Paradigm Hyperloop - ECE Design Challenge

Section 1 - Research Question

Choose amongst your group to answer **one** of the below research questions. Write up a formal document or presentation detailing your solution.

A battery pack for the propulsion system

Electric Motors require a high amount of energy almost instantaneously. DC Motors can range between 90 and 200 Volts where AC Motors can require upwards of 300 Volts. Each can draw 10s of Amps instantaneously depending on the desired acceleration.

Your challenge is to design a battery pack that can reach the higher bounds of these motors (300 Volts, ~20 Amps). There are many things to consider! Some might include:

- Do Lead Acid batteries make sense? What about Lithium Ion? What other technologies are out there?
- How do you design the pack to be safe? How can I make sure that I don't shock, even kill myself if I accidentally short the battery.
- How do I keep track of the life of the batteries? Is there a way for me to know how charged they are or how much longer they can last?
- What tradeoffs are there between battery life and instantaneous supply?

The electronics necessary for a life-supporting cabin

Imagine, you leave Boston on your trusted Paradigm Hyperloop Pod at 1:30PM expecting to arrive in DC by 2 PM. 10 minutes into your trip, the red light starts flashing and something is going wrong, There's a hole in your pod! What do you do? What can be done? What do you wish those crazy college students did in order to make sure you're safe?

Hollywood aside, how would you design the life support system for the cabin of a Hyperloop pod. Some considerations might include:

- How do you make systems fault tolerant? If something does go wrong with a board/ a program. How do you ensure that it won't cause people to suffocate/overheat in a enclosed fast moving tomb.
- How do you detect when things are going wrong? What kind of sensors would you use? What things would you monitor
- How would you design your electronics to respond to a failure?
- What lower order things are there to consider? (i.e Air conditioning, Lights, etc.)

A communication system for full-speed Hyperloop pods

With a Hyperloop pod traveling at hundreds of miles/hour it's important of information for the Hyperloop pods to communicate: possibly with each other, probably with something central. What if a pod breaks down further on the track and your pod needs to break?

Your challenge is to design a communication system for a Hyperloop pod so that it can communicate back and forth with some system. Some considerations might include:

- How do cars/planes/trains communicate with other systems? Would something that they do make sense for a Hyperloop Pod?
- How do you ensure that data gets to where it's going? What kind of data do you expect to send?
- What technology would you use? Wifi? Cellular? Carrier Pigeons with notes attached to their legs? Why did you make the choice you made? What were the tradeoffs you considered?
- What kind of protocols would you use to communicate?

A method of transferring power from the Hypertube to a pod

Most modern day train based methods of transit have some sort of third rail or raised power line as a way to transfer power from the ground to the moving vehicle. What if we didn't have to worry about batteries on a our Hyperloop pod because we had one **really** long chain of extension cords that would unroll as the pod traveled to its destination and then once there, some poor sap would have to re-roll the cord back up for the next trip?

What would you design to transfer power from the ground to our pod? Some considerations might include:

- You're crazy this doesn't make any sense batteries are clearly the right answer.. Here's why!
- What kind of mechanism would be needed to transfer the power? A third rail? A raised powerline? A dedicated Pikachu per pod? Why?
- What is the efficiency of this system? Is there significant power loss?
- What makes this system safe? How do you prevent someone from accidentally touching something deadly?

Precisely measuring position (or distance) of a pod in the Hypertube

What do you mean we took a wrong turn at Albuquerque? We were supposed to go 100 miles then hang a straight? What do you mean we actually went 300 miles and managed and ran into the end of the tube because we *clearly* knew where we were? Apparently having an accurate measurement of where we are in the tube is an important thing to keep track of!

