Row-bots Design Proposal

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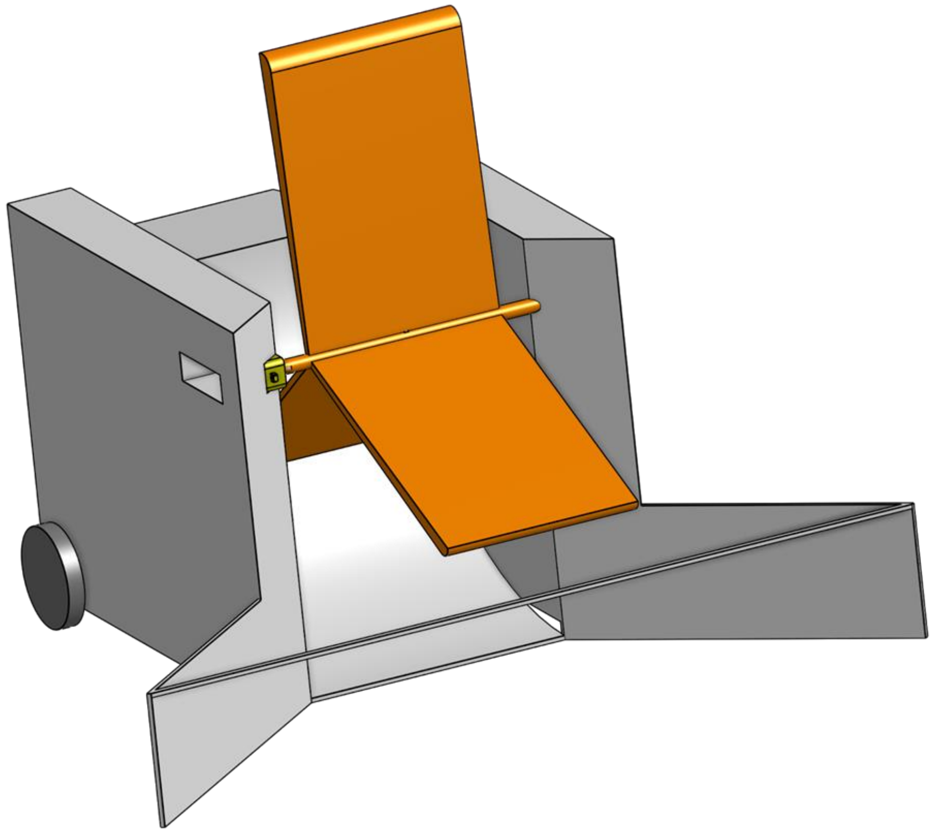
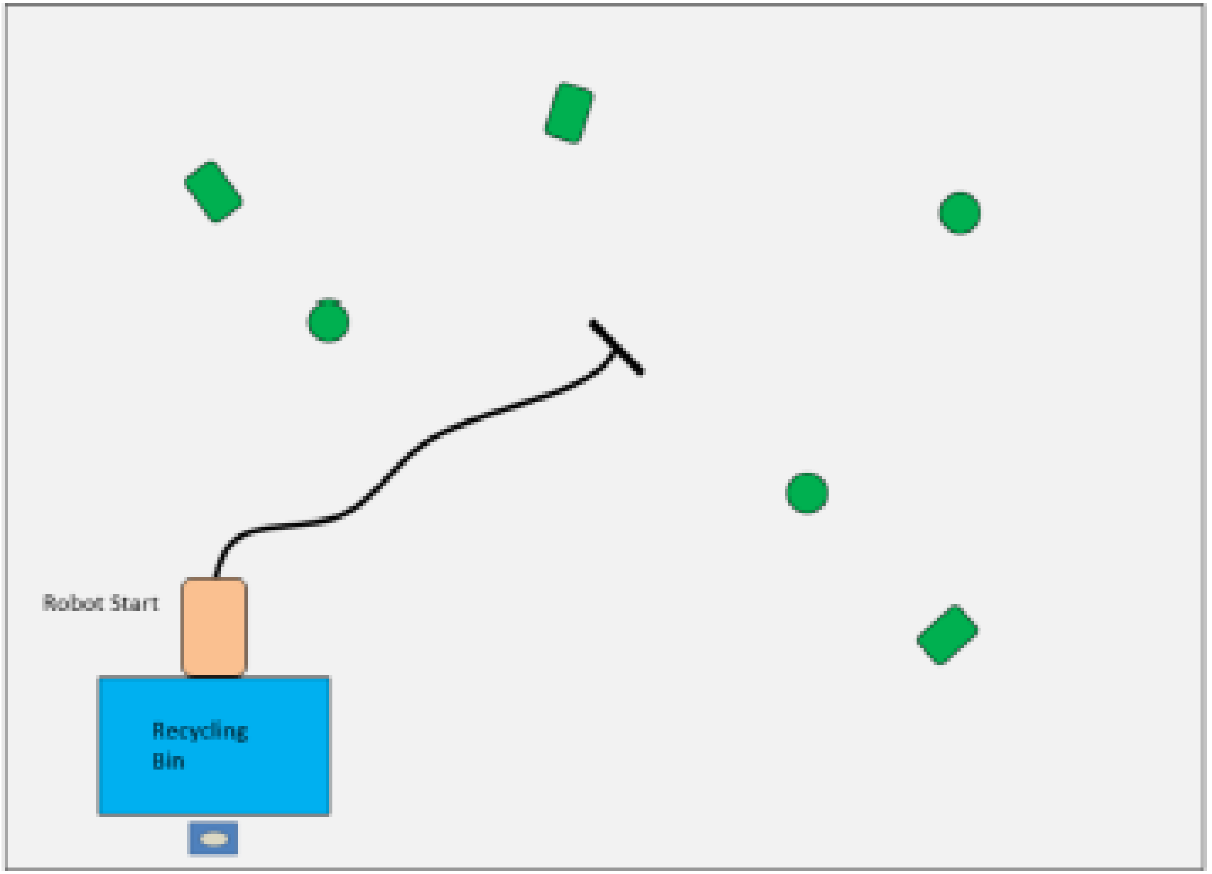


Outline

- Design Process
- Robot Overview
- Electronics
- Calculations
- Risk Analysis
- Project Scope

Competition Overview

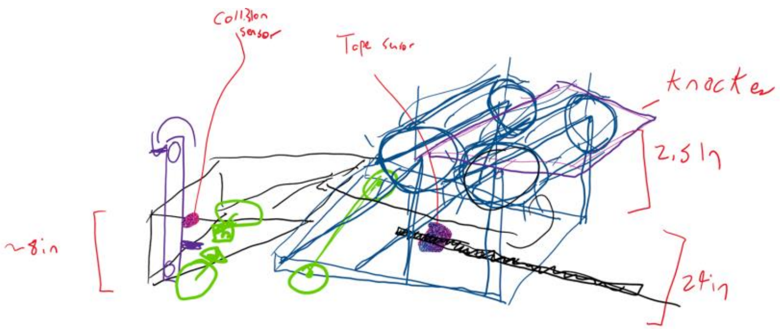
The robot must locate, collect and place cans (green icons) in the recycling bin autonomously

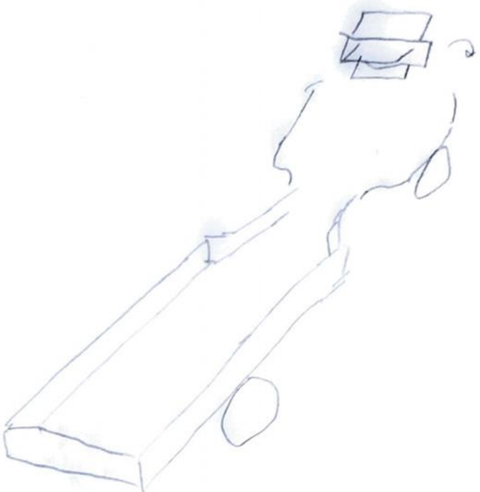


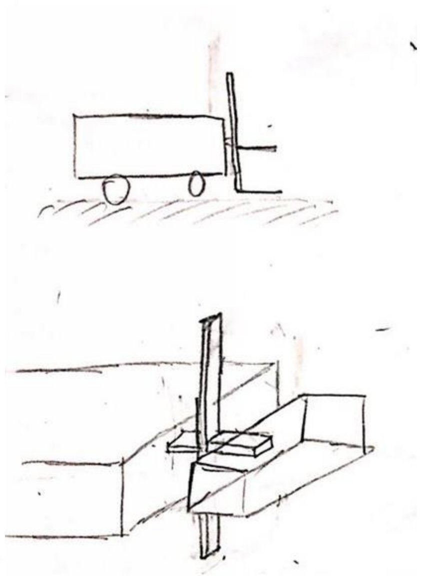
Strategy Decisions

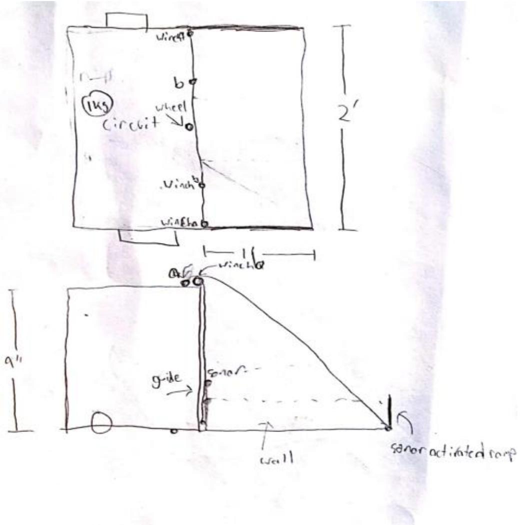
Sweep or target	Sweep
How many cans to return at once	6
Navigation	Tape Path
Moving during pick up	Yes
Robot width	2’
8” or 2” box height	8’’

Idea Generation:
15-minute sketches

