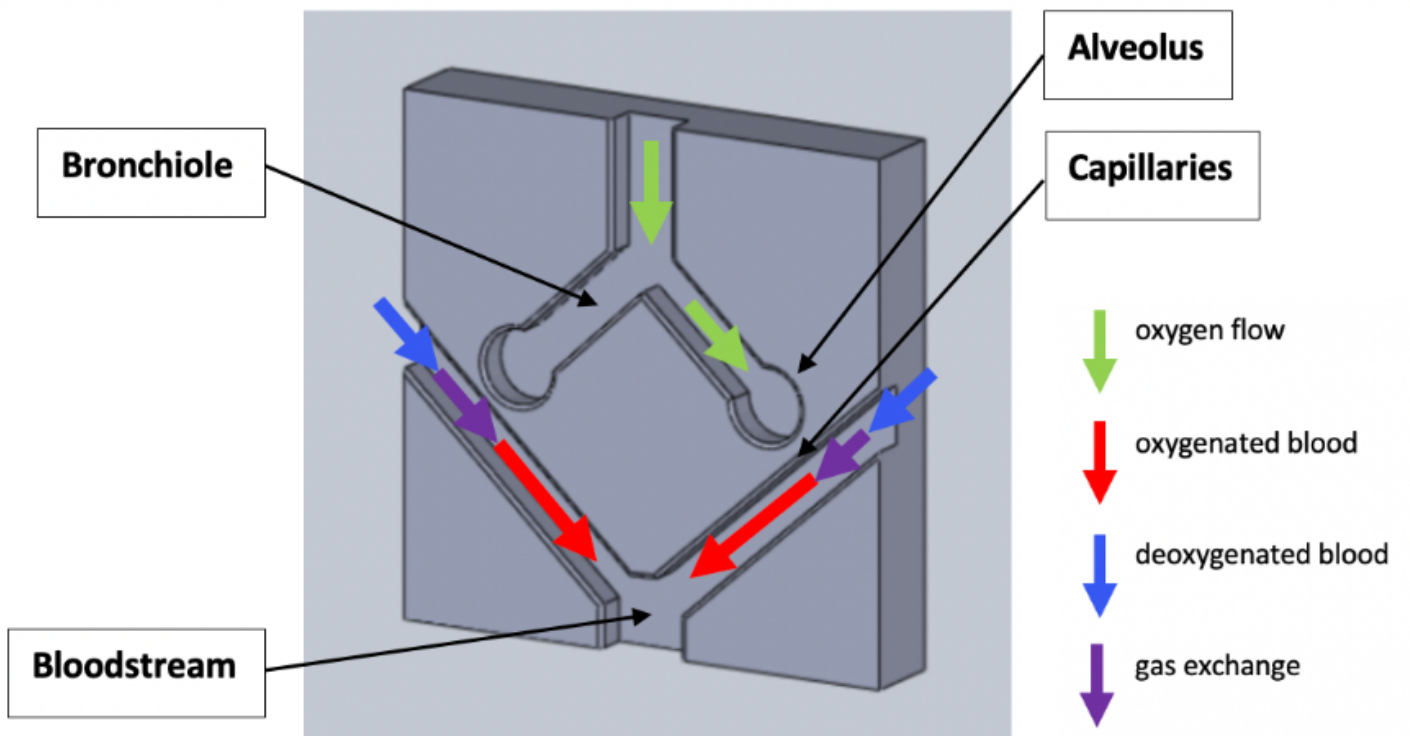
Date: 10/8/2020

Content by: Zoe

Present: n/a

Goals: Document design with oxygen flow representation

Content:



Conclusions/action items:

Use as a basis to refer to when fabricating.



2020/10/14 - Materials list

Title: Initial materials list

Date: 10/14/2020

Content by: Zoe

Present: n/a

Goals: Document main materials needed for the first order

Content:

LEDs

- silicon clips for LED strip (<https://www.adafruit.com/product/1644>)
- RGB LED strip (<https://www.adafruit.com/product/2842?length=1>)
- RGB LED strip diffused in tube (<https://www.adafruit.com/product/4245>)
- RGB LED ring for alveoli (<https://www.adafruit.com/product/1643>)



Microcontroller

- Arduino (for now, already have multiple)
- Code

Base

- styrofoam to model idea and use for experimenting with LEDs

(https://www.amazon.com/Silverlake-Craft-Foam-Block-Arrangements/dp/B082C51Z6W/ref=sr_1_19_sspa?dchild=1&keywords=styrofoam+12x12&qid=1602690333&sr=8-19-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlnaWVvYyUwPjZTErjBLSTFGMkcmZW5jcnlwdGVkSWQ9QTA1Njg1MjQxTDJmVWkxVERKSDNBmVUy3J5cHRIZEFkSWQ9QTAwNjk4OTkyS1I)

Conclusions/action items:

Meet with client to discuss ordering of materials.



2020/11/03 - Dials and Buttons

ZOE SCHMANSKI - Nov 03, 2020, 3:30 PM CST

Title: Possible Dials and Buttons

Date: 11/3/2020

Content by: Zoe

Present: n/a

Goals: Look into possible buttons or dials to be used to control the ratios represented by the device

Content:

Button

- implement a separate button for each ratio
- push the button for the desired ratio
- could also implement a power button for the model



https://www.amazon.com/outstanding-Button-Switch-Momentary-Pre-soldered/dp/B07Z4T7DM1/ref=sr_1_6?crid=MF6JRT79IUC6&dchild=1&keywords=push+button+with+wire&qid=1604438650&srefix=push+button+with%2Caps%2C233&sr=8-6

Dial

- end goal to represent infinite V/Q ratios
- initially could have set number of ratios on the dial



https://www.amazon.com/RV24YN20S-Potentiometer-Inverter-Regulation-Control/dp/B0795R7PXZ/ref=sr_1_13?dchild=1&keywords=dial+control+knob+with+wires&qid=1604438795&sr=8-13

Conclusions/action items:

Meet with team on Wednesday to talk about progress.



2020/10/16 - Wiring/Soldering

ZOE SCHMANSKI - Oct 16, 2020, 1:59 PM CDT

Title: Wiring and Soldering of the LEDs to make different lengths

Date: 10/16/2020

Content by: Zoe

Present: n/a

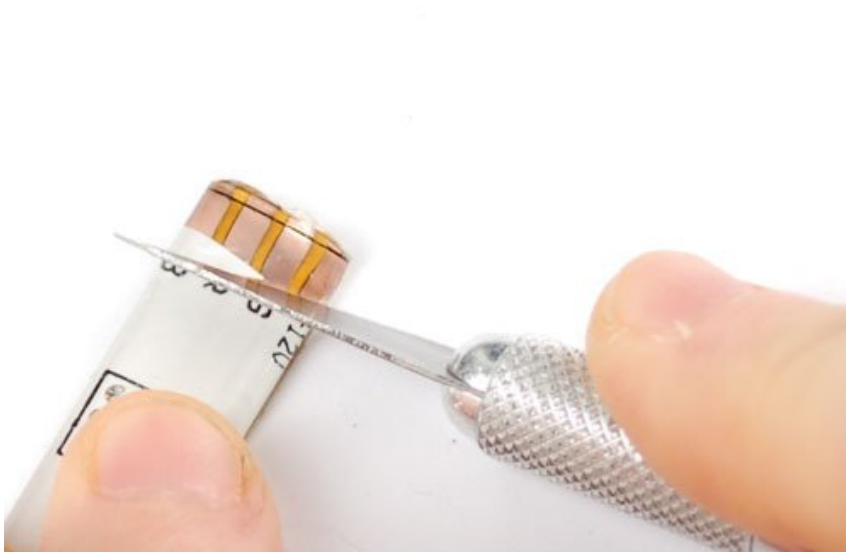
Goals: Find ways to change the length of LEDs to fit the base model

Content:

Connecting up to the strip is fairly easy, you'll want to solder four wires to the copper tabs. We'll use white for +12V, then red, green and blue wires for the corresponding LED colors.



Cut away the waterproof overmolding at one end of the strip. The strips are symmetric so it doesn't matter which end you use.



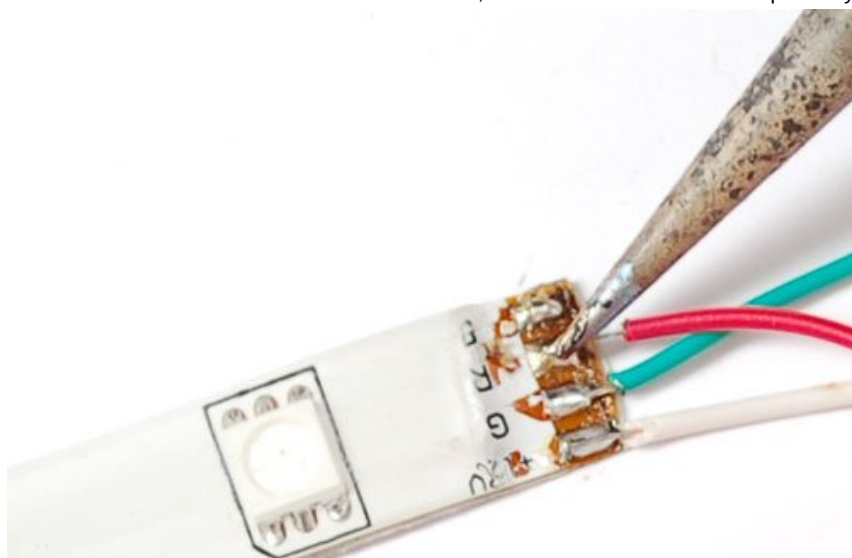
Scrape away the rubber to expose the copper pads.



Melt some solder onto the pads to tin them and also burn away any left over rubber.



Solder the four wires on. We used stranded wire, which is more flexible and is probably a better choice than solid-core.



To protect the wires and maintain some waterproofness, you can use heatshrink.

Conclusions/action items:

Use for longer LED strips purchased to create shorter strips.

<https://learn.adafruit.com/rgb-led-strips/arduino-code?view=all>



2020/10/16 - LED code

ZOE SCHMANSKI - Nov 11, 2020, 4:04 PM CST

Title: Possible code for LEDs

Date: 10/16/2020

Content by: Zoe

Present: n/a

Goals: Document possible code to use for programming the LEDs to represent oxygen flow

Content:

Britt's

```
#include <Adafruit_NeoPixel.h>
```

```
#include <elapsedMillis.h>
```

```
//Number of LEDs in my strip
```

```
int LED_NUMBER = 16;
```

```
//I use elapsedMillis rather than delay
```

```
elapsedMillis time;
```

```
//Starting position for the "off" LED
```

```
int position = 0;
```

```
//Red will begin at the end of the strip
```

```
int red = LED_NUMBER;
```

```
//Blue will begin at the beginning of the strip
```

```
int blue = 0;
```

```
//Initiating Neopixels
```

```
Adafruit_NeoPixel capillaryLED(LED_NUMBER, 9, NEO_GRB + NEO_KHZ800);
```

```
void setup(){
```

```
capillaryLED.begin();
```

```
//This will turn on every LED with the correct shade/color
```

```
for(int i = 0; i < LED_NUMBER; i++){
```

```
    //Total = 16 = Red + blue
```

```
    capillaryLED.setPixelColor(i, red, 0, blue);
```

```
    capillaryLED.show();
```

```
    red--;
```

```
    blue++;
```

```
}

red = LED_NUMBER;

blue = 0;

}

void loop() {

  //Sets time for the off LED
  if (time > 100){

    //If it reaches end of the LED strip, it will start over from the beginning
    if(position < LED_NUMBER){

      //This will turn on every LED
      for(int i = 0; i < LED_NUMBER; i++){

        //Setting LED Colors (Position, red, green, blue)
        capillaryLED.setPixelColor(i, red, 0, blue);

        //Lighting up the LEDs
        capillaryLED.show();

        red--;

        blue++;

      }

      //Setting the single off LED for each run through
      capillaryLED.setPixelColor(position, 0, 0, 0);

      capillaryLED.show();

      position++;

      time = 0;

      red = LED_NUMBER;

      blue = 0;

    }

    else{

      position = 0;

    }

  }

}

}
```

From AdaFruit

```
1. // color swirl! connect an RGB LED to the PWM pins as indicated
2. // in the #defines
3. // public domain, enjoy!
4.
5. #define REDPIN 5
6. #define GREENPIN 6
7. #define BLUEPIN 3
8.
9. #define FADESPEED 5 // make this higher to slow down
10.
11. void setup() {
12.   pinMode(REDPIN, OUTPUT);
13.   pinMode(GREENPIN, OUTPUT);
14.   pinMode(BLUEPIN, OUTPUT);
15. }
16.
17.
18. void loop() {
19.   int r, g, b;
20.
21.   // fade from blue to violet
22.   for (r = 0; r < 256; r++) {
23.     analogWrite(REDPIN, r);
24.     delay(FADESPEED);
25.   }
26.   // fade from violet to red
27.   for (b = 255; b > 0; b--) {
28.     analogWrite(BLUEPIN, b);
29.     delay(FADESPEED);
30.   }
31.   // fade from red to yellow
32.   for (g = 0; g < 256; g++) {
33.     analogWrite(GREENPIN, g);
34.     delay(FADESPEED);
35.   }
36.   // fade from yellow to green
37.   for (r = 255; r > 0; r--) {
38.     analogWrite(REDPIN, r);
39.     delay(FADESPEED);
40.   }
41.   // fade from green to teal
42.   for (b = 0; b < 256; b++) {
43.     analogWrite(BLUEPIN, b);
44.     delay(FADESPEED);
45.   }
46.   // fade from teal to blue
47.   for (g = 255; g > 0; g--) {
48.     analogWrite(GREENPIN, g);
49.     delay(FADESPEED);
50.   }
51. }
```

Conclusions/action items:

Experiment with code once LEDs come in the mail.

<https://learn.adafruit.com/rgb-led-strips/arduino-code>



2020/10/16 - Arduino Microcontroller Set-up

ZOE SCHMANSKI - Oct 16, 2020, 2:03 PM CDT

Title: Circuitry Set-up for Arduino Microcontroller

Date: 10/16/2020

Content by: Zoe

Present: n/a

Goals: Depict ways of wiring the arduino and LEDs

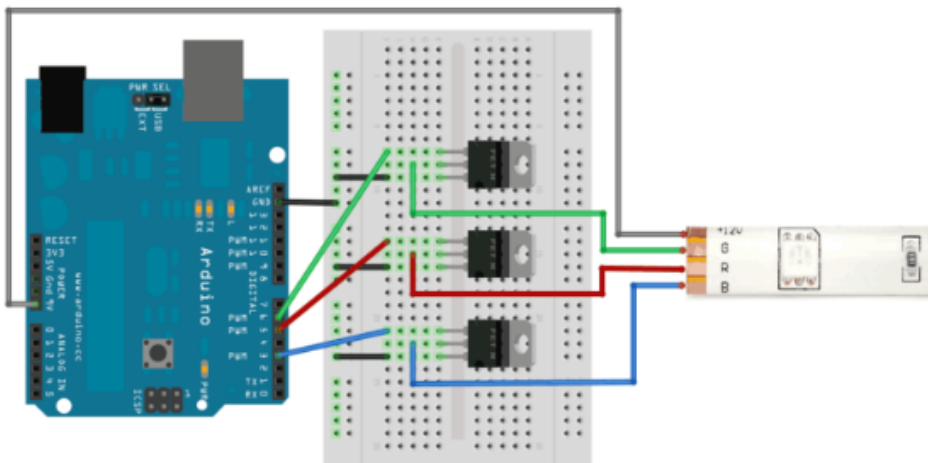
Content:

This diagram shows connecting up with N-Channel MOSFETs where the Gate is pin 1, the Drain is pin 2 and the Source is pin 3

The IRLB8721's can handle up to **16 Amps** of continuous current - so that's at least 750 LEDs, and if you don't have them all on bright white, 1500 LEDs. You may need to heat sink depending on the continuous/overall power draw/dissipation



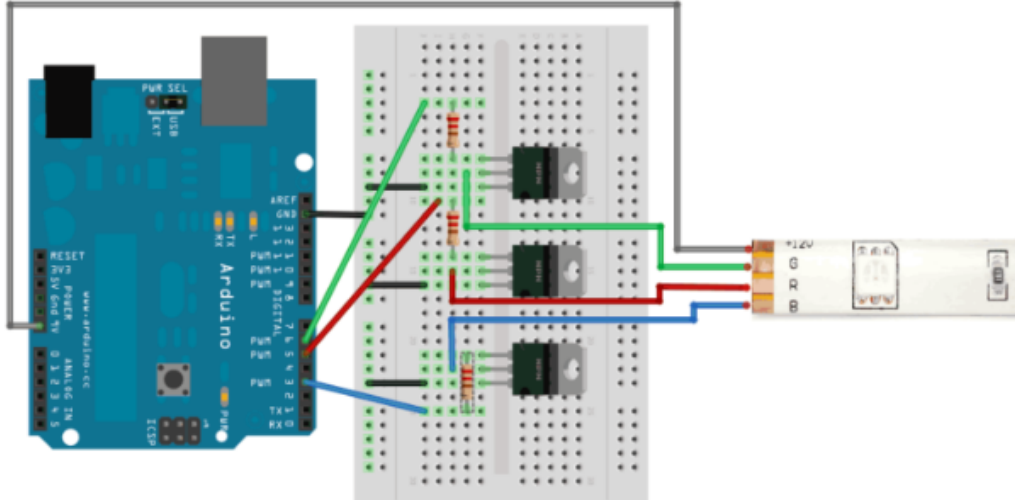
For longer strips requiring more than 1 Amp, wire the power directly to the strip, then run power and ground wires back to the Arduino.



This diagram shows connecting up with power NPN transistors such as TIP120, where Base is pin 1, Collector is pin 2 and Emitter is pin 3. Its very similar except this time we have 100-220 ohm resistors between the PWM output pin and the base.



For longer strips requiring more than 1A, wire power directly to the strip, then run power and ground wires back to the Arduino.



Conclusions/action items:

Build once the LEDs are delivered in the mail.

<https://learn.adafruit.com/rgb-led-strips/arduino-code?view=all>



2020/11/16 - LED Fade Code

ZOE SCHMANSKI - Nov 16, 2020, 6:56 PM CST

Title: Fade LED Code

Date: 11/16/2020

Content by: Zoe

Present: n/a

Goals: Code to brighten and dim a single color LED to represent oxygen concentrations

Content:

/*

Fade

This example shows how to fade an LED on pin 9 using the analogWrite() function.

The analogWrite() function uses PWM, so if you want to change the pin you're using, be sure to use another PWM capable pin. On most Arduino, the PWM pins are identified with a "~" sign, like ~3, ~5, ~6, ~9, ~10 and ~11.

This example code is in the public domain.

<http://www.arduino.cc/en/Tutorial/Fade>

*/

```
int led = 9;      // the PWM pin the LED is attached to
int brightness = 0; // how bright the LED is
int fadeAmount = 5; // how many points to fade the LED by
```

// the setup routine runs once when you press reset:

```
void setup() {
  // declare pin 9 to be an output:
  pinMode(led, OUTPUT);
}
```

// the loop routine runs over and over again forever:

```
void loop() {
  // set the brightness of pin 9:
  analogWrite(led, brightness);

  // change the brightness for next time through the loop:
  brightness = brightness + fadeAmount;

  // reverse the direction of the fading at the ends of the fade:
  if (brightness <= 0 || brightness >= 255) {
    fadeAmount = -fadeAmount;
  }
  // wait for 30 milliseconds to see the dimming effect
  delay(30);
}
```

<https://www.arduino.cc/en/Tutorial/BuiltInExamples/Fade>

Conclusions/action items:

Experiment with arduino and LED



2020/11/17 - LED Dimming Code

ZOE SCHMANSKI - Nov 16, 2020, 6:58 PM CST

Title: Dimming LED Code

Date: 11/17/2020

Content by: Zoe

Present: n/a

Goals: Dimming LED brightness to monitor oxygen concentrations

Content:

```
// These constants won't change. They're used to give names to the pins used:
const int analogInPin = A0; // Analog input pin that the potentiometer is attached to
const int analogOutPin = 9; // Analog output pin that the LED is attached to

int sensorValue = 0; // value read from the pot
int outputValue = 0; // value output to the PWM (analog out)

void setup() {
  // initialize serial communications at 9600 bps:
  Serial.begin(9600);
}

void loop() {
  // read the analog in value:
  sensorValue = analogRead(analogInPin);
  // map it to the range of the analog out:
  outputValue = map(sensorValue, 0, 1023, 0, 255);
  // change the analog out value:
  analogWrite(analogOutPin, outputValue);

  // print the results to the Serial Monitor:
  Serial.print("sensor = ");
  Serial.print(sensorValue);
  Serial.print("\t output = ");
  Serial.println(outputValue);

  // wait 2 milliseconds before the next loop for the analog-to-digital
  // converter to settle after the last reading:
  delay(2);
}
```

Conclusions/action items:

Experiment with arduino and LEDs

<https://create.arduino.cc/projecthub/NIKHIL1916/led-dimming-circuit-8d6c9e>



2020/09/09- Ventilation/Perfusion Mismatch

JENNA EIZADI (eizadi@wisc.edu) - Sep 16, 2020, 12:27 PM CDT

Title: Research on Ventilation/Perfusion (V/Q) Mismatching

Date: 2020/09/03

Content by: Jenna

Present: Jenna

Goals: To accumulate background knowledge on the problem known as ventilation/perfusion mismatching in the lungs and understand the challenges behind teaching this concept.

Content:

VQ Mismatch Video Notes [1]

- ventilation: the exchange of air between the lungs and atmosphere so that oxygen can be exchanged for carbon dioxide in the alveoli
- perfusion: the passage of blood, a blood substitute, or other fluid through the blood vessels or other natural channels in an organ or tissue
- hypoxemia: below-normal level of oxygen in the blood
- blood that passes through the lungs via the pulmonary artery is oxygenated and the saturation of oxygen is related to the V/Q ratio or the amount of exchange for the quantity of blood in one system (alveoli and artery)
- one problem is that it is hard to distinguish the cause of ventilation/perfusion mismatching
 - asthma, COPD, pulmonary hypertension, pulmonary embolism, pneumonia, ILDs, cystic fibrosis...
 - the most common cause of hypoxemia
- V/Q ratio in one alveoli or portion of the pulmonary artery affects the whole system because either blood flow will be redirected to other parts of the lungs changing the V/Q ratios in these areas or the cumulative effect of a decreased/increased V/Q ratio will be seen in the blood re-entering the circulatory system via the pulmonary vein

V/Q Perfusion Ratio [2]

- V/Q ratio is the ratio between the amount of air getting to the alveoli (ml/min) and the amount of blood being sent to the lungs (ml/min)
 - high V/Q means either increasing ventilation or decreasing blood flow
 - low V/Q means either decreasing ventilation or increasing blood flow
- changing V/Q rate physiologically
 - the V/Q ratio in the lungs changes as you move from the apex to the base due to changing blood flow from the effect of gravity (more blood accumulates in the base because gravity pulls it downwards)
 - highest V/Q ratio at the apex because good ventilation but poor blood flow and vice versa for the base
 - when you stand up, V/Q mismatch occurs because more blood flows to the base of the lungs

Conclusions/action items:

Ventilation/Perfusion mismatching occurs

[1] <https://www.youtube.com/watch?v=1s1pymQlhqU>

[2] <https://courses.kcumb.edu/physio/adaptations/vq.htm>



2020/09/16 - Teaching VQ Relationships in the lungs

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 11:31 AM CDT

Title: Teaching V/Q Relationships in the Lungs

Date: 2020/09/16

Content by: Jenna

Present:

Goals: Paper sent to us by the client, Dr. Green on teaching the ventilation/perfusion relationship in the lungs.

Content:

- Ventilation and perfusion matching form the basic foundation for lung function
- Suggestions for a teaching model
 - want to build from simple to complex
 - use simple analogies for visualization
 - integrate the concept of alveolar-arterial O2 differences
 - use hypoxemia as a consistent example
 - use clinical examples to solidify concepts
- Simple: lung is one large unit where gas exchange occurs, bathtub analogy
 - relationship between ventilation and perfusion determines the level of O2 or CO2 in the alveolar space
- Bathtub: level of water in the bathtub is the level of O2 in the alveolus, ventilation bringing air with O2 into the alveolus is pouring water into the tub and O2 leaving into the blood is the drain
 - if the amount of water coming into the tub is greater than that leaving the drain, the water level (PAO2) rises
 - high V/Q ratio in the above example

Conclusions/action items:

Identify the key concepts of V/Q that we need to model and consider most probably an LED approach to demonstrating these teaching models in physical form.

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 12:34 PM CDT

Adv Physiol Educ 35: 108-116, 2009.
doi:10.1152/advan.00117.2009

Refresh Course

Teaching ventilation/perfusion relationships in the lung

Robb W. Glenny
Department of Medicine and Physiology and Biophysics, University of Washington, Seattle, Washington
Submitted 27 May 2008; accepted in final form 9 July 2008

Green RW. Teaching ventilation/perfusion relationships in the lung. *Adv Physiol Educ* 35: 108-116, 2009. doi:10.1152/advan.00117.2009. The level review is meant to serve as a reference for faculty teaching respiratory physiology to medical students. The concepts of ventilation and perfusion matching are one of the most challenging ideas to learn and teach. Some strategies to consider in teaching these concepts are: 1) to build from simple to more complex by starting with a single lung unit and then adding additional units representing shunt, dead space, and alveolar dead space; 2) to use simple analogies, such as a bathtub, to help students conceptualize key ideas. That is, once the concept of alveolar-arterial O₂ differences and the shunt unit for teaching alveolar-arterial O₂ differences are added, finally, use the bathtub model of ventilation and perfusion matching to help students understand and provide clinical relevance. Finally, use clinically relevant examples at each step and solidify core concepts by discussing differential diagnoses at the end of the lecture(s).

Key words: alveolar-arterial O₂ differences; alveolar dead space; shunt; hypoxemia

THE CONCEPTS OF ventilation and perfusion matching are some of the most challenging ideas to teach medical students learning respiratory physiology. These concepts form the basic foundation for lung function and are therefore key building blocks for their understanding of pathophysiology in the lung. It is important to have an approach that will allow students to actively grasp and then solidify their understanding of ventilation and perfusion relationships. This brief report will review some strategies for accomplishing these goals. It is helpful to keep the following issues in mind while designing the educational lecture and materials: 1) build from simple to complex; 2) use simple analogies to help students "visualize" the relationship between regional ventilation and perfusion; 3) integrate the concept of alveolar-arterial O₂ differences as the students become more complex; 4) use the various mechanisms of hypoxemia as a conceptual thread to hold the different parts of the lecture together; and 5) help students solidify their understanding of these new concepts by using clinically relevant examples of ventilation and perfusion relationships and demonstrate the relevance of the material they are learning to health care.

Background Simple

At an introductory level, the lung can be thought of as one large unit in which fresh air and oxygenated blood are delivered to a single unit with oxidized gases and oxygenated blood leaving the unit. A simple schematic of this single unit is shown in Fig. 1 and can be used to introduce the relationship and alveolar-arterial O₂ differences to the students. A simple analogy, such as a bathtub, may help students visualize how the relationship

between ventilation and perfusion determines the level of O₂ or CO₂ in the alveolar space. When used to explain alveolar-arterial differences of alveolar P_{O₂} (P_{AO₂}), the level of water in the bathtub represents the level of O₂ in the alveolus (P_{AO₂}), ventilation (V_E) bringing air with O₂ into the alveolus is analogous to the water pouring water into the tub, and the O₂ leaving the alveolus by way of blood flow (Q) is represented by the water leaving the tub via the drain (Fig. 2). If the amount of water coming into the tub is greater than that leaving the drain, the water level (P_{AO₂}) will rise. If the water leaving the drain is greater than the water coming into the tub, the water level (P_{AO₂}) will fall.

It must be acknowledged that this is a simplified model because, in reality, the level in the bathtub influences the flow in and out of the tub and drain. However, as an initial simple model, it is easily understood by students. In addition, students should be shown that the level of CO₂ in the alveolus is related to the upper and drain flows, but in an inverse relationship with O₂ because CO₂ delivery to the alveolus is via blood and CO₂ removal is via ventilation (Fig. 1). As O₂ consumption and CO₂ delivery are equal to total blood flow (Q), a high ventilation-to-perfusion ratio (V/Q) ratio will produce an increased P_{AO₂} and a decreased alveolar P_{O₂} (P_{AO₂}), whereas a low V/Q ratio will result in a decreased P_{AO₂} and an increased P_{O₂}. The relationship between P_{AO₂} and P_{AO₂} is determined by the ratio between V_E and Q. Students can easily see that the levels of O₂ and CO₂ are related inversely through shared ventilation and blood flow (Fig. 4). This is an especially important concept because it sets the stage for understanding why hypoxemia occurs due to hypoventilation.

Mathematical equations can be intimidating to students, but if they comprehend the concepts discussed, usually, the students are more likely to understand and remember the equations. With the bathtub analogy as a foundation, the simple equations for determining P_{AO₂} in a lung unit can be introduced. Under steady-state conditions, the amount of O₂ consumed must be equal to the amount of O₂ removed from the unit, as follows:

$$V_E \cdot (F_{iO_2} - F_{eO_2}) = Q \cdot (F_{aO_2} - F_{vO_2}) \quad (1)$$

where V_E is O₂ consumption, F_{iO₂} is the fraction of inspired O₂, and F_{eO₂} is the fraction of expired O₂. (1). For those students who have had cardiovascular physiology, it is also to show the similarities between Eq. 1 and the Fick principle for measuring V_{O₂} by rearranging Eq. 1 as follows:

$$F_{aO_2} = \frac{V_{O_2}}{V_E} + F_{vO_2} \quad (2)$$

and changing the fraction of gases to partial pressures, one can arrive at the following equation (3):

Address for reprint requests and other correspondence: R. W. Glenny, Univ. of Washington, Box 356223, Seattle, WA 98195; e-mail: glenny@u.washington.edu.

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0898-1221/09/35108-09\$15.00
DOI: 10.1152/advan.00117.2009

Teaching_VQ_Glenny.pdf(426.2 KB) - download



2020/09/16 - Cardiovascular Computer Model for Undergraduate Teaching

JENNA EIZADI (eizadi@wisc.edu) - Sep 16, 2020, 11:04 AM CDT

Title: A computer model for the cardiovascular system: development of an e-learning tool for teaching of medical students

Date: 2020/09/16

Content by: Jenna

Present:

Goals: To gain insight into the types of teaching models already existing.

Content:

- Incorporated a Lumped Parameter Model (LPM) into an e-learning environment to create a tool to help students, undergraduate medical students, in particular, understand cardiovascular physiology, map disease progression, and classify the severity of a disease [1]

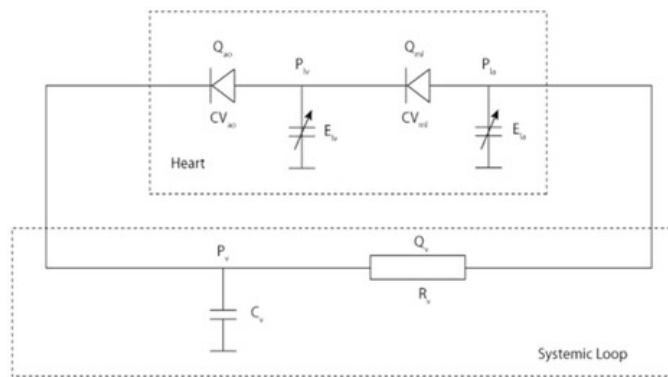


Figure 1. Lumped parameter model of the left heart as an electrical analog.

- Components modeled in circuitry above as related to cardiovascular physiology [1]
 - capacitor (C): elastic property of the large arteries (total arterial compliance)
 - resistor (R): frictional loss in the smaller vessels (systemic vascular resistance)
 - variable capacitors: pumping chambers (Ela=left atrium, Elv=left ventricle)
 - diodes: valves (CVao=aortic valve, CVmi=mitral valve)
- Can create more advanced LPM models to mimic various other complexities including coronary circulation to facilitate clinical diagnosis [2]
- Normal, hypertension, heart failure, and hemorrhage pathological processes were modeled with various severities [1]

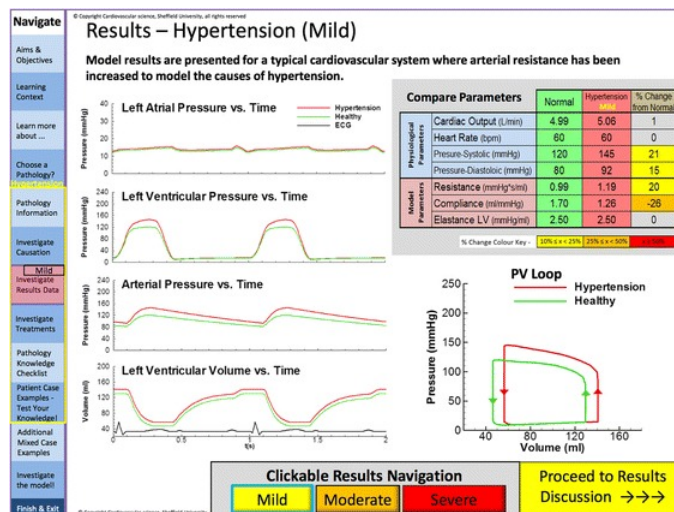


Figure 2. Screenshot from the lumped parameter results in mild hypertension.

- E-learning environment allows students to repeatedly go through simulations to become familiar with different pathologies and introduces opportunities to include relevant information for each including posing questions for a more interactive learning experience

[1]

- Found from a study completed within the paper that improvement was found in student's knowledge and understanding after e-learning environment exposure [1]
- As related to V/P Mismatching
 - Create an e-learning model to add on lung visual to a model of the heart as well
 - Could easily identify concentrations of oxygen and V/P ratios with different colors
 - Allow for easy incorporation of many different pathologies and clinical cases
 - Downside is that it is all online and would be better suited to individual learning

Conclusions/action items:

The model created in this paper is more readily focused on coronary diseases as compared to our goal of modeling the cardiovascular topic of V/P mismatch, however it demonstrates that ability to create an e-learning environment with certain characteristics that allow students to interact with various pathologies. We might want to consider a similar e-learning environment as a possible design idea as it would be easy to incorporate into a classroom and would allow for not only an integration of various diseases, but clear modeling of the concentration gradients in the extremities as a result. The difficulty we would encounter is needing to have a strong computer programming background to create such a platform.

[1] Warriner Dr, Bayley M, Shi Y, Lawford PV, Narracott A, Fenner J (2017) Computer model for the cardiovascular system: development of an e-learning tool for teaching of medical students. *BMC Med Educ* 17: 017-1058.

[2] Duanmu Z, Yin M, Fan X, Yang X, Luo X. A patient-specific lumped-parameter model of coronary circulation. *Sci Rep.* 2018;8(1):874. Published 2018 Jan 17. doi:10.1038/s41598-018-19164-w.



2020/09/16 - The Application of Complex Research Simulation Models in Education

JENNA EIZADI (eizadi@wisc.edu) - Sep 16, 2020, 12:14 PM CDT

Title: The Application of Complex Research Simulation Models in Education; a Generic Approach

Date: 2020/09/16

Content by: Jenna

Present:

Goals: Research into the category of research simulation model designs as it pertains to education.

Content:

- Circ-Adapt is a computational model of the heart and circulation that is used to investigate clinical aspects [1]
 - a schematic overview which we should strive to mimic in our own diagram
 - transferred to an educational application
- Circ-Adapt incorporates mechanical and hemodynamic interactions [1]
- parameters can be adapted to obtain needed physiological behavior of heart and vessel walls [1]
 - volume can also be adapted
- Circ-Adapt is written in C++ and developed in Matlab [1]
- Can simulate a number of different cardiac diseases and produce pressure and volume graphs for different parts of the heart [1]

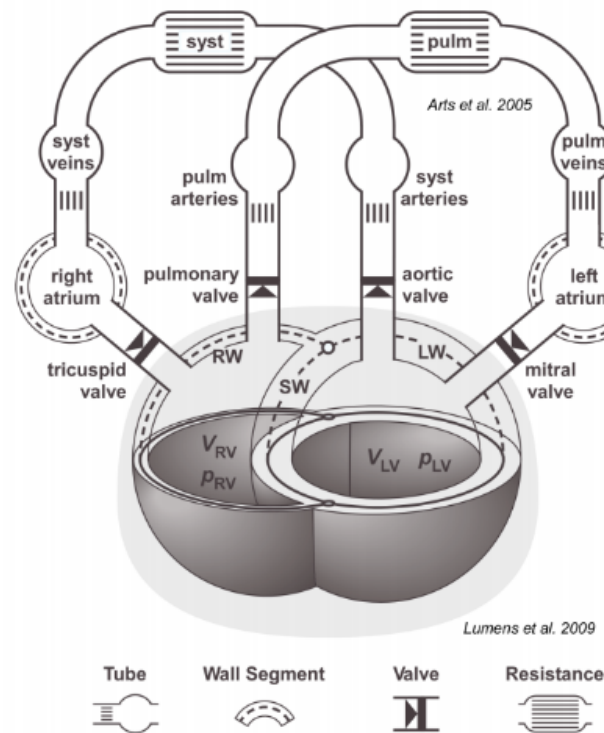


Figure 1. Schematic overview of the CircAdapt model [1].

- How this pertains to our model
 - Would be a good idea to include a schematic overview of the design similar to the one in Figure 1
 - Could include the alveoli and capillary bed as the major structures but also identify the other parts of the system
 - I like the set-up of having each part of the cardiovascular system identified but focusing in on the most relevant parts
 - Another example of an e-learning type tool that has been developed for teaching

Conclusions/action items:

The CircAdapt model is yet another example of an e-learning tool that has been developed to facilitate the teaching of cardiovascular pathologies in a more interactive manner. Again, it would be difficult to develop a tool such as this one with limited computer programming knowledge, but seeing

as this is built in Matlab and written in C++, the idea is more promising. We should consider adding an e-learning design idea to our matrix.

[1] W.Dassen *et al.*, "The application of complex research simulation models in education; A generic approach," *2011 Computing in Cardiology*, Hangzhou, pp.465-468.



2020/09/10 - Liquid Flow and Dye Model

JENNA EIZADI (eizadi@wisc.edu) - Sep 16, 2020, 10:13 AM CDT

Title: Liquid Flow and Dye Concentration Model for V/P Mismatching

Date: 2020/09/10

Content by: Jenna

Present:

Goals: To identify one potential design idea that was introduced by the client, Dr. Christopher Green.

Content:

- The model illustrates how the ventilation-perfusion (V/P) ratio determines the partial pressure of oxygen gas in a lung unit [1]
- The powdered dye is continuously added at a rate V to mimic the addition of O_2 by alveolar ventilation and removed by water pumped through the unit to simulate the blood flow Q that removes the O_2 [1]
 - The concentration of the dye is given by V/Q
- Represents the factors controlling alveolar PO_2 [1]

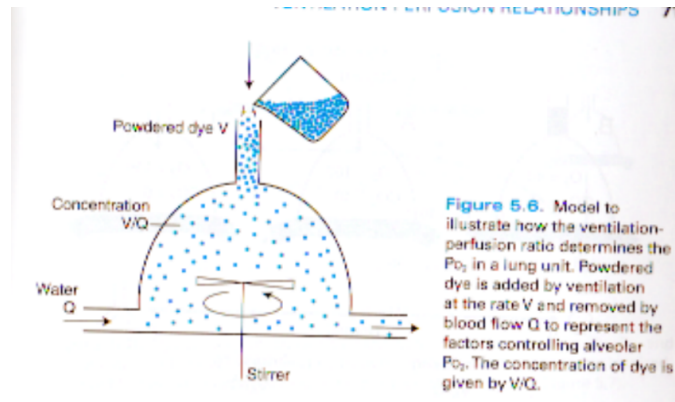


Figure 1. Model to illustrate how the V/P ratio determines the partial pressure of oxygen in a lung unit.

- Components of the model as shown in Figure 1
 - Powdered dye: represents addition of O_2 by ventilation at a rate V
 - Water: blood flow, removes O_2 at a rate Q
 - Stirrer: mixes the contents of the lung unit, mimics gas diffusion
 - Lung unit: casing for the rest of the components, would need to be clear as to see the dye and water mixture
- Other critical components not shown in Figure 1
 - Pumping and filtration system for recycling and filtering water mixed with dye
 - Waste bin if water is to not be reused
 - Housing for water and dye
 - Electronics to run pumps and stirrer
 - Tubing

Conclusions/action items:

While this model would be visual and easy to understand, the mechanics behind the model are not trivial. Not only would it be difficult to run such a model multiple times in a session without having to refill a water reservoir, it would be challenging to store and manipulate. I think our team should consider other possible designs before returning to this one in particular.

[1] West's Pulmonary Physiology, Tenth Edition, John B. West and Andrew Luks, Wolters Kluwer, 2016, pp 70-71. I



2020/09/21 - Online E-learning model

JENNA EIZADI (eizadi@wisc.edu) - Sep 24, 2020, 10:50 PM CDT

Title: Online E-Learning Model

Date: 2020/09/21

Content by: Jenna

Present:

Goals: Brainstorm design ideas for the V/P mismatching teaching model.

Content:

One idea for the V/P mismatch teaching model is an online e-learning model similar to those used for teaching cardiac diseases from my research on competing designs. In this way, we would be able to model the correct anatomy and individualize learning by having each student have access to the model from their laptop. We would need to develop a web or computer application capable of being programmed with a few, or unlimited, settings of ratios for ventilation and perfusion. From these ratios, we could identify the different pathologies they correspond to as well as posing questions and providing more insight into the diagnosis, prognosis, and treatment of the different clinical situations. In the Cardiovascular Computer Model previously mentioned in Competing Designs, the designers of the model created different clinical cases in which students were then able to identify the corresponding pathologies.

Conclusions/action items:

Being that many of us have little computer programming experience, this would be a very difficult project to realize and most likely not the best option at this moment. Also, it seemed that the client would like to have a physical model representing the V/P mismatching problem so that it can be used during class time and projected to the lecture. As an action item, we should propose an e-learning model to the client to make sure that this is not the best option for his purposes before moving on to physical models.



2020/09/23 - Combination Model of LED and Fluid

JENNA EIZADI (eizadi@wisc.edu) - Sep 25, 2020, 1:39 PM CDT

Title: Combination Model with both LEDs and Fluidics

Date: 2020/09/23

Content by: Jenna

Present:

Goals: Brainstorm a design for the V/P mismatch teaching model to propose to the client.

Content:

A combination model adapted both from our own design idea of an electronic LED model and the liquid flow model from the paper received from our client. This design would encompass principles of both being that the "dye" that is contained in the liquid flow model would instead be varying colors and brightnesses of LEDs. The main issue our client had with the liquid flow model was that it would be messy and difficult to clean up, store, and reset, due to the dye that would need to be filtered out. My idea for this combination design model is to expand on that point and create a system that is easily reset but also can be modeled with a fluid that potentially can amplify the LEDs and portray different settings of V/P mismatch ratios. The main difficulties we would run into in this model would be identifying a fluid that serves as an amplifier for light and creating a system that utilizes liquid in a simple way so that the resetting of the model and storage is not difficult.

Conclusions/action items:

We should present our ideas to the client during the next meeting, 9/25, and get his opinion and preferences. Then, we will need to create a design matrix and decide on a singular preliminary design that we will want to pursue.



2020/10/05 - Proposed Designs for LED Mechanism Design Matrix

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 11:59 AM CDT

Title: Proposed Preliminary Designs for LED Mechanism

Date: 2020/10/05

Content by:

Present:

Goals: To outline the three preliminary designs considered for the LED mechanism.

Content:

1. Original LED Model

- LED Flow model lined with singular LEDs of different colors
- each individual LED linked together into a system and some component altering the colors of the system
- no gradient of colors possible, or difficult to implement



Figure 1. Individual LEDs lining LED Flow Model.

2. Diffused LED Model

- LED strip lining the LED Flow model
- strip would allow for each color gradient to be achieved and also allows for different colors to be demonstrated on the same strip
- can model a large variety of different V/Q ratios
- diffused tubing would increase the light diffraction and intensify the colors of the LEDs

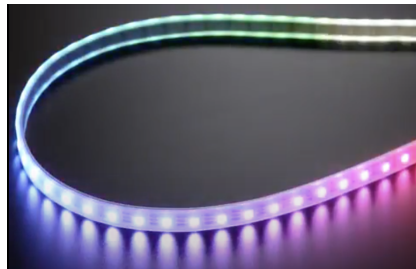


Figure 2. LED strip in diffused tubing with different color gradients.

