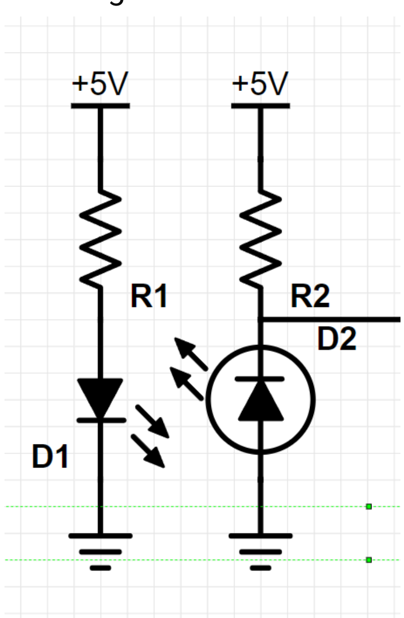
CECS 311-Final Project
Line Following Robot
Anthony Keroles
Tylor Franca

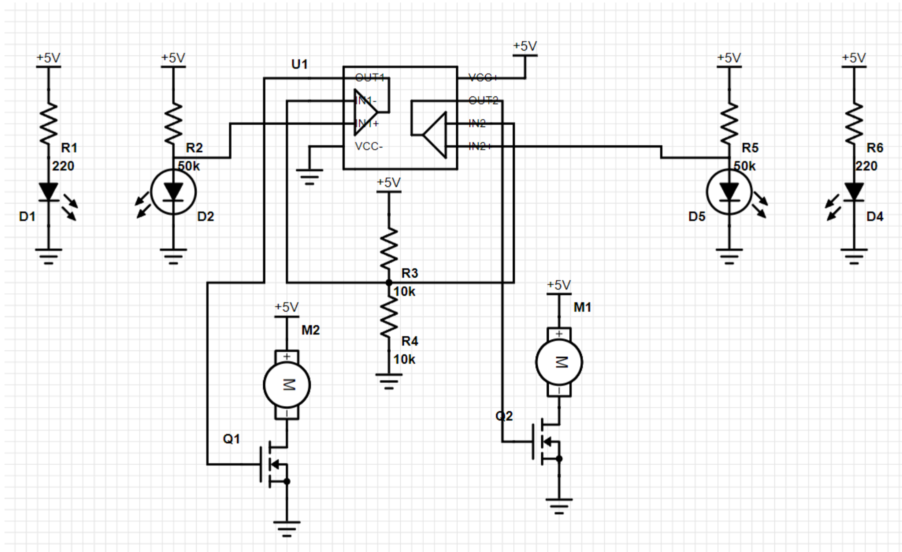
This project focused on using many of the components we learned about this semester to build a line following robot. The goal is to build a robot which will navigate a path, made of black tape on white poster board without using the aid of any programmable devices such as FPGAs or microcontrollers. This project requires learning and understanding of the core concepts of analog circuitry and components. These include the led IR emitter and receiver, OP amplifier comparator, transistors or mosfets and their use as switches, Dc motors, and adjusting the resistance values to adjust these components and the voltage/current we want them to output or have run through them.

The way we approached this problem was to first figure out how to use the infrared emitter and receiver diodes. Through the use of both diodes we are able to create a measurable voltage difference when the infrared light is reflected back to the sensor off of a white paper or not detected when it meets black tape. The way we do this in the circuit is by powering the infrared emitter like a normal led with a current limiting resistor and next to it having a circuit with a larger resistance and the receiver reverse biased going to ground. That will look like this with the D1 being the emitter and D2 being the receiver diode.

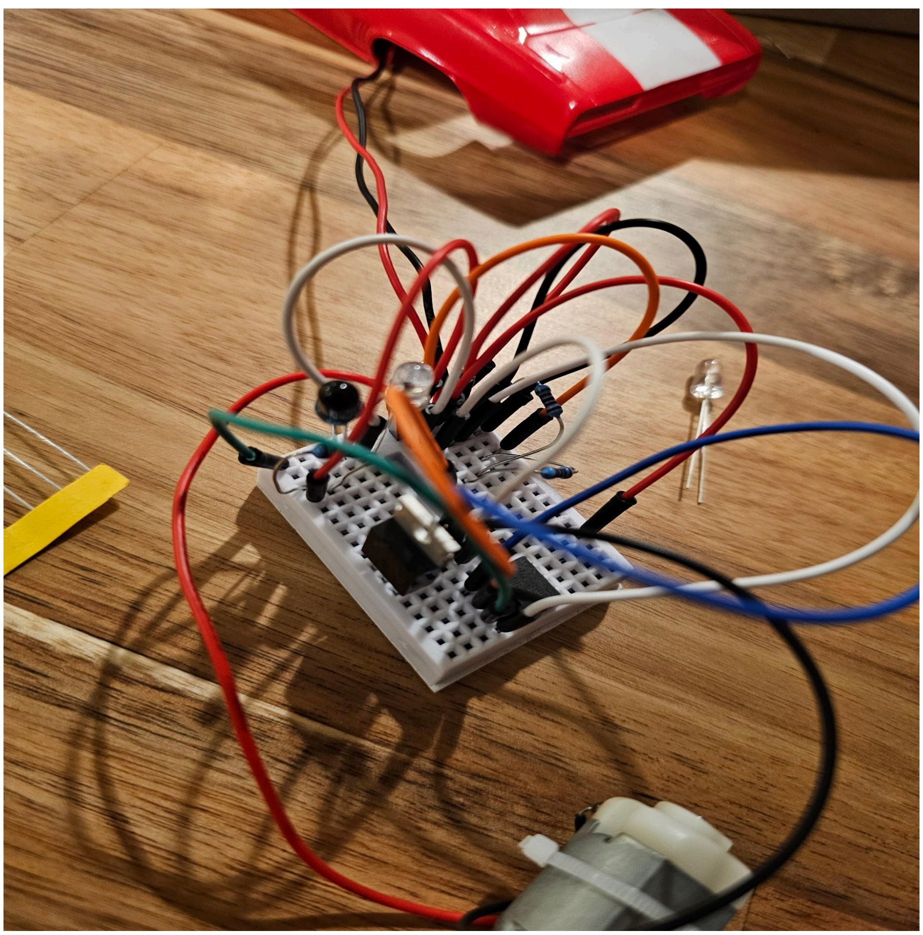


Taking an output between the resistor and the receiver diode will give us a voltage that is high when there is no infrared light reaching the receiver and low when there is light reaching it. Now the example given in class showed a 1k ohm resistor for the emitter and 10k ohm resistor for the receiver. With this setup we only had about a 0.5 volt difference between a white paper and black tape when measuring between the receiver diode and the resistor. So we increased the current of the emitter diode by using a 220 ohm resistor and were able to get a voltage drop from about 5.5v while under black tape to 0.5v under white paper. Now we had an IR sensor capable of outputting different voltages but to drive the motor we needed a way to tell the difference the range of voltages so the motors did not move while over white paper. To do this we used the LM358 which is an OP amp comparator which takes 2 voltages and depending on which one is higher outputs either a high or low signal with a voltage based on the rail voltage. So we connected the output of the IR sensor to the first Vin of the comparator. However we needed a reference voltage. We decided to use a voltage divider to use as the reference voltage. Given that we had a large difference between the white and black voltages, we decided to make the reference voltage right in between them at 2.5-3v depending on how charged the battery was. We did this by taking 2 10k ohm resistors and putting them in series from power to ground. The voltage between them is half of the voltage dropped across the whole circuit giving us the input voltage divided by 2. After connecting the voltage divider to the reference voltage on the comparator (Vref). After connecting the VCC + and the ground rails we were able to measure either ~5v or 0v signal out of the comparator based on whether the sensor was on white or black. This confused us because our understanding was that the high voltage would be the same as the input VCC+. We looked into our comparator the LM358 and found that the rail does drop some voltage across it. Now we thought the next step would be to power our motor from the output however we looked up the maximum sourcing current of the Lm 358 and found that it could only source 30mA while the motors we were using required a minimum of about 500mA. This meant we had to use the comparator output to power a switch which would turn the motor on with enough current. Now initially we planned to use a transistor to control the motor but with a battery power circuit where the current and voltage drop over time we ended up going with a mosfet which only depended upon the voltage to switch it on. The three pins on the mosfet are the source drain and Gate pins. To use the mosfet as a switch we connected the output of the comparator to the Gate pin. We connected the source to ground and for the motor we put one side on power and the other to the drain pin which when the mosfet is powered or switched on completes the circuit to ground.

We started by creating a schematic of what the whole thing should look like.

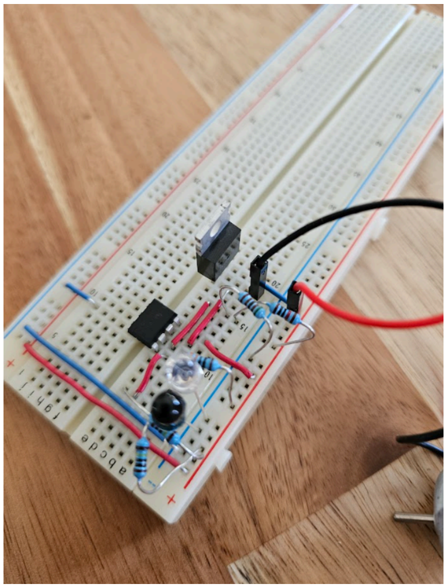


This is what the prototype of the first circuit we built with one sensor and motor looked like.

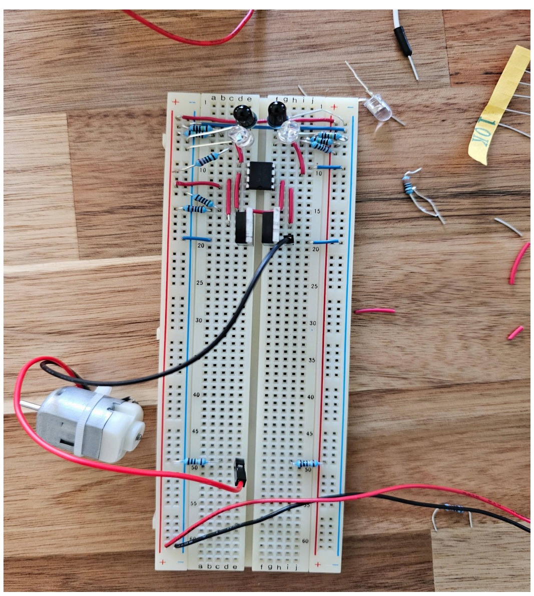


Now that we had a fully working sensor which powered the motor we started working on cleaning up the design and adding another sensor.

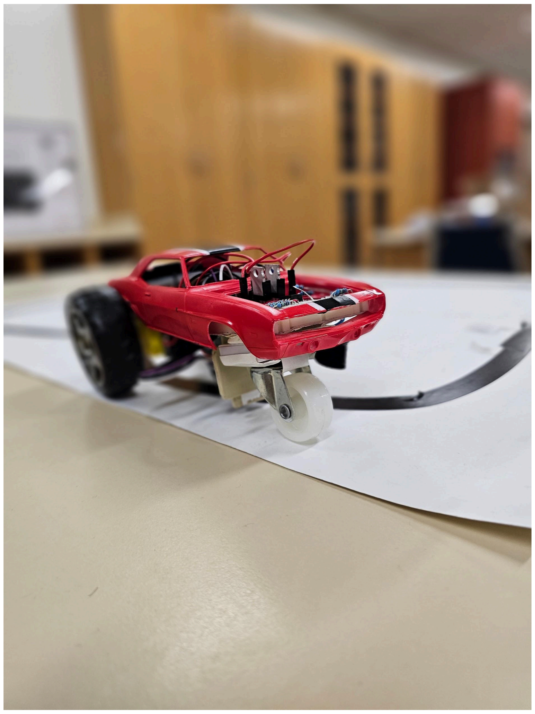
We cleaned up a lot of the wires which made the circuit look like this.

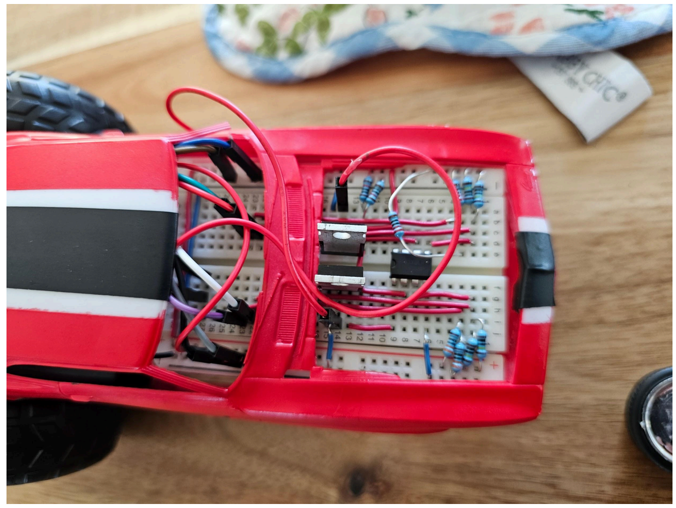


We then mirrored the design for the second motor and used the same voltage divider for the other reference voltage on the comparator which looked like this.



Now that we had the logic behind it working we began on the construction of the car. We wanted to fit it inside a model 1969 camaro z/28 so we used a smaller breadboard and used wires to be able to move the sensors around and we fit the battery pack behind it. We mounted the motors under the battery so the wheels would be at the rear. We used a piece of plastic and hot glue to hold the sensors towards the front of the can and mounted a swivel wheel as a third point of contact to keep the front of the car up. This is what the car looks like all wrapped up.





The robot did not work well when we first built it. The first problem we ran into was the car was moving too fast and its momentum would carry it past turns and we would not follow the line. We fixed this by creating a 3v line from the battery which we used to drive both motors. Troubleshooting continued as the line follower was inconsistent, sometimes making turns perfectly, sometimes getting stuck or running off the track. We had to adjust the sensor multiple times to find a sweet spot where it was pretty consistent. We found it worked best when the sensors were just a bit closer than the width of the tape, because the motors are on when the sensors are over the tape it could do straight lines really well and also had them far enough apart to complete turns successfully. The robot did follow the line however we had to move it really slow and it did occasionally get stuck. One of the biggest improvements we would make if we did this again would be to improve the build quality because our setup was very flimsy and we had many issues due to sensors or connections coming loose which made troubleshooting take longer than it should have. We really like how well the logic of the circuit came together and it was a fun problem to tackle. Another big take away we took is to leave a lot of time for optimization because we had a working prototype. We were sure the rest would be easy but issues arose and we had very limited time to address them. We will keep these lessons in mind for future projects.