Your challenge is to find or design a way to accurately determine where a pod is in the tube (or alternatively measure how far you've traveled in the tube, both are valid). Your system can include tools/sensors/systems both on the pod and in the tube. Some considerations could include:

- What technologies are used today to measure position? Would a GPS work? Would an IMU work? What even is an IMU? Could any of these work for us?
- How do you account for error or uncertainty in your measurements?
- How can you make this system redundant? What happens if one sensor fails?
- Would you implement things just on the pod? Just in the tube? Both? Why?

A Linear Induction Motor (LIM) system to propel a pod

What even is a linear induction motor? Maglev trains use them and Maglev trains are cool! Right? We should really use one to push our pod forward!

Your challenge is to find/design a LIM system to propel the pod forward! Some considerations might include:

- How much power does this system require? Does it get us farther for less energy? Is the coolness of magnets worth it?
- How do Linear Induction Motors even work? "Magnets" isn't a good enough answer.
- Are LIM systems subject to intense heat? If so what might you do to alleviate it?
- What kind of materials would we need to use in order to propel us forward in the tube? Are these materials expensive? Are these materials heavy?
- How do we go about controlling a LIM? Can you just flip a switch and go?
- Do we need to put larger batteries on the pod? Doe the ground handle all the extra power requirements?
- What kind of infrastructure would we need in place to make this happen?

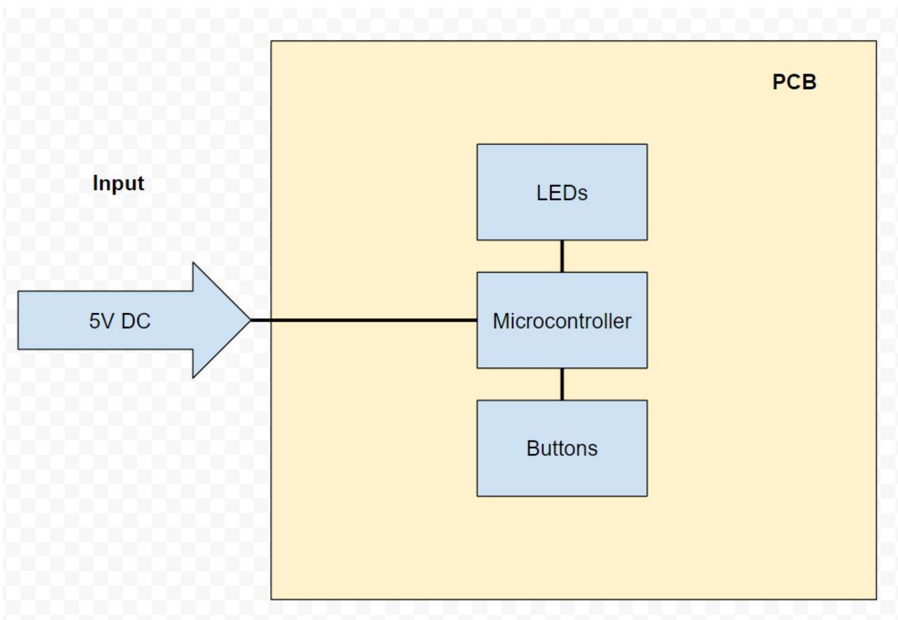
Section 2 - PCB Deliverable

Depending on your group level, design a PCB in KiCAD with the requirements outlined below and submit your files to GitHub. Write up an explanation of how your code would work or provide some sample code for your microcontroller. Also include any necessary datasheets for important ICs (Do not need for resistors, LEDs, buttons, etc) Feel free to go up a level if you feel your group is capable as well as add any extra components that you think will better your solution or display your talents.

GitHub Link: https://github.com/ncwarren/canada-ece-recruits

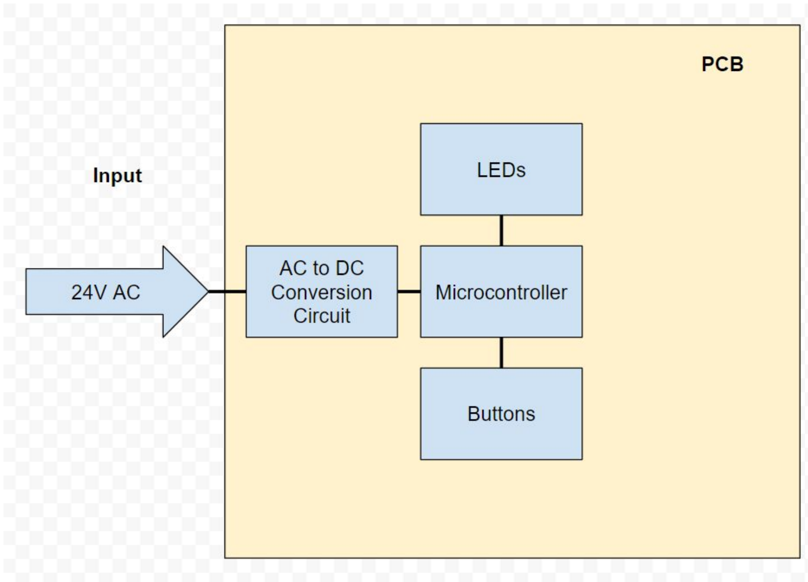
ENGI One Level

- Design a PCB with a microcontroller that controls LEDs through inputs taken from push buttons. The PCB may be powered from a DC voltage source.



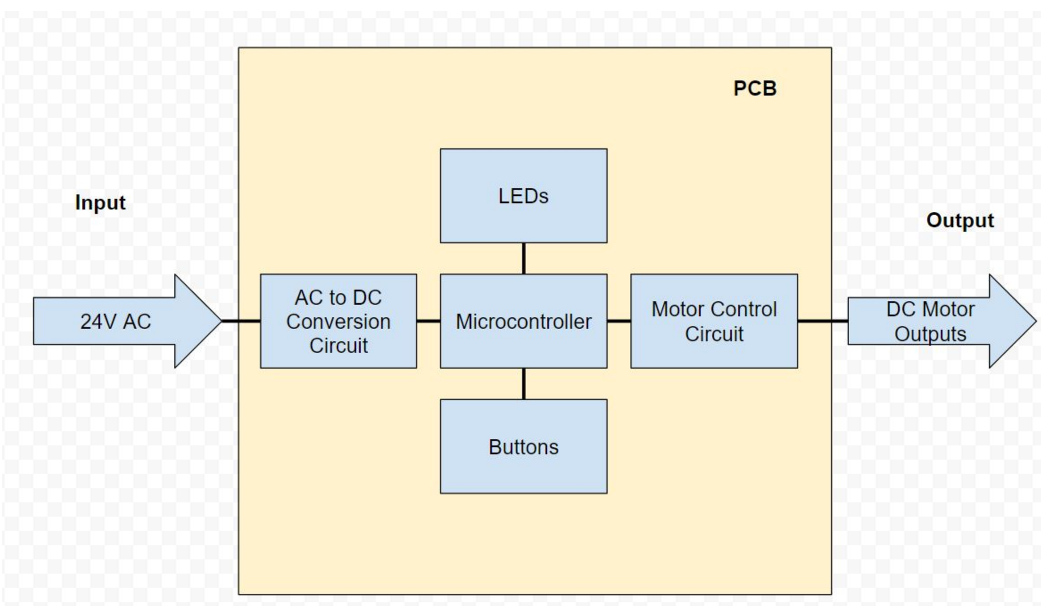
Term 3 Level

- Design a PCB with a microcontroller that controls LEDs through inputs taken from push buttons. The PCB **MUST** be powered from a **24V AC** voltage source.



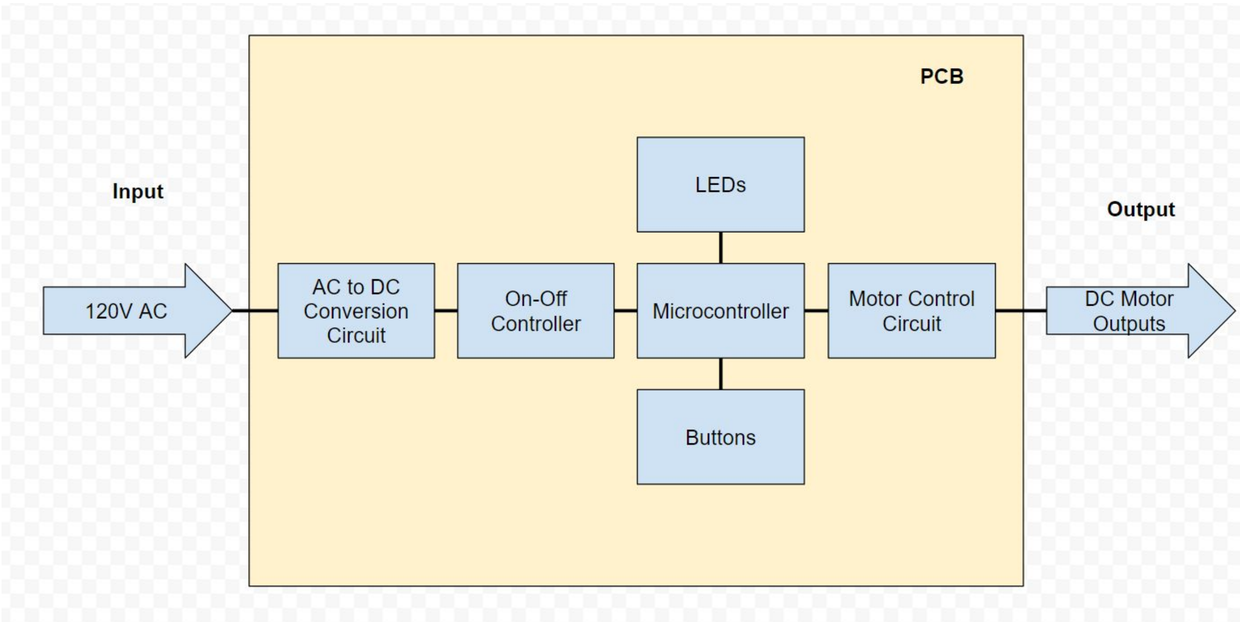
Senior Level

- Design a PCB with a microcontroller that controls a small DC Motor (5V, current < 300mA). Buttons should be used to change the state of the motor and LEDs should be used to indicate which state the motor is currently in. The PCB **MUST** be powered from an **24V AC** voltage source.



Advanced Level

- Additions/Changes to the senior level PCB:
  - Design a ON-OFF Controller Circuit for the DC Power.
  - The PCB to be powered from a **120V AC** source (line).
  - 5V DC Motor Changed to 9V DC



Section 3 - Matlab Deliverable

Using the battery discharge data provided in the attached Matlab file determine the operating time of your system assuming this battery is used as a power supply with the DC/DC converter of your choice (a boost converter for example).

Assume that the only non ideal effect of the battery is the discharge data provided. You may assume as many components are ideal as you wish, however the purpose of this challenge is to try to model the effects of as many non ideal components as possible.

```
%Given the following battery discharge curve and standard resistance values
%How long will your design operate for off of the given battery?

proto_vBatt = 4.2*exp(-linspace(0,0.1,1600));
proto_vBatt1 = 3.8*exp(-0.25*(linspace(0,3,400)));
vBatt = [proto_vBatt, proto_vBatt1];
figure(1)
plot(vBatt)
title('Voltage Vs Storage Capacity')
xlabel('mAhr')
ylabel('Voltage (V)')

%Solution: generate an energy consumption model of your system, account for
%your voltage regulation (via boost/buck boost converter). Then determine
%how long it will take for enough energy to be drained from the battery
%that its voltage is so low it is no longer usable to the DC/DC converter
```