PharaoBots CDR

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ME72

Changes from PDR

Detailed CAD and Electronic Schematic

Larger spindles to accommodate for new EC dimension

New motors to accommodate for voltage

New outer design protecting wheels, enhancing combat ability

Game Strategy

- **All robots - Self-sufficient**
  - Each can collect, climb, and deposit
- **1 High Torque Robot (Climber Cleopatra)**
  - Prioritize Climbing and Pushing
  - Able to push and block on both ramp and deck
  - High survivability
- **1 Faster Robot (Runner Ramses)**
  - Prioritize ground collection
  - Autonomous
  - Prioritize climbing and speed

Game Strategy

Assumptions:

1.
Everyone will collect the two rows of pellets as soon as possible at the start of the strategy

2.
The runner robot will start its motion from the team entrance

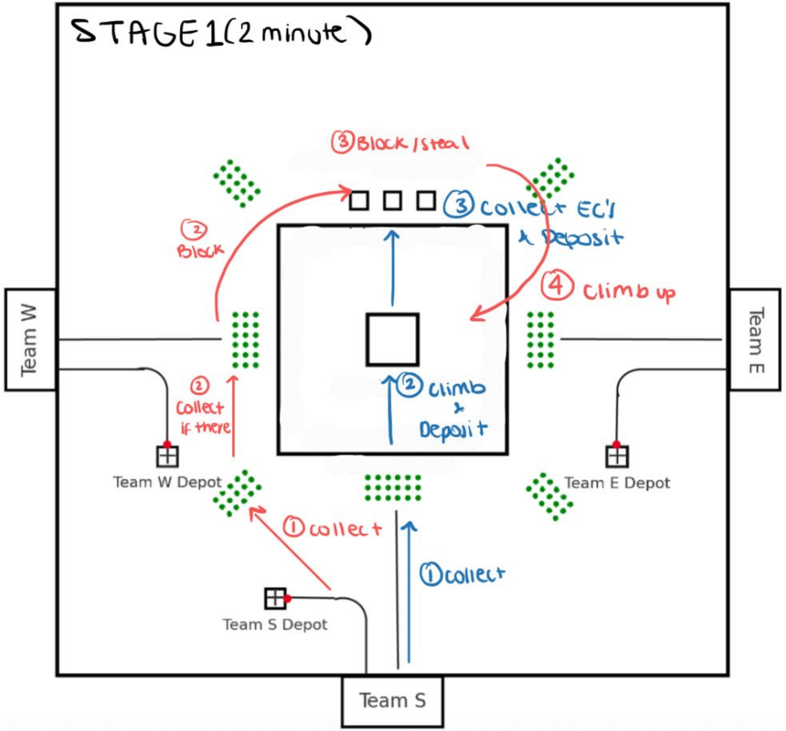
3.
The runner will start with the first cluster of pellets collected during the autonomous time

Gameplan

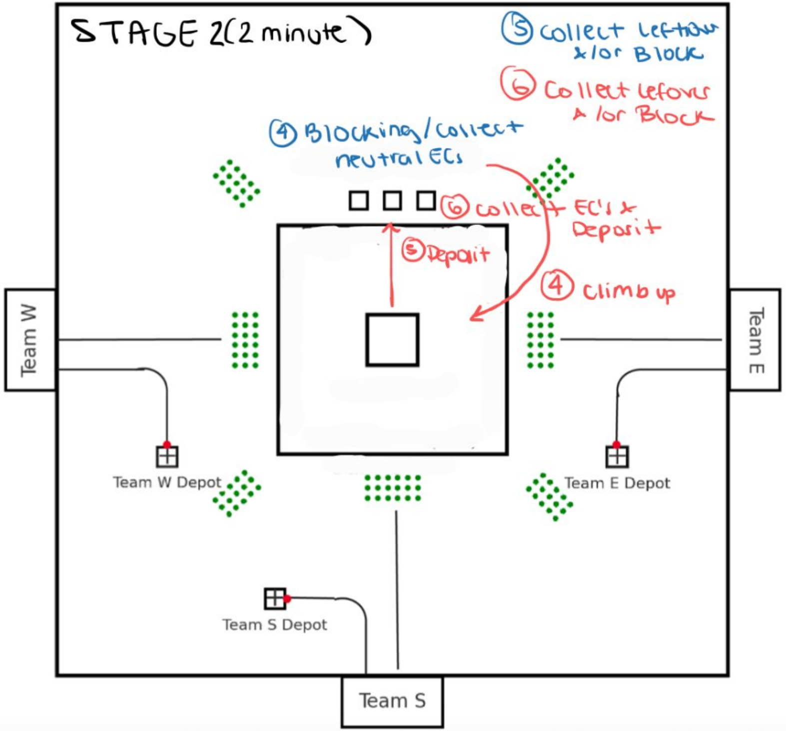
Strategy (Teleoperated Section):

1. Runner collects primary batch and heads to pyramid deck to deposit
2. Climber collects secondary batch and travel to vaults to intercept neutral EC's or to enemy ramps to block enemy climbers
3. Runner deposits, head down brachi, and collects EC's
4. If all the funnels are blocked in stalemate by other teams, then we pivot strategies to drop pellets in our depot to still get points
   a. Could also then collect the grey pellets and take them to the deck once stalemate ends

Assume post-autonomous



Assume all pellets gone

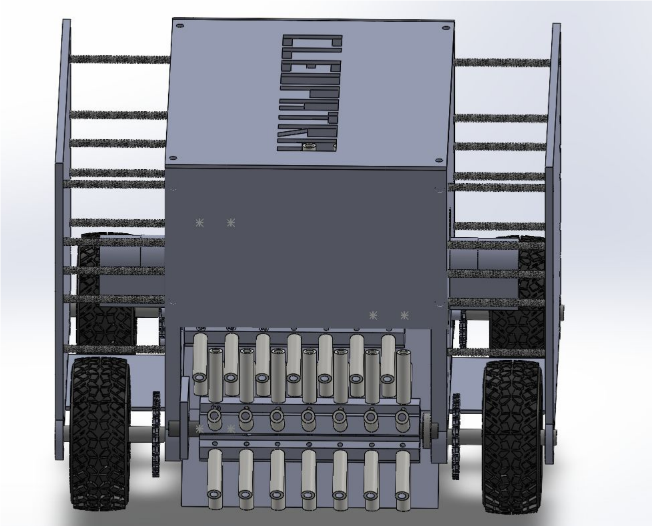


Climber Robot
Runner Robot

Climber Robot Design Functions (Cleopatra)

Goal: Climb rapidly and maintain stability under contact

- Outer Protective wall
  - Larger surface area for contact
- Front load weight
  - Brings center of gravity forward
- High torque
  - Provide sufficient force to climb under load
- Thick, grippable wheels



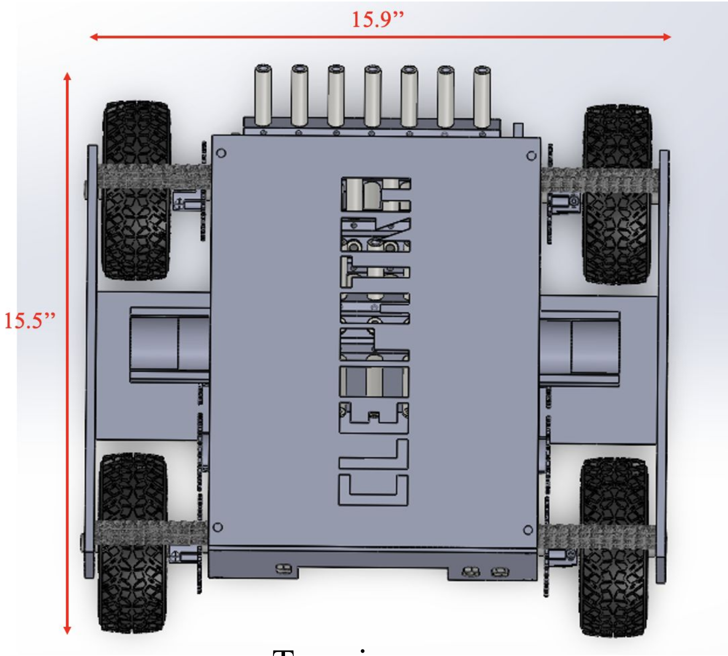
Front view

Robot Geometry (Climber)

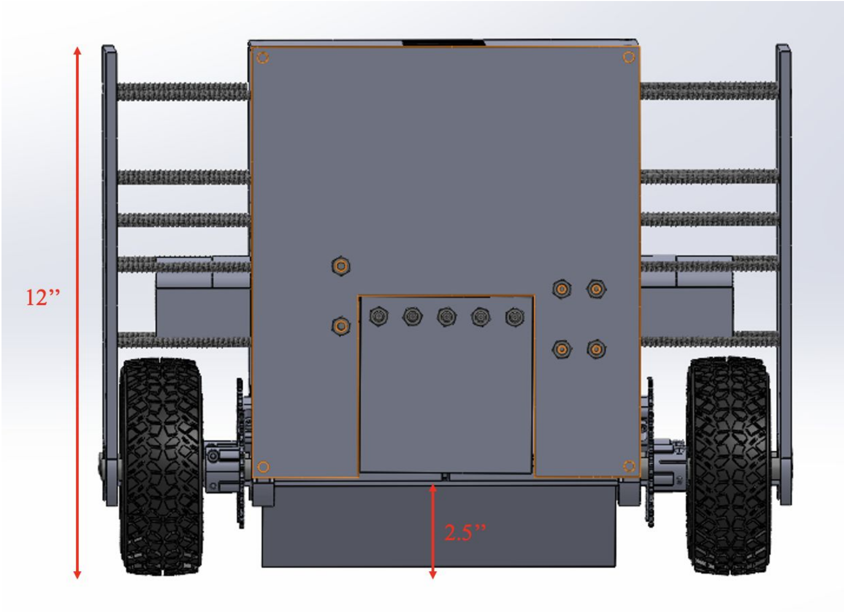
Meets 16” x 16” size requirement

Estimated Weight

Climber Cleopatra: 25 lb = 11.3 kg



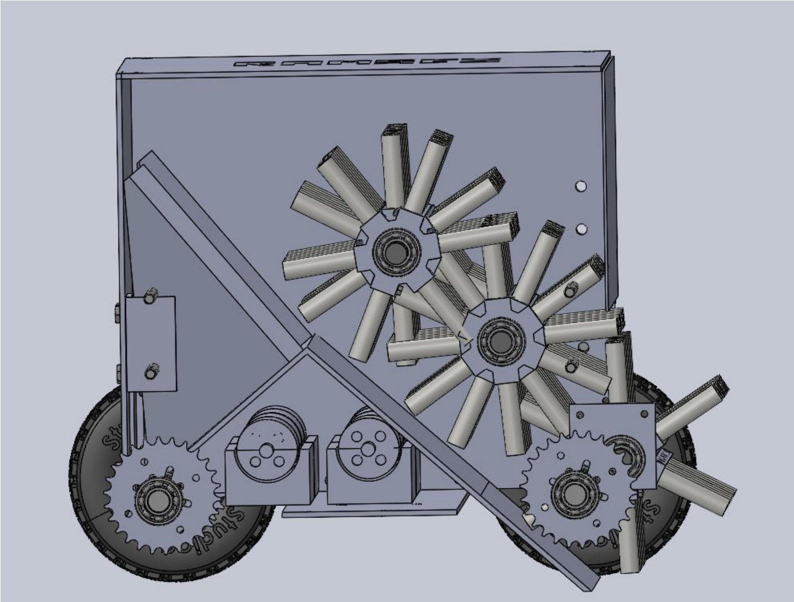
Top view



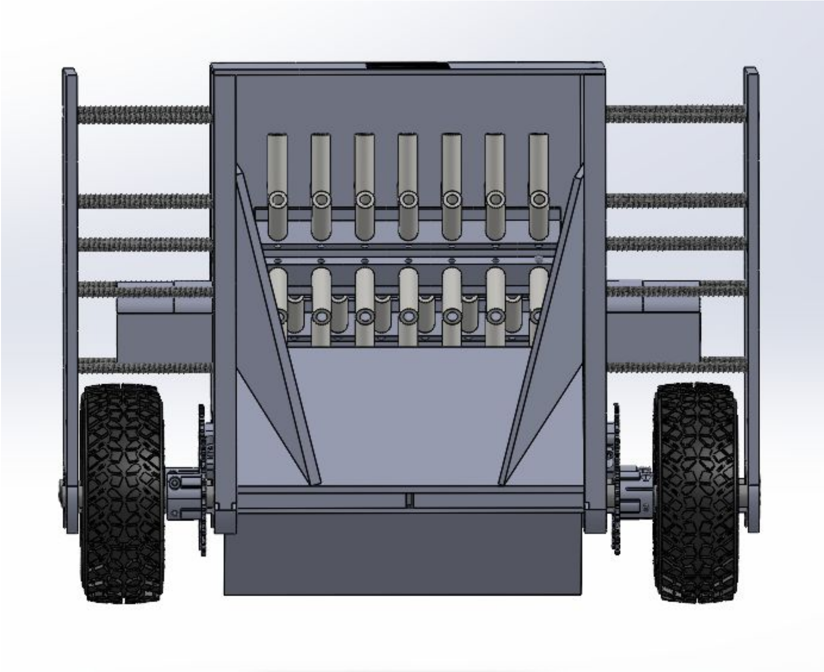
Back view

Climber Robot CAD

Side view inside



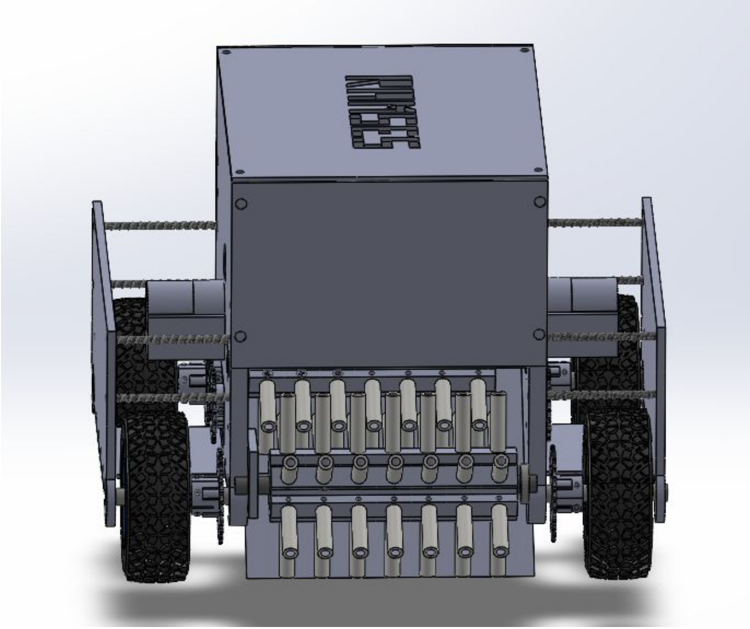
Funnel section back view



Runner Robot Design Functions (Ramses)

Goal: Lighter robot, performs autonomous task, intercept ECs. Can still climb.

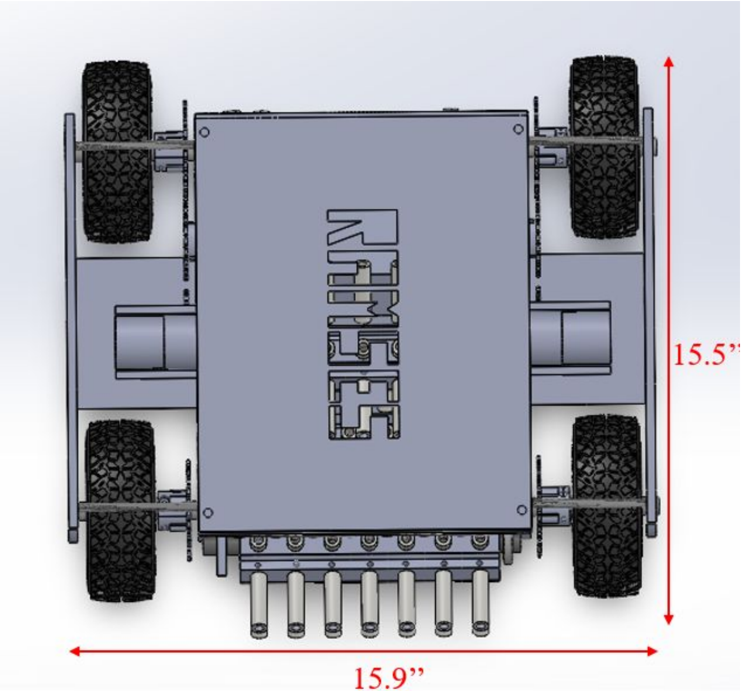
- Lightweight
  - Allows more speed
- Autonomous code
- Front load weight
  - Brings center of gravity forward
- Thick, grippable wheels



Front view

Robot Geometry (Runner)

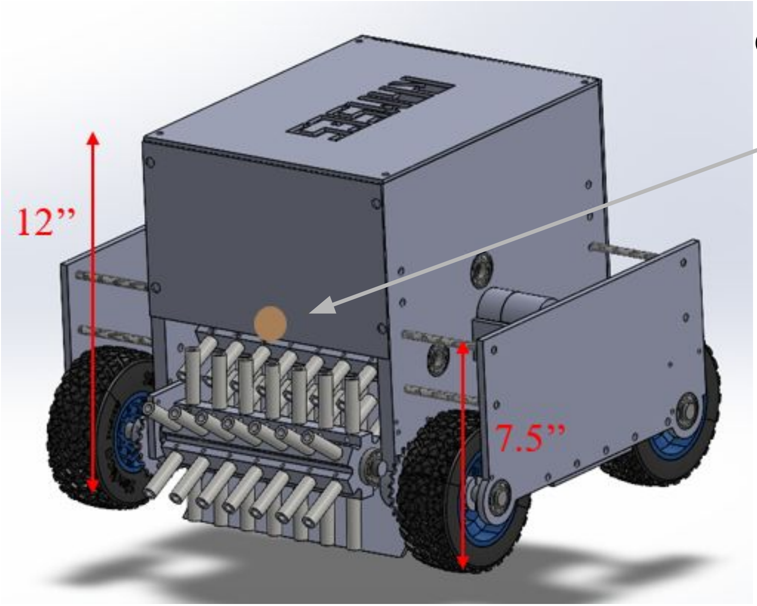
Meets 16” x 16” size requirement



Top view

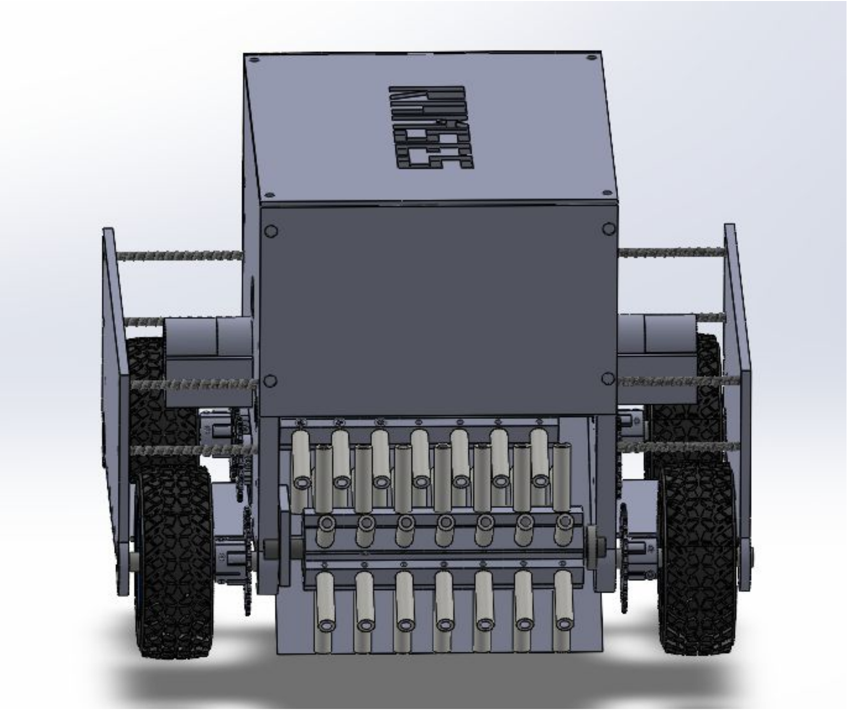
Estimated Weight

Runner Ramses: 18 lb = 8.2 kg

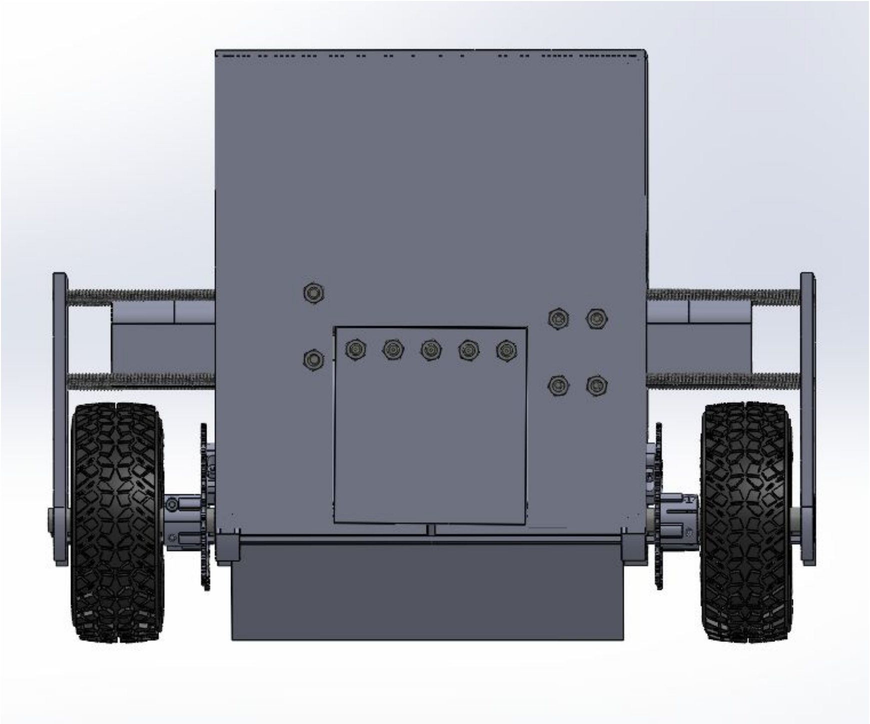


Isometric view

Runner Robot CAD

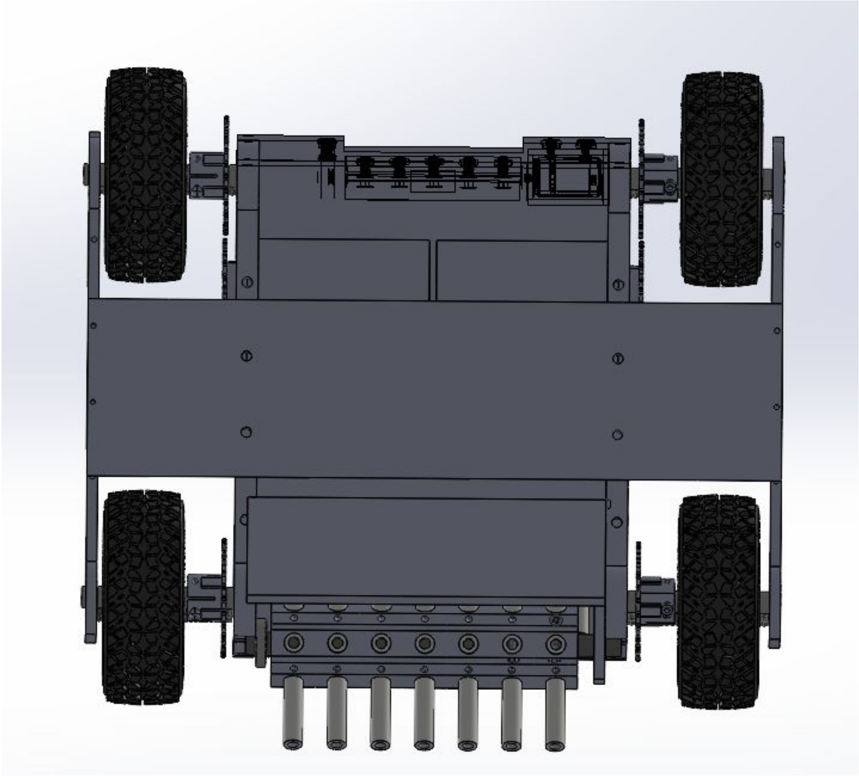


Front view

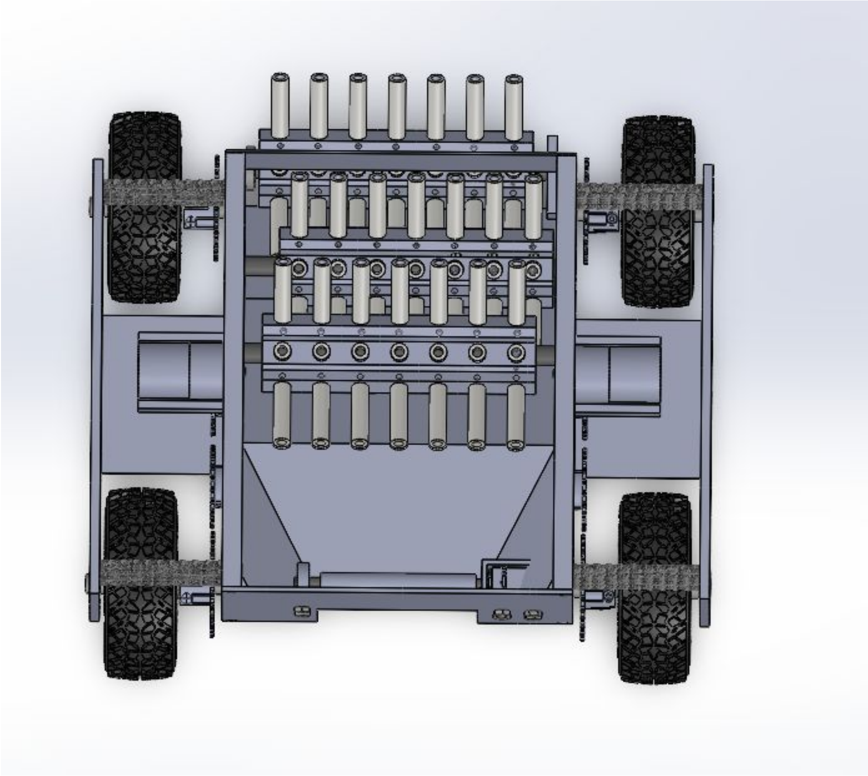


Back view

Universal Top and Bottom Configuration



Bottom view



Top section (top plate open) view

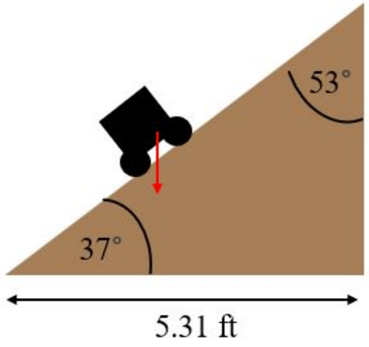
Animation

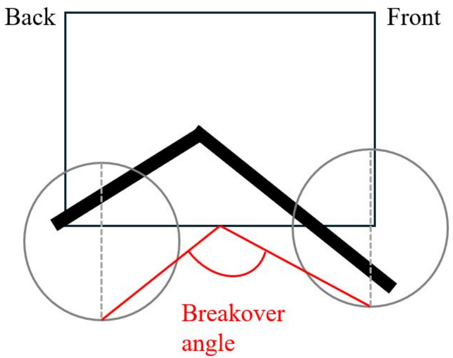
Animation from SolidWorks Exploded view to Model view showing assembly

Clearance Calculations

Our robot is expected to go up a 37 degree incline, three factors are taken into consideration:

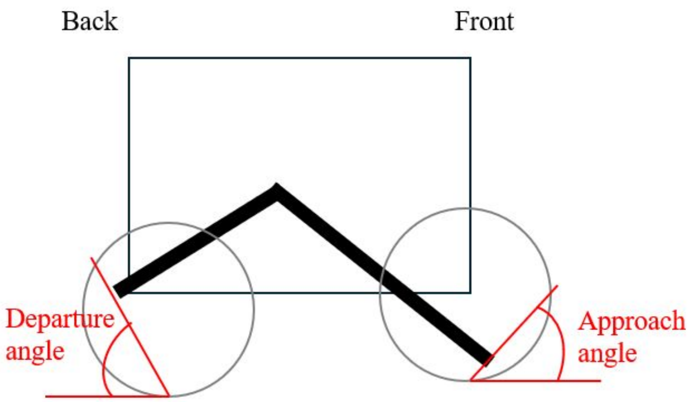
- **Breakover angle:** min angle that the center base of the vehicle can clear (assuming wheel diameter 4.92 in)
  Angle on top of incline: 53° + 90°= 143°
  2 x arctan (5.54/2.46) = 132.19° < 143°
  With the wheel diameter of 4.92 in and the robot base flush with the centerline of the wheel, the robot will be able to clear the top of the incline.
  The base of the robot will be 2.46” off the ground.





Clearance Calculations

- **Approach Angle:** max angle that the front of the vehicle can clear when getting on an incline
- **Departure Angle:** max angle of incline that the back of the incline when getting off an incline
- Approach angle taken conservatively to be 45 degrees
- Back wall 1in in front of back wheels
- Front wheels 1.96in in front of front wall
- Departure angle is ample at 59 degrees

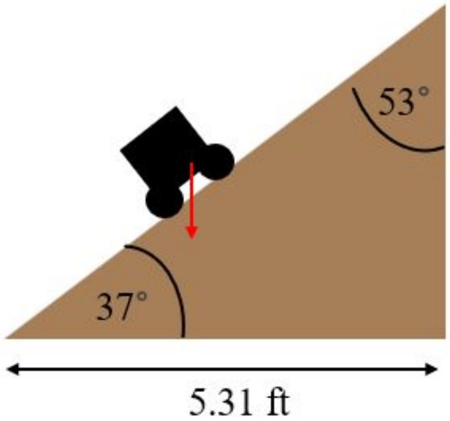


Tipping Angle Calculations

- **Center of Gravity:** The approx location is 6.5 in in front of the back of the vehicle and 4 in off the ground
- **Tipping Angle:** θ = 90° - arctan (height of robot/width of robot)

Height of robot is approx 7in, width is 16in, thus tipping angle is 66.4° < 37°

Our robots can safely travel up the incline without tipping

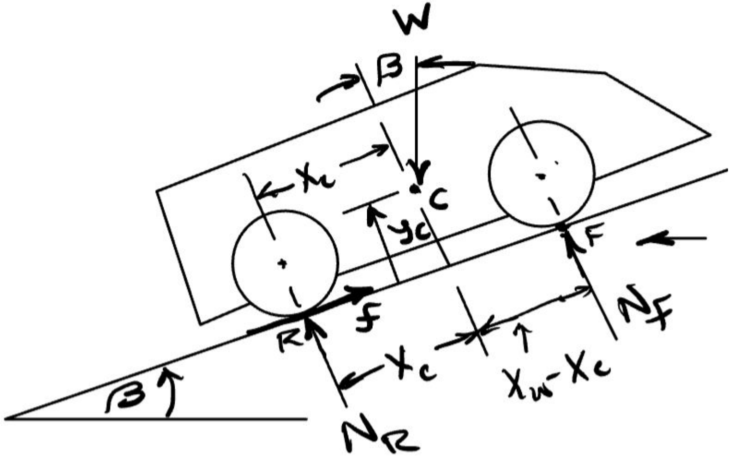


Moving Slippage

- Assuming weight of robot is distributed evenly on all four wheels:
- m = 6 lb, r = 1 in R = 2.5 in
- Static friction coefficient ~ 0.9
- θ_slip = arctan (μ_S*(R+r)/r) = 72.4° > 37°
- Our robot will not slip when driving up the slope

Stationary slippage

- X_c and X_w denote the COM relative to the centerline of the back wheel and the distance between the centerline of the wheels. Y_c denotes the position of COM off the ground.
- μ_S~0.9, X_W=10 in X_C= 4 in Y_C = 4 in
- $\mu_S*(1-X_C X_W)/(1-\mu_S*(Y_C)/(X_W)) = 0.844 \leq$ tan 37° = 0.754
- Our robot will not slide when parked on an incline of 37°



Weight Estimation

Shop battery weight: 241g ~ 0.5 lb

- Cad full weight (walls and chassis) ~ 11 lb
- Motor weight ~ 4.5lb (400-500g each motor)
- Intake motors weight -200g each motor ~ 0.5 lb
- Backdoor motor weight - 55 grams ~ 0.1 lb
- Wheels weight - 0.2565 kg*4 = 1.026 kg ~ 3 lb
- Estimated drivetrain weight ~ 3 lb

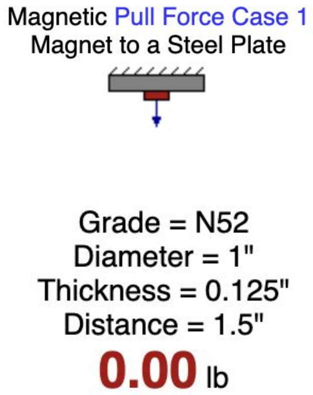
➔ Climber ~ 25 lb, Runner ~18lb

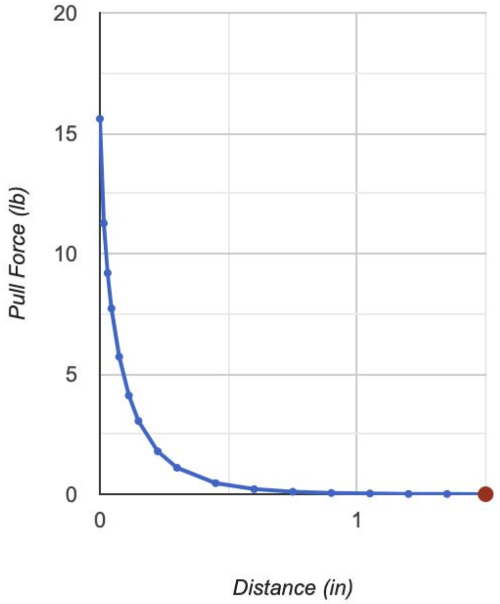
Magnetic Considerations

Consider strong magnet: Neodymium (Grade N52)

To allow for 2.5” clearance, distance between magnet and metal surface to exert any pull force.

Magnet produces no pull force at desired distance, making magneti integration unjustifiable.



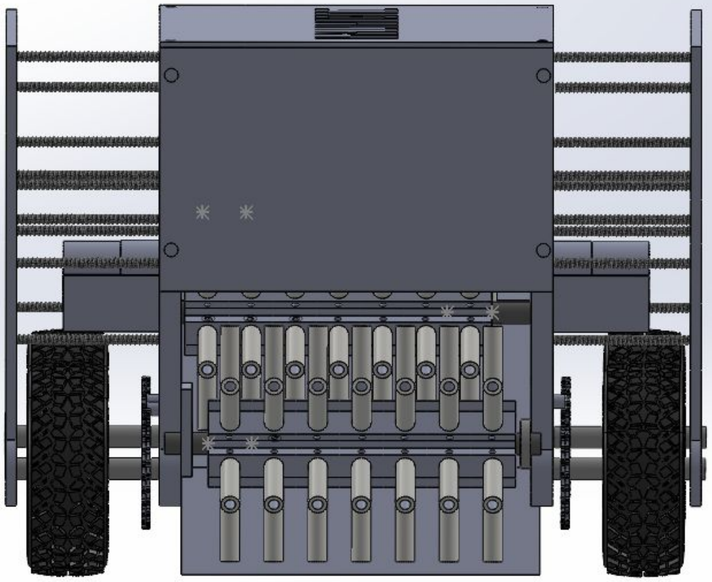


Intake Mechanism

Tube Intake Design

Advantages:

- Great for picking up smaller objects (pellets) and larger objects (EC)
- Highly efficient
- Inexpensive & easy to maintain

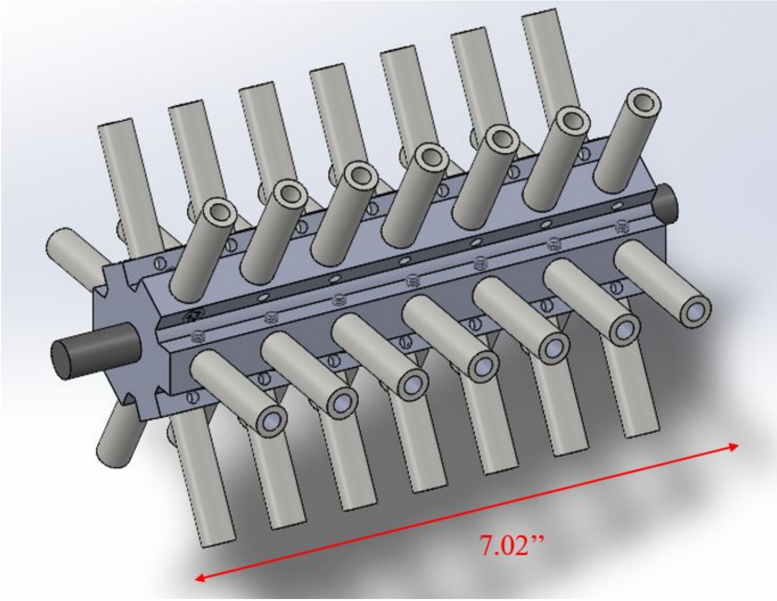


With front panel for electronics storage

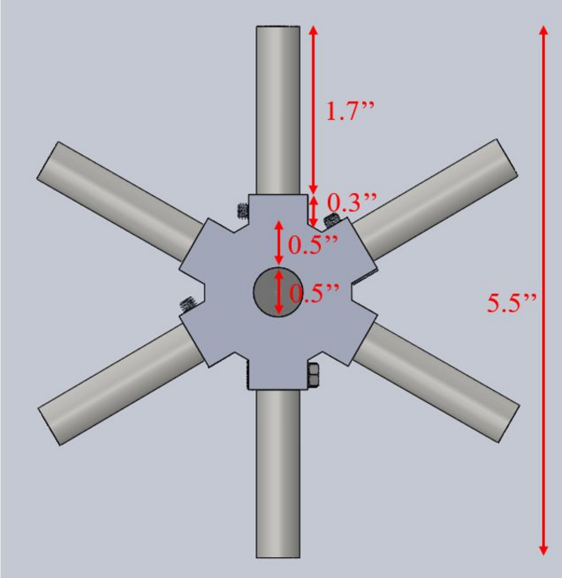
Intake Mechanism

Spindle Design

1 spindle row = 7 tube stars = 7.02 inches



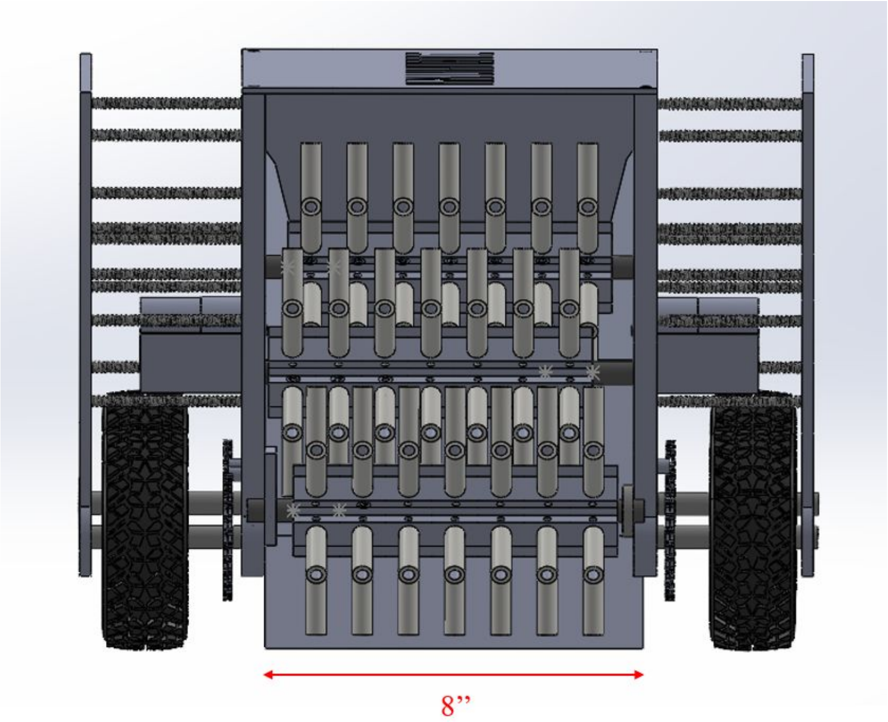
- Durometer tubing
  (OD: 7/16”, ID: 1/4”)
- Tubes attached to spinning D-shaft with 3D printed custom connectors.



Intake Mechanism

Implementation

- 8 in intake opening
- 3 rows of overlapping tube intakes
- Middle row shifted one tube to allow overlapping

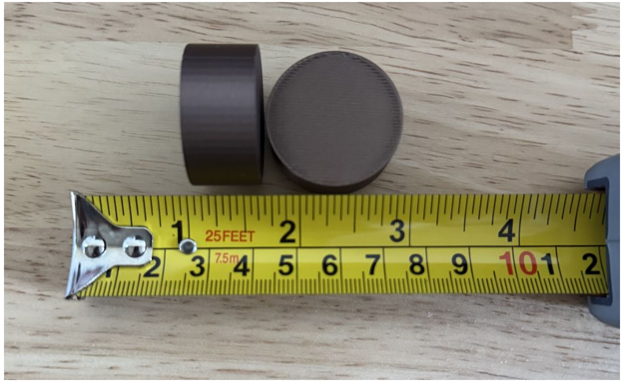


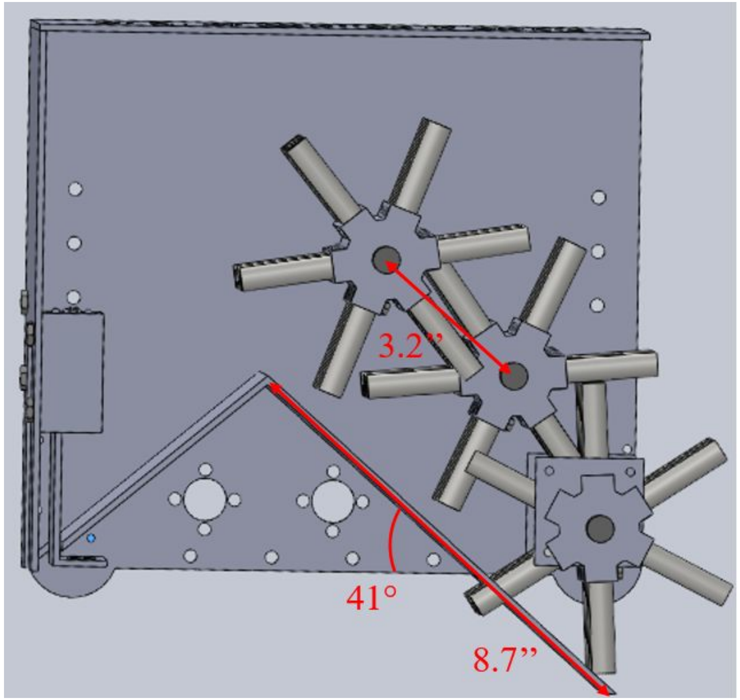
Internal section view

Intake Mechanism

Intake Ramp

- 7 tube stars on each row
- Rods 3.2 in apart
- Intake ramp approx 8.7”at 41°
- Bottom of intake ramp 0.5 in from ground



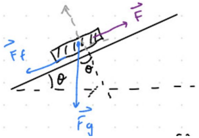


Side view with reduced components

Intake Motor Calculations

Spindle torque requirement calculations:

Assumptions: Ramp angle max is 45° and the coefficient of friction on a metal surface is 0.4



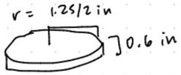
$$F_x = F_f + mgsin(\theta) - F, F_f = \mu F_N$$

$$F_y = -mgcos(\theta) = -F_N$$

$$\Rightarrow F = 0.4(mgcos(45°)) + mgsin(45°)$$

Figuring out mass:

Since pellets are PLA (density $\simeq kg/m^3$



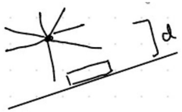
$$v = \pi r^2 h = \pi(\frac{1.25}{2}in)^2(0.6in) = 0.7363in^3$$

$$0.7363in^3 \frac{1ft^3}{(12in)^3}\frac{(0.3048m)^3}{(1ft)^3} = 1.20659 * 10^{-5}$$

then $d = m/v \rightarrow m = dv = 1300kg/m^3 = 0.01568kg$

Finding force:

$$F = 0.1523N$$



Determining motor torque

Assuming $d \leq 2''$ and there are 3 pellets/row and 3 row of spindles

$$T = 0.0696Nm$$

- Estimations:
  - *Estimated PLA* ~ 1300 kg/m^3 for the pellets
    - ~This is a higher density than the expected pellet material, high-density polyethylene (HDPE), of ~930-970 kg/m^3 as outlined in the Rules
  - *Estimated Coefficient of Friction*: 0.4 (Chaplin and Chilson)
- Indicates the spindle motor with 3 rows of spindles connected must have torque >=0.069 N*m

Intake Motor Choice

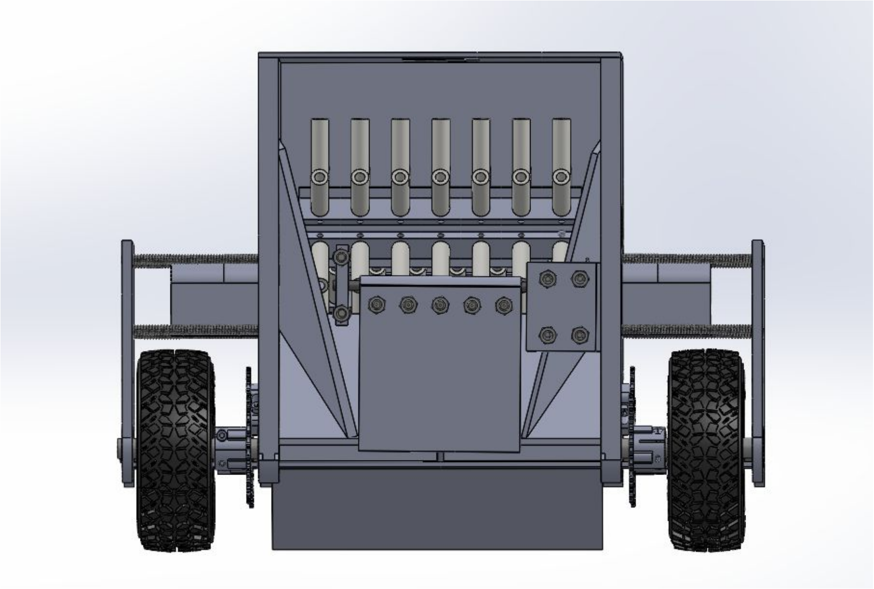
Image source:
https://www.amazon.com/Greartisan-Electric-Reduction-Centric-Diameter/dp/B072R5G5GR?th=1

Product name: Greartisan DC 12V 550RPM Gear Motor High Torque Electric Micro Speed Reduction Centric Output Shaft 37mm Diameter Gearbox

- Pros:
  - High rated rpm (550 rpm) and torque that we need (0.7 kg*cm)
  - Cheap!
- Specification:
  - Size:
    - Gearbox Size: 37 x 22.5mm (1.46" x 0.89") (D*L)
    - Motor Size: 36.2 x 33.3mm (1.43" x 1.31") (D*L)
    - Shaft: 6*14mm (0.24" x 0.55") (D*L), D-shaped
- Cons:
  - Will need to have more than one motor for all the spindle rows

Dumping Mechanism Design

- Releases pellets **controlled and quickly** onto summit funnels
- Pellets slide **via gravity** through inclined reservoir into funnel
- **L-shaped door** rotates **upward** with bottom-mounted **magnetic fixation**
- **Servo motor** controls door opening/closing
- **Door width: 4 in** in case the robot is not fully aligned with funnel



Back View without back plate (Runner)

Angle Calculations

Pellets will slide on incline > 11.5°:

Weight of pellets

Density of HDPE: $\rho_{\text{HDPE}} = 0.95\ \text{g/cm}^3 = 0.0345\ \text{in}^3$

Diameter of pellet: $d = 1.25$ in

Volume of a cylinder: $V_{\text{pellet}} = \pi \times r^2 \times h = \pi \times 0.625^2 \times 0.6 = 0.736\ \text{in}^3$

Mass of one pellet: $m_{\text{pellet}} = \rho_{\text{HDPE}} \times V_{\text{pellet}} = 0.0345 \times 0.736 = 0.0254\ \text{lb} = 11.5\ \text{g}$

Mass of 15 pellets (ideal batch): $m_{15} = 15 \times 11.5\ \text{g} = 173\ \text{g}$

Friction Force vs Parallel Force

Kinetic friction factor between aluminum and HDPE: $\mu_k = 0.2$

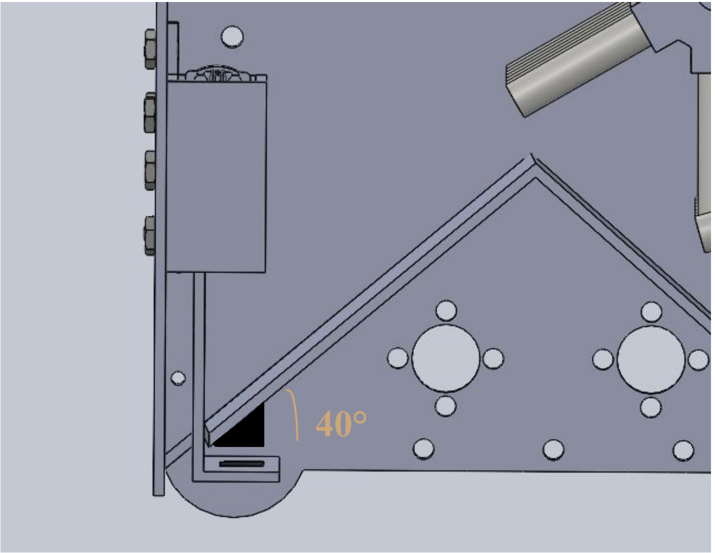
As an approximation assume that the normal force is equal to the weight:

$F_N = F_W = m \times g = 0.0115g \times 9.81m/s^2 = 0.113N$

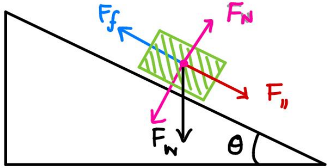
Friction force: $F_f = \mu_k \times F_N = 0.2 \times 0.113N = 0.022563N$

For a pellet to slide down without external force it has to be greater than the friction force $F_{||} > F_f$:

$F_{||} = m \times g \times sin(\Theta) \Rightarrow \Theta = 11.5°$



Side view inside



Weight and Magnet Calculations

Calculating minimum magnet strength needed to hold the weight of the pellet batch (15 pellets)

Magnet Strength

Area Magnet: $A_{magnet} = 0.5in^2 = 0.000322m^2$

The force of the magnet has to be greater than the force the 15 pellets exert on the door (1.69 N): $F > F_{||}$

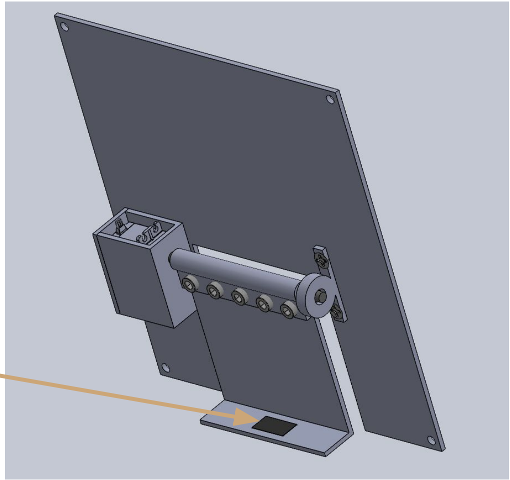
Magnetic Force: $F = \frac{B^2 A}{2\mu_0}$ where $\mu_0 = 4\pi \times 10^{-7}$ N/A^2

The flux density of the magnet needed is:

$$B = \sqrt{\frac{2\mu_0 F}{A}} = \sqrt{\frac{2\mu_0 \times 1.69 \text{ N}}{0.000322 \text{ m}^2}} = 0.1149 \text{ T} = 1148.6 \text{ G} \Rightarrow \text{Chosen magnet: 2000 G}$$

Magnetic force of magnet with 2000 G: $F = 5.12N$

Magnet needed in locking mechanism:
Magnetic Rubber (Y Grade)
Size: 1” x 0.5”



Inside view

Hinge Mechanism & Motor Choice

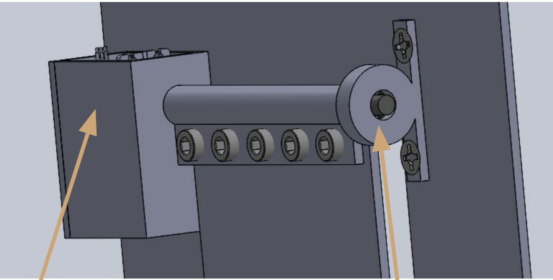
Torque needed given a magnetic force of 5.12 N:

Torque Calculation for Servo Motor to Overcome Magnetic Force

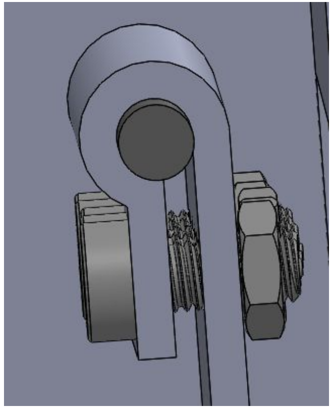
The door should open at most $\alpha = 60°$:

Torque: $\tau = F * r * sin(\alpha) = 0.1m * 5.12N * sin(60) = 0.44Nm$

View from inside the robot



Side view



Servo motor holder

Rod fixation with bearing

Motor choice given the torque calculation:

MG995 Servo
Torque ~ 9.4 kg*cm

Image source: https://www.jsumo.com/mg995-metal-gear-rc-servo-motor-towerpro

Four wheel vs. two wheel drive

Four-Wheel Drive:

- Advantages:
  - Less torque required by each motor individually
  - Able to keep moving in case of 1 motor failure
  - Ensures equal up or down ramp motion
- Disadvantages:
  - Motors are expensive so it restricts the rest of budget
  - Need to account for parallel motors in roboclaw

Two-Wheel Drive:

- Advantages:
  - Less motors needed
  - Less complexity (ie. no need to account for parallel motors in roboclaw)
- Disadvantages:
  - Double the torque output required by each motor
  - Less factor of safety in the case of one motor failure

We decided on a 4-wheel drive

Motor Choice

Nominal Voltage	12V
No load RPM	315 RPM
Rated RPM	150 RPM
No Load Current	<500 mA
Rated Current	<6 A
Stall Current	12 A
Rated Torque	20 kg.cm = 1.96 N*m
Stall Torque	38 kg.cm
Cost	43.95 → 350 (total)
Gearbox Size	-42 mm diameter, -66.5 mm length
Motor Size	-42 mm diameter, -43.5 mm length
Shaft Size	- 8 mm diameter -22 mm length, D-shaped

42mm DC Planetary Gear Motor, 12V, 315 RPM

https://www.robotshop.com/products/e-s-motor-42mm-dc-planetary-gear-motor-12v-315-rpm

Motor Choice

Image source: https://www.robotshop.com/products/e-s-motor-36mm-diameter-high-torque-planetary-gear-motor-24v-440rpm?pr_prod_strat=e5_desc&pr_rec_id=2ae7d25cc&pr_rec_pid=7487499698337&pr_ref_pid=7487504318625&pr_seq=uniform

Product name: 42mm DC Planetary Gear Motor, 12V, 315 RPM

- Pros:
  - Combination of high torque and high speeds when climbing
- Cons:
  - Does not have an encoder
    - We decided if needed for autonomous section we can add a separate encoder module
    - Expensive

Torque Requirements (Climber Robot)

- Estimations:
  - **Weight**: 25 lbs → 111.20 N
  - **Rolling resistance coefficient**: 0.04
    - (White et al., n.d.)
- Force calculations on ramp:
  - *Force due to gravity*: 111.20 N * sin(37) → 66.93 N
  - *Rolling Resistance Force*: 111.20 N * cos(37) * 0.04 = 3.55 N
  - *Total Force* = 66.93 N+ 3.55 N = 70.5 N
- Using 5 in. (0.0625 m) wheels for clearance:
  - Total Torque = 66.93 N * 0.0625 m = 4.40 N*m
- For 4 wheels and conversion:
  - **Torque** = (4.40/4) * 10.197 = 11.23 kg*cm per wheel (T = 1.10 N*m)

Torque Requirements (Runner Robot)

- Estimations:
  - **Weight**: 18 lbs → 80.07 N
  - **Rolling resistance coefficient**: 0.04
    - (White et al., n.d.)
- Force calculations on ramp:
  - *Force due to gravity*: 80.07 N * sin(37) → 48.19 N
  - *Rolling Resistance Force*: 80.07 N* cos(37) * 0.04 = 2.56 N
  - *Total Force* = 48.19 N+ 2.56 N = 50.74 N
- Using 5 in. (0.0625 m) wheels for clearance:
  - Total Torque = 50.74 N * 0.0625 m = 3.17 N*m
- For 4 wheels and conversion:
  - **Torque** = (3.17/4) * 10.197 = 8.08 kg*cm per wheel (T = 0.79 N*m)

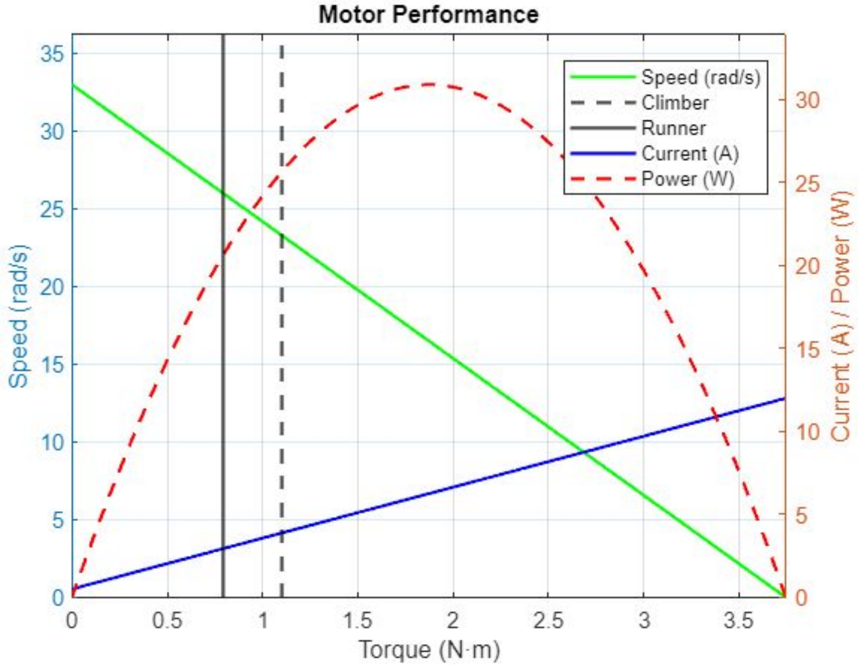
Motor Performance Analysis

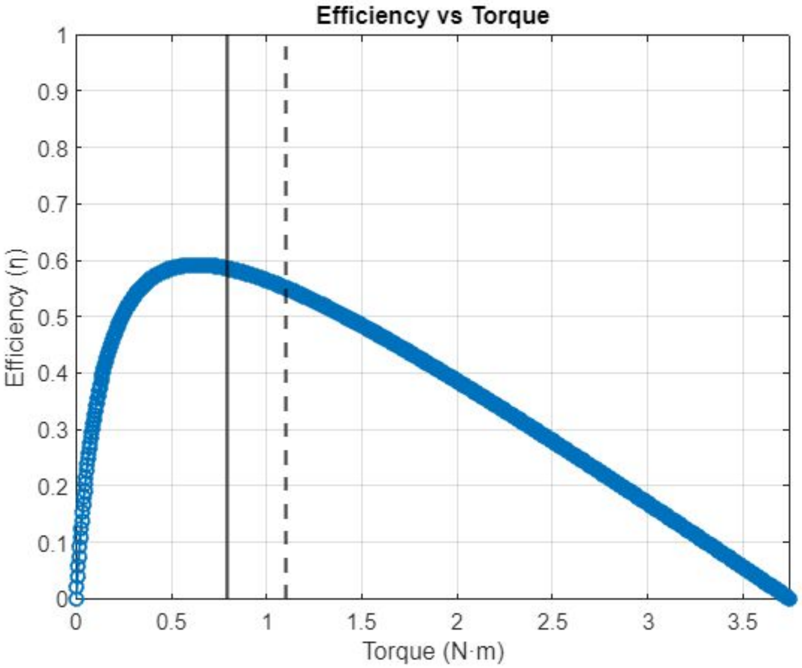
```matlab
% Motor parameters
N = 1.3; % gear ratio
Ts_metric = 38.18182; % torque stall in kg*cm
Ts = Ts_metric * (9.81 / 100); % torque stall in N*m
w0_rpm = 315 ; % no load rpm
w0 = w0_rpm * ((2 * pi) / 60); % no load rad/s
V0 = 12; % rated voltage
i0 = 0.5; % no load current (A)
is = 12; % stall current (A)

ToH = 1.10093172364; % Operating Torque N/m per motor for Climber
ToL= 0.792670841032; % Operating Torque N/m per motor for Runner

% Original motor performance functions
speed = @(T) w0 * (1 - (T / Ts)); % rad/s
current = @(T) i0 + (is - i0) * (T / Ts); % A
power = @(T) w0 * T - (w0 / Ts) .* T.^2; % W
efficiency = @(T) ((T .* w0) .* (1 - (T ./ Ts))) ./ ...
    (V0 .* (i0 + (is - i0) .* T ./ Ts));

x = linspace(0, Ts, 1000);

speed1 = speed(x);
current1 = current(x);
power1 = power(x);
efficiency1 = efficiency(x);
```

```matlab
% === Motor Performance Plot with dual  ===
figure;
yyaxis left
plot(x, speed1, 'g', 'LineWidth', 1.5);
ylabel('Speed (rad/s)');
ylim([0, w0*1.1]);
hold on;

yyaxis right
plot(x, current1, 'b', 'LineWidth', 1.5);
hold on;
plot(x, power1, 'r', 'LineWidth', 1.5);
ylabel('Current (A) / Power (W)');
ylim([0, max(power1)*1.1]);

hold on;
xline(ToH, '--k', 'LineWidth', 1.5);
hold on;
xline(ToL, 'k', 'LineWidth', 1.5);

xlabel('Torque (N·m)');
title('Motor Performance');
legend({'Speed (rad/s)', 'Current (A)', 'Power (W)', 'Heavy', 'Light'}, 'Location', 'best');
grid on;
xlim([0, Ts]);
```

```matlab
% === Efficiency Plot ===
figure;
plot(x, efficiency1, '-o', 'LineWidth', 1.2);
hold on;
xline(ToH, '--k', 'LineWidth', 1.5);
hold on;
xline(ToL, 'k', 'LineWidth', 1.5);
ylim([0 1]);
xlim([0 Ts]);
title('Efficiency vs Torque');
xlabel('Torque (N·m)');
ylabel('Efficiency (η)');
grid on;
```

Motor Performance Analysis





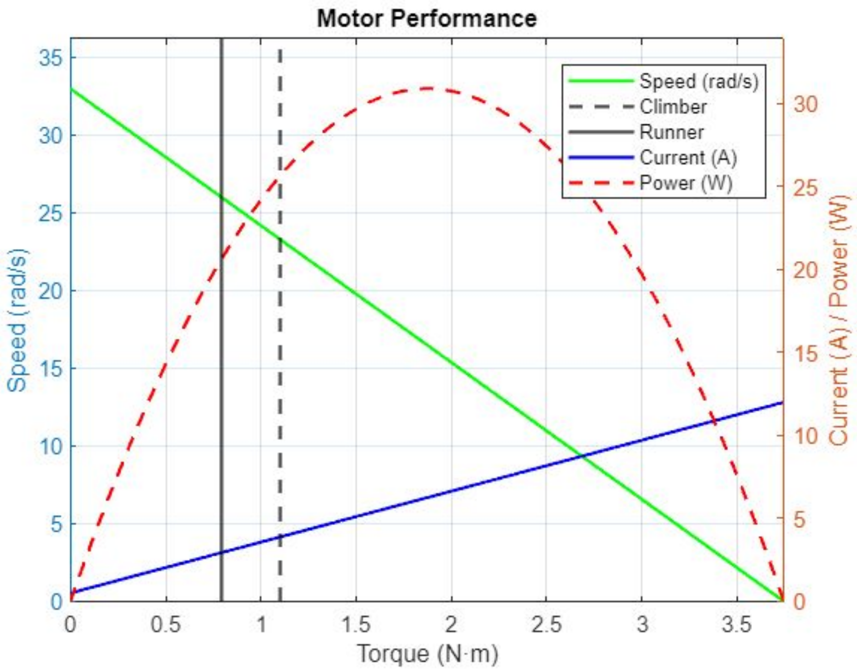
Motor Performance Analysis (While Climbing)

Climber Torque T = 1.10 N*m

- Rotational Speed = 23.29 rad/s
  - Actual Speed = 23.29 * 0.0625 m = 1.455 m/s
- Power Generated = Torque * Rot Speed(rad/s) → Power = (1.10) * 23.29 = 25.61 W
- Current Drawn = 3.94 A

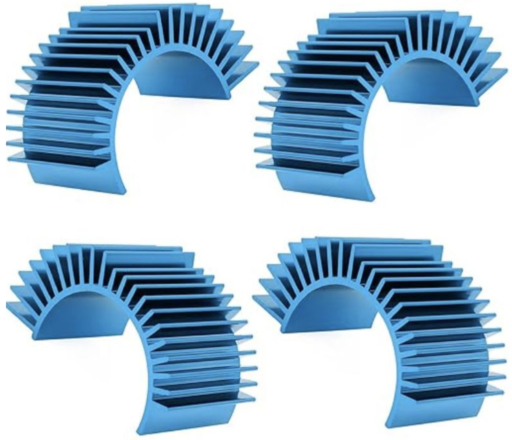
Runner Robot Torque T = 0.79 N*m

- Rotational Speed = 26.00 rad/s
  - Actual Speed = 26.00 * 0.0625 m = 1.624 m/s
- Power Generated = Torque * Rot Speed(rad/s) → Power = (0.79) * 26.00 = 20.54 W
- Current Drawn = 2.84 A



Motor cooling system

- Heat sinks around all driving motors to prevent overheating
- Sizing matches OD of chosen driving motors



https://www.walmart.com/ip/2Pcs-42mm-Motor-Cooling-Fan-Heat-Sink-for-1-10-E-Maxx-E-Summit-Arrma-1-8-Kraton-Talion-RC-Car-Red/13590105012?wmlspartner=wlpa&selectedSellerId=102637450

Wheel Choice

All-terrain wheels will be used:

- They maximize traction on the incline
- Good for flat, hard surfaces
- Simple and efficient, easy to maintain
- Good maneuverability
- Can take up to 88 lbs
- Wheel weight = 9.5 oz or 0.594 lb (0.257) kg

Wheel dimensions:

- 4.92 in diameter for clearances purposes
- 1.85 in width
- 0.5 in bore diameter

Image Source:
https://www.studica.com/studica-robotics-brand/125mm-all-terrain-wheel-set?gad_source=1&gad_campaignid=216324968&gbraid=0AAAAAD_wtpaseM9ein5S01SOcN_Soosh3&gclid=Cj0KCQjwo63HBhCKARIsAHOHV_WR8MD7d0x5KxaaBUxbBT0ImEPNEsmtgjNdF_yOTWTGj87Udb7vx7EaAniWEALw_wcB

Drivetrain

- Motors will be located under the inclined ramp section and connect to the wheels through a chain and sprocket mechanism
  - Motor shaft is D-shaped → will attach a gear onto the D-shaft with gear hub
  - Wheel shaft will be a ½ in shaft based on wheel bore size
  - Chain is of adjustable length to optimize for robot specifications
- The chosen gears are less than 1 in in diameter larger than the motor diameter to ensure compatibility

Example of chain and sprocket parts:

Image source: https://www.vexrobotics.com/iq-chainsprock.html?srsltid=AfmBOoqOMtf3uXSEQeAqP_In6NPrBe_cQvAddMJ1YREsB5aE3YJdDy9O

Drivetrain - Chain and Sprocket Ratio Selection

We decided to go with a gear tooth ratio of 26 teeth (on the wheel shaft)

to 20 teeth (on the motor shaft)

- 1.3 multiplier for increase in our wheels torque
- 0.77 multiplier for speed reduction

Chain:

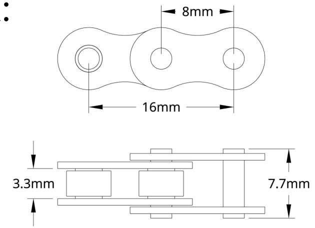


Image Source:
https://www.gobilda.com/8mm-pitch-steel-chain-connecting-link-6-pack/

26 tooth sprocket

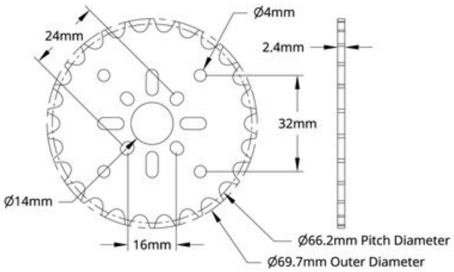


Image source:
https://www.gobilda.com/8mm-pitch-acetal-hub-mount-sprocket-14mm-bore-26-tooth/

20 tooth sprocket

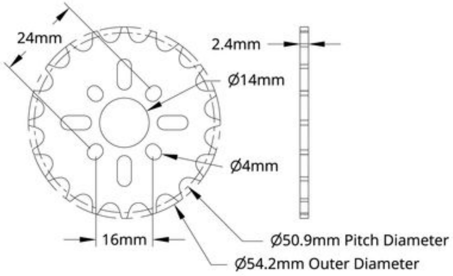
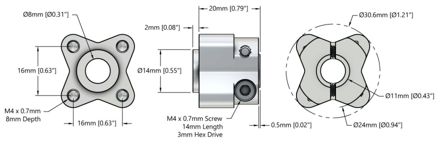


Image source:
https://www.gobilda.com/8mm-pitch-acetal-hub-mount-sprocket-14mm-bore-20-tooth/

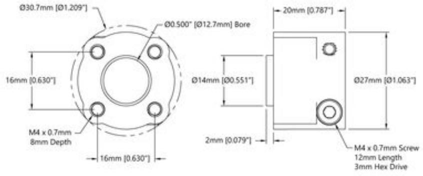
Hubs: 8 mm D-shaft motor



Patented

Image source: https://www.gobilda.com/1310-series-hyper-hub-8mm-bore/

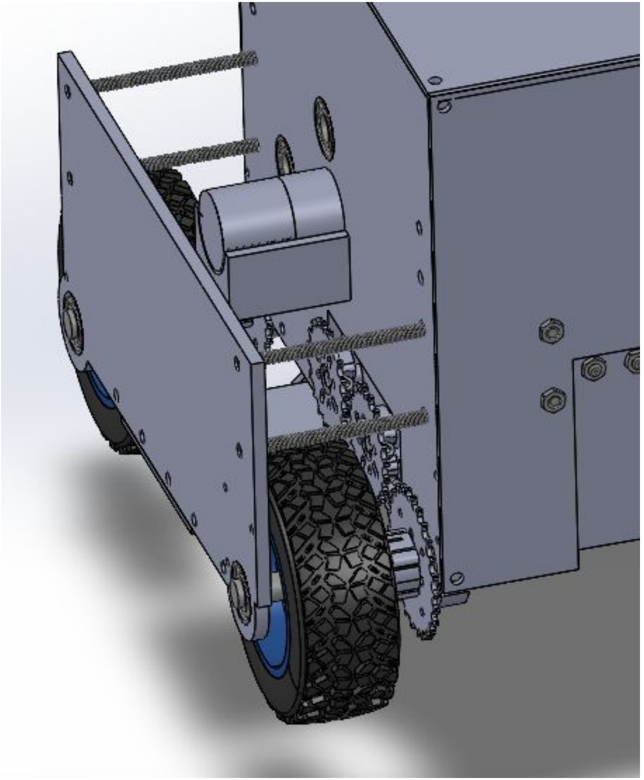
Hubs: ½ shaft

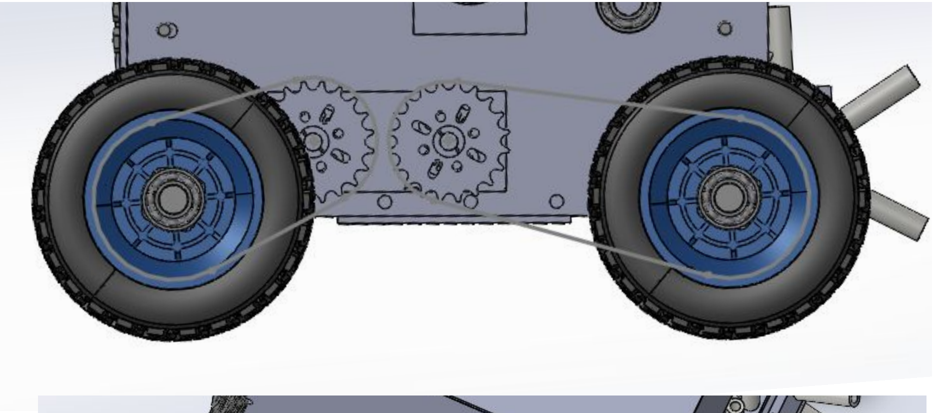


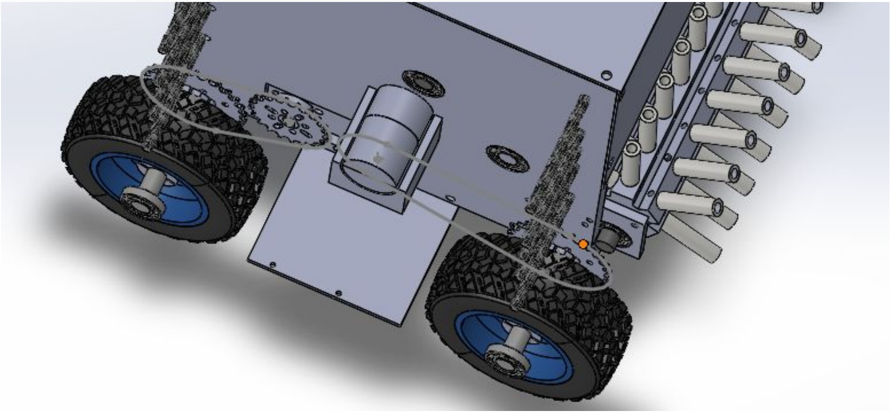
Patented

Image Source: https://www.gobilda.com/1310-series-hyper-hub-1-2-bore/

Drivetrain Assembly CAD







Drivetrain - Chain and Sprocket Length

$$L = \frac{2C}{P} + \frac{N+n}{2} + \frac{P\left(((N-n)/2*\pi)^2\right)}{C}$$

$$C = 2.5in = 6.35cm$$

$$P = 8mm = 0.8cm$$

$$N = 26teeth$$

$$m = 20teeth$$

$$L = \frac{2*6.35}{0.8} + \frac{26+20}{2} + \frac{0.8\left(((26-20)/2*\pi)^2\right.}{6.35}$$

Chain length in terms of links = 38.9

Number of chain links needed = 39

$$L = \frac{2C}{P} + \frac{N+n}{2} + \frac{P\left(((N-n)/2*\pi)^2\right)}{C}$$

$$C = 4.8in = 12.2cm$$

$$P = 8mm = 0.8cm$$

$$N = 26teeth$$

$$m = 20teeth$$

$$L = \frac{2*12.2}{0.8} + \frac{26+20}{2} + \frac{0.8\left(((26-20)/2*\pi)^2\right.}{12.2}$$

Chain length in terms of links = 53.56

Number of chain links needed = 54

Formula from: https://docs.revrobotics.com/duo-build/motion/sprockets-and-chain/sprockets-and-chain-advanced

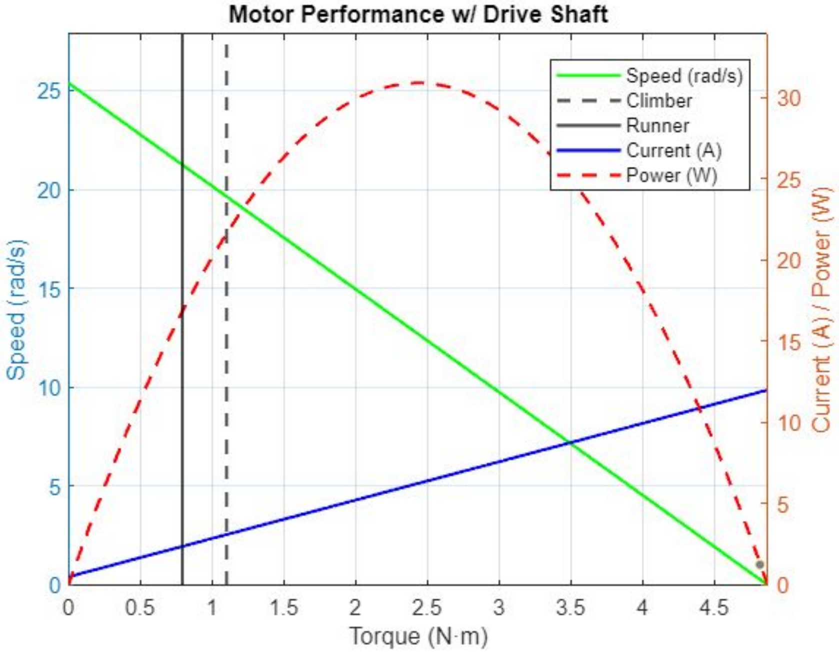
Motor Performance Analysis with Drivetrain

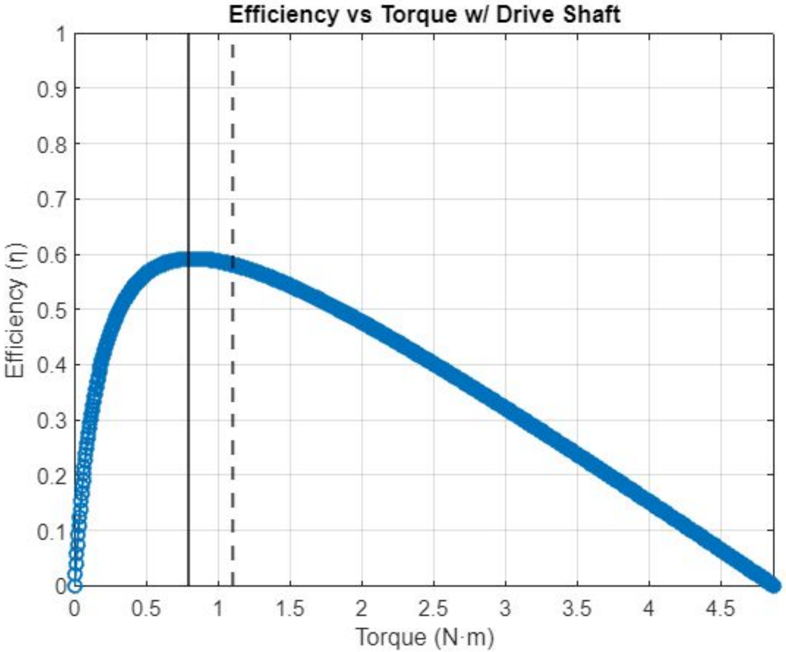
```
% Motor parameters with Gear Ratio
N = 1.3; % gear ratio
Ts_metric = 38.18182 * N; % torque stall in kg*cm
Ts = Ts_metric * (9.81 / 100); % torque stall in N*m
w0_rpm = 315 ; % no load rpm
w0 = w0_rpm * ((2 * pi) / 60)/N; % no load rad/s
V0 = 12; % rated voltage
i0 = 0.5; % no load current (A)
is = 12; % stall current (A)

ToH = 1.10093172364; % Operating Torque N/m per motor for Climber
ToL= 0.792670841032; % Operating Torque N/m per motor for Runner

% Original motor performance functions
speed = @(T) w0 * (1 - (T / Ts)); % rad/s
current = @(T) i0 + (is - i0) * (T / Ts); % A
power = @(T) w0 * T - (w0 / Ts) .* T.^2; % W
efficiency = @(T) ((T .* w0) .* (1 - (T ./ Ts))) ./ ...
    (V0 .* (i0 + (is - i0) .* T ./ Ts));

x = linspace(0, Ts, 1000);

speed1 = speed(x);
current1 = current(x);
power1 = power(x);
efficiency1 = efficiency(x);
```

```
% === Motor Performance Plot with dual y-axes ===
figure;
yyaxis left
plot(x, speed1, 'g', 'LineWidth', 1.5);
ylabel('Speed (rad/s)');
ylim([0, w0*1.1]);
hold on;

yyaxis right
plot(x, current1, 'b', 'LineWidth', 1.5);
hold on;
plot(x, power1, 'r', 'LineWidth', 1.5);
ylabel('Current (A) / Power (W)');
ylim([0, max(power1)*1.1]);

hold on;
xline(ToH, '--k', 'LineWidth', 1.5);

hold on;
xline(ToL, 'k', 'LineWidth', 1.5);

xlabel('Torque (N·m)');
title('Motor Performance w/ Drive Shaft');
legend({'Speed (rad/s)', 'Current (A)', 'Power (W)', 'Climber', 'Runner'}, 'Location', 'best');
grid on;
xlim([0, Ts]);
```

```
% === Efficiency Plot ===
figure;
plot(x, efficiency1, '-o', 'LineWidth', 1.2);
hold on;
xline(ToH, '--k', 'LineWidth', 1.5);
hold on;
xline(ToL, 'k', 'LineWidth', 1.5);
ylim([0 1]);
xlim([0 Ts]);
title('Efficiency vs Torque w/ Drive Shaft');
xlabel('Torque (N·m)');
ylabel('Efficiency (η)');
grid on;
```

Motor Performance Analysis with Drive Train





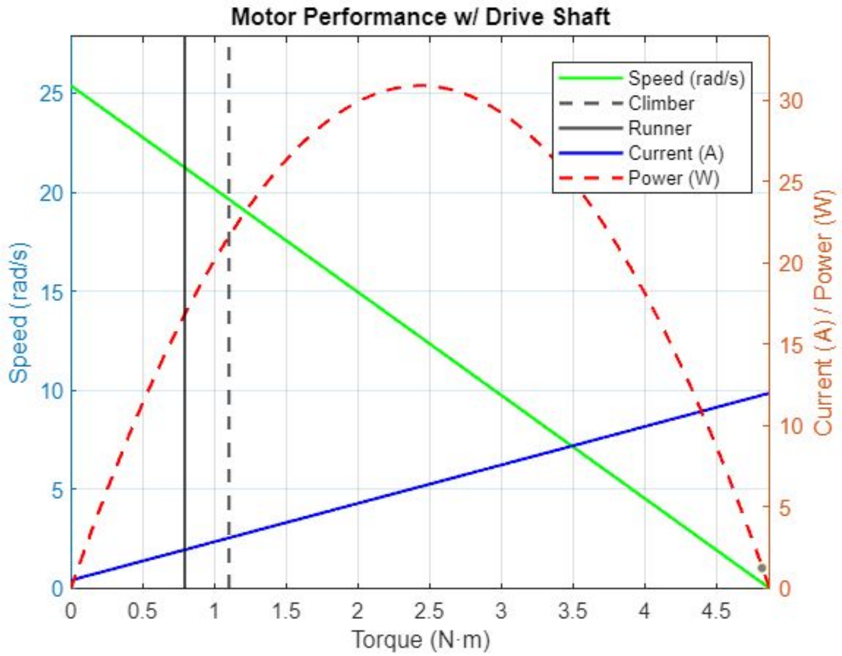
Motor Performance Analysis with Drivetrain

Climber Torque T = 1.10 N*m

- Rotational Speed = 19.66 rad/s
    - Actual Speed = 19.66 * 0.0625 m = 1.229 m/s
- Power Generated = Torque * Rot Speed(rad/s) → Power = (1.10) * 19.66 = 21.63 W
- Current Drawn = 3.08 A

Runner Robot Torque T = 0.79 N*m

- Rotational Speed = 21.26 rad/s
    - Actual Speed = 21.26 * 0.0625 m = 1.329 m/s
- Power Generated = Torque * Rot Speed(rad/s) → Power = (0.79) * 21.26 = 16.7954 W
- Current Drawn = 2.34 A



Power-to-Weight Ratio

Climber Robot:

- *Power* = 21.63 W
- *Weight* = 25 lbs = 11.3 kg*9.81 m/s^2 = 110.85 N

Ratio = 21.63 W / 110.85 N = 0.195 W/N

Runner Robot:

- *Power* = 16.7954 W
- *Weight* = 18 lbs = 8.16 kg * 9.81 m/s^2 = 80.05 N

Ratio = 16.8 W / 80.05 N = 0.210 W/N

Current Draw by Drivetrain & Motors

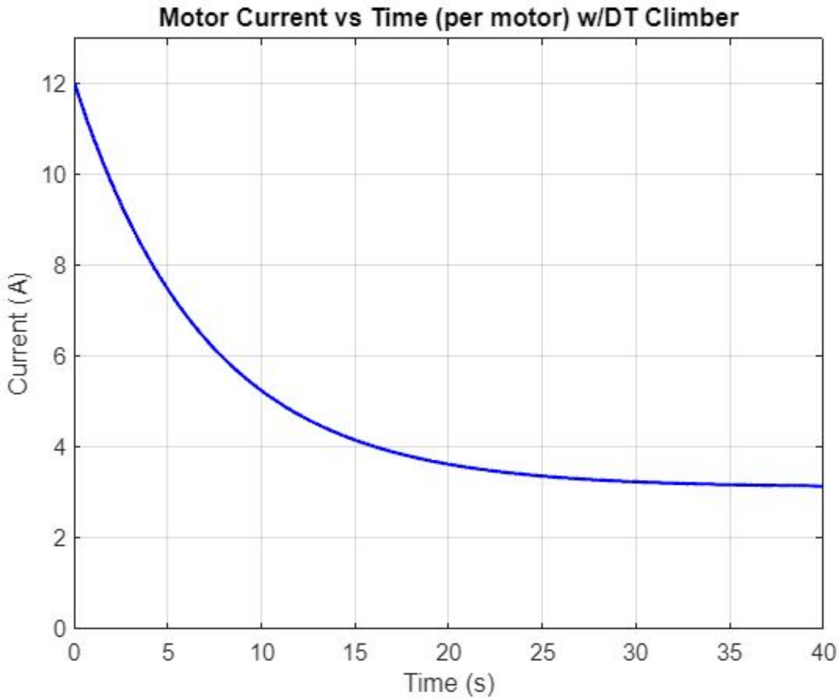
Climber Robots:

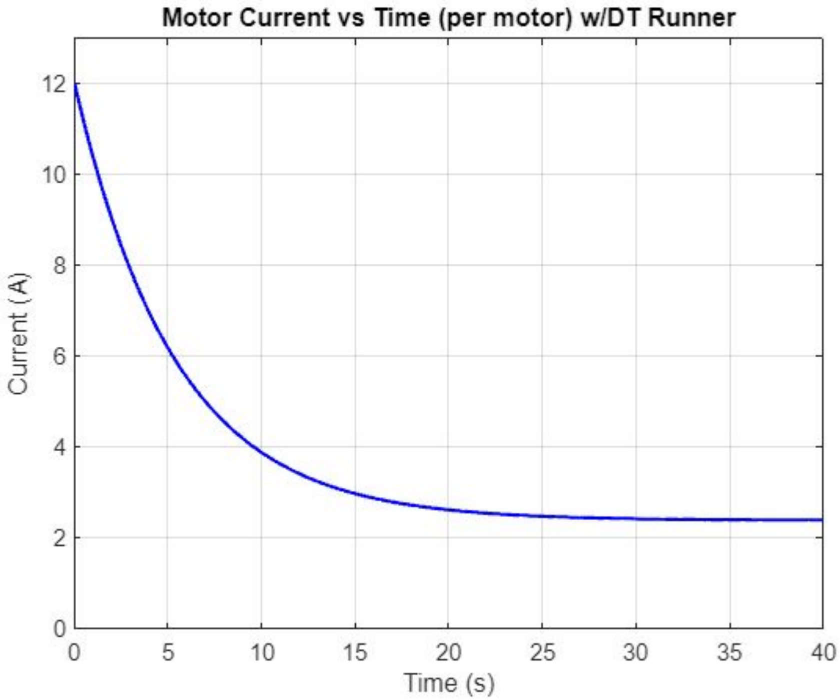
```
% === Extra motor performance plot for HEAVY ===
Tx1 = ToH * 4; % load torque in N*m HEAVY
r = 0.062484; % radius in m
meff = 13.7335395499; % effective mass in kg
time_constant = (4 * Ts / 100) / (r^2 * w0 * meff);
current_draw = @(t) i0 + (is - i0) .* (((Tx1 / 100) / (4 * Ts / 100)) +
    (exp(-time_constant .* t)) .* (1 - ((Tx1 / 100) / (4 * Ts / 100))));

y = linspace(0, 40, 1000);
current_draw1 = current_draw(y);

figure;
plot(y, current_draw1, 'b', 'LineWidth', 1.5);
title('Motor Current vs Time (per motor) w/DS HEAVY');
xlabel('Time (s)');
ylabel('Current (A)');
ylim([0 22]);
grid on;
```

Runner

```
% === Extra motor performance plot for LIGHT ===
Tx2 = ToL * 4; % load torque in N*m LIGHT
r = 0.062484; % radius in m
meff = 10.5594772355; % effective mass in kg
time_constant = (4 * Ts / 100) / (r^2 * w0 * meff);
current_draw = @(t) i0 + (is - i0) .* (((Tx2 / 100) / (4 * Ts / 100)) + ...
    (exp(-time_constant .* t)) .* (1 - ((Tx2 / 100) / (4 * Ts / 100))));

y = linspace(0, 40, 1000);
current_draw1 = current_draw(y);

figure;
plot(y, current_draw1, 'b', 'LineWidth', 1.5);
title('Motor Current vs Time (per motor) w/DS LIGHT');
xlabel('Time (s)');
ylabel('Current (A)');
ylim([0 22]);
grid on;
```

Current Draw by Drivetrain & Motors





Electronics Requirements

Runner Robot

Part	Link	Quantity	Voltage needed	Current needed	Peak current	Total voltage	Total cont. current	Total pk. current
Driving Motor	https://www.robotshop.com/products/e-s-motor-42mm-dc-planetary-gear-motor-12v-315-rpm	4	12 V	~6 A	12 A	12 V	24 A	48 A
Backdoor Motor	https://www.jsumo.com/mg995-metal-gear-rc-servo-motor-towerpro	1	4.8-6 V	~0.4 A	~1.2 A	~5 V	0.4 A	1.2
Intake Motor	https://www.amazon.com/Greartisan-Electric-Reduction-Centric-Diameter/dp/B072R5G5GR?th=1	2	12 V	0.5 A	Not listed	12 V	1 A	??
Receiver	https://www.amazon.com/GoolRC-FS-iA6B-Receiver-Compatible-Transmitter/dp/B07XJWDMFX?th=1	1	4.0-6.5 V	~0.5 A (not listed)	Not listed	~5 V	~0.5 A	--
Arduino MEGA	https://docs.arduino.cc/hardware/mega-2560/#tech-specs	1	5 V	0.05 - 0.07 A (depends on what is run, probably want to recalculate more thoroughly later)	Not listed (depends on what is run, probably want to recalculate more thoroughly later)	5 V	0.07 A	--
Infrared sensor	https://www.digikey.com/en/products/detail/sunfounder/ST0050/22116814	3	3.3-5V	~0.01 A (not actually listed)	Not listed	3.3 - 5 V	~0.03 A	--
2x60 A Roboclaw	https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE	1	-	-	-	Supplies additional 5 V voltage (source: Spec sheet from https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE)	Supplies additional 3A current (source: Spec sheet from https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE)	--

Climber Robot

Part	Link	Quantity	Voltage needed	Current needed	Peak current	Total voltage	Total cont. current	Total pk. current
Driving Motor	https://www.robotshop.com/products/e-s-motor-42mm-dc-planetary-gear-motor-12v-315-rpm	4	12 V	~6 A	12 A	12 V	24 A	48 A
Backdoor Motor	https://www.jsumo.com/mg995-metal-gear-rc-servo-motor-towerpro	1	4.8-6 V	~0.4 A	~1.2 A	~5 V	0.4 A	1.2 A
Intake Motor	https://www.amazon.com/Greartisan-Electric-Reduction-Centric-Diameter/dp/B072R5G5GR?th=1	2	12 V	0.5 A	Not listed	12 V	1 A	??
Receiver	https://www.amazon.com/GoolRC-FS-iA6B-Receiver-Compatible-Transmitter/dp/B07XJWDMFX?th=1	1	4.0-6.5 V	~0.5 A (not listed)	Not listed	~5 V	~0.5 A	--
Arduino MEGA	https://docs.arduino.cc/hardware/mega-2560/#tech-specs	1	5 V	0.05 - 0.07 A (depends on what is run, probably want to recalculate more thoroughly later)	Not listed (depends on what is run, probably want to recalculate more thoroughly later)	5 V	0.07 A	--
2x60 A Roboclaw	https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE	1	-	-	-	Supplies additional 5 V voltage (source: Spec sheet from https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE)	Supplies additional 3A current (source: Spec sheet from https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEu-3FXTkgZxeVK-AFWX-RZ6MmTzAYi64YOKH8KaoCeiv3rPAwWByLRoC0WgQAvD_BwE)	--

Battery Calculations

- Capacity: 3000mAh
- Voltage: 4S1P / 4 Cell / 14.8V
- Discharge: 25C Constant / 50C Burst
- Weight: 278g
- Dimensions: 150x45x24mm

Max current provided:

3.0 Ah * 50 C = 150 A

Stall current needed:

4 * 12 A drive motors + 2 * ~2 A intake motors + ~1 A for additional electronics = 53 A

150 A > 53 A → **this battery is sufficient for the stall current condition.**

Continuous current:

3.0 Ah * 25 C = 75 A

Continuous current needed:

at most 6 A * 4 motors + 1 A ~1 A for additional electronics = 26 A

75 A > 26 A → **this battery is sufficient for the stall current condition.**

Battery Calculations (Continued)

Needed energy budget from all electronics:

Current draw per motor (climber – more current-intensive case):

- 3.08 A climbing
- ~1 A flat ground current draw
- 12 A stall current when accelerating

Across a 270-second match, we estimate:

- ~6.6 ft ramp / 4.032 ft/s ramp drive time * 10 ascends = 17 s climb
- ~ 233 s cruise time
- ~20 s stall (accelerating and pushing)

I_avg_needed ~= 10 A total, including intake motors and additional electronics

Energy budget per round from battery:

I_avg_budget = 0.8 * 3.0 Ah * 60/4.5 = **32 A**

$$I_{avg} = \frac{\sum I_i t_i}{T}$$

I_avg_needed < I_avg_budget: The battery provides enough current per round.

Battery Calculations (Continued)

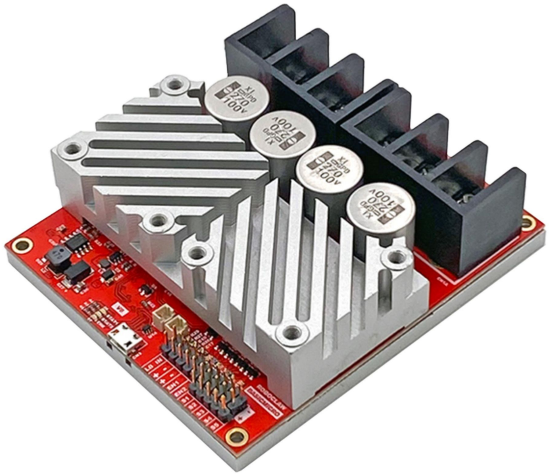
- Capacity: 3000mAh
- Voltage: 4S1P / 4 Cell / 14.8V
- Discharge: 25C Constant / 50C Burst
- Weight: 278g
- Dimensions: 150x45x24mm

Battery Life:

3.0 Ah / (~10 A) = 0.3 h = 18 min

The batteries could theoretically last 4 rounds, but should be charged in between rounds or switched out to optimize voltage.

Roboclaw Calculations



2x60 A Roboclaw:
https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEnScaMdnmqN4qR8ckW4JIlaGvNCY0dejyPUdPdCRLMqfrGZmOJT9hRoC3p4QAvD_BwE

Continuous current:

Roboclaw provides 60 A per channel → 30 A per motor

Motors need ~6 A continuous current each

6 A < 30 A → **2x60 A Roboclaw will satisfy needed continuous current**

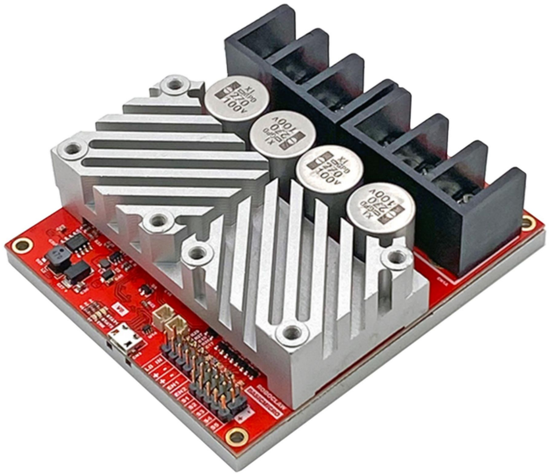
Stall current:

Roboclaw provides 120 A peak current per channel → 60 A per motor

Motors are rated for 12 A stall current

12 A < 60 A → **2x60 A Roboclaw will satisfy needed stall current**

Roboclaw 5V BEC Power System



2x60 A Roboclaw:
https://www.gobilda.com/roboclaw-2x60a-motor-controller/?setCurrencyId=1&sku=IMC414&gad_source=1&gad_campaignid=12299979486&gbraid=0AAAAC78-tPIdWUYAyoAaF1Qh8Q4YA0qs&gclid=CjwKCAjwpOfHBhAxEiwAm1SwEnScaMdnmqN4qR8ckW4JIlaGvNCY0dejyPUdPdCRLMqfrGZmOJT9hRoC3p4QAvD_BwE

Encoder Power (+ -)

The pins labeled + and - are the source power pins for encoders. The positive (+) is located at the board edge and supplies +5VDC. The ground (-) pin is near the heatsink. On ST models all power must come from the 5V screw terminals and the GND screw terminals.

RoboClaw supports 3.3V or 5V logic levels, travel limit switches, home switches, emergency stop switches, power supplies, braking systems and contactors. A built-in switching mode BEC supplies 5VDC at up to 3 Amp for powering user devices. In addition power supplies can be utilized by enabling the built in voltage clamping control feature.

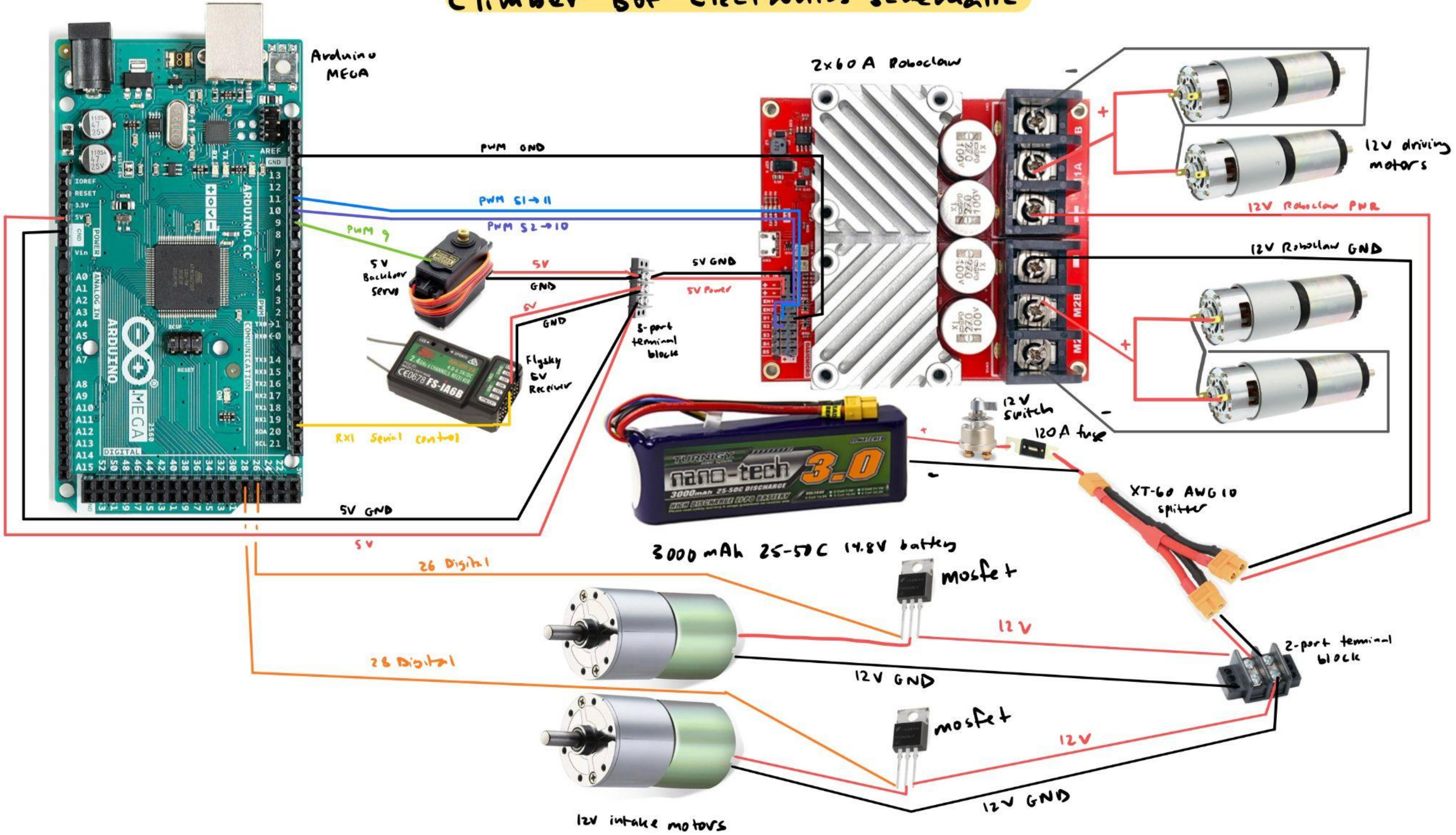
Electronics powered from 5V power source:

- Backdoor motor: **1.2 A stall**, 5 V
- Receiver: **0.5 A**, 5 V
- Arduino: **~0.07 A**, 5 V
- IR Sensors: ~0.01 A * 3 = **0.03 A**, 5 V

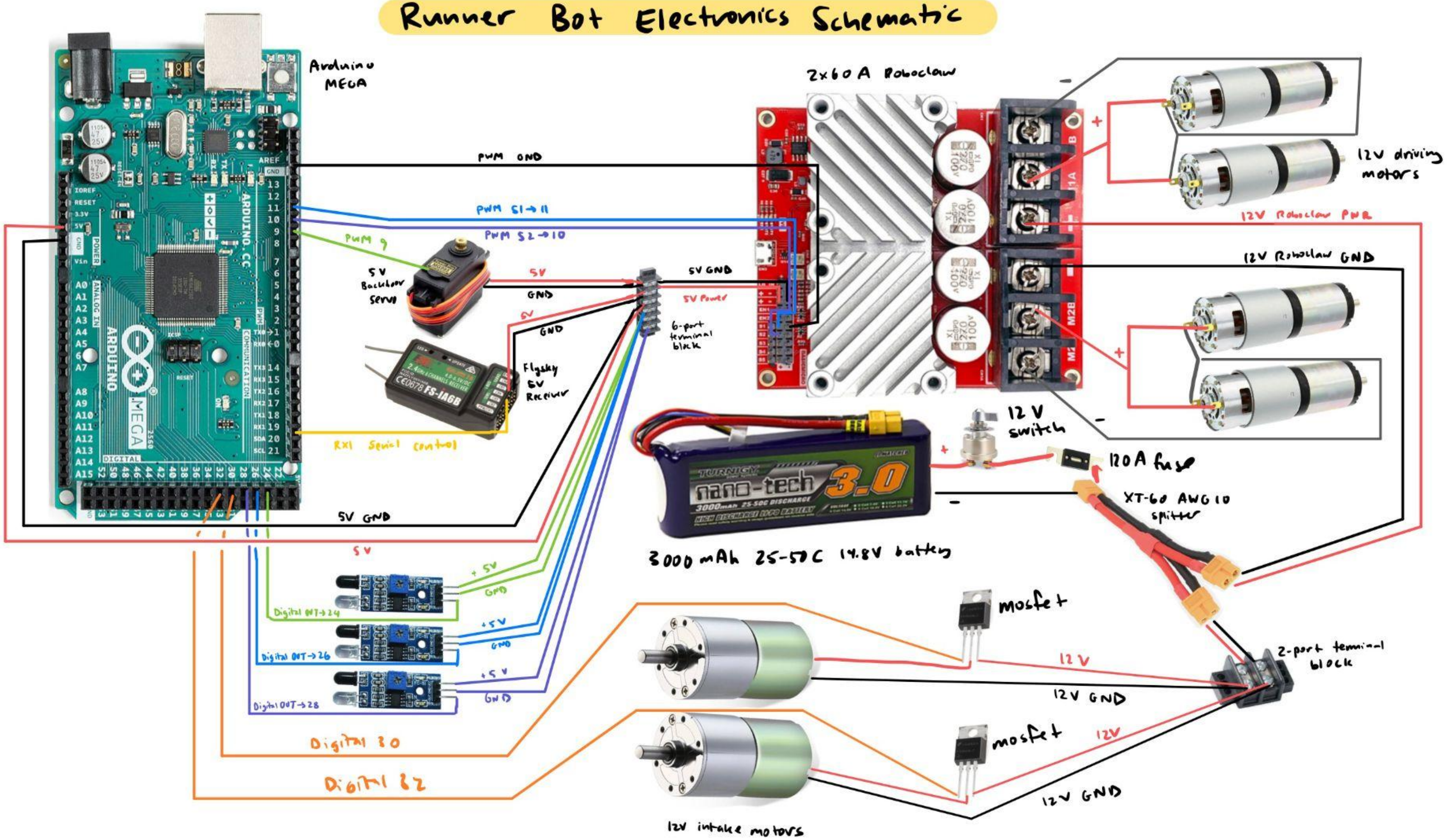
Total worst-case current draw: 1.8 A < 3 A

(will not overdraw from the Roboclaw)

Climber Bot Electronics Schematic



Runner Bot Electronics Schematic



Insulation & Control

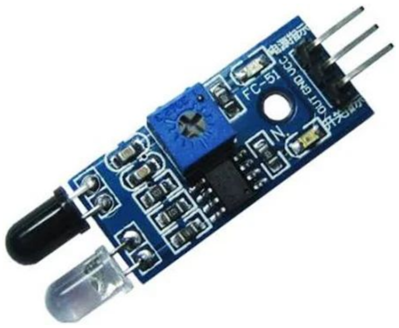
- Insulation & Protection
  - 12 AWG for battery connections
    - Lipo battery (main feed) → Roboclaw & Intake motors
  - 14 AWG for everything attached to Roboclaw BEC
    - Backdoor servo motor, receiver, IR sensors, arduino
  - Solder and heat shrink wires to protect exposed metal, electrical tape to secure
  - Insulate casings of electronics using insulating electrical tape
  - All electronics (except motors) stored in central location at top of robot for easy access
- RC Control
  - As stated in rules

Autonomous

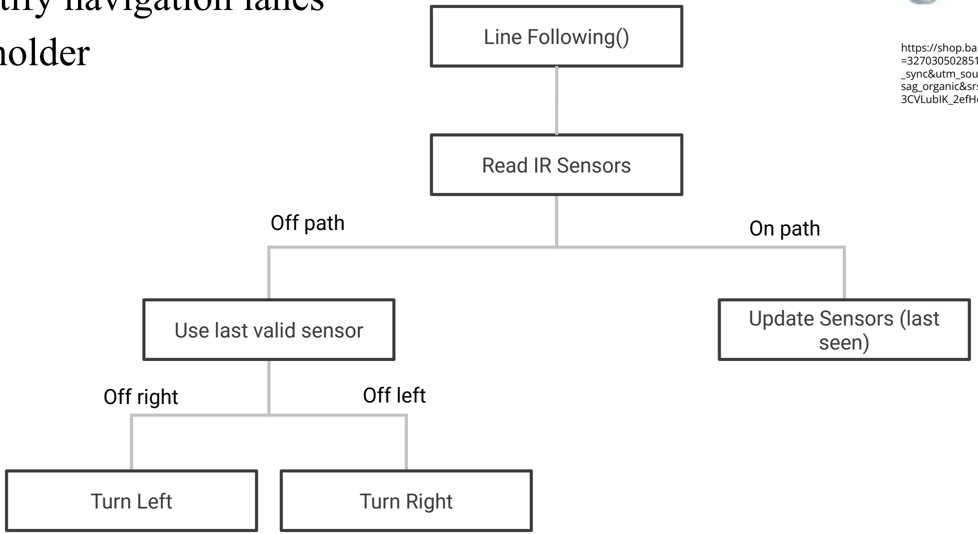
Runner Robot will contain autonomous component (30s)

Game strategy: Line-follow to press button first.

- 3 IR Sensors to identify navigation lanes
- 3D print IR Sensor holder



https://shop.barnabasrobotics.com/products/ir-sensor-module?variant=32703050285149&country=US&currency=USD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&srsltid=AfmBOopMdm11bDZA9tOeuKknV7ehVpllAKqExD_3CVLubIK_2efHo_XA2G4



Design Strengths & Weaknesses

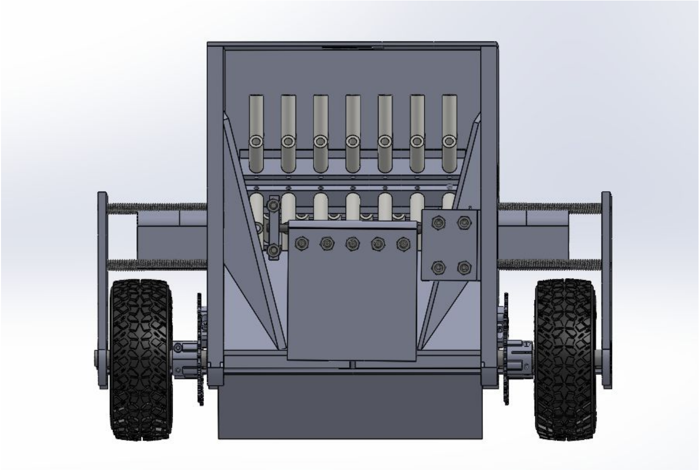
Strengths	Weaknesses
Both robots capable of all tasks	Partially exposed front spindle rod
Large contact surface area	Complex assembly
Extra space for electronics and counterbalances in chassis	Higher COG due to higher location of lipo battery
Energy-efficient intake + dispensing system	

Risk Assessment

Possible failure points:

- Combat time/time motors are near stall are much longer than anticipated based on other teams' strategies
- Collision with corner of robot resulting in damage of intake rod could eliminate all scoring capabilities

Material Considerations



Inner Chassis Plates: ½ ” Aluminum plates

- Lightweight, durable, easily cut in WaterJet

Intake and Reservoir Ramp: 1/16” Aluminum

Spindles: Surgical Tubing intake

- Allows for deformity but rigid enough to pick up pellets

Dumping Mechanism Door: 3D printing (PLA)

Outer Plates: 0.22” polycarbonate sheets

- 50% less weight than aluminum plates, higher impact resistance

Bearing Selection

Wheels

- Shaft size: 0.5”

Intake bearings

- Shaft size: 0.5”

Selection: Flanged Ball Bearings

Limit Dynamic Load: 1600 Pounds

Limit Dynamic Speed: 4600 rpm

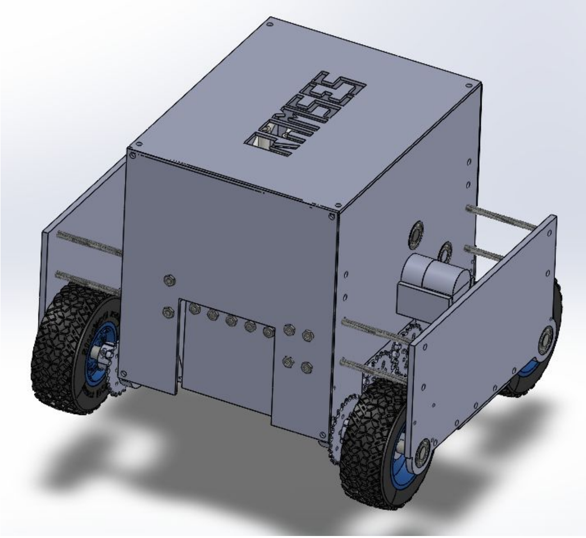
½” x 1 ⅛” x ½”

bearings

Material + Protection Considerations

Materials:

- Majority of chassis made of aluminum sheets cut to size
- Outer walls made out of polycarbonate which has much higher impact resistance to absorbs shocks and can flex without cracking or shattering as opposed to permanently denting (it is also much lighter).



Protection:

- Outer walls protect wheels and ramp walls against impact
- Front wall extends down to protect intake

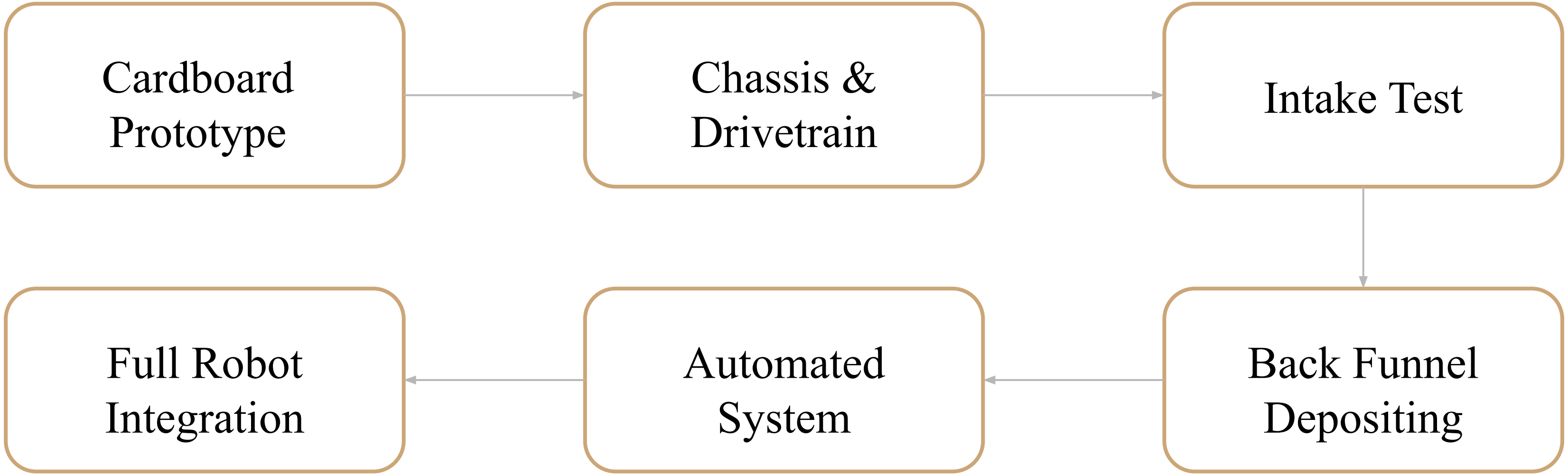
Durability in Fights

- We can calculate the momentum that each robot can impact based on mass and velocity.
    - Climber:
        - (315 rpm *2*pi/60)* 9.07185 kg = 299.25 N * s
    - Speedy
        - (315 rpm * 2*pi/60) * 6.80389 kg = 224.438 N * s
- After impact, if we assume velocity goes to zero this also represents the impulse generated on collision and how much impulse we can impart on another team's robot during the combat phase.
- We plan to prevent impact from opposing team robots by maneuvering to the side as well as the design change of our outer walls to polycarbonate instead of aluminum.

Manufacturing Process

- Walls (ramp, outer)
  - Aluminum sheets cut roughly to size, mill down to precision
  - Holes milled in for the intake rods, threaded rods, attachment
- Intake + Spindles
  - Ramp cut with CNC machine, holes are inserted for wall attachment
  - Spindle Creation: Cutting down the rods that hold the spindles, attaching rod onto the sides perpendicular to the intake ramp, attach each spindle to their respective rod
- Back Assembly
  - Opening of the door cut out of back wall
  - Door itself will be 3D printed
  - Will also 3D print hinge jig attached to the servo motor

Subsystem Testing



Mobility Assessment

We plan to demonstrate the climber robot by end of fall term with the following parameters:

Horizontal Ground Speed Goal:

w = 25.8 rad/s

v = w * 0.06 m = 1.4 m/s

Climb Speed Goal:

w = 23.29 rad/s

v = w * 0.06 m = 1.23 m/s

Torque loading during climb:

T = 1.10 N*m

Ability to turn in desired left/right and reverse directions

BOM

PART	DESCRIPTION	QTY	INDIVIDUAL COST	SUBTOTAL	TOTAL	
Intake Motors	https://www.amazon.com	6	15.99	95.94		
Main wheel motor (8 motors)	https://www.robotshop.com/produc	8	43.95	351.6	Running Subtotal:	1148.56
1/2 shaft gear hub	https://www.gobilda.com/1310-seri	8	7.99	63.92	Percent Budget Used:	95.71333333
8 mm shaft gear hub	https://www.gobilda.com/1310-seri	8	7.99	63.92		
20 tooth gear	https://www.gobilda.com/8mm-pitc	4	2.49	9.96		
26 tooth gear	https://www.gobilda.com/8mm-pitc	4	2.49	9.96		
Chain	https://www.gobilda.com/8mm-pitc	1	11.99	11.99		
Chain linking pack	https://www.gobilda.com/8mm-pitc	1	2.99	2.99		
Wheel 4 pack	https://www.studica.com/studica-ro	2	69.99	139.98		
Aluminum sheet, 12x16x1/8"	https://www.amazon.com/ACXFOI	1	20.59	20.59		
Aluminum sheet, 12x16x1/2"	https://www.speedymetals.com/p-2	1	$88.92	$88.92		
PLA (1kg)	https://us.store.bambulab.com/prod	1	24.99	24.99		
Polycarbonate 24 x 24 x 1/4"	https://www.robotshop.com/produc	2	49.49	98.98		
XT60 Female Connectors	https://www.amazon.com/ELFCUL	1	7.99	7.99		
XT60 10 AWG 1 male to 2 female	https://www.ebay.com/itm/1753460	1	4.91	4.91		
6-port terminal block	https://www.harborfreight.com/6-ci	1	6.99	6.99		
4-port terminal block	https://www.overtons.com/blue-sea	1	3.71	3.71		
2-port terminal block	https://www.delcity.net/store/relays	1	2.99	2.99		
12V Battery disconnect	https://www.amazon.com/12-48V-N	1	16.99	16.99		
120 A Fuse	https://www.amazon.com/BOJACK	1	6.99	6.99		
Motor Fans	https://www.walmart.com/ip/2Pcs-4	2	10.39	20.78		
IR Sensors	https://shop.barnabasrobotics.com/	3	3.95	11.85		
Flanged Ball Bearings	https://www.amazon.com/Bonbo-B	1	12.88	12.88		10-pack
Surgical Tube	https://www.mcmaster.com/5234K	1	43.25	43.25		
Threaded rods	https://www.mcmaster.com/99086A	1	9.63	9.63		
M6 Screws	Passivated 18-8 Stainless Steel Phil	1	12.72	12.72		
M6 Nuts	Zinc-Plated Steel Hex Nut, Mediun	1	3.14	3.14		

Timeline

Milestone/Task	Date	Duration (Days)	7-oct	8-oct	9-oct	10-oct	11-oct	12-oct	13-oct	14-oct	15-oct	16-oct
Preliminary Design Phase	**10/07 - 10/16**	**9**										
Game and Rules Introduction	7-oct	1										
Brainstorming	8-oct	1										
Game Strategy decisions	9-oct	1										
Desing Decitions	10/10 - 10/12	3										
Updating desing based on rule updates	13-oct	1										
preliminary BOM	14-oct	1										
Make PDR presentation	10/15 - 10/16	2										
PDR presentation	16-oct	1										
			17-oct	18-oct	19-oct	20-oct	21-oct	22-oct	23-oct			
Critical Design Phase	**10/17 - 10/23**	6										
Review PDR Feedback	17-oct	1										
Adress Feedback	10/18 - 10/20	3										
Create CAD	10/21 - 10/22	4										
Make CDR presentation	10/22 - 10/23	2										
CDR presentation	23-oct	1										

Timeline

Milestone/Task	Date	Duration	24-oct	25-oct	26-oct	27-oct	28-oct	29-oct	30-oct	31-oct	1-nov	2-nov	3-nov	4-nov	5-nov	6-nov	7-nov	8-nov	9-nov	10-nov	11-nov	12-nov	13-nov
Fall Fabrication and Assembly	10/24 - 12/05	42																					
Review CDR Feedback	10/24 - 10/28	5																					
Redesign necessary parts	10/29 - 11/02	5																					
Prototype for clearance check	11/03 - 11/05	3																					
Adress any issues after prototyping	11/06 - 11/09	4																					
Finalize BOM	10-nov	1																					
Order Climber robot chassi Materials	11/11 -11/15	5																					
Machine main chassi plates	11/16 - 11/18	4																					
Machine bottom plate	11/17 - 11/18	2																					
3D print motor holders	11/17 - 11/19	3																					
Machine side chassi plate	11/20-11/21	2																					
Assemble Drivetrain	11/22 - 11/25	4																					
Adress any issues after assembly	11/26 - 11/30	5																					
Gather speed and acceleration data	1-dic	1																					
Test	11/2 - 11/4	2																					
Mobility Demo	4-nov	1																					

Milestone/Task	Date	Duration	14-nov	15-nov	16-nov	17-nov	18-nov	19-nov	20-nov	21-nov	22-nov	23-nov	24-nov	25-nov	26-nov	27-nov	28-nov	29-nov	30-nov	1-dic	2-dic	3-dic	4-dic	5-dic
Fall Fabrication and Assembly	10/24 - 12/05	42																						
Review CDR Feedback	10/24 - 10/28	5																						
Redesign necessary parts	10/29 - 11/02	5																						
Prototype for clearance check	11/03 - 11/05	3																						
Adress any issues after prototyping	11/06 - 11/09	4																						
Finalize BOM	10-nov	1																						
Order Climber robot chassi Materials	11/11 -11/15	5																						
Machine main chassi plates	11/16 - 11/18	4																						
Machine bottom plate	11/17 - 11/18	2																						
3D print motor holders	11/17 - 11/19	3																						
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Assemble Drivetrain	11/22 - 11/25	4																						
Adress any issues after assembly	11/26 - 11/30	5																						
Gather speed and acceleration data	1-dic	1																						
Test	11/2 - 11/4	2																						
Mobility Demo	4-nov	1																						

Timeline

Milestone/Task	Date	Duration	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Winter Fabrication and Assembly	01/05 - 03/18	72										
Print Intake mechanism parts												
Assemble Intake												
Machine/Print dumping mechanism												
Assemble dumping mechanism												
Assemble full robot (climber)												
Maching and assemble runner chassi												
machine and assemble runner intake												
Machina nd asssemble dumping mechanism												
Test robots - familiarize controls												
Final stretch - competition												

Questions?

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Backup Slides

Subsystem Testing - Details

- Cardboard prototype for clearances:
    - Create some sort of prototype with an incline at the same degree, and manually roll the prototype over the incline to see if the ramp clears.
- Chassis test with wheels on incline
    - Prior to combining with the intake mechanism can test the chassis with the motors and drivetrains connected to test if robot is meeting our expected mobility (velocity and climb times)
    - Will test motor to gear connection through the chain and sprocket on one half of the chassis then test the motor to gear connection through the chain and sprocket on the other half of the chassis
    - Test the climb time and the horizontal ground average moving times

Subsystem Testing - Details

- Intake test
  - Once we've attached our spindles, we plan to complete two separate tests: one with using one row of spindles and then how all four rows will function in working together to collecting the pellets.
- Back funnel depositing
  - Test the dumping mechanism: In general just by opening the back gate after collecting the pellets to see how they would deposit.
  - Test the magnet: We would close the back gate and see if the magnet would be strong enough to keep the gate closed as the robot moves, and goes up the incline.
  - Test the servo: Test if the electronics function properly and also if the servo is strong enough to open and close the gate.

RC Control Features

Slow, medium, fast acceleration control

Direction control