3. Water-Submerged LED Model

- LED strip lining the LED Flow model but also submerged in water
- attempts to increase the light intensity with light diffraction in water
- the drawback is the difficulty in creating a model with water incorporated with electronic components
- could become messy depending on the type of design pursued

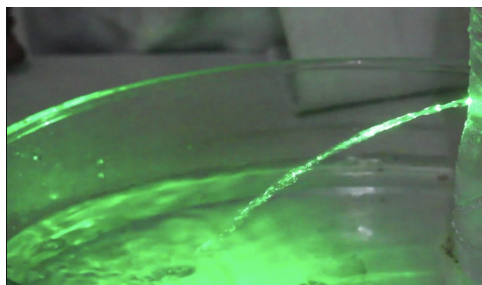


Figure 3. LED light diffraction in a stream of water.

Conclusions/action items:

We will need to create criteria and evaluate each of these proposed designs using a design matrix to decide upon a final design.



2020/10/05 - Proposed Designs for Design Matrix

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 12:08 PM CDT

Title: Proposed Preliminary Designs for Flow Mechanism

Date: 2020/10/05

Content by:

Present:

Goals: To outline the three preliminary designs considered for the flow mechanism.

Content:

1. LED Flow Model

- alveolar duct leading into a single alveolus surrounded by a capillary tube
- LED lining both the capillary tube and alveolar duct to represent blood flow and gas flow
- the color change could also indicate oxygenation of the bloodstream and gas exchange

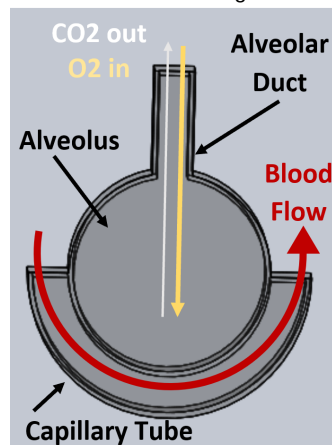


Figure 1. LED flow model with arrows representing the flow of substances through the tubing.

2. Bead Flow Model

- consists of a tube representing a bronchiole connected to two alveoli surrounded by a single capillary tube
- model flow using beads in water and pumps controlling the amount of water and beads in the system
- number of beads=the amount of ventilation and the ratio of beads to water=amount of perfusion
- regulate the release of beads using a flexible tube with modifiable diameter to model different ratios of V/P

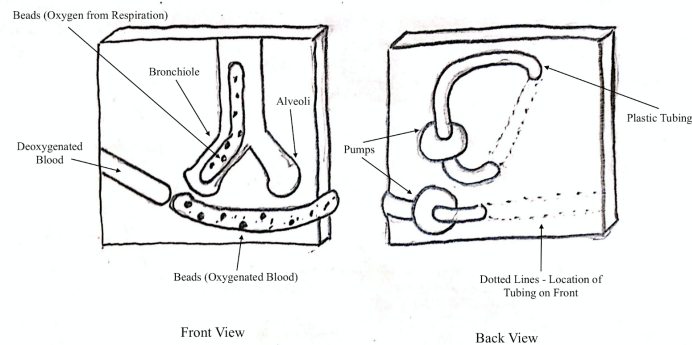


Figure 2. Bead flow model with black dots representing beads as well as tubing through the front and back of the design. Pumps also included on the back view moving water through the system.

3. Water Flow Model

- based on John West's model in the textbook entitled *Respiratory Physiology* detailed in the competing designs section of lab archives
- the model includes a closed water system and a water pump

- dye would then be inserted into the alveolar portion and flow into the capillary tubing with the amount of dye added representing different ratios of V/P
- could become messy depending on the type of design pursued

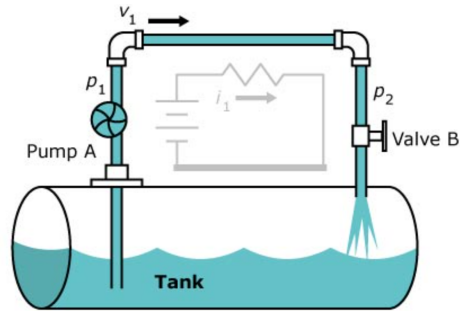


Figure 3. Closed water tank system showing a pumping mechanism as well as a storage tank.

Conclusions/action items:

We will need to create criteria and evaluate each of these proposed designs using a design matrix to decide upon a final design.



2020/10/05 - Design Matrix for LED Mechanism

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 12:04 PM CDT

Title: Design Matrix for LED Mechanism

Date: 2020/10/05


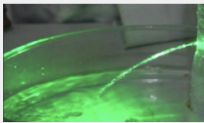

Content by:

Present:

Goals: To determine a final proposed design for the LED mechanism.

Content:

Table 1. The design matrix with categories on the left, their weights in parentheses, and each design labeled on the first row. The dark green cells represent the designs that won each category as well as the design that won overall.

LED Designs	Diffused LEDs		LEDs + Water		Original LEDs	
Categories						
Effectiveness (50) (Competency)	5/5	50	5/5	50	3/5	30
Ease of Fabrication (35)	4/5	28	3/5	21	5/5	35
Safety (10)	5/5	10	4/5	8	4/5	8
Cost (5)	4/5	4	3/5	3	5/5	5
Total (100)	92		82		78	

- Effectiveness: clarity of the device in portraying V/Q ratios and how well the device would appear in front of a lecture full of students
- Ease of Fabrication: the ability of the team to incorporate the LEDs into the LED Flow Model
- Safety: electrical and other outstanding hazardous concerns
- Cost: cost of fabrication

Conclusions/action items:

The Diffused LEDs will be used in modeling the V/Q mismatching concept in combination with the LED Flow Model from the previous design matrix. The design will include the base model representing the alveoli and bloodstream along with the visual flow representation using the color gradient of a strip of LEDs encased in diffused tubing. The team now needs to begin brainstorming the fabrication of this device including a fabrication plan and parts list.



2020/10/05 - Design Matrix for Flow Mechanism

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 11:53 AM CDT

Title: Design Matrix for Flow Mechanism

Date: 2020/10/05

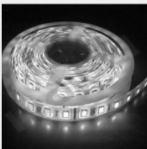
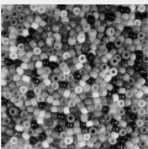

Content by:

Present:

Goals: To determine a final proposed design for the flow mechanism.

Content:

Table 1. The design matrix with categories on the left, their weights in parentheses, and each design labeled on the first row. The dark green cells represent the designs that won each category as well as the design that won overall.

Designs	LEDS 		BEADS 		DYE 	
Categories						
Effectiveness (35) (Competency)	5/5	35	3/5	21	2/5	14
Ease of Use (30)	5/5	30	4/5	24	1/5	6
Ease of Fabrication (15)	4/5	12	3/5	9	2/5	6
Viability (10)	4/5	8	4/5	8	2/5	4
Safety (5)	3/5	3	4/5	4	4/5	4
Cost (5)	4/5	4	3/5	3	2/5	2
Total (100)	92		69		36	

- Effectiveness: accuracy of the device to portray V/Q mismatching and how well the device would appear in front of a lecture full of students
- Ease of Use: how intuitive the device would be to operate for someone without a technical background, also easiness of setup and storage of the device
- Ease of Fabrication: the ability of the team to produce the model
- Viability: the ability of the device to last for a long period of time with no decrease in performance
- Safety: electrical and other outstanding hazardous concerns
- Cost: cost of fabrication and reset of the device

Conclusions/action items:

The LEDs design won the flow mechanism design matrix because of its effectiveness in teaching the V/Q mismatching concept in addition to being easy to use and fabricate. This model also is cost-effective and will be able to be used for many years without decreases in performance. The next step for the team is to create proposed designs for LED modeling.



2020/10/06 - Proposed Final Design

JENNA EIZADI (eizadi@wisc.edu) - Oct 07, 2020, 12:07 PM CDT

Title: Proposed Final Design

Date: 10/06/2020

Content by:

Present:

Goals: Demonstrate the proposed final design.

Content:

- combination of the LED Flow model along with the Diffused LED design
- tubing representing the alveoli and the bloodstream
- visual flow representation with LED strip encased in diffusive tubing to amplify light
- dial incorporated somewhere into the base to allow for different V/Q ratios to be modeled

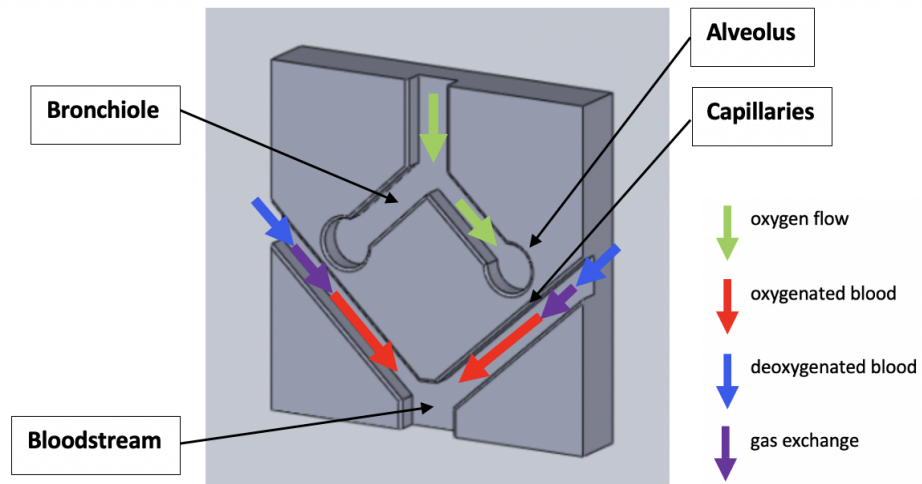


Figure 1. CAD drawing of the base modeling the alveoli and bloodstream with arrows demonstrating flow gradients represented with LEDs.

Conclusions/action items:

Create a fabrication plan and materials list for this proposed final design and begin ordering parts to create a prototype.

2020/11/06 - Buttons and Dial Ideas

JENNA EIZADI (eizadi@wisc.edu) - Nov 13, 2020, 10:10 AM CST

Title: Button and Dial Options

Date: 11/06/2020

Content by: Jenna

Present:

Goals: To research the options available for buttons or dials to be incorporated into the existing set-up to allow a user to change the V/Q ratios.

