BME Design-Fall 2020 - Marshall Walters
Complete Notebook

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Marshall Walters

on

Dec 09, 2020 @12:22 AM CST

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Team contact Information

NOAH WILLIAMS - Sep 08, 2020, 8:59 PM CDT

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Project description

Marshall Walters - Oct 07, 2020, 11:41 PM CDT

Course Number: BME 200/300

Project Name: Remote Euthanasia System

Short Name: remote_injection

Project description/problem statement:

Due to a new contract with the Navy, Dr. Aleksey Sobakin and Dr. Marlowe Eldridge are testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom of the ocean. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have three main subsystems. For the housing subsystem, There must be a way to secure the syringe within the device and to prevent it from moving or being accidentally discharged. For the injection subsystem, there must be a way to pump the euthanasia solution out of the syringe and into the vein in a timely, complete manner. Finally, there must be a remote control subsystem that enables the device to perform the injection protocol upon a button press by a researcher outside of the hyperbaric chamber.

About the client:

Dr. Aleksey Sobakin is an associate scientist in the UW Department of Pediatrics. Dr. Aleksey does research in Orthopedic Surgery, Sports Medicine and Emergency Medicine. Dr. Marlowe Eldridge is a professor and chief of the Division of Pediatric Critical Care. Dr. Eldridge's research broadly involves cardiopulmonary interactions in congenital and acquired heart and lung diseases.

2020/09/18 - Preliminary Client Meeting

Marshall Walters - Sep 18, 2020, 1:19 PM CDT

Title: Preliminary Client Meeting

Date: 9/18/20

Content by: All

Present: All

Goals: To better understand our client's experimental design, expectations for the project, and clarifying questions that we still had.

Content:

1. **Can you describe your experiment? How will the sheep be being handled in the hyperbaric chamber? What conditions are being tested?**
    1. 172 hrs under pressure
        1. Observe physiological (heart rate, ecg)
    2. 5 atm of pressure (simulate disabled submarine)
    3. How long can sheep survive under this pressure? Can they survive for over 172 hrs?
        1. Mimics the number of days that sailors would be stranded in the submarine
            1. Estimated time of escape 172hrs
    4. Control the O_2/CO_2 levels
        1. ~3%
        2. CO_2 levels will raise in a disabled
    5. Type of Sheep
        1. Adult Female sheep
        2. @ specific weight (78-90kg) & body composition → plays big role in decompression sickness
            1. Models the human body composition
2. **Do the needles need to be reusable? Or are you envisioning that we utilize a system that can be "re-loaded" with a new syringe & solution?**
    1. Reloaded -- syringe prepared previously with IV line into sheep neck
    2. Our device just
    3. Hostra (plum A+ & plum 360) → competing designs (potentially modify to be remote controlled)
        1. Non-Remote injection device (set for 1 atm-2atm)
    4. Perfusion pump?
    5. Client would like us to make it on our own
3. **What type of hyperbaric chamber are you using in your experiment? What type of pressure will the sheep be under at any given time (atm)?**
    1. Dixie Manufacturing Co -- Hyperbaric chamber

    2. 5 atm of pressure (simulate disabled submarine)
    3. Whole chamber is pressurized
4. **How far will the researcher be from a sheep in the chamber? (To determine distance that remote signaling will need to cover)**
    1. 5 inch chamber wall?
    2. Sheep observed 24/7
    3. Researcher will be around the chamber at all times → be prepared to use the device
5. **We were envisioning targeting the jugular vein for the intravenous injection. Is this what you were envisioning as well?**
    1. Yes
6. **How much euthanasia solution will be required per injection?**
    1. 20 cc
7. **How durable will our device need to be? How long will it be used for? Should it be waterproof?**
    1. Humidity considerations → not expecting it to be an issue
        1. Not to be submerged
    2. 50-60% Humidity; 20-22C Temperature
8. **What is our budget for this device? How many devices are desired?**
    1. 2 sheep in hyperbaric chamber at a time
        1. 2 devices -- send estimate to client
    2. In pairs, b/c calm one another when placed together
9. **In order to get a better grasp on what type of governmental approval/standards that our device will need to meet, what type of standards is your experiment required to uphold? From IACUC?**
    1. 24/7 shifts required

Sheep are held steady in box that can control gas levels

Maybe one box that can pump two at a time

Syringes

- Medical grade syringes
- 20 cc Kendall monoject syringes with Luer lock tip

Euthanasaia

- Takes 10-20 seconds
- Pentobarbital (euthanasia solution for dogs)

Conclusions/action items:

We will plan to update the PDS with the above information to reflect what is required of us for this project. Also, we established a weekly meeting time of 12pm on Fridays for our team to touch base with the clients.

2020/09/25 - 2nd Client Meeting

Marshall Walters - Sep 28, 2020, 4:07 PM CDT

Title: 2nd Client Meeting

Date: 9/25/2020

Content by: Marshall

Present: All Team & Clients

Goals: To document what was discovered from the client meeting.

Content:

- Discussed with the client about the possibility of using one stepper motor/lead screw set up to activate either one of two syringes
  - Other option is just to mirror the design
- The Remote can be wireless (RF or Bluetooth) or wired (can be brought outside of the chamber)
  - May want to evaluate strengths and weaknesses
- We can calculate the force required to plunge the syringe
  - https://engineering.stackexchange.com/questions/2046/force-required-to-empty-a-syringe
  - https://www.quora.com/I-wish-to-estimate-the-force-required-to-dispense-an-extremely-viscous-liquid-from-a-custom-syringe-What-meaningful-calculations-can-i-do-1
- We will want to look at the equations for the stepper motor/leadscrew and create a list of criteria that we want the client to define for us

Conclusions/action items:

We will want to be sure to look into a wireless vs. wired set up and to have the client define the criteria for the leadscrew/stepper motor set up.

Marshall Walters - Sep 28, 2020, 4:07 PM CDT

- Discussed with the client about the possibility of using one stepper motor/lead screw set up to activate either one of two syringes
  - Other option is just to mirror the design
- The Remote can be wireless (RF or Bluetooth) or wired (can be brought outside of the chamber)
  - May want to evaluate strengths and weaknesses
- We can calculate the force required to plunge the syringe
  - https://engineering.stackexchange.com/questions/[illegible]/force-required-to-empty-a-syringe
  - https://www.quora.com/I-wish-to-estimate-the-force-required-to-dispense-an-extremely-viscous-liquid-from-a-custom-syringe-What-meaningful-calculations-can-I-do-1
- We will want to look at the equations for the stepper motor/leadscrew and create a list of criteria that we want the client to define for us

Client_Meeting_-_9_25_20.pdf(22.1 KB) - download

2020/10/9 - In-Person Client Meeting

Marshall Walters - Oct 13, 2020, 11:13 PM CDT

Title: In-Person Client Meeting

Date: 10/13/2020

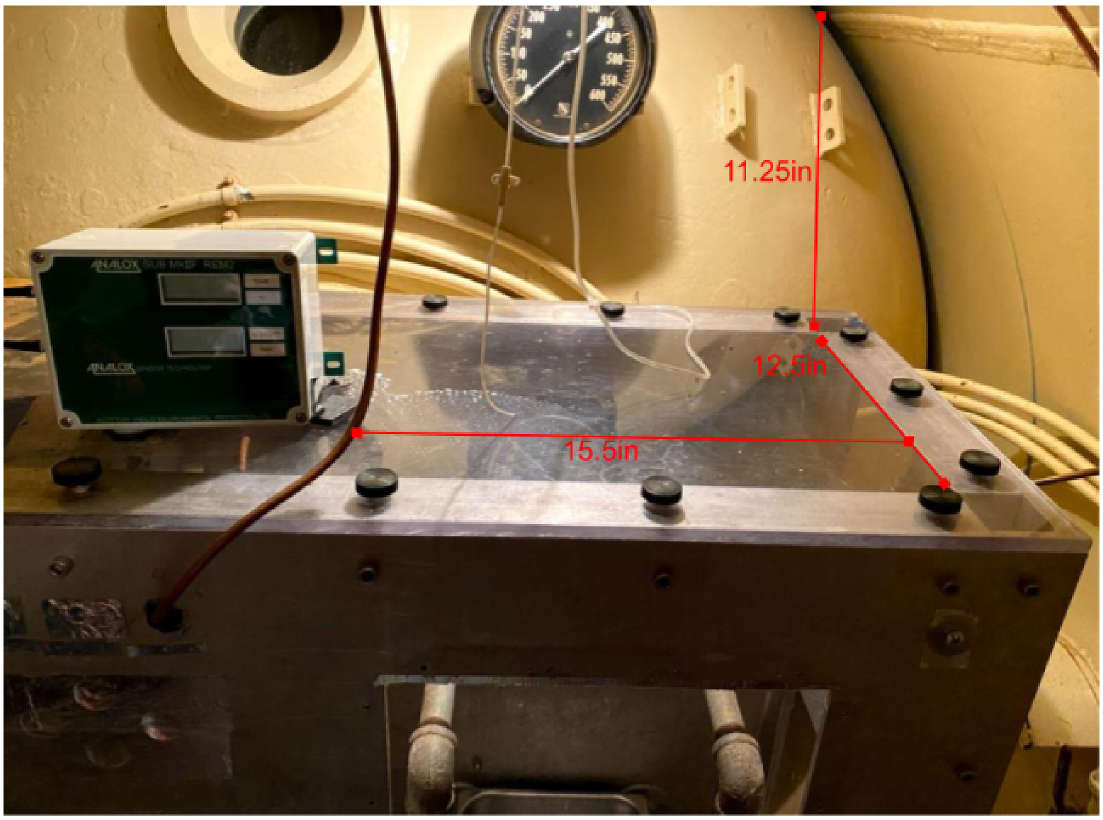
Content by: Marshall

Present: Marshall, Pierson, Noah

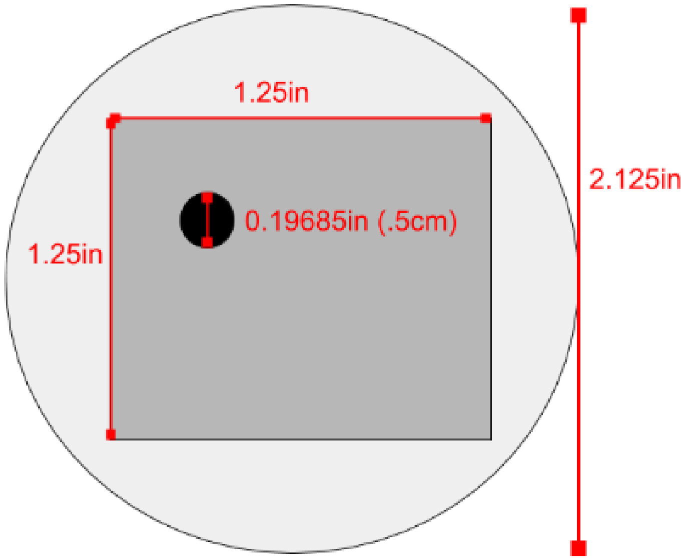
Goals: To get measurements of the chamber, syringe, and the required length for the remote control. Furthermore, it was beneficial to get a look inside the chamber to understand what conditions the sheep would be in.

Content:

- Measurement for top of the Sheep Holding Cage (where device will have to sit)



- Estimated Length Required for Remote Control Cord
    - ~12ft required
        - ~4ft from Cage top (picture above) to Output Hole of Hyperbaric Chamber
        - ~5ft from Output Hole to side of Hyperbaric Chamber
        - ~3ft from side of Hyperbaric Chamber to Researcher
- Output Bore Hole Measurements



-
    - The client said that they would be able to drill as hole of any diameter for us if required (that being said, there is already a hole with a diameter of .5cm)
- See attached for rest of the pictures that we took.

Conclusions/action items:

The next steps will be to use these measurements so we can create the perfectly sized apparatus for the hyperbaric chamber environment.

Marshall Walters - Oct 13, 2020, 11:14 PM CDT

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Marshall Walters - Oct 13, 2020, 11:14 PM CDT

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Marshall Walters - Oct 13, 2020, 11:15 PM CDT

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2020/10/16 - In-Person Client Meeting

CATE FITZGERALD - Oct 16, 2020, 2:44 PM CDT

Title: In-Person Client Meeting

Date: 10/16/2020

Content by: Cate

Present: Cate, Riley, Arnie

Goals: To see the chamber and get clarifications on design aspects/

Content:

Safety Concerns:

- Compliance with regulations regarding experiments performed in oxygen enriched environments.

- Utilizing grease/lubricant or a nitrogen enriched bath in order to prevent fires.

- Using a brushless motor.

- Having a voltage input below 24 V in DC.

- Contacting the manufacturer about motor history in hyberbaric environments.

Conclusions/action items:

The next steps will be to research how fires occur in oxygen enriched environments and see what we can to prevent them.

2020/09/11 - Advisor Meeting

PIERSON FISHER - Sep 11, 2020, 2:51 PM CDT

Title: Advisor Meeting

Date: 9/11/2020

Content by: Pierson Fisher

Present: All

Goals: Meet Kip Ludwig, and begin the process of understanding the grading rubric and the deliverables for the class.

Content:

Moment of Silence

Today the team met with Dr. Kip Ludwig and discussed the rubrics that we will be graded on. Afterwards, we met with each other to discuss meeting times for the coming week and discuss starting individual research on relevant topics for the project.

Conclusions/action items:

The team will meet twice before the first PDS is due on 9/17/20 to work together on it, and make sure that it is fully filled out by the due date.

2020/10/16 - Advisor Meeting

Marshall Walters - Oct 16, 2020, 3:13 PM CDT

Title: Advisor Meeting

Date: 10/16/2020

Content by: Marshall Walters

Present: Pierson, Marshall, Cate, Riley

Goals: To field questions regarding stepper motor and fluid calculations.

Content:

- **Viscosity of Pentobarbital**
  - Dr. Ludwig described that Pentobarbital is similar to Fatal+ which both have a similar consistency to water; thus, we should be able to use the viscosity of water in any fluid dynamic calculations as Pentobarbital's viscosity is unknown
- **Force to Plunge Syringe**
  - Dr. Ludwig enlightened us that we may be missing the force required to overcome the "pushback" due the gauge pressure of the vein that we are trying to inject into
    - This website (https://www.chegg.com/homework-help/32-n-force-applied-plunger-hypodermic-needle-diameter-plunge-chapter-10-problem-73gp-solution-9780321625922-exc) has a problem that we can run to help us factor in the gauge pressure of the jugular vein
- **Hazard Research for Motor**
  - During the meeting, Cate brought up some key considerations (brought to her by the client) in regard to the safety of our purposed motor.
    - We are thinking of going forward with (https://www.omc-stepperonline.com/linear-stepper-motor/nema-17-non-captive-34mm-stack-04a-lead-2mm007874-length-150mm-17ls13-0404n-150d.html?mfp=178-motor-type%5BNon-Captive%2CExternal%5D%2C179-lead-travel-revolution-mm%5B2%5D%2C181-lead-screw-length-mm%5B140%2C150%5D)
      - We will need to research Brushless motor fire hazards (where fires typically start if we need to apply lubricant) and how these motors operate in oxygen rich environments

Conclusions/action items:

The next steps will be to finalize our investigations into the safety considerations for the stepper motor and then move to purchase the stepper motor with its coupled leadscrew.

2020/10/07 - Design Matrix & Preliminary Designs

Marshall Walters - Oct 07, 2020, 11:37 P

Title: Design Matrix & Preliminary Designs

Date: 10/7/2020

Content by: Team

Present: Team

Goals: To capture our design matrix, its criteria, and our preliminary designs.

Content:

- **Design Matrix & Criteria**
Designs	Rack and Pinion		Linear Actuator		Lead Screw Plunge	
Reliability (30)	3	18	4	24	5	30
Efficiency (25)	5	25	3	15	4	20
Robustness (20)	4	16	3	12	5	20
Feasibility (15)	4	12	5	15	3	9
Ease of Use (10)	4	8	4	8	5	10
Cost (5)	5	5	1	1	3	3
Total (100)	84		75		92	

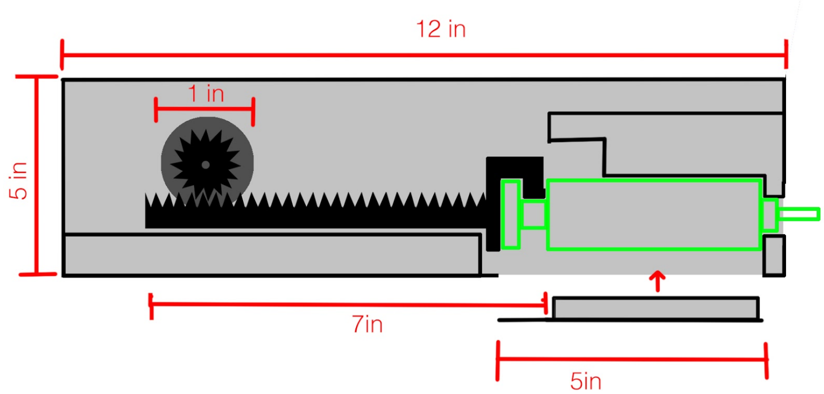
    - Criteria:
      - **Reliability:** Consistent delivery of expected results; the mechanical pumping system must be able to be used over and over without worry of it malfunctioning; if the system fails to be reliable, the animal's well-being may be at stake
      - **Feasibility:** Can the design be constructed and developed in a reasonable amount of time?
      - **Ease of Use:** Can the syringe be easily inserted into the design? Does the remote activation system work through the glass or is it finicky?
      - **Robustness:** Can the design pass the hazard analysis or drop test? Will the box/components be able to withstand the pressure induced by the hyperbaric chamber (5 atm)?
      - **Efficiency:** Can the design effectively and speedily administer the desired dosage in a reasonable amount of time? Is the response time between the receiver and the remote button activation delay minimized?
      - **Cost:** How much will each unit cost to manufacture?
- **Preliminary Designs**
  - Rack and Pinion
    - The Rack and Pinion design utilized a small direct current motor to drive a pinion gear which was fixed to the motor's output shaft (Figure 1). The pinion gear was in constant contact with a linear rack gear that was pinned against a smooth surface by the pinion gear. This gearing was able to translate the rotational motion of the motor into linear motion. The linear motion generated by this assembly was then used to depress the plunger of the syringe, since the syringe and rack gear were in constant contact. The rack gear was attached to the plunger of the syringe via a hook-like protrusion on the gear's end, which the end of the plunger slotted into (Figure 1). This protrusion's purpose was twofold: prevent accidental depression caused by the air pressure and prevent the syringe from shifting in its chamber. The high air pressure within the chamber could have depressed the plunger, since the liquid inside was filled at 1 ATM, and thus a pressure differential existed around the syringe. The protrusion on the rack gear locked the plunger in place, preventing this accidental discharge. Additionally, the protrusion kept the syringe in place by stabilizing it from the back. Other directional stabilization was provided by chocks molded into the device's housing, and the chock attached to the removable trapdoor (Figure 1). The syringe was to be loaded and removed from the device through this removable trapdoor located on the underside of the device housing. The syringe was loaded in a similar manner to a shotgun shell, in that the nose is pushed up and into the chamber, which then allows it to slide forward as the back slides up and in. Once in, it is completely encased by chocks, locking it in place. This device had two advantages over the other designs, namely efficiency and cost. It would have been made primarily out of 3D printed carbon fiber reinforced PLA, which costs around $33 per kilogram, and approximately 700 grams would have been needed to print this design. This would have been cheaper than the other designs, which would have been made out of metal or wood. It also used a small DC motor which had a relatively low power draw, and the nature of the rack and pinion gear assembly would have allowed the motor to depress the syringe with relatively little energy.
    - 

      Figure 1: A side view of the Rack and Pinion design with dimensions labeled in inches
  - Linear Actuator
    - The Linear Actuator design utilized two commercial linear actuator systems placed within a housing with their respective plunger arms interfacing with syringes (Figure 2). This design offers three key functionalities. First, the syringe would be able to be easily inserted into the box with the flat side of

its plunger interfacing with the arm of the linear actuator where a holding apparatus keeps the syringe plunger from depressing prematurely due to the high pressures of the hyperbaric chamber. Subsequently, once used, the syringes are easily removable from the apparatus as to facilitate its use for the client. Second, the design made use of robust, consistent linear actuators to drive the plunging motion of the syringe when required by the user (Figure 2). These linear actuators are able to be purchased from commercial vendors with the specific function of translating an object linearly. As these are commercial systems, this would give confidence that the system would work consistently and without fail for many cycles. These linear actuators would be capable of being wired to a control board PCB that can interface and read the input of a receiver that can direct function. Once activated, linear actuators can generate high forces; however, they tend to act very slowly over their defined displacement. That being said, this function provided confidence that the linear actuator would be able to depress the plunger into the syringe without obstacle. Third, this design acts to incorporate two linear actuators within one housing that is controlled by a central control PCB (Figure 2). This PCB would read inputs from the user controller that could specify which linear actuator, and by extension, which syringe is required to be depressed. This would enable only one system to be built that includes selectivity for which syringe is to be activated depending on the sheeps' conditions within the chamber and to the discretion of the user. Although this design offered consistency, selectivity, and robustness, the linear actuators are often very expensive than other linear motion motors. That being said, the pressure induced by the hyperbaric chamber also presents challenges in finding a linear actuator that can hold up to the pressures. As the linear actuators are often closed systems, the high pressure induced by the hyperbaric chamber may pose risks in disrupting function of the design over repeated use. Furthermore, linear actuators tend to be heavy, and large which would put undue strain on the housing and those that move the apparatus.

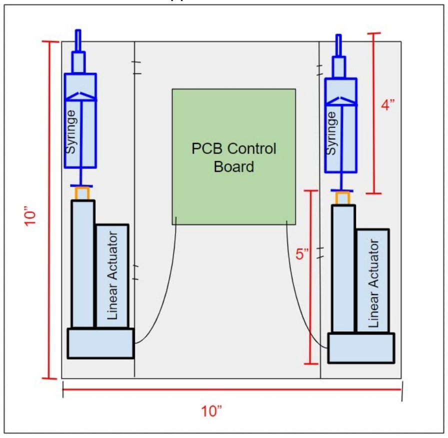
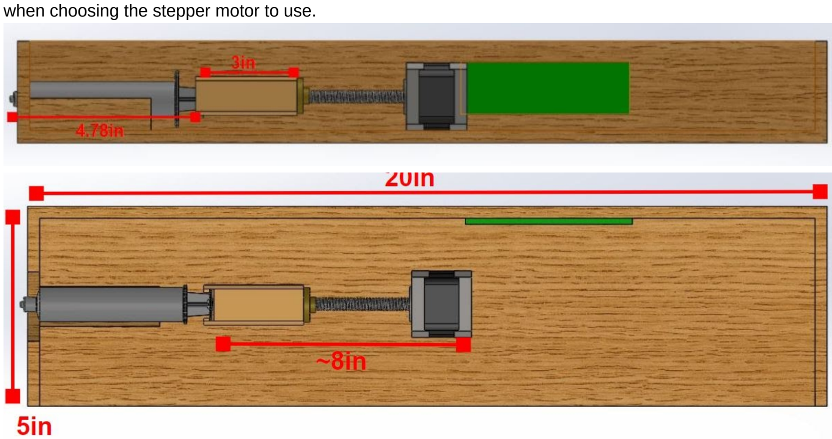
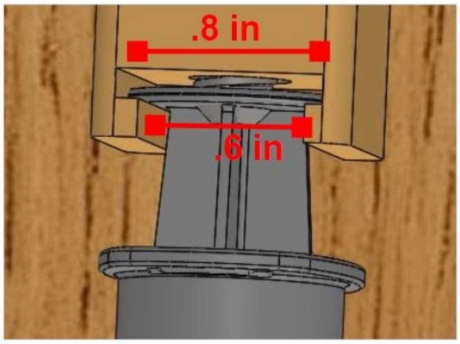
- 

Figure 2: A top view of the Linear Actuator design with dimensions labeled in inches

- Lead Screw Plunge
  - The Lead Screw Plunge utilized a lead screw coupled with a stepper motor in order to generate the linear motion required to depress the plunger of the syringe (Figure 3). The Lead Screw Plunge has three key parts that enable its function. First, the syringe was able to be easily slotted in the top of the apparatus such that the plunger of the syringe was able to interface with the holding cap (Figure 4) on the leadscrew and also be secured within the housing. The syringe would rest on a guide built into the housing that would pin the syringe between the front opening of the housing (where the tubing feeds through) and the holding cap (Figure 3). By enabling this functionality, this would enable the user to easily insert the syringe into the box without worrying about accidental discharge or rupturing the tubing. This is key as the device is to be used many times which would require reloading of the syringe and accidental discharge of the syringe would be detrimental for the client's experiment. Second, there is a holding cap that is capable of being threaded onto the leadscrew such that it holds the plunger of the syringe in place (just in case the 5 atm pressure of the chamber causes the syringe to naturally depress) and will also allow for the forced plunging of the syringe as the leadscrew is in contact with the top of the syringe through the holding cap (Figure 3). As the top of plunger is held in place within the holding cap, the holding cap prevents the syringe from prematurely discharging euthanasia solution as the chamber is is pressurized. Finally, the main linear pushing mechanism comes in the form of a leadscrew coupled with a stepper motor that essentially force feeds the leadscrew forward (the stepper motor "walks" away in a direction away from the syringe) into the plunger of the syringe. This motion causes the release of the euthanasia solution from the syringe into the sheep. Luckily, the stepper motor and lead screw set is highly customizable to the design considerations at hand in terms of depression speed and strength; thus, this system can be made to fit under any depression speed requirements defined by the client. This stepper motor is electrically controlled via a PCB control board which would enable an interface with a microcontroller that can control its function (after some calibration) after a remote signal is sensed. Although this design offers customizability, ease-of-use, and robustness, this design requires a fair amount of moving parts to work harmoniously which will require careful, patient calibration. Next, the stepper motor chosen may be loud which could startle the sheep; however, this was taken into consideration when choosing the stepper motor to use.
  - 

    - *Figure 3:* A side and top view of the Lead Screw Plunge design with dimensions labeled in inches.

- 

    - *Figure 4:* A closeup view of the interface between the plunger of the syringe and the slot in the holding cap with dimensions labeled in inches. The leadscrew is fed through the holding cap so it is still able to interface with the plunger to depress it upon controller activation.

Conclusions/action items:

The establishment of our Design Matrix and our Preliminary Designs was key in allowing our team to find our direction and which design we will be moving forward with. We will be moving forv with developing the Lead Screw Plunge into the future.

2020/10/13 - Syringe Measurements

Marshall Walters - Oct 13, 2020, 11:38

Title: Syringe Measurements

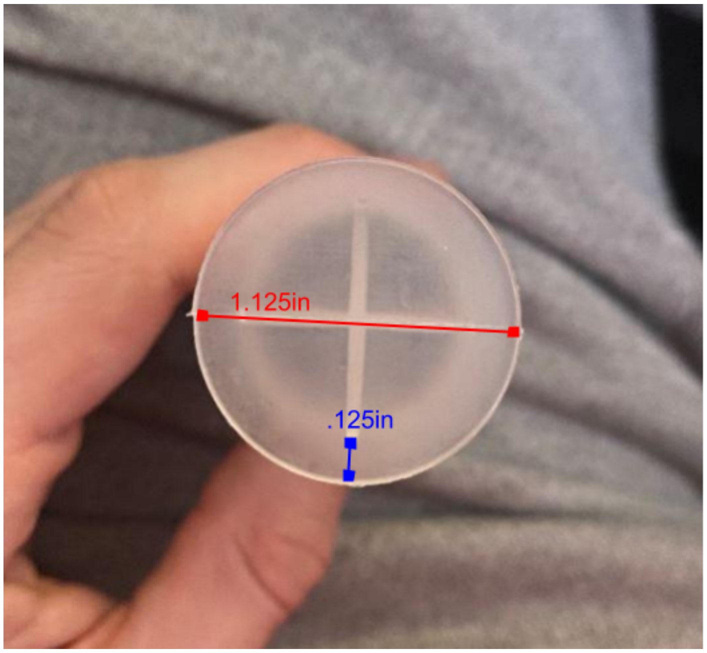
Date: 10/13/2020

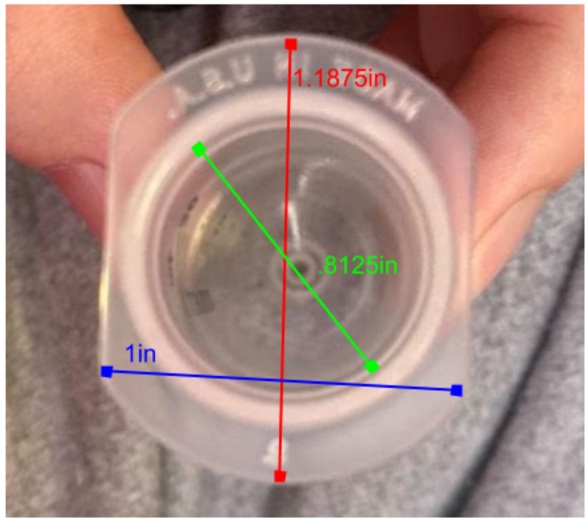
Content by: Marshall

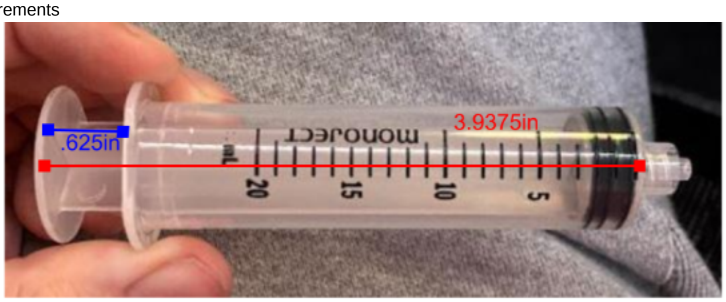
Present: N/A

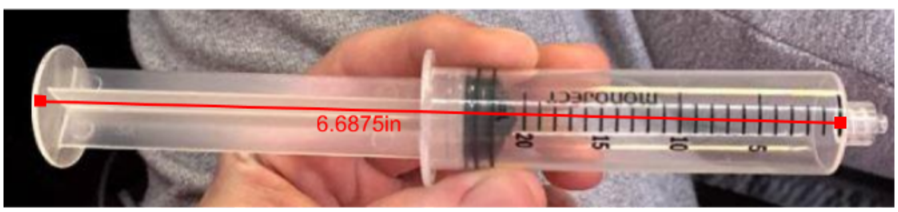
Goals: To capture the measurements of the syringe that the client will be using.

Content:

- Plunger & Internals
  - 



- Side Profile Measurements
  - 



Conclusions/action items:

The next steps will be to use these dimensions in order to appropriately scale the housing, holding cap, and leadscrew. Onward to design!

2020/11/02 - Stepper Motor Measurements

Marshall Walters - Nov 02, 2020, 3:30 PM CST

Title: Stepper Motor Measurements

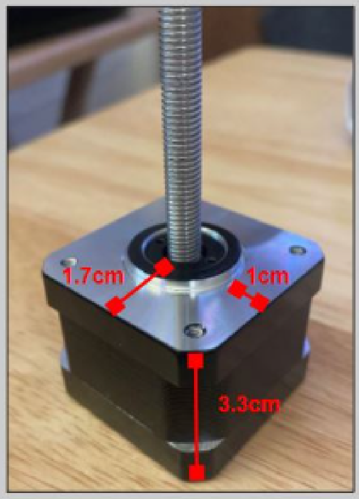
Date: 11/2/2020

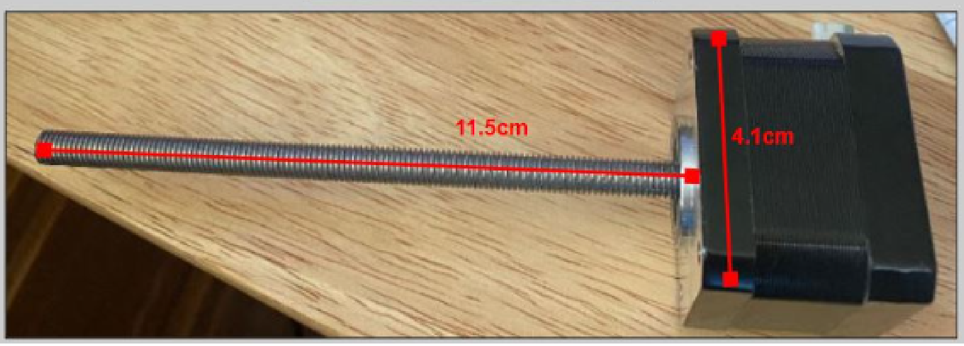
Content by: Marshall

Present: N/A

Goals: To capture the key measurements of the stepper motor for use in the project.

Content:





Conclusions/action items:

The next steps to use these measurements to create the back half of the structural housing.

2020/12/08 - Final Expense Report

Title: Final Expense Report

Date: 12/8/2020

Content by: Arnie & Riley

Present: N/A

Goals: To document and organize all expenses for the project.

Content:

Dates	Product Name	Link to Part
10/19/20	Carbon Fiber Filament	
10/19/20	Stepper Motor	https://www.omc-stepperonline.com/nema-17-non-captive-34mm-stac
11/16/20	Microcontroller	https://www.digikey.com/en/products/detail/microchip-technology/AT89S52-24PU/1008597?s
11/16/20	33pF Capacitor	https://www.digikey.com/en/products/detail/tdk-corporation/FA28C0G1H330JNU00/738
11/16/20	Crystal Oscillator	https://www.digikey.com/en
11/25/20	Voltage Regulator	https://www.digikey.com/en/products/detail/maxim-integrated/MAX751CPA/1240221
11/25/20	3.7 V Battery	https://www.digikey.com/en/products/detail/sparkfun-electronics/PRT-
11/25/20	0.47µF Capacitor	https://www.digikey.com/en/products/detail/tdk-corporation/FA16X7R1H474KNU00/738
11/25/20	4.7µF Capacitor	https://www.digikey.com/en/products/detail/tdk-corporation/FG26X7R1H475KRT00/73
11/25/20	22µH Inductor	https://www.digikey.com/en/products/detail/bourns
11/25/20	20V Diode	https://www.digikey.com/en/products/detail/stmicroelectronics/1N5817/770
11/25/20	12V Battery	https://www.digikey.com/en/products/detail/panasonic-bsg/HHR-150AAB01F10/
11/25/20	Double Sided Tape	https://www.amazon.com/Gori dchild=1&keywords=Gorilla+Heavy+Duty+Double+Sided+Mounting+Tape%2C+1%22+x+60%2
11/25/20	Wire Kit	https://www.amazon.com/Fermerry dchild=1&keywords=Fermerry+22AWG+Stranded+Wire+Electric+Fence+Wire+Tinned+Copper+Hook+up+Wire+Kit+22+Gauge+6+Colors+10Ft+Each%2810+
11/25/20	Toggle Switch	https://www.grainger.com/product/4X203?gclid=Cj0KCQiA-rj9BRCAARIsANB_4AC7IVLcH7VY3ExNEiZF8lyDr-xTy4-MNmsq3RlgQZ4kEdId10mnouYaAu rj9BRCAARIsANB_4AC7IVLcH7VY3ExNEiZF8lyDr-xTy4-MNmsq3RlgQZ4kEdId10mnouYaAuDUEALw_wcB:G:s&s_kwcid=AL!2966!3!2

2020/10/07 - 3D Printing Protocol

Marshall Walters - Oct 07, 2020, 11:11 PM CDT

Title: 3D Printing Protocol

Date: 10/7/2020

Content by: Noah Williams

Present: N/A

Goals: To outline the protocol and process for 3D printing.

Content:

There are 4 components to any 3D printed part: the ceiling, floor, infill, and shell. The shell consists of a set number of concentric and adjacent walls that runs along the vertical axis of the print. The ceiling and floor consist of a set number of completely solid layers of material, and sit on top of and below the shell. Together, the shell, ceiling, and floor form a complete and connected surface. This surface bounds the infill, which is a three dimensional grid with hollow cells. Infill is calculated as a percentage of interior volume. Since the components all needed to withstand 5 ATM of pressure, resistance to deformation from pressure was the key parameter that was optimized during the printing process.

Each part was printed with the following settings:

1. A 0.4 mm extruder nozzle was used because it offered a good balance between horizontal adhesion and precision.
2. A layer height of 0.12 mm was used because it promoted strong vertical adhesion and minimized layer lines on slanted top/bottom surfaces.
3. A shell width of 1.6 mm (4 passes) was used, since it provided a good balance between weight and resistance to deformation.
4. A ceiling and roof thickness of 1.08mm (9 layers) was used since it provided a top and bottom with a similar strength to the shell, to maintain uniformity.
5. An infill density of 40% was used. Although a much lower infill density, as low as 15%, would have sufficed, the design team felt it was important to “over-build” the components due to the catastrophic events that could have occurred if this device had failed.
6. A hot-end temperature of 210℃ was used as per the filament manufacturer’s recommended settings.
7. A heated bed and enclosure were not used, as PLA does not require either.

Conclusions/action items:

This will be useful when we move to 3D print the structural components for the remote euthanasia system. This provides a clear protocol that is required to operate a 3D printing system.

2020/12/08 3D modeling

NOAH WILLIAMS - Dec 08, 2020, 9:50 PM CST

Title: 3D Modeling Information

Date: 11/23

Content by: Noah Williams

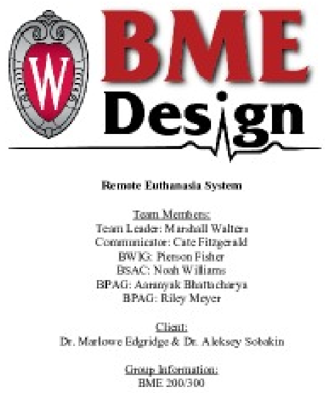
Goals: to describe the process for 3D modeling and exporting models for 3d printing

Content: I designed two of the four 3d printed components for the device. The first part, the motor holder, was designed in SOLIDWORKS. It was designed to be able to guide the holding cap while it moves forward and backwards with the lead screw, as well as to hold the stepper motor. I wanted to allow movement between the holding cap and the motor holder, but wanted the stepper motor to be held inside the part through friction alone. This was able to be accomplished by varying the tolerances that were used. No tolerance was built into the motor compartment, so that when the 3D printer inevitably over extruded on portions of the part, it would help to wedge the motor in. A 0.5 mm tolerance was used between the holding cap and the walls of the guide portion of the motor holder. For the pegs, which would slot into the syringe holder, a 0.24 mm tolerance was used, as that equivalent to half of the distance that I have set my 3d printer to leave between the support material and the model. Support was used on the bottom side of the peg and the top side of the hole that it connects into, it could be expected that each part could have variances of up to .12 mm, which necessitated a .24 mm tolerance.

The second component, the holding cap, was designed in Fusion 360. Before printing this piece, I printed 13 test prints of 5mm tall circular nuts with varying thread sizes, as the thread of the lead screw, 6.35x2 was not available in fusion. I tested each of these test nuts by attempting to thread them on the lead screw, and then varying the next one accordingly until I had a thread size that would thread on. I eventually settled on an m7x0.5 pipe threading. It allowed the lead screw to thread in completely. The holding cap is likely to be the first failure point of the device, since it is the only connection between the motor and the lead screw. Because of this, I wanted to make sure it was very strong, so I made each wall as thick as I could.

Product Design Specifications - PDS

Marshall Walters - Oct 07, 2020, 11:05 PM CDT


BME Design

Remote Euthanasia System

Team Members:
Team Leader: Marshall Walters
Communicator: Cate Fitzgerald
BWIG: Pierson Fisher
BSAC: Noah Williams
BPAG: Aaranyak Bhattacharya
BPAG: Riley Meyer

Client:
Dr. Marlowe Edgridge & Dr. Aleksey Sobakin

Group Information:
BME 200/300

PDS_-_Remote_Euthanasia_System.pdf(386.4 KB) - download

Progress Reports

Marshall Walters - Oct 07, 2020, 11:02 PM CDT

Remote Euthanasia System (remote_euthanasia_system)

Client: Dr. Aleksey Sobakin
Client contact: Dr. Aleksey Sobakin - sobakin@wisc.edu
Alternate contact: Prof Marlowe Eldridge - meldridge@pediatrics.wisc.edu

Advisor: Dr. Kip Ludwig - kip.ludwig@wisc.edu

Team Members:
Marshall Walters - mwalters@wisc.edu - (Team Leader)
Cate Fitzgerald - cmfitzgerald3@wisc.edu - (Team Communicator)
Pierson Fisher - pfisher@wisc.edu - (BWIG)
Aunnayak Bhattacharya - abhattacha25@wisc.edu - (BPAG)
Riley Meyer - rbmeyer@wisc.edu - (BPAG)
Noah Williams - nmwilliams2@wisc.edu - (BSAC)

Date: September 24th, 2020

Problem Statement
Due to a new contract with the Navy, Dr. Aleksey Sobakin and Dr. Marlowe Eldridge are testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom of the ocean. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have three main subsystems. For the housing subsystem, There must be a way to secure the syringe within the device and to prevent it from moving or being accidentally discharged. For the injection subsystem, there must be a way to pump the euthanasia solution out of the syringe and into the vein in a timely, complete manner. Finally, the their must be a remote control subsystem, that enable the device to perform the injection protocol upon a button press by a researcher outside of the hyperbaric chamber.

Brief Status Update
We have been working to complete the Product Design Specifications to the best of our ability despite not having a client meeting yet. We plan on updating the PDS with any new information that we find out. Furthermore, we are continuing to research key pieces of our design in order to be able to produce our three designs for the design matrix.

9-24-2020_--_Progress_Report.pdf(134.3 KB) - download

Marshall Walters - Oct 07, 2020, 11:02 PM CDT

Remote Euthanasia System (remote_euthanasia_system)

Client: Dr. Aleksey Sobakin
Client contact: Dr. Aleksey Sobakin - sobakin@wisc.edu
Alternate contact: Prof Marlowe Eldridge - meldridge@pediatrics.wisc.edu

Advisor: Dr. Kip Ludwig - kip.ludwig@wisc.edu

Team Members:
Marshall Walters - mwalters@wisc.edu - (Team Leader)
Cate Fitzgerald - cmfitzgerald3@wisc.edu - (Team Communicator)
Pierson Fisher - pfisher@wisc.edu - (BWIG)
Aunnayak Bhattacharya - abhattacha25@wisc.edu - (BPAG)
Riley Meyer - rbmeyer@wisc.edu - (BPAG)
Noah Williams - nmwilliams2@wisc.edu - (BSAC)

Date: September 17th, 2020

Problem Statement
Due to a new contract with the Navy, Dr. Aleksey Sobakin and Dr. Marlowe Eldridge are testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom of the ocean. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have various subsystems. For the housing subsystem, There must be a way to secure the injection system to the sheep and to prevent it from moving. For the needle movement subsystem, there must be a way to inject and to retract the needle into the desired vein. Finally, for the injection subsystem, there must be a way to pump the euthanasia solution out of the needle and into the vein in a timely, complete manner.

Brief Status Update
We have been working to complete the Product Design Specifications to the best of our ability despite not having a client meeting yet. We plan on updating the PDS with any new information that we find out. Furthermore, we are continuing to research key pieces of our design in order to be able to produce our three designs for the design matrix.

Summary of Weekly Team Member Design Accomplishments
- Team:
  - Completed the PDS Draft
  - Will meet with the clients on Friday (9/18)
  - Continuing LabArchives research into project designs
- Marshall Walters:

9-17-2020_--_Progress_Report.pdf(111 KB) - download

Marshall Walters - Oct 07, 2020, 11:02 PM CDT

Remote Euthanasia System (remote_euthanasia_system)

Client: Dr. Aleksey Sobakin
Client contact: Dr. Aleksey Sobakin - sobakin@wisc.edu
Alternate contact: Prof Marlowe Eldridge - meldridge@pediatrics.wisc.edu

Advisor: Dr. Kip Ludwig - kip.ludwig@wisc.edu

Team Members:
Marshall Walters - mwalters@wisc.edu - (Team Leader)
Cate Fitzgerald - cmfitzgerald3@wisc.edu - (Team Communicator)
Pierson Fisher - pfisher@wisc.edu - (BWIG)
Aamayak Bhattacharya - abhattacha25@wisc.edu - (BPAG)
Riley Meyer - rbmeyer@wisc.edu - (BPAG)
Noah Williams - nmwilliams2@wisc.edu - (BSAC)

Date: September 10th, 2020

Problem Statement
Due to a new contract with the Navy, Dr. Aleksey Sobakin and Dr. Marlowe Eldridge are testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom of the ocean. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have various subsystems. For the housing subsystem, There must be a way to secure the injection system to the sheep and to prevent it from moving. For the needle movement subsystem, there must be a way to inject and to retract the needle into the desired vein. Finally, for the injection subsystem, there must be a way to pump the euthanasia solution out of the needle and into the vein in a timely, complete manner.

Brief Status Update
Not much was accomplished during this first week. All Day 1 Design Tasks were completed. The team developed a preliminary problem statement for the progress report. Both Dr. Kip Ludwig and Dr. Aleksey Eldridge were contacted in order to set up meeting times. We also created a tentative schedule for the year.

Summary of Weekly Team Member Design Accomplishments
- Team:
  - Complete Day 1 Tasks.
  - Get into contact with Dr. Kip Ludwig and arrange a weekly meeting time.
  - Get into contact with Dr. Aleksey Eldridge and arrange an initial meeting time with him.

9-10-2020_--_Progress_Report.pdf(110.4 KB) - download

Marshall Walters - Oct 07, 2020, 11:04 PM CDT

Remote Euthanasia System (remote_euthanasia_system)

Client: Dr. Aleksey Sobakin
Client contact: Dr. Aleksey Sobakin - sobakin@wisc.edu
Alternate contact: Prof Marlowe Eldridge - meldridge@pediatrics.wisc.edu

Advisor: Dr. Kip Ludwig - kip.ludwig@wisc.edu

Team Members:
Marshall Walters - mwalters@wisc.edu - (Team Leader)
Cate Fitzgerald - cmfitzgerald3@wisc.edu - (Team Communicator)
Pierson Fisher - pfisher@wisc.edu - (BWIG)
Aamayak Bhattacharya - abhattacha25@wisc.edu - (BPAG)
Riley Meyer - rbmeyer@wisc.edu - (BPAG)
Noah Williams - nmwilliams2@wisc.edu - (BSAC)

Date: October 1st, 2020

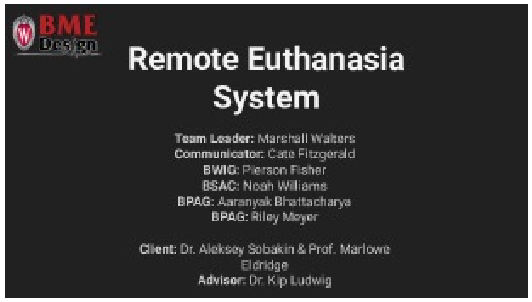
Problem Statement
Due to a new contract with the Navy, Dr. Aleksey Sobakin and Dr. Marlowe Eldridge are testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom of the ocean. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have three main subsystems. For the housing subsystem, There must be a way to secure the syringe within the device and to prevent it from moving or being accidentally discharged. For the injection subsystem, there must be a way to pump the euthanasia solution out of the syringe and into the vein in a timely, complete manner. Finally, there must be a remote control subsystem that enables the device to perform the injection protocol upon a button press by a researcher outside of the hyperbaric chamber.

Brief Status Update
We have been working to update the Product Design Specifications to reflect the information we gathered from the client meetings and from our design matrix. Furthermore, we have come to decide on a final design that we will be moving forward in prototyping and creating for this project, the Lead Screw Plunge. This device makes use of a lead screw and stepper motor combination to forcefully at a controlled rate expel all sodium pentobarbital into the sheep on queue.

Progress_Report_10_1_20.pdf(135.2 KB) - download

Preliminary Presentation

Marshall Walters - Oct 07, 2020, 11:14 PM CDT



,

Remote_Euthanasia_System_-_Preliminary_Presentation_-_BME300_200.pdf(1007.6 KB) - download

Preliminary Paper

Marshall Walters - Oct 09, 2020, 12:54 AM CDT

Remote Euthanasia System

Preliminary Design Report
Biomedical Engineering Design 200/300
Department of Biomedical Engineering
University of Wisconsin-Madison
October 9th, 2020

Team Members:
Team Leader: Marshall Walters
Communicator: Cate Fitzgerald
BWIG: Pierson Fisher
BSAC: Noah Williams
BPAG: Aamayak Bhattacharya
BPAG: Riley Meyer

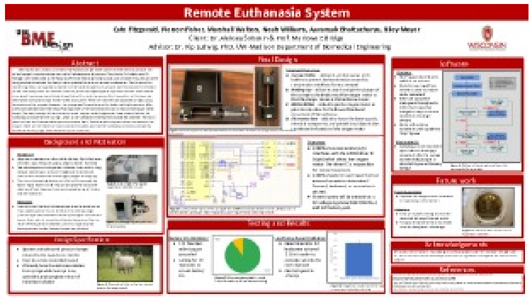
Client:
Dr. Aleksey Sobakin
Dr. Marlowe Edgridge

Advisor:
Dr. Kip Ludwig

Preliminary_Report.pdf(613.4 KB) - download

Final Poster

Marshall Walters - Dec 07, 2020, 9:09 PM CST



2020_Final_Poster.pdf(1.8 MB) - download

Marshall Walters - Dec 07, 2020, 9:09 PM CST

RemoteEuthanasiaSystem_FinalPosterPresentation_MarshallPiersonCateArnieRileyNoah_BME300200.mp4(30.5 MB) - download

Final Paper

Marshall Walters - Dec 08, 2020, 9:40 PM CST

Remote Euthanasia System

Final Design Report
Biomedical Engineering Design 200/300
Department of Biomedical Engineering
University of Wisconsin-Madison
December 9th, 2020

Team Members:
Team Leader: Marshall Walters
Communicator: Cate Fitzgerald
BWIG: Pierson Fisher
BSAC: Noah Williams
BPAG: Aamayak Bhattacharya
BPAG: Riley Meyer

Client:
Dr. Aleksey Sobakin
Dr. Marlowe Edgridge

Advisor:
Dr. Kip Ludwig

remote_injection-Final_Report.pdf(4 MB) - download

Team Meeting 9/4/20

CATE FITZGERALD - Sep 07, 2020, 7:11 PM CDT

Title: Team Meeting 9/4/20

Date: 9/4/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald, Marshall Walters, Pierson Fisher, and Riley Meyer, Aaranyak Bhattacharya, Noah Williams Jr.

Goals: Discuss initial project logistics.

Content:

GOALS: Set up a microsoft Teams account, it is how we will communicate & virtually meet.
Choose a current picture and a Baby picture, and send them to prfisher@wisc.edu as soon as possible.
ALL – SWAP COURSE ENROLLMENT INTO YOUR ADVISOR'S LAB SECTION
200s -- You've got to pick your role
Noah -- BSAC
Arnie -- BPAG
Riley -- BPAG
Which meeting time do you prefer?
Thursdays @ 6:30pm - 7:30pm
Mondays @ 6:30pm - 7:30pm
BSAC - Sign up to be a Mentor
Please write out your phone numbers so we can make a GroupMe
Cate -- 847-217-5061
Pierson -- 262-388-7060
Marshall -- 213-359-3815
Noah -- (608) 609-4745
Riley -- 608-295-3654
Aaranyak -- 414-943-7458
Advisor Meeting
2:00pm - 2:30pm
1:30pm - 2:00pm
1:00pm - 1:30pm
Start Research!!

