Question 1 : What progress have you made toward your final project since last report? What are your next steps? How are you partitioning the work?

We created Simulink model of our control system and are in the process of testing each component and building the assembly.

Our next steps include:

- Be able to get reasonable feedback from the ultrasonic sensor
- Be able to control two DC motors to move forward/backward at a fixed speed
- Purchase additional components if necessary
- Be able to control two DC motors to turn at same speed but in reverse direction to allow for a 90-degree turn
- Be able to implement a PID controller to allow for deceleration of the two DC motors and distance control
- Finalize CAD model and prepare simulation results for sensors, actuators, and the control system

Since both of our members are still living on campus, we are working on the project together while meeting up. Besides that, currently one member is focusing on interfacing with the DC motors, and one member is focusing on interfacing with the ultrasonic sensor.

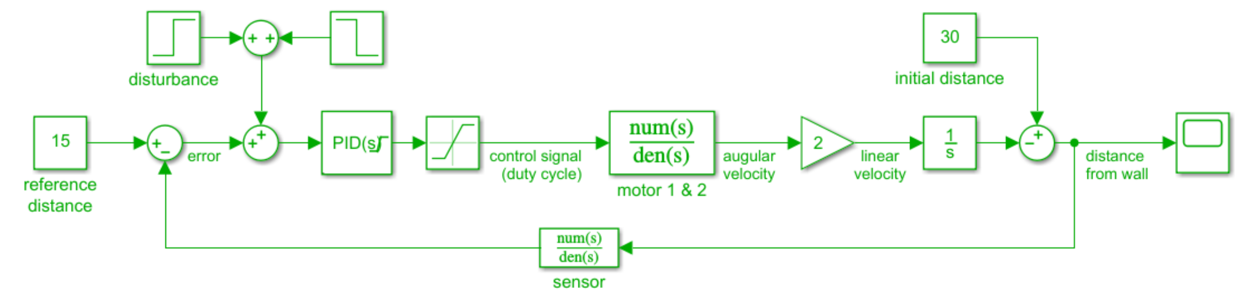
Question 2: Have your milestones or plans changed? Do you have any concerns?

Our milestones have not changed, some of the concerns are:

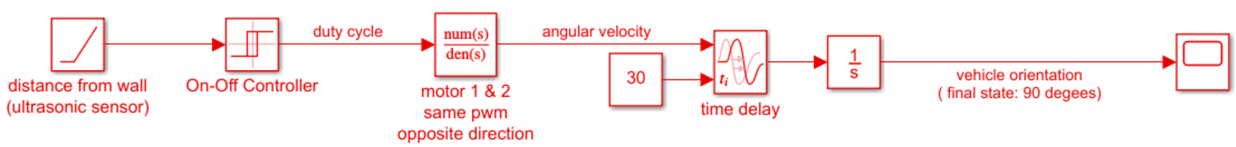
- There is a chance that our selected motors fail to generate enough torque to drive the entire vehicle. The motor appears to be 'weak' during testing, and with the added battery packs and breadboard, the vehicle weight is heavier than expected.
- There is a chance that the two DC motors turn at different speeds even with same supply voltage and PWM value. If this problem cannot be solved by setting a fixed ratio between the two input PWM values, optical encoders are needed to track the motor speed, and then a PID controller can be implemented to control the two wheels to move at the same speed.
- Still, acquiring new parts during this time is much slower due to the COVID-19 outbreak, so any damaged or missing components might significantly delay our progress.

<u>Question 3: All systems are required to have some sort of PID (or at least P) control. Draw a block diagram illustrating the closed-loop model for your mechatronics system, with inputs and outputs (sensors and actuators) labeled. Explain why you will or will not use Integral and Derivative control for your system.</u>

Using a PID controller,
0. If the wall is far away, the vehicle will go straight at constant speed
1. If the vehicle is approaching a wall, it will decelerate and eventually stop at the set distance (safety limit)



2. Once the vehicle stops, disable distance reading & PID controller, turn vehicle at 90 degrees (CW)



Proportional control is used to maintain the vehicle at a set distance from the wall. if the wall is far away, the vehicle will go straight at constant speed. If the vehicle is approaching a wall, it will decelerate and eventually stop at a set distance.
Though a PID controller would work slightly better for the scheme, since it can possibly allow for faster system response and eliminate steady state error, it is decided that a P controller is good enough for our application.
Since our goal is to ensure that the vehicle do not bump into the wall, as long as the vehicle is at a safe distance away from the wall, precise position control (e.g. eliminate steady state error) is not needed. The undesirable small oscillations could be reduced by turning off the motor once the error is smaller than a certain threshold.

<u>Question 4: During the expo, we will perturb your system to test the robustness of your controller. What perturbations are you sensing, and are you testing your system to ensure it can handle them? (Don't forget to test your system in more than just the optimal scenario!)</u>
While the system is under operation, distance perturbations are expected and will be corrected after being fed back to the control loop.
The system will be tested by pushing the vehicle forward randomly on its way approaching the wall. The control scheme should compensate for the disturbance sensed. This process might involve some trial and error.

Question 5: What practical considerations (e.g. actuator or sensor saturation) will you make as you develop your system controller?

Since the ultrasonic sensor has a specified range of 10 – 400 cm, the safety limit distance is set to be higher than this value. Also, it limits the system to be functional only if it starts at a distance within the range,

Since the DC motors can only deliver certain amount of torque, it is important to keep the mechanical system relatively lightweight.

One thing that we did not take into consideration is that, due to imperfections in the mechanical (e.g. friction) and electrical system, two identical DC motors might drive the wheels at different speeds, even with same supply voltage and duty cycle. This will forbid the vehicle from moving in a straight line.

If this problem cannot be easily fixed by adjusting the mechanical system / PWM ratio between two wheels, two encoders will be added to the system. Once we have angular velocity feedback from the encoders, a PID controller can be implemented to ensure that the two wheels are turning at almost the same speed. One wheel can be the master, and one wheel can be programmed to turn at the same speed as the master.