Content:

Potentiometer (Variable resistor)

- Home appliances use potentiometers behind the dials to change the volume of sounds in TVs or speakers
- Read in the output voltage of potentiometer into an analog input pin in a microcontroller, convert the voltage to digital form, and use this value to alter color/dimness of LEDs [1]

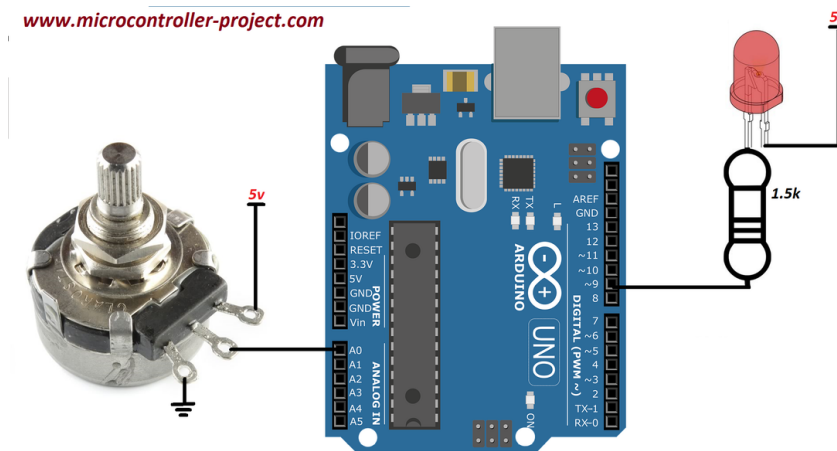
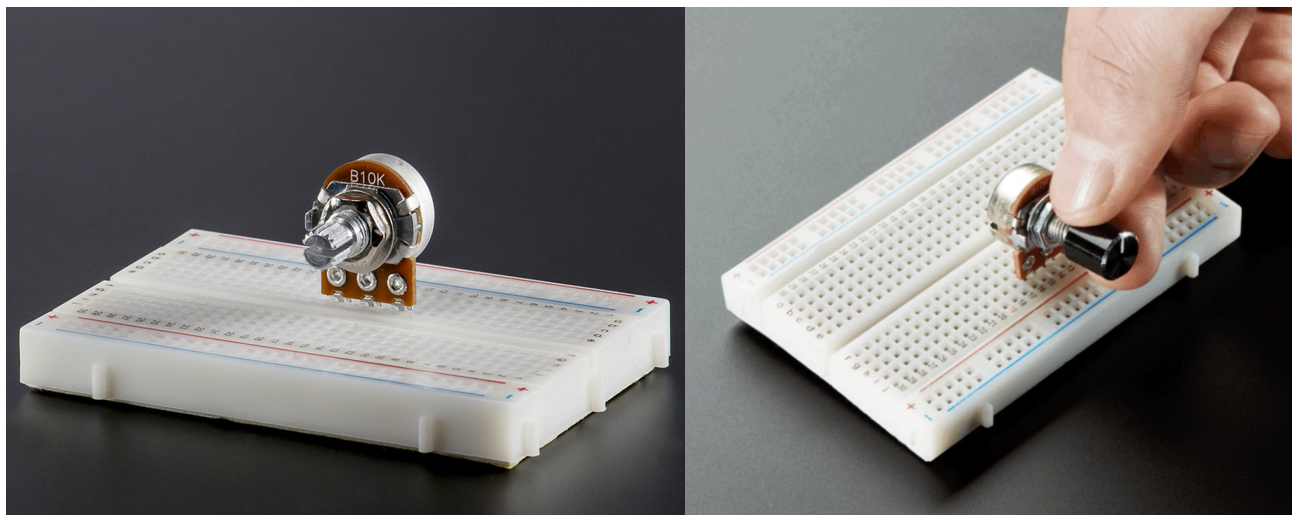


Figure 1. Example of a potentiometer incorporated into a set-up to control the brightness of a single LED through Arduino UNO.

- Panel Mount 10k potentiometer that is breadboard friendly and a knob



Figures 2&3. Potentiometer that is breadboard friendly with a corresponding knob for easy adjustment.

- Slide Potentiometer with plastic knob is another option that offers a slightly different movement range that slides instead of twists to change the resistance
 - would really depend on our preference for the project, but most likely a dial will be easier to use

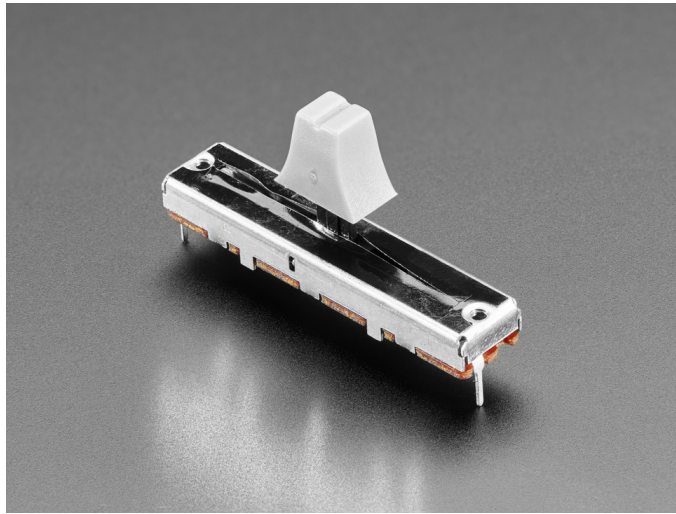


Figure 4. Sliding Potentiometer to change the resistance.

- Amazon options:
 - [Band selector rotary switch with knob](#)
 - [10K Ohm Linear potentiometer](#) with wire attachment so breadboard not needed
 - [60 piece kit](#) of different potentiometers

Buttons

- Tactile buttons could be used to switch between a few pre-set values but it would be difficult to model many values this way
- Adafruit sells a few very basic options
- Inexpensive and can be easily incorporated into an Arduino UNO
- [Tactile switch button](#)

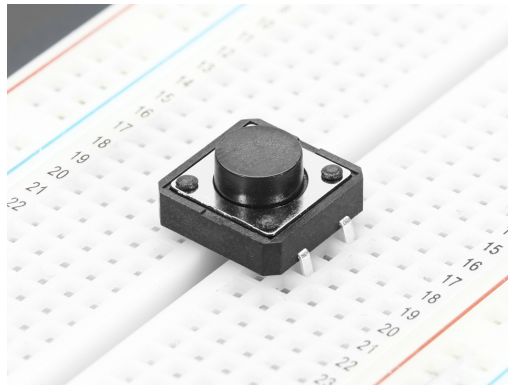


Figure 5. Tactile switch button on a breadboard.

- [Amazon variety pack of Tactile Push Buttons](#)
 - 250 pieces of 25 different tactile buttons to choose from, all breadboard friendly

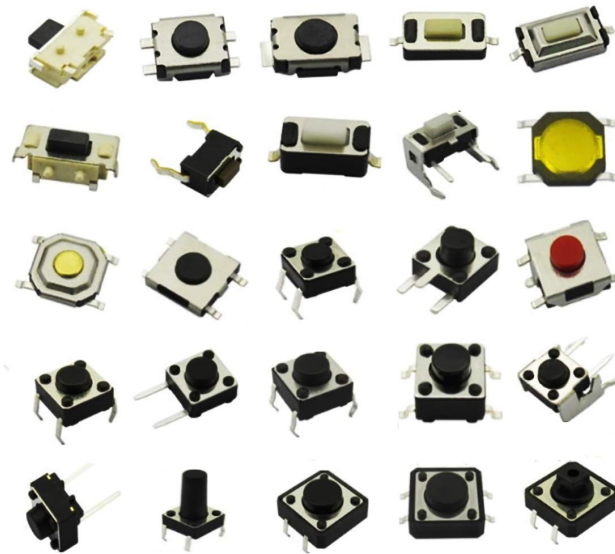


Figure 6. Different types of tactile buttons included in the Amazon kit mentioned above.

Conclusions/action items:

We need to now meet as a group and decide which route we want to go (in my mind there are only 2: button or dial) and purchase the components to begin incorporating them into our LED and Arduino design.

[1] <https://www.engineersgarage.com/electronic-projects/fading-led-with-potentiometer-using-arduino/>



2020/10/21 - Materials List for Final Design

JENNA EIZADI (eizadi@wisc.edu) - Oct 23, 2020, 12:20 PM CDT

Title: LED Materials List for LED Flow Final Design

Date: 10/20/2020

Content by: Jenna

Present:

Goals: To perform a search of all relevant LED materials for our LED Flow Final Design proposed previously.

Content:

NeoPixel RGB Neon-like LED Flex Strip with Silicone Tube

- 1 meter long LED strip encased in a silicone tube
- price: \$34.95
- flexible and bendy, strong and durable weather-proof casing
- the silicone acts as a diffuser and is a translucent rubber
- JST SM 3 pin connector at the input, needs 9V to 12V (ideal) for power pins and NeoPixel on the third pin
- Programmable

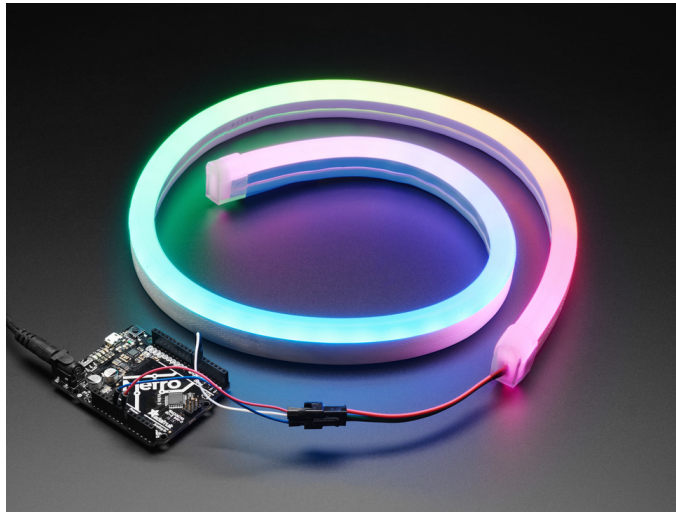


Figure 1. LED Strip encased in silicone tubing modeling a gradient of RGB colors. Also, note attached to a microcontroller.

NeoPixel Ring: 12 RGB LED Circular with Integrated Drivers

- 12 smart LED NeoPixels arranged in a circle
- price: \$7.50
- The outer diameter of 1.5" (37 mm), the inner diameter of 1" (23.3 mm), the thickness of 0.3" (6.7 mm)
- Powered with 5 V DC
 - Can be integrated with an Arduino
- Programmable

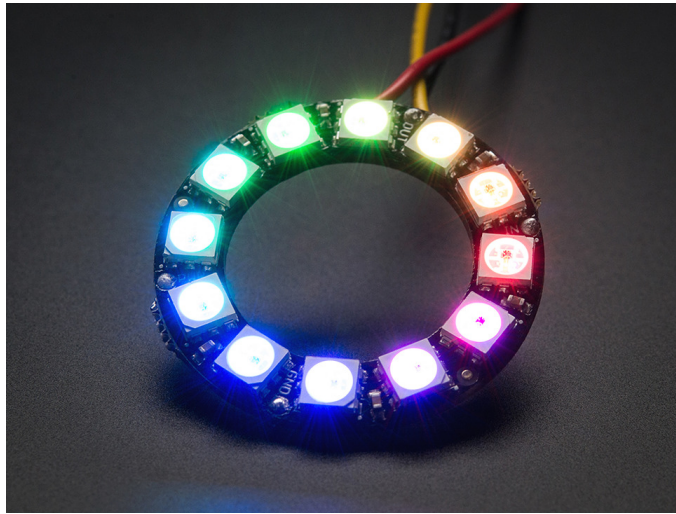


Figure 2. 12 LED Circular NeoPixel Ring.

NeoPixel Ring: 16 RGB LED Circular with Integrated Drivers

- similar to the above 12 LED Circular NeoPixel Ring, but instead has 16 LEDs
- price: \$9.95
- The outer diameter of 1.8" (44.5 mm), the inner diameter of 1.2" (31.7 mm), the thickness of 0.3" (6.7 mm)
- Depending on our alveolar diameter, would prefer one size over the other

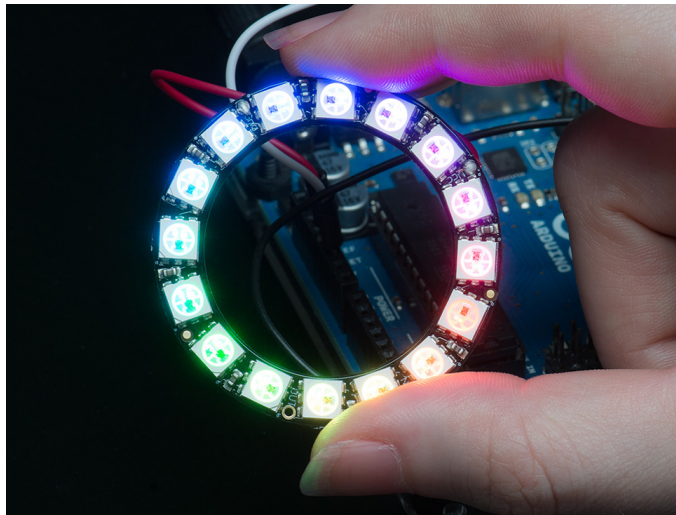


Figure 3. 16 LED Circular NeoPixel Ring.

Adafruit NeoPixel LED Strip with 3-pin JST Connector

- NeoPixel LED Strip that is 0.5 m long and has a JST PH 3-pin plug
- price: \$12.50
- reel with three 100mm long wires with addressable LEDs so 30 individually-controlled RGB LEDs
- can easily cut the strip at any point, flexible PCB material
- powered by 3-5 V DC power supply



Figure 4. LED Strip that is 0.5 m long with 30 individually controlled RGB LEDs.

Conclusions/action items:

Purchase these materials and, once they arrive, begin incorporating them with the rest of our design and determine which parts will work best for our purposes.



2020/10/22 - Arduino Connection to LED

JENNA EIZADI (eizadi@wisc.edu) - Oct 23, 2020, 12:19 PM CDT

Title: Arduino UNO Connection to LED Strip

Date: 10/22/2020

Content by: Jenna

Present:

Goals: To research how to connect an Arduino UNO to the LED strips we have purchased.

Content:

Basic Connections

- using 5V DC power supply
- connect +5V input on the strip to the + terminal on the power supply, DIN to a digital pin on Arduino, and - on the strip to both the minus terminal on the DC supply and a GND pin on Arduino
- recommended to add a large capacitor (~1000 uF) across + and - terminals to prevent the initial onrush of current from damaging pixels
- adding a ~470-ohm resistor between the microcontroller's data pin and data input on NeoPixels can prevent spikes on the data line that can damage the first pixel (most should rings should already have this)
- the NeoPixels will not need an external power supply if just a few pixels are used but might want to consider adding a separate DC supply

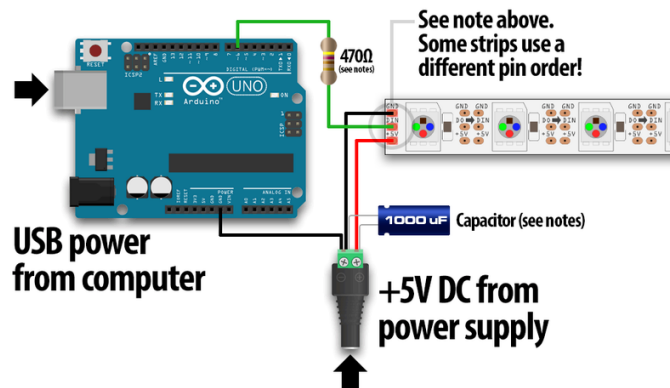


Figure 1. Arduino UNO connected to an LED Strip powered by a 5V DC power supply. Note the capacitor and resistor added between connections.

Distributing Power

- the longer a wire is, the more resistance it has, the more voltage drops along its length, and the color of NeoPixels can be affected by this drop if it is significant
- to account for this, you can supply the strip in the middle to get the best color consistency possible

Conclusions/action items:

Once the ordered LEDs arrive, begin playing with them using the pre-existing code available on the Adafruit website for controlling NeoPixel strips and get familiar with the set-up. From there, we will need to determine which LEDs will need external 5V power supplies and how we can incorporate this into our design.



2020/10/23 - Existing Arduino NeoPixel LED Code

JENNA EIZADI (eizadi@wisc.edu) - Oct 23, 2020, 12:23 PM CDT

Title: Existing Arduino Code for Integration with NeoPixel LEDs

Date: 10/23/2020

Content by: Jenna

Present:

Goals: To present existing LED code supplies by a team member who has previously worked with NeoPixel LEDs.

Content:

```
#include <Adafruit_NeoPixel.h>
#include <elapsedMillis.h>

//Number of LEDs in my strip
int LED_NUMBER = 16;
//I use elapsedMillis rather than delay
elapsedMillis time;
//Starting position for the "off" LED
int position = 0;
//Red will begin at the end of the strip
int red = LED_NUMBER;
//Blue will begin at the beginning of the strip
int blue = 0;

//Initiating Neopixels
Adafruit_NeoPixel capillaryLED(LED_NUMBER, 29, NEO_GRB + NEO_KHZ800);

void setup(){
  capillaryLED.begin();

  //This will turn on every LED with the correct shade/color
  for(int i = 0; i < LED_NUMBER; i++){
    //Total = 16 = Red + blue

    capillaryLED.setPixelColor(i, red, 0, blue);
    capillaryLED.show();
    red--;
    blue++;
  }
  red = LED_NUMBER;
  blue = 0;
}

void loop() {
  //Sets time for the off LED
  if (time > 100){
    //If it reaches end of the LED strip, it will start over from the beginning
    if(position < LED_NUMBER){
      //This will turn on every LED
      for(int i = 0; i < LED_NUMBER; i++){
        //Setting LED Colors (Position, red, green, blue)
        capillaryLED.setPixelColor(i, red, 0, blue);
        //Lighting up the LEDs
        capillaryLED.show();
        red--;
      }
    }
  }
}
```

```
    blue++;  
  }  
  //Setting the single off LED for each run through  
  capillaryLED.setPixelColor(position, 0, 0, 0);  
  capillaryLED.show();  
  position++;  
  time = 0;  
  red = LED_NUMBER;  
  blue = 0;  
  }  
  else{  
    position = 0;  
  }  
  
}  
  
}
```

Conclusions/action items:

Upload this to an Arduino UNO board in a circuit with an LED NeoPixel strip and try to modify the LED's colors through programming.



2020/11/03 - 3D Printed CAD Model

JENNA EIZADI (eizadi@wisc.edu) - Dec 08, 2020, 11:00 PM CST

Title: 3D Printed CAD Model

Date: 11/03/2020

Content by: Me

Present: Me

Goals: To report on the 3D printed CAD model we created.

Content:

The base of our design is a 3D printed model in PLA as shown in Figure 1. The silicone LED is cut to length and placed into the capillary section of the base (the bottom portion) and then wired to the Arduino Uno and an external 12V power supply through a power barrel jack connector mounted on a breadboard. The circular LED is placed into the alveolus portion of the base and is powered by the 5V supplied by the Arduino. The schematic for the circuit can be found in the following Lab Archives entry.

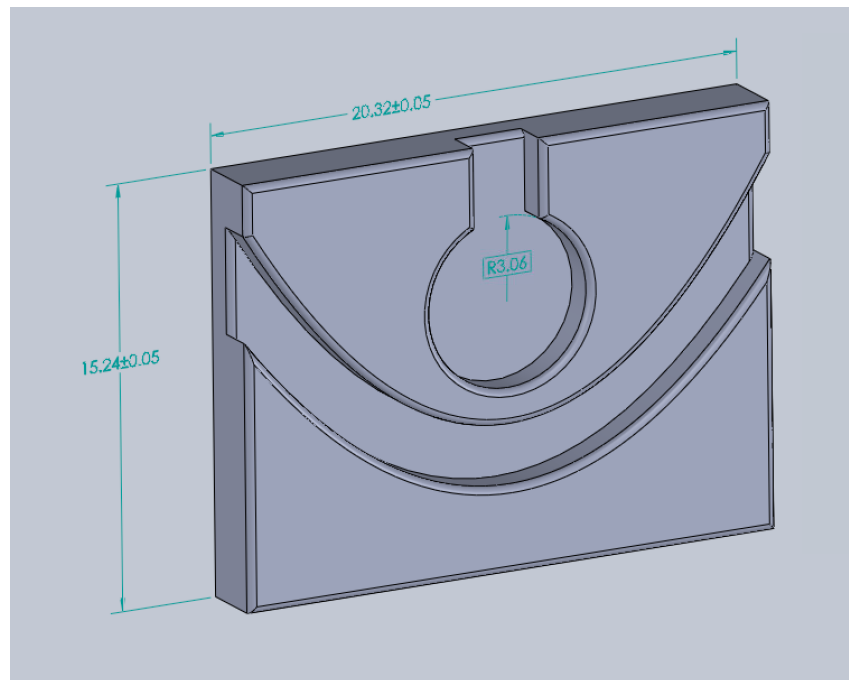


Figure 1. 3D CAD Model of our design that is 3D printed in PLA.

Conclusions/action items:

We will now need to perform testing with the 3D Printed Device to validate that our model functions as we hope.

2020/11/10 - Circuit Design with LED

JENNA EIZADI (eizadi@wisc.edu) - Dec 08, 2020, 10:54 PM CST

Title: Circuit Design with LED Integration

Date: 2020/11/10

Content by: Me

Present: Me

Goals: To display our circuit with the LEDs integrated into it.

Content:

Brittany created this great schematic of our circuit with the LEDs, a 12 V power supply, an Arduino Uno, and a Barrel Jack Connector. I wanted to include this here to demonstrate how we have powered the LEDs. From here, the Arduino Uno is able to control the brightness and different colors of the LEDs per our code.

The barrel jack connector is placed in a breadboard for the time being so that the necessary attachments can be made with a simple set of wires, but in the future, we may want to change this so that it can be easily integrated into our 3D CAD model. In addition, we may need to consider other ways to supply the necessary power to the Silicon Strip LED (it requires 12 V) in order to make our device more easily used and moved in a classroom setting. These are all considerations we will need to discuss in more detail next semester.

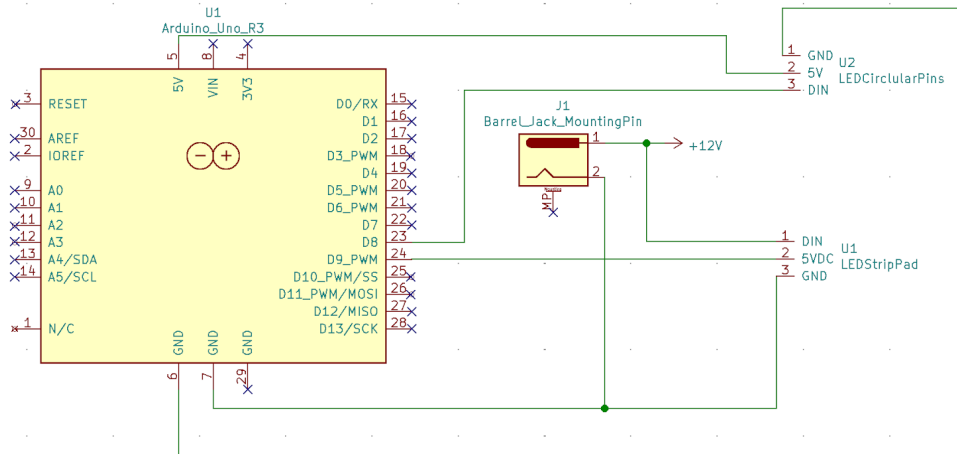


Figure 1. LED circuit with 12V power supply, Arduino Uno, and Barrel Jack Connector

Conclusions/action items:

As I mentioned previously, the next step is integrating this circuit into our 3D CAD model so that it is more easily used, moved, and stored. This will be an important consideration for next semesters work.



2020/11/15 - Final Design Prototype

JENNA EIZADI (eizadi@wisc.edu) - Dec 08, 2020, 11:06 PM CST

Title: Final Design Prototype

Date: 11/15/2020

Content by: Me

Present: Me

Goals: To show our final design prototype that we will perform testing with.

Content:

Figure 1 shows our final design prototype that we were able to fabricate within the first semester. The final design consists of silicon covered LED strip representing a capillary surrounding a single alveolus with a circular LED. A gradient of blue to red represents the flow of oxygen in the bloodstream with blue representing deoxygenated blood and red representing oxygenated. To model various V/P ratios, the color of the capillary will change with an increase in red in the gradient to show an increase in oxygen correlated to higher rates of perfusion, and thus a lower ratio, and vice versa for an increase in blue. The circular LED in the alveolus becomes brighter and has a faster rate of turning on and off when there is an increase in ventilation and a higher ratio.

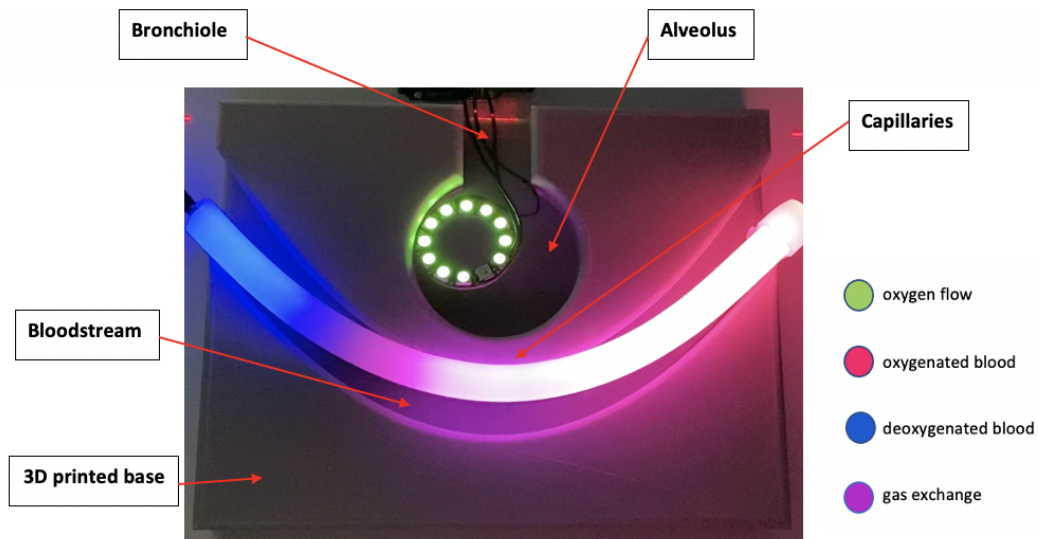


Figure 1. 3D printed base modeling the alveolus and capillary along with the ring and silicon LEDs to show the oxygen gradient for the various V/Q ratios.

Conclusions/action items:

Testing will need to be done on our final design prototype to determine how well we accomplished modeling ratios.



2020/11/19 - Testing Protocols

JENNA EIZADI (eizadi@wisc.edu) - Nov 20, 2020, 1:55 PM CST

Title: Testing Protocols

Date: 11/19/2020

Content by: Me

Present:

Goals: To outline various testing protocols to be used in device validation.

Content:

Verification Testing

- quantitative numbers; take the human interaction away
- some kind of intensity measure between one versus the other for different ratios
 - can take pictures of each ratio and then use a computer program (Matlab, image J...) to look at the intensity profile with one with respect to the other to show that one ratio is significantly different as compared to the other
 - connect that with how we perceive these differences with our eyes, need to find some kind of number to determine how humans are able to distinguish between different colors and intensities

Validation Testing

Document camera testing

- use teaching lab in ECB to get access to a document camera
- test various colors and brightnesses and see if the various levels are distinguishable
- test subjects will have to be the team members able to attend the session
 - possibly have them rank brightnesses from least to most bright
 - for colors, have them distinguish between different colors and potentially test a gradient of colors as well
- data will most likely be in the form of most to least bright/name the color and we can do accuracy and precision testing afterward
- also, will be important to note if the features of our device are prominent meaning that the alveoli and capillary are distinguishable from the rest of the device
- could also test both the silicon and strip LEDs to see if one is better than the other

Zoom/video testing

- record videos of various ratios with different colors and brightnesses and ask people to distinguish between the different levels
- test subjects can be anyone-preferably people with no knowledge of V/P mismatch (family members?)
 - rank brightnesses in different videos and do subsequent testing for accuracy and precision
 - distinguish between different colors and gradients potentially by either naming the colors
- data would most likely be in the form of a quiz that we would administer before and after they watch the videos to see how their understanding changes with our device
 - we might need to give a brief overview of V/P mismatching before hand

Testing with medical students

- can also send the videos created in the above zoom tests to Remington and have him show them to medical students and perform the same tests as above
 - we would explain what the various brightnesses/colors mean in terms of V/P mismatching
- could give us an idea of how well the message is being translated through our device
- data would most likely be in the form of a quiz that we would administer to the medical students before and after they watch the videos to see how their understanding changes with our device

Conclusions/action items:

We should decide upon which tests are most important to do and start planning for those.



2020/12/05 - Testing Procedure

JENNA EIZADI (eizadi@wisc.edu) - Dec 08, 2020, 11:26 PM CST

Title: Testing Procedure

Date: 12/05/2020

Content by: Me

Present: Me

Goals: To elaborate on the type of testing and the procedure for testing done on our model.

Content:

Focus: the ability of the model to produce a distinguishable difference in LED intensity under a document camera given varying levels of LED brightness

Levels of brightness tested: 10, 25, 50, 100, 150, 200, 255

Procedure:

- Levels of brightness were altered in the Arduino code
- Images were taken with a smartphone of both the model and the projection of the model through the document camera at each level of brightness
- post-processing, the images were uploaded to ImageJ and analyzed for the average intensity using the following procedure
 - for the alveolus, the same circular area was highlighted in each image using the boundaries of the circular hollowed-out portion of the 3D printed base as a guide
 - for the capillary, the channel that the silicone LED rests in was highlighted
 - ImageJ was then used to provide the average intensity of the light in these regions

Data:

Circular LED

Brightness	Measured Intensity
10	151.33
25	154.153
50	162.955
100	171.343
150	183.042
200	183.774
255	186.07

Silicon Strip LED

10	168.072
25	169.028
50	165.71
100	173.261
150	173.288
200	173.79
255	174.022

Conclusions/action items:

Perform statistical testing to analyze the results of these tests.



2020/12/06 - Linear Regression T-Test

JENNA EIZADI (eizadi@wisc.edu) - Dec 08, 2020, 11:24 PM CST

Title: Linear Regression T-Test

Date: 12/06/2020

Content by: Me

Present: Me

Goals: To analyze our results from the testing performed.

Content:

A linear regression T-Test was performed on both the alveolus and capillary brightnesses. This test indicates whether any two variables are linearly correlated. In each test, the Arduino value indicating LED brightness was the independent variable and the intensity of the LEDs measured with ImageJ was the dependent variable.

The null hypothesis was defined as there is no linear relationship between the brightness and intensity of the LEDs and the alternative hypothesis was that a linear relationship exists.

For the images of the alveolus, it was found that the test yielded statistically significant results at a p-value of 0.01, meaning that the brightness level and intensity of the LEDs are linearly correlated. This suggests that for the circular LED, there is a significant increase in the intensity with an increase in brightness. The linear relationship is further demonstrated in the plot in Figure 1, with the trendline determined from the Linear Regression T-Test included. The coefficient of determination (R^2) is defined at 0.908 and, from this value, the correlation coefficient (R) is 0.95, indicating a strong, positive linear correlation.

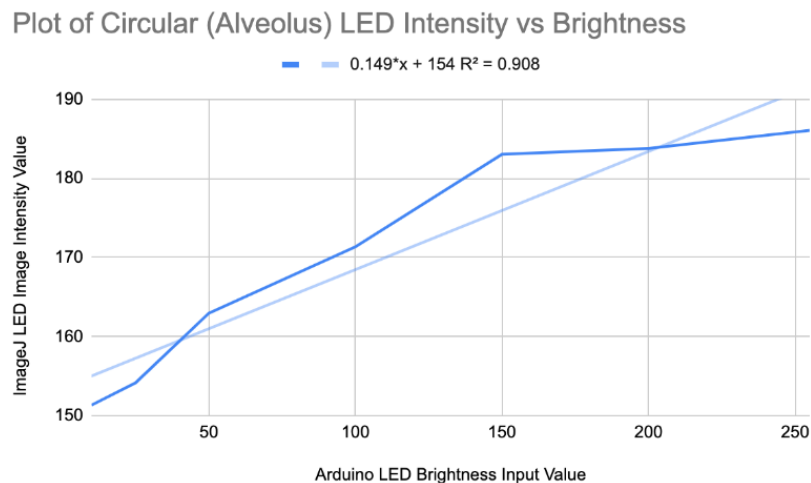


Figure 1. A plot of the circular LED intensity versus brightness with the trendline and R^2 value included.

For the capillary images, the results concluded that it cannot be assumed that there is a linear relationship between the brightness and intensity of the silicon strip LED at a p-value of 0.01, meaning that there was no significant evidence to prove that there is a difference in each brightness level. The plot of this data is shown in Figure 2, along with the trendline.

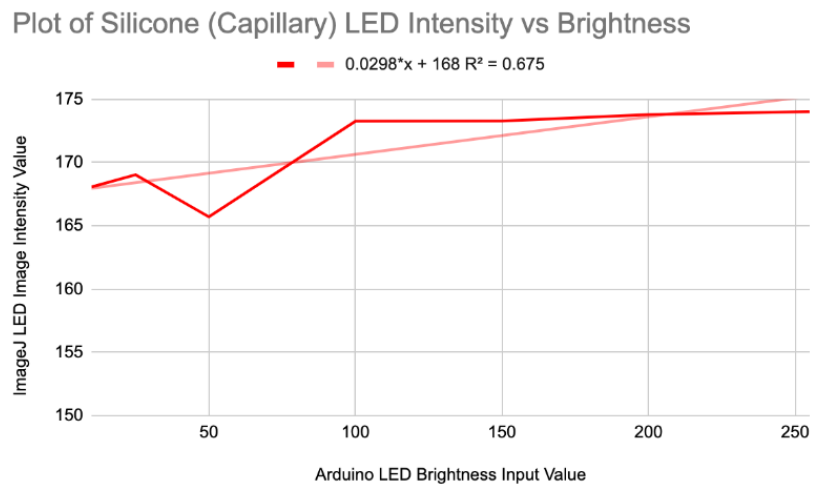


Figure 2. A plot of the silicon strip LED intensity versus brightness with the trendline and R^2 value included.

Conclusions/action items:

We will need to keep these testing results in mind next semester as we reconfigure our prototype and potentially, will need to consider a different type of LED that more easily distinguishes between different brightness levels.



2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.



Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: