Design proposal

Team Technology Moment

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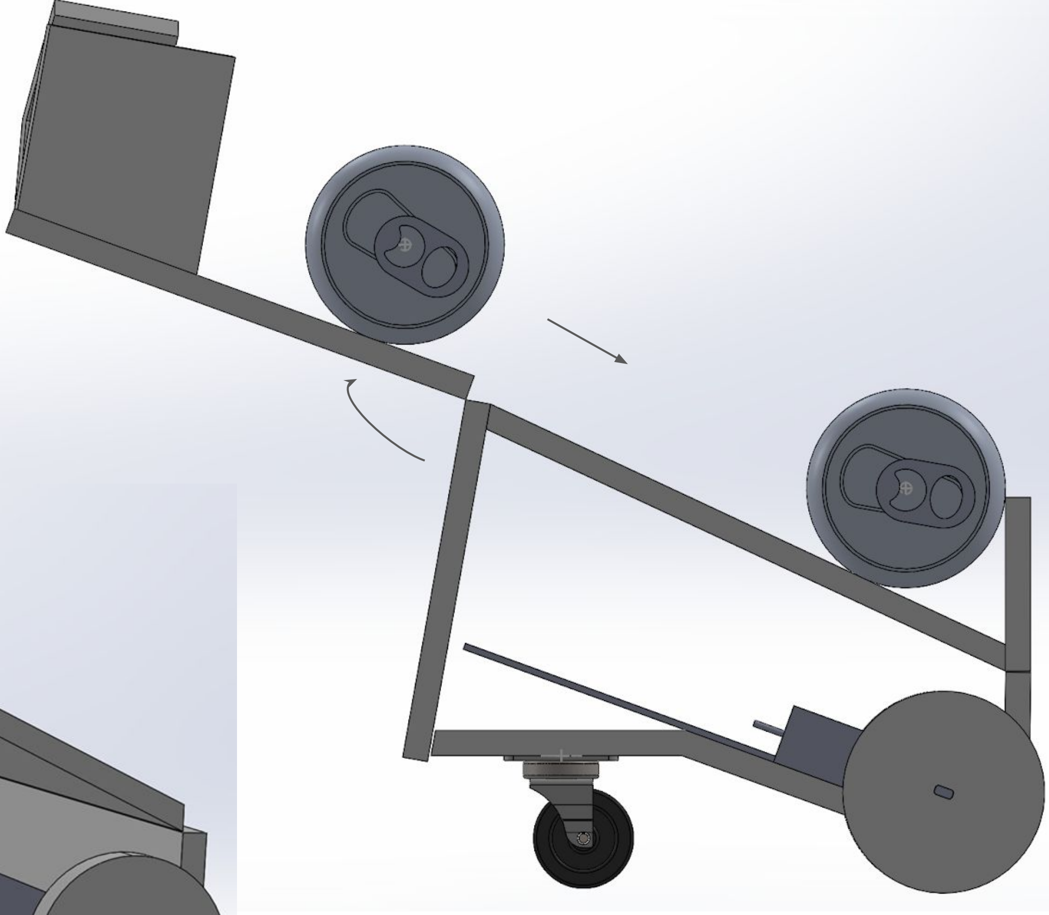
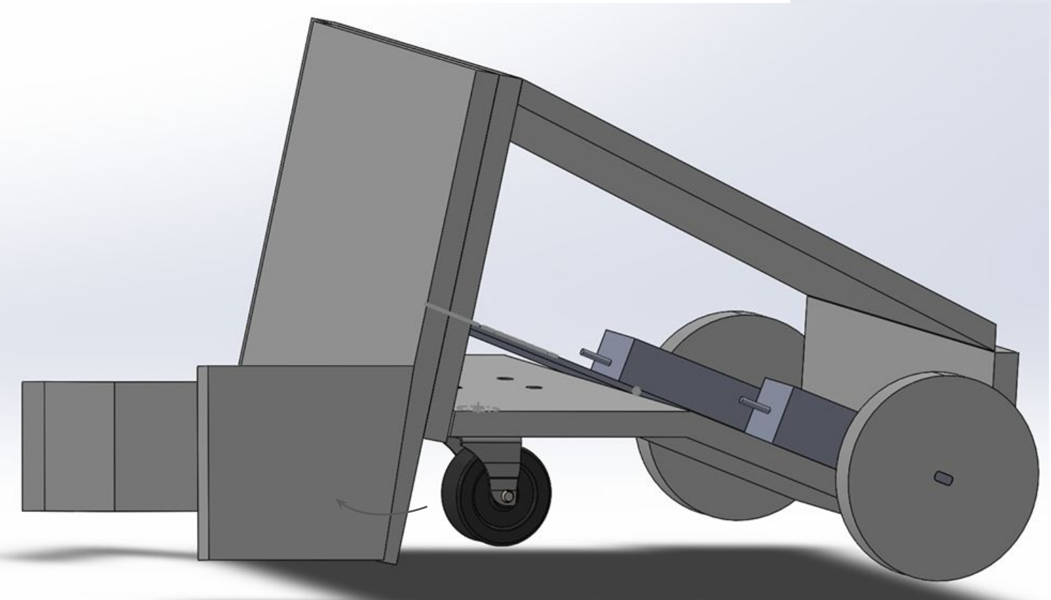
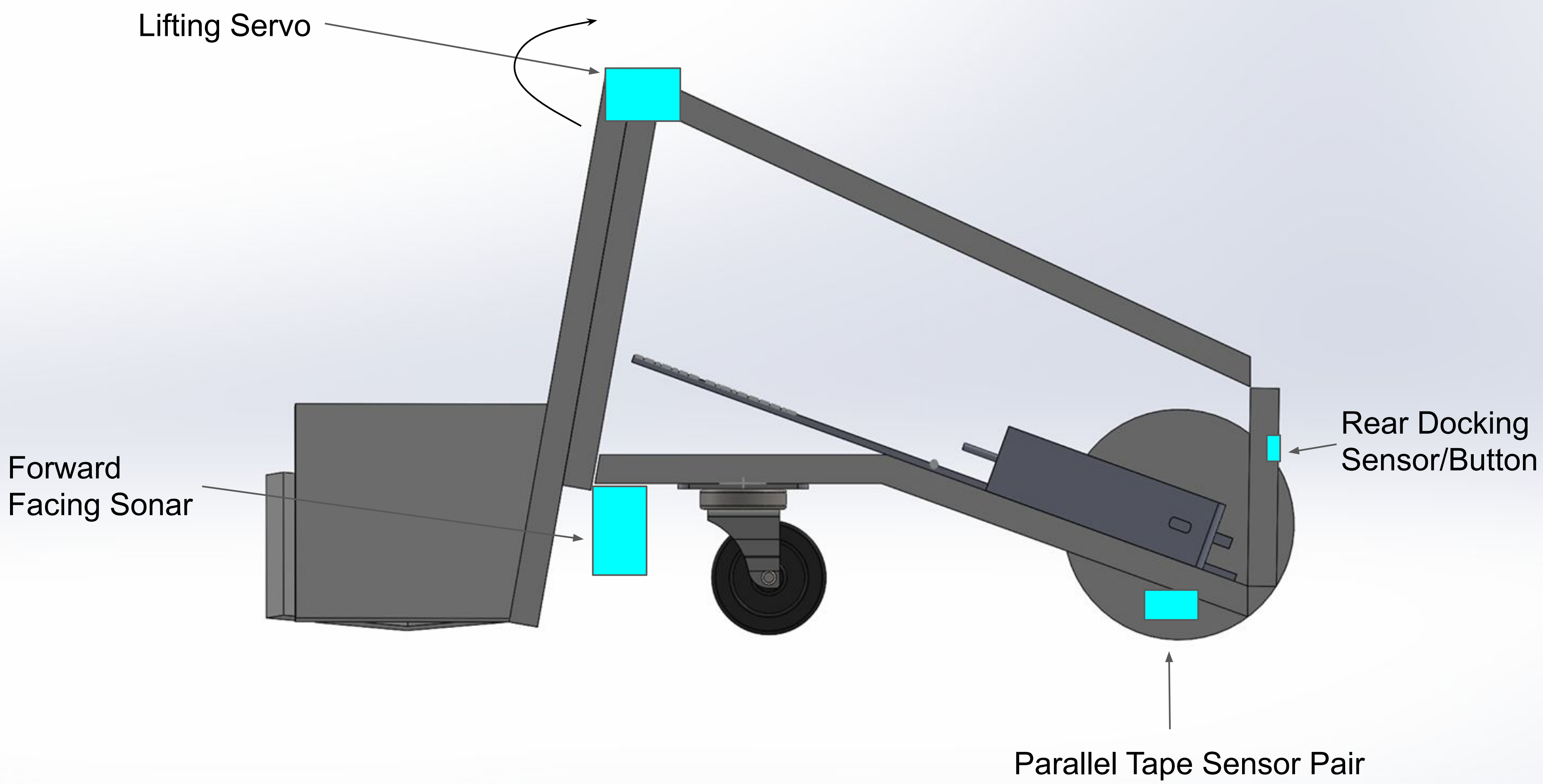
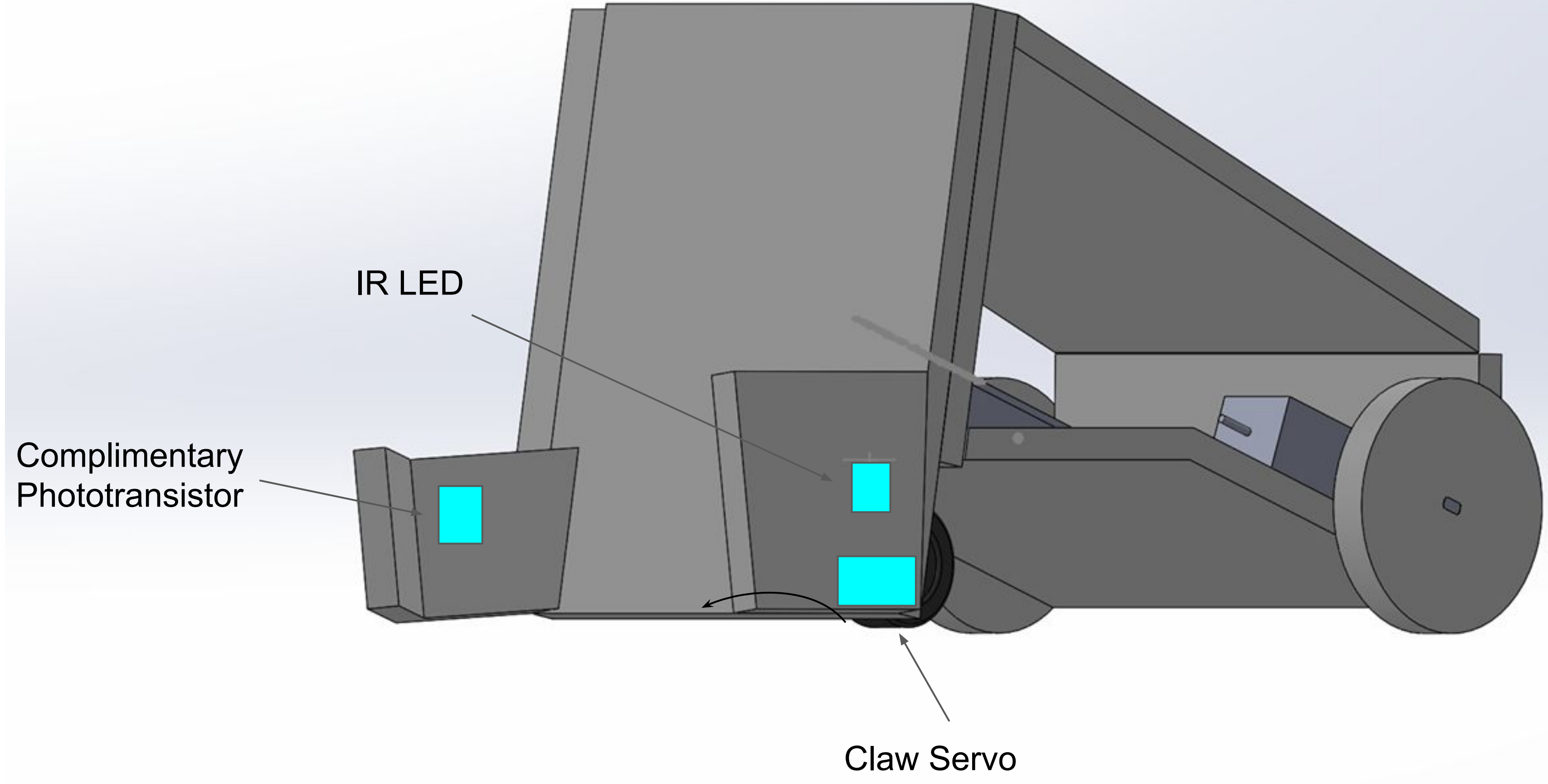
How does it work



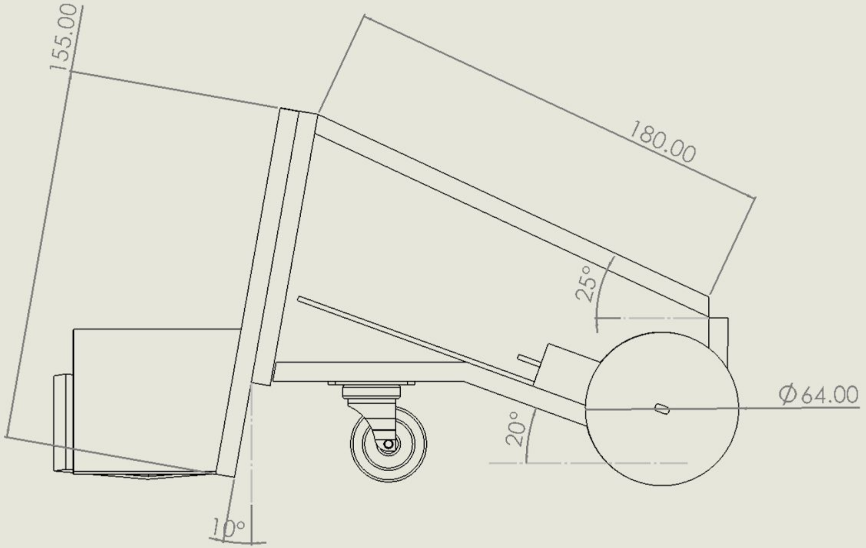


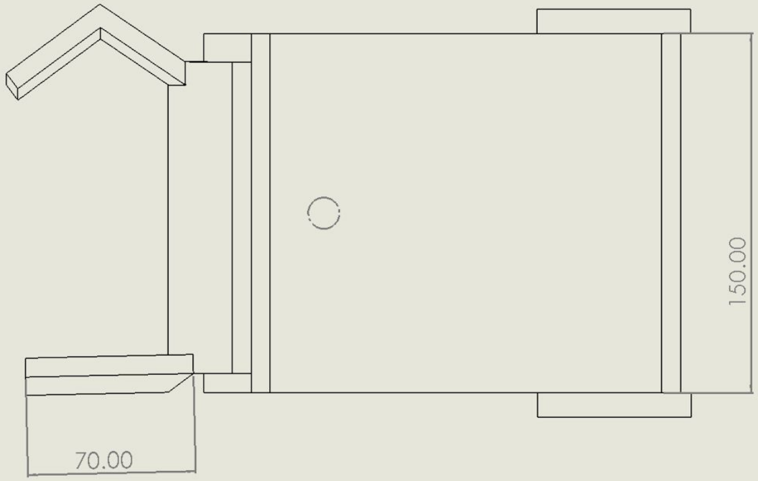

Lifting Servo
Forward
Facing Sonar
Rear Docking
Sensor/Button
Parallel Tape Sensor Pair

Arm system



Dimensions





Attributes

Caster = 52g   Motor = 29g Natasha = 31g Boris = 29g Screen= 4g

Servo (large/small) = 57g/10g Blue Pill = 10g   Electronics = 35g 9V = 44g

Plastic @ .0002g/mm^3 -> Chassis (with claw) = 183.71g

Total mass = 52+2*29+31+2*29+4+57+10+10+35+4*44+184

Total mass = 675g

Idealized speed is v = 3πrad/s*16mm = 15 cm/s

V = 15 cm/s - should be tested experimentally in future

Servo torque

Lifting Servo:

$$\tau = rFsin\theta$$

$$r = .0155m \quad \theta = 90^{\circ}$$

$$F = F_{claw} + F_{can} = (m_{claw} + m_{can})g$$

$$= (54.86g + 21.0g) * \frac{1kg}{1000g} * 9.81\frac{m}{s^2}$$

$$= 0.744N$$

$$\tau = 0.0115N \bullet m$$

Max = .42N-m

Claw Servo:

$$\tau = rFsin\theta$$

$$r = .007m \quad \theta = 45^{\circ}$$

$$F = mg$$

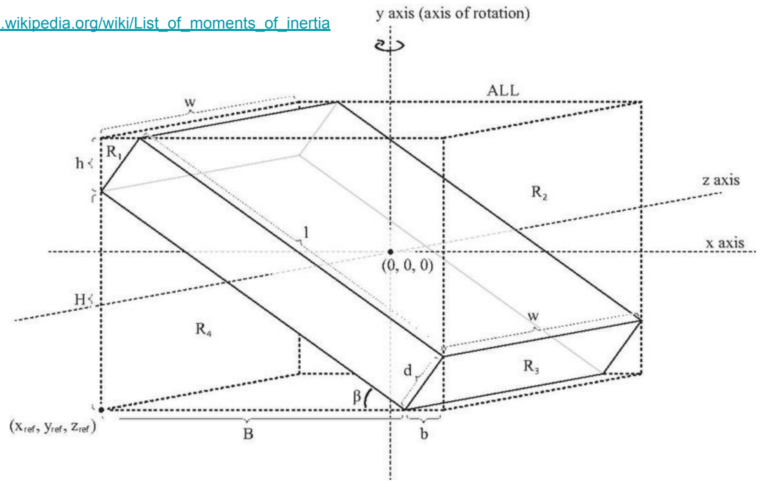
$$= (5.41g) * \frac{1kg}{1000g} * 9.81\frac{m}{s^2}$$

$$= .0530N$$

$$\tau = .000263N \bullet m$$

Max = .015N-m

source: https://en.wikipedia.org/wiki/List_of_moments_of_inertia



Turning

Approximating our robot shape to a tilted box with uniform mass

$$I = \frac{m}{12}(l^2 cos(\beta)^2 + d^2 \sin(\beta)^2 + w^2)$$

$$I = 2.793 * 10^{-3}\, m$$

$$\text{wheel ratio, G} = \frac{C_{wheel}}{w * \pi} = 2.34$$

$$T = \frac{2 * .8g * 7.5cm}{32mm} = 3.68Ncm$$

$$\alpha = \frac{\mathrm{T}}{I} = 13.17\frac{rad}{s}$$

$$We\ have\ an\ acceleration\ period\ t_0 = \frac{\omega_{max}}{\alpha} = 0.715s, \omega_{max} = 3\pi\ from\ max\ RPM = 90$$

$$on\ 180°\ turn\ we\ have$$

$$\mathrm{G}^*\pi - \frac{t_0^2\alpha}{2} = \omega_{max}(t - t_0), \mathrm{t} = 1.148\mathrm{s}$$

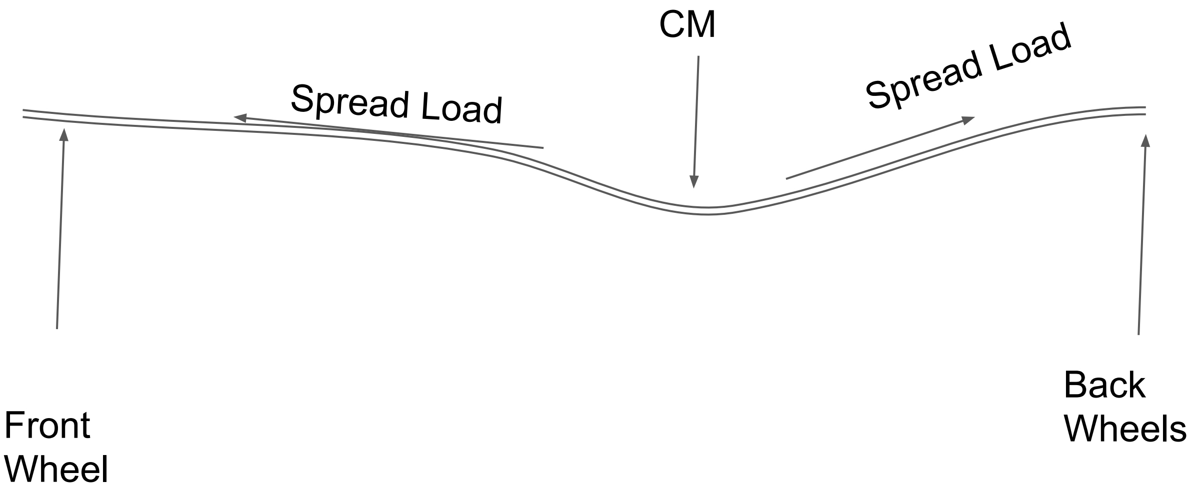
$$on\ 360°\ turn\ we\ have$$

$$\mathrm{G}^*2\pi - \frac{t_0^2\alpha}{2} = \omega_{max}(t - t_0), \mathrm{t} = 1.918\mathrm{s}$$

Design Choices to Reduce Deflection

-Heavy components near the front and back of robot overtop of wheels

-Double thick plastic layer on bottom to increase strength

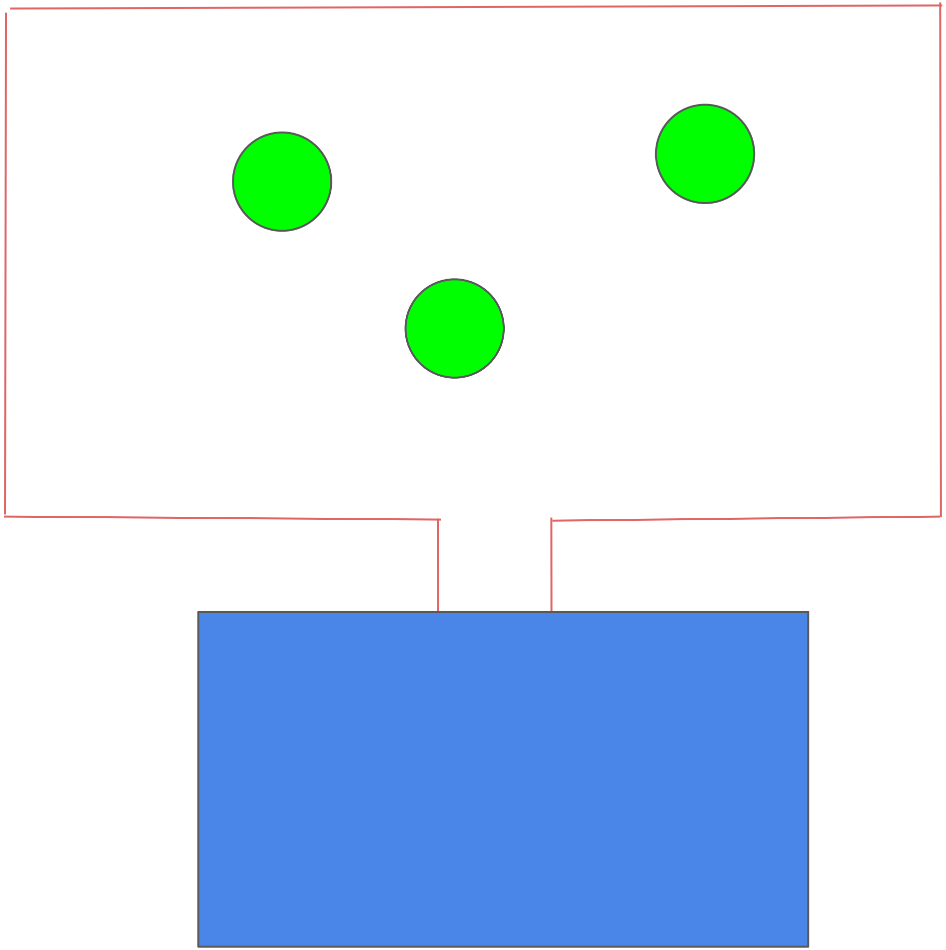


Tape Layout/ Strategy

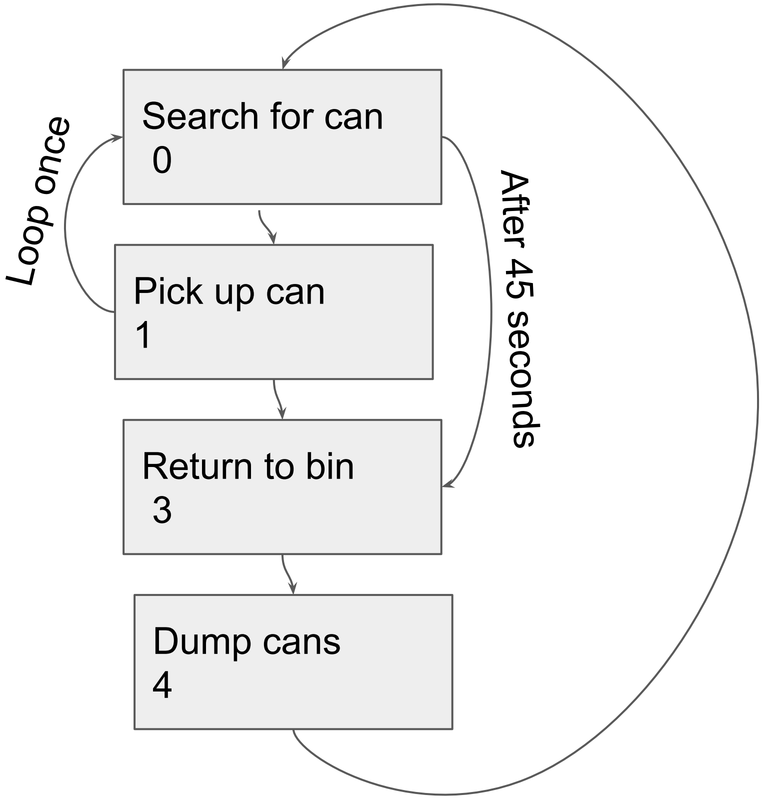
Tape barrier will always lead back to bin. Robot must hit tape barrier to exit.

No beacon used/needed.

Minimum capacity of 2 cans in worst case. We plan to take 2 trips and collect 4 cans.



Code design



Search for can
0
Pick up can
1
Return to bin
3
Dump cans
4
Loop once
After 45 seconds

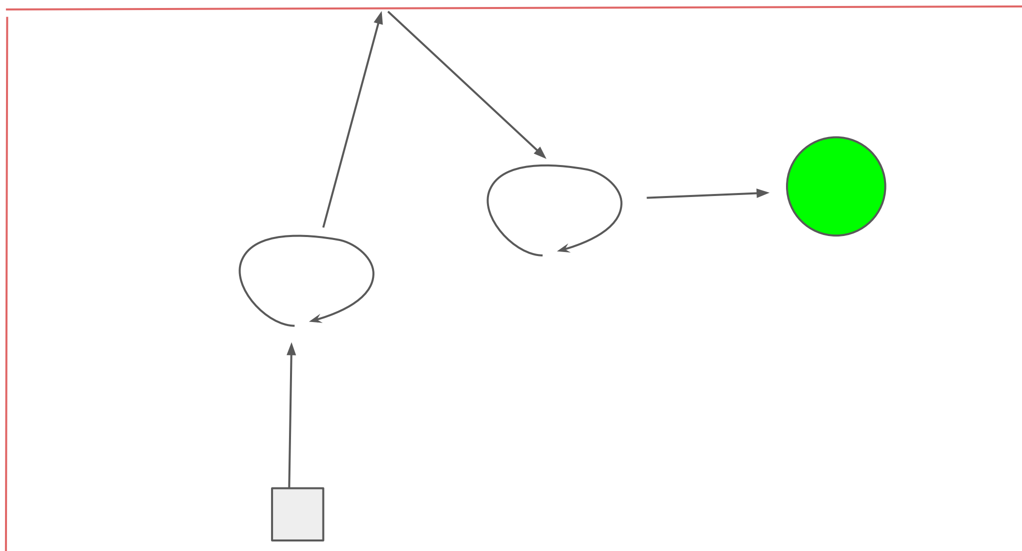
Search Algorithm

Drive forward 2ft, rotate ~360° if can is detected by sonar drive until it is close enough and pick up

If encountering tape align with normal using tape detectors and exit tape at 45°

Risks:

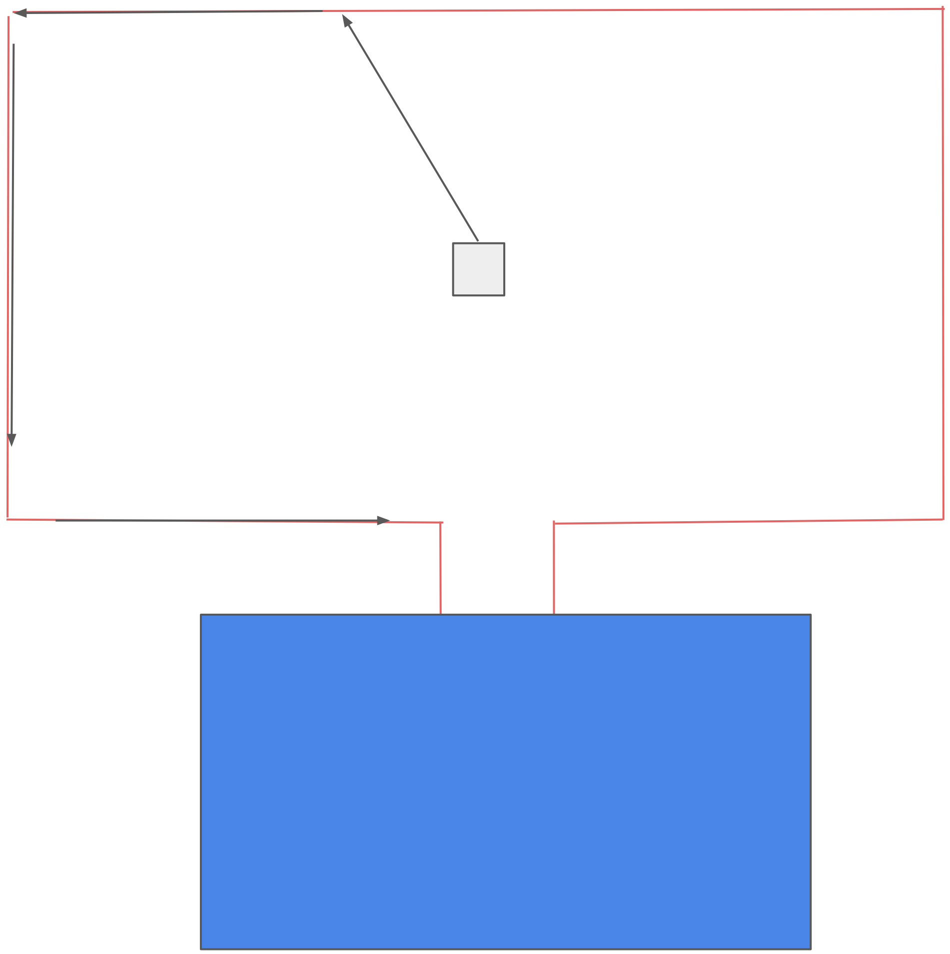
- Incident angle is calculated incorrectly/turning issues leads to exiting the surface or leaving at weird angles.
- Robot drives too close and knocks away can.



Return Algorithm

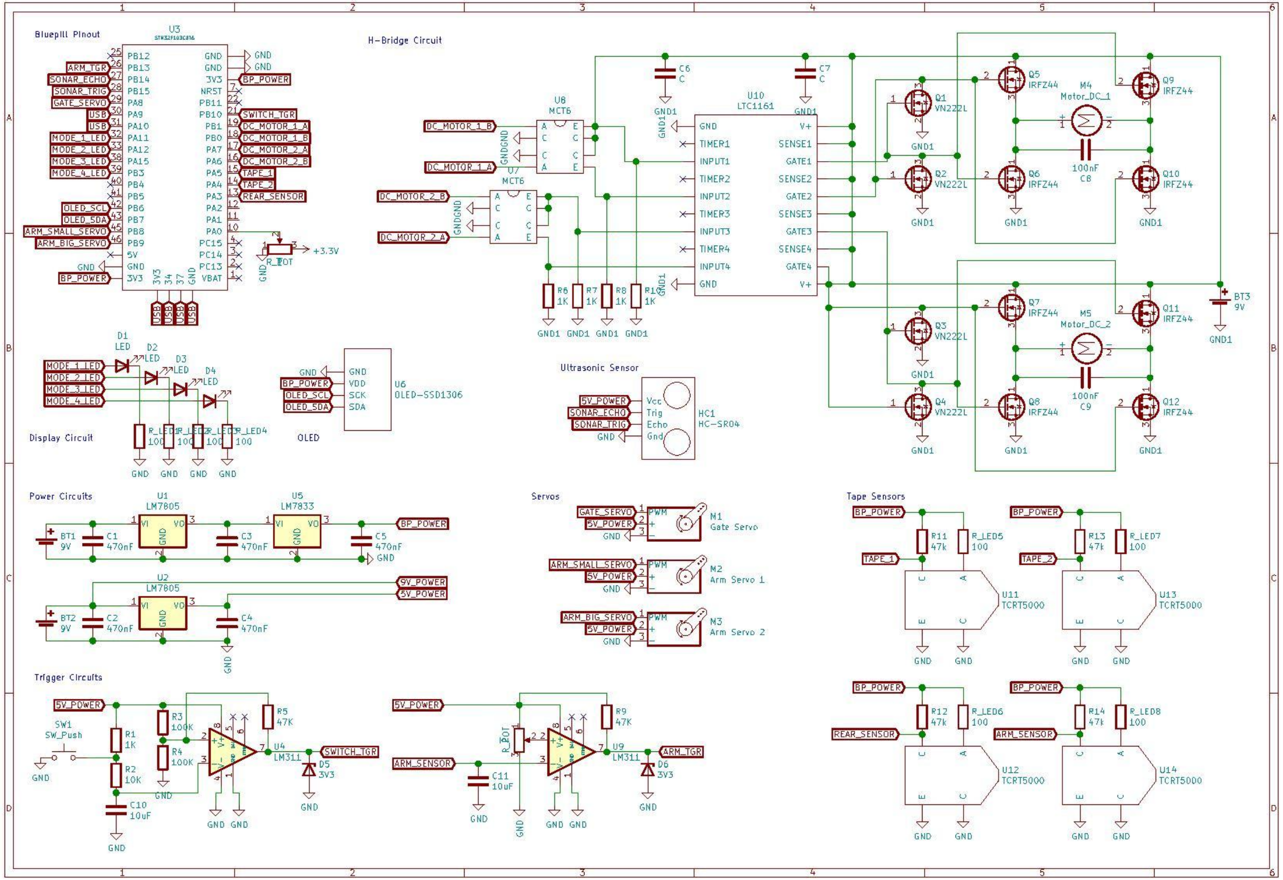
Drive in current (random direction) until hitting tape

Drive backwards on tape until triggering docking button/sensor



Risks:
Taking the long way back.
Lower control driving forwards.

Electrical Design



Circuit Schematics

H-Bridge

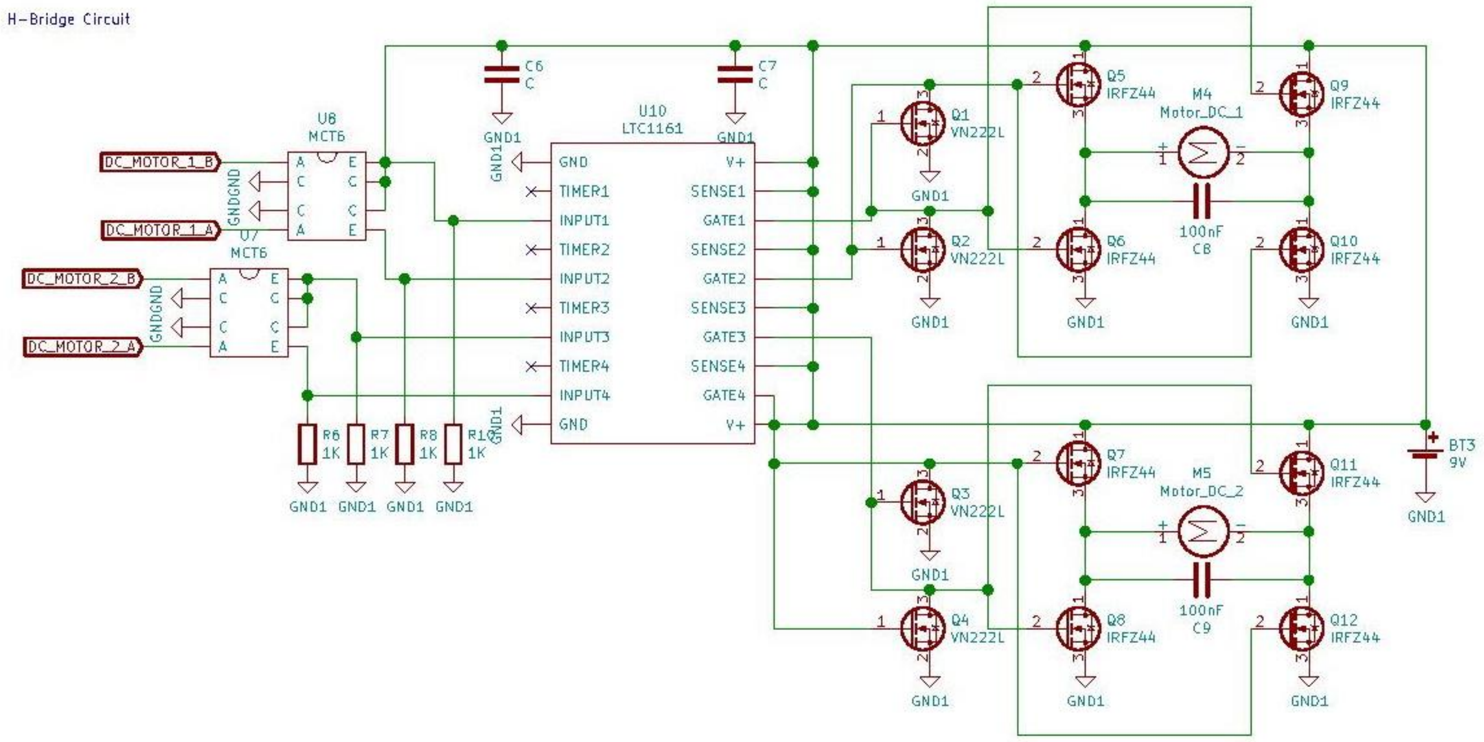
1 9V Battery/Power pack

1 Gate Driver

2 Optoisolators

Noise reducing capacitors

Separate ground (GND1)

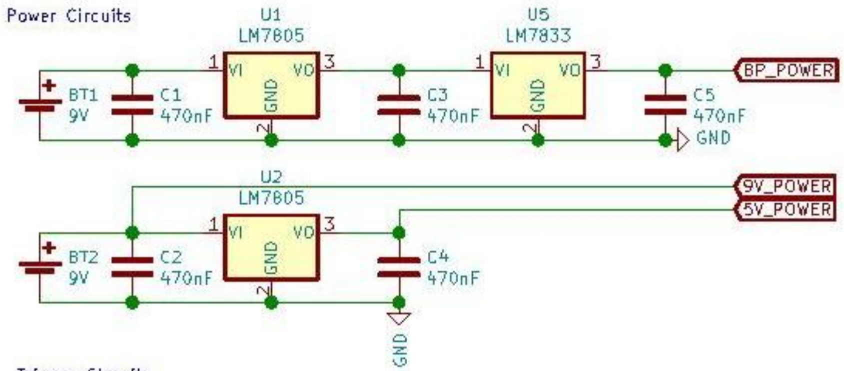


Circuit Schematics

Power

2 x 9V batteries

- 3V3 for Bluepil (BP_Power)
- 5V from another battery for servos (5V_Power)

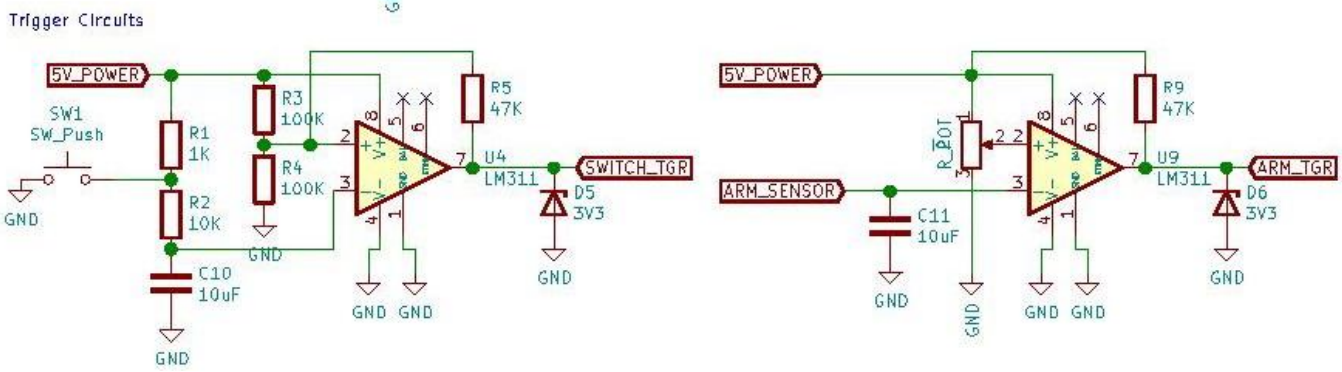


Triggers

Schmitt trigger for button/sensor at rear of robot

Schmitt trigger for sensor on robot arm - signal to close claw

- Threshold adjustable via turnpot
- Frees up analog inputs



Circuit Schematics

Sensors/Servos

Servos powered by separate 5V from Bluepill

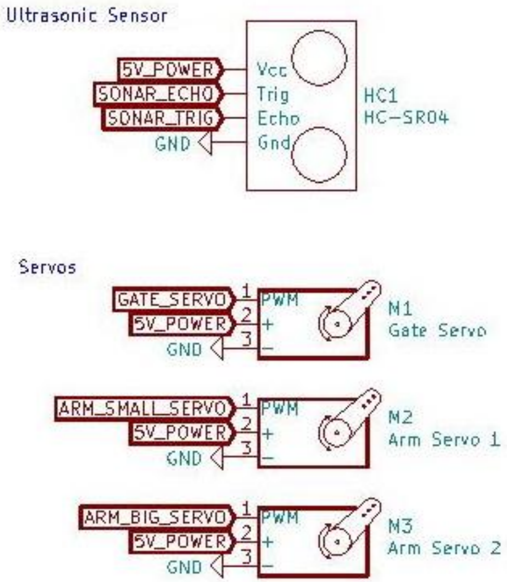
4 tape sensors:

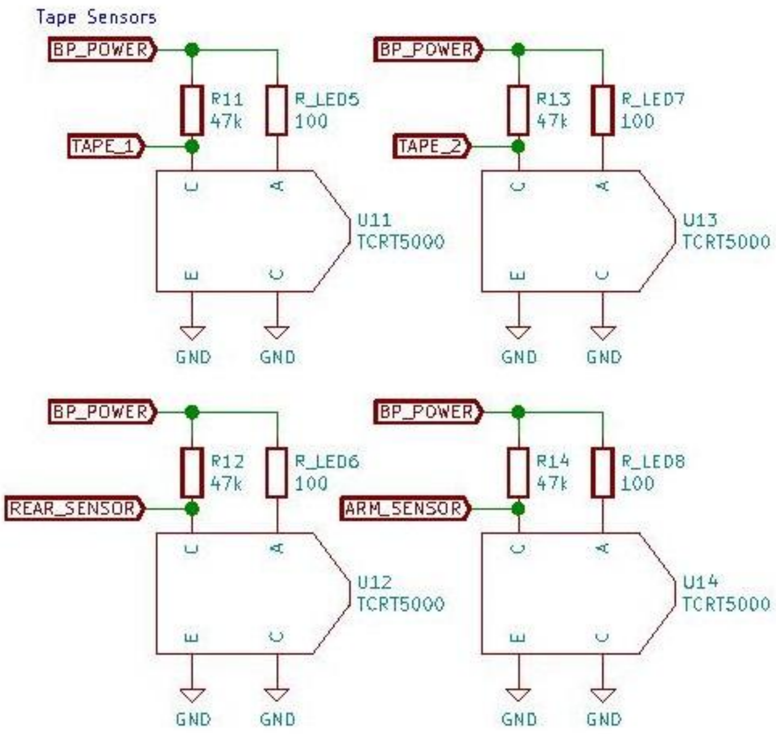
- 2 on bottom
- One on arm
- One on rear

3 servos:

- 2 for arm (1 big, 1 small)
- 1 for rear gate

2 Digital pins for ultrasonic sensor





Circuit Schematics

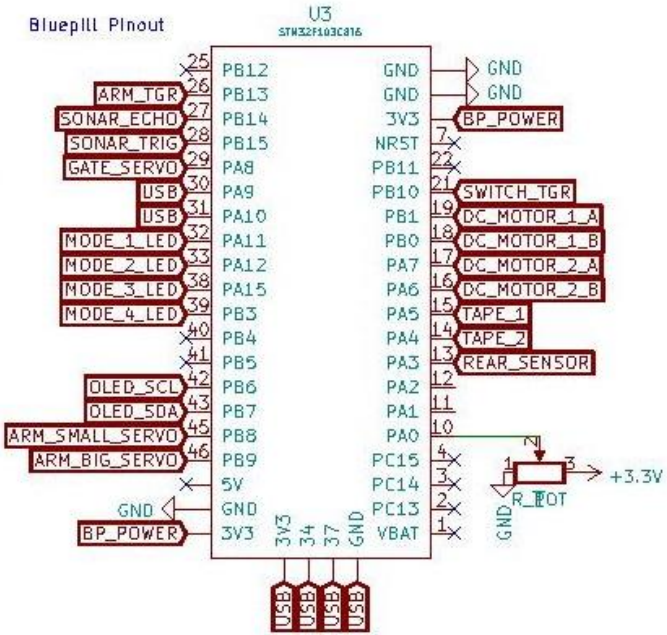
Bluepill Pinout

Almost all PWM and Analog input pins in use

- PA1 and PA2 left free if needed in future

Turnpot in PA0 for testing, debugging, parameter adjustment

Free digital I/O pins can be used for buttons - improved user interface

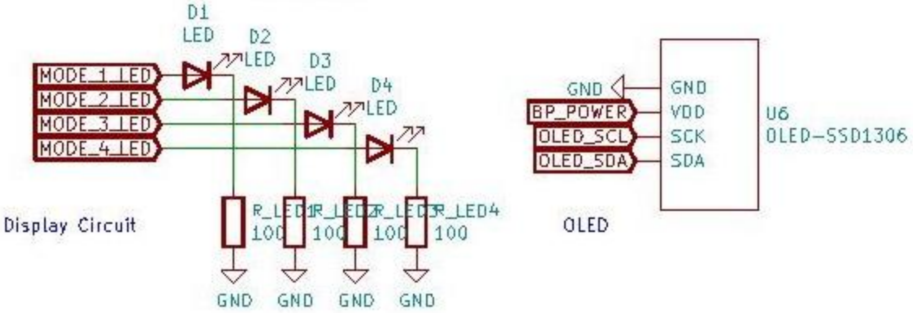


Display

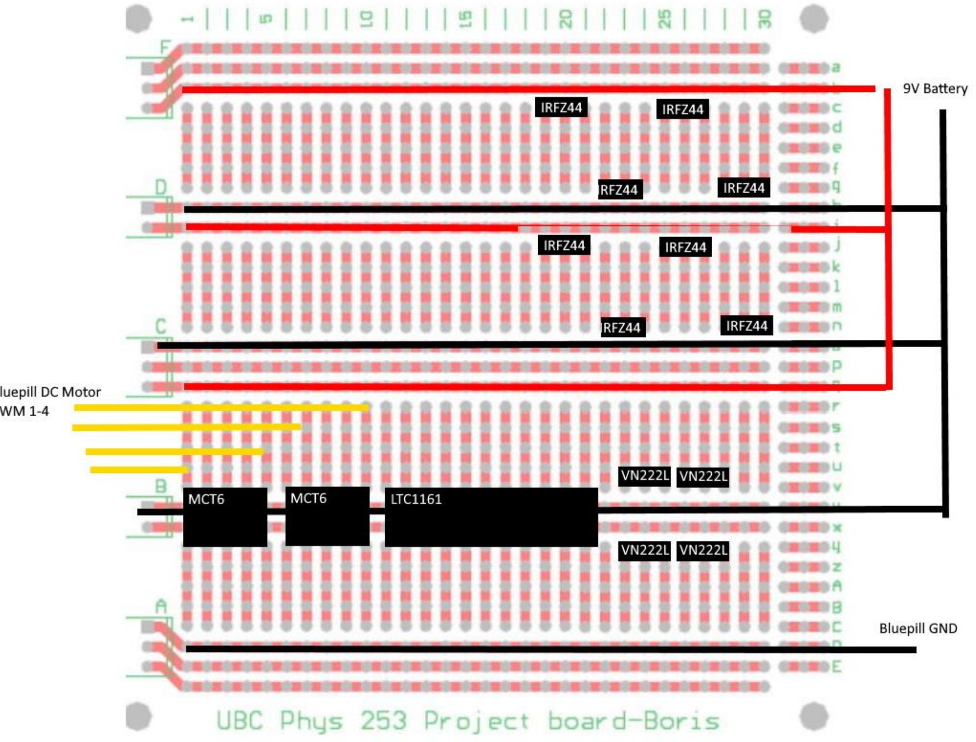
4 LEDs to display up to 4 robot modes

- Can also be used for entertainment purposes

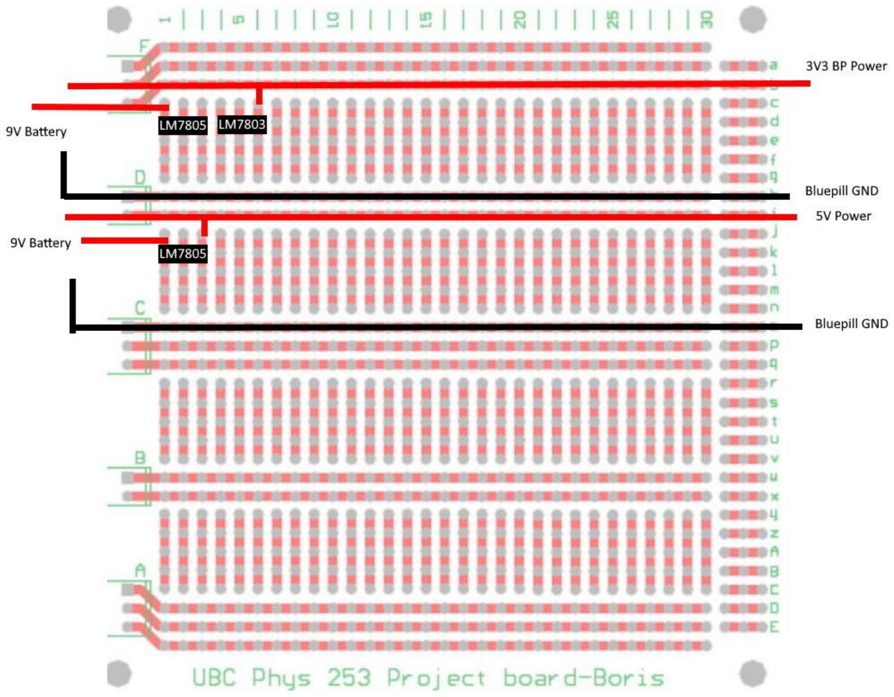
OLED to display relevant information - useful at different stages of testing



PCB Design

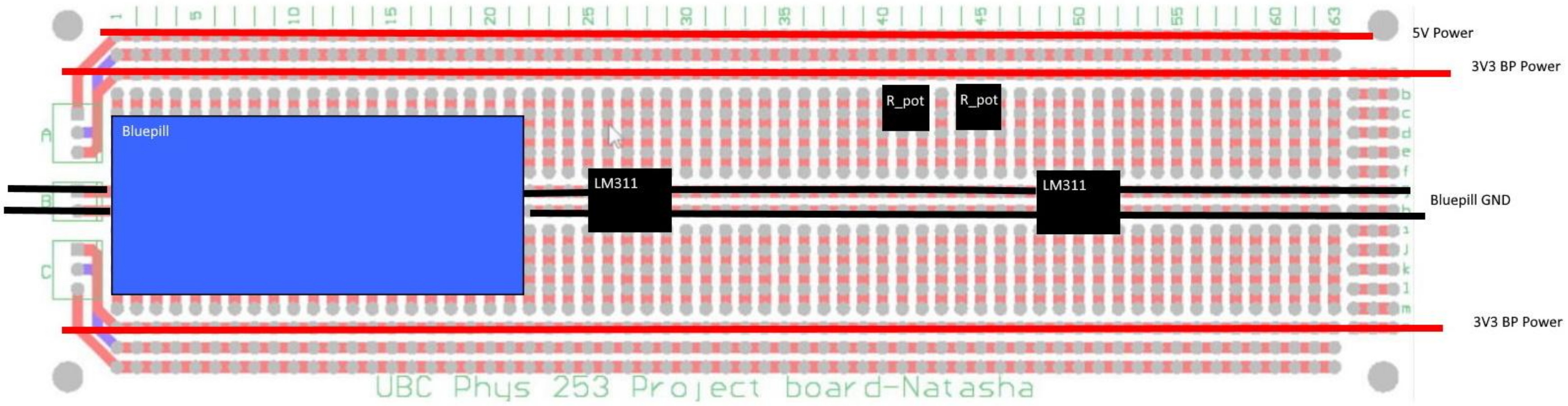


H-Bridge Board



Power Board

PCB Design



Bluepill Board

PCB Design

Only major components shown

3 boards - 2 Boris, 1 Natasha

- Small PCB could be substituted for power board - more soldering but saves space

Most other components (servos, DC motors) not soldered onto PCB board directly - interface with Bluepill by plugging into header pins

- More flexibility in design, easier to debug

Noise Reduction/Grounding

Shielded circuit box

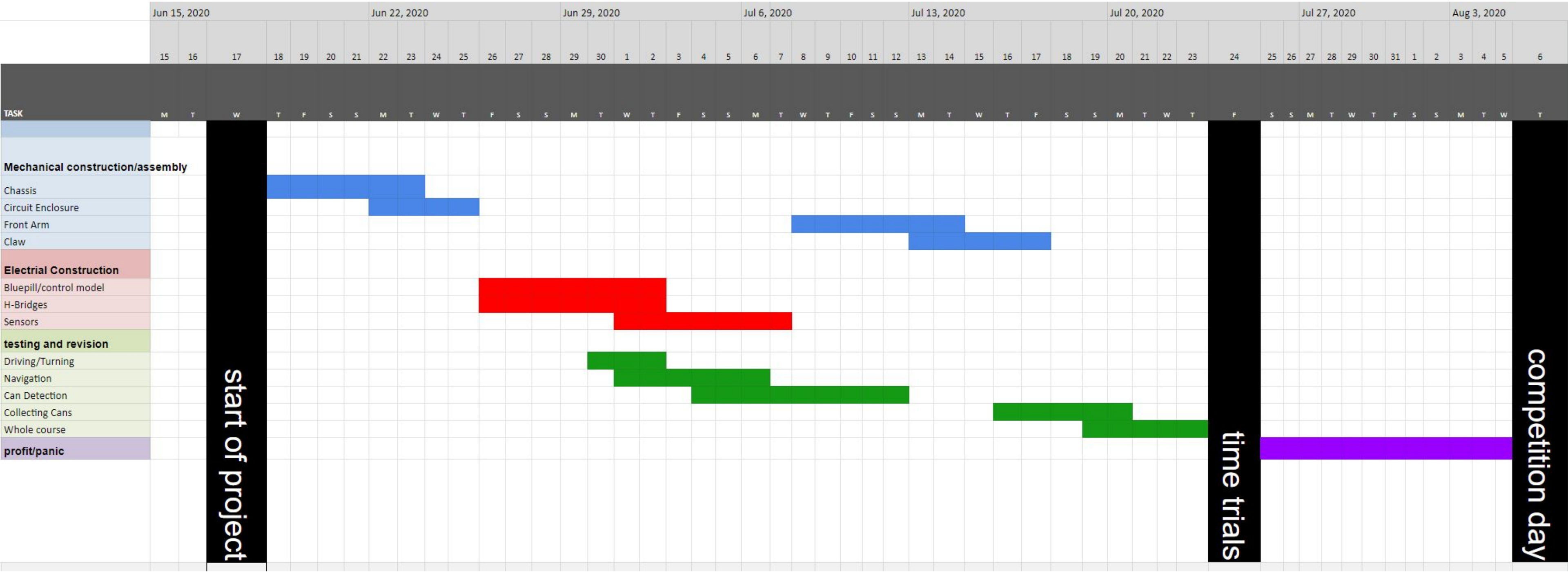
- Aluminum foil

Shielded Cable

- Motor wires
- Sensor signal wires
- Long wires extending from circuit box

All power and ground lines connected to **power PCB board at one point**

Project Organization



Teamwork Strategy

Universal code structure reduces labor

Threshold constants unique for each competition surface and individual robot build

Division of design tasks to prevent redundancies and encourage specialization