Meeting Times:

Thursdays @ 6:30pm - 7:30pm
Mondays @ 6:30pm - 7:30pm

Marshall
Monday after 2:30pm
Tuesdays after 5:30pm
Wednesdays after 5pm
Thursdays after 12pm
Friday after

Cate
Monday after 1pm
Tuesday after 3:30pm
Friday after 11pm
Thursday after 6pm
Friday after 11pm (I think it would be best to meet after or before our client meetings on Friday)
Monday or Wednesday I will be ay my lab and my hours will change, but that is TBD

Pierson:
Everyday after 5:30 (Not Tuesday after 7)

Conclusions/action items: During this meeting, we discussed the basics of this project and when we are able to meet. We scheduled a team meeting for Monday, 9/7/20. We all completed Day 1 Tasks and contacted Dr. Kip Ludwig and arranged a weekly meeting time. Cate contacted Dr. Aleksey Eldridge and arranged an initial meeting time with him. We would all like to begin background research on sheep anatomy, past research or patents, history of euthansia treatments, and client wants/needs.

Team Meeting 9/7/20

Marshall Walters - Sep 07, 2020, 9:45 PM CDT

Title: Team Meeting 9/7/20

Date: 9/7/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald, Marshall Walters, Pierson Fisher, and Riley Meyer

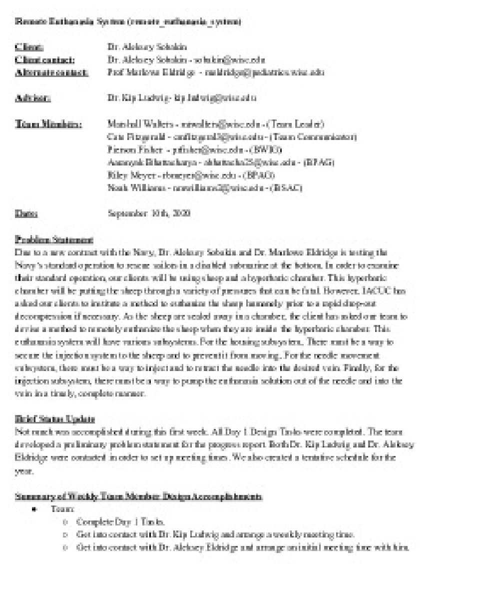
Goals: Complete our first progress report.

Content:

See attached.

Conclusions/action items: During this meeting, we completed our first progress report. We also discussed project logistics and LabArchive entries. We would like to send our initial progress report to our client, and set up a meeting time with our client. We will also meet with our advisor on Friday. This week, we will also begin research on basic anatomy, past research or patents, and history of euthansia treatments.

Marshall Walters - Sep 07, 2020, 9:45 PM CDT



Remote Euthanasia System (remote_euthanasia_system)

Client: Dr. Aleksey Sobolkin
Client contact: Dr. Aleksey Sobolkin - sobolkin@wisc.edu
Alternate contact: Prof Marlowe Eldridge - meldridge@pediatrics.wisc.edu

Advisor: Dr. Kip Ludwig - kip.ludwig@wisc.edu

Team Members: Marshall Walters - mwalters@wisc.edu - (Team Leader)
Cate Fitzgerald - cmfitzgerald3@wisc.edu - (Team Communicator)
Pierson Fisher - pfisher@wisc.edu - (BWIG)
Aaranyak Bhattacharya - abhattacha25@wisc.edu - (BPAG)
Riley Meyer - rbmeyer@wisc.edu - (BPAG)
Noah Williams - nmwilliams2@wisc.edu - (BSAC)

Date: September 10th, 2020

Problem Statement
Due to a new contract with the Navy, Dr. Aleksey Sobolkin and Dr. Marlowe Eldridge is testing the Navy's standard operation to rescue sailors in a disabled submarine at the bottom. In order to examine their standard operation, our clients will be using sheep and a hyperbaric chamber. This hyperbaric chamber will be putting the sheep through a variety of pressures that can be fatal. However, IACUC has asked our clients to institute a method to euthanize the sheep humanely prior to a rapid drop-out decompression if necessary. As the sheep are sealed away in a chamber, the client has asked our team to devise a method to remotely euthanize the sheep when they are inside the hyperbaric chamber. This euthanasia system will have various subsystems. For the housing subsystem, There must be a way to secure the injection system to the sheep and to prevent it from moving. For the needle movement subsystem, there must be a way to inject and to retract the needle into the desired vein. Finally, for the injection subsystem, there must be a way to pump the euthanasia solution out of the needle and into the vein in a timely, complete manner.

Brief Status Update
Not much was accomplished during this first week. All Day 1 Design Tasks were completed. The team developed a preliminary problem statement for the progress report. Both Dr. Kip Ludwig and Dr. Aleksey Eldridge were contacted in order to set up meeting times. We also created a tentative schedule for the year.

Summary of Weekly Team Member Design Accomplishments
- Team:
  - Complete Day 1 Tasks.
  - Get into contact with Dr. Kip Ludwig and arrange a weekly meeting time.
  - Get into contact with Dr. Aleksey Eldridge and arrange an initial meeting time with him.

9-7-2020_-_Progress_Report.pdf(110.3 KB) - download

Team Meeting 9/14/20

RILEY MEYER - Sep 14, 2020, 3:56 PM CDT

Title: Team Meeting 9/14/2020

Date: 9/14/2020

Content by: Riley Meyer

Present: Riley Meyer, Cate Fitzgerald, Marshall Walters, Pierson Fisher, Aaranyak Bhattacharya, and Noah Williams Jr.

Goals: Work on our Product Design Specifications

Content:

- Started work on the PDS
- Started talking about initial design ideas
- Assigned roles to fill in the PDS
- Discussed different methods of euthanization

Conclusions/action items:

During this meeting we worked on our Product Design Specifications. We also assigned roles to fill in different aspects of the PDS. We will be able to have more thorough answers to the PDS after our client meeting this Friday. Later this week we will be able to finish the PDS and fill our client in with some design ideas. In addition to prior statements, we will be continuing research and refining our ideas.

Team Meeting 9/17/20

RILEY MEYER - Sep 17, 2020, 6:45 PM CDT

Title: Team Meeting 9/17/20

Date: 8/17/2020

Content by: Riley Meyer

Present: Riley Meyer, Cate Fitzgerald, Marshall Walters, Pierson Fisher, Aaranyak Bhattacharya, and Noah Williams Jr.

Goals: Continue working on the PDS

Content:

- Continued working on the PDS
- Proof read all aspects of the PDS
- Organized sections of the PDS and questions for the client

Conclusions/action items:

During this meeting we worked to finalize the initial PDS. Each team member worked to edit and proofread the document up until completion. Our top priority after meeting with the client is coming up with designs for the design matrix with the information from the clients. At this point in the design process, we are waiting on a client meeting to continue developing new ideas for the rest of the project.

2020/10/12 - Team Meeting (Future Plans)

Marshall Walters - Oct 13, 2020, 10:51 PM CDT

Title: Team Meeting (Future Plans)

Date: 10/13/2020

Content by: All

Present: All

Goals: To outline the key components that we need to hammer out so we can have a working product. Also, we want to specify some of our members to focus their time/research on specific sectors of the project.

Content:

- **Stepper Motor & Lead Screw**
    - We need to determine which motor we are going with and which lead screw we are going with
        - NEXT STEPS
            - Identify Stepper Motor & Order
            - Identify Lead Screw & Order
- **Structure/Housing** -- Noah/Riley
    - With the dimensions of the box/syringe, we need to finalize out Solidworks/CAD drawing of our box/guide for the syringe
        - NEXT STEPS
            - Finalize a housing that can hold Stepper Motor/Leadscrew & fully opened syringe (look at dimensions)
            - Finalize holder for syringe in box that will pin the syringe body from moving either forward or backward
            - Determine if 3D printing is best or if manufacturing it via wood is preferable
- **Holding Cap** -- Noah/Riley
    - With the new dimensions of the syringe, we need to finalize the Solidworks representation of the holding cap for printing
        - NEXT STEPS
            - Determine the best leadscrew nut to secure the holding cap onto
            - Confirm that the leadscrew nut works with our leadscrew
                - The opening of the Holding Cap must just be able to hold the plunger of the syringe and allow the leadscrew to interface with the plunger
            - Determine best length of holding cap
- **Circuitry (Stepper Motor Driver Circuit)**
    - Must be able to operate with the stepper motor that we have chosen
        - NEXT STEPS
            - Determine topology of circuit
            - Determine best components
            - Optimize the system to have the functionality we require
- **Circuitry (Battery)** -- Arnie
    - The stepper motor/lead screw setup in conjunction with PCB will need to last at a minimum 172 hours
        - NEXT STEPS
            - Determine the best power source (cannot be wired)
            - Determine how it will fit into housing
- **Circuitry (Wired Remote)** -- Arnie
    - Figure out how to make the stepper motor driver circuit remote controlled
        - NEXT STEPS
        - Look into existing technology
        - Look at how we can integrate a remote into our system
            - What type of remote?
                - Light switch? -- press a button to complete the circuit -- only operates when it needs to

Conclusions/action items:

The next immediate step will be to determine which Stepper motor and Leadscrew we will be using. After we determine the motor, the rest of the pieces will fall into place. While we are figuring out the motor, Riley/Noah will be focusing on modeling an updated design of the housing and holding cap. Arnie will be focusing his research on the battery and remote control.

2020/09/07 - Risks of a Hyperbaric Chamber

Marshall Walters - Sep 07, 2020, 10:13 PM CDT

Title: Risks of a Hyperbaric Chamber

Date: 9/7/2020

Content by: Marshall Walters

Present: N/A

Goals: To understand what type of health risks that a sheep may be put under when in the hyperbaric chamber.

Content:

[1] Hospital & Clinics, U., 2020. *Medical Risks Of Hyperbaric Oxygen Therapy*. [online] University of Iowa Hospitals & Clinics. Available at: <https://uihc.org/health-topics/medical-risks-hyperbaric-oxygen-therapy> [Accessed 8 September 2020].

As this article is in reference to human health risks, I will be isolating and making note of those that I believe may be applicable to sheep.

Medical Risks to Sheep in a Hyperbaric Chamber

- *Pneumothorax or Pulmonary barotrauma*
    - Lung tissue damage may occur due to the pressure change which can result in a collapsed lung
- *Decompression Sickness*
    - Result of the uptake of nitrogen into the blood when air is breathed at increased ambient pressure
    - Decompression Sickness can result in:
        - pain
        - neurological injury
        - cardiopulmonary collapse
        - possibly death (a painful death)

Conclusions/action items:

By understanding the health risks to the sheep that are placed into the hyperbaric chamber, it provides a better understanding as to why our project is important. Although the device will be used to take a life, the device will be doing so humanely, and in a process as painless as possible. This is a much better alternative than the issues connect to the hyperbaric chamber like decompression sickness and pneumothorax.

2020/09/07 - Lethal Injection Protocol for Sheep

Marshall Walters - Sep 07, 2020, 11:23 PM CDT

Title: Lethal Injection Protocol for Sheep

Date: 9/7/2020

Content by: Marshall Walters

Present: N/A

Goals: To understand the type of solution typically used for lethal injection and where the needle is placed for intravenous delivery in sheep.

Content:

[1] Hover, K., 2020. *Casualty In Sheep*. 1st ed. [ebook] https://www.sheepvetsoc.org.uk/, pp.1-11. Available at: <https://www.sheepvetsoc.org.uk/sites/default/files/Casualty%20sheep%20K%20Hover.pdf> [Accessed 8 September 2020].

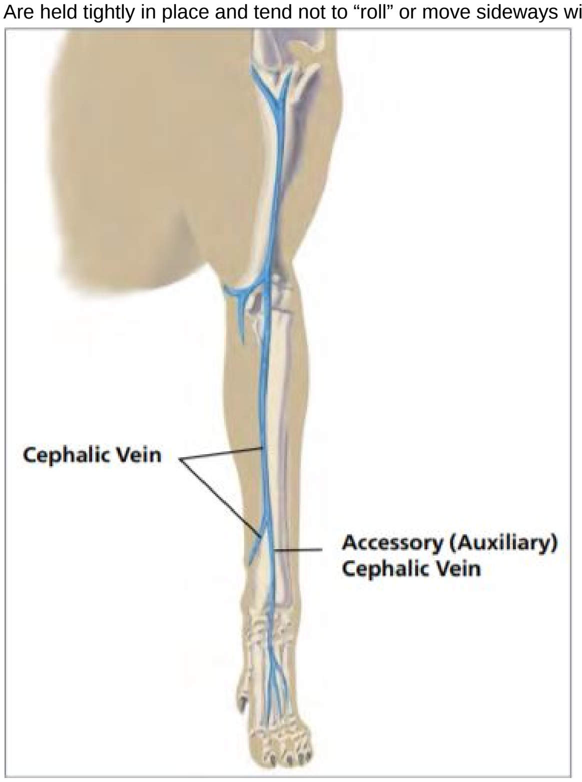
Typical Injection

- Typically, an overdose of anaesthetic (barbiturate) or sodium phenobarbital is utilized for the lethal injection

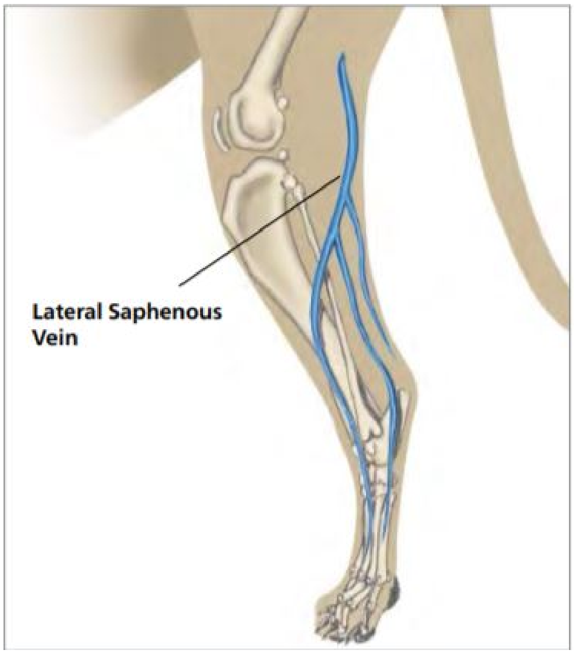
---

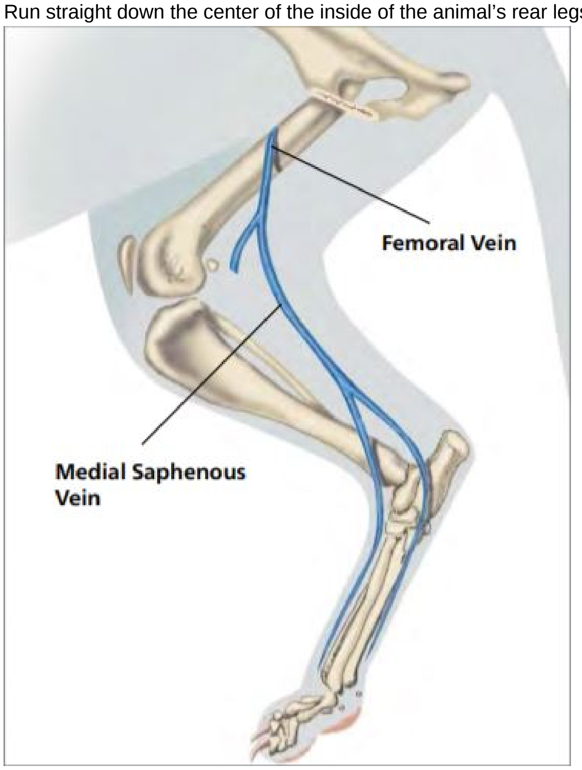
[2] 2013. *EUTHANASIA REFERENCE MANUAL*. 2nd ed. [ebook] The Humane Society of the United States, pp.7-21. Available at: <https://www.animalsheltering.org/sites/default/files/documents/euthanasia-reference-manual.pdf> [Accessed 8 September 2020].

Selecting Veins for IV Injection (Options)

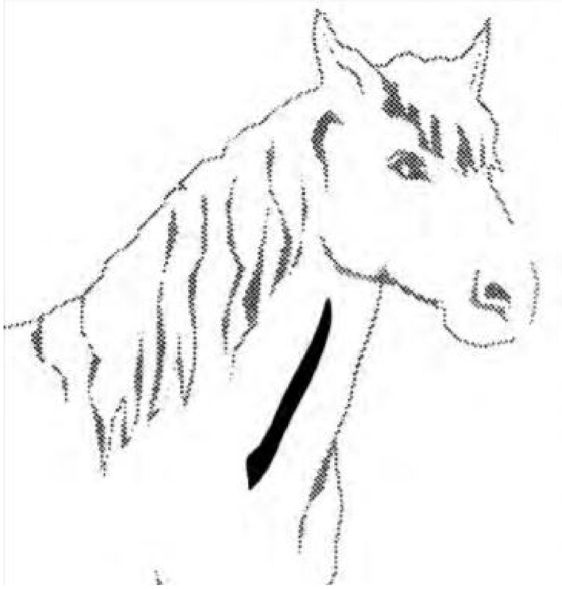
- **Cephalic Veins**
    - Run down the front of each foreleg of an animal
    - Are held tightly in place and tend not to "roll" or move sideways within the leg
    - 

- **Lateral saphenous veins**
    - Run down the outside of the animal's rear legs and then cross diagonally across the leg just above the hock.
    - Must be injected away from the hock joint or they can roll

- 

- **Medial Saphenous Vein (aka Femoral Veins)**
  - Run straight down the center of the inside of the animal's rear legs
  - 

- **Jugular Vein**
  - Run down each side of the neck of most mammals
  - Often visible in larger mammals

- 

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[3] Infovets.com. 2020. *Giving Injections*. [online] Available at: <https://www.infovets.com/healthysmrm/C275.htm> [Accessed 8 September 2020].

Protocol for Intravenous Injection for Sheep/Goats

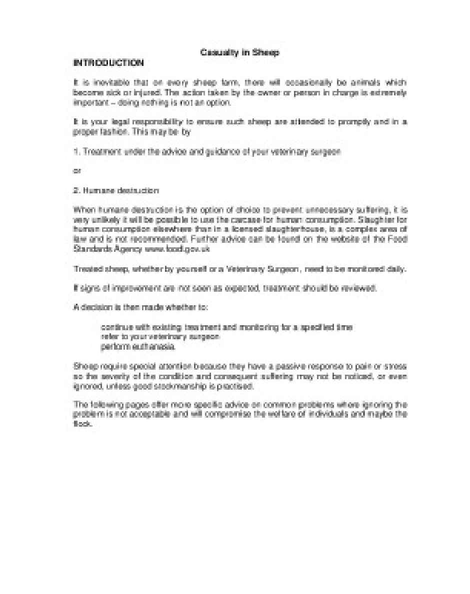
- Injections via IV means are spread to all tissues very rapidly
- Its best to use a needle **1 to 1 ½ inches in length** and **18-20 gauge in diameter**
- Protocol as described by the article:
    - **1.** "This picture shows an easy way to restrain a sheep or goat when trying to administer an injection IV or when trying to collect blood out of the jugular vein."
        - 
    - **2.** "Clean the jugular region of the neck with alcohol. This will sanitize the area and make the vein easier to see. On animals with a lot of hair or wool, it sometimes helps to also clip the jugular area."
        - 

- **3.** "The thumb of one hand is placed on the lower portion of the vein. Once the vein is fully distended, the needle should be placed in a downward direction. Every effort should be made to avoid the carotid artery that is located just behind the jugular vein. No injection should ever be given in the carotid artery (see below for additional details). Once the needle is in place, the lower hand can be removed."
    - 
- **4.** "With the lower hand removed, no blood should come out of the needle. If blood continues to squirt out of the top of the needle, it could be in the carotid artery. If there is any question on the location of the needle, it should be removed and the process started over again. If everything seems correct, blood can be drawn or an injection can be given."
    - 

Conclusions/action items:

These articles provided great insight into the intravenous injection process for mammals, including sheep. It appears that we will have four veins to choose from with the jugular vein potentially being the easiest to inject into with a stationary system attached to the neck of the sheep. It is likely that a barbiturate overdose will be used in the experiment; however, we can confirm this with our clients. We will look into using a needle with **1 to 1 ½ inches in length** and **18-20 gauge in diameter** as its specifications. Finally, we will take extra effort to avoid the carotid artery and to insert the needle downward toward the feet of the animal.

Marshall Walters - Sep 07, 2020, 11:23 PM CDT



Casualty in Sheep

INTRODUCTION

It is inevitable that on every sheep farm, there will occasionally be animals which become sick or injured. The action taken by the owner or person in charge is extremely important – doing nothing is not an option.

It is your legal responsibility to ensure such sheep are attended to promptly and in a proper fashion. This may be by

1. Treatment under the advice and guidance of your veterinary surgeon

or

2. Humane destruction

When humane destruction is the option of choice to prevent unnecessary suffering, it is very unlikely it will be possible to use the carcase for human consumption. Slaughter for human consumption elsewhere than in a licensed slaughterhouse, is a complex area of law and is not recommended. Further advice can be found on the website of the Food Standards Agency www.food.gov.uk

Treated sheep, whether by yourself or a Veterinary Surgeon, need to be monitored daily.

If signs of improvement are not seen as expected, treatment should be reviewed.

A decision is then made whether to:

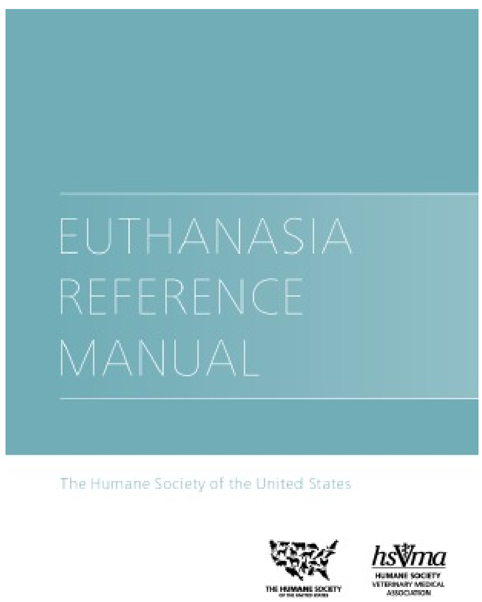
continue with existing treatment and monitoring for a specified time
refer to your veterinary surgeon
perform euthanasia.

Sheep require special attention because they have a passive response to pain or stress so the severity of the condition and consequent suffering may not be noticed, or even ignored, unless good stockmanship is practised.

The following pages offer more specific advice on common problems where ignoring the problem is not acceptable and will compromise the welfare of individuals and maybe the flock.

Casualty_sheep_K_Hover.pdf(673.3 KB) - download

Marshall Walters - Sep 07, 2020, 11:24 PM CDT



euthanasia-reference-manual.pdf(8.5 MB) - download

2020/09/07 - Current Remote Injection Systems For Large Animals

Marshall Walters - Sep 07, 2020, 9:59 PM CDT

Title: Current Remote Injection Systems For Large Animals

Date: 9/7/2020

Content by: Marshall

Present: N/A

Goals: To understand how large animals are injected with syringes in order to better grasp what the injection system would look like for this project.

Content:

[1] Chancey, E., 2020. Remote Injection Systems. [online] Vetfolio.com. Available at: <https://www.vetfolio.com/learn/article/remote-injection-systems> [Accessed 7 September 2020].

Commonly Tools for Injection

- Blowpipe
- Dart gun
- Pole syringe

Comparison of Remote Injection Projectors

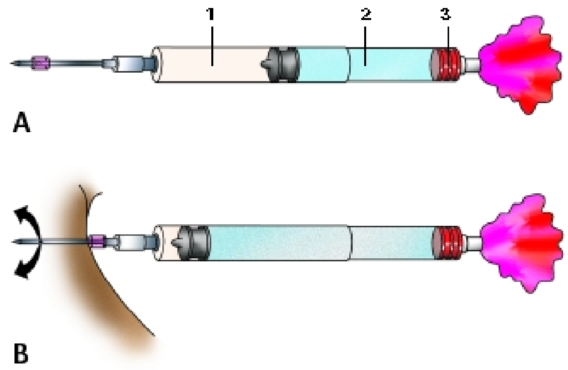
Projector	*Propellant*	*Distance (m)*	*Volume (ml)*	*Animal Type*
Blowpipe (lung powered)	Expulsion of breath	<20	3	Small and large; thin skinned
Blowpipe (powered)	Compressed CO_2 or air	30	10	Medium to large; thick skinned
Dart gun (pistol, rifle, shotgun)	Compressed CO_2, compressed air, or .22-caliber blank cartridge	120	25	Large; pachyderms

Types of Needles

- Smooth
    - Generally will fall out quickly when the animal moves
    - Can bounce out of the animal if the delivery method is too pressurized
- Barbed
    - Will lodge into the animal; however, are more damaging to the animal that it is used on

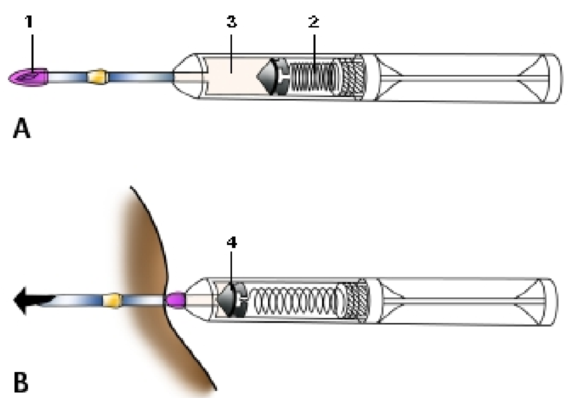
Types of Delivery Methods (Solution expulsion from Needle)

- Air-pressurized Dart



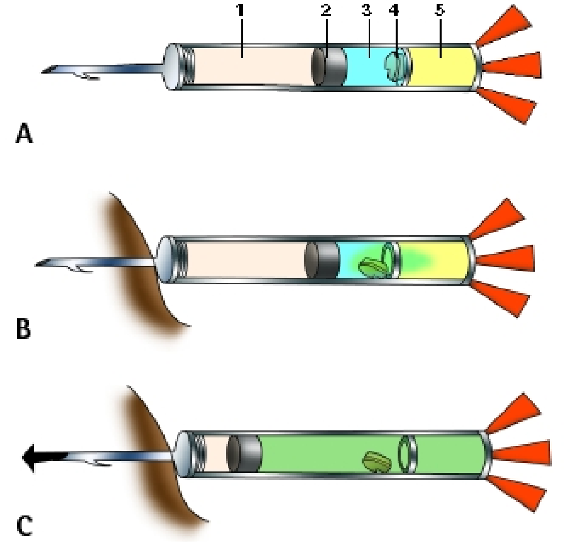
Air-pressurized blow dart in flight (A) and following skin penetration (B). Note the different components: (1) drug chamber, (2) pressurization chamber, and (3) one-way valve.

  -
  - This system my prove the most straight-forward to implement; one could use pressurized gas to force the drug chamber emptied utilizing a pneumatic valve controlled by a micro-controller
    - A design issue we will need to tackle is re-usability & how to "re-cock" the syringe for another use in another animal
    - Another option is that we use a reload system that is capable of locking and using a disposable needle with the solution already included
      - We would then need a system to expel the contents (we will need to see what type of needles they have in mind)
- Spring-pressurized Dart



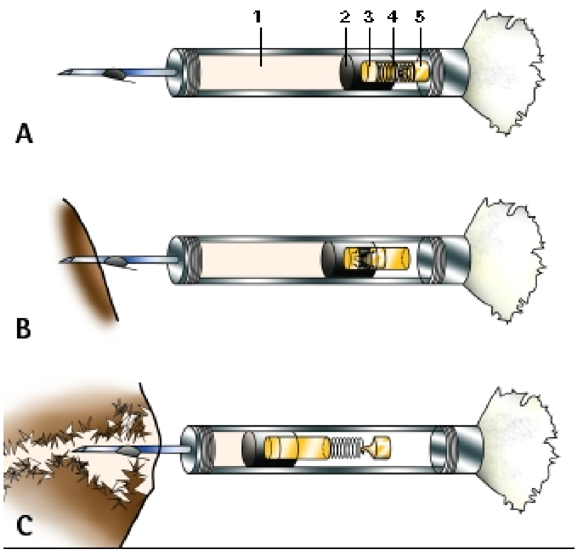
Spring-pressurized dart. (A) The dart is ready for firing, with (1) a tight-fitting cap occluding the dart's needle while (2) the coiled spring pressurizes (3) the agent. (B) Dart in the final stage of injection. The needle's cap slides backward as the needle penetrates the skin, allowing the spring to push (4) the plunger forward, injecting the agent.

  -
- Soda-Acid Injection System



Dart syringe using a soda–acid injection system; both components are in liquid form, which helps to accelerate the reaction. Note the components: (1) Drug chamber; (2) plunger; (3) saturated solution of sodium bicarbonate; (4) asymmetric weight seated in an O-ring; (5) acetic acid. (A) Dart in flight. (B) Dart on impact. When the weight falls forward, the soda and acid are able to mix. (C) Dart during the last stage of injection.

- Powder Charge Injection System



Dart with a powder charge injection system. Note the components: (1) Drug chamber; (2) plunger; (3) explosive charge; (4) spring; (5) firing pin. (A) Dart in flight. (B) Dart impacting skin with firing pin compressing the spring and detonating the charge. (C) Dart during the last stage of injection. Note the tissue damage that is possible with this type of dart system.

Checklist to Keep In Mind

Ways to Prevent Dart Impact Injuries

- **Select the proper delivery equipment**, including projector, dart, and needle.
- **Select the proper power charge** to discharge the dart's contents.
- **Select the proper velocity** at which to deliver the dart.
- Limit the use of power projectors to **animals weighing >15 kg (33 lb)**.
- Dart animals only in the **muscle masses of the shoulder, upper hind leg, or rump.**
- **Do not use needles that are longer than necessary**; if a long needle must be used, place an extra sealing sleeve near the hub of the needle.
- **Understand the capabilities and limitations** of the system being implemented.

Conclusions/action items:

This article provided great insight into the design considerations that are important when wanting to inject animals. We will need to keep in mind the type of needle used, the type of delivery system implemented, and that the proper power charge/velocity is utilized for the needle to break the skin and enter the vein. The article had fantastic graphics that highlighted four delivery methods utilized in modern veterinary work. Out of the four, I believe that the air-pressurized system would be most feasible to discharge the solution from the needle.

2020/09/21 - Infusion Pumps for Hyperbaric Chambers

Marshall Walters - Sep 22, 2020, 12:12 AM CDT

Title: Design Considerations for use of Infusion Pumps in Hyperbaric Chambers

Date: 9/21/2020

Content by: Marshall

Present: N/A

Goals: To understand the type of infusion pumps commercially available for use in a hyperbaric chamber.

Content:

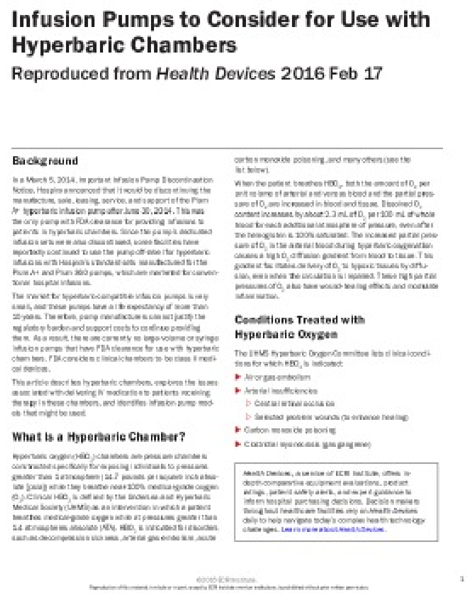
[1] 2016. Infusion Pumps To Consider For Use With Hyperbaric Chambers. 1st ed. ECRI Institute, pp.1-6.

- Large-Volume Pumps (for pumping from outside to inside hyperbaric chamber -- required to overcome pressure difference)
    - Baxter Flo-Gard 6201
    - CME Body Guard 323 Color Vision
    - Zyno Medical Corp. Z-800F
    - CareFusion/Alaris MedSystem III
    - CareFusion Alaris System 8015 Large-Volume Pump
    - Imed/Alaris Gemini PC1/PC2
    - Medical Technology Products MTP
        - As we are only required to pump 20 ml of fluid into a sheep, I do not believe that we will need to focus on the large-volume pumps that are capable of pumping large amounts of fluid. Instead, we can look to focus on the syringe pumps as we will be working with syringes.
- Syringe Pumps
    - Atom Medical Corp. 235
    - CareFusion Alaris System 8110 Syringe Pump
    - Fresenius Vial Infusion Technology PILOTE Hyperbaric

Conclusions/action items:

This source provided many places to launch from in order to investigate competing infusion pump designs. I believe that investigating the Syringe Pumps sounds like it will be the most promising. In upcoming journal entries, I will investigate these designs.

Marshall Walters - Sep 22, 2020, 12:12 AM CDT


Infusion Pumps to Consider for Use with Hyperbaric Chambers

Reproduced from *Health Devices* 2016 Feb 17

Background

What is a Hyperbaric Chamber?

Conditions Treated with Hyperbaric Oxygen

ECRI_Institute_Infusion_Pumps_to_Consider_for_Use_with_Hyperbaric_Chambers.pdf(311.6 KB) - download

2020/09/22 - Ethical Implications of Project

Marshall Walters - Sep 22, 2020, 12:38 AM CDT

Title: Ethical Implications of Project

Date: 9/22/2020

Content by: Marshall

Present: N/A

Goals: To better understand the ethical implications of the project at hand.

Content:

[1] Rollin B. E. (2009). Ethics and euthanasia. The Canadian veterinary journal = La revue veterinaire canadienne, 50(10), 1081–1086.

- "It is widely believed that ending an animal's life painlessly doesn't harm the animal — one is not aborting its life's goal or project [1]"
    - Outside of innate or hard-wired tendencies, an animal is unlikely to anticipate the end of its life or interacting with its future progeny
        - Thus, it is thought that involuntary euthanasia can be seen as not inhibiting the long-term plans of an animal, but allowing the animal to take a painless, less-traumatic end
        - That being said, it is still a tough decision to take a life as there is no going back -- once the animal has been euthanized, it is gone for good
            - I believe that this is where many people get uneasy about euthanasia as who in actually has the authority to decide life/death for an animal
- Animal Welfare should be considered in terms of the Five Freedoms
    - (1) Freedom from Hunger and Thirst
        - Clear, quick access to fresh water and a well maintained diet for full health
    - (2) Freedom from Discomfort
        - Shelter & comfortable resting areas
    - (3) Freedom From Pain, Injury, or Disease
        - Rapid diagnosis & treatment
    - (4) Freedom to Express Normal Behavior
        - Provide ample space, company from own kind, and proper facilities
    - (5) Freedom from Fear and Distress
        - Avoid mental suffering of animal

Conclusions/action items:

I believe that this journal article provides a well structured argument around the ethical debate of euthanasia. The evaluation of the five freedoms provides a clear framework by which an animal should be maintained within. However, when it comes to deciding to euthanizing an animal, one must consider what the alternative is. If more pain and suffering is awaiting the animal if euthanasia is avoided, then it may likely be in the animal's immediate interest to undergo euthanasia. This is a heavy decision for an individual to make as there is a clear, tangible finality in choosing to euthanize an animal that must be weighed against the animal's current/future suffering.

2020/09/22 - Alternative Uses of Project for Society

Marshall Walters - Sep 22, 2020, 12:44 AM CDT

Title: Alternative Uses of Project for the Benefit of Society

Date: 9/22/2020

Content by: Marshall Walters

Present: N/A

Goals: To evaluate alternative uses for the remote euthanasia device that can extend beyond the immediate use to euthanize sheep.

Content:

Although the remote euthanasia system is functioning to euthanize an animal, the base functionality of the device may be able to be extended to use in society. At its core, the remote euthanasia system must pump solution via tubing in a pressurized environment. There is a clear need for infusion pumping system in a hyperbaric environment; thus, instead of pumping euthanasia solution (sodium pentobarbital), the device could be used to pump IV fluids/injections into a patient under hyperbaric chamber therapy. It is important to realize that although on the surface that this system is being designed for the humane dispatching of sheep that there may be applications beyond the scope of the project.

Conclusions/action items:

Although not immediately important for the project at hand, it is important to remember that the design we devise may be able to be applied beyond the scope of the project.

2020/09/07 - Preliminary Individual Brainstorming

Marshall Walters - Sep 08, 2020, 12:18 AM CDT

Title: Preliminary Individual Brainstorming

Date: 9/7/2020

Content by: Marshall Walters

Present: N/A

Goals: To document any wayward ideas and preliminary design concepts for future reference.

Content:

Below are my ideas broken down into bullet points for easy viewing:

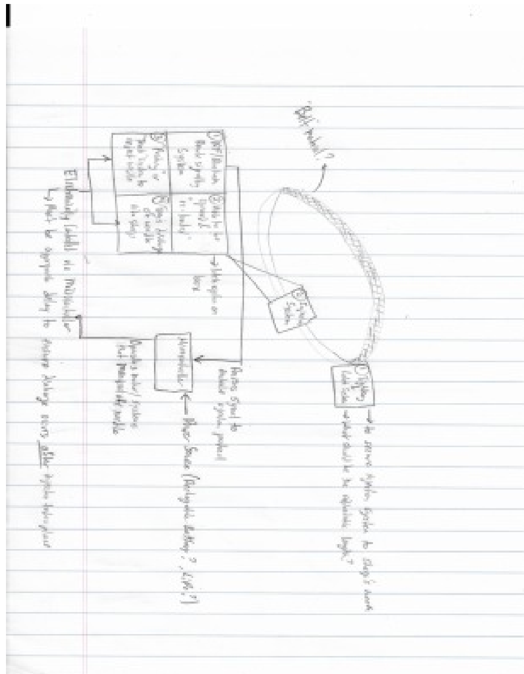
Initial Overview of Design Components & Preliminary Design Considerations

- Components
    - "Belt"
        - Will secure the Injection System to the desired region to allow for proper injection
        - Will be adjustable (to allow for a range of sheep neck sizes)
        - *Design Considerations:*
            - What material?
            - Length?
    - Tightening & Latching System
        - Will be a method to tighten the "belt" and prevent to prevent the "belt" from loosening when secured to the sheep's neck
        - Will be the method by which the "belt" can be adjusted to fit on a range of sheep necks
        - *Design Considerations*:
            - What type of system? (like just look at how typical backpacks work or other items with adjustable loops)
            - What should be the adjustable length of the "belt"? (likely define in terms of circumference)
            - How will this system be integrated into the "belt"?
    - Injection System
        - 5 modules
            - *RF/Bluetooth (??) Remote Signalling System (electrical)*
                - Able to pick up signal from remote control held by researchers
                - Signals the microcontroller to initiate "injection protocol"
            - *Able to be opened and to be "re-loaded" with a new syringe (mechanical)*
                - likely need to incorporate a latching system on the injection system housing
            - *Needle Puncture System (electrical/mechanical)*
                - "Pushing" or "Track" system??
                - Electronically controlled by microcontroller
            - *Needle Discharge System (electrical/mechanical)*
                - Forces discharge of needle's contents into sheep
                - Electronically controlled by microcontroller
                    - Must be appropriate delay to ensure that discharge occurs AFTER vein puncture is complete.
            - *Microcontroller (electrical) [BRAIN OF THE OPERATIONS]*
                - *Design Considerations*:
                    - What microcontroller should we use?
                    - How is this microcontroller programmed?
                    - How will this microcontroller interface with the Needle Puncture and Needle Discharge Systems
                    - How is the system to be powered? Rechargeable Battery [LiPo]?

Conclusions/action items:

This initial brainstorm braindump will assist me in conceptualizing this project and will help my identify where I should research further. All of the Design Considerations and the 5 modules of the Injection System present many avenues of potential future research.

Marshall Walters - Sep 07, 2020, 11:58 PM CDT



Preliminary_DesignConceptsIdeas.pdf(1.3 MB) - download

2020/09/13 - Motors for Linear Motion

Marshall Walters - Oct 06, 2020, 9:44 PM CDT

Title: Motors for Linear Motion

Date: 9/13/2020

Content by: Marshall

Present: N/A

Goals: To understand the considerations when it comes to selecting a motor for linear motion.

Content:

[1] Group, T., 2020. Selecting The Proper Motor For Linear Motion Applications. [online] Techbriefs.com. Available at: <https://www.techbriefs.com/component/content/article/tb/supplements/mcat/features/articles/20419> [Accessed 14 September 2020].

- Once the motor is selected it must:
  - Meet the demands of load acceleration,
  - Overcome friction in the system
  - Overcome the effect of gravity
  - Maintain a safe maximum operating temperature

[2] Montone, D., 2013. How To Pick Motors For Linear Motion. [online] Machine Design. Available at: <https://www.machinedesign.com/motors-drives/article/21831643/how-to-pick-motors-for-linear-motion> [Accessed 14 September 2020].

- **Define the Problem [2]:**
  - *Key Items to Know:*
    - Load Mass
    - Mass orientation
    - A-to-B move distance & time
    - Dwell time
      - wait time before either accelerating after decelerating or visa versa
    - Move profile
    - Rotary-to-linear conversion
    - Load support
    - Overall Size
    - Drive Architecture
      - Keep it simple for a low cost
    - Drive Control
    - Drive Power Supply
    - Worst-case ambient temperature
  - *How much power is needed to move the load in the required time?*
    - **P = ((g*Load_Mass)*(A_to_B_distance)) / time**
      - This equation will give you a power that is less than the peak power to accelerate/decelerate
        - Doesn't factor in extra power to overcome system losses like friction

- **Pick the Motor [1]**
  - *Option 1: DC Stepper Motor*
    - Pros
      - Open loop positioning – No encoder required
      - Simple “pulse and direction” signal needed for rotation
      - High torque density at low speeds
      - Motor can be in a “stall” position without exceeding the temperature rating
      - Lowest cost solution
    - Cons
      - No position correction in the event the load exceeds the output torque
      - Low power density – torque drops off dramatically at higher speeds
      - Motor draws continuous current, even at standstill
      - High iron losses above 3000 RPM
      - Noticeable cogging at low speeds (can be improved with a micro-stepping drive)
      - Ringing (resonance) at low speeds
  - *Option 2: DC Brush Servo Motor*

- <u>Pros</u>
    - Linear speed/torque curve (compared with a stepper)
    - Low-cost drive electronics (4 power switching devices)
    - Many different configurations available
    - Highly customizable
    - Easy to control and integrate
    - Very smooth operation possible at low speeds (depends on the number of slots and commutator bars)
    - High power density – flatter torque at higher speeds (compared with a stepper)
- <u>Cons</u>
    - Motor will draw high current in an overload condition (same as the brushless motor)
    - Method of feedback needed for closed-loop positioning (same as the brushless motor)
    - Angular velocity is more limited due to mechanical factors in the armature design and brush system
    - Carbon brush wear and EMI generation
    - High thermal resistance (copper is in the armature circuit)

- *Option 3: DC Brushless Servo Motor*
    - <u>Pros</u>
        - High power density – flatter torque at higher speeds (compared with a stepper)
        - Linear speed/torque curve (compared with a stepper)
        - Electronic commutation – no mechanical brushes
        - Low thermal resistance (copper is in the stator circuit)
        - Highest move response and acceleration possible (compared with stepper or brush DC motors)
        - Smooth operation possible (dependent on motor magnetic design and control technology)
    - <u>Cons</u>
        - Highest cost among the 3 motor technologies
        - Motor will draw high current in an overload condition (same as the brush motor)
        - Method of feedback needed for closed-loop positioning (same as the brush motor)
        - Higher drive complexity and cost — (6 power switching devices)
        - Method of rotor position detection for electronic commutation

- **<u>Gearmotor Output (utilizing a leadscrew setup to transfer rotary to linear motion) [2]</u>**
    - What's the velocity, reflected inertia, and reflected load at the gearmotor output shaft?
        - First, calculate the peak linear velocity of the application with its .33-.33-.33 motion profile:
            - **Vpeak = (3*(linear_distance)) / (2*time)**
                - May need to look for other equations for different motion profiles
        - Second, calculate the minimum pitch needed to keep the leadscrew speed at desired max RPM
            - **Pmin (min pitch) = (Vpeak * 60) / (RPM_max)**
        - Third, calculate the peak shaft speed of the leadscrew (rad/sec) for desired linear velocity
            - **Peak leadscrew speed = (Vpeak * 60) / (pitch) --> units are RPM**
                - pitch must be greater than Pmin
            - **Wpk = (Peak_leadscrew_speed * 2pi) / (60) --> (rad/sec)**
            - Selected leadscrew will have a:
                - Leadscrew efficiency (ns)
                - Inertia (Js)
        - Fourth, determine the total reflected inertia (JT) back from the load to the leadscrew shaft
            - **JL = (Load_Mass) * (pitch / 2pi)^2**
            - **JT = Js + JL**
        - Fifth, determine the shaft torque needed to accelerate the load inertia (Ta)
            - **Ta = Tj + Tf + Tg**
                - **Tj = JT * alpha** -- (torque required to overcome load inertia)
                    - **a = (Vpeak - Vi) / (final_time - initial_time)**
                        - final time = .33sec bc of motion profile
                    - **alpha = (a * 2pi) / pitch --> rad/sec^2**
                - **Tf = (cos(load_orientation) * load_mass * g * coeff_friction * pitch) / (2pi * ns)** -- (torque required to overcome friction)
                - **Tg = (sin(load_orientation) * load_mass * g * pitch) / (2pi * ns)** -- (torque required to overcome gravity)
                    - load_orientation:
                        - horizontal -- 0deg
                        - vertical -- 90deg
                - **Td = -Ta**

- What is the RMS torque (Trms) required at the gearmotor shaft?

$$T_{\text{rms}} = \sqrt{\frac{t_1 T_1^2 + t_2 T_2^2 + t_3 T_3^2}{t_1 + t_2 + t_3 + t_{\text{dwell}}}}$$

    -
        - The 1/3-1/3-1/3 motion profile over 1 sec means that **Ta** Nm (1) is applied for 0.333 sec, then **Tg** Nm (2) is applied for 0.333 sec, then **Td** Nm (3) for the remaining 0.333 sec.
    - Motor is thermally overloaded if the Trms falls outside the continuous-operating area of the DC-motor curve

- **Define total power [2]**
    - What are the final load parameters at the leadscrew input shaft (gearmotor output shaft)?
        - **peak_Power = Ta * Wpk**
        - **avrg_Power = ((load_mass * g * linear_dist) / time) / ns**

- **Choose gearbox [2]**
    - Gearmotor output acts as reducer/gearbox input
        - reducer/gearbox output acts as leadscrew input
    - What motor-gearbox combination (gearmotor) meets the load parameters?
        - *Design Considerations*
            - Total footprint
            - Audible noise limits
            - Price
            - Maximum torque capability of gearbox must exceed peak torque
        - Determine the motor's performance at its reference voltage (one below that of our power supply) -- allows for additional voltage "boosting" during peak-power events
            - Confirm that the motor's continuous output torque is above that of **Ta (motor) & Trms (motor)**
        - Determine and define a "reducer" that can safely output a max torque above the peak-torque requirements
            - Given reducer with N gear ratio & ng gearbox efficiency
                - **Ta (motor) = (Ta / N) / ng**
                - **Trms (motor) = (Trms / N) / ng**
                - **Wpk (motor) = Wpk * N**
                - **Ppk (motor) = Ta (motor) * Wpk (motor)**

- **Spec the Drive**
    - Can the drive and power supply meet the requirements of the load?
        - First, calculate the required peak current:
            - **Ipk = (Ta (motor) / Kt) + Io**
                - Kt - torque constant (defined by motor specs)
                - Io (defined by motor specs)
            - **Irms = (Trms (motor) / Kt) + Io**
        - Second, calculate the minimum bus voltage required for Ppk:
            - **Vbus = (Ipk * Rm) + (Wpk * Ke)**
                - Rm (motor terminal resistance) (defined by motor specs)
                - Ke (voltage constant) (defined by motor specs)
        - Confirm that supply bus voltage is over required bus voltage

- **Check Heating**
    - What is the motor's worst-case temperature under load at worst case ambient temp (Tamb)
        - **0r = (Rth * Irms^2 * Rm) / (1 - (Rth * Irms^2 * Rm * .00392))**
            - Rth (thermal resistance) (defined by motor specs)
        - **0m = 0r + 0amb**

  - Confirm that the motor remains within safe temperature limits as defined by its specs

Conclusions/action items:

These two sources provided a great framework to find the perfect motor for a linear movement design. It should be noted that utilizing these calculations would be useful if we were to buy a motor, gearbox, and produce a leadscrew set up separately. It will be important to example the feasibility of this based on the specs of the needle, its weight, and the distance that we want it to travel. However, one this is for sure, we will want to utilize linear motion in order to "push" the needle into the jugular vein of the sheep; thus, we will need to consider a system that can take/transform the rotary motion of the motor into linear motion. This motor can then be likely controlled by a microcontroller that can dictate if it is on or off. These details will be the biggest piece of difficutly in the project. I believe that we will first need to determine how we want to "push" the needle before we look into how to drive the motion. To reach this end, a leadscrew may prove useful; however, more research will need to be done in order to better understand if a leadscrew can offer the speed and force required to keep this device humane. This may require developing a housing that can be attached to the leadscrew that interacts with the needle. The leadscrew then can drive the needle into the sheep at a certain speed and force.

2020/09/23 - Understanding Push & Pull Solenoids

Marshall Walters - Sep 23, 2020, 11:47 PM CDT

Title: Understanding Push & Pull Solenoids

Date: 9/23/2020

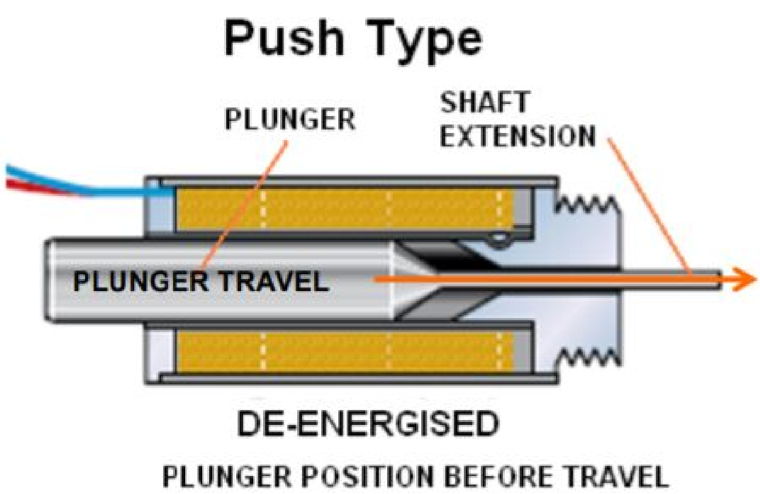
Content by: Marshall Walters

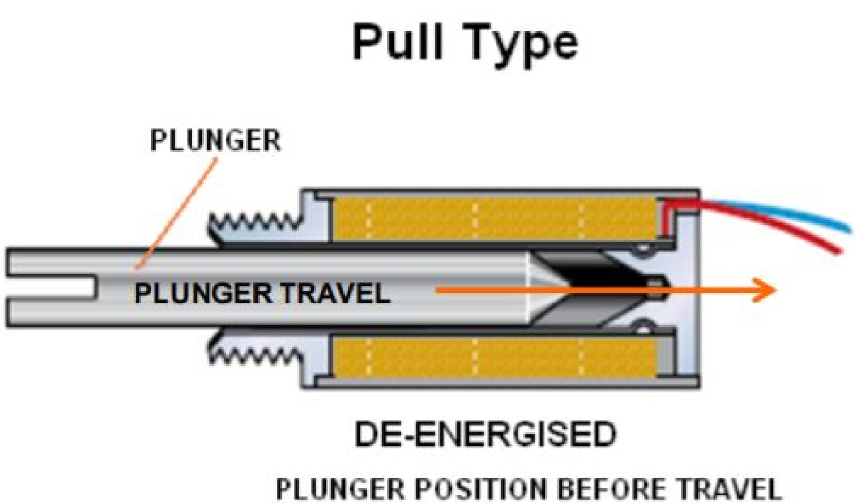
Present: N/A

Goals: To understand what Push & Pull Solenoids are and to see where if they are suitable for our project.

Content:

[1] 2020. Understanding Pull & Push Solenoids. 1st ed. [ebook] Johnson Electric. Available at: <https://www.newark.com/wcsstore/ExtendedSitesCatalogAssetStore/cms/asset/pdf/americas/common/johnson-electric/Johnson_Electric__Tech_Brief_3___Pull_vs_Push_Solenoids.pdf> [Accessed 24 September 2020].

- General Info
  - A push/pull solenoid consists of a plunger that is accelerated by a solenoid when powered
    - When power is applied to solenoid, a magnetic field is generated that attracts (push) or pulls (pull) the plunger into the coil towards the bottom of the solenoid
  - 

  - 

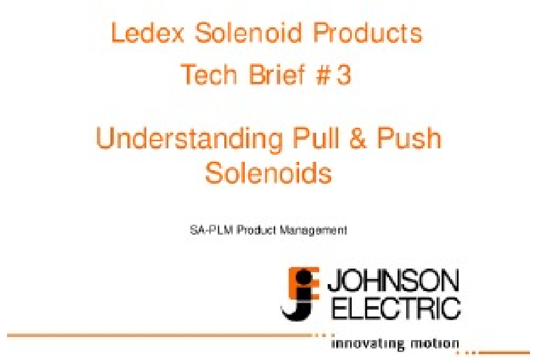
    - Operate quickly (in millisecond range)
    - Can generate sustained large forces
    - Do not move very far (millimeter range)

- Stroke
    - The stroke of a solenoid is defined by the physical space between the plunger and the base of the solenoid
        - The closer the plunger gets to the base (the physical distance between the plunger and base is nearing 0), the stronger the attracting force and applied force

Conclusions/action items:

The push/pull solenoid is attractive as the main injection mechanism for this design due to its quick function and ability generate large forces that can ensure that the syringe is plunged quickly, and completely. However, a big issue is the max stroke distance which appears to be in the millimeter range which would not be sufficient to fully depress the syringe. It will be important to understand the dimensions of the syringe in order to better understand if this is a viable option.

Marshall Walters - Sep 23, 2020, 11:47 PM CDT


Ledex Solenoid Products
Tech Brief # 3

Understanding Pull & Push Solenoids

SA-PLM Product Management

JOHNSON ELECTRIC
innovating motion

Johnson_Electric__Tech_Brief_3___Pull_vs_Push_Solenoids.pdf(490.7 KB) - download

2020/09/24 - Design Idea (Leadscrew Plunge)

Marshall Walters - Sep 24, 2020, 12:51 AM CDT

Title: Design Idea (Leadscrew Plunge)

Date: 9/24/2020

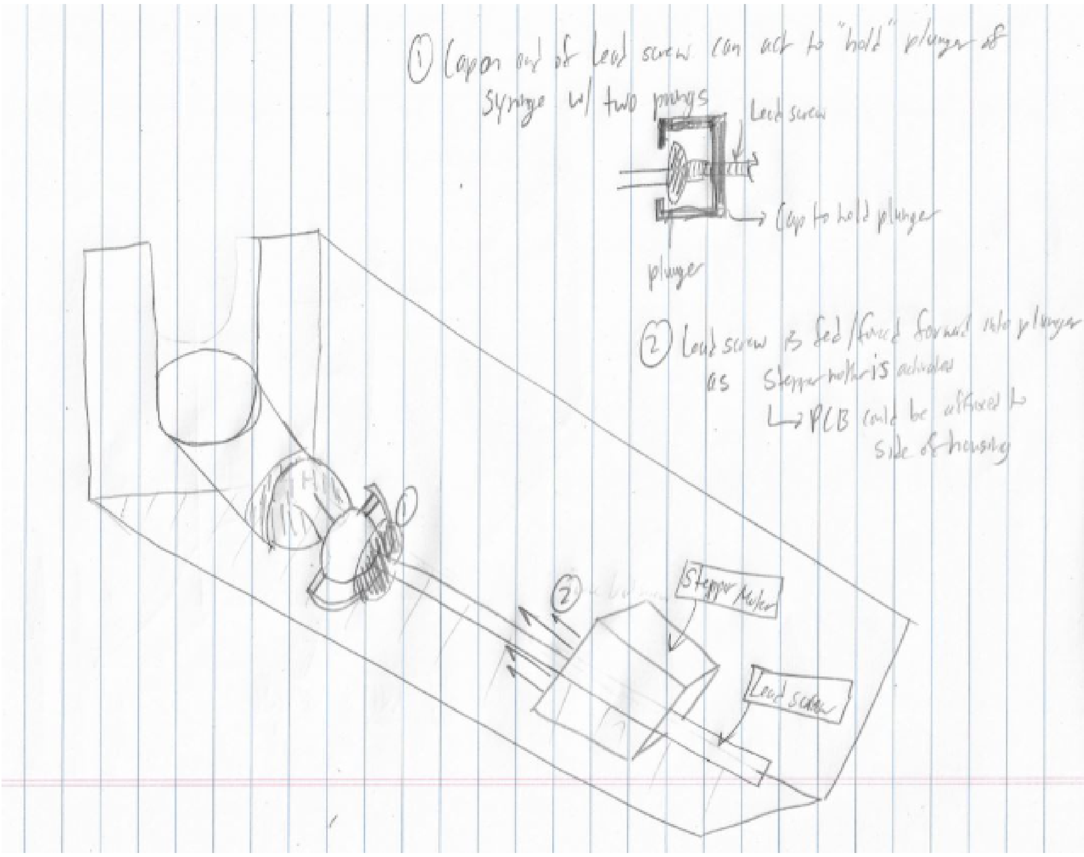
Content by: Marshall

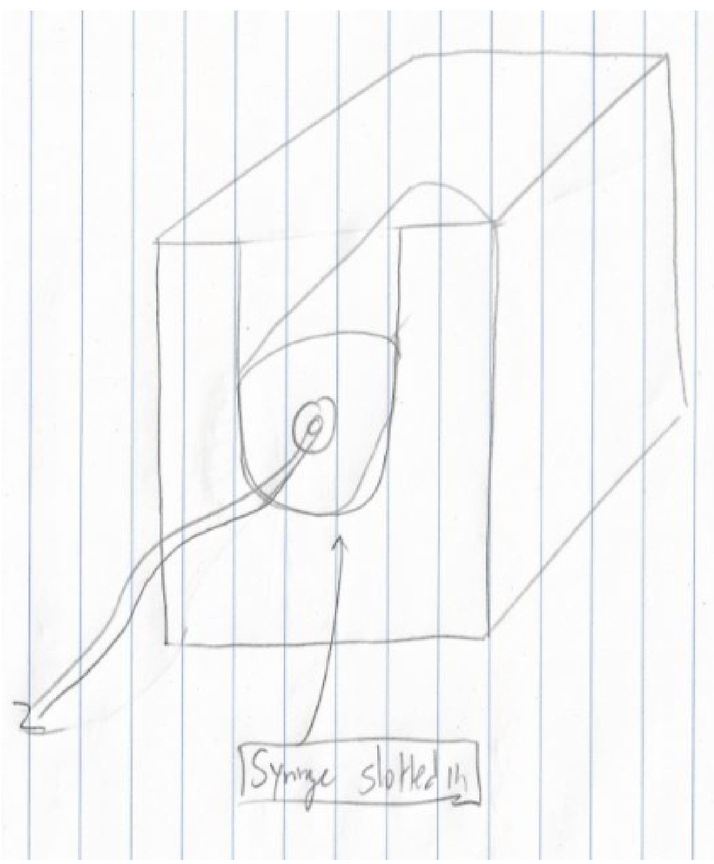
Present: N/A

Goals: To outline my idea for the primarily functioning injection mechanism that causes the syringe to depress to release the euthanasia system.

Content:

- My design has three key parts that enable its function:
    - (1) The syringe is able to be easily slotted in the top of the apparatus such that it is able to interface with the holding cap on the leadscrew and also be secured within the box
        - This would enable the researcher to easily insert the syringe into the box without worrying about accidental discharge or rupturing the tubing
    - (2) There is a holding cap that is capable of being threaded onto the leadscrew such that it holds the plunger of the syringe in place (just in case the 5 atm pressure of the chamber causes the syringe to naturally depress) and will also allow for the forced plunging of the syringe (due to (3)) as the leadscrew is in contact with the top of the syringe through the holding cap
        - This will act to prevent the syringe from prematurely discharging euthanasia system as the chamber is is pressurized
    - (3) The main pushing mechanism comes in the form of a leadscrew coupled with a stepper motor that essentially force feeds the leadscrew forward (the stepper motor "walks" away in a direction away from the syringe) into the plunger of the syringe -- this would cause the euthanasia solution to enter the sheep
        - This stepper motor is electrically controlled which would enable an interface with a microcontroller that can control its function (after some calibration) after a remote signal is sensed
        - The leadscrew can be purchased and modified in order to fit our specific sizing needs
- Design Cons:
    - More moving parts; this design may be costly as a result; however, should be well below 200 dollars.
    - The stepper motor may move slowly (10-20 seconds) depending on the force required force the euthanasia solution out of the syringe
    - May be loud depending on the stepper motor chosen for the job (scare the sheep?)





Conclusions/action items:

The next steps will be to present this design to my team during our design matrix meeting in the afternoon of 9/24.

2020/10/01 - Lead Screw Plunge (Solidworks Representation & Overview)

Title: Lead Screw Plunge (Solidworks Representation & Overview)

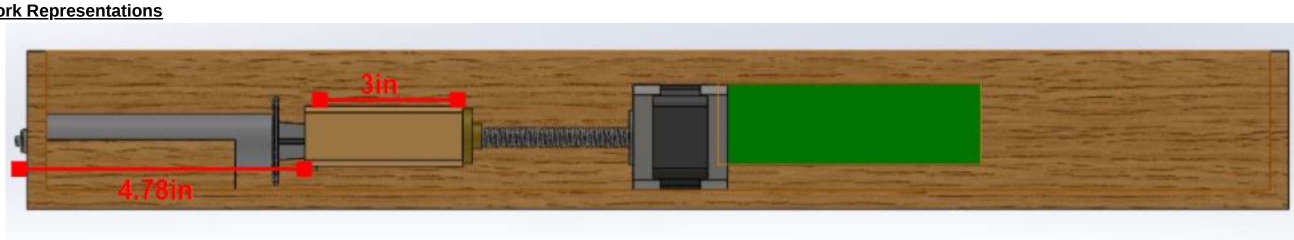
Date: 2020/10/1

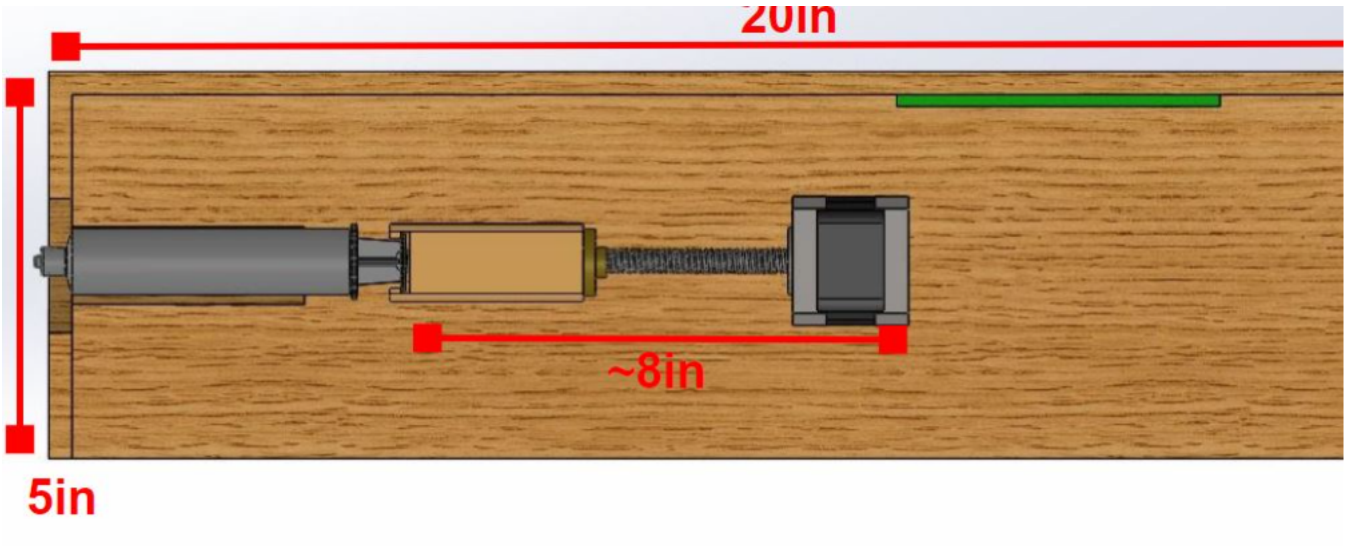
Content by: Marshall Walters

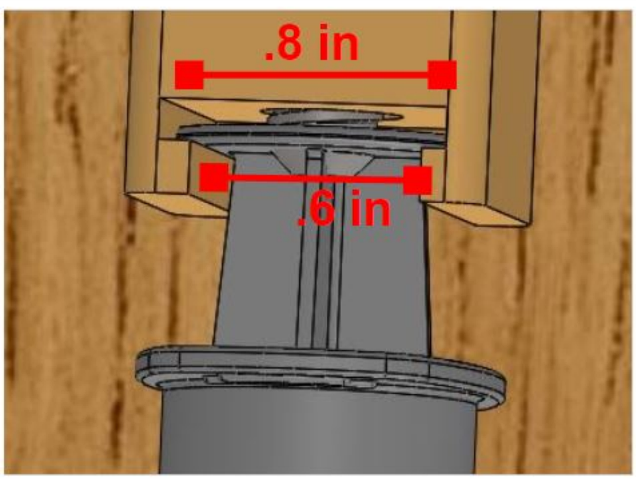
Present: N/A

Goals: To capture the clear overview of the Lead Screw Plunge design in words and in Solidworks visuals.

Content:

- **Solidwork Representations**
  - 

  - 

  - 

    - The above images showcase a top and side view of the Lead Screw Plunge Design as well as a closeup view of the interface between the plunger of the syringe and t cap. The leadscrew is fed through the holding cap so it is still able to interface with the plunger to depress it upon controller activation.
- **Overview of Design**
  - The Lead Screw Plunge utilized a lead screw coupled with a stepper motor in order to generate the linear motion required to depress the plunger of the syringe. The Lead Scre enable its function. First, the syringe was able to be easily slotted in the top of the apparatus such that the plunger of the syringe was able to interface with the holding cap on tl within the housing. The syringe would rest on a guide built into the housing that would pin the syringe between the front opening of the housing (where the tubing feeds through this functionality, this would enable the user to easily insert the syringe into the box without worrying about accidental discharge or rupturing the tubing. This is key as the device would require reloading of the syringe and accidental discharge of the syringe would be detrimental for the client's experiment. Second, there is a holding cap that is capable of leadscrew such that it holds the plunger of the syringe in place (just in case the 5 atm pressure of the chamber causes the syringe to naturally depress) and will also allow for th the leadscrew is in contact with the top of the syringe through the holding cap. As the top of plunger is held in place within the holding cap, the holding cap prevents the syringe euthanasia solution as the chamber is is pressurized. Finally, the main linear pushing mechanism comes in the form of a leadscrew coupled with a stepper motor that essentiall forward (the stepper motor "walks" away in a direction away from the syringe) into the plunger of the syringe. This motion causes the release of the euthanasia solution from the

the stepper motor and lead screw set is highly customizable to the design considerations at hand in terms of depression speed and strength; thus, this system can be made to f requirements defined by the client. This stepper motor is electrically controlled via a PCB control board which would enable an interface with a microcontroller that can control it after a remote signal is sensed. Although this design offers customizability, ease-of-use, and robustness, this design requires a fair amount of moving parts to work harmonious calibration. Next, the stepper motor chosen may be loud which could startle the sheep; however, this was taken into consideration when choosing the stepper motor to use.

Conclusions/action items:

These Solidwork representations and written overview of the Lead Screw Plunge will serve as a great launching pad for the future prototyping efforts. I believe that these serve as a way to dire effectively complete this project.

2020/10/07 - Stepper Motor Driver Circuit

Marshall Walters - Oct 08, 2020, 1:01 AM CDT

Title: Stepper Motor Driver Circuit

Date: 10/7/2020

Content by: Marshall

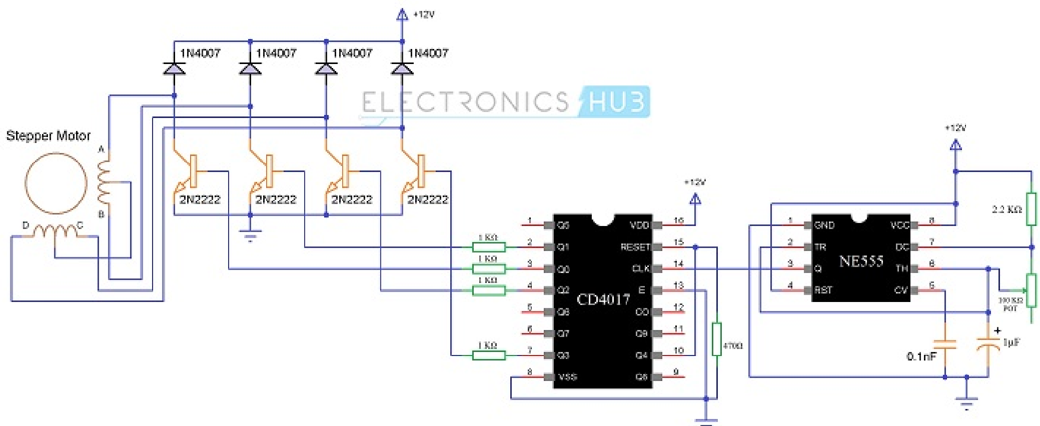
Present: N/A

Goals: To get a better idea about the circuitry required to run a stepper motor.

Content:

[1] Electronics Hub. 2017. Stepper Motor Driver Circuit. [online] Available at: <https://www.electronicshub.org/stepper-motor-driver-circuit/> [Accessed 7 October 2020].

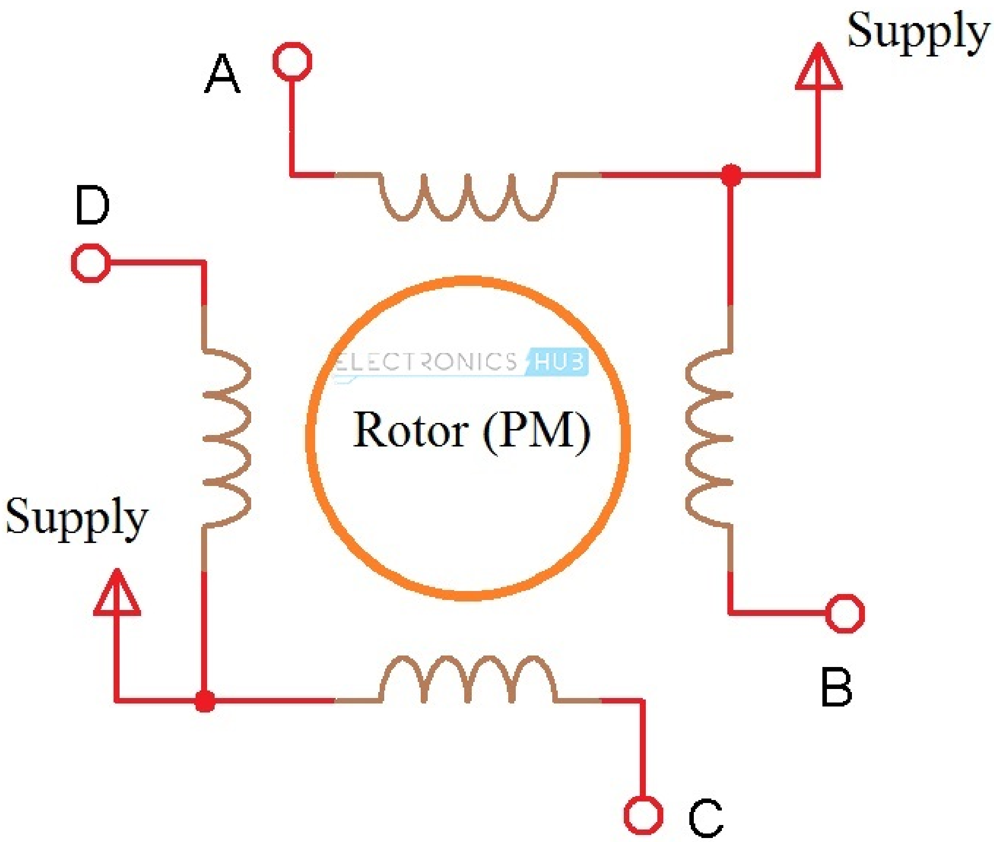
- **Overview of Functionality**
  - A Stepper Motor Driver is a circuit or device that provides the necessary current and voltage to a Stepper Motor so that the motor has a smooth operation
    - Key components of Driver:
      - Pulse signals produced from a controller
      - A driver that converts pulses into Stepper Motor Motion
- **Example -- Circuit Overview, Diagram, and Components**
  - In this example posed by the source, a simple 12V Stepper Motor Driver Circuit with 555 Timer IC (acting as a controller) and a CD4017 Decade Counter (acting as the driver)



  -
    - Circuit Diagram for the Example posed by source
  - Component List:
    - 555 Timer IC
    - CD4017 Johnson Decade Counter (10 Decoded Outputs)
    - 4 x 2N2222 NPN Transistors
    - 4 x 1N4007 PN Junction Diodes
    - 4 x 1 KΩ Resistors (1/4 Watt)
    - 2.2 KΩ Resistor (1/4 Watt)
    - 470 Ω Resistor (1/4 Watt)
    - 100 KΩ Potentiometer (Knob type)
    - 100 pF Ceramic Disc Capacitor (Code – 101) (Also read as 0.1 nF)
    - 1µF 16V Polarized Capacitor
    - 12V Stepper Motor (Unipolar – 5 Wire)
    - Connecting Wires
    - Breadboard (Prototyping Board)
    - 12V Power supply
- **Example -- Key Component Descriptions (Timer, Driver, and Motor)**
  - 555 Timer IC
    - The timer utilized has three modes -- Astable Multivibrator (Pulse Generator), Monostable Multivibrator (Time Delays) and Bistable Multivibrator (Flip – Flop). The mode utilized in this project was the "Astable Multivibrator" for its pulse generating capabilities
      - *It will be key to do research into these various modes and to different options for timers (pros/cons)*
  - CD4017 Decade Counter
    - Produces 10 "decoded outputs" -- hence the Decade counter name
    - In this application, the CD4017 is being used as a stepper motor driver; thus, this circuit is effectively a "Binary Counter Circuit"
      - *It will be important to do extra research into what a Binary Counter Circuit is and where the amount of decoded outputs comes into play*
  - Stepper Motor
    - There are two possible choices for stepper motor -- Unipolar or Bipolar
      - In this example, a Unipolar type Stepper Motor with 5 – wire configuration was used

        - For a driver circuit for a Unipolar Stepper Motor, it can be constructed with a few transistors or a Darlington Transistor IC (ULN2003)
            - *It will be important to do research into Transistor ICs*
    - On the other hand, for the driver circuit for a Bipolar Stepper Motor, it requires a "H-bridge type" connection; thus, a H-bridge IC (like L293D) can be utilized
        - *It will be important to do research into a H-bridge type connections and H-bridge ICs*

- **Example -- Circuit Design**
    - *I will include the verbatim description of the circuitry design as I believe it provides the most clarity on what the device does an how it operates; however, I will be breaking it up into different sections for ease of viewing.*
        - **Setting up and Operating Timer**
            - We will start with the Square wave Generator i.e. 555 IC in Astable Mode. A 2.2 KΩ Resistor is connected between the VCC and Discharge Pin of 555 (Pin 7).
            - A 100 KΩ Potentiometer is connected between the Discharge Pin (Pin 7) and the Threshold pin (Pin 6), which is in turn shorted with the Trigger Pin (Pin 2).
            - A 1 µF Capacitor is connected between the Trigger pin (Pin 2) and GND. A Bypass Capacitor of 100 pF is connected at the Control Voltage Pin (Pin 5). The other pins i.e. VCC (Pin 8) is connected to 12V supply, Reset Pin (Pin 4) to 12V supply and Ground Pin (Pin 1) to GND.
                - *It may be beneficial to do research into how to wire these Timers and the rhyme/reason as to why certain components are connected the way they are*
        - **Connecting Timer to Driver & Setting up Driver**
            - The Output of 555 Timer IC i.e. the Pin 3 is given as Clock Input to the CD4017 Counter IC i.e. to its 14th Pin. The VDD and VSS pins of CD4017 i.e. Pin 16 and 8 are connected to 12V Supply and GND respectively. Enable Pin (Pin 13) is connected to ground.
        - **Setting up Driver-Motor Connection**
            - We need to control the 4 coil terminals of two coils in the stepper motor. Hence, we need only 4 outputs from the driver. These outputs are Q0 to Q3 i.e. Pins 3, 2, 4 and 7 respectively. The outputs of the Counter are connected to base terminals of 4 transistors through separate 1 KΩ Resistors.
                - *It may be beneficial to do research into transistor logic and the principles that govern them*
            - The counter must reset on the fifth pulse and hence the Q4 (Pin 10) which in nothing but the fifth output, is connected to the reset pin of CD4017 i.e. pin 15 and this pin is connected to GND through a 470 Ω Resistor.
            - The Stepper Motor is a Unipolar Type in 5 wire configuration. The center pin is shorted internally and is connected to the supply (12V here).
            - The other 4 terminals of the stepper motor are the ends of two coils. They must be connected to the collector terminals of the four transistors.
                - It important that they are connected in the sequence of firing of the outputs. Finally, four diodes are connected between the collector terminals and supply. Diodes are very important as they will protect the transistors from inductive spiking.
                    - *It may be beneficial to research inductive spiking as it appears we will be working with transistors*
- **Example -- How to Operate the System**
    - As the 555 Timer IC acts as a square wave generator, the frequency of the square wave will vary (from 7Hz to 340Hz) based on the position of the potentiometer
    - This square wave (produced by the Timer) acts as the "Clock Input" for the CD4017 Counter IC
        - For every positive transition (low to high) of the clock signal, the counter output advances by one count
    - For the first positive transition (first count), the Q0 will be high -- second transition, Q1 will be high
        - This will continue (incremental turning on of Q0 to Q3) until the fifth output where Q4 is connected to the "Reset" pin so that the counter will reset and the process will start again
    - These outputs (Q0 to Q3) are given to 4 different transistors (@ Base), which in turn are connected to the 4 coil terminals (@ Collector) which activates motor function



-
- Upon activation of Q0, the corresponding transistor will be fed voltage and will be activated -- the supply from the transistor will go through A to GND which will energize the coil and cause it to act as an electromagnet
  - The rotor will get attracted and turn to that position
- This process will occur with Q1 (powers B), Q2 (powers C), and Q3 (powers D)
  - This will cause the rotor to turn and the speed of rotation is dictated by the frequency of the clock signal (which is altered by the potentiometer connected to the 555 Timer IC)

Conclusions/action items:

I believe that this website proved fantastic insight to what the process entails in order to devise and create a Stepper Motor Driver Circuit for our chosen stepper motor (when we choose it). This proves why having a driver circuit is necessary in order to coordinate an appropriate response/function. Throughout the readings, I made notes where I felt it would be important to do extra research (in italics). Furthermore, the website goes on to say that this design is not an efficient one, which leads me to wonder why that is the case. I believe it will be important to research how to optimize a driver circuit like this so we create the most professional product for the client.

2020/10/14 - Force to Plunge Syringe (Calculations)

Marshall Walters - Oct 14, 2020, 9:52 PM CDT

Title: Plunge Syringe Calculations

Date: 10/14/2020

Content by: Marshall

Present: N/A

Goals: To characterize and understand the forces that the stepper motor/lead screw must overcome to drive the plunger into the syringe.

Content:

[1] Lathrop, O., 2020. *Force Required To Empty A Syringe*. [online] Engineering Stack Exchange. Available at: <https://engineering.stackexchange.com/questions/2046/force-required-to-empty-a-syringe> [Accessed 14 October 2020].

- The question proposed in this engineering forum was:
    - "Find the magnitude of the force that needs to be applied to a piston of a 20ml syringe with 1cm diameter tube to drain it in 20 seconds through a 40mm length needle of 0.2mm inner diameter. The fluid inside the syringe is water."
- The proposal to solve for the problem does not include viscosity of the liquid which is useful in the case of pentobarbital which does not have viscosity data available on data sheets (see attached).
    - **Tube Information:**
        - Diameter of Syringe (**Ds**) = **2.06375 cm**
        - Syringe Area (**As**) = (Ds)^2 * (pi) * (1/4) = **3.345061092 cm^2**
        - Distance Syringe Plunger Travels (**Dp**) = **.07 m**
    - **Calculating Energy & Force to Move Fluid**:
        - Tube Diameter (**Dt**) = **.0025 m**
            - Tube Area (**At**) = (Dt)^2 * (pi) * (1/4) = **4.908738521e-6 m^2**
        - Volume of Fluid (**Vf**) = 20ml or **20x10-6** m^3
        - <u>Desired Speed</u>:
            - Total Time = **10s**
            - Speed Required (**Vr**)= ((Vf)/(At))/10 = **.4074366543 m/s**
        - Total Kinetic Energy Imparted onto Liquid (**KEr**) = .5*(.024)*(Vr)^2 = **.0019920555 J**
            - Mass of 20ml of Pentobarbital = (20cm^3) * (1.2 g/cm^3) = **.024 kg**
        - Total Force Required (Fr) = (KEr)/(Dp) = **.00285 N**
    - **Adjusting for Laminar Flow**
        - Total Force Required Adjusted (Fra) = Fr * .179 = **.00336 N**

Conclusions/action items:

The calculation above takes into account only the density of Pentobarbital, the tubing diameter, and that the flow through the tube will be laminar. This calculation does not take into account that the viscosity of pentobarbital as this value could not be found. That being said, the force required to force 20ml of solution out of our syringe based solely on the kinetic energy requirements in very small (mainly in part to the tubing large diameter). Therefore, it likely won't be a concern that the stepper motor/leadscrew will have any issues with pumping out the solution. In calculations going forward, I am going to assume that it will take 1N in order to force the solution out of the syringe as this should take into account the extra force required due to the viscosity of pentobarbital.

Marshall Walters - Oct 14, 2020, 9:52 PM CDT

SAFETY DATA SHEET
Pentobarbital

Page 1 of 5

Section 1. Identification of the Substance/Mixture and of the Company/Undertaking

1.1 **Product Code:** 20965
Product Name: Pentobarbital
Synonyms: 5-ethyl-5-(1-methylbutyl)-2,4,6(1H,3H,5H)-pyrimidinetrione; NSC 28708; (±)-Pentobarbital; (±)-Pentobarbitone

1.2 **Relevant identified uses of the substance or mixture and uses advised against:**
Relevant identified uses: For research use only, not for human or veterinary use.

1.3 **Details of the Supplier of the Safety Data Sheet:**
Company Name: Cayman Chemical Company
1180 E. Ellsworth Rd.
Ann Arbor, MI 48108
Web site address: www.caymanchem.com
Information: Cayman Chemical Company +1 (734)971-3335

1.4 **Emergency telephone number:**
Emergency Contact: CHEMTREC Within USA and Canada +1 (800)424-9300
CHEMTREC Outside USA and Canada +1 (703)527-3887

Section 2. Hazards Identification

2.1 **Classification of the Substance or Mixture:**
Acute Toxicity: Inhalation, Category 4
Acute Toxicity: Oral, Category 3
Acute Toxicity: Skin, Category 4
Toxic To Reproduction, Category 2

2.2 **Label Elements:**

GHS Signal Word: **Danger**
GHS Hazard Phrases:
H301: Toxic if swallowed.
H312: Harmful in contact with skin.
H332: Harmful if inhaled.
H361: Suspected of damaging fertility or the unborn child.
GHS Precaution Phrases:
P201: Obtain special instructions before use.
P202: Do not handle until all safety precautions have been read and understood.
P261: Avoid breathing [dust/fume/gas/mist/vapors/spray].
P264: Wash [hands] thoroughly after handling.
P280: Wear [protective gloves/protective clothing/eye protection/face protection].
GHS Response Phrases:
P301+310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
P302+352: IF ON SKIN: Wash with plenty of soap and water.
P304+340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P308+313: IF exposed or concerned: Get medical attention/advice.
P312: Call a POISON CENTER or doctor/physician if you feel unwell.
P321: Specific treatment (see ... on this label).

Multi-region format

Pentobarbital_SafetySheet.pdf(26.6 KB) - download

2020/10/14 - Stepper Motor Design Calculations

Marshall Walters - Oct 19, 2020, 3:46 PM CDT

Title: Stepper Motor Design Calculations

Date: 10/14/2020

Content by: Marshall

Present: N/A

Goals: To determine the correct motor specifications that our chosen motor must meet in order to work consistently for our application.

Content:

- Defining the problem:
  - *Key Items to Know:*
    - Force Required to Move Load = **1N**
    - Mass orientation = **Horizontal**
    - A-to-B move distance = **.07m**
    - Time = **10s**
    - *Dwell time = .5s? (This value isn't important for our project as we will just need on extension)*
      - wait time before either accelerating after decelerating or visa versa
    - Move profile = **1/3-1/3-1/3 trapezoid**
      - Offers controlled acceleration/deceleration (https://www.motioncontroltips.com/what-is-a-motion-profile)
    - Rotary-to-linear conversion -- LEADSCREW SPECS?
      - Length -- 150 mm
        - The leadscrew is expected to be able to extend at least 7cm (to fully plunge the plunger)
      - Lead/Rev = 2mm --> **if we need to travel 70mm --> 35 rev in 10s --> 3.5rev/s *60 --> 210 RPM (Desired)**
        - Choice 1 -- https://www.omc-stepperonline.com/linear-stepper-motor/nema-17-non-captive-34mm-stack-04a-lead-2mm007874-length-150mm-17ls13-0404n-150d.html?mfp=178-motor-type%5BNon-Captive%2CExternal%5D%2C179-lead-travel-revolution-mm%5B2%5D%2C181-lead-screw-length-mm%5B140%2C150%5D
        - Choice 2 -- https://www.omc-stepperonline.com/linear-stepper-motor/nema-23-non-captive-56mm-stack-2a-lead-2mm007874-length-150mm-23ls22-2004n-150t.html?mfp=178-motor-type%5BNon-Captive%2CExternal%5D%2C179-lead-travel-revolution-mm%5B2%5D%2C181-lead-screw-length-mm%5B140%2C150%5D
      - Pitch -- 2mm
    - Drive Power Supply -- UNKNOWN
    - Worst-case ambient temperature = **25 C**
  - *How much power is needed to move the load in the required time?*
    - **P** = ((1N)*(A_to_B_distance)) / 10s = **.007 W**

- **Gearmotor Output (utilizing a leadscrew setup to transfer rotary to linear motion) [2]**
  - *What's the velocity, reflected inertia, and reflected load at the gearmotor output shaft?*
    - First, calculate the peak linear velocity of the application with its .33-.33-.33 motion profile:
      - **Vpeak =** (3*(linear_distance)) / (2*time) **=** (3*(.07)) / (2*10) = **.0105 m/s**
    - Second, calculate the minimum pitch needed to keep the leadscrew speed at desired max RPM
      - **Pmin (min pitch) =** (Vpeak * 60) / (RPM_max) **=** (.0105 * 60) / (210) = 3 mm

Conclusions/action items:

Based on the seemingly low force required to plunge the syringe and the seemingly low power requirement from the stepper motor to complete the task, I believe moving forward with purchasing the "Choice 1" stepper motor will be the best next steps.

2020/10/19 - Force to Plunge a Syringe into Jugular Vein (Calculations)

Marshall Walters - Oct 19, 2020, 3:45 PM CDT

Title: Force to Plunge a Syringe into Jugular Vein (Calculations)

Date: 10/19/2020

Content by: Marshall Walters

Present: N/A

Goals: To understand the force required to plunge a syringe into jugular vein (by factoring in the pressure of the vein).

Content:

[1] 2020. [online] Available at: <https://www.chegg.com/homework-help/32-n-force-applied-plunger-hypodermic-needle-diameter-plunge-chapter-10-problem-73gp-solution-9780321625922-exc> [Accessed 19 October 2020].

[2] Constable, P., Hinchcliff, K., Done, S., Grünberg, W. and Radostits, O., 2017. *Veterinary Medicine*. 11th ed. pp.113-152.

- Utilizing the textbook question defined in the above link and the previous determined force required, **the force to depress the plunger of a syringe into the jugular vein** was determined
  - Typical Jugular Vein gauged pressure is 1kPa (on the high end) [2] -- this is equal to 1000 N/m^2
  - Radius of plunger is .0142875m
  - Force required = (1000) * pi * (.0142875)^2 = **.6413N**

Conclusions/action items:

With these calculations, we now know that it will take .00336 N to overcome the kinetic energy required to expel the solution out of the needle and an addition .6413N to plunge the syringe into a jugular vein with a gauge pressure on the high end of 1kPa. Thus, our previous use of 1N for the calculations for the Stepper Motor stand, we can move forward with purchasing it.

2020/10/20 - H-Bridge & Transistor Basics

Marshall Walters - Oct 21, 2020, 12:51

Title: H-Bridge & Transistor Basics

Date: 10/20/2020

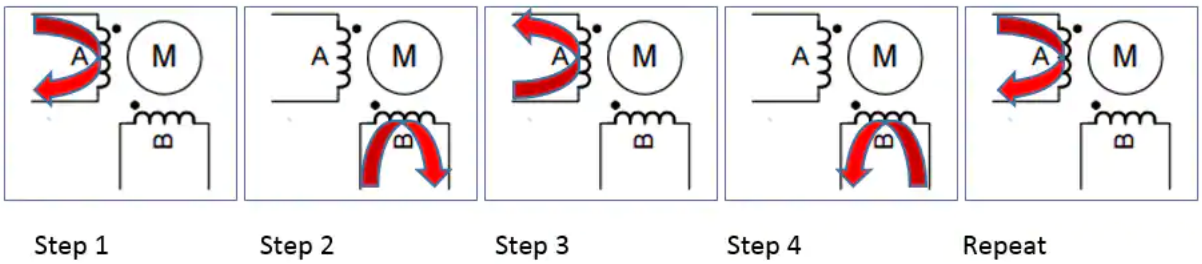
Content by: Marshall

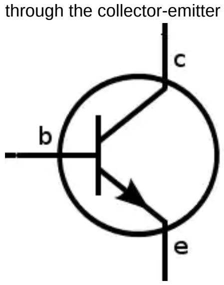
Present: N/A

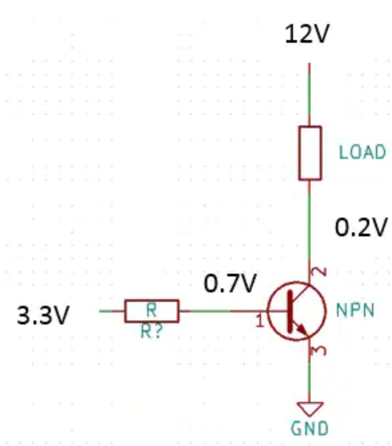
Goals: To understand how to create a H-bridge to enable the function of a bipolar stepper motor.

Content:

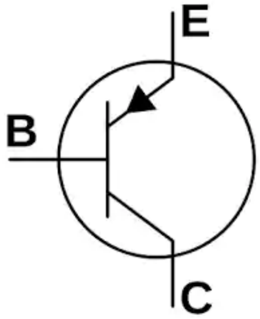
[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October

- A bipolar motor (unlike a unipolar motor) has a total of four wires and two coils -- this requires a H-bridge to run.
  - 

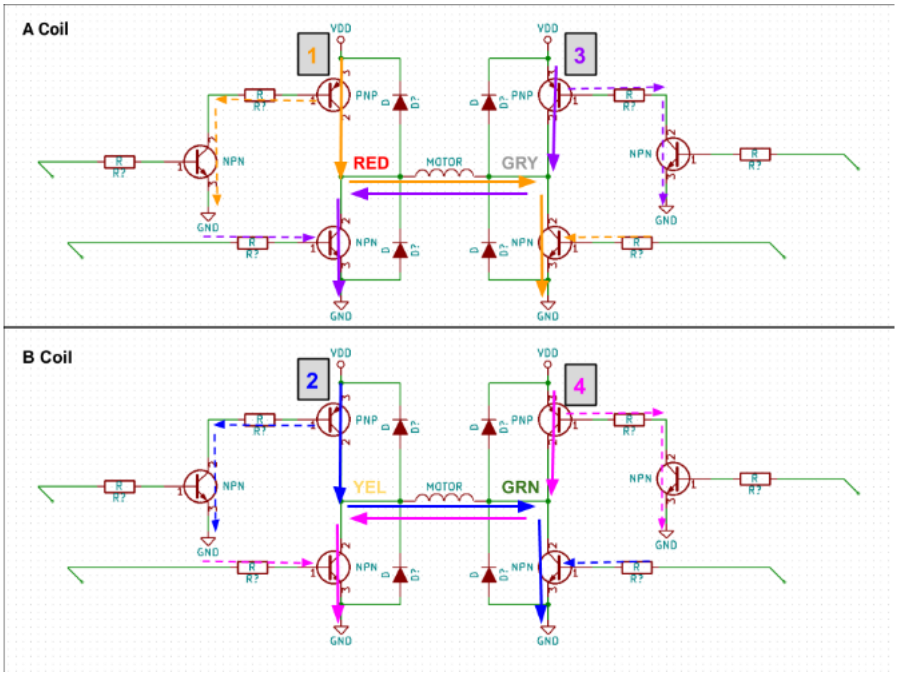
- **Transistor Mechanics**
  - A transistor is a current-controlled current limiting device. There are three pins to a transistor: the base, collector, and emitter.
  - **NPN Transistors**
    - Although can be substituted for MOSFETs, NPN Transistors are less prone to Electro Static Discharge (ESD) and take less voltage to use; thus, we will be moving forward with using transistors over MOSFETs
      - *These are two key pieces that we want to minimize as our device will be in an oxygen-rich environment*
    - **When a small current passes from base to emitter, a larger current is allowed to flow from collector to the emitter.**
      - **The current from C-E is equal to (Beta) * (The current from B-E)**
        - **Beta is the gain of the transistor**
      - A transistor is called saturated if there is more than enough current going through the base such that the transistor isn't limiting current through the collector-emitter anymore
      - 

    - One can think of the Base-emitter connection being a diode
      - **The voltage drop between base to emitter is .7V**
    - NPN transistors should be used to control ground utilizing the follow topology as to avoid limiting voltage (as the emitter (3) MUST be .7V less than the base (1))
      - 

  - **PNP Transistors**
    - **Current flows from emitter to base** (opposite when compared to NPN) **which then allows current to flow from the emitter to collector** (opposite when compared to NPN)

- 

- **The base MUST be .7V lower than the emitter**
  - In order to shut off, the base must have an equal voltage to that of the emitter
  - This is why PNP transistors can be paired with NPN, when the NPN is off, current cant flow from emitter to base (thus the PNP is off)

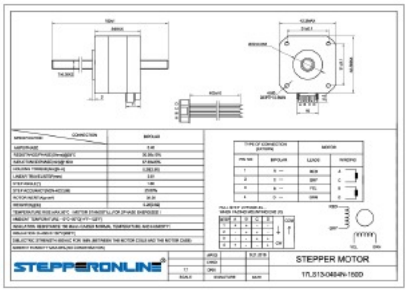
- **H-Bridge**
  - Utilizing the topology presented in the article and the data sheet of the stepper motor we will be using (see attached), the following topology will be utilized as out H-Bridge:
    - 

      - This topology has a couple distinct parts that should be explained:
        1. The numbering and wire labels (RED, GRY, YEL, GRN) dictates how our stepper motor will need to be wired and the order in which the coils need to have current passed through them in order to allow for clockwise motion (run the steps 4 to 1 in order to achieve counterclockwise motion)
        2. Each steps has current that runs from a source (VDD) through a PNP transistor (emitter to collector), through the inductive load of the motor coil, and then terminates to ground via NPN transistor (collector to emitter)
           - The starting PNP transistor is turned off and on by the accompanying NPN transistor that dictates if emitter-base connection of the PNP draws current. If the controlling NPN has its base activated, current will flow from the collector to the emitter which will allow current to flow from the emitter to the base of the starting PNP (thus, activating and enabling current to flow from the emitter to collector to the inductive load). This activated powering is represented by the dashed lines.
           - The terminal NPN transistor must also have its base activated in order to enable the function of the circuit (represented by the dashed lines)
        3. The starting PNP transistors and terminal NPN transistors make use of flyback diodes which prevent the motor from generating a high voltage (which could potentially fry the transistors/motor)
      - The timing of this circuit will need to be determined by a Driver IC which will be the source of future research.

Conclusions/action items:

From the above research, the H-bridge topology has been defined. The next steps are to determine which specific discrete components should be used (PNP, NPN, resistors, and diodes). Fur it will be important to investigate which Driver IC and accompanying Timer IC should be used to drive this H-bridge topology. It will important that we enable both clockwise and counterclockwis function to extend and retract the leadscrew.

Marshall Walters - Oct 20, 2020, 10:51 PM CDT



17LS13-0404N-150D.pdf(146.3 KB) - download

2020/10/20 - How to Choose H-Bridge Components

Marshall Walters - Oct 20, 2020, 11:39 PM CDT

Title: How to Choose H-Bridge Components

Date: 10/20/2020

Content by: Marshall

Present: N/A

Goals: To understand how to choose the correct discrete components for use in an H-Bridge.

Content:

[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October 2020].

- **How to choose the discrete components**
    - **Diodes**
        - Choose diodes that are current rated for our application
            - The current in the motor must pass through the diodes
        - To avoid excessive heat, try to find diodes that have a lower forward voltage
    - **Transistors**
        - Choose transistors that are current rated for the application
            - Avoid excessive heat by choosing a lower collector-emitter saturation voltage
        - A higher transition frequency will lower the amount of time the transistor is in active state
        - A low power dissipation means the transistor is meant be used as a switch
    - **Small signal transistors (turn starting PNP off/on)**
        - The collector-emitter breakdown voltage is higher than the motor power supply
        - A higher frequency transition is good to have
    - **Resistors**
        - All resistors except the one attached to the base of the PNP are expected to experience minimal voltage and current
            - Once you know the amount of current passing through the PNP transistor, the voltage is essentially the motor supply voltage (can calculate power)
        - Power ratings above .25W should be more than enough for most applications

This article provides a fantastic example for choosing specific components to go with a specific motor. When it comes time to determine which specific components we should use, then it will be important to use this article as a guide.

Conclusions/action items:

The next steps in terms of the H-Bridge is to choose the specific discrete components we will use (using the framework described in the source/above). Finally, I believe modelling the circuit in LTSPICE would be valuable to determine if it functions in the topology we have defined.

2020/11/3 - L293D (Dual H-Bridge Driver IC)

Marshall Walters - Nov 03, 2020, 8:16 PM CST

Title: L293D (Dual H-Bridge Driver IC)

Date: 11/3/2020

Content by: Marshall Walters

Present: N/A

Goals: To do a deep dive into the data sheet of the L293D and to understand its functionality.

Content:

[1] Industries, A., 2020. Dual H-Bridge Motor Driver For DC Or Steppers - 600Ma - L293D. [online] Adafruit.com. Available at: <https://www.adafruit.com/product/807> [Accessed 4 November 2020].

- **Key Characteristics**
  - Wide Supply-Voltage Range (4.5V to 36V)
  - Internal ESD Protection & Thermal Shutdown (Safety)
  - Output current of up to 600mA
    - We only require 400mA to drive our motor
- **Wiring**

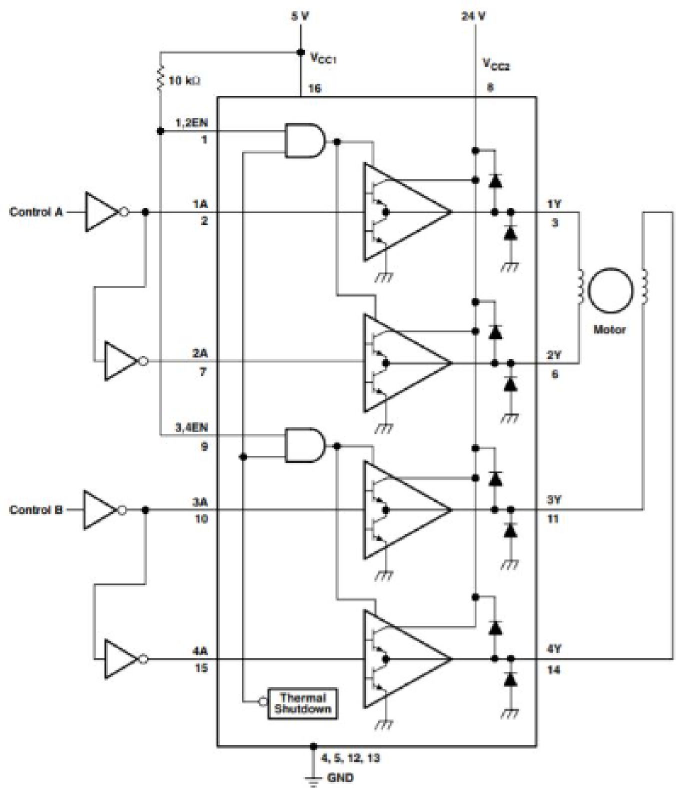


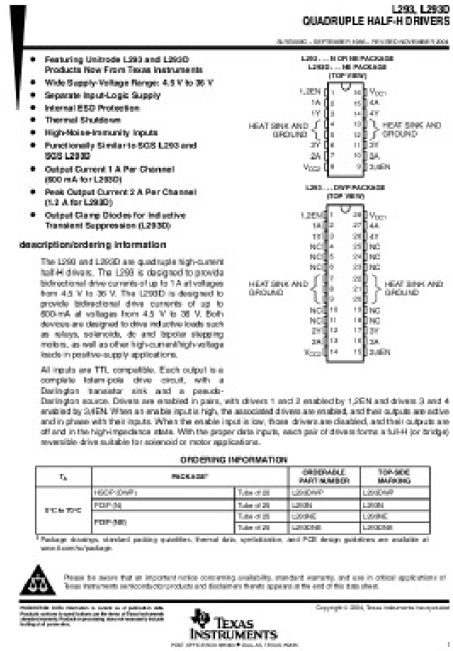
Figure 3. Two-Phase Motor Driver (L293D)

  -
    - GND Pins 4,5,12,13
    - Use 1Y/2Y for one of the coils and 3Y/4Y for the other coils
    - Pin 16 & Pin 8 have power
      - Will need to confirm Voltage Requirements at ports
- It will be key to review the various websites that give an explanation of how to hook up the L293D Driver IC to the MCU and to power
  - The extra articles will be very helpful in the set up of this circuit
- If we only have one battery source with a specific voltage, then we may need to look into how we will operate this device and manipulating the single voltage source

Conclusions/action items:

Based on undocumented research and internet searching, it was found that the L293D was commonly used for stepper motor applications and there are a lot of websites that offer insight into how to wire and use a L293D with its accompanying microcontroller. Furthermore, the L293D appears to meet the requirements to run our stepper motor. Thus, it is a win-win in information available and in technical capabilities. The next steps will be to purchase some L293D to use with the accompanying 8051 microcontroller.

Marshall Walters - Nov 03, 2020, 8:16 PM CST


L293, L293D
QUADRUPLE HALF-H DRIVERS

l293d.pdf(374.9 KB) - download

2020/11/03 - AT89S52 8-bit Microcontroller

Marshall Walters - Nov 03, 2020, 9:03 PM CST

Title: AT89S52 8-bit Microcontroller

Date: 11/3/2020

Content by: Marshall

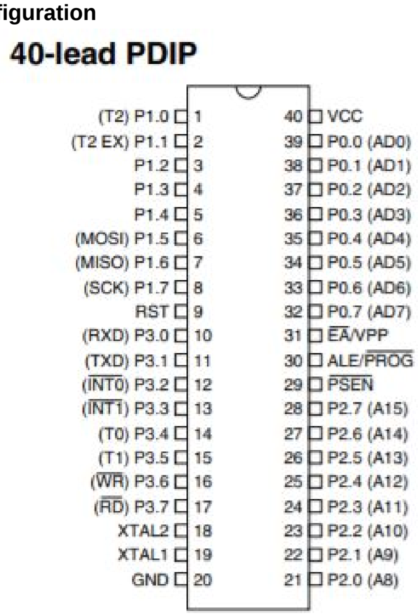
Present: N/A

Goals: To understand the AT89S52 8-bit Microcontroller in terms of its pins and how it operates.

Content:

[1] 2020. 8-Bit Microcontroller With 8K Bytes In-System Programmable Flash - AT89S52. [ebook] Atmel Corporation, pp.1-38. Available at: <https://ww1.microchip.com/downloads/en/DeviceDoc/doc1919.pdf> [Accessed 4 November 2020].

- **Key Features**
  - 8K Bytes of In-System Programmable (ISP) Flash Memory
  - 4.0V to 5.5V Operating Range
  - Fully Static Operation: 0 Hz to 33 MHz
  - Three-level Program Memory Lock
  - 256 x 8-bit Internal RAM
  - 32 Programmable I/O Lines
  - Three 16-bit Timer/Counters
  - Eight Interrupt Sources
  - Full Duplex UART Serial Channel
  - Low-power Idle and Power-down Modes
  - Interrupt Recovery from Power-down Mode
  - Watchdog Timer
  - Dual Data Pointer
  - Power-off Flag
  - Fast Programming Time
  - Flexible ISP Programming (Byte and Page Mode)
- **Pin Configuration**



  -
    - *Port 0*
      - 8-bit open drain bidirectional I/O Port
    - *Port 1*
      - 8-bit bidirectional I/O port with internal pull-ups
        - Internal pull-ups act to bias the inputs of digital gates to stop them from floating about randomly when there is no input condition

            - Alternative Functions (other than I/O)
                - P1.0 -- T2 (external count input to Timer/Counter 2), clock-out
                - P1.1 -- T2EX (Timer/Counter 2 capture/reload trigger and direction control)
                - P1.5 -- MOSI (used for In-System Programming)
                - P1.6 -- MISO (used for In-System Programming)
                - P1.7 -- SCK (used for In-System Programming)
        - *Port 2*
            - 8-bit bidirectional I/O port with internal pull-ups
            - Emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses
            - Receives the high-order address bits and some control signals during Flash programming and verification
        - *Port 3*
            - 8-bit bidirectional I/O port with internal pull-ups
            - Alternative Functions
                - P3.0 -- RXD (serial input port)
                - P3.1 -- TXD (serial output port)
                - P3.2 -- INT0 (external interrupt 0)
                - P3.3 -- INT1 (external interrupt 1)
                - P3.4 -- T0 (timer 0 external input)
                - P3.5 -- T1 (timer 1 external input)
                - P3.6 -- WR (external data memory write strobe)
                - P3.7 -- RD (external data memory read strobe)
        - *RST*
            - Reset input
                - High on this pin for two machine cycles while oscillator is running acts to reset the device
        - *ALE/PROG*
            - Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory
            - This pin is also the program pulse input (PROG) during Flash programming
        - *PSEN*
            - Program Store Enable (PSEN) is the read strobe to external program memory
        - *EA/VPP* ***(Seems key for programming)***
            - External Access Enable
                - Strap to GND for accessing external program memory locations starting at 0000H up to FFFFH.
                - Strap to VCC for internal program executions
                - This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming
        - *XTAL1*
            - Input to the inverting oscillator amplifier and input to the internal clock operating circuit
        - *XTAL2*
            - Output from the inverting oscillator amplifier
- **Key Function**
    - *Watchdog Timer* (See Documentation for how to Enable/Use)
        - The WDT is intended as a recovery method in situations where the CPU may be subjected to software upsets
        - When WDT overflows, it will drive an output RESET HIGH pulse at the RST pin
    - *3 Internal Timers*
    - *Idle Mode*
        - CPU puts itself to sleep while all the on-chip peripherals remain active
            - The content of the on-chip RAM and all the special functions registers remain unchanged during this mode
        - terminated by any enabled interrupt or by a hardware reset
    - *Power-down Mode*
        - The on-chip RAM and Special Function Registers retain their values until the Power-down mode is terminated
        - Exit from Power-down mode can be initiated either by a hardware reset or by an enabled external interrupt
        - The reset should not be activated before VCC is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize

Conclusions/action items:

After some undocumented research, it was found that the AT89C51 was used in many different stepper motor application in conjunction with L293D. However, the AT89C51 was discontinued and the company recommended using the AT89S52 in similar applications. The pins on each device and certain aspects of the device act the same. As there is much documentation on the use of the 8051 microcontrollers, we saw it as an opportunity to complete this project in a timely manner as we can likely lean on these resources. The next steps are to order these microcontrollers, understand how it is to be wired up to the L293D, and to understand how to program the device for our specific function.

Marshall Walters - Nov 03, 2020, 9:04 PM CST

Features
- Compatible with MCS®-51 Products
- 8K Bytes of In-System Programmable (ISP) Flash Memory
  - Endurance: 10,000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MHz
- Three-level Program Memory Lock
- 256 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Eight Interrupt Sources
- Full Duplex UART Serial Channel
- Low-power Idle and Power-down Modes
- Interrupt Recovery from Power-down Mode
- Watchdog Timer
- Dual Data Pointer
- Power-off Flag
- Fast Programming Time
- Flexible ISP Programming (Byte and Page Mode)
- Green (Pb/Halide-free) Packaging Option

1. Description

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

8-bit Microcontroller with 8K Bytes In-System Programmable Flash

AT89S52

doc1919.pdf(550.9 KB) - download

2020/11/10 - All About Crystal Oscillators

Marshall Walters - Nov 10, 2020, 9:36 PM CST

Title: All About Crystal Oscillators

Date: 11/10/2020

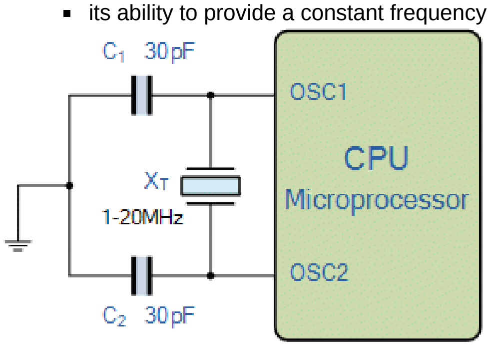
Content by: Marshall

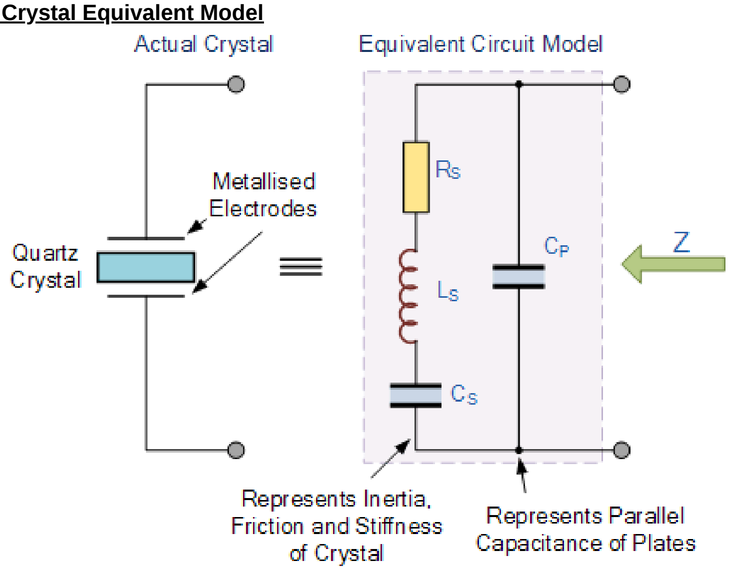
Present: N/A

Goals: To understand what crystal oscillators are and if we require one in our project.

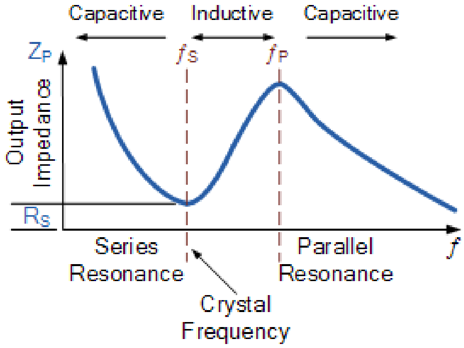
Content:

[1] Electronics Tutorials. 2020. Quartz Crystal Oscillators. [online] Available at: <https://www.electronics-tutorials.ws/oscillator/crystal.html> [Accessed 10 November 2020].

- **<u>Overview</u>**
    - *Useful for its frequency stability*
        - its ability to provide a constant frequency output under varying load conditions
    - 

    - Work based on a piezo-electric effect
        - An electrical charge produces a mechanical force by changing the shape of the crystal & vice versa
- **<u>Quartz Crystal Equivalent Model</u>**
    - 

        - *Series RLC Circuit*
            - Represents the mechanical vibrations of the crystal
        - *Parallel Capacitance (Cp)*
            - Represents the electrical connections to the crystal
- **<u>Series Resonance & Parallel Resonance</u>**

- 

    - At the series resonance frequency, the series capacitor Cs and the inductor Ls reduces the crystals impedance to a minimum and equals Rs -- this is fs
        - Below fs, the crystal is capacitive
        - Above fs, the crystal is inductive until reaching fp
    - At the parallel resonance frequency (fp), the crystal's impedance reaches its maximum value
- *Equations*

$$R = R \quad \text{and} \quad X_{LS} = 2\pi f L_S$$

$$X_{CS} = \frac{1}{2\pi f C_S} \quad \text{and} \quad X_{CP} = \frac{1}{2\pi f C_P}$$

$$Z_S = \sqrt{R_S^2 + (X_{LS} - X_{CS})^2}$$

$$\therefore Z_P = \frac{Z_S \times X_{CP}}{Z_S + X_{CP}}$$

$$f_S = \frac{1}{2\pi\sqrt{L_S C_S}}$$

$$f_P = \frac{1}{2\pi\sqrt{L_S\left(\frac{C_P C_S}{C_P + C_S}\right)}}$$

- **Q-Factor**

$$Q = \frac{X_L}{R} = \frac{2\pi f L}{R} = \frac{2\pi \times 9.987 \times 10^6 \times 0.002546}{6.4}$$

$$Q = 24966 \quad \text{or} \quad 25{,}000$$

    - The higher the Q-Factor, the greater the frequency stability of the oscillator
- **Function in Microcontrollers**
    - To generate clock waveform b/c crystal oscillators provide the highest accuracy and frequency stability
        - The CPU clock dictates how fast the processor can run and process the data with a microcontroller
    - In our application with the AT89S52, the quartz crystal oscillator produces a train of continuous square wave pulses whose frequency is determined by the crystal itself

Conclusions/action items:

As it appears that one can hook up a quartz crystal to control the square wave (PWM) of our microcontroller, this quartz crystal would act to dictate the speed of the motor. However, that being said, I believe that we want to customize our own PWM pulse that is generated by one of the microcontroller's internal timers so we can make the perfect speed we want our motor to operate. I am going to move forward with not integrating an oscillator into our final wiring diagram.

2020/11/10 - Programming Guide: AT89S52

Marshall Walters - Nov 24, 2020, 2:21 PM CST

Title: Programming Guide: AT89S52

Date: 11/10/2020

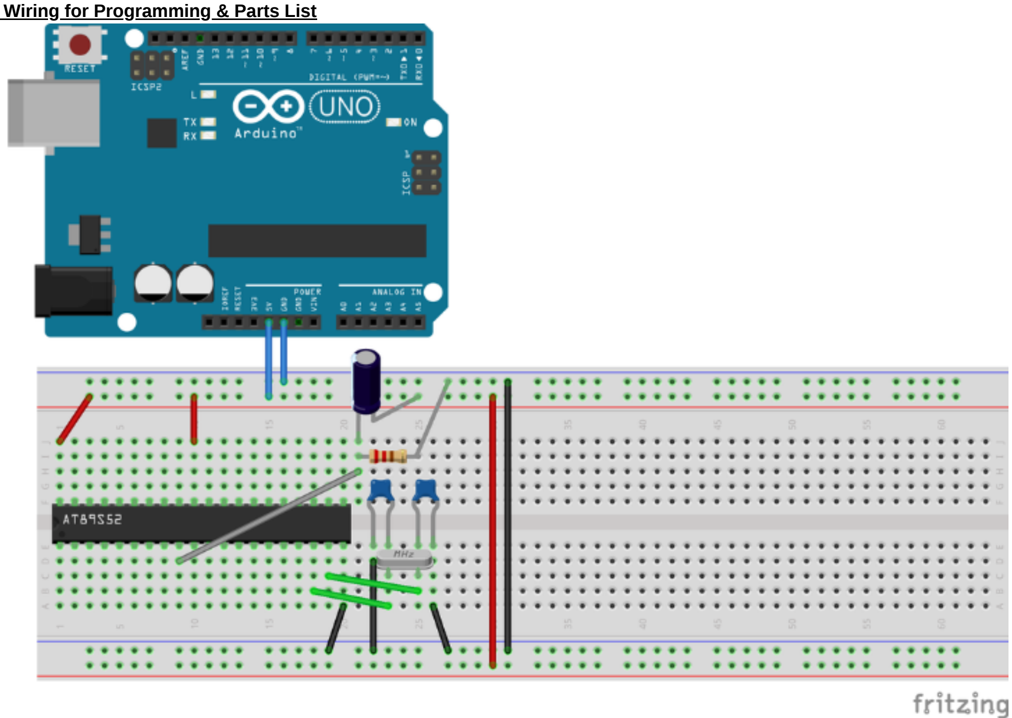
Content by: Marshall

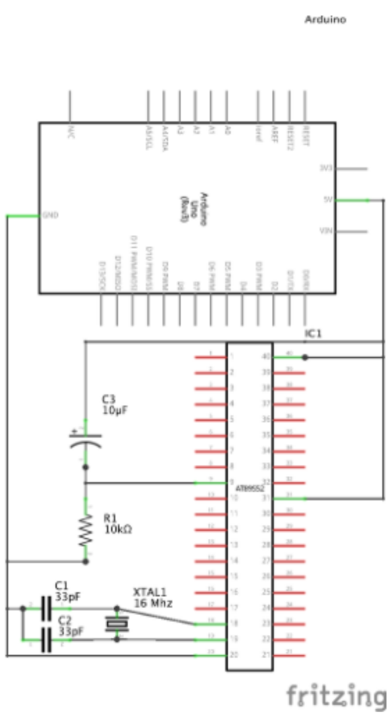
Present: N/A

Goals: To understand how to program the AT89S52 in terms of topology and IDE.

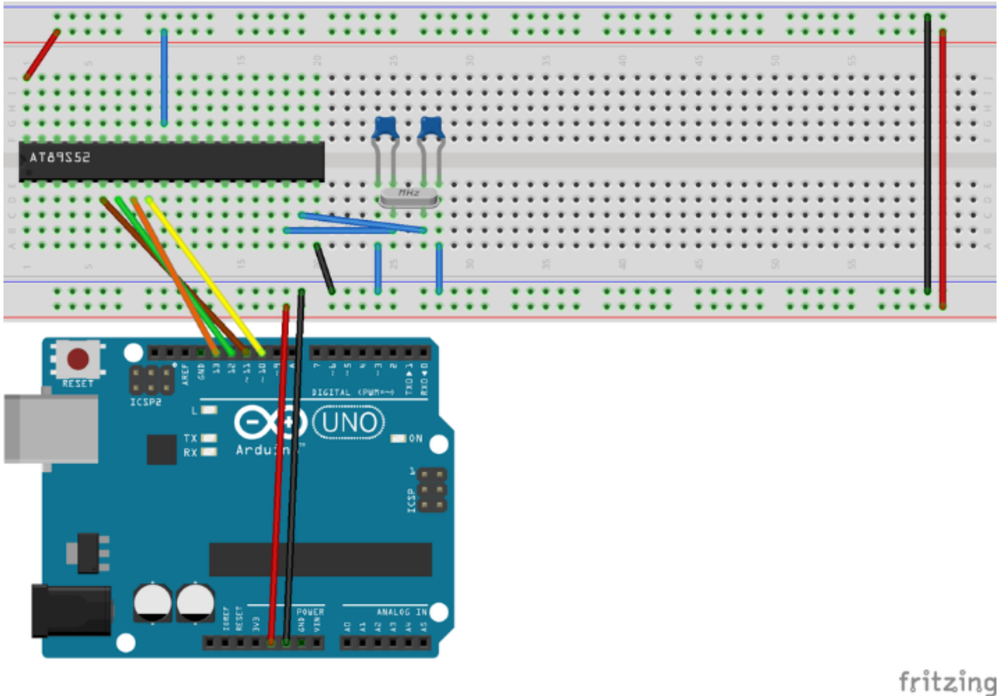
Content:

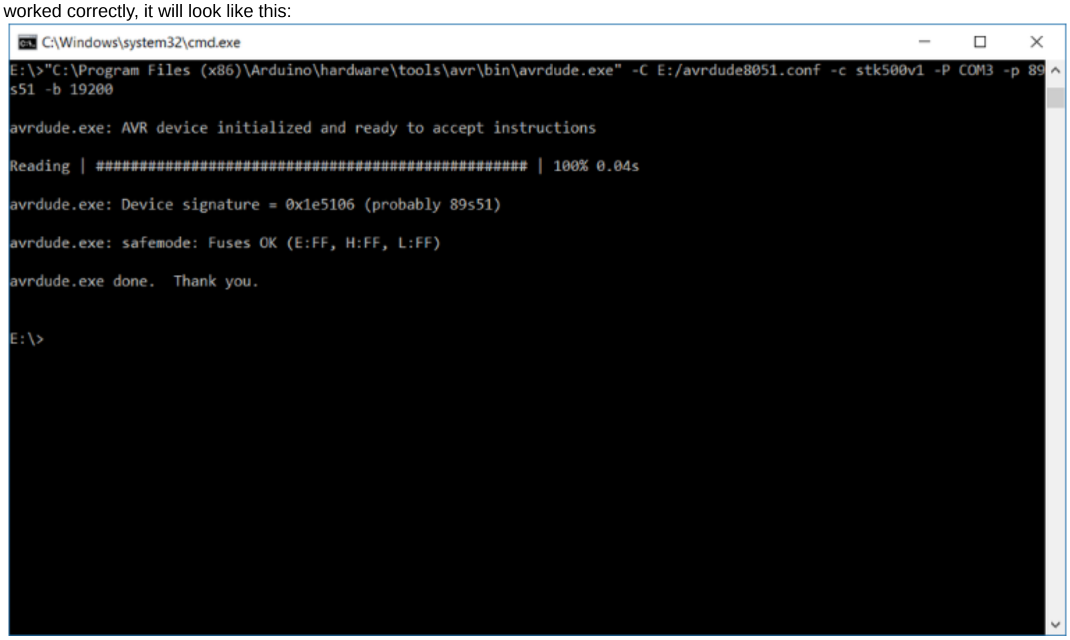
[1] Chen, T., 2020. *Program 8051 (AT89 Series) With Arduino*. [online] Instructables. Available at: <https://www.instructables.com/Program-8051-With-Arduino/> [Accessed 11 November 2020].

- **Step 1: Wiring for Programming & Parts List**
  - 

  - 

    - *Required Parts List*
      - CLOCK:

            - 1x Crystal Oscillator, less than 33Mhz
                - 2x Capacitors, about 33pF depending on which crystal you use
        - RESET CIRCUIT
            - 1x 10kOhm Resistor
            - 1x 10µF Capacitor
- **Step 2: Wire AT89S52 to Arduino**
    - 

        - RST pin on the 8051 to pin 10 on the Arduino;
        - Pin 8 (P1.7) on the 8051 to pin 13 on the Arduino (SCK);
        - Pin 7 (P1.6) on the 8051 to pin 12 on the Arduino (MISO);
        - Pin 6 (P1.5) on the 8051 to pin 11 on the Arduino (MOSI).
- **Step 3: Programming Using Avrdude**
    - First, upload the sketch named "ArduinoISP" onto the Arduino via Verify/Compile
        - Find via "File" -> "Examples" -> "11.ArduinoISP"
    - Second, download the configuration file for avrdude to allow the ArduinoIDE to program the AT89S52
    - Third, double check wiring and run via cmd.exe:
        - "C:\Program Files (x86)\Arduino\hardware\tools\avr\bin\avrdude.exe" -C E:/avrdude8051.conf -c stk500v1 -P COM3 -p 89s52 -b 19200
            - You might want to replace the path to "avrdude.exe" with your installation path of the Arduino IDE
            - Replace "COM3" with the serial port name of the arduino you use as the programmer
            - Replace "E:/avrdude8051.conf" with path to the configuration you just downloaded
- **Step 4: Programming Using Avrdude**
    - If setup worked correctly, it will look like this:
        - 

```
C:\Windows\system32\cmd.exe
E:\>"C:\Program Files (x86)\Arduino\hardware\tools\avr\bin\avrdude.exe" -C E:/avrdude8051.conf -c stk500v1 -P COM3 -p 89
s51 -b 19200

avrdude.exe: AVR device initialized and ready to accept instructions

Reading | ################################################## | 100% 0.04s

avrdude.exe: Device signature = 0x1e5106 (probably 89s51)

avrdude.exe: safemode: Fuses OK (E:FF, H:FF, L:FF)

avrdude.exe done.  Thank you.


E:\>
```

    - Upload a hex program by running the following command:
        - -U flash:w:YOURPROGRAM.HEX

            - "C:\>"C:\Program Files (x86)\Arduino\hardware\tools\avr\bin\avrdude.exe" -C "C:\Users\MRWal\OneDrive\Desktop\avrdude8051.conf" -c stk500v1 -P COM3 -p 89s52 -b 19200 -U flash:w:\Users\MRWal\OneDrive\Desktop\RES_1.hex
    - Verify, run avrdude via:
        - -U flash:v:YOURPROGRAM.HEX
            - "C:\>"C:\Program Files (x86)\Arduino\hardware\tools\avr\bin\avrdude.exe" -C "C:\Users\MRWal\OneDrive\Desktop\avrdude8051.conf" -c stk500v1 -P COM3 -p 89s52 -b 19200 -U flash:v:\Users\MRWal\OneDrive\Desktop\RES_1.hex

[2] GrSpy. 2019. Program AT89S52 With Arduino - Grspy. [online] Available at: <https://www.grspy.com/program-at89s52-with-arduino/> [Accessed 11 November 2020].

- **Something to Keep In Mind**
    - If the uploading doesn't work, then we may need to go to line 81 of the ArduinoISP and uncomment "#define USE_OLD_STYLE_WIRING"
- **How to produce a HEX file**
    - First, download the Keil uVision IDE via https://www.keil.com/download/
        - May have to install the C51 Development Tools before programming via https://www.keil.com/demo/eval/c51.htm
    - Second, start a new Keil uVision project targeting the AT89S52 via:
        - Select Project -> New uVision Project. On the following dialog select the “AT89S52” target from the “Legacy Device Database”
    - Third, press "Yes" on the prompt asking to copy the STARTUP.A51 file into the project
    - Fourth, from the project tree on the left, select the “Source Group 1” item, right click on it and choose “Add new item”.
        - Then select “C File” option and give it a name, e.g. blinky.c.
    - Fifth, before building the program, make sure the correct crystal frequency is in the project's target options (Target tab) and be sure to generate the hex file (“Create HEX File” checkbox) in the Output tab.

Conclusions/action items:

Utilizing the above wiring and setup for avrdude, I am confident that we will be able to program the AT89S52 with the ArduinoIDE via the Arduino Uno. That being said, we will need to purchase a crystal oscillator and potentially some new capacitors. Finally, we will need to look into producing the HEX file. The HEX file appears to need to be coded in C so wish me luck.

2020/11/10 - Choosing Crystal Oscillator for Programming

Title: Choosing Crystal Oscillator for Programming

Date: 11/10/2020

Content by: Marshall

Present: N/A

Goals: To determine which crystal oscillator to use for programming

Content:

[1] Adafruit Industries - Makers, hackers, artists, designers and engineers!. 2020. Choosing The Right Crystal And Caps For Your Design. [online] Available at: <https://blog.adafruit.com/2012/(

- *Based on the sources I saw for the Arduino programming, they used a 11.0592 MHz crystal oscillator; thus, I decided to find a 11.0592 MHz crystal oscillator*
- When choosing the two capacitors (C1 and C2) that you attach to the crystal in the programming set up, use the following formula:
  - C1, C2 = 2*CL – 2*Cstray
    - CL is the Load Capacitance (as defined in the datasheet)
    - Cstray is the stray capacitance from the rest of the circuit (it is approximated to be 3-5pF)
- **I identified a 11.0592 MHz crystal oscillator that has a CL of 20pF**
  - **Thus, using the equation, we find that C1 and C2 need to be 30pf to 34pf; thus, I think going forward with using two 33pF capacitors should be a good idea.**
  - The crystal oscillator can be found here: https://www.digikey.com/en/products/detail/iqd-frequency-products/LFXTAL003515BULK/8633684?s=N4IgjCBcoMwKxVAYygMwIYBsDOBTANCAPZQDa4ALDAGwAMMIAuoQA4AuUIAymwE4CWAOwDmIAL6FqATkQgUkDDgLEyICmDAAOKQHYmrDpG58hoieE0NoctFjyES
  - 33pF Capacitors:
    - https://www.digikey.com/en/products/detail/tdk-corporation/FA28C0G1H330JNU00/7384520

Conclusions/action items:

I have identified a crystal oscillator that I believe will work for our purposes. The next steps will be to go forward and purchase this crystal oscillator for use in programming.

2020/11/18 - HEX Program Code

Marshall Walters - Nov 18, 2020, 4:33 PM CST

Title: HEX Program Code

Date: 11/18/2020

Content by: Marshall

Present: N/A

Goals: To define and highlight the functionality of the HEX Program that we will be burning onto the AT89S52.

Content:

- ***(A) Defining Variables and PWM***

```
include <reg52.h>
include <intrins.h>

/* Define value to be loaded in timer for PWM period of 20 milli second */
define PWM_Period 0xB7FE

sbit PWM_Out_Pin = P2^0; /* PWM Out Pin for speed control */

  sbit sw1=P1^2;  /* Connected to 4A and drive 4Y */
  sbit sw2=P1^1; /* Connected to 2A and drive 2Y */
  sbit sw3=P1^3; /* Connected to 3A and drive 3Y */
  sbit sw4=P1^0; /* Connected to 1A and drive 1Y */

  sbit forward = P3^0;
  sbit backward = P3^1;
  sbit stop = P3^2;

unsigned int ON_Period, OFF_Period, DutyCycle;
```

- ***(A) Described***
  - PWM_Period is defined by a hexadecimal number
    - The period is equal to (1/0xB7FE) for instance
  - We then define the pins that will interface with the remote (forward/backward/stop)
  - We then define the pins that will wire into the L293D (sw1, sw2, sw3, sw4)
  - Wiring stepper motor to L293D
    - RED to 4Y
    - YEL to 2Y
    - GRY to 3Y
    - GRN to 1Y
- ***(B) Setup Functions (delay, Timer)***

```
/* Function to provide delay of 1ms at 11.0592 MHz */
void delay(unsigned int count)
{
   int i,j;
   for(i=0; i<count; i++)
        for(j=0; j<112; j++);
}

void Timer_init()
{
        TMOD = 0x01; /* Timer0 mode1 */
        TH0 = (PWM_Period >> 8);
        TL0 = PWM_Period;
        TR0 = 1; /* Start timer0 */
}
```

```
/* Timer0 interrupt service routine (ISR) */
void Timer0_ISR() interrupt 1
{
	PWM_Out_Pin = !PWM_Out_Pin;
	if(PWM_Out_Pin)
	{
		TH0 = (ON_Period >> 8);
		TL0 = ON_Period;
	}
	else
	{
		TH0 = (OFF_Period >> 8);
		TL0 = OFF_Period;
	}
}

/* Calculate ON & OFF period from PWM period */
void Set_DutyCycle()
{
	float period = 65535 - PWM_Period;
	ON_Period = period;
	OFF_Period = (period - ON_Period);
	ON_Period = 65535 - ON_Period;
	OFF_Period = 65535 - OFF_Period;
}
```

- ***(B) Described***
    - Timer_init(), Timer0_ISR(), Set_DutyCycle() act to establish the internal Timer of the AT89S52
        - These act to establish the PWM based on what was defined above
- ***(C) Main***

```
void main()
{
	int z=0;
	Timer_init();
	Set_DutyCycle();
	P3=0xff;
	P1=0x00;
	abc:
	while(stop==0)
	{
		forward=1;
		backward=1;
	}

	while(1)
	{
		 if(forward==0)
							{
		  while(forward==0);
						while(1)
						{
							z++;
							if(z==1)
							{
							 sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
							 if(backward==0 || stop==0)
	   break;
							}
```

```
else if(z==2)
{
 sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==3)
{
 sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==4)
{
 sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==5)
{
 sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==6)
{
 sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==7)
{
 sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
 if(backward==0 || stop==0)
break;
}
else if(z==8)
{
 z=0;
 sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
 if(backward==0 || stop==0)
break;
}
}
}

if(backward==0)
{
 while(backward==0);
while(1)
{
z++;
if(z==1)
{
 sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
 if(forward==0 || stop==0)
break;
```

```
                    }
                    else if(z==2)
                    {
                     sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
                    else if(z==3)
                    {
                     sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
                    else if(z==4)
                    {
                     sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
                    else if(z==5)
                    {
                     sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
                    else if(z==6)
                    {
                     sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
                    else if(z==7)
                    {
                    sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
                    if(forward==0 || stop==0)
    break;
                    }
                    else if(z==8)
                    {
                     z=0;
                     sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
                     if(forward==0 || stop==0)
    break;
                    }
               }
              }
              if(stop==0)
                   goto abc;
          }
}
```

Conclusions/action items:

All the code highlighted in purple will be converted to a HEX file based on the protocol defined in other notebook pages. This code allows for the PWM to be defined by a timer within the AT89S52 and allows for a bi polar stepper motor to be run. These code was created by massing two other examples together that were used to define the wiring of the system. This code will require testing to perfect.

2020/11/23 - Generating HEX File

Marshall Walters - Nov 23, 2020, 9:45 AM CST

Title: Generate HEX File

Date: 11/23/2020

Content by: Marshall

Present: N/A

Goals: To produce a HEX file from the Keil uVision IDE.

Content:

- Utilizing the notebook pages regarding programming with an Arduino, the protocol for downloading and producing a HEX file for a AT89S52 via the Keil uVision IDE was used.
    - The crystal oscillator value was set to 11.0592 MHz in the settings
    - The C code from the previous notebook entry was input into the IDE and then compiled
- See attached for HEX file for upload to the AT89S52 via Arduino UNO

Conclusions/action items:

The next steps will be to take this HEX file and burn it onto the AT89S52 in order to coordinate its function. There will need to be edits to this HEX file in order to allow for only a set amount of movement forward and a set amount of movement backwards so the client can't accidently ruin the enclosure and prevent the device from functioning.

Marshall Walters - Nov 23, 2020, 9:45 AM CST

RES_1.hex(3.4 KB) - download

2020/12/04 - Software Flow Diagram

Marshall Walters - Dec 07, 2020, 9:18 PM CST

Title: Software Flow Diagram

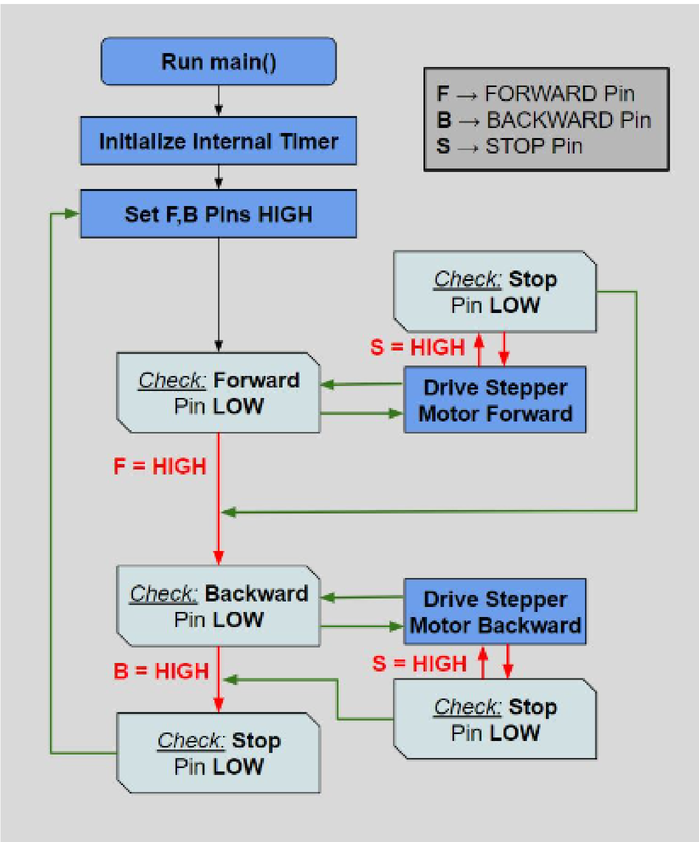
Date: 12/7/2020

Content by: Marshall

Present: N/A

Goals: To outline the functionality of the software program in an easy to view format.

Content:



On the Software front, a HEX program (produced in Keil uVision) was burned onto the AT89S52 using an Arduino Uno. The program operates by first initializing an internal timer of the microcontroller so it produces its own PWM (pulse width modulation) timer in order to set the rhythm/timing of the following checks. This PWM timer dictates the speed of the motor as a result and can be adjusted accordingly. After initializing an internal timer, the system start in the STOP position by setting the Forward and Backward pins of the microcontroller to HIGH. This effectively starts the system off at a clean slate, waiting for input. Next, the program enters a while loop that consistently checks if the forward OR the backward pins have been activated by the user via the remote. Once activated, the program will initialize the necessary powering of the Driver IC in order to drive the motor either forward or backward by altering which of the four pins attached to the driver IC are receiving power. As long as the Forward or Backward pins are activated, the forward and backward motion will ensue until the STOP pin is activate which will disengage the movement and bring the program back to the starting, clean state.

With all that being said, due to the poor visibility of the researchers to the inside of the hyperbaric chamber, we want to be able to have them hit the switch and to have the motor move as much as necessary in order to fully retract or fully plunge the syringe without damaging the housing. We aim to improve this program by instituting a movement cap to force the system back to the STOP state as soon as the plunger is fully retracted or depressed.

Conclusions/action items:

The next steps will be to present this software flow diagram during the final poster presentation!

2020/11/3 - Ideas for Wiring of L239D & AT89S52 40-lead PDIP

Marshall Walters - Nov 24, 2020, 2:42 PM CST

Title: Ideas for Wiring of L239D & AT89S52 40-lead PDIP

Date: 11/3/2020

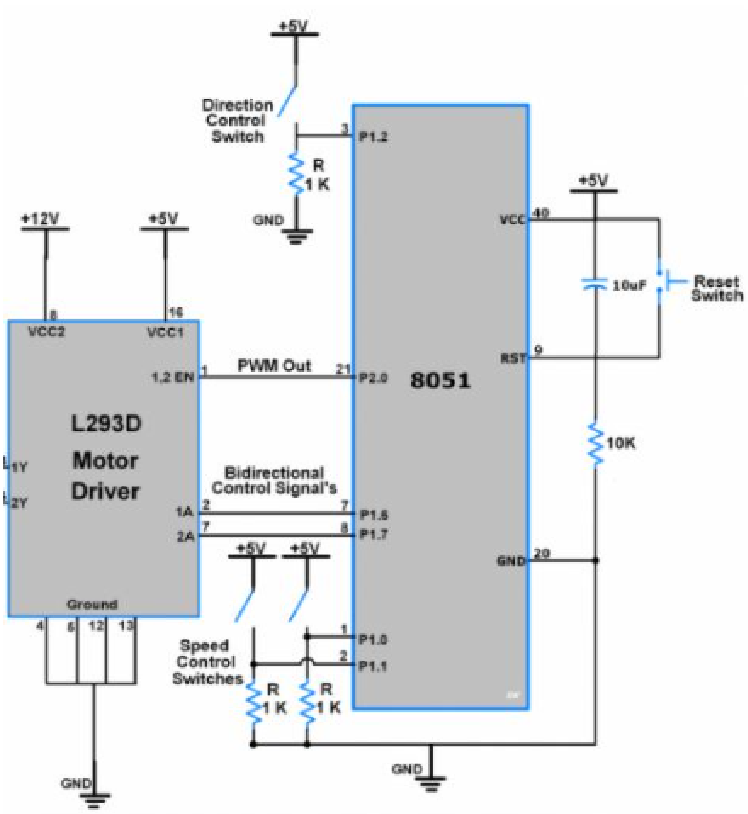
Content by: Marshall

Present: N/A

Goals: To determine how the L239D & AT89S52 will be wired to allow for forward and reverse movement.

Content:

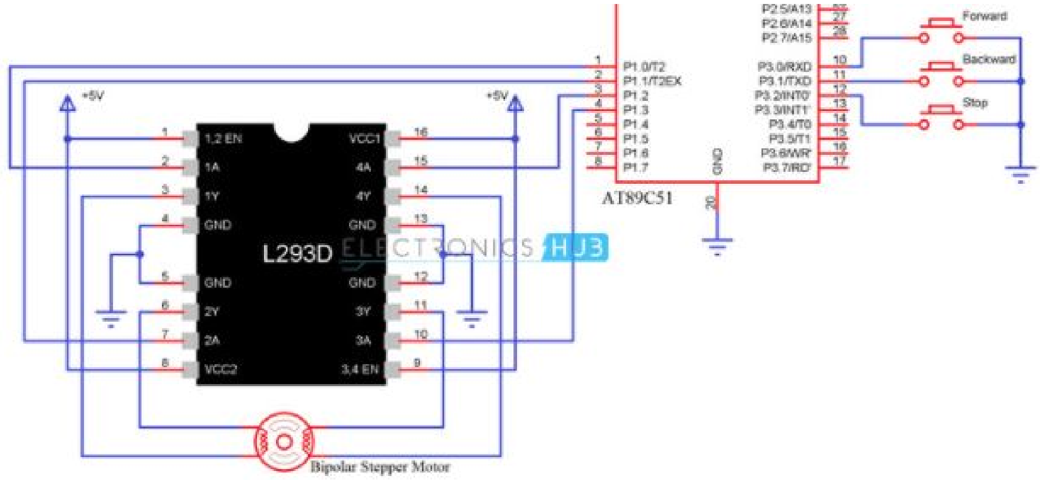
[1] Electronicwings.com. 2020. DC Motor Interfacing With 8051 | 8051 Controller. [online] Available at: <https://www.electronicwings.com/8051/dc-motor-interfacing-with-8051> [Accessed 4 November 2020].

- **Circuitry Components 1 -** (Wiring of AT89S52 to L239D *(Mostly)*) [1]
    - 

    -
        - I don't believe that we will need speed control switches (P1.0, P1.1) as we will choose a specific PWM in order to achieve a perfect speed for our application
            - A timer within the AT89S52 can be used to generate the PWM
        - The direction control should be expanded to include a STOP signal
        - It seems like VCC2 should be set to 12V as we are using a 12V motor
        - Some other designs include use of the oscillator ports (XTAL1 and XTAL2) with a 11.0592 MHz Crystal -- **WHY? and WHY not this one?**

[2] Electronics Hub. 2020. Stepper Motor Interfacing With 8051 Microcontroller. [online] Available at: <https://www.electronicshub.org/stepper-motor-control-using-8051-microcontroller/#Circuit_1_Stepper_Motor_Control_using_8051_Microcontroller_L293D> [Accessed 4 November 2020].

- **Circuitry Components 2** - Wiring of L293D w/ Stepper Motor [2]



- As our stepper motor will have two coils that we will need to be able to drive, we should plan to wire as seen (1Y/2Y for one coil & 3Y/4Y for the other coil)
- Disregard VCC2 pin in this depiction
- This shows how to integrate a Forward, Backward, and Stop option (via using three pins on microcontroller & 3 three pins on L293D (1A, 2A, 3A))

Conclusions/action items:

Although not integrated into one topology that shows the correct connection of all parts, if the selected circuitry components are integrated into one another we should have a functional AT89S52 and a functional L293D. The L239D would be wired to drive a 12V motor. The internal timer of AT89S52 would be used to generate a PWM to control the speed of the stepper motor. Finally, the system should allow for a Forward action, Backward (reverse) action, and a Stop action. This should allow full functionality of the device from the remote device. The next steps include: identify and purchase the required 12V/5V power supply, identify and purchase the discrete components, determine if an oscillator is necessary, and finalize the topology of the wiring of the L239D and the AT89S52.

2020/12/04 - AT89S52, L293D, Stepper Motor Wiring

Marshall Walters - Dec 07, 2020, 9:23 PM CST

Title: AT89S52, L293D, Stepper Motor Wiring

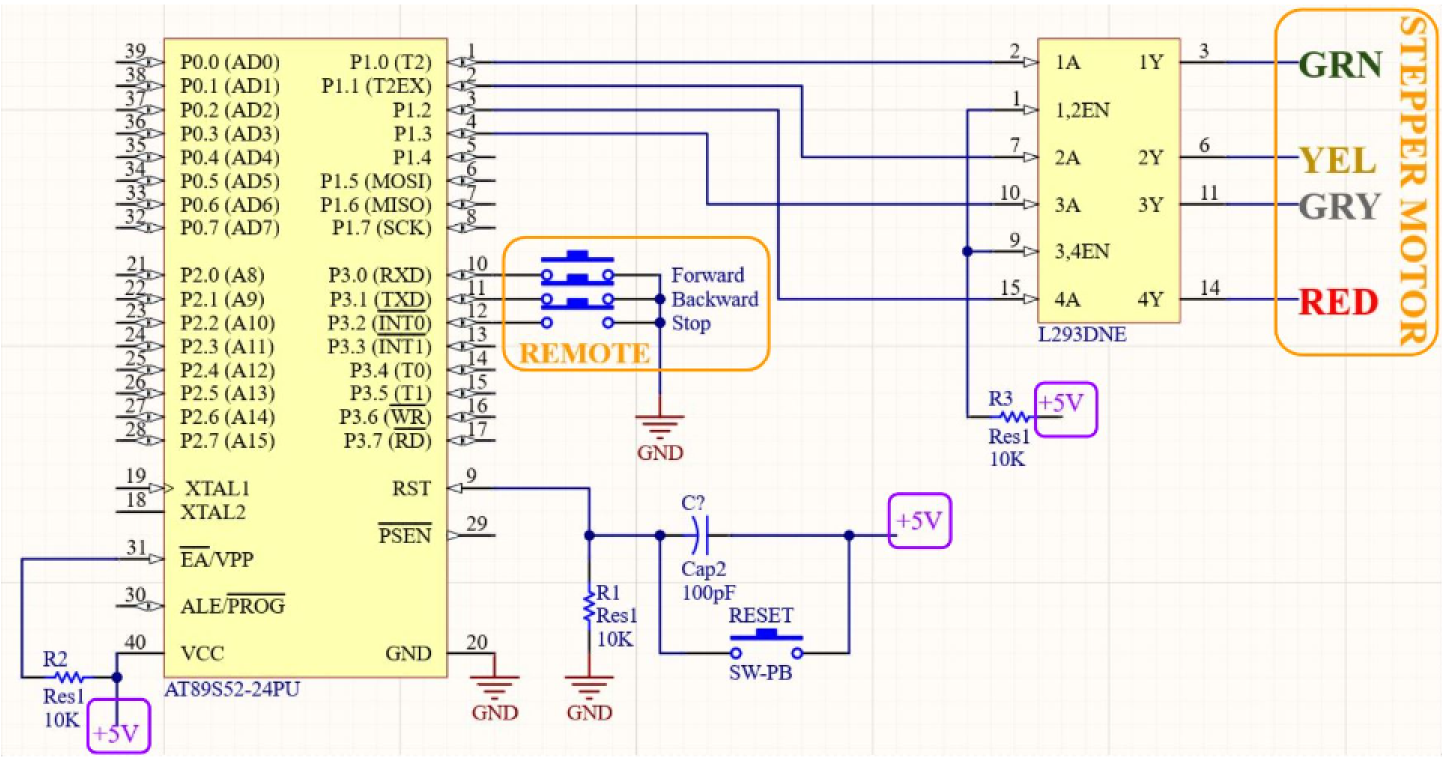
Date: 12/4/2020

Content by: Marshall

Present: N/A

Goals: To outline the wiring of the circuitry of our system and to outline the functionality of each piece.

Content:



The AT89S52 microcontroller (seen on the left side of Figure **3) is used to coordinate the forward or backward movement of the stepper motor based on input from the user. In order to satisfy the base wiring requirements as defined by the AT89S52 documentation, Pin 20 was wired to ground, Pin 40 to 5V, Pin 31 to 5V via a 10K resistor, and Pin 29 was wired in such a fashion to institute a reset switch (Figure **3). Next, three pins of the AT89S52 (Pin 10, Pin 11, and Pin 12) are dedicated to interfacing with a switch remote that is to be wired outside of the hyperbaric chamber and that will be in the hand of the researchers. This switch remote has three positions (FORWARD, BACKWARD, and STOP) which act to ground their corresponding pin (Pin 10, Pin 11, and Pin 12 respectively) when switched by the user (Figure **3). The grounding of these pins serves as user input to signal the microcontroller software to initiate or stop motor movement.

In terms of the connections between the microcontroller and the driver IC, there are four pins of the AT89S52 (Pin 1, Pin 2, Pin 3, and Pin 4) that are dedicated to interface with the L293D Driver IC (which can be seen on the right side of Figure **3). Pins 1, 2, 3, and 4 of the AT89S52 wire into four ports on the L293D (1A, 2A, 4A, and 3A respectively). When one of these four ports of the L293D are powered HIGH, the corresponding Y port (e.g. when A1 is powered HIGH, Y1 is activated) is opened to allow current through to drive the bipolar stepper motor. Depending on the order by which the A ports of the L293D are powered, the stepper motor will produce forward or backward linear motion of the leadscrew. Finally, Pin 1 and Pin 9 of the L293D are connected to 5V in order to enable the dual H-bridge functionality of the L293D unit.

Conclusions/action items:

The next step will be to present the wiring of the AT89S52, L293D, Stepper Motor during the Final Poster Presentation.

2020/11/30 - UPDATED HEX Program Code - INTERNAL TIMER

Marshall Walters - Nov 30, 2020, 11:20 AM CST

Title: UPDATED HEX Program Code

Date: 11/30/2020

Content by: Marshall

Present: N/A

Goals: To update the original HEX program to remove the setting of the PWM pin and to set stop to HIGH when forward/backward are activated.

Content:

```
include <reg52.h>
include <intrins.h>

/* Define value to be loaded in timer for PWM period of 20 milli second */
define PWM_Period 0xB7FE

  sbit sw1=P1^2;  /* Connected to 4A and drive 4Y */
  sbit sw2=P1^1; /* Connected to 2A and drive 2Y */
  sbit sw3=P1^3; /* Connected to 3A and drive 3Y */
  sbit sw4=P1^0; /* Connected to 1A and drive 1Y */

  sbit forward = P3^0;
  sbit backward = P3^1;
  sbit stop = P3^2;

unsigned int ON_Period, OFF_Period, DutyCycle;

/* Function to provide delay of 1ms at 11.0592 MHz */
void delay(unsigned int count)
{
   int i,j;
   for(i=0; i<count; i++)
        for(j=0; j<112; j++);
}

void Timer_init()
{
        TMOD = 0x01; /* Timer0 mode1 */
        TH0 = (PWM_Period >> 8);
        TL0 = PWM_Period;
        TR0 = 1; /* Start timer0 */
}

/* Timer0 interrupt service routine (ISR) */
void Timer0_ISR() interrupt 1
{
        PWM_Out_Pin = !PWM_Out_Pin;
        if(PWM_Out_Pin)
        {
                TH0 = (ON_Period >> 8);
                TL0 = ON_Period;
        }
        else
        {
                TH0 = (OFF_Period >> 8);
```

```
        TL0 = OFF_Period;
    }
}

/* Calculate ON & OFF period from PWM period */
void Set_DutyCycle()
{
    float period = 65535 - PWM_Period;
    ON_Period = period;
    OFF_Period = (period - ON_Period);
    ON_Period = 65535 - ON_Period;
    OFF_Period = 65535 - OFF_Period;
}
void main()
{
    int z=0;
    Timer_init();
    Set_DutyCycle();
    P3=0xff;
    P1=0x00;
    abc:
    while(stop==0)
    {
        forward=1;
        backward=1;
    }

    while(1)
    {
         if(forward==0)
                                        {
                                        stop=1;
          while(forward==0);
                                   while(1)
                                   {
                                        z++;
                                        if(z==1)
                                        {
                                         sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
                                         if(backward==0 || stop==0)
      break;
                                        }
                                        else if(z==2)
                                        {
                                         sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
                                         if(backward==0 || stop==0)
      break;
                                        }
                                        else if(z==3)
                                        {
                                         sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
                                         if(backward==0 || stop==0)
      break;
                                        }
                                        else if(z==4)
                                        {
                                         sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
```

```
                                                 if(backward==0 || stop==0)
    break;
                                                }
                                                else if(z==5)
                                                {
                                                 sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
                                                 if(backward==0 || stop==0)
    break;
                                                }
                                                else if(z==6)
                                                {
                                                 sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
                                                 if(backward==0 || stop==0)
    break;
                                                }
                                                else if(z==7)
                                                {
                                                 sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
                                                 if(backward==0 || stop==0)
    break;
                                                }
                                                else if(z==8)
                                                {
                                                 z=0;
                                                 sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
                                                 if(backward==0 || stop==0)
    break;
                                                }
                                     }
                                    }

  if(backward==0)
                                    {
                                    stop=1;
   while(backward==0);
                                          while(1)
                                          {
                                                z++;
                                                if(z==1)
                                                {
                                                 sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
                                                 if(forward==0 || stop==0)
    break;
                                                }
                                                else if(z==2)
                                                {
                                                 sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
                                                 if(forward==0 || stop==0)
    break;
                                                }
                                                else if(z==3)
                                                {
                                                 sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
                                                 if(forward==0 || stop==0)
    break;
                                                }
                                                else if(z==4)
```

```
                                                {
                                                 sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
                                                 if(forward==0 || stop==0)
          break;
                                                }
                                                else if(z==5)
                                                {
                                                 sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
                                                 if(forward==0 || stop==0)
          break;
                                                }
                                                else if(z==6)
                                                {
                                                 sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
                                                 if(forward==0 || stop==0)
          break;
                                                }
                                                else if(z==7)
                                                {
                                                sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
                                                if(forward==0 || stop==0)
          break;
                                                }
                                                else if(z==8)
                                                {
                                                 z=0;
                                                 sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
                                                 if(forward==0 || stop==0)
          break;
                                                }
                                     }
                                    }
                                    if(stop==0)
                                          goto abc;
                              }
}
```

Conclusions/action items:

All the code highlighted in purple will be converted to a HEX file based on the protocol defined in other notebook pages. This code allows for the PWM to be defined by a timer within the AT89S52 and allows for a bi polar stepper motor to be run. These code was created by massing two other examples together that were used to define the wiring of the system. This code has been updated in order to set the STOP pin to HIGH when the forward/backward impulse are used. The PWM out pin was also removed.

Marshall Walters - Nov 30, 2020, 11:38 AM CST

RES_2_InternalTimer.hex(3.4 KB) - download

2020/11/30 - UPDATED HEX Program Code - Crystal Oscillator as Timer

Marshall Walters - Nov 30, 2020, 11:22 AM CST

Title: UPDATED HEX Program Code

Date: 11/30/2020

Content by: Marshall

Present: N/A

Goals: To update the original HEX program to remove the setting of the PWM pin and to set stop to HIGH when forward/backward are activated.

Content:

```
include <reg52.h>
include <intrins.h>

  sbit sw1=P1^2;  /* Connected to 4A and drive 4Y */
  sbit sw2=P1^1; /* Connected to 2A and drive 2Y */
  sbit sw3=P1^3; /* Connected to 3A and drive 3Y */
  sbit sw4=P1^0; /* Connected to 1A and drive 1Y */

  sbit forward = P3^0;
  sbit backward = P3^1;
  sbit stop = P3^2;

/* Function to provide delay of 1ms at 11.0592 MHz */
void delay(unsigned int count)
{
    int i,j;
    for(i=0; i<count; i++)
          for(j=0; j<112; j++);
}


void main()
{
          int z=0;
          P3=0xff;
          P1=0x00;
          abc:
          while(stop==0)
          {
                    forward=1;
                    backward=1;
          }

          while(1)
          {
                     if(forward==0)
                                                                {
                                                                stop=1;
                       while(forward==0);
                                                  while(1)
                                                  {
                                                            z++;
                                                            if(z==1)
                                                            {
```

```
                    sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==2)
                   {
                    sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==3)
                   {
                    sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==4)
                   {
                    sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==5)
                   {
                    sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==6)
                   {
                    sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==7)
                   {
                    sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
                   else if(z==8)
                   {
                    z=0;
                    sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
                    if(backward==0 || stop==0)
    break;
                   }
              }
             }

  if(backward==0)
             {
             stop=1;
   while(backward==0);
                 while(1)
                 {
                   z++;
```

```
						if(z==1)
						{
						 sw1=1;sw2=0;sw3=0;sw4=1;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==2)
						{
						 sw1=0;sw2=0;sw3=0;sw4=1;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==3)
						{
						 sw1=0;sw2=0;sw3=1;sw4=1;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==4)
						{
						 sw1=0;sw2=0;sw3=1;sw4=0;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==5)
						{
						 sw1=0;sw2=1;sw3=1;sw4=0;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==6)
						{
						 sw1=0;sw2=1;sw3=0;sw4=0;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
						else if(z==7)
						{
						sw1=1;sw2=1;sw3=0;sw4=0;delay(30);
						if(forward==0 || stop==0)
	break;
						}
						else if(z==8)
						{
						 z=0;
						 sw1=1;sw2=0;sw3=0;sw4=0;delay(30);
						 if(forward==0 || stop==0)
	break;
						}
					 }
					}
					if(stop==0)
						goto abc;
				}
}
```

Conclusions/action items:

All the code highlighted in purple will be converted to a HEX file based on the protocol defined in other notebook pages. This code assumes that a Crystal Oscillator is being used to set the PWM of the microcontroller. That being said, the methods involved with setting up the internal Timer have been removed.

Marshall Walters - Nov 30, 2020, 11:38 AM CST

RES_2_CrystalOscillator.hex(1.6 KB) - download

Shop Permit: Green Pass

Marshall Walters - Sep 25, 2019, 8:36 AM CDT

MW_GreenPass.jpg(584 KB) - download

Sheep Injection

CATE FITZGERALD - Sep 13, 2020, 11:53 AM CDT

Title: Sheep Injection

Date: 9/10/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Locate the major veins and arteries in a sheep.

Content:

Sciencedirect.com. 2020. Jugular Vein - An Overview | Sciencedirect Topics. [online] Available at: <https://www.sciencedirect.com/topics/immunology-and-microbiology/jugular-vein#:~:text=In%20sheep%20and%20goats%20the,adequate%20visualization%20of%20the%20vein.> [Accessed 10 September 2020].

Intravenous Injections are often given through the jugular vein, but great caution needs to be taken when injecting in order to insure that no other major arteries or veins are nicked, causing a more painful and less humane death. The jugular vein often is used to administer intravenous drugs. In sheep, the jugular vein can be found lying in a line starting at the base of the ear running down the neck to the thoracic inlet. It is often necessary to part the wool to give adequate visualization of the vein. This is important because we may need to add a component that is able to navigate the thick wool. Adequate restraint is critical to avoid inadvertent puncture of other structures such as the trachea or esophagus. A 4-cm, 20-gauge needle can be used for venipuncture.

Conclusions/action items: Injection entry will most likely be through the jugular vein. To insure a successful injection, it is helpful to remove the wool and locate the vein directly. Since we will just be euthanizing sheep, we should take this into consideration to allow for a more humane death, so I propose creating a device that can also navigate the thick wool on a sheep. A 4-cm 20-gauge needle is also recommended for injections, so this is a helpful measurement to follow. I am going to continue to research previous injections on sheep and see if similar articles align. I am also going to research how euthansia treatments have been done on large animals in the past.

On-Farm Euthanasia

CATE FITZGERALD - Sep 13, 2020, 11:53 AM CDT

Title: On-Farm Euthanasia

Date: 9/10/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Understand how euthanasia treatments have been done on large animals in the past.

Content:

Omafra.gov.on.ca. 2020. On-Farm Euthanasia Of Sheep And Goats. [online] Available at: <http://www.omafra.gov.on.ca/english/livestock/animalcare/facts/info_euthanasia_shgt.htm> [Accessed 10 September 2020].

Intravenous administration of a barbiturate is one of the best rated ways to euthanize an animal humanely. You must restrain the animal, which may pose some problems for our device. It can only be administered by licenced veterinarian/restrictions regarding carcass disposal.

Ucanr.edu. 2020. [online] Available at: <https://ucanr.edu/sites/UCCE_LR/files/228027.pdf> [Accessed 10 September 2020].

When properly administered by the intravenous route, barbiturate overdose (sodium pentobarbital) depresses the central nervous system, causing deep anesthesia that results in respiratory and cardiac arrest. This method of euthanasia results in minimal pain (needle puncture) sensation. Barbiturate overdose is less disturbing to observers but also more expensive than other options. It is also illegal for a non-veterinarian to possess injectable euthanasia products. Confirmation of death is essential. Immediately following the euthanasia method a standing animal should collapse and may experience a period of muscle contraction (usually no longer than 20 seconds). This will be followed by a period of relaxation and some poorly coordinated kicking or paddling movements. The pupils of the eyes should be totally dilated. The animal must be monitored for 5 minutes to confirm death. Death may be confirmed by the absence of breathing, a heartbeat, and a corneal reflex. To check a corneal reflex (blinking response), touch the animal's cornea (surface of the eye); there should be no response to the touch if the animal is dead. The presence of any eye movement or blinking at this time is evidence of sustained or recovering brain activity and the individual should repeat the same or an alternative euthanasia procedure.

Conclusions/action items: The safest and most humane method for us will be by injection. However to make this humane, which is our main goal, we will need to add many extra steps. This includes restraining the animal and finding a way to dispose of the animal. One site said that this could only be done by the vet that provided the medicine. Just disposing of the bodies in general is a big issue that I didn't even think about. We will need to get medicine prescribed from a vet, because it is illegal for us to possess it. We may also need to focus on confirmation of death. Every website says that that is very important, so we ma need to install a video camera or apply a device that can measure temperature or heart palpitations to confirm death. This will make the process humane, which is one of my number one goals since I am an animal lover.

Jugular Injection

CATE FITZGERALD - Sep 13, 2020, 11:54 AM CDT

Title: Jugular Injection

Date: 9/10/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Understand how the jugular vein has been located on sheep by vets in the past.

Content:

Ouv.vt.edu. 2020. [online] Available at: <https://ouv.vt.edu/content/dam/ouv_vt_edu/sops/large-animal/sop-sheep-blood-collection.pdf> [Accessed 10 September 2020].

Below is a procedure used to extract blood from sheep in the jugular vein. I am quoting it and stating here that it was pasted to get the exact procedure:
a. Restrain animal with head elevated and jugular vein exposed (Figure 1).
i. Stand sheep with animal's back against your legs. Alternatively, set the sheep on its rump with
its back against your legs (tipping or "set-up"). Hold the head of the sheep at about a 30° angle
to the side to extend neck and expose jugular.
ii. Collection is most easily performed with two handlers – one to restrain and one to collect blood.
With experience, one handler can hold and collect blood – with sheep set between your legs,
tuck head under arm, and access jugular from above.
b. Clip (optional) a small area over the jugular groove, and swipe with antiseptic gauze to remove
superficial dirt and debris. This may also assist in visualizing raised vein.
c. Occlude jugular vein by applying pressure at the base of the jugular groove and visualize raised vein.
d. With bevel up, insert needle through skin and into vein at 20° angle (Figure 2).
e. Using vacutainer method - once needle inserted, stabilize needle and push the vacutainer tube into hub.
If you have hit the vein, blood will flow freely into tube. Multiple tubes can be filled by removing filled
tube and replacing with fresh tube (Figure 3).
f. Using needle and syringe method – before use, break the seal on the syringe by gently pulling back
plunger. Clear air, and with needle attached to syringe, insert needle at 20° angle, and aspirate syringe
to confirm insertion and collect blood.
g. If you have missed the vein, you can carefully reposition needle until vessel penetrated. Vessel may be
fairly deep and roll away from needle. Typically no more than two to three attempts should be made at a
time to minimize distress to the animal and potential damage to the vein.
NOTE: When using vacutainer, do not pull needle out of skin with vacutainer tube attached, as this will
cause vacuum to be lost.
h. Once collection complete, release pressure to the vein (and detach vacutainer tube if used), then,
applying pressure over injection site with gauze, remove needle.
i. Dispose of needle in approved Sharps container.
j. In order to ensure adequate hemostasis, apply pressure with gauze for 30 to 60 seconds.
k. Serial samples can be taken by alternating sides, and by moving insertion sites caudally, as long as there
is no hematoma formation.

Figure 1. Pull Head to the Side and Occlude Jugular to Visualize Vein

Figure 2. Insert Needle

Figure 3. Collect Blood

Figure 1: Includes the three figures referenced directly in the procedure.

Conclusions/action items: This is a detailed procedure of how blood has been extracted from the jugular vein. This is interesting because it is a common procedure and highlights how this vein should be handled. Different sections of the paper also stated that the cephalic or femoral vein are the other most common large veins in sheep. Big problems of handling veins can be solved if you're careful and enter the vein at 30 degrees or less, use a gauge of needle smaller than the vein, and apply pressure if bleeding occurs.

Hyperbaric Pressures

CATE FITZGERALD - Sep 28, 2020, 6:35 PM CDT

Title: Hyberbaric Pressures

Date: 9/10/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: See the risks of being at hyberbaric pressures.

Content:

Mayoclinic.org. 2020. Hyperbaric Oxygen Therapy - Mayo Clinic. [online] Available at: <https://www.mayoclinic.org/tests-procedures/hyperbaric-oxygen-therapy/about/pac-20394380#:~:text=Potential%20risks%20include%3A,by%20air%20pressure%20changes%20(barotrauma)> [Accessed 10 September 2020].

Risks at very high pressures include temporary nearsightedness caused by temporary eye lens changes,middle ear injuries, including leaking fluid and eardrum rupture, due to increased air pressure, lung collapse caused by air pressure changes (barotrauma), and seizures as a result of too much oxygen (oxygen toxicity) in your central nervous system.

Conclusions/action items: These are the most common symptoms of being at a high temperature.The one that concerns me the most is lung collapse. This may be the primary cause of our injection or solution. I am curious if we have to monitor when sheep need to be euthanized, or if a system is already in place to do do. If not, we may also need to see how these symptoms appear in sheep. I will contact my client and ask about this and continue doing research on the pressure in submarines and sheep anatomy.

Client's Research Wishes

CATE FITZGERALD - Sep 20, 2020, 1:24 PM CDT

Title: Client's Research Wishes

Date: 9/20/20

Content by: Cate Fitzgerald

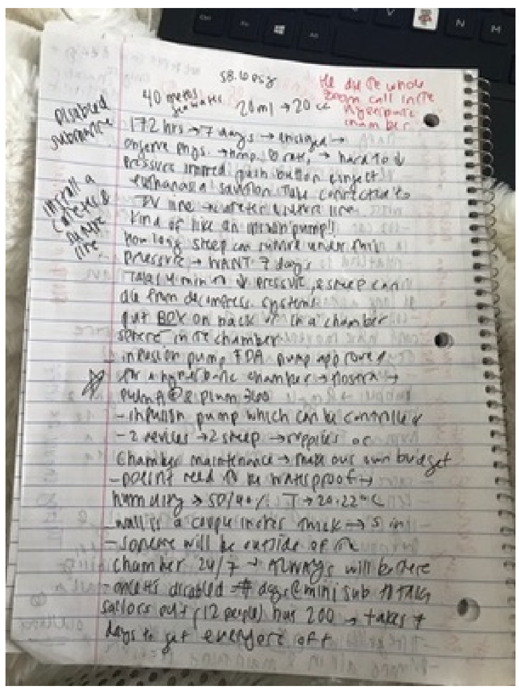
Present: BME 200/300 Team, Dr. Sobakin, and Dr. Eldridge

Goals: Understand the client's desires and see what they want us to research more of.

Content: Research notes pasted below.

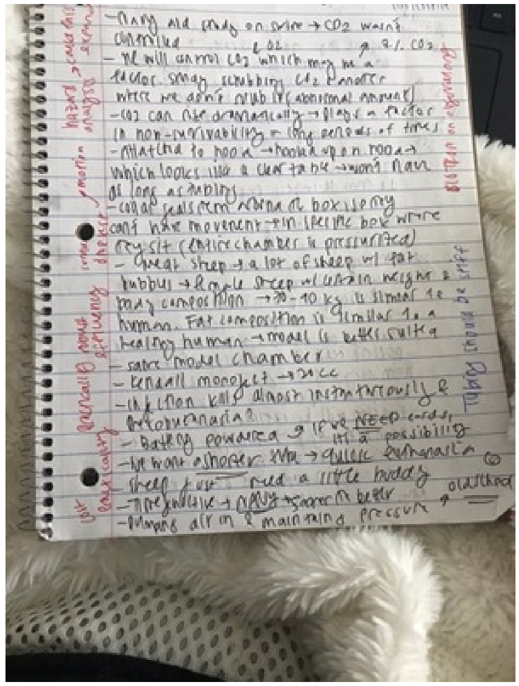
Conclusions/action items: Now that we know our client better, we have a better understanding of what we can research. We need to grasp a better understanding of hydrolic systems and how to mechanically pump a solution into a sutured catheter. I originally had done the majority of my research on sheep anatomy and veins, but now I need to focus more on the mechanical system that we are creating, as the first part is basically taken care of. I will now focus my research on microsystems and technology to pump the solution.

CATE FITZGERALD - Sep 20, 2020, 1:20 PM CDT


172 hrs → 7 days →
kind of like an insulin pump!)
how long sheep can survive under this pressure → WANT 7 days
put BOX on back
- infusion pump which can be controlled
- 2 devices → 2 sheep
chamber maintenance → make our own budget
humidity → 50/40% T → 20-22°C
- someone will be outside of the chamber 24/7 → always will be there
sailors out (12 people) has 200 → takes 7 days to get everyone off

CF797A83-5B56-497E-BFF4-069CBF7E6412.jpg(65.4 KB) - download

CATE FITZGERALD - Sep 20, 2020, 1:20 PM CDT


[illegible] CO_2 [illegible]
- [illegible] CO_2 which [illegible]
[illegible]
- CO_2 can rise dramatically → [illegible] a factor in non-survivability [illegible] periods of time
[illegible]
which looks like a clear tank [illegible]
[illegible]
- [illegible] sheep [illegible] a lot of sheep w/ fat [illegible]
[illegible] weight [illegible]
[illegible] composition [illegible] kg [illegible] similar to human. Fat composition is similar to a [illegible] human [illegible] model [illegible]
- [illegible] model chamber
- Kendall [illegible] → 24 cc
- [illegible] almost instantaneously [illegible]
[illegible] if we NEED [illegible] its a possibility
[illegible] need a little [illegible]
[illegible] air in [illegible] maintaining pressure

83077A14-C34B-4FC5-B6C2-D1A95A12F5BE.jpg(70.6 KB) - download

Pentobarbital

CATE FITZGERALD - Oct 08, 2020, 8:53 PM CDT

Title: Pentobarbital

Date: 10/8/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Evaluate why pentobarbital is the best option for our project.

Content:

Johnson, A. and Sadiq, N., 2020. Pentobarbital. [online] Ncbi.nlm.nih.gov. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK545288/> [Accessed 16 September 2020].

AHC Research Services - University of Minnesota. 2020. Euthanasia Guidelines. [online] Available at: <https://www.researchservices.umn.edu/services-name/research-animal-resources/research-support/guidelines/euthanasia> [Accessed 14 September 2020].

Pentobarbital is the most common medication to administer for animal euthanization. It can be used in smaller doses as it is used as an anti seizure medication. Size of the animal being euthanized is a crucial part in how much they need to administer, and as a result, the client will be using similar sized female sheep in order to consistently use a similar dosage. Typically, a dosage of 100 mg per kilogram of body mass of the sheep is required to adequately dispatch a sheep. Pentobarbital behaves as an incompressible fluid much like water. The shelf life of sodium pentobarbital is rated at 3 years when unopened, and 28 days after opening the package.

Conclusions/action items: Pentobarbital will be used because it is historically effective for large animal euthanasia. The dosage administered depends on the size of the sheep, which is why our clients will be using similarly sized female sheep in order to keep this calculation relatively constant. In the future, we need to see how this solutions flows and how viscous it is.

Infusion Pumps

CATE FITZGERALD - Sep 22, 2020, 4:54 PM CDT

Title: Infusion Pumps

Date: 9/22/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn more about current infusion pumps and how they are used.

Content:

file:///C:/Users/catef/Downloads/ECRI_Institute_Infusion_Pumps_to_Consider_for_Use_with_Hyperbaric_Chambers.pdf

Hospira, the only FDA approved infusion pump for high pressure environments, announced that it would be discontinuing the manufacture, sale, leasing, service, and support of the Plum A+ hyperbaric infusion pump. As a result, the market for hyperbaric-compatible infusion pumps is very small, and these pumps have a life expectancy of more than 10 years.

Hyperbaric oxygen (HBO2) chambers are the pressure chambers that Hospira used. When the patient breathes HBO2, both the amount of O2 per unit volume of arterial and venous blood and the partial pressure of O2 are increased in blood and tissue. Dissolved O2 content increases by about 2.3 mL of O2 per 100 mL of whole blood for each additional atmosphere of pressure, even after the hemoglobin is 100% saturated. The increased partial pressure of O2 in the arterial blood during hyperbaric oxygenation causes a high O2 diffusion gradient from blood to tissue. These high partial
pressures of O2 also have wound-healing effects and modulate inflammation.

Hospira created their device for many hyberbaric chambers, but the one most similar to our is the monoplace chamber. For IV infusions delivered to patients in monoplace chambers, the infusion pump was located adjacent to the chamber. The infusion pump administration set was connected to a specialized fitting in a port in the chamber hatch, allowing a seal. Inside the chamber, tubing from the specialized fitting is connected to the patient’s IV catheter. The infusion pump’s occlusion pressure is set to maximum. In order to deliver the IV solution into the pressurized environment, the pump must be able to generate 30 psi or more without alarming and stopping the infusion.

When using a chamber like this, you have to worry about the possibilities of fires. A clinical hyperbaric chamber combines the use of a pressurized atmosphere with the use of oxygen, which creates an increased risk of fire. These devices also must pass man regulations. NFPA 99 requires the safety director of the hyperbaric facility to be responsible for all equipment used in the hyperbaric environment. A comprehensive evaluation and risk assessment for anything in the chamber must be completed and documented under different hyperbaric conditions to ensure that the equipment is safe for use with or within a chamber.

Conclusions/action items: Hospira created the first FDA approved infusion pump for hyberbaric chambers, but recently retired this model. It could be a great example of something that we could try to replicate while adding things that we need such as a microcontroller and bluetooth device. Their device took in the factor of HBO2 and also followed many regulations, as a high pressure environment can cause fires and other unique issues. This is a great example of a device that was FDA approved and worked effectively. I am going to continue to look at this device to see why it was retired, and specific parts that made it successful.

Hyberbaric Chambers

CATE FITZGERALD - Oct 05, 2020, 2:13 PM CDT

Title: Hyberbaric Chambers

Date: 10/5/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Look at current hyperbaric chambers and how they are used.

Content:

R. M. Leach, P. J. Rees, and P. Wilmshurst, “Hyperbaric oxygen therapy,” BMJ (Clinical research ed.), 24-Oct-1998. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1114115/. [Accessed: 01-Oct-2020].

Hyperbaric chambers are often utilized to to help fight infection or minimize injury. They are usually used at around 1.5 atm, 15-18 m of water.

Mayoclinic.org. 2020. Hyperbaric Oxygen Therapy - Mayo Clinic. [online] Available at: <https://www.mayoclinic.org/tests-procedures/hyperbaric-oxygen-therapy/about/pac-20394380#:~:text=Potential%20risks%20include%3A,by%20air%20pressure%20changes%20(barotrauma)> [Accessed 10 September 2020].

Too much exposure in a hyperbaric chamber may result in:
Lung collapse caused by air pressure changes (barotrauma)
Seizures as a result of too much oxygen (oxygen toxicity)

In a hyperbaric oxygen therapy chamber, the air pressure is increased to three times higher than normal air pressure. Under these conditions, your lungs can gather more oxygen than would be possible breathing pure oxygen at normal air pressure.

Your blood carries this oxygen throughout your body. This helps fight bacteria and stimulate the release of substances called growth factors and stem cells, which promote healing.

Depending on the chamber used, typical chambers are:

A unit designed for 1 person. In an individual (monoplace) unit, you lie down on a table that slides into a clear plastic tube.
A room designed to accommodate several people. In a multiperson hyperbaric oxygen room — which usually looks like a large hospital room — you may sit or lie down.

Conclusions/action items: These are the current hyperbaric chambers used for treatment. Although these chambers will look different to the ones we are using, symptoms occuring from treatment will be the same. The sheep in the chamber will experience potential lung collapse as a result of the pressure change and that is a big reason that the euthanasia system is involved. The current chambers on the market are not similar to what we are dealing with, but give us a good idea of their purpose. I will continue to research chambers and communicate with the client to see which one we are using.

Ethical Effect

CATE FITZGERALD - Sep 20, 2020, 12:31 PM CDT

Title: Ethical Effect

Date: 9/20/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Understand the ethical effects of our project.

Content:

Rollin, B., 2020. Ethics And Euthanasia. [online] PubMed Central (PMC). Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2748292/> [Accessed 20 September 2020].

Euthanasia of animals is a very controversial topic. Ethics come into play because a life is at stake, and it is not black and white on when it is okay to take a life away. After doing some research, a group has decided that an animal life shall not be taken unless it follows the “five freedoms:”

Freedom from Hunger and Thirst — by ready access to fresh water and a diet to maintain full health and vigor.

Freedom from Discomfort — by providing an appropriate environment including shelter and a comfortable resting area.

Freedom from Pain, Injury or Disease — by prevention or rapid diagnosis and treatment.

Freedom to Express Normal Behavior — by providing sufficient space, proper facilities and company of the animal’s own kind.

Freedom from Fear and Distress — by ensuring conditions and treatment which avoid mental suffering.

People seem to feel less passionate about taking away a life, as long as it benefits the animal and prevents them from suffering. This is unique in our case because the research that our client is performing is causing some suffering, and we are tasked to take this pain and suffering away. Our group was created to take this research team's ethical concerns away, as we are in charge of giving the "five freedoms" to the sheep in pain.

Conclusions/action items: Our project is very unique because it is the most ethically charged challenge in BME 200/300. We have to think about what are we doing and act in the most ethical way possible, as we are taking a life away. Biomedical engineers are often tasked to prolong life, and we are tasked to take lives away, making ethics a huge topic in our project. We must continue to act ethically and realize the signifcance of this project.

Societal and Global Effect

CATE FITZGERALD - Sep 27, 2020, 10:27 PM CDT

Title: Societal and Global Effect

Date: 9/20/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Analyze the societal and global effects of our project.

Content: Our project has the capability of having a very positive or negative societal effect. When lives are taken, there is always a negative connotation and understanding of what is being done. Society could take what we are doing as very wrong since our client is conducting researching that is resulting in required death, while we are the ones creating a device to kill. However, our product is going to be utilized in order for our clients to act more ethically and humanely. Our design can also have a major positive impact as it can be expanded to other areas. Our design can be expanded to automatically inject medicine to humans and people that need medicine to survive. Our device can IMPROVE society and have a large positive impact on it.

Conclusions/action items: Our project has the opportunity to make a very positive societal impact. If we work hard and do everything we can, we can expand this project across many platforms to make a big difference. Our design has the opportunity to improve the way that medicine is injected. This could revolutionize the way that insulin is given and could regulate timed injections. I am going to continue to advise my team to dream big while working on this project, because we could change the world! I have lofty goals, but every biomedical engineer should.

Team Effect

CATE FITZGERALD - Sep 27, 2020, 10:04 PM CDT

Title: Team Effect

Date: 9/27/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Determine how this project will affect our team.

Content:

This project will have a large impact on our team as it involves taking a life away. It will force our team to consider ethical options, and thus shape the way we think and look at future projects. This is a great project because instead of prolonging life, we are ending some, allowing us to look at design projects. Not only will we learn how to design a product in an extreme environment and strengthen our hardware and electronic skills, but we will learn more about ethics and societal and global effects of our project in the process.

Conclusion/action items: Our team will grow as engineers and people in the process as a result of this project. It is so unique and is unlike any other project in BME design. Our team will be changed as our ethical concerns for animals and others will grow.

Economic Effect

CATE FITZGERALD - Sep 27, 2020, 10:14 PM CDT

Title: Economic Effect

Date: 9/27/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Determine how this project affects the economy.

Content:

“Economic Euthanasia On The Rise,” Veterinary Practice News, 10-Jun-2009. [Online]. Available: https://www.veterinarypracticenews.com/economic-euthanasia-on-the-rise/. [Accessed: 28-Sep-2020].

Economic Euthanizations are becoming more common. The economy has driven some owners to engage in economic euthanasia because of the financial burden of caring for a pet. Economic euthanasias are occurring at higher frequencies in practices where the community has been hit hard by the down economy. This applies to our project because not only do our clients want to humanely euthanize sheep, but it can be seen as a cheaper option than attempting to prolong the sheep's lives. The economic effect of this project highlights the growing market of euthanizing animals in order to save money.

Conclusions/action items: The economic impact of this project is more evident than I initially thought. Of course, our design team is tasked to humanely euthanize sheep, however now it is more clear that we are also performing this action to save the researchers money. Euthanization is much cheaper than all of the requirements to prolong these sheeps' lives, so our team also has a big economic impact on this project.

Environmental Effect

CATE FITZGERALD - Sep 27, 2020, 10:22 PM CDT

Title: Environmental Effect

Date: 9/27/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Understand the environmental impact of our project.

Content: The biggest environmental impact of this project falls on how these animals are disposed. Anything that decomposes into the Earth, affects it. We are injecting sheep with a euthanization solution, and if disposed of incorrectly, could dispose into the Earth. These animals need to be taken care of after euthanizations and dealt with properly. They shall not be dumped and allowed to decompose and spread their chemicals into the ground. Any project involving chemicals always has to consider where these chemicals will end up.

Conclusions/action items: It is our ethical duty to protect the environment. Since we are using chemicals, we need to make sure that these chemicals aren't being released improperly into the environment. As a result, we need to be sure that these sheep are being disposed of correctly and in a way that doesn't hurt the environment.

Rough Design Idea

CATE FITZGERALD - Sep 22, 2020, 5:01 PM CDT

Title: Rough Design Idea

Date: 9/22/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

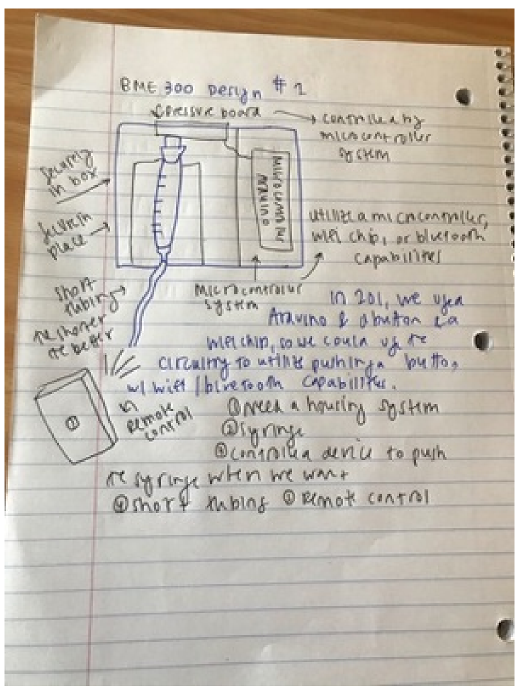
Goals: Create a rough design idea highlighting the parts we want in a successful design.

Content:

Image pasted below!

Conclusions/action items: We need a device that is robust and efficient. This includes a housing system for the components to sit in to ensure that they are safe if any rustling or movement occurs. We need a 20 ml syringe that is planted in the housing system and attached to the tube that will inject the solution into the animal. The tubing must be as short as possible to ensure a quick death. I was thinking that a pressure board could be mounted above the syringe. This board would be controlled by a microcontroller, such as an Arduino, to automate it to press down to inject the solution. This is just a rough sketch, but it emphasizes the fact that we need a housing system, a syringe, a control device such as an Arduino, short tubing, and a remote control utilizing Wifi or bluetooth capabilities. I am going to continue to work with my team to get a better idea on how to finalize a design with these elements.

CATE FITZGERALD - Sep 22, 2020, 5:03 PM CDT



Rough_Sketch.jpg(51.4 KB) - download

Motor Math

CATE FITZGERALD - Oct 05, 2020, 2:03 PM CDT

Title: Motor Math

Date: 10/5/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Begin to understand the type of math we will need when using a motored component.

Content:

Montone, D., 2013. How To Pick Motors For Linear Motion. [online] Machine Design. Available at: <https://www.machinedesign.com/motors-drives/article/21831643/how-to-pick-motors-for-linear-motion> [Accessed 14 September 2020].

To begin a linear design, determine the mass of what moves and how fast it goes from A to B. It is helpful to understand the following components in your motor:

Load's mass = ---

Mass orientation: Vertical?

A-to-B move distance and time = ---- mm in ----- sec

Dwell time = ------ sec

Drive power supply = ---- Vdc

Worst-case ambient temperature = -----

Because force = ma (where a = acceleration due to gravity = 9.81 m/sec2), the --------kg mass lifted against gravity requires a force of mass times this value of 9.81 m/sec2

To solve for power needed to move your load in a required time:

Power= Force (Linear Distance)/Time

To solve for the desired velocity:

If the motor has a 1/3 1/3 1/3 profile you can use the equation:

Vpeak= 3*Linear distance / 2*time

The pitch required for the lead screw is:

P= Vpeak*60 / maximum screw rpm

Conclusions/action items: This research shows the minimum calculations for solving for our motor's power and peak velocity. This will although us to solve for the pitch required for your lead screw. These calculations are important because we want to customize our velocity and force input. These calculations allow us to do this and help us find our desired lead screw calculation as well. I will continue to research what makes a good motor and lead screw and look these up once we perform our calculations.

Lead Screw Choice

CATE FITZGERALD - Oct 07, 2020, 2:57 PM CDT

Title: Lead Screw Choice

Date: 10/5/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn how to choose the correct lead screw for our project.

Content:

https://www.motioncontroltips.com/how-to-select-a-lead-screw/

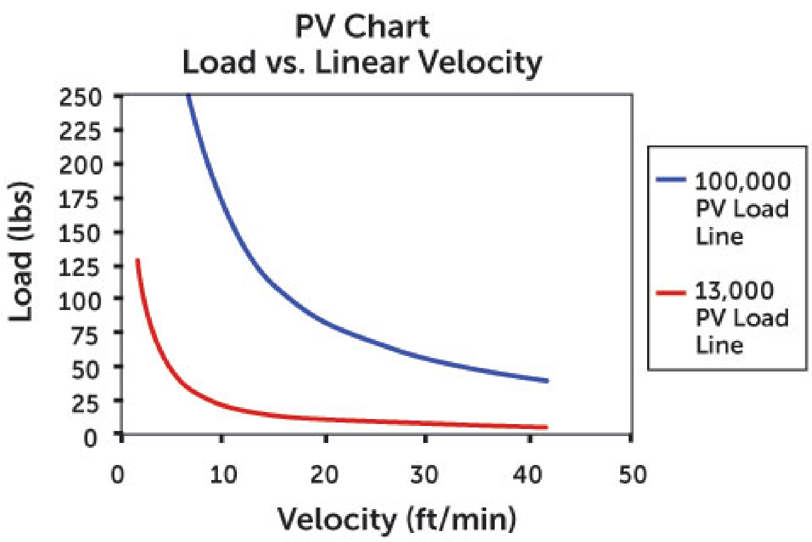
Lead screws use a thread to convert rotary motion to linear motion. The performance of a lead screw depends on the coefficient of friction between the nut and the screw, which in turn depends on the material used for the nut and screw.

Choosing the correct nut:

Begin by looking at the required load capacity. Plastic nuts are typically used for light loads of less than 100 lbs, although plastic nut designs for 300 lbs and beyond are possible. Bronze nuts can be used for applications in excess of several thousand pounds. Our project will most likely us a plastic nut, but may consider a bronze nut if its in the price range to make it more robust,

Pressure-velocity factor

The pressure-velocity, or PV factor, is the product of the pressure and velocity between the nut and screw. It helps determine the load, speed and duty cycle that the nut can handle. Plastic materials have an intrinsic PV rating, the point at which frictional heat causes permanent deformation of the plastic. So the more load applied to a lead screw assembly, the slower it must be turned to avoid exceeding the nut's PV limit.



$$PV = \frac{\text{Load}}{\text{Projected Area}} \times \text{Velocity}$$

Figure 1. An image relating pressure and velocity to highlight the pressure velocity factor.

Velocity:

Lead screws come in a wide range of leads, from under 0.050 in. to 2.00 in./rev or more. The use of a wide range of leads can deliver a wide variation in jog speeds up to 70 in./sec. Devices that need to be positioned with a high level of accuracy can use a lead screw with a low helix angle to obtain high positioning resolution.

Conclusions/action items: This research highlights what is important when choosing the correct lead screw. We need to choose a correct nut and screw based on these factors. We have the choice of a bronze or plastic nut. We could use a plastic nut as we aren't applying a large weight, however our clients may want something more robust. Once we choose our nut, we can choose our desired velocity utilizing the pressure velocity factor. I will continue to research nuts and screws perfect for our project.

Motor Choice

CATE FITZGERALD - Oct 08, 2020, 5:26 PM CDT

Title: Motor Math

Date: 10/8/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Determine the factors required when choosing the correct motor.

Content:

Group, T., 2020. Selecting The Proper Motor For Linear Motion Applications. [online] Techbriefs.com. Available at: <https://www.techbriefs.com/component/content/article/tb/supplements/mcat/features/articles/20419> [Accessed 14 September 2020].

Choosing the correct motor relies on many factors. There are three main motor devices that our team is looking at:

The first is the DC Stepper Motor. It has open loop positioning so no encoder is required. It utilizes a simple “pulse and direction” signal needed for rotation and has a high torque density at low speeds. However, there is no position correction in the event the load exceeds the output torque. It has a low power density meaning that the torque drops off dramatically at higher speed and the motor draws continuous current, even at standstill and experiences high iron losses above 3000 RPM

Another option is the DC Brush Servo Motor. It has linear speed/torque curve and low-cost drive electronics.There are many different configurations available, it is highly customizable, and easy to control and integrate. It has a very smooth operation system possible at low speeds (depends on the number of slots and commutator bars) and a high power density. However, the motor will draw high current in an overload condition, and the angular velocity is more limited due to mechanical factors in the armature design and brush system

A third option is the DC Brushless Servo Motor. It has a high power density. It has electronic commutation, meaning it does not require mechanical brushes, and low thermal resistance (copper is in the stator circuit). This motor has the highest move response and acceleration possible and smooth operation possible. It is the most expensive of the three motors listed. The motor will draw high current in an overload condition and will use the method of feedback needed for closed-loop positioning. It has a high drive complexity and cost and a method of rotor position detection for electronic commutation.

Conclusions/action items: This research describes the various types of motors that we can use for our project. There are three main types and we want to choose one that works best in a high pressure environment and that can couple with a lead screw device. I am going to continue researching motors and see which one can be bought the easiest and work best in the chamber we are using.

Testing

CATE FITZGERALD - Oct 08, 2020, 8:45 PM CDT

Title: Testing

Date: 10/8/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Consider possible testing protocols for the project.

Content:

- Test the stepper motor and lead screw by actuating it and measuring its speed. Record the time it takes to move a certain distance and use this information to calculate speed. The test is performed in 1 ATM and 5 ATM with ten trials in each pressure. This is done on a 95% confidence interval.

- Verify that all of the euthanasia solution contained within the syringe is expelled. This is done by actuating the device five times and observing the syringe to determine if any solution remained after each trial.

-Determine whether the device's battery will last for the entire duration of the experiment, which is 7 days. This test is performed in two different ways. First, the theoretical life of the battery while the device is powered on and in use is calculated. Second, the device is powered on and ran continuously until the battery is drained to the point where the device can no longer function. These values are then compared to the minimum required life of the battery, 7 days. The experimentally determined battery life needs to be at least 20% longer than the required 7 days in order for the device to pass the test.

Conclusions/action items: These are three possible things we want to evaluate. It is important that our device expels ALL of the solution quickly and is able to last the duration of the experiment. We need to perform these tests once we create a prototype.

Red Permit

CATE FITZGERALD - Oct 08, 2020, 4:23 PM CDT

Title: Red Permit Certificate

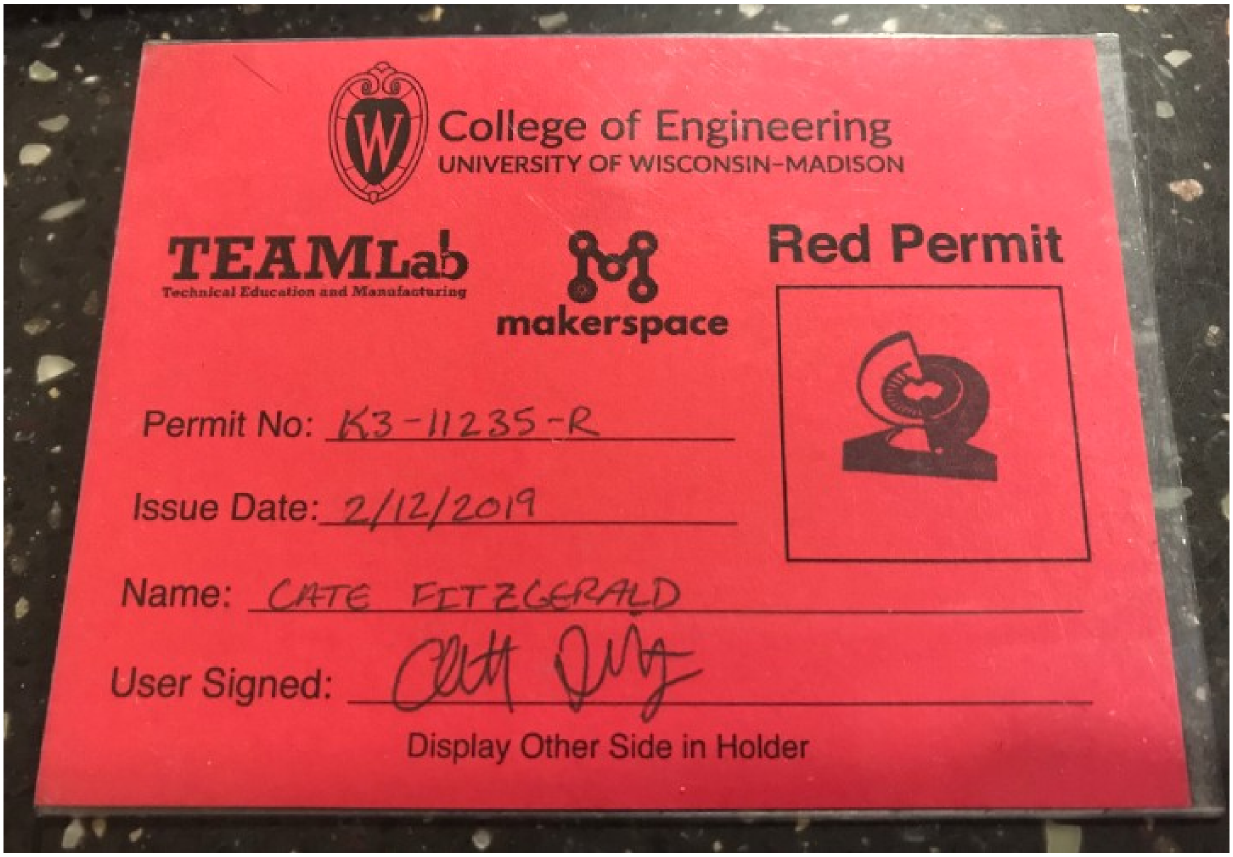
Date: 10/8/20

Content by: Cate

Present: Cate

Goals: Obtain the Red Permit certificate.

Content:



Conclusions/action items: This permit could be significant in building our sample holder and internalizing our stepper motor and lead screw device.

Plunging into the Jugular Vein

CATE FITZGERALD - Oct 21, 2020, 12:35 PM CDT

Title: Plunging into the Jugular Vein

Date: 10/19/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: To understand the force required to plunge a syringe into jugular vein.

Content:

[1] 2020. [online] Available at: <https://www.chegg.com/homework-help/32-n-force-applied-plunger-hypodermic-needle-diameter-plunge-chapter-10-problem-73gp-solution-9780321625922-exc> [Accessed 19 October 2020].

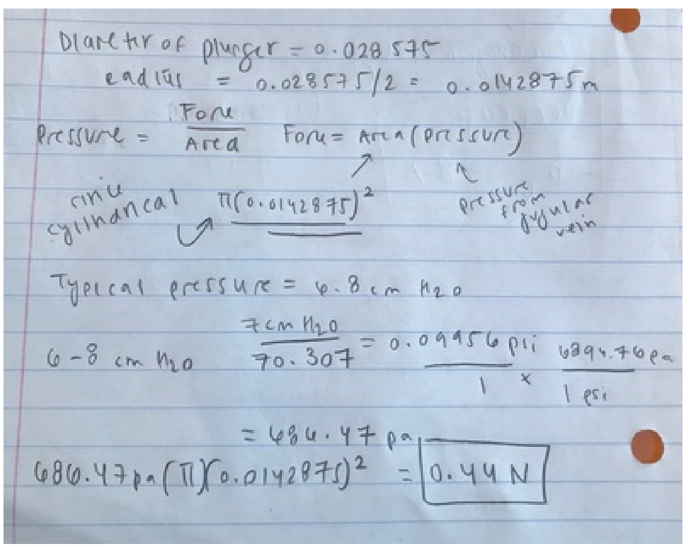
[2] A. B. Rivard, “Anatomy, Head and Neck, Internal Jugular Vein,” StatPearls [Internet]., 27-Jul-2020. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK513258/. [Accessed: 21-Oct-2020].

Calculations are added below!

Conclusions/action items:

With these calculations, it will take 0.44 N to counter the pressure from the jugular vein. This means that the motor we selected can handle this pressure and that we should purchase it and begin prototyping!

CATE FITZGERALD - Oct 21, 2020, 12:37 PM CDT



Calculations_for_Plunging_into_the_Jugular_Vein.jpg(246.9 KB) - download

Bipolar Motor

CATE FITZGERALD - Oct 21, 2020, 12:54 PM CDT

Title: Bipolar Motor

Date: 10/21/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Comprehend the basics of an Bipolar Motor

Content:

[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October 2020].

A bipolar stepper motor has four wires and two coils. To make it rotate, there needs to be a current sent through the coils. It runs similarly to a simple stepper that only has four steps. In the first stage, it will align the magnet with the first coil. The next step will rotate the magnet 90 degrees. Sending current backwards through the first coil reverses the magnetic polarity. Opposite coils are connected, but generate opposing magnetic fields relative to the central magnet. A typical stepper motor will have 200 steps per revolution.

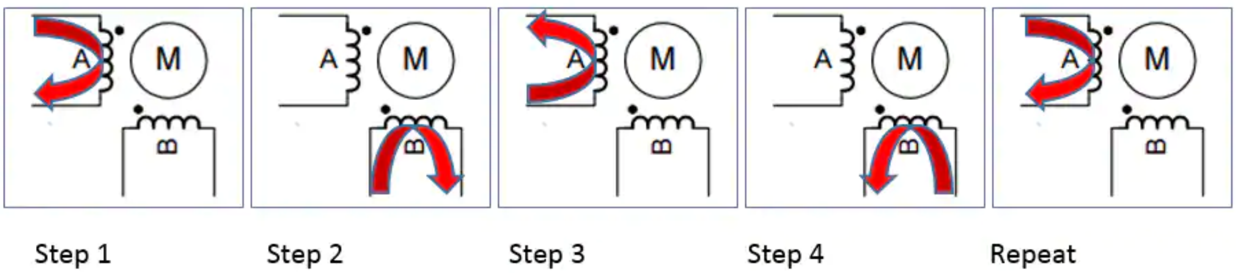


Figure 1. This figures summarizes how a Bipolar Motor functions. It will initially align the magnet with the first coil. It will next rotate the magnet 90 degrees. Opposite coils are connected, but generate opposing magnetic fields relative to the central magnet.

Conclusions/action items: We will be using a bipolar stepper motor. It is simple and efficient and is easily able to develop magnetic fields. I will continue to research this kind of motor and see how it will fit into our project.

Transistors

CATE FITZGERALD - Oct 21, 2020, 1:18 PM CDT

Title: Transitors

Date: 10/21/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Comprehend the basics of Transitos

Content:

[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October 2020].

A transistor is a current-controlled current limiting device. There are three pins to a transistor: the base, collector, and emitter.

NPN Transistors:

When a small current passes from the base to the emitter, a larger current is allowed to flow from the collector to the emitter. It is important to remember them as current-based devices.

The current through the current source is β (beta) multiplied by the current through the diode (ib). β is the gain of the transistor. This model only works if the transistor isn't saturated. A transistor is saturated if there is more than enough current going through the base such that the transistor isn't limiting current through the collector-emitter anymore.

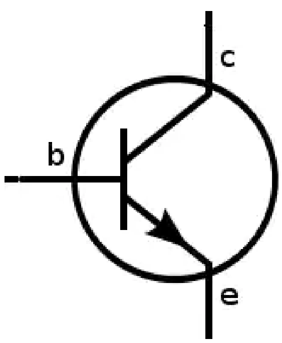


Figure 1.1 An image of a typical NPN Transistor.

PNP Transistors:

It is similar to an NPN transistor, except that current must flow from the emitter to the base to allow current to flow from the emitter to collector. When a small current passes through the diode, a much larger current is allowed across the emitter and collector. Just like an NPN, a diode exists across the base to emitter. There will still be a 0.7V drop across the diode. It is just facing the other direction.

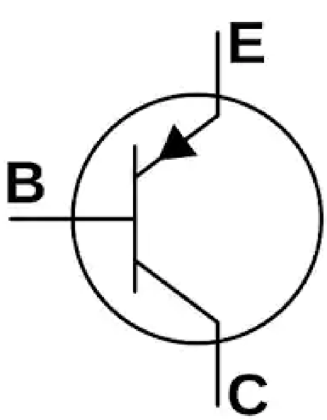


Figure 1.2 An image of a typical PNP Transistor.

Conclusions/action items: A transistor will be necessary for our project, but we need to decide which one is more efficient for what we are doing. It will be important to have team meetings to decide which aspects of the circuit are necessary and which are not. I will continue to research circuitry components to see how a transistor fits in and which one is better.

H-Bridge Components

CATE FITZGERALD - Oct 21, 2020, 1:46 PM CDT

Title: H-Bridge Components

Date: 10/21/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Comprehend the basics of H-Bridges.

Content:

[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October 2020].

An H-Bridge circuit will be comprised of a combination of the following components. It is important to choose each based on the application in our project:

Diodes: Choose a diode based on CURRENT!!! When switching from on to off, the current in the motor must pass through the diodes. To avoid excessive heat, try to find diodes that have a lower forward voltage.

Transistors: H-bridge transistors also depend on CURRENT! You can try to avoid excessive heat by choosing a lower collector-emitter saturation voltage. A higher transition frequency cis helpful because it will lower the amount of time the transistor is in the active state. A low power dissipation means the transistor is meant to be used as a switch.

Small signal transistors: The biggest attribute to look for is that the Collector-emitter breakdown voltage is higher than your motor power supply. A higher frequency transition is also good. These aren't SUPER important, but often included in an H-Bridge.

Resistors: These allow a fraction of the current passing through the transistors. It allows you to customize the current that passes through! The two NPN resistors will also see minimal voltage levels. Once you know the amount of current passing through the transistor, the voltage is essentially the motor supply voltage. Power ratings above ¼ watt should be more than enough for most applications

Alternatives: Stepper drivers can be as simple as an H-bridge package. Texas Instruments provide a wide array of drivers with varying degrees of control. For any stepper motor application, Texas Instruments will have a chip for it. Allegro also has a wide variety of drivers. The drivers that have the most functionality built in are the Trinamic chips.

Conclusions/action items: These components will be needed to construct our H-Bridge. All of these components allow our circuit to be very customizable and to find an exact voltage and current uptake. I will continue to research these components and perform calculations to see the current and voltage we need for our project.

Calculating Current and Velocity

CATE FITZGERALD - Oct 21, 2020, 1:39 PM CDT

Title: Calculating Current and Velocity

Date: 10/21/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: All of the components in an H-Bridge are dependent on current. I want to learn how to calculate our desired current for our project.

Content:

[1] Parks, C., 2016. How To Drive A Stepper Motor. [online] digikey.com. Available at: <https://www.digikey.com/eewiki/display/Motley/How+to+Drive+a+Stepper+Motor> [Accessed 21 October 2020].

Current:

The voltage of Vref will be proportional to the current through the coils. If you want to set the current before you connect the motors, be sure to power down the board before you connect the motors. Monitor the voltage on the Vref pin. To lower current, turn the screw counter-clockwise. Another way to calibrate the current is to see how well the motor performs. Decrease the current until the motor performs badly. Then, increase the current until the motor performs desirably.

Velocity:

If you use the H-bridge, you can step the motor inside the timer interrupt. If you use a step/dir driver, you can toggle a pin autonomously by setting a compare/capture pin to PWM mode. The speed of the motor will be determined by your time delay. The driver's datasheet will have information on timing characteristics. In this case, if I run a 1 MHz clock, I need to wait 20 clocks between actions. you ignore the timing characteristics, you may lose your position. The chip will think the motor is somewhere else. UTILIZE A DATA SHEET!!

$$V = \frac{d\ (revolution)}{t\ (s)} = \frac{1\ (steps)}{time\ period\ (s)}$$

Figure 1.1: This is a common calculation used to find our desired velocity for our H-Bridge circuit.

Conclusions/action items: In our H-Bridge, we will need to customize our current and velocity in order to get our desired properties. Both of these factors can be found using our circuit's data sheet and by solving for current using resistors and Vref. These factors are important and simplify the circuit greatly. We have done many things like this in previous classes, so it will simpligy everything!

H-Bridge General Info

CATE FITZGERALD - Oct 21, 2020, 1:55 PM CDT

Title: H-Bridge General Info

Date: 10/21/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Comprehend the basics of H-Bridges.

Content:

[1] Ø. N. Dahl, W. says, Walt, A. Says, Admin, M. says, Michael, R. P. says, R. Pueblo, G. R. says, G. Reeve, A. says, Amit, S. says, Sanket, P. Y. says, P. Yadav, D. S. says, D. Subhash, A. says, Anubhav, D. says, Damilare, J. Says, and John, “What Is an H-Bridge?,” Build Electronic Circuits, 25-Jun-2020. [Online]. Available: https://www.build-electronic-circuits.com/h-bridge/. [Accessed: 21-Oct-2020].

An H-bridge is a simple circuit that lets you control a DC motor to go backward or forward. You normally use it with a microcontroller, such as an Arduino, to control motors.

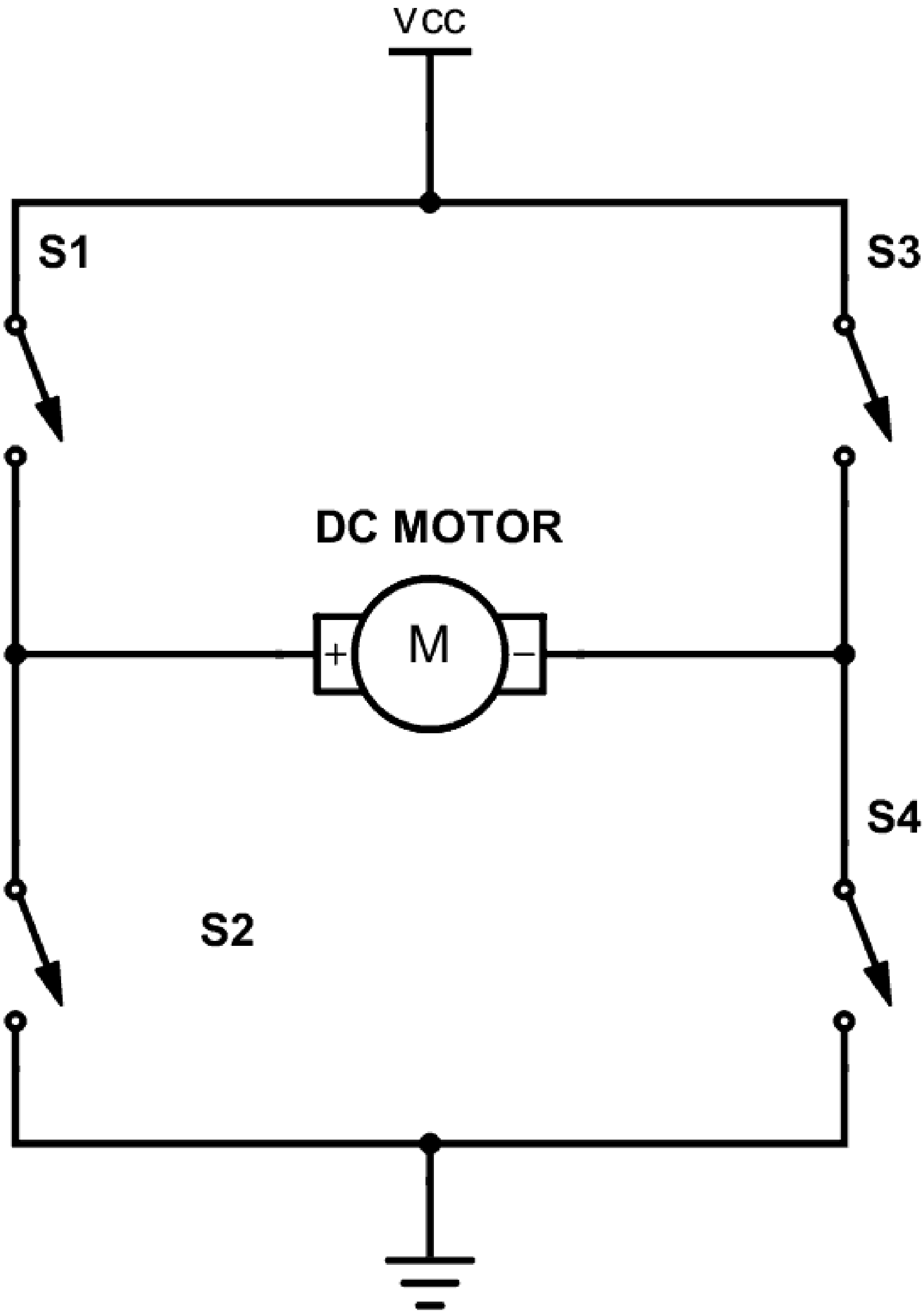


Figure 1. The topology of a typical H-Bridge.

If you close switch 1 and 4, you have plus connected to the left side of the motor and minus to the other side. And the motor will start spinning in one direction. If you instead close switch 2 and 3, you have plus connected to the right side and minus to the left side. And the motor spins in the opposite direction

You can build an H-bridge with four **transistors.**

Transistors can work as a switch that you can open and close with the voltage on the base. Since the transistor can be a switch, you'll be able to make the motor spin in either direction by turning on and off the four transistors in the circuit above. Usually, you control the transistors from a microcontroller, such as Arduino. The most important thing is that all the transistors can handle enough current for the motor. Otherwise it will burn out. What turns the transistor on or off is the voltage difference between the base and the emitter. With PNP transistors at the top, you can use a higher voltage for VCC than you use for the base of the transistors. Choose transistors with low voltage drop. For example BD135/BD136 or MOSFET transistors. If you add diodes in the reverse direction for the transistors, you give a path for the current to take to release this energy. Without them, you risk that the voltage rises and damages your transistors.

Conclusions/action items: These components will be needed to construct our H-Bridge. The H-Bridge circuit is perfect for our project as we need something that is controlled via a Microcontroller. Transistors are essential and often need diodes to help with energy release. This is a good start on research, but I need to continue seeing what specific transistors and diodes we need.

Choosing the Correct Transistor

CATE FITZGERALD - Oct 27, 2020, 6:37 PM CDT

Title: Choosing the Correct Transistor

Date: 10/27/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Choose the right transistor for our project.

Content:

[1] A. Carter, “Choosing a Suitable PNP or NPN Transistor Switch,” EEWeb, 19-Mar-2018. [Online]. Available: https://www.eeweb.com/choosing-a-suitable-pnp-or-npn-transistor-switch/. [Accessed: 27-Oct-2020].

For our project, we will need to select a specific transistor.

The procedure for choosing a suitable PNP transistor is exactly the same as that for an NPN transistor. In choosing a suitable switching transistor:

The transistor’s maximum collector current must be greater than the load current: **Greater than 0.4 A**

The transistor’s maximum current gain must be at least 5 times the load current divided by the maximum output current from the IC

Choose a transistor which meets the requirements and making a note of its properties

Calculate an approximate value for the base resistor

A protection diode is necessary if the load is a motor or relay coil by connecting across the load to protect the transistor from the brief high voltage when the load is switched OFF.

Conclusions/action items: We need to perform more calculations to determine which transistor we should buy for our circuit. It needs to exceed 0.4 A and comply with the output we have determined. I will continue to do these calculations and see what we need.

Motor/Transistor Selection

CATE FITZGERALD - Oct 28, 2020, 2:35 PM CDT

Title: Motor/Transistor Selection

Date: 10/28/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Choose the right transistor for our project.

Content:

[1] D. Cook, “H-Bridge Motor Driver Using Bipolar Transistors,” Bipolar Transistor HBridge Motor Driver - Robot Room. [Online]. Available: https://www.robotroom.com/BipolarHBridge.html. [Accessed: 28-Oct-2020].

The typical H-bridge circuit is just four copies of a resistor + transistor + diode.

You can use a combination of PNP and NPN **transistors:**

NPN transistors: They connect the motor to ground (negative terminal of the battery).

PNP transistors: They connect the motor to +2.2V to +9.6V (positive terminal of the battery).

Resistors:
A resistor value of 1 kilohm (1000 ohms) is often chosen to provide enough current to fully turn on (saturate) the transistor. A higher resistance would waste less power, but might cause the motor to receive less power. A lower resistance would waste more power, but wouldn’t likely provide better performance for motors running on consumer batteries.

Diodes:
Diodes provide a safe path for the motor energy to be dispersed or returned to the battery when the motor is commanded to coast or stop. Without diodes, a motor voltage spike can force its way through the unprotected transistors, damaging or destroying them.

For the **motor** chosen:
Measure the resistance of the two motor wires using a multimeter. If the motor resistance is less than 5 ohms, then the transistor parts listed in this article are too weak to power the motor.

In this article, the author ran an H-Bridge with 3 different transistors:

Set	NPN	PNP	Cost	Performance
'Classic'	2N3904	2N3906	$0.28	Poor
'Intermediate'	2N2222A	2N2907A	$0.40	Moderate
'Professional'	ZTX1049A**	ZTX968	$3.50	Outstanding

The diodes are commonly used parts: 1N914, 1N4001, or 1N5817. The 1N5817 is superior, and is the type I personally use in my motor drivers.

Conclusions/action items: Transistors are relatively cheap and can vary. It would be beneficial to buy a professional transistor set as they have a much better performance. Diodes are also commonly used and aren't as precise, so any recommended one can be used as they are just used to regulate power input. I will talk with my team about these parts and see if we can begin to purchase these components!

ZTX1049A Transistor

CATE FITZGERALD - Oct 28, 2020, 2:46 PM CDT

Title: ZTX1049A Transistor

Date: 10/28/20

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Choose the right transistor for our project.

Content:

ZTX1049A Transistor:

https://www.diodes.com/assets/Datasheets/ZTX1049A.pdf

This is the transistor that I think is best for our project The datasheet is pasted in the link above. I like that is has a diode already incorporated into it, meaning that it is one less component that we need to purchase and add to our circuit. It is an NPN transistor. Its brother PNP transistor is the **ZTX968** transistor.

Here are some facts about it:

Vce Saturation (Max) @ Ib, Ic
220mV @ 50mA, 4A
Current - Collector Cutoff (Max)
10nA
DC Current Gain (hFE) (Min) @ Ic, Vce
300 @ 1A, 2V
Frequency - Transition
180MHz
Operating Temperature
-55°C ~ 200°C (TJ)
Current - Collector (Ic) (Max)
4 A
Voltage - Collector Emitter Breakdown (Max)
25 V
Power - Max
1 W
Base Product Number
ZTX1049A

Conclusions/action items: This transistor has been consistently been rated very well! It can handle a lot more current and power than our project needs, so we are able to personalize it using resistors. I have heard nothing but good things about this transistor type and I am going to talk with the team to see if we should purchase it! This would eliminate the need to buy diodes as well, which would make our circuit less bulky and save us time for waiting for another part.

Crystal Oscillators

CATE FITZGERALD - Nov 12, 2020, 7:08 PM CST

Title: Crystal Oscillators

Date: 11/12/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: To understand what crystal oscillators are and if they are what we are looking for for our porject.

Content:

Electronics Tutorials. 2020. Quartz Crystal Oscillators. [online] Available at: <https://www.electronics-tutorials.ws/oscillator/crystal.html> [Accessed 10 November 2020].

To obtain a very high level of oscillator stability a **Quartz Crystal** is generally used as the frequency determining device to produce another types of oscillator circuit known generally as a **Quartz Crystal Oscillator**, (XO).

When a voltage source is applied to a small thin piece of quartz crystal, it begins to change shape producing a characteristic known as the **Piezo-electric effect**. This Piezo-electric Effect is the property of a crystal by which an electrical charge produces a mechanical force by changing the shape of the crystal and vice versa, a mechanical force applied to the crystal produces an electrical charge.

Then, piezo-electric devices can be classed as Transducers as they convert energy of one kind into energy of another (electrical to mechanical or mechanical to electrical). This piezo-electric effect produces mechanical vibrations or oscillations which can be used to replace the standard LC tank circuit in the previous oscillators.

The quartz crystal used in a **Quartz Crystal Oscillator** is a very small, thin piece or wafer of cut quartz with the two parallel surfaces metallised to make the required electrical connections. The physical size and thickness of a piece of quartz crystal is tightly controlled since it affects the final or fundamental frequency of oscillations. The fundamental frequency is generally called the crystals “characteristic frequency”.

Quart Crystal Oscillator

Conclusions/action items:

This type of crystal may allow us to customize the speed of the motor. It is a good option and seems relatively simple, and I am relatively familiar with piezo-electric devices as a result of BME310. This oscillator can convert energy and thus oscillations of our desired frequency. I will continue to research this crystal oscillator and see if it fits into our project.

AT89S52 8-bit Microcontroller

CATE FITZGERALD - Nov 12, 2020, 7:39 PM CST

Title: AT89S52 8-bit Microcontroller

Date: 11/12/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: To understand what a AT89S52 8-bit Microcontroller and how we are able to program it.

Content:

https://ww1.microchip.com/downloads/en/DeviceDoc/doc1919.pdf

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. The AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following standard features:

8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

Conclusions/action items: This could be a potentially good option for our project- or at least something similar to it! It has many components that we need for our project, and extra timers and counters that could be helpful. I am going to look at other options for this project and consult with Marshall about my findings.

Benefits of a Crystal Oscillators

CATE FITZGERALD - Nov 12, 2020, 7:50 PM CST

Title: Benefits of a Crystal Oscillators

Date: 11/12/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn the benefits of a crystal oscillator and see if these advantages are helpful to our project.

Content:

Semiconductor, “Advantages, disadvantages and applications of crystal oscillator,” *Semiconductor for You*, 19-Jun-2017. [Online]. Available: https://www.semiconductorforu.com/advantages-disadvantages-applications-crystal-oscillator/. [Accessed: 13-Nov-2020].

Advantages:

- The crystal oscillator has very low frequency drift due to change in temperature and other parameters.
- The crystal oscillator Q is very high.
- It has Automatic amplitude control.
- It has very high frequency stability.
- The crystal oscillator is possible to obtain very high precise and stable frequency of oscillators.
- It has High frequency of operation.

Disadvantages:

- Crystals of low fundamental frequencies are not easily available.
- These are suitable for high frequency application.

Applications:

- Often used in radio and TV transmitters.
- Used as a crystal clock in microprocessors.
- Frequently used in the frequency synthesizers.
- It is used in special types of receivers.

Conclusions/action items: A crystal oscillator has very low frequency drift due to change in temperature and other parameters. It has automatic amplitude control and a very high frequency stability which may be helpful to our project. I think that this could be a great option for our project and I am going to continue to look at how it has been used and fits into programming.

Commands in C

CATE FITZGERALD - Nov 18, 2020, 5:59 PM CST

Title: Coding in C

Date: 11/18/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn the basic commands of learning to code in C

Content:

"List of all Keywords in C Language," *Programiz*. [Online]. Available: https://www.programiz.com/c-programming/list-all-keywords-c-language. [Accessed: 18-Nov-2020].

break and continue

The break statement terminates the innermost loop immediately when it's encountered. It's also used to terminate the switch statement.

The continue statement skips the statements after it inside the loop for the iteration.

```
for (i=1;i<=10;++i){
   if (i==3)
   continue;
   if (i==7)
   break;
   printf("%d ",i);
}
```

switch, case and default

The switch and case statement is used when a block of statements has to be executed among many blocks. For example:

```
switch(expression)
{
    case '1':
    //some statements to execute when 1
    break;
    case '5':
    //some statements to execute when 5
    break;
    default:
    //some statements to execute when default;


}
```

const

An identifier can be declared constant by using the const keyword.

```
const int a = 5;
```

do...while

```
int i;
do
{
   printf("%d ",i);
   i++;
}
while (i<10)
```

if and else

In C programming, if and else are used to make decisions.

```
if (i == 1)
   printf("i is 1.")
else
   printf("i is not 1.")
```

goto

The goto statement is used to transfer control of the program to the specified label. For example:

```
for(i=1; i<5; ++i)
{
    if (i==10)
    goto error;
}
printf("i is not 10");
error:
    printf("Error, count cannot be 10.");
```

return

The return keyword terminates the function and returns the value.

```
int func() {
    int b = 5;
    return b;
}
```

register

The register keyword creates register variables which are much faster than normal variables.

```
register int var1;
```

static

The `static` keyword creates a static variable. The value of the static variables persists until the end of the program. For example:

```
static int var;
```

struct

The struct keyword is used for declaring a structure. A structure can hold variables of different types under a single name.

```
struct student{
    char name[80];
     float marks;
```

```
    int age;
}s1, s2;
```

Conclusions/action items: These are a few commands in C that could be useful to us. We are going to need to declare variable and potentially use for-loops. We need to identify how to fit this into our code that is compatible with C. I will continue to look up tips and tricks for using C and see how we can incorporate it into a HEX file.

Operators in C

CATE FITZGERALD - Nov 18, 2020, 6:08 PM CST

Title: Declaring Variables in C

Date: 11/18/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn the basic Operators in C

Content:

"Operators," *C*. [Online]. Available: https://www.tutorialspoint.com/cprogramming/c_operators.htm. [Accessed: 19-Nov-2020].

Operator	Description	Example
+	Adds two operands.	A + B = 30
−	Subtracts second operand from the first.	A − B = -10
*	Multiplies both operands.	A * B = 200
/	Divides numerator by de-numerator.	B / A = 2
%	Modulus Operator and remainder of after an integer division.	B % A = 0
++	Increment operator increases the integer value by one.	A++ = 11
--	Decrement operator decreases the integer value by one.	A-- = 9

Operator	Description	Example
==	Checks if the values of two operands are equal or not. If yes, then the condition becomes true.	(A == B) is not true.
!=	Checks if the values of two operands are equal or not. If the values are not equal, then the condition becomes true.	(A != B) is true.
>	Checks if the value of left operand is greater than the value of right operand. If yes, then the condition becomes true.	(A > B) is not true.
<	Checks if the value of left operand is less than the value of right operand. If yes, then the condition becomes true.	(A < B) is true.
>=	Checks if the value of left operand is greater than or equal to the value of right operand. If yes, then the condition becomes true.	(A >= B) is not true.
<=	Checks if the value of left operand is less than or equal to the value of right operand.	(A <= B) is true.

	If yes, then the condition becomes true.	

<table>
<tr><th>Operator</th><th>Description</th><th>Example</th></tr>
<tr><td>&&</td><td>Called Logical AND operator. If both the operands are non-zero, then the condition becomes true.</td><td>(A && B) is false.</td></tr>
<tr><td>||</td><td>Called Logical OR Operator. If any of the two operands is non-zero, then the condition becomes true.</td><td>(A || B) is true.</td></tr>
<tr><td>!</td><td>Called Logical NOT Operator. It is used to reverse the logical state of its operand. If a condition is true, then Logical NOT operator will make it false.</td><td>!(A && B) is true.</td></tr>
</table>

<table>
<tr><th>Operator</th><th>Description</th><th>Example</th></tr>
<tr><td>=</td><td>Simple assignment operator. Assigns values from right side operands to left side operand</td><td>C = A + B will assign the value of A + B to C</td></tr>
<tr><td>+=</td><td>Add AND assignment operator. It adds the right operand to the left operand and assign the result to the left operand.</td><td>C += A is equivalent to C = C + A</td></tr>
<tr><td>-=</td><td>Subtract AND assignment operator. It subtracts the right operand from the left operand and assigns the result to the left operand.</td><td>C -= A is equivalent to C = C - A</td></tr>
<tr><td>*=</td><td>Multiply AND assignment operator. It multiplies the right operand with the left operand and assigns the result to the left operand.</td><td>C *= A is equivalent to C = C * A</td></tr>
<tr><td>/=</td><td>Divide AND assignment operator. It divides the left operand with the right operand and assigns the result to the left operand.</td><td>C /= A is equivalent to C = C / A</td></tr>
<tr><td>%=</td><td>Modulus AND assignment operator. It takes modulus using two operands and assigns the result to the left operand.</td><td>C %= A is equivalent to C = C % A</td></tr>
<tr><td><<=</td><td>Left shift AND assignment operator.</td><td>C <<= 2 is same as C = C << 2</td></tr>
<tr><td>>>=</td><td>Right shift AND assignment operator.</td><td>C >>= 2 is same as C = C >> 2</td></tr>
<tr><td>&=</td><td>Bitwise AND assignment operator.</td><td>C &= 2 is same as C = C & 2</td></tr>
<tr><td>^=</td><td>Bitwise exclusive OR and assignment operator.</td><td>C ^= 2 is same as C = C ^ 2</td></tr>
<tr><td>|=</td><td>Bitwise inclusive OR and assignment operator.</td><td>C |= 2 is same as C = C | 2</td></tr>
</table>

Operator	Description	Example

sizeof()	Returns the size of a variable.	sizeof(a), where a is integer, will return 4.
&	Returns the address of a variable.	&a; returns the actual address of the variable.
*	Pointer to a variable.	*a;
? :	Conditional Expression.	If Condition is true ? then value X : otherwise value Y

Conclusions/action items: These are the main operators in C that could be useful to us. We are not familiar with coding in C, so it is helpful to see that the operators are similar in other languages. We need to identify how to fit this into our code that is compatible with C. I will continue to look up tips and tricks for using C and see how we can incorporate it into a HEX file.

Functions in C

CATE FITZGERALD - Nov 18, 2020, 6:51 PM CST

Title: Functions in C

Date: 11/18/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn how to declare a function in C.

Content:

"Functions," *C*. [Online]. Available: https://www.tutorialspoint.com/cprogramming/c_functions.htm. [Accessed: 19-Nov-2020].

Every C program has at least one function, which is main(), and all the most trivial programs can define additional functions.

The C standard library provides numerous built-in functions that your program can call. For example, strcat() to concatenate two strings, memcpy() to copy one memory location to another location, and many more functions.

A function definition in C programming consists of a *function header* and a *function body*. Here are all the parts of a function −

- Return Type − A function may return a value. The return_type is the data type of the value the function returns. Some functions perform the desired operations without returning a value. In this case, the return_type is the keyword void.
- Function Name − This is the actual name of the function. The function name and the parameter list together constitute the function signature.
- Parameters − A parameter is like a placeholder. When a function is invoked, you pass a value to the parameter. This value is referred to as actual parameter or argument. The parameter list refers to the type, order, and number of the parameters of a function. Parameters are optional; that is, a function may contain no parameters.
- Function Body − The function body contains a collection of statements that define what the function does.

Here is an example of a function used in C. Take note of the syntax:

```
/* function declaration */
int max(int num1, int num2);

int main () {

   /* local variable definition */
   int a = 100;
   int b = 200;
   int ret;

   /* calling a function to get max value */
   ret = max(a, b);

   printf( "Max value is : %d\n", ret );

   return 0;
}

/* function returning the max between two numbers */
int max(int num1, int num2) {
```

```
   /* local variable declaration */
   int result;

   if (num1 > num2)
      result = num1;
   else
      result = num2;

   return result;
}
```

Conclusions/action items: This entry explains how to both construct and declare a function in C. We will need to do this and it it important to look at the syntax. Everything is very similar to Python and Arduino, except there are a few minor changes that we must make. I will take this into account when creating the HEX file.

C Syntax

CATE FITZGERALD - Nov 18, 2020, 7:01 PM CST

Title: Functions in C

Date: 11/18/2020

Content by: Cate Fitzgerald

Present: Cate Fitzgerald

Goals: Learn how to declare a function in C.

Content:

"C Syntax Rules - Learn the ABCs of Programming in C Language," *DataFlair*, 03-Jul-2019. [Online]. Available: https://data-flair.training/blogs/c-basic-syntax-rules/. [Accessed: 19-Nov-2020].

- clrscr() – This function is predefined in the header file <conio.h>. clrscr() helps to clear the screen.
- printf() – This is another function that helps you to display the message on the output screen. This function is defined in <stdio.h>. In the above program, it is pretty clear that the printf() function helps you display the output message: "Welcome to DataFlair".
- getch() – This function is defined in conio.h and is used to hold the output screen until we hit the next key after we run the program.

A C syntax/program consists of a series of tokens:

1. Keywords
2. Identifiers/Variables
3. Constants
4. Punctuators
5. Operators

Rules for naming identifiers or variables

- No special character can be used to name a variable except underscore(_).
- The variable name cannot start with a digit, it can be a letter or an underscore.
- No keyword can be used as an identifier.

A semicolon is used to show the ending of a statement. It acts as a separator between two statements. If you miss this statement at the end of any line, the compiler would join the statement with the next line of code and will give a syntax error.

There are two types of comments:

1. Single line comments
2. Multi-line comment

For single line comment just put '//' before the comment line

For multi-line comment /*——*/ , the statements of comment should be enclosed within /* and */.

In a C program, whitespace is generally a blank line. The C programming language uses whitespaces to describe blanks, newline characters, and comments.

Whitespace separates one statement from another statement for the compiler to identify. In this statement,

int data ;

If you don't provide proper whitespace within the statements where it is needed, then the compilation will not be correct and you will not be able to get the desired output.

Semicolons are *provided to terminate the statement*. A Semicolon indicates the start and end of statement execution.

This tells the compiler that the statement is completed. If a semicolon is not placed at the end of a statement, then the program will not compile generating a compilation error message.

SUMMARY:

1. C is a case sensitive language. Most of the program statements are in lower case.
2. All statements must necessarily terminate with a semicolon.
3. Whitespaces should be provided only between variables and keywords.

Conclusions/action items: This entry describes the main syntax operations in C. It seems relatively similar and will be very helpful for our project. We need to remember to end every statement with a semicolon and to work in lowercase. I will use this knowledge to construct a HEX file with Marshall.

Testing Procedure

CATE FITZGERALD - Dec 08, 2020, 11:38 AM CST

Title: Testing Procedure

Date: 12/8/20

Content by: Cate Fitzgerald

Present: The whole team!

Goals: Create a procedure for testing the efficiency of our device.

Content:

Battery life testing:

The team would set up the full device and let it sit fully plugged into the power sources for 172 hours. After the device has been in this state for 172 hours, the device would be activated to ensure it works and this would constitute one trial. If the device did not function after 72 hours, a battery with a higher Ah rating would be necessary. The team would aim to run 10 trials. A proportion of success to failures would be constructed to communicate the success of this validation test.

Speed testing:

The team would turn the switch to the “on” position for an interval, and would measure the time it takes to move 2.75 inches (or the total distance that the plunger needs to travel to fully expel all liquid in the syringe). This would constitute one trial, and the team would aim to run 50 trials. Next, the team would calculate the velocity for each trial. The velocities across all trials would then be averaged and then a 95% confidence interval would be created to characterize the velocity profile of the stepper motor. The client desired that the device take at most 10 seconds to fully dispense the liquid so the team would aim for a mean speed of .275 in/s across trials.

Conclusions/action items: In order to meet the clients requests, the team needs to validate that the system could be activated after being on for 172 hours and validate that the speed of the lead screw is sufficient to fully plunge the syringe in roughly ten seconds. The clients have asked that the device last for 7 days because that is how long it takes a team to fully vacate a compromised submarine of its full crew. These tests need to be ran in order to ensure that the device is able to last in these conditions and successfully inject the solution at a good rate. After obtaining this data, we will analyze it using t-tests and bootstrap tests.

Statistical Results

CATE FITZGERALD - Dec 08, 2020, 8:47 PM CST

Title: Statistical Analysis

Date: 12/8/20

Content by: Cate Fitzgerald

Present: The whole team!

Goals: Analyze the results of our testing.

Content:

Although the team was not able to directly test the data, future testing data can be analyzed using bootstrap t-tests and chi-square tests. Bootstrap t-tests and chi-square tests will be used to analyze the results found during testing the lead screw speed validation. For all of the tests run, an alpha value of 0.05 will be used. The accuracy of the lead screw velocity will be determined by running a bootstrap t-test. The t-test is run on the measured velocity that the lead screw obtained and compared with the second device's velocity. The results will be used to determine if the differences between the measured velocity and the desired velocity is statistically significant. After running the test, the team hoped to obtain a p-value < 0.01. If the p-value is larger than the alpha value, the null hypothesis that the distances are considered equal is not rejected. If the p-value is less than the value of alpha the null hypothesis is rejected, which means the difference in velocity is not caused by chance. There is a significant difference between the two devices' velocities. In these tests, we expect to obtain a p-value of less than 0.01 which would support that the difference in velocity is not caused by chance, but by other factors that we can control. A similar procedure will be ran in order to analyze the battery life testing.

Conclusions/action items: After analyzing our results, we anticipate that our device will be able to withstand the conditions of the hyperbaric chamber. We anticipate that after analyzing our test results, we will obtain a p-value of less than 0.01. After testing our device, we will make the necessary steps to improve it based on the results.

Expected Results

CATE FITZGERALD - Dec 08, 2020, 11:56 AM CST

Title: Expected Results

Date: 12/8/20

Content by: Cate Fitzgerald (Graphs made my Marshall)

Present: The whole team!

Goals: Anticipate the results of our testing.

Content:

We anticipate that when testing the battery life of our device, it will be successful 90% of the time. The device needs to last for 7 days. If it not able to withstand that amount of time, it is considered a failure. If the device did not function after 172 hours, that is a failure and we anticipate that happening 10% of the time during testing.

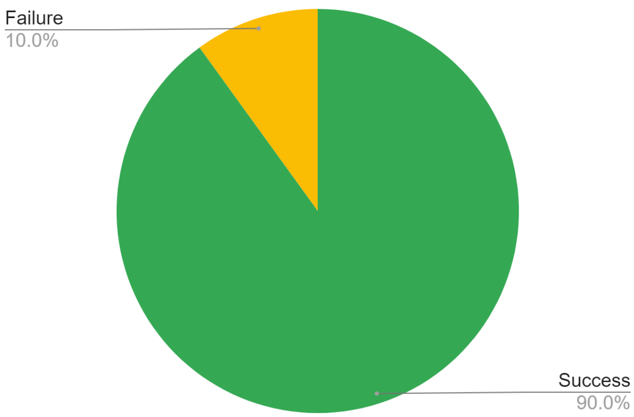


Figure 1: Minimum acceptable results from the battery life validation testing

We anticipate that when testing the velocity of the device, it will consistently travel at around 0.245-0.280 in/sec. The velocities across all trials would then be averaged and then a 95% confidence interval would be created to characterize the velocity profile of the stepper motor. The client desired that the device take at most 10 seconds to fully dispense the liquid so the team would aim for a mean speed of .275 in/s across trials.

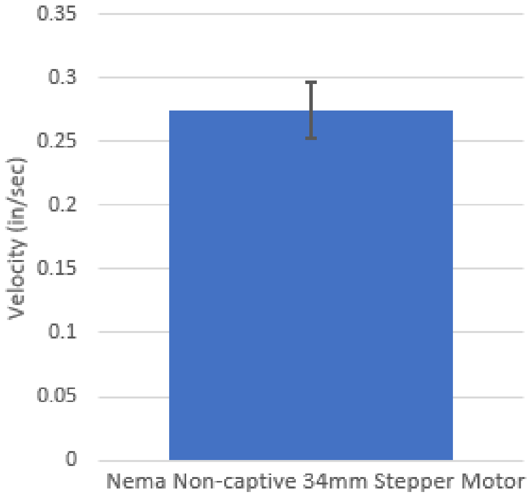


Figure 2: Expected results from the lead screw speed validation testing

Conclusions/action items: These are the expected results obtained once we begin testing. We aim to have the battery last for at least 172 hours and for the velocity of the device to be around 0.275 in/sec. We anticipate obtaining relatively good results after testing. Now we just have to test and see if these expected results are valid!

Sheep Jugular Vein

PIERSON FISHER - Sep 17, 2020, 9:35 AM CDT

Title: Sheep Jugular Vein

Date: 9/17/2020

Content by: Pierson Fisher

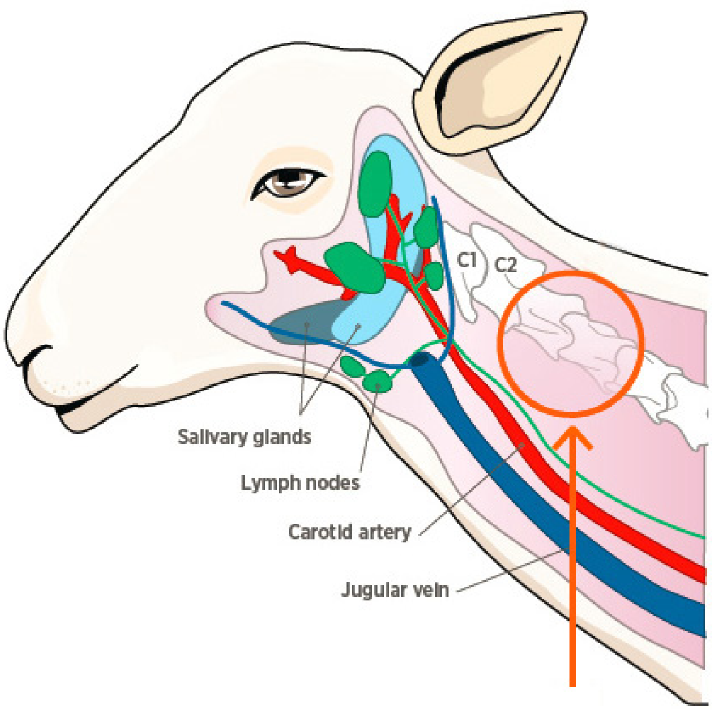
Present: Pierson Fisher

Goals: To understand the dimensions and location of the Jugular vein, most commonly used in sheep euthanasia.

Content:

Based on a study done on 50 sheep, "The average maximal diameter of 50 JVs was 13.34 ± 1.18 mm. Each vein contained an average of 4.36 ± 0.98 valves. All valves were competent and 96.3% were bicuspid". This information gives us a great opportunity to know how much error we have. The valves are less important in this case, as the purpose of them is to assure blood flow in the correct direction, which we will assume is correct, but the dimensions are extremely important. With a 20-gauge (.908 mm) needle being used for injection, and a sheep's jugular vein averaging 13.34 mm+/-1.18mm based on the source attached below, the team has between 5 and 7 mm of error in either direction to assure with 95% confidence that the needle hits the jugular of a sheep.

The image below is meant for vaccinations, but the anatomy is very helpful for our purpose, so that we may see where the vein is relative to the skin.



https://www.zoetis.com.au/livestock-solutions/sheep/maximise-lamb-productivity/best-practice-vaccination-for-lambs.aspx

Conclusions/action items:

Begin thinking about how we can assure this much accuracy on such a large animal, as missing the vein with the needle is very bad, and would cause suffering for an animal, so we must figure out a way to make the needle stay in one place.

PIERSON FISHER - Sep 17, 2020, 9:16 AM CDT

Radiol Oncol 2008; 42(2): 59-65.

The ovine jugular vein as a model for interventional radiology procedures

Wei Lu[1,2], Won Kyu Park[1,3], Barry Uchida[1], Hans A. Timmermans[1], Dusan Pavcnik[1], Frederick S. Keller[1], Josef Rösch[1]

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Background. *Detailed knowledge of the ovine jugular vein anatomy and physiology is a prerequisite for proper use of sheep as working or as experimental model in interventional radiology.*
Material and methods. *Ascending and descending jugular venograms in tilted position were done in 25 sheep to evaluate the jugular vein (JV) size and anatomy of its valves.*
Results. *The average maximal diameter of 50 JVs was 11.34 ± 1.18 mm. Each vein contained an average of 4.36 ± 0.58 valves. All valves were competent and 96.3% were bicuspid.*
Conclusions. *Because of similarities between ovine JV and human femoral vein in regards to diameters, number and type of valves and function of their valves with increased central and hydrostatic pressure, the ovine JV is a good model for evaluation of creation of JV valve incompetence, percutaneous valve transplantation and evaluation of prosthetic valve devices.*

Key words: jugular vein; experimental model, ovine; interventional radiology

Introduction

Percutaneous techniques have emerged as minimally invasive options in the treatment of chronic venous insufficiency. For replacement of diseased or absent venous valves, several artificial percutaneously implanted valves have been developed over the last 10 years.[1-9] The ovine jugular vein (JV) has been often used for testing of the new valve devices because of its similar size to human femoral vein.[3,4,10] However, to our knowledge, there has not been a detailed study on the ovine JV angiographic anatomy, particularly regarding the number, distribution and type of its valves. The purpose of this study is to describe the angiographic anatomy of the ovine JV and its valves as a suitable model for interventional radiology procedures.

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The_Ovine_Jugular_Vein_as_a_Model_for_Interventional_Radiology_Procedures.pdf(105.1 KB) - download

Auto injector needle

PIERSON FISHER - Oct 08, 2020, 10:45 PM CDT

Title: Auto injector Needle

Date: 10/8/20

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: To develop a way to safely deliver the chemical to the sheep

Content:

One way that chemicals are injected into people is by auto injecting needle, similar to an Epi-pen. The major downsides of this design are lack of accuracy, as it is normally used on the leg. The team needs to use it on the neck of the sheep in the jugular vein most likely, but the hidden needle technology used may be useful for the team. Many Epi pens have a needle inside the tip that you need to press on the tip to activate and it will protrude, this could be useful for out group to assure that the sheep does not accidentally poke itself with the needle while in the chamber. Unfortunately, diagrams of this technology are not well documented, as the never-see-needle (c) is copyrighted, but a similar concept could be used for the team's needs.

Conclusions/action items:

Consider different injection methods to euthanize the sheep.

Project Significance within the team

PIERSON FISHER - Sep 17, 2020, 9:45 AM CDT

Title: Team significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of the team within the project, and the significance of the project to the team.

Content:

Working on this project gives the team an idea of what the real world problems are, as well as a better understanding of the ethical implications of animal research, specifically animal research with a high risk of animal death.

Conclusions/action items:

Continue to consider the implications of animal research and understand that the project's ultimate goal does involve a humane death of an animal.

Project Significance within the economy

PIERSON FISHER - Sep 17, 2020, 9:55 AM CDT

Title: Economic significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of the economy within the project,.

Content:

This one is a little more arbitrary, but as the economy continues to stagnate, and after COVID, assuredly it will rise, there will be more testing to be done, so having the opportunity to do testing for a government operation like the Navy during this time is a great privilege, as there must be less funding for such testing during these trying times. Additionally, clients, producers, and many other resources may just disappear at any time during this project, and we must be prepared to work around those obstacles.

Conclusions/action items:

Understand that the economy has adverse effects on every project, and that we must be prepared to overcome that at any time.

Project Significance within the environment

PIERSON FISHER - Sep 17, 2020, 10:06 AM CDT

Title: Environmental significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of the environment within the project.

Content:

I think the biggest effect this project could have on the environment is assuring that the chemicals are disposed of correctly, and the sheep are taken care of correctly after death. Releasing chemicals into the environment has negative effects that can't be understated, but the sheep being killed humanely, and being disposed of correctly are just as important to the planet's overall health.

Conclusions/action items:

Be environmentally concious about the decisions that the team makes, and know the consequences.

Project Significance within Society

PIERSON FISHER - Sep 17, 2020, 10:13 AM CDT

Title: Societal significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of society within the project

Content:

I think that the biggest societal impact we will have with this project is the people that will not be happy that we are creating a way to kill sheep, humanely or not.

Conclusions/action items:

This is something that we must keep in mind while progressing with the project, as people will surely disagree with what we are doing.

Project Significance in global context

PIERSON FISHER - Sep 17, 2020, 10:49 AM CDT

Title: Global significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of the project in a global context.

Content:

This is a project that is being commissioned indirectly by the Navy, so the global implications here are actually quite important. The work that the team does on this project could be used all around the world ans ave many human lives in the process.

Conclusions/action items:

I'm proud to be working on a project with so many positive implications, and possibilities for life saving technologies instead of focusing on the death that our project brings directly.

Project Significance in ethical context

PIERSON FISHER - Sep 17, 2020, 10:56 AM CDT

Title: Ethical significance to the project

Date: 9/17/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the significance of the project from an ethical standpoint.

Content:

The ethics of killing an animal is always something to consider. For me, I think about the human lives that we are working on saving, and that helps me understand the importance of this project. Is a life worth a life if one is an animal and one is a human? I think this project justifies that sacrifice.

Conclusions/action items:

Death is a part of life, and the lives we save are hopefully worth the lives we end on this process.

Rack and Pinion Design

PIERSON FISHER - Oct 05, 2020, 10:06 AM CDT

Title: Rack and Pinion Design

Date: 9/23/20

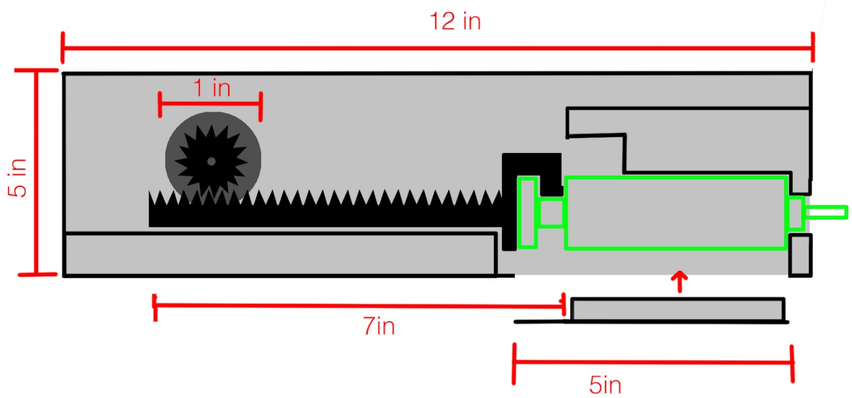
Content by: Pierson Fisher

Present: Noah WIlliams

Goals: Develop a design that meets all criteria given by the client that also solves the prolem

Content:

One way to propel the plunger of the syringe would be to use a rack and Pinion system. This would involve using a round gear and a linear gear to convert rotational motion into translational motion, as shown below.



This design is beneficial because it has only 2 moving parts, as well as having the lowest power draw of the three designs, but it is plastic and therefore may not hold up under pressure or continuous use.

Conclusions/action items:

Put this deign into the Design Matrix and decide which of the three designs to proceed with.

Linear Actuator Design

PIERSON FISHER - Oct 05, 2020, 10:14 AM CDT

Title: Linear Actuator

Date: 9/23/20

Content by: Pierson Fisher

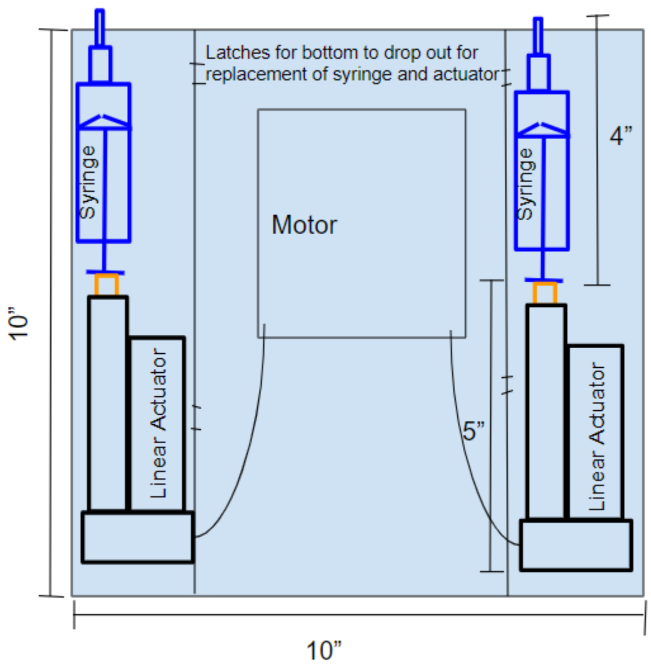
Present: Full Group

Goals: Develop another design that meets criteria given by the client that completes the required task.

Content:

Using a linear actuator would result in a very reliable way to depress the syringe, but it would be extremely expensive, and not a very good experience of engineering for the group, as our job would be done for us.

Here is a diagram of the design using a linear Actuator.



This would be a very powerful alternative to the other designs, as these are industrial tools built specifically for purposes like this.

Conclusions/action items:

Put this design in the Design matrix, and compare with the others in order to learn what the best design is for the team and client, and move on with that.

Lead Screw Plunge Design

PIERSON FISHER - Oct 05, 2020, 10:20 AM CDT

Title: Lead Screw Plunge

Date: 9/23/20

Content by: Pierson Fisher

Present: Marshall Walters

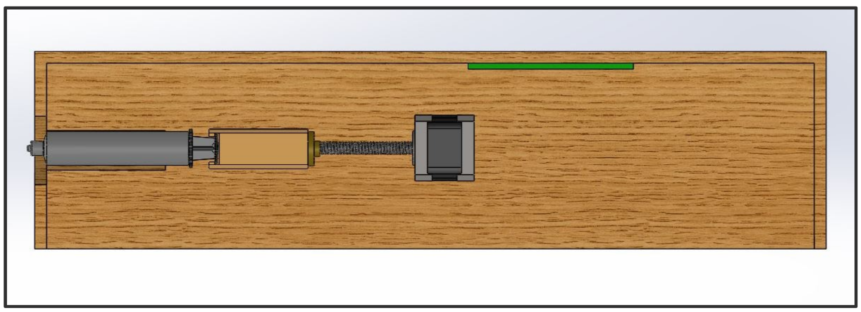
Goals: Develop another design that meets criteria given by the client that completes the required task.

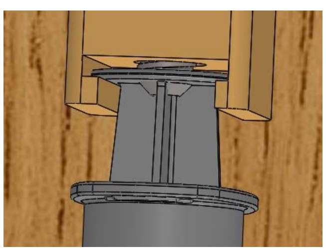
Content:

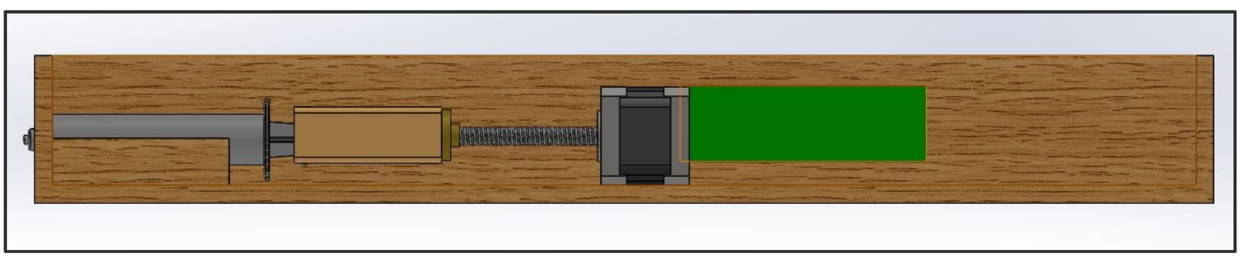
This design has a threaded holding cap to stop the syringe from accidentally depressing, as well as a top down loading method, which should make it easier to use.

Additionally, the gear ratio is customizable to size, speed, and many other criteria, giving the team the opportunity to create a unique design depending on changing criteria.

Here is a diagram of the design using a Lead Screw Plunge:







Conclusions/action items:

Put this design in the Design matrix, and compare with the others in order to learn what the best design is for the team and client, and move on with that.

Design Matrix

PIERSON FISHER - Oct 05, 2020, 10:24 AM CDT

Title: Design Matrix

Date: 10/3/20

Content by: Full Group

Present: Full Group

Goals: The choose the design that will work best for our group and our client.

Content:

Designs	Rack and Pinion		Linear Actuator		Lead Screw Plunge	
Reliability (30)	3	18	4	24	5	30
Efficiency (25)	5	25	3	15	4	20
Robustness (20)	4	16	3	12	5	20
Feasibility (15)	4	12	5	15	3	9
Ease of Use (10)	4	8	4	8	5	10
Cost (5)	5	5	1	1	3	3
Total (100)	84		75		92	

Reliability	Consistent delivery of expected results; the mechanical pumping system must be able to be used over and over without worry of it malfunctioning; if the system fails to be reliable, the animal's well-being may be at stake
Feasibility	Can the design be constructed and developed in a reasonable amount of time?
Ease of Use	Can the syringe be easily inserted into the design? Does the remote activation system work through the glass or is it finicky?
Robustness	Can the design pass the hazard analysis or drop test? Will the box/components be able to withstand the pressure induced by the hyperbaric chamber (5 atm)?
Efficiency	Can the design effectively and speedily administer the desired dosage in a reasonable amount of time? Is the response time between the receiver and the remote button activation delay minimized?
Cost	How much will each unit cost to manufacture?

This is the design matrix, with the defined criteria, and the winning scores. The Lead screw plunge won the most categories, primarily because of its customizability and the ability of the team to change its specifications to the needs of the project.

Conclusions/action items:

Based on the findings above, the team will be moving forward with the Lead Screw Plunge design, and begin fabrication in the coming weeks.

Stepper Motor

PIERSON FISHER - Oct 08, 2020, 10:35 PM CDT

Title: Stepper Motor analysis

Date: 10/8/20

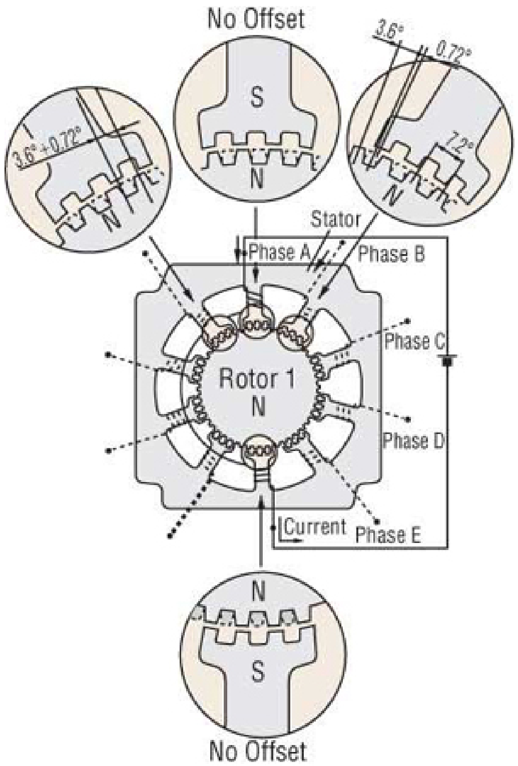
Content by: Pierson Fisher

Present: Pierson Fisher

Goals: Understand the process of a stepper motor

Content:

A stepper motor works by rotating a large drum around a threaded rod. The two are polarized in opposite directions, and the force each other to rotate on opposite directions. But, the threaded rod is held in place by its threads, so rather than rotating, it moves through the magnetic field to "rotate" the threads while providing linear translation to the whole rod.



This diagram shows how the phases of the magnetic field unalign and realign and how it forces the rod in the middle to move.

https://www.orientalmotor.com/stepper-motors/technology/stepper-motor-overview.html

Conclusions/action items:

The team will be moving forward with the lead screw design, and this will be valuable information when determining how to use the motor to depress the syringe.

Battery and Power Supply Research

PIERSON FISHER - Dec 05, 2020, 9:20 PM CST

Title: 5V and 12V Power Supply/Battery feasability

Date: 11/5/2020

Content by: Pierson Fisher

Present: Pierson Fisher

Goals: To find 2 power supplies, one that is 5V and one that is 12V, to implement into our project.

Content:

To begin, let's find a 5V power supply, and a 5V battery, and compare and contrast.

Many portable charges operate at an output of 5V, but they require the ability to be turned on manually.

https://www.adafruit.com/product/1565

An example of this would be the USB battery pack for Raspberry Pi, which has 2 5V outputs, but only connects via mini USB, which the group does not have.

Additionally, this battery pack only has 5000mAh of power, and an output of 2.1A, so 5000mAh/2.1A, means it can only provide power for 2.381 hours when turned on. So, if there was a way to turn the remote on at the same time as the circuit, that would be great, but the purpose of this battery is to power the circuit turning on, so I don't believe this is a possibility.

Using the following forum, it appears we aren't the first to have this problem: https://electronics.stackexchange.com/questions/13114/5v-battery-smaller-is-better

I believe the best path to take is either to have a 9V battery that we regulate down using an SMPS, or use a boost regulator to pump a lithium ion battery up to 5V.

The regulator is more expensive, more complex to build, and larger, as it is mean to regulate anywhere from 5V to 24V. Whereas the boost regulator sells on digikey, which is easily accessible by the team for $0.61, and is much smaller.

The digikey ordering link is: https://www.digikey.com/en/products/filter/pmic-voltage-regulators-dc-dc-switching-regulators/739?s=N4IgjCBcoLQExVAYygFwE4FcCmAaEA9lANogCsIAuvgA6pQggC%2BT%2BCkpAsgMIAKYANgAsABipMgA

The circuit that would do this process look like so:

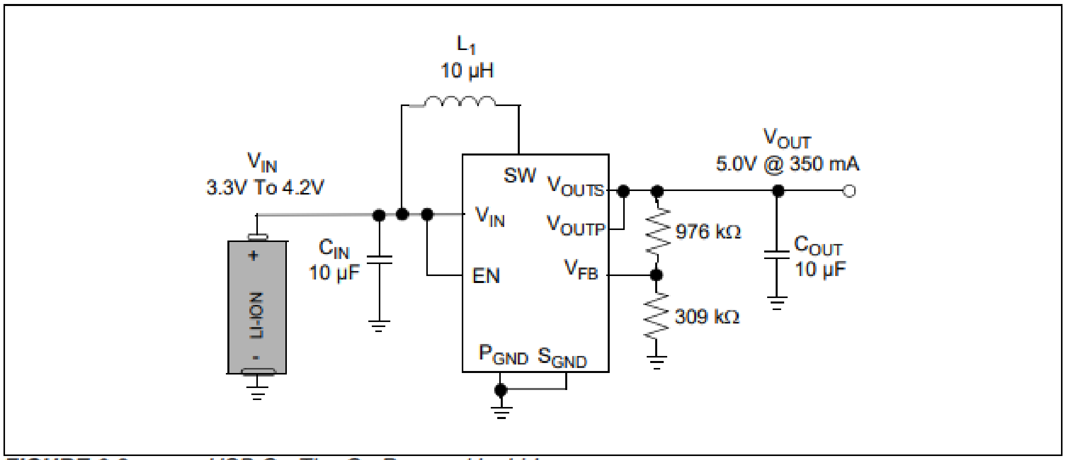


FIGURE 6-2: *USB On-The-Go Powered by Li-Ion.*

After more looking, we need a through hole voltage regualtor, which this will satisfy:

https://www.digikey.com/en/products/detail/maxim-integrated/MAX751CPA/1240221

ORDER LINK FOR LI-ION BATTERY - https://www.digikey.com/en/products/detail/sparkfun-electronics/PRT-13855/7559594

So the team would build this circuit, and then put this apparatus in the box with the motor.

Research has shown that Pressure of less than 12 atm do not adversely effect Lithium ion batteries, and they have been found to work in much higher pressures.

https://phys.org/news/2018-11-pressure-li-ion-batteries.html

For the 12V output, there are other options. The most common way to create a 12V battery is by packaging smaller batteries together and wiring them together like so:

Conclusions/action items:

PIERSON FISHER - Nov 05, 2020, 1:07 PM CST

MICROCHIP

MCP1640/B/C/D

0.65V Start-Up Synchronous Boost Regulator with True Output Disconnect or Input/Output Bypass Option

Features

- Up to 96% Typical Efficiency
- 800 mA Typical Peak Input Current Limit:
  - I_{OUT} = 100 mA @ 1.2V V_{IN}, 3.3V V_{OUT}
  - I_{OUT} > 350 mA @ 2.4V V_{IN}, 3.3V V_{OUT}
  - I_{OUT} = 350 mA @ 3.3V V_{IN}, 5.0V V_{OUT}
- Low Start-Up Voltage: 0.65V, typical 3.3V V_{OUT} @ 1 mA
- Low Operating Input Voltage: 0.35V, typical 3.3V V_{OUT} @ 1 mA
- Adjustable Output Voltage Range: 2.0V to 5.5V
- Maximum Input Voltage ≤ V_{OUT} < 5.5V
- Automatic PFM/PWM Operation (MCP1640/C):
  - PFM Operation Disabled (MCP1640B/D)
  - PWM Operation: 500 kHz
- Low Device Quiescent Current: 19 µA, typical PFM Mode (not switching)
- Internal Synchronous Rectifier
- Internal Compensation
- Inrush Current Limiting and Internal Soft Start
- Selectable, Logic Controlled Shutdown States:
  - True Load Disconnect Option (MCP1640/B)
  - Input to Output Bypass Option (MCP1640C/D)
- Shutdown Current (All States): < 1 µA
- Low Noise, Anti-Ringing Control
- Overtemperature Protection
- Available Packages:
  - 6-Lead SOT-23
  - 8-Lead 2 x 3 mm DFN

Applications

- One, Two and Three Cell Alkaline and NiMH/NiCd Portable Products
- Single-Cell Li-Ion to 5V Converters
- Li Coin Cell Powered Devices
- Personal Medical Products
- Wireless Sensors
- Handheld Instruments
- GPS Receivers
- Bluetooth Headsets
- +3.3V to +5.0V Distributed Power Supply

General Description

The MCP1640/B/C/D is a compact, high-efficiency, fixed frequency, synchronous step-up DC-DC converter. It provides an easy-to-use power supply solution for applications powered by either single-cell, two-cell, or three-cell alkaline, NiCd, NiMH, and single-cell Li-Ion or Li-Polymer batteries.

Low-voltage technology allows the regulator to start-up without high inrush current or output voltage overshoot from a low 0.65V input. High efficiency is accomplished by integrating the low resistance N-Channel Boost switch and synchronous P-Channel switch. All compensation and protection circuitry is integrated to minimize the number of external components. For standby applications, the MCP1640 consumes only 19 µA while operating at no load, and provides a true disconnect from input to output while in Shutdown (EN = GND). Additional device options are available by operating in PWM-Only mode and connecting input to output while the device is in Shutdown.

The "true" load disconnect mode provides input-to-output isolation while the device is disabled by removing the normal boost regulator diode path from input-to-output. The Input-to-Output Bypass mode option connects the input to the output using the integrated low resistance P-Channel MOSFET, which provides a low bias voltage for circuits operating in Deep Sleep mode. Both options consume less than 1 µA of input current.

Output voltage is set by a small external resistor divider. Two package options are available, 6-Lead SOT-23 and 8-Lead 2 x 3 mm DFN.

Package Types

MCP1640 6-Lead SOT-23 | MCP1640 8-Lead 2 x 3 DFN*

* Includes Exposed Thermal Pad (EP); see Table 3-1.

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MCP1640_datasheet.pdf(738.2 KB) - download

Effective Euthanasia Solution for Sheep

NOAH WILLIAMS - Oct 08, 2020, 6:36 PM CDT

Title: Effective Euthanasia Solution for Sheep

Content by: Noah Williams

Present: N/A

Goals: N/A

Content:

[5] AHC Research Services - University of Minnesota. 2020. *Euthanasia Guidelines*. [online] Available at: <https://www.researchservices.umn.edu/services-name/research-animal-resources/research-support/guidelines/euthanasia> [Accessed 14 September 2020].

Euthanasia can be performed using sodium pentobarbital. Typically, a dosage of 100 mg per kilogram of body mass of the sheep is required to adequately dispatch a sheep [5]. The shelf life of sodium pentobarbital is rated at 3 years when unopened, and 28 days after opening the package [5]. However, it is regulated by the government, and our group cannot purchase it without a veterinary license. That will not be a problem, though, as the client already has it. Sodium pentobarbital is a barbiturate that works by attacking the central nervous system, killing the sheep less than a minute after injection.

Conclusion: This will be an effective solution for use in our device, since only around 20 ml will be needed to terminate the sheep. That will make the job of pumping it easier, since lower volumes will require less force to expel from the syringe.

Infusion Pumps vs Syringe Pumps

NOAH WILLIAMS - Oct 05, 2020, 1:39 PM CDT

Title: Research Into Competing Designs

Date: 10/5

Content by: Noah Williams

Present: N/A

Goals: N/A

Content:

[1] Sigma international, *Sigma Spectrum Operators Manual*. Sigma International, Medina, NY, 2008.

[2] Alina Updated on: May 26, "What is a Syringe Pump? Infusion Pump vs. Syringe Pump Comparison," *Chemyx Inc*, 26-May-2020. [Online]. Available: https://www.chemyx.com/support/knowledge-base/getting-started/what-is-a-syringe-pump-3/. [Accessed: 05-Oct-2020].

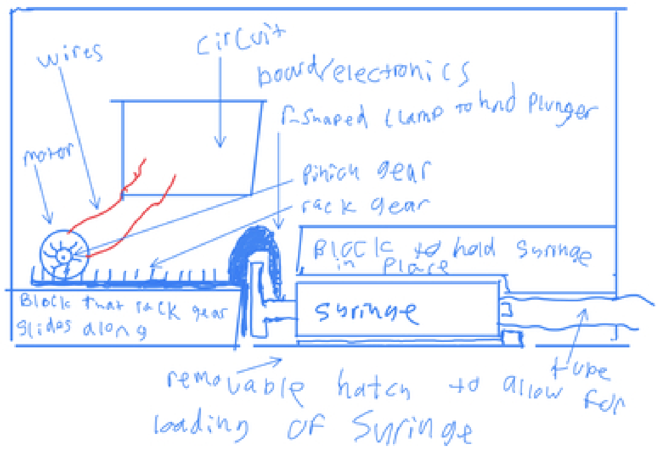
Infusion pumps are pumps that are designed to inject fluid for prolonged periods of time, such as the Baxter Sigma Spectrum[1]. This device sells for north of $1000, and is designed to be extremely robust and last for decades. The pump draws fluid from a reservoir and then feeds that fluid through a tube into the patient's vein. It can vary the rate and pressure with which it pumps the solution. However, it is not rated for use in above 1.4 atmospheres of pressure, which would pose a significant problem, as this experiment is being performed at up to 5 atmospheres of pressure.

While infusion pumps are designed to pump large amounts of fluid over long periods of time, syringe pumps are designed to pump fluid out of one or more syringes mounted inside of the device [2]. They are used primarily for research purposes, and while there are some commercially available, none meet the needs of this experiment. They are usually operated via a keypad mounted directly on the unit, which would not work for this experiment. However, the design of these would likely cause these syringe pumps to function better under the air pressure of this experiment than the infusion pump would, but are still not rated for anywhere near the amount of pressure our device must withstand.

Conclusions/action items: Price and a lack of atmospheric resistance prevent us from using any of the commercially available devices.

Preliminary design

NOAH WILLIAMS - Sep 24, 2020, 12:40 PM CDT



IMG_B02A13528AC1-1.jpeg(964.3 KB) - download

NOAH WILLIAMS - Sep 24, 2020, 12:48 PM CDT

For my design, I decided to use a motor mounted perpendicular to the direction of the syringe to drive a rack and pinion gear setup. The rotational motion of the motor is translated into linear motion via the rack and pinion, which is used to push an r-shaped piece that is hard-mounted onto the end of the rack gear. This piece would be designed to fit snugly around the plunger of the syringe in such a way that so that the plunger could not move, once inside of the r-shaped piece, unless pushed or pulled by the motor. This is specifically to counteract the compressive force of the air pressure inside the hyperbaric chamber, so that the solution cannot be prematurely expelled by the high air pressure. The syringe would be held in place by multiple blocks mounted on the walls of the box that would prevent the body of the syringe from moving. The syringe is to be loaded and unloaded by a removable hatch located directly under it.

NOAH WILLIAMS - Oct 05, 2020, 1:43 PM CDT

circuit-board(168.6 KB) - download

General Research into Arduinos

NOAH WILLIAMS - Sep 08, 2020, 9:50 PM CDT

Title: Preliminary research into Arduinos

Date: 9/8

Content by: Noah Williams

Present: N/A

Goals: To understand how Arduinos work and could be used in our project

Content:

Arduinos may be a cheap and effective way of creating a remote control device. An Arduino Starter Kit costs around $53, though we likely wouldn't need everything in the starter kit, and could probably piece together the components we need for cheaper. The actual Arduino board can be bought for between $20 and $40, depending on the model. They speak C++, and can be programmed to send and receive a command wirelessly, which we could use as the electronics for our device. A motor driver is needed for an Arduino to power a motor, if we wish to use a motor to expel the solution, but a push-pull solenoid can be directly powered by the Arduino. Code for actuating the solenoid is very simple.

My idea would be to use a master Arduino to act as a wireless remote to send signals to the slave Arduinos inside the euthanasia devices that are attached to the sheep. The slave Arduinos will then execute a command to actuate a push-pull solenoid that acts like a plunger on a syringe and expels the euthanasia solution into the vein. If needed, a motor and motor driver could also be used to perform this function through the use of a gear attached to the output shaft of the motor and a gear rack attached to the plunger of the syringe.

https://randomnerdtutorials.com/rf-433mhz-transmitter-receiver-module-with-arduino/

https://store.arduino.cc/usa/

https://sproboticworks.com/blog/choosing-the-right-motor-driver

https://core-electronics.com.au/tutorials/solenoid-control-with-arduino.html

Conclusion Items:

I have determined that using a set of slave Arduinos, controlled by a single master Arduino through the use of wireless transmitters and receivers, we could wirelessly actuate a push-pull solenoid or a motor that could expel euthanasia from a reservoir and into a vein.

Shop Permit: Red Pass

NOAH WILLIAMS - Oct 05, 2020, 1:03 PM CDT

As part of InterEgr-150 last year, I received a red pass. However, I was never actually given a physical pass, and instead I was allowed access to machinery when the Team Lab or Makerspace employees would look up my name. This is how it was done for everyone in my class, last year.

Personal 3D printer

NOAH WILLIAMS - Oct 05, 2020, 1:17 PM CDT

Title: Personal 3D Printers Notes

Date: 10/5

Content by: Noah Williams

Present: n/a

Goals: n/a

Content:

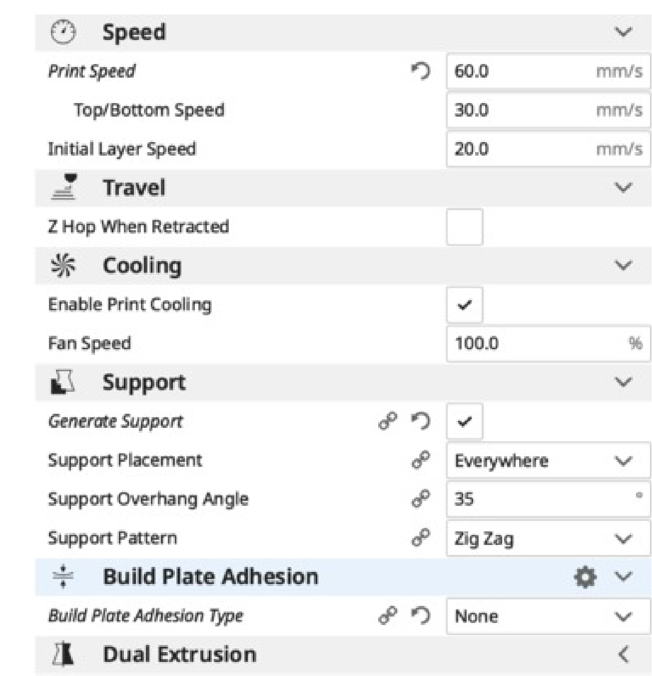
I have two 3D printers that I will be using for this project. One is a Creality Ender 3 and the other is a Reality CR-10S. The Ender 3 is currently experiencing thermal runaway issues, which I am unable to diagnose the source of, so I will not be utilizing that until I can fix it. I have ample experience using these machines, and have built many large-scale projects on them, including a screen-accurate Pit Droid (from Star Wars: The Phantom Menace and The Mandalorian) and a wearable set of Clone Trooper Armor (from Star Wars: Revenge of the Sith). I am use Windows 3D builder to cut and resize the files, and Cura to slice the files for printing. I use Priline 1.75mm PLA filament, and will be printing our device in Priline 1.75mm carbon-fiber reinforced PLA.

I will be using my personal devices for this since I can print much faster, better, and cheaper than can be done at the Makerspace. At the Makerspace, they charge $80 per kilogram of PLA. On my printers, I can print a kilogram for under $20. Additionally, since I have so much experience on my printers and using my filament, I know exactly what settings my printer can handle, and can change print profiles to maximize different parameters, such as speed, strength, detail, weight, and surface quality.

Below I have attached my print settings that I will be using for the first draft of our device.

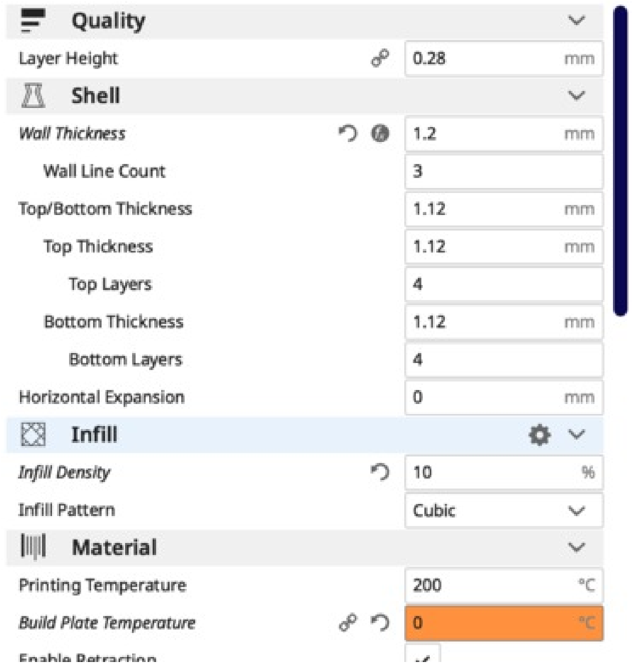
Conclusions/action items: I will use my 3D Printers to create prototypes of our device.

NOAH WILLIAMS - Oct 05, 2020, 1:10 PM CDT



Screen_Shot_2020-10-05_at_1.10.19_PM.png(124.2 KB) - download

NOAH WILLIAMS - Oct 05, 2020, 1:10 PM CDT



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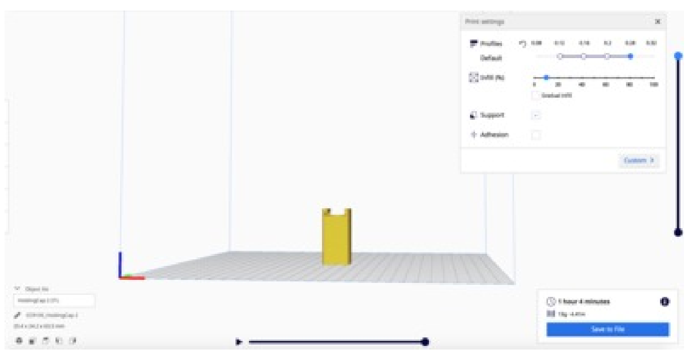
NOAH WILLIAMS - Oct 05, 2020, 1:10 PM CDT



Screen_Shot_2020-10-05_at_1.09.52_PM.png(479.9 KB) - download

Project Impact

NOAH WILLIAMS - Oct 06, 2020, 10:15 PM CDT

NOAH WILLIAMS - Oct 08, 2020, 6:15 PM CDT

Title: Project Significance

Date: 10/6

Content by: Noah Williams

Present: N/A

Goals: To understand the wider impact of our project

Content:

Team- Through working on this project, our team will gain a better understanding of the ethical implications involved with using large, intelligent animals in research; how and when to use euthanasia to end a life; and how redundancy is necessary to avoid potential suffering caused by a faulty device.

Economic- This device could be a potentially much cheaper alternative to existing syringe and infusion pumps, which cost north of $1000 refurbished. Our device should be able to be made and sold for under $200. It also has functionality that existing models do not currently offer, such as pressure resistance and remote control actuation.

Environmental- A large part of our project is being printed in PLA, which is made from corn, tapioca, and other starches. This means that the PLA is biodegradable. When our device is no longer needed, many components of it can be composted.

Societal- This device could aid in pivotal research, not only in this experiment, but in many others that also require humane methods of terminating animals under high pressure.

Global- If successful, this device could play a major role in updating the procedures for rescuing stranded submariners, not just in the United States Navy, but in navies of all nations with submarines. This could save countless lives.

Ethical- This device's entire purpose is to treat the sheep as humanely as possible, and to minimize any suffering. It aims to put them down rapidly and painlessly if there is an indication that they are in imminent danger of experiencing severe pain. Additionally, the experiment that this device is being used for is attempting to improve the Navy's rescue procedures for submariners who are trapped in disabled submarines. If successful it would minimize suffering for many men and women serving our country.

Conclusions/action items: Overall, our device could play a significant role in many important studies, which could have overwhelmingly positive impacts on the lives of many.

11/6 tape experiment

NOAH WILLIAMS - Dec 08, 2020, 10:37 PM CST

Title: Testing the Strength of Double Sided Tape

Date: 10/30-11/6

Content by: Noah Williams

Goals: To determine how long the double sided tape we planned to use could hold this device.

Content:

From 11/1 to 11/6 the entire device that was printed, at that time, which consisted of the motor holder and the syringe holder, was taped to the side of my bureau, which has smooth wood sides, using two 1/2" x 1/2" pieces of Gorilla extra strength double sided tape. This tape will be used to hold the device down to the bench top on which it will sit, so that the sheep cannot pull it off the bench. This tape is often used for automotive applications, such as holding down interior panels or weather-proofing seams between body panels, so it should be more than capable of holding our device for 7 days when sitting on a metal bench top. I wanted to see how it would do when using less than the planned amount of tape, and hanging vertically. We plan to use two 1/4" by 5" strips, as well as two 2"x3" pieces to hold the device on the table. On the 7th day of the experiment, the device was still hanging and took significant effort to remove. This tape will be strong enough for our application.

11/10 testing of the holding cap

NOAH WILLIAMS - Dec 08, 2020, 10:18 PM CST

Title: Testing the compressive capabilities of the holding cap

Date: performed on 11/10

Content by: Noah Williams

Goals: to determine if the 3d printed golding cap

Content: Since the holding cap is going to be under compression from the syringe counteracting the force of the stepper motor, I wanted to see if I could cause the holding cap to fail by standing on it. All of the force applied during the experiment will be concentrated on the top and bottom of the holding cap, as that is where the lead screw and syringe contact it. I balanced myself on the top of the holding cap, with the bottom end sitting on a hard tile floor. This means that the forces were only applied on the top and bottom of the component. I weigh around 230 lbs, and the holding cap did not deform at all under my weight.

Proper Euthanasia procedures

AARANYAK BHATTACHARYA - Oct 08, 2020, 11:46 AM CDT

Title: Euthanasia procedure research

Date: 10/05/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Understand the standard operating procedures of administering euthanasia to animals in lab settings and otherwise.

Content:

Most veterinary procedures use pentobarbital to euthanize animals. Pentobarbital is a seizure medication, which in large doses causes heart and brain function to cease. It is said that the animal feels no pain during this process [1].

The AVMA (American Veterinary Medical Association) has many guidelines when it comes to the procedures of the euthanasia. There are many adverse affects in euthanasia procedures when done in a lab setting, as physiological lab data could be swayed by the injection of euthanasia solutions, "For example, isoflurane may artificially elevate blood glucose concentrations" [2]. The paper goes on to detail many acceptable methods and euthanasia methods in both lab and veterinary clinic settings.

Conclusions/action items:

Our client will want to know what went wrong in the chamber if the device is ever needed to activate in the chamber. It would be crucial to know if whatever solution being administered has any adverse affects on the body of the sheep after it is euthanized, in order to factor it into final observations and conclusions as to why the chamber caused a change on the health of the sheep.

[1]: https://pets.webmd.com/what-happens-put-pet-to-sleep#1

[2]: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.avma.org/sites/default/files/2020-01/2020-Euthanasia-Final-1-17-20.pdf

Possible RC unit

AARANYAK BHATTACHARYA - Oct 08, 2020, 12:37 PM CDT

Title: RC Unit

Date: 10/08/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Analyze a possible RC unit for our project

Content:

https://www.aliexpress.com/i/32817342296.html

It is very important to our client that the process of delivering the euthanasia solution happen remotely. It is much easier and practical to use a radio controller instead of having to wire in a remote control into the chamber. This remote's distance is stated as "20-200m", so it can be reasonably inferred that it would be able to communicate with the receiver inside the chamber, but this will have to be tested if we are to go with this specific device. The transmitter remote itself has two buttons, which is very crucial for the purposes of our device. With this receiver, we would be able to wire it to two different motors, since there will be two sheep in the chamber at a time. Two buttons would be very good as it ensures that the researcher will be able to remotely activate the device on either or both of the sheep depending on the situation. The unit itself is very cheap from this retailer, being under $10.

Conclusions/action items:

This RC unit is a very good option and fits the specifications needed for our project. It is very significant that the RC unit we choose has two buttons or we would have to buy two remotes which may be too much of a burden to label which is which, when it is much easier to have two buttons (A or B) on one remote to activate the devices in the chamber depending on which one needs to be activated. We also need to analyze the effective range of our RC unit, to ensure that the receiver will be able to communicate with the remote through the thick walls of the hyperbaric chamber during testing.

Wireless/Wired remote systems research (10/21/20)

AARANYAK BHATTACHARYA - Oct 21, 2020, 1:54 PM CDT

Title: Research into Wireless/wired remote systems

Date: 10/21/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Research the different options for the remote control used to operate the device from the outside of the chamber

Content:

Wired:

Pros:

- Does not need standby power, will be powered by the power supply of the device
    - Standby power (Often called ghost load or vampire draw), is defined as the power drawn by a device while waiting to be turned on by a wireless remote control. We would need to implement power source on both a wireless remote control and the device inside to have them work together.
    - https://standby.lbl.gov/measure/
- Distance and thickness of Hyperbaric chamber does not matter in terms of operation, as long as there is a stable wired connection between the remote and the device.
- Very easy to implement wired connections from a remote (with attached motor control) to a motor
- Allows for fast Response time once the button is pressed

Cons:

- Must consider wire length and connection to the device through the walls of the chamber
- Wires must be secured to the outside of the chamber in order to prevent general obstruction during experimentation.
- Controller (depending on wire length) must be kept close to the chamber during experimentation.

Wireless:

Pros:

- Minimizes the space taken up by the device through the chamber (no wires or chamber compartments needed to support the wireless system)
- Depending on the wireless receiver, very fast response time.
- More freedom of movement for the controller, can be placed anywhere and used if it is within an operable range.

Cons:

- Requires its own power supply in addition to another power supply within the device (See standby power explanation above)
- Must take into account the thickness of the hyperbaric walls in interference between the controller outside and the receiver inside
- Requires more circuit knowledge to establish radio communication between the controller and the device

Conclusions/action items:

Through the research presented above, a wired system would be more beneficial to the purposes of our project, as it minimizes the overall power supplies needed and is very efficient once a connection is established. Additionally, our client has indicated that they would like a wired system as well, so it would be logical to move forward in the planning process for our device to look into wired options for our device.

Remote research (10/29/20-10/31/20)

AARANYAK BHATTACHARYA - Oct 31, 2020, 11:44 AM CDT

Title: Remote Research and Wiring diagram

Date: 10/29/20-10/31/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Research the methods of connecting wired remotes to circuit components such as motors and microcontrollers.

Content:

Once the power supply is supplied to the microcontroller, there needs to be some sort of system to ensure that the power is only supplied to the stepper motor when needed, which requires the use of a button on a remote controller. The button on the controller for our project is a very crucial component of the device, as it is what starts the entire process of injecting the Euthanasia solution into each individual sheep. There are two options for the remote controller, building a simple switch from scratch or incorporating a pre-built controller.

Pre-Built Option:

Source: https://www.amazon.com/Vello-RS-C1II-Remote-Switch-Select/dp/B007CB58NY

Shown above is a pre-built one button remote switch used for shutter releases in a camera. There is no power supply in the remote itself because it is powered by the camera, and acts simply as an exterior switch, which is very similar to what we need for our design, something that doesn't need any exterior power and can be wired to work from a distance. Additionally it is relatively cheap ($11) and would come from a domestic seller, which ensures that we would not have to wait long to receive the product.

However, the crucial thing for the function of our device is the connection from the switch to the microcontroller. So we would need to know what types of switches and inputs can be incorporated into the microcontroller before ordering any pre-built switches and remote controls.

Simple Switch Option:

Another option once proper power is supplied to the circuit, is to incorporate a simple switch to control current flow from the power source to the stepper motor. However, since these switches are relatively small, a housing (possibly 3d printed or made out of wood/other material) would need to be fit around it to provide easy grip and visibility for when it is needed to be used.

"Snap" Switch

Source: https://www.amazon.com/Snap-Switch-Hinge-Roller-Lever/dp/B00IOFUY4K

These types of switches would work well with adding inputs into the device, however, there would be concerns on accidental pressing of the buttons if someone brushed past it and it collided onto the sides of the chamber, necessitating the need for some type of safety cover on the switches. Also, the button cannot be easily seen as it is not very colorful but the housing around it mitigates this problem as we are not only attaching the switch by itself into the circuitry.

Toggle Switch With Cover:

Source: https://www.amazon.com/Pilot-Automotive-PL-SW26-Performance-Toggle/dp/B000GTMUUI/ref=asc_df_B000GTMUUI/?tag=hyprod-20&linkCode=df0&hvadid=312136800234&hvpos=&hvnetw=g&hvrand=18123819854899882433&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018945&hvtargid=pla-568946543240&psc=1

This toggle switch is very nice as it can be inputted into a circuit with relative ease and it provides a safety cover that can be flipped up to gain access to the actual switch. This ensures that there will be no concern for accidental switch activations. Additionally, the red color on the safety cover ensures that the researchers will be able to easily see where the button is at all times.

Another button option:

Source: https://www.amazon.com/Fastronix-Button-Momentary-Switch-Neoprene/dp/B07GM3KSVZ/ref=pd_bxgy_img_2/134-8281540-2166111?_encoding=UTF8&pd_rd_i=B07GM3KSVZ&pd_rd_r=d98ead3a-6022-4d28-a073-c04bb1d85fc5&pd_rd_w=Oy736&pd_rd_wg=Wjnze&pf_rd_p=ce6c479b-ef53-49a6-845b-bbbf35c28dd3&pf_rd_r=WG05KJMZB5M09AKKY014&psc=1&refRID=WG05KJMZB5M09AKKY014

This is another button option, although it does not have any safety switch, it is still a better option than the snap switch as there it takes up less surface area and could be less prone to accidental pressing.

Conclusions/action items:

We need to do more research on what type of inputs and switch types can be incorporated into the microcontroller that we are using for the device. Once we find out our options, the toggle switch with cover or the last button shown in the options would be the best options if they could be incorporated. We also need to design (if we are choosing to incorporate a switch that is not prebuilt into the circuitry) a housing for the switch to make it look more like a remote control that would let the researchers know where the button to activate the device is at all times during experimentation.

Remote Control connection and circuit diagrams(11/05/20-11/07/20)

AARANYAK BHATTACHARYA - Nov 07, 2020, 6:33 PM CST

Title: Switch and motor diagrams for remote control connection options

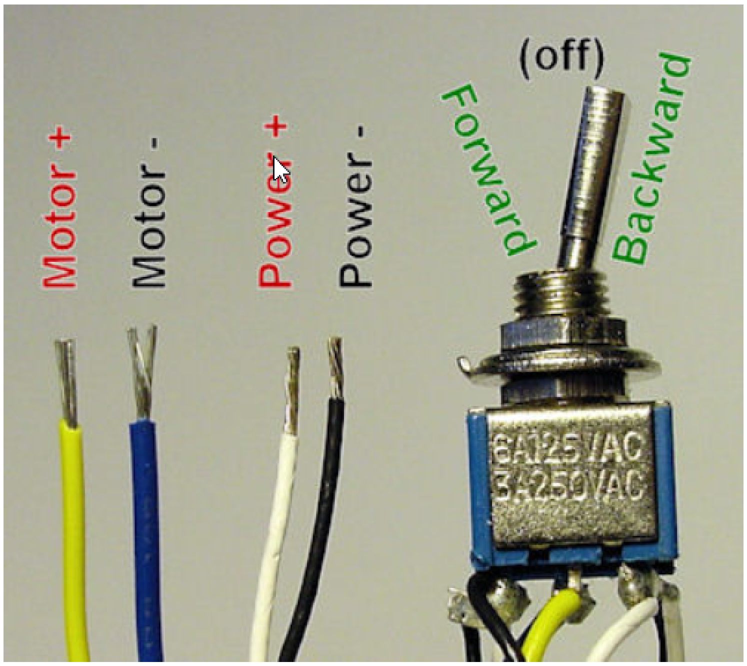
Date: 11/05/20-11/07/20

Content by: Aaranyak Bhattacharya

Present: N/A

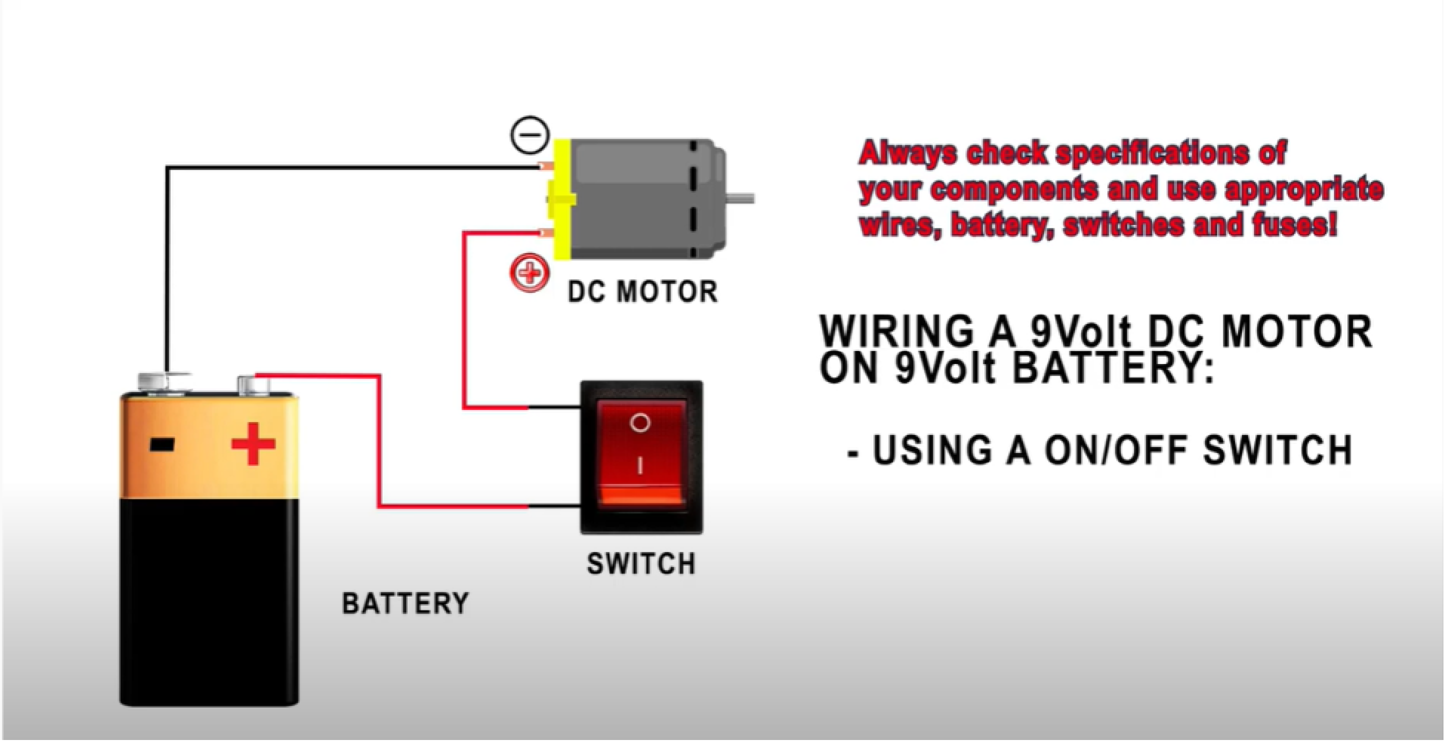
Goals: Research remote control connection options and look up circuit diagrams

Content:



Source: http://www.robotroom.com/DPDT-Bidirectional-Motor-Switch.html

The picture and the website above has some very helpful information about wiring a switch that would control a motor to go forwards and backwards. Since we have a microcontroller idea and board idea, we will be able to decide how to wire in a switch of our choosing using the information on the website. The good thing also about using this information is that the switch they chose is very close to our switch choice, a toggle switch, which would allow forwards and backwards activation of the stepper motor, and also a neutral position which would keep the motor off.



Screenshot from: https://www.youtube.com/watch?v=z0oIeUU4aWY&ab_channel=SecurityTechAdvice

This video is very important as it shows the way to wire in a switch in a way so the switch controls the flow of power from the power source by acting as a toggle in the circuit. This can aid us as it will help us to draw circuit diagrams for our device.

Conclusions/action items:

It will be very important to look at the video and read over the website this coming Sunday, as it will aid us in deciding how to wire in the switch and draw up circuit diagrams.

Remote Control Switch buy links and feedback research (11/11/20-11/14/20)

AARANYAK BHATTACHARYA - Nov 14, 2020, 2:21 PM CST

Title: Shop links for Switches and research on the feedback on our project

Date: 11/11/20-11/14/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Give two options for the toggle switches used in the project, and additionally research the feedback left on our piazza show and tell post.

Content:

Switches:

Source: https://www.grainger.com/product/4X203?gclid=Cj0KCQiA-rj9BRCAARIsANB_4AC7IVLcH7VY3ExNEiZF8lyDr-xTy4-MNmsq3RlgQZ4kEdId10mnouYaAuDUEALw_wcB&cm_mmc=PPC:+Google+PLA&ef_id=Cj0KCQiA-rj9BRCAARIsANB_4AC7IVLcH7VY3ExNEiZF8lyDr-xTy4-MNmsq3RlgQZ4kEdId10mnouYaAuDUEALw_wcB:G:s&s_kwcid=AL!2966!3!281698275255!!!g!471571925921!&gucid=N:N:PS:Paid:GGL:CSM-2295:4P7A1P:2050123

This is a toggle switch with three pins, which is very good for a triple input connection with our microcontroller. This switch is different than the other option as it has a "momentary on" function rather than a static on position. This video (https://www.youtube.com/watch?v=pRah5XyphRM&ab_channel=RichWhile-Cooper) shows the momentary on function at 1:38. Essentially, there would be a spring that would return the switch back to the off position. This allows increased user input to either manually activate the motor backwards or forwards to a desired position if needed. The momentary on function is a good addition, but is not really a necessity for the purposes of the project, as a static on position would work just fine.

Extra Video: https://www.youtube.com/watch?v=CQTj85GvD6Y&ab_channel=ServoCity

Source: https://www.grainger.com/product/4X848?gclid=Cj0KCQiA-rj9BRCAARIsANB_4ACDxbGr0Ofcln3egaKzonjUGpA5pxUJFlLF17tEUMNNM1rEho1-fDoaAm2tEALw_wcB&cm_mmc=PPC:+Google+PLA&ef_id=Cj0KCQiA-rj9BRCAARIsANB_4ACDxbGr0Ofcln3egaKzonjUGpA5pxUJFlLF17tEUMNNM1rEho1-fDoaAm2tEALw_wcB:G:s&s_kwcid=AL!2966!3!281698275255!!!g!471571925921!&gucid=N:N:PS:Paid:GGL:CSM-2295:4P7A1P:20501231

This similar looking switch costs about $3 less, because it does not have a momentary on function, only 3 static positions, which is still very good for the purposes and needs of our device. It also has 3 pins and capabilities to support 3 independent positions with their own functions (motor forwards/backwards, off).

Feedback Research:

The feedback gave some good suggestions for the types of syringes we might want to consider.

-https://www.kdscientific.com/kds-stainless-steel-syringes.html (A high pressure syringe that can potentially withstand the pressure difference better than our current syringe choice.

-https://www.cetoni.com/products/high-pressure-syringe-pump-nemesys-2600n/ (A syringe pump that is on the pricier side, very well equipped to withstand pressure differences).

Conclusions/action items:

There are two good options for the switches on our proposed remote for our project. We need to meet and discuss the feedback given on our syringe options and decide whether or not we want to buy the momentary on switch and discuss how to connect the switch to the microcontroller and program the different positions to correspond with the motor functions.

Wire research (11/19/20-11/21/20)

Title: Wire Research

Date: 11/19/20-11/21/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Find links to buy wires that can be used to connect our battery and other electrical components together

Content:

Source: https://www.amazon.com/TYUMEN-Electrical-Extension-Flexible-Lighting/dp/B07DDG7J9K/ref=asc_df_B07DDG7J9K/?tag=hyprod-20&linkCode=df0&hvadid=312039830589&hvpos=&hvnetw=g&hvrand=11199458773917273212&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9018948&hvtargid=582748873902&psc=1&tag=&ref=&adgrpid=63202739518&hvpone=&hvptwo=&hvadid=312039830589&hvpos=&hvnetw=g&hvrand=11199458773917273212&hvqmt=&hvdev=c&hvdvcmdl=&

Source: https://www.amazon.com/Fermerry-Stranded-Electric-Tinned-Copper/dp/B089CQHRDT/ref=sr_1_1_sspa?dchild=1&keywords=electrical+wire&qid=1605995940&s=electronics&sr=1-1 spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzN0RDRFJONzU3M0kzJmVuY3J5cHRlZElkPUEwODA0OTEyMlNNR1YwMDFERkxGVCZlbmNyeXB0ZWRBZElkPUEwODY0NDg(

These are two very good options for simple insulated wiring that we can incorporate into our devices. The second option is much more of a better deal, it offers more wire choices at a more eff

Conclusions/action items:

It will be more cost effective to buy the multiple wires choice shown in the second picture, we will have more wires to work with. Additionally, the different colored wire choices allow us to differe
repairs/fixes when anything in the circuit needs to be changed.

3d Modeling of Remote Control (11/27/20-11/28/20)

AARANYAK BHATTACHARYA - Dec 07, 2020, 9:21 PM CST

Title: 3d Model of Remote Control cover and switch housing

Date: 11/27/20-11/28/20

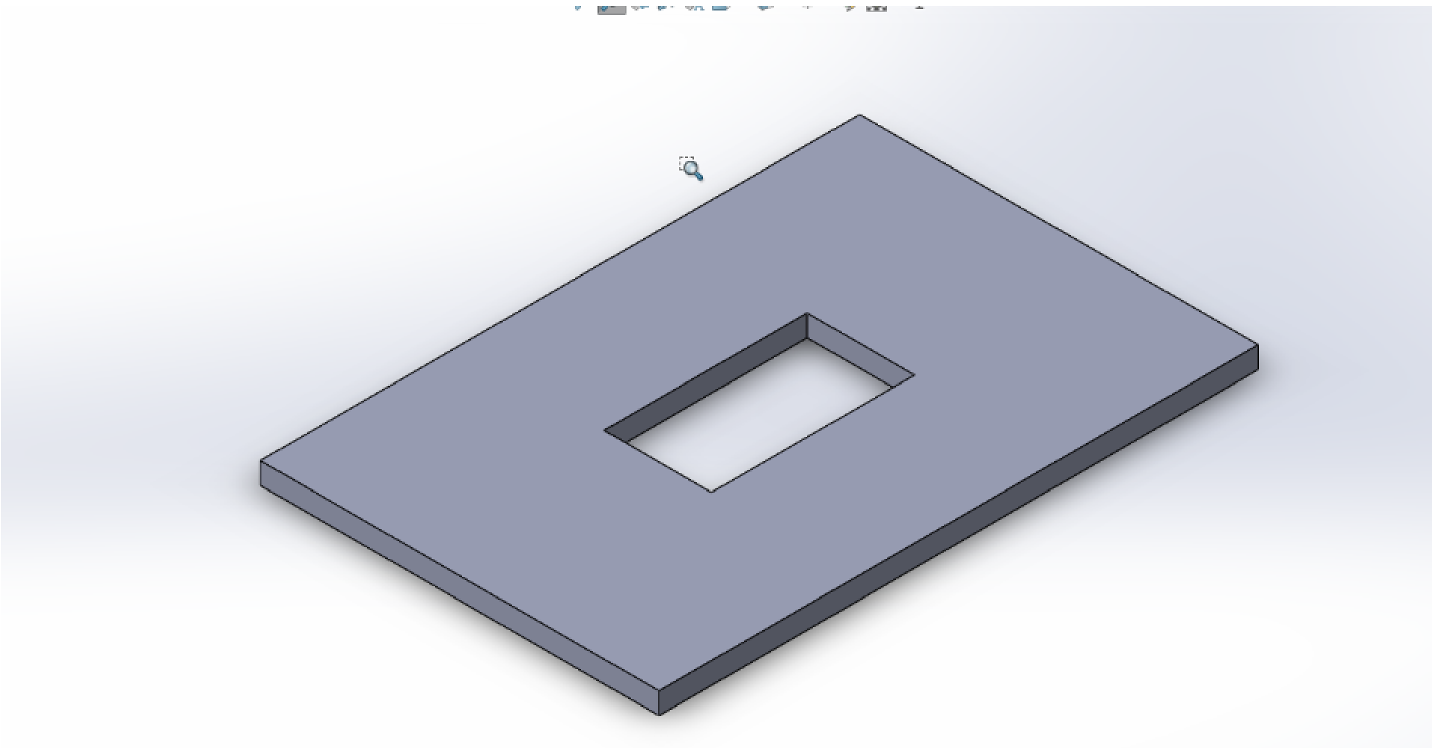
Content by: Aaranyak Bhattacharya

Present: N/A

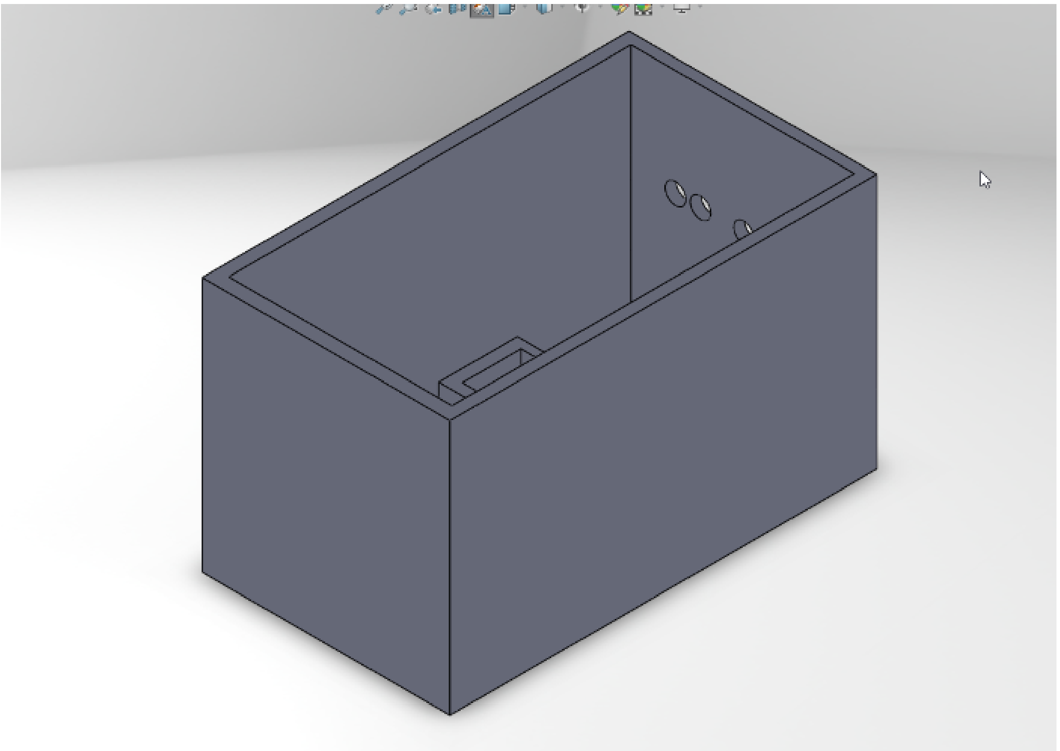
Goals: Create a 3d model of the remote control housing for 3d printing

Content:

3d model is currently without dimensions as I am still getting in touch with Grainger for the dimensions of the switch as it has not been shipped to our team yet.



Shown Above: Top Cover for the remote control, will be glued on top of the **Bottom Piece** (Shown below)



Conclusions/action items:

As a 3d model has been created and can be changed in order to fit the switch, the next steps are to get the exact measurements of the switch in order to properly put dimensions on the remote control so it can incorporate the switch into it snugly.

Grainger information on Switch (12/08/20)

AARANYAK BHATTACHARYA - Dec 08, 2020, 3:48 PM CST

AARANYAK BHATTACHARYA - Dec 08, 2020, 3:56 PM CST

Title: Information on toggle switch provided by Grainger

Date: 12/08/2029

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Call Grainger and obtain information about toggle switch measurements

Content:

Since the "contact us" emailing section on Grainger.com did not work, I called them today and received very helpful schematics and diagrams for the toggle switch that we will be ordering.

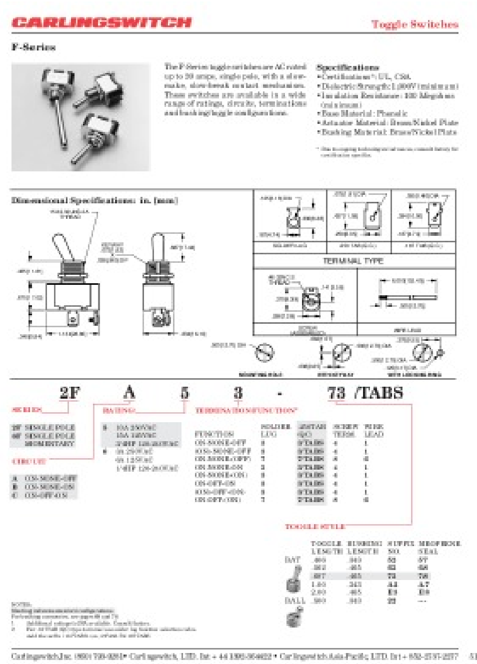
A separate lab archives page will be created after this one as the pdf is very large. (Labeled Grainger information continued).

Conclusions/action items:

Now that the exact measurements have been obtained for the toggle switch. The remote control cover and bottom piece's dimensions can be changed to ensure that the toggle switch will properly fit.

Grainger information Continued (12/08/20)

AARANYAK BHATTACHARYA - Dec 08, 2020, 3:55 PM CST



graingerinfo.PDF(53.5 KB) - download

Final Remote Control 3d Model given Grainger info (12/08/20)

AARANYAK BHATTACHARYA - Dec 08, 2020, 4:58 PM CST

Title: Final 3d Model with specific measurements

Date: 12/08/20

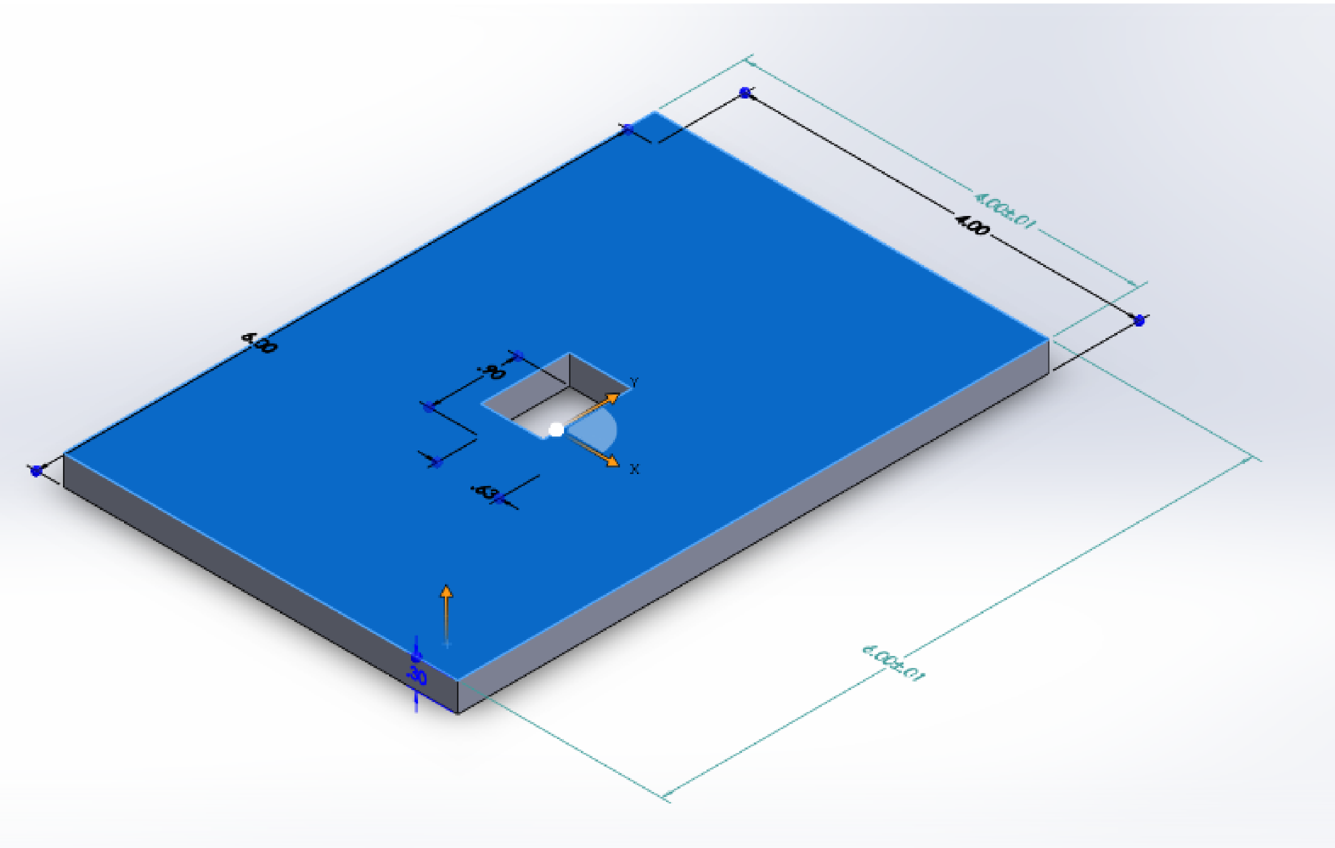
Content by: Aaranyak Bhattacharya

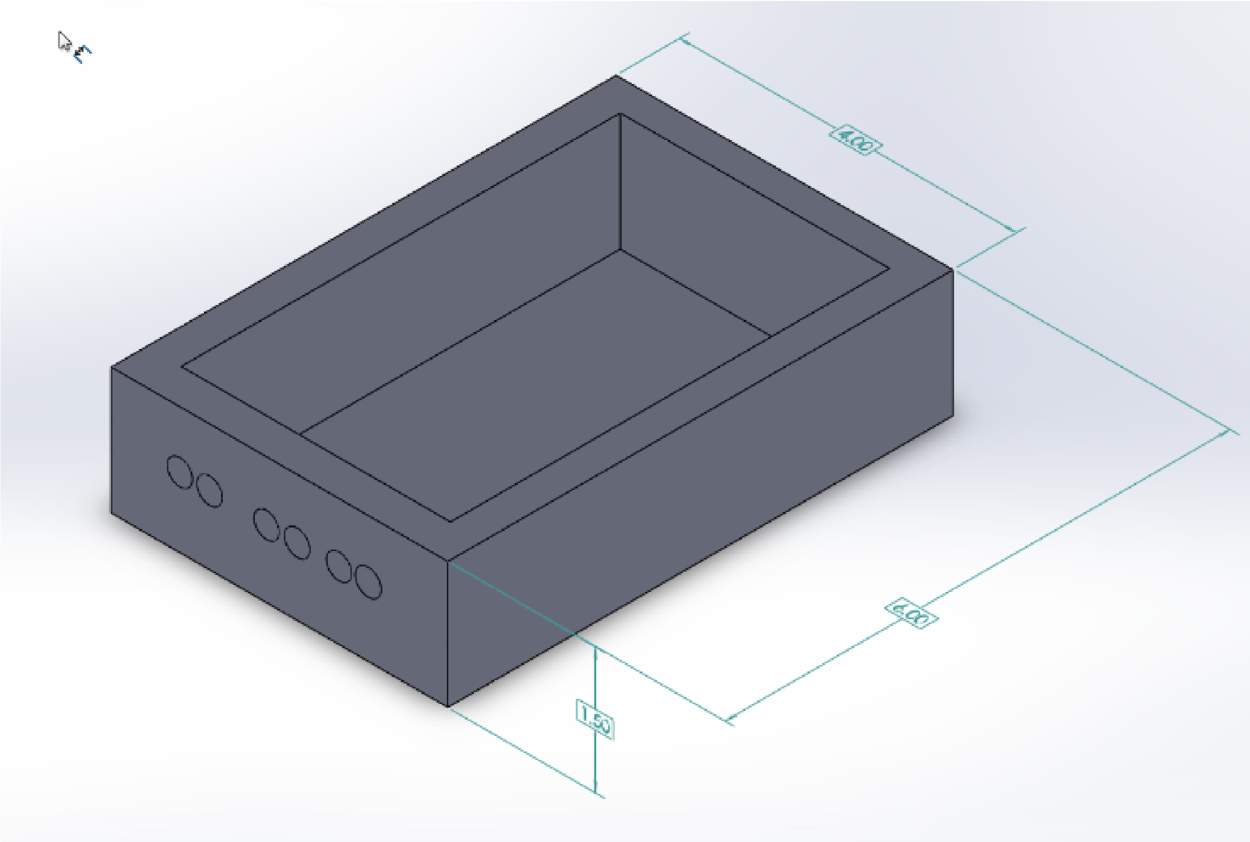
Present: N/A

Goals: Create a final 3d model for the remote control with dimensions

Content:

Since there needs to be some room for the wires to be under the toggle switch, the height of the bottom piece should be twice the pin length and the height of the toggle switch body, which is approximately 1.5 inches. I decided to make the remote control 6 by 4 inches to be held in a hand comfortably. The top cover also allows the square part of the toggle switch to be flush and allows the rest of the toggle switch (the exterior parts of the center square) to be glued to the top cover. The top cover also is now shown to be perfectly flush with the dimensions of the bottom piece.





Conclusions/action items:

Now that there is a coherent remote control 3d model, the next step is to slice it and figure out if it can be made by a 3d printer. If not, try to change pieces and dimensions of it to be compatible with a 3d printer.

Possible competing design

AARANYAK BHATTACHARYA - Oct 08, 2020, 12:14 PM CDT

Title: Anesthesia Infusion Pump

Date: 10/04/20

Content by: Aaranyak Bhattacharya

Present: N/A

Goals: Analyze a competing design for a syringe device

Content:

https://wilburnmedicalusa.com/syringe-pump/anesthesia-syringe-pump-4100-fda-approved/?gclid=Cj0KCQjw8fr7BRDSARIsAK0Qqr7jh3RAgFyl1mE2MZpWkZIuppnC-EArYmH3_OcD5Mvl7YpMPLEXyAoaAhUPEALw_wcB

Shown above is a design for a device that can deliver solutions mechanically using an attached syringe. Since there are no actual "Euthanasia devices" this device could still be used to understand how our device can function remotely. The device itself has many features and settings pertaining to variable syringe sizes and the force at which the plunger would be depressed. The device is battery operated and no external power is needed to supply it. The syringe itself is stabilized and held in place by clips and tight fitting attachments as shown, and the plunger itself is held stationary while the body is moved onto the plunger by mechanical means.

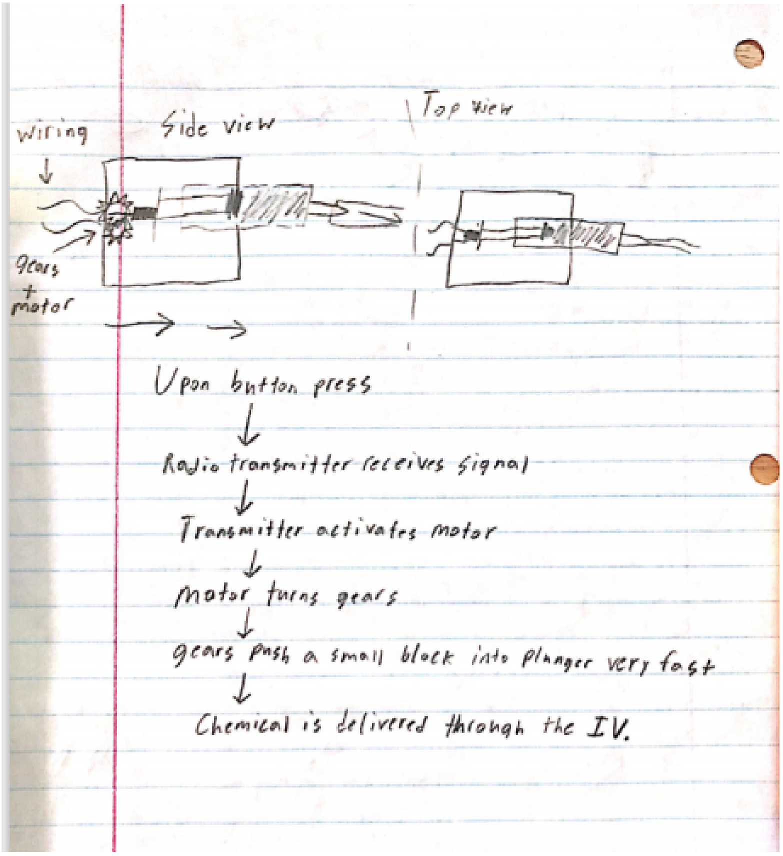
Additionally, the device can be programmed and changed to fit the user's needs, allowing for flexible usage in hospital settings from patient to patient. The device allows for multiple syringe attachments and variable forces to ensure that the solutions delivered by the device come out at a constant rate or at a rate determined by the user of the device.

Conclusions/action items:

This device's features and qualifications were very informative in providing a framework for what our device should look like and perform like. Our device would need to encapsulate the syringe and be able to depress the syringe while keeping the upper body of the syringe stable. It also factors into our considerations on whether we want to depress the plunger into the body of the syringe, or if we want the body to be pressed onto the plunger to deliver the euthanasia solution. Though a programmed and variable syringe size design is not needed for use in our client's chamber setting, it is still important to understand that these types of design choices are preferred in laboratory research and hospital settings.

Gear and block design

AARANYAK BHATTACHARYA - Oct 08, 2020, 11:20 AM CDT



My design suggestion incorporated gears and a motor that would push a block onto the plunger of the syringe. The motor would be connected to a controller (not shown) that would receive a radio signal from the researcher once the button was pressed. The advantages of this design are the relatively simple components that are not hard to order and efficient pushing of the plunger once the motor is started. There would be trouble however in securing the syringe body to the housing of the device, because slippage and the pushing of the plunger can cause the body of the syringe to be unstable, and could even be pushed out of the box it is housed in. These disadvantages would negatively affect the delivery of the euthanasia solution.

Red Permit

AARANYAK BHATTACHARYA - Oct 08, 2020, 11:04 AM CDT

For InterEGR 170 last year it was required to go through the training to receive a red permit to use the makerspace and teamlab spaces. I trained and received a red permit and laser 1 permits electronically.

You have the following permits and upgrades:

Name	Date
Red Permit	02/11/2020
Laser 1	02/18/2020

2020/9/16 - Pentobarbital

RILEY MEYER - Oct 07, 2020, 2:13 PM CDT

Title: 9-16-2020 Pentobarbital

Date: 9-16-2020

Content by: Riley Meyer

Present: N/A

Goals: Find out more information about the most common chemical for animal euthanization

Content:

Johnson, A. and Sadiq, N., 2020. *Pentobarbital*. [online] Ncbi.nlm.nih.gov. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK545288/> [Accessed 16 September 2020].

- Pentobarbital is the most common medication to administer for animal euthanization
- In smaller doses it is used as an anti seizure medication.
- It can be sometimes used as a coma inducing drug.
- Size of the animal being euthanized is a crucial part in how much they need to administer.
- Pentobarbital works as an incompressible fluid much like water.

Conclusions/action items:

This piece of research proves to be somewhat valuable as we move on with our project. Pentobarbital is the assumed chemical of choice of our client so knowing more about it gives us a better idea of how to incorporate it into our project. Most likely whoever will be using our design to administer the euthanasia will have already done the math on how much the animal will need to be euthanized, so we just need to accommodate for the largest amount needed. Given that Pentobarbital is incompressible, it should have similar properties to water when dealing with pressure. Lastly, with the information about the drug, we will know how it can be administered as well as how durable our device will need to be.

2020/09/10-Decompression Sickness and Sheep

RILEY MEYER - Sep 10, 2020, 9:10 PM CDT

Title: Decompression Sickness and Sheep

Date: 9/10/2020

Content by: Riley M.

Present: N/A

Goals: To better understand how decompression sickness affects sheep

Content:

Ball, R., Lehner, C. and Parker, E., 1999. *Predicting Risk Of Decompression Sickness In Humans From Outcomes In Sheep | Journal Of Applied Physiology*. [online] Journals.physiology.org. Available at: <https://journals.physiology.org/doi/full/10.1152/jappl.1999.86.6.1920> [Accessed 10 September 2020].

- Sheep have a very similar cardiovascular system compared to humans, so testing the cardiovascular systems of sheep can help determine what would happen to humans under the same circumstance.
- Decompression sickness is sometimes known as the "bends" where bubbles of air form in the blood vessels and cause immense pain in addition to other symptoms.
- Some symptoms of decompression sickness include:
    - Painful joints
    - Rash
    - Cardiopulmonary Collapse
    - Neurological Dysfunction
- The gas within the blood stream comes from the compressed air that is breathed in during a dive or in hyperbaric chamber.

Conclusions/action items:

This online journal gives insight on how an organism gets decompression sickness as well as how animal testing can help figure out problems in humans. The journal stated that sheep were used as test subjects to determine how humans would respond to decompression sickness because of how similarly their blood flowed compared to humans. With the information of decompression sickness and sheep anatomy, we will be able to make informed decisions on how to proceed with our project. Since the sheep will be in hyperbaric chambers, we have to find a way to inject the euthanasia fluid under high pressure with the sheep.

2020/09/28 - Syringes Under Pressure

RILEY MEYER - Sep 28, 2020, 11:26 AM CDT

Title: 2020/09/28 Syringes Under Pressure

Date: 09/28/2020

Content by: Riley Meyer

Present: N/A

Goals: Figure out how syringes will work under pressure in the hyperbaric chamber

Content:

Hopson, A. and Greenstein, A., 2007. Intravenous infusions in hyperbaric chambers: effect of compression on syringe function. *The Association of Anaesthetists of Great Britain and Ireland*, [online] p.602. Available at: <https://associationofanaesthetists-publications.onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2044.2007.05027.x> [Accessed 27 September 2020].

- Syringes will generally tend to not expel fluid under higher pressure because the gasses inside the syringe compress pulling the fluid into the syringe.

Conclusions/action items:

This new information will help us come up with some better methods for holding the syringes. Knowing that they will tend to pull liquid in, we need to make sure that the plunger only moves when we want it to to avoid complications with the sheep. In addition, we will also need to account for the increased resistance the mechanism will go through to push fluid out of the syringe. Overall, this research will help us create improved designs to better our product for the client.

2020/10/07- External Pressure and Flow Rate Correlation

RILEY MEYER - Oct 07, 2020, 2:29 PM CDT

Title: 2020/10/07 External Pressure and Flow rate correlation

Date: 10/7/2020

Content by: Riley Meyer

Present: N/A

Goals:

- Determine how pressure affects different size diameter tubing

Content:

Karnak, I., Büyükpamukçu, N. and Tanyel, F., 2001. *The Effects Of Flow Rate, Length And External Pressure Upon The Pressure Required For Fluid To Flow Through A Ureter*. [online] BJU International. Available at: <https://bjui-journals.onlinelibrary.wiley.com/doi/full/10.1046/j.1464-410X.2001.02304.x> [Accessed 7 October 2020].

- External pressure increases the flow rate required to preform the indicated operations.
- External pressure and flow rate are some what correlated with an r = .727 meaning that they are also some what related to each other

Conclusions/action items:

Given this new information, we should be able to do calculations to determine how fast the liquid will need to be expelled. The increased flow rate can be achieved by increasing the pressure and speed applied by the lead screw. Depending on whether or not the syringe will be completely full will change our calculations. Overall, this new information will allow us to improve our design and give the client some specifications in terms of statistics.

2020/09/08 - Competing Injection Methods

Title: Competing Injection Methods

Date: 09/08/2020

Content by: Riley M.

Present: N/A

Goals: To determine if there are other designs that serve a similar purpose as our design will.

Content:

Wyss, M., Scheurer, S., Aeschlimann, R. and Thalmann, C., 2016. *EP2026865B1 - Arrangement For Introducing A Liquid Into The Body Of A Patient - Google Patents*. [online] Patents.google

Wyss, M., Scheurer, S., Aeschlimann, R. and Thalmann, C., 2016. *Patent Image Of Insulin Injector*. [image] Available at: <https://patentimages.storage.googleapis.com/5f/b3/72/66e817ea

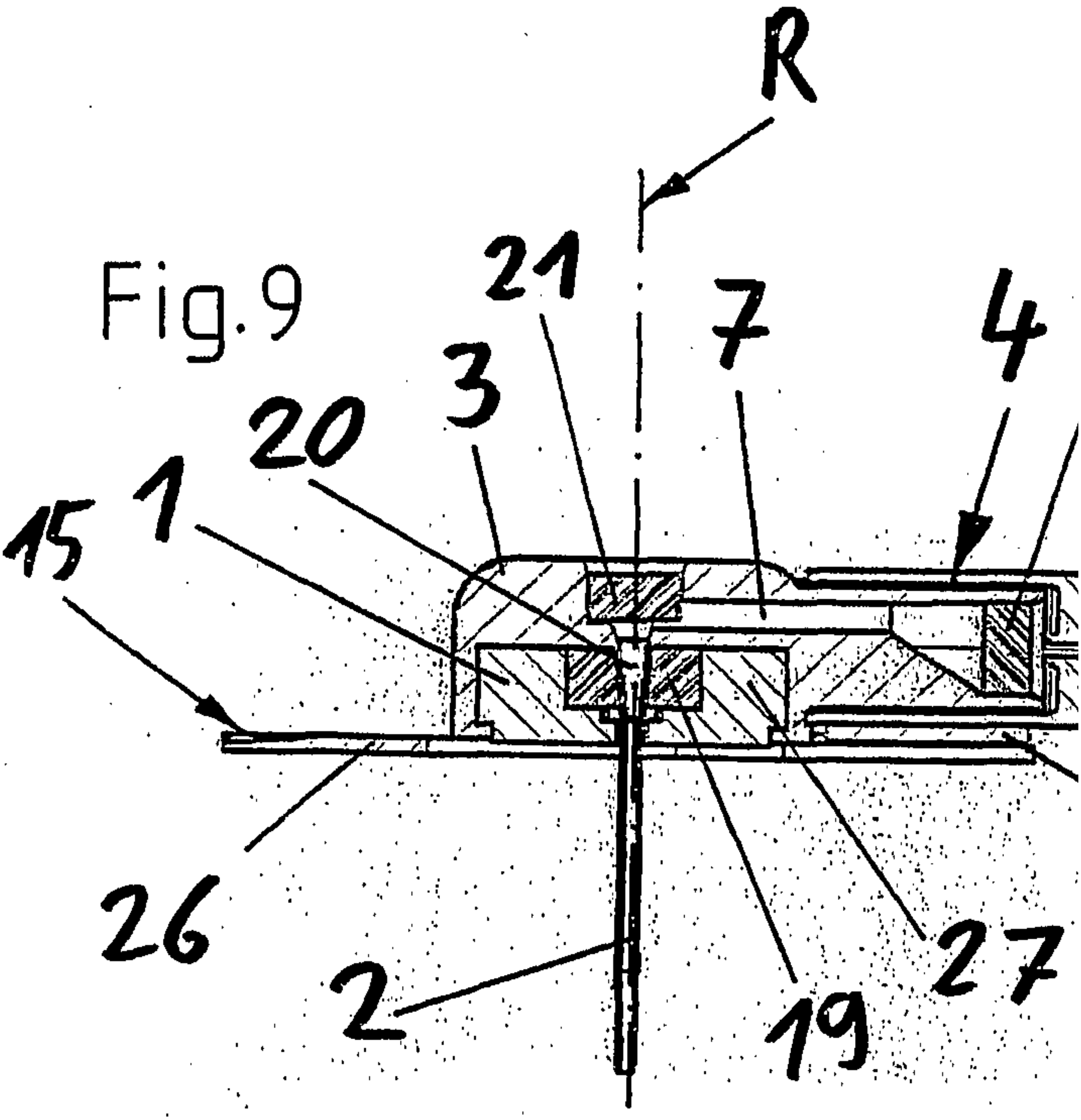
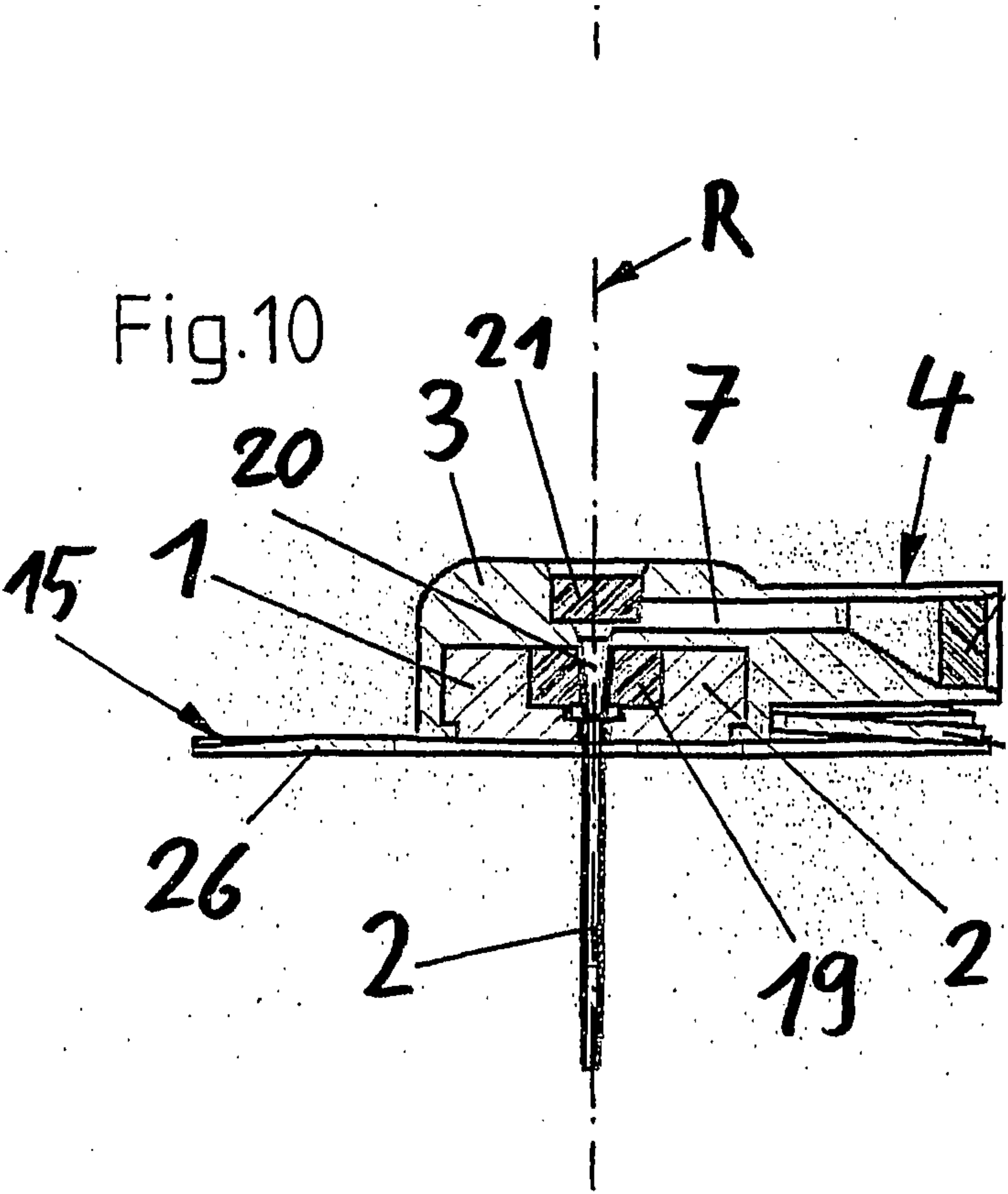
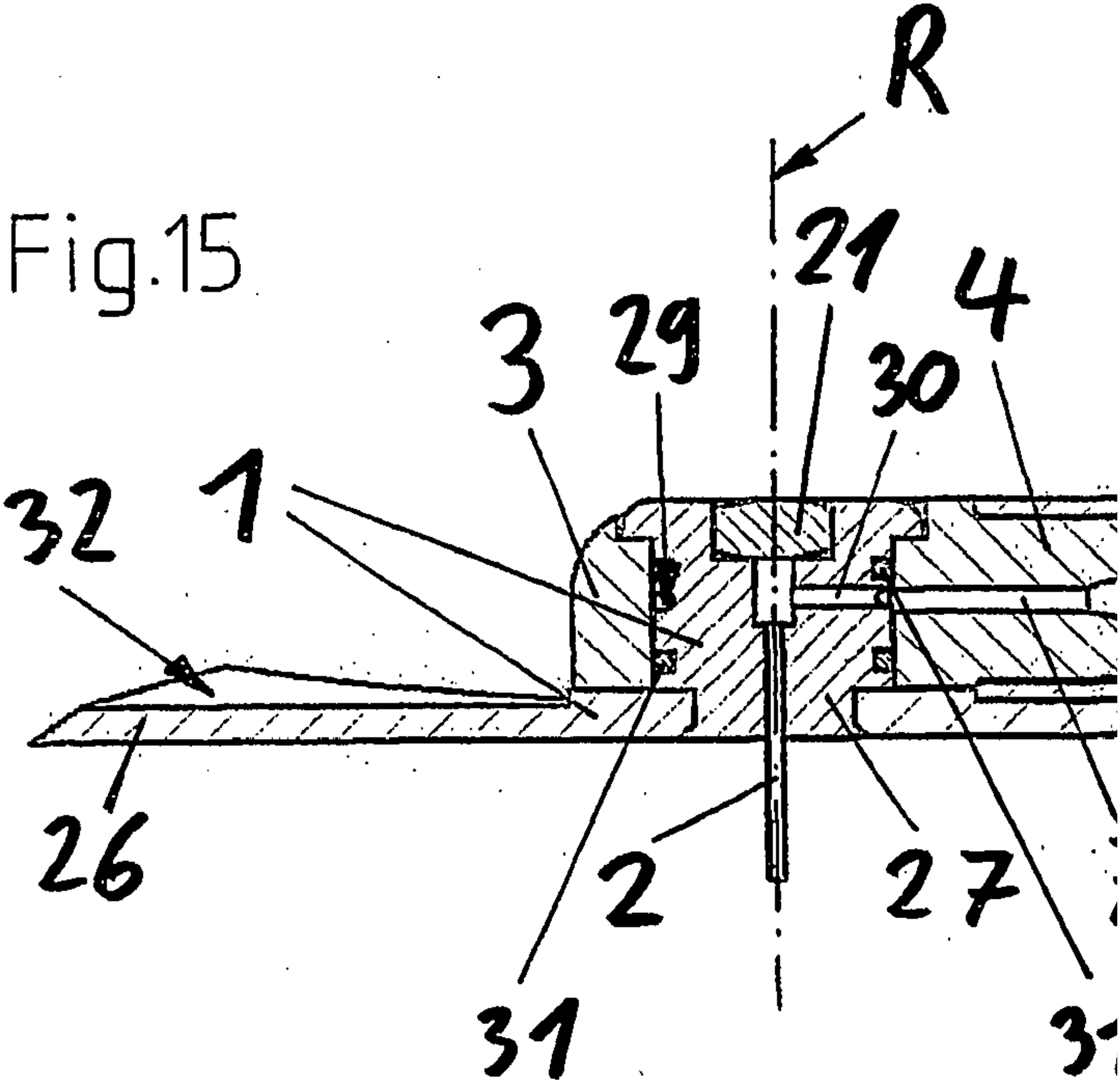


Fig.10





Conclusions/action items:

Google patents was able to provide me with a competing design to inject fluid into a patient. This patent comes from the European Patent office and the design uses a housing to hold two nee upon this idea. This patent acts as a stepping stone to finding out more about methods of injection in patients and being able to develop something of our own to work on live animals.

2020/10/07-Real World Implications

RILEY MEYER - Oct 07, 2020, 2:48 PM CDT

Title: 2020/10/07 Real World Implications

Date: 10/07/2020

Content by: Riley Meyer

Present: N/A

Goals:

- Determine if there could be both positive and negative implications from the project.

Content:

Romano, N., 2019. *The Danger Of Assisted Suicide Laws*. [online] The Danger of Assisted Suicide Laws. Available at: <http://blogs.tiu.edu/wp-content/uploads/2019/11/NCD_Assisted_Suicide_Report_508.pdf> [Accessed 7 October 2020].

- There are both positive and negative implications that can arise from this project.
- The implications extend through various aspects of society and other cultures.
- Laws can be put in place to prevent or allow assisted euthanization.

Conclusions/action items:

This project has the possibility of carrying some large societal implications around with it. There are many arguments already that are both for and against the use of euthanizing humans. On the positive side, our project can develop something that will help farmers and veterinarians with their careers, and the device might be able to be used to end a person's pain and suffering. This then goes toward the negative aspect in that ending someone or something's life prematurely could be considered inhumane. My first thought on this project was what the navy would do if given the opportunity to use this technology? A negative aspect of this could be that they use it to end another human's life without their consent in the terms of military tactics. They could also use it be humane to those in severe pain or for testing animals at the end of their lives. Overall, our design project has the possibility of creating both positive and negative implications that could affect the world and society itself.

2020/09/14-Attached Box Design

RILEY MEYER - Sep 14, 2020, 1:41 PM CDT

Title: Attached Box Design

Date: 09/14/2020

Content by: Riley Meyer

Present: N/A

Goals: To come up with a possible design for the Remote Euthanasia Project

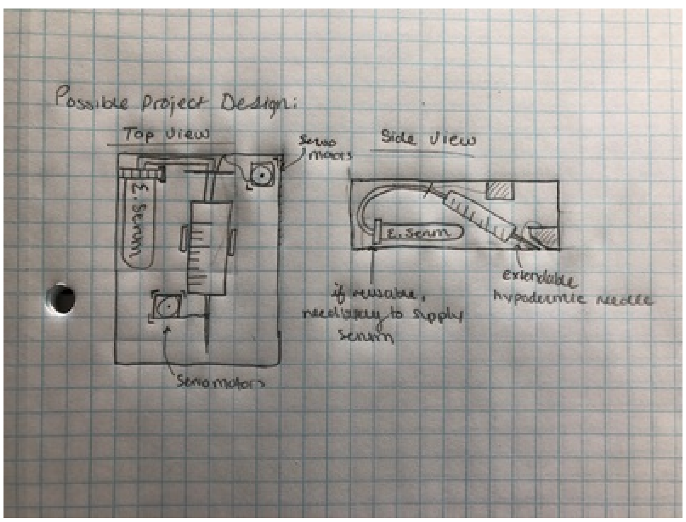
Content:

- My possible design would be a box that is attached to the sheep
- Inside the box are the necessary implements to be able to euthanize the sheep(needle, serum, etc.)
- In addition to the necessary tools, I thought we could use an extending needle activated by servos to put the needle in the sheep.

Conclusions/action items:

This would be a compact design that could attach to the sheep without having to put the needle in throughout the duration of the experiment. My design could also be reusable given that it can eb sterilized in between because it allows the user to add more serum. Lastly, This design would only work if we know exactly where the sheep's vein is otherwise, the serum will not work. While the design may not be feasible, I believe that it could provide us with some possible additions to other designs.

RILEY MEYER - Sep 14, 2020, 1:30 PM CDT



Attached_Box.jpg(411.9 KB) - download

2020/09/23- Dual needle design

RILEY MEYER - Sep 23, 2020, 2:01 PM CDT

Title: 2020/09/23 Dual Needle Design

Date: 09/23/2020

Content by: Riley Meyer

Present: N/A

Goals: To create a design that conforms to the needs of the client.

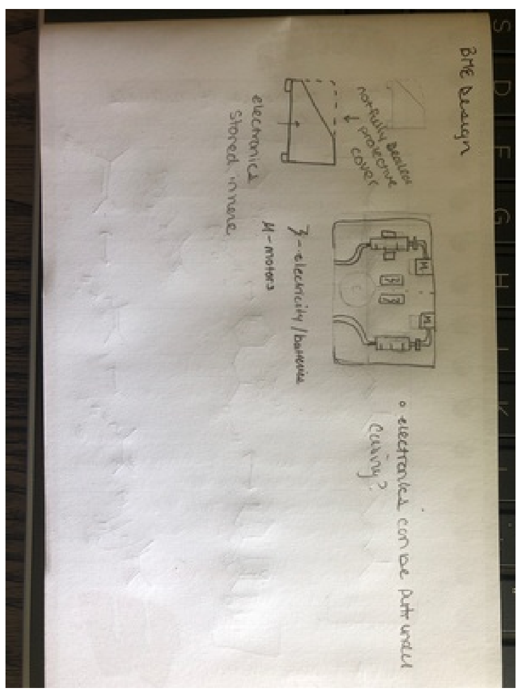
Content:

See attached picture.

Conclusions/action items:

This is a possible design for the design matrix that would work for both sheep in the chamber. Instead of making two different devices with separate remotes, we can simply it down to one device with one remote. The dotted line down the middle is to show that the device should be the same on both sides in terms of components and hardware. This box would sit on top of the chamber(where the sheep have their heads inside) inside the hyperbaric chamber and connect directly into the pre-existing medical IV, and when the researchers need to put down an animal they press the corresponding button on the remote and the task is complete..

RILEY MEYER - Sep 23, 2020, 1:56 PM CDT



Dual_Needle_Drawing.jpg(569 KB) - download

2020/10/14- Structural Design

RILEY MEYER - Oct 14, 2020, 6:30 PM CDT

Title: 2020/10/14 Structural Design

Date: 10/14/2020

Content by: Riley Meyer

Present: N/A

Goals:

- Draw/come up with a design to work with Noah on

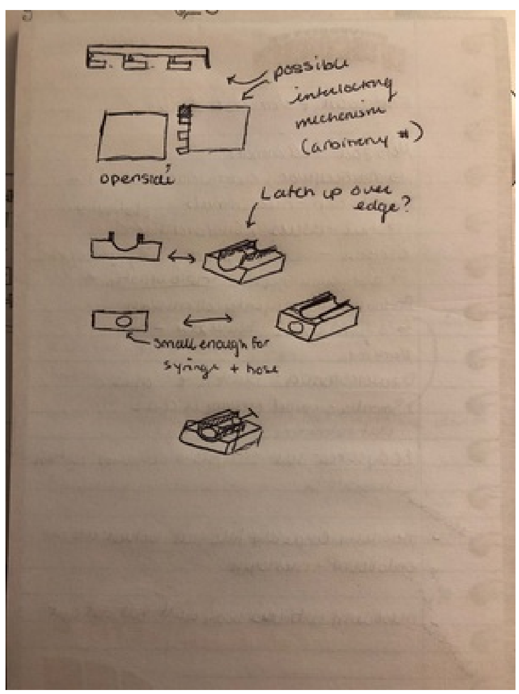
Content:

See attached Picture.

Conclusions/action items:

This design is something that I came up with to bring to my meeting with Noah. It features a way that we can interlock the different pieces together which Noah wanted to go over. It provides a slot for the syringe to sit in and a plate at the front like in Noah's design. In addition, it has walls along the divot and a latch of some kind on top to secure the needle from the sides and above. The design will be discussed at a later meeting with Noah and a revised one will come along after the meeting.

RILEY MEYER - Oct 14, 2020, 6:28 PM CDT



815BAAD8-775E-4022-9457-C3DF57FBBCB0.jpg(448.3 KB) - download

2020/11/02 - Back Half Structure

RILEY MEYER - Nov 02, 2020, 2:44 PM CST

Title: 2020/11/02 Back Half Structure

Date: 11/02/2020

Content by: Riley

Present: N/A

Goals:

- Write up a possible design for the back half of the structural component for Noah

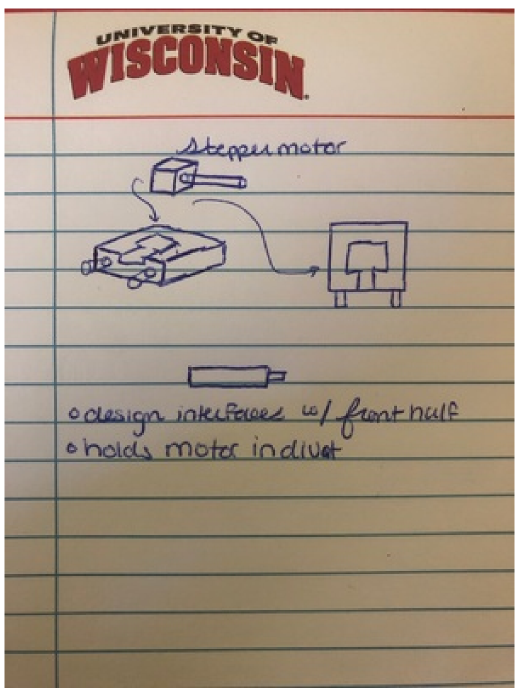
Content:

See picture attached.

Conclusions/action items:

This design will help Noah and I decide how we plan to proceed with the back half of the structural design. This design allows the motor to sit inside the component and then interface with the syringe and front half of the structural component. This should provide us with the basis to finish up the structural aspects of the design very soon.

RILEY MEYER - Nov 02, 2020, 2:45 PM CST



A9946F05-11B7-4CFD-9EB7-BBCE784B2663.jpg(471.3 KB) - download

2020/11/11 - Adhesive

Title: 2020/11/11 Adhesive

Date: 11/11/2020

Content by: Riley Meyer

Present: N/A

Goals:

- Research different types of adhesives/ways to secure the housing

Content:

Double Sided Suction Cups:

Link: https://www.amazon.com/NUOLUX-Double-Suction-Sucker-Plastic/dp/B00ZWSPYXS/ref=sr_1_7?dchild=1&keywords=double+sided+suction+cups&qid=1605124119&sr=8-7

The double sided suction cups would provide us with a way to secure the housing to the glass. However, I am uncertain whether or not the suction cups will be flush to the glass, so it is possib

Double Sided Tape:

Link: https://www.amazon.com/Nano-Double-Sided-Tape-Multipurpose/dp/B07VNSXY31/ref=sr_1_1_sspa?dchild=1&keywords=Heavy%2BDuty%2BDouble%2BSided%2BTape&qid=160512
spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzVVNKQVdNNEdENlM3JmVuY3J5cHRlZElkPUEwOTcyNzA1OUEzM0VVS0oxT1pGJmVuY3J5cHRlZEFkSWQ9QTA5OTA0NzNOQUhTQ0

Double sided tape would provide an alternative to the double sided suction cups in securing the housing. The tape would allow the housing to lay virtually flat on the glass, but depending on th

Conclusions/action items:

I will present these two methods of securing the housing at the meeting. At the current moment, I believe that the doubled sided tape will be our best chance at having the housing be level and but there may be better versions of them that we could use.

2020/11/15 - Double Sided Mounting Tape

RILEY MEYER - Nov 15, 2020, 12:30 PM CST

Title: 2020/11/15 Double Sided Mounting Tape

Date: 11/15/2020

Content by: Riley M.

Present: N/A

Goals:

- Choose/look into double sided tapes suggestions

Content:

https://www.amazon.com/dp/B082TQ3KB5/ref=cm_sw_r_cp_api_fabc_4xSRFbABCAVGR?_encoding=UTF8&psc=1

This is tape that Noah suggested we use when it comes time to secure the housing. He used it on his 3-D printer and he said that it would be removable and leave no residue behind.

Conclusions/action items:

The tape that can be purchased at the link above is what will most likely be used to secure the housing. We will be doing tests with the tape using Noah's existing roll, but if we end up using the tape, we will purchase it from the link above.

2020/10/27- Structural Dimensions

RILEY MEYER - Oct 27, 2020, 3:18 PM CDT

Title: 2020/10/27 Structural Design Dimensions

Date: 10/27/2020

Content by: Riley Meyer

Present: N/A

Goals:

- Layout the dimensions of the front half of the structural design

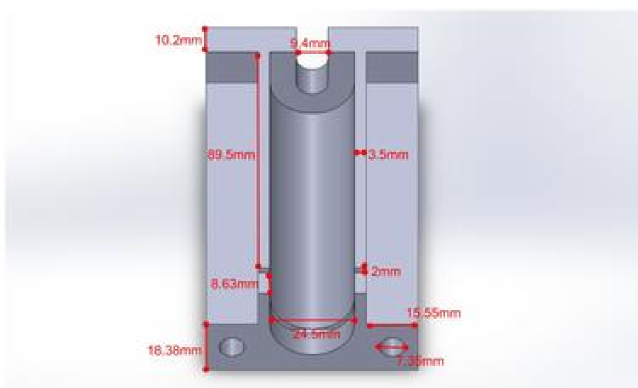
Content:

See image attached.

Conclusions/action items:

This is what I have been working on for the past 2 weeks or so. This is the first half of the structural component for our project. The second half will be coming soon once we are able to define all the dimensions of the motor and electronics!

RILEY MEYER - Oct 27, 2020, 3:14 PM CDT



Syringe_Housing_Drawing.jpg(32.4 KB) - download The picture above is the front half of our structural design with dimensions.

2020/12/08-Final Structural Design

RILEY MEYER - Dec 08, 2020, 2:41 PM CST

Title: 2020/12/08 Final Structural Design

Date: 12/08/2020

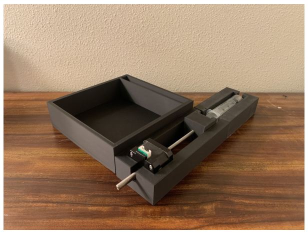
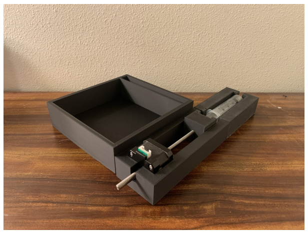
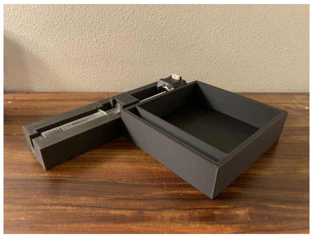
Content by: Riley Meyer

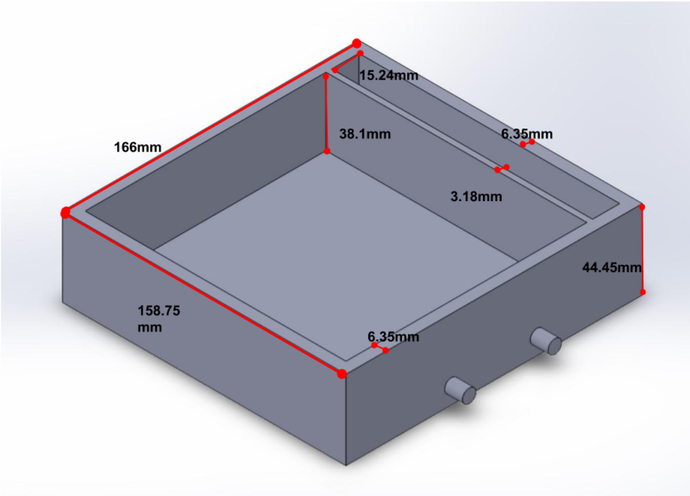
Present: N/A

Goals:

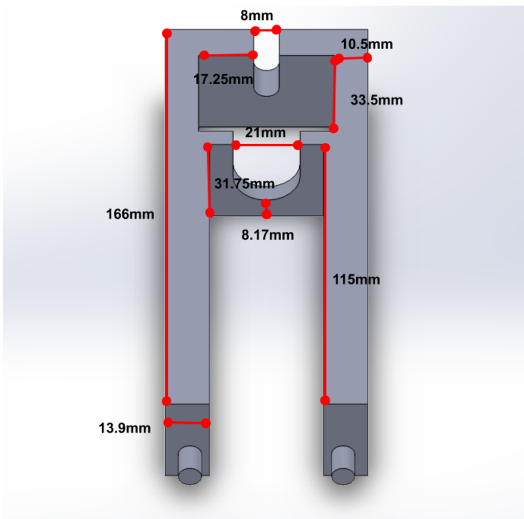
- Depict the final structural design

Content:

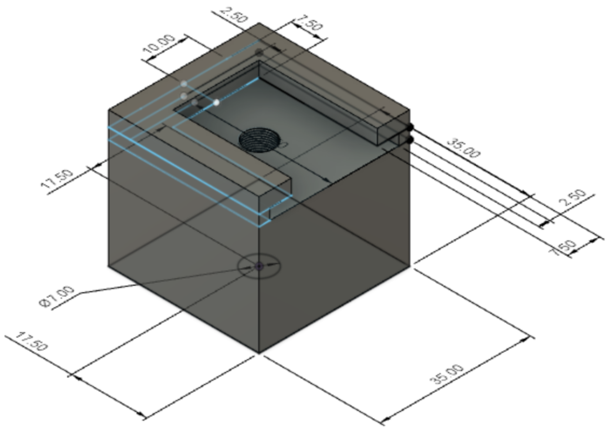





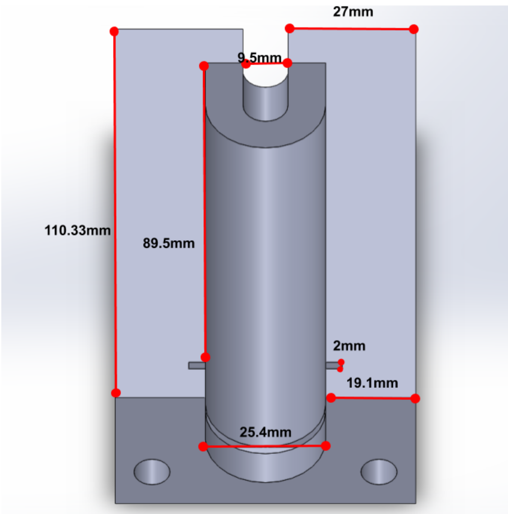


15.24mm
166mm
38.1mm
6.35mm
3.18mm
44.45mm
158.75
mm
6.35mm



8mm
10.5mm
17.25mm
33.5mm
21mm
31.75mm
166mm
8.17mm
115mm
13.9mm





Conclusions/action items:

This is the final structural design. From left to right they are as follows: electronic base, motor holder, holding cap, and the syringe housing. The electronics base is used to hold all electronics required to run the device. The motor holder holds the stepper motor and keeps the lead screw parallel to ensure even forces. The holding cap is fixed on the lead screw and holds the plunger of the syringe which can then compress the syringe using the motor. Lastly, the syringe housing holds the syringe that the client has filled with euthanasia fluid.

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.

2014/11/03-Template

John Puccinelli - Nov 03, 2014, 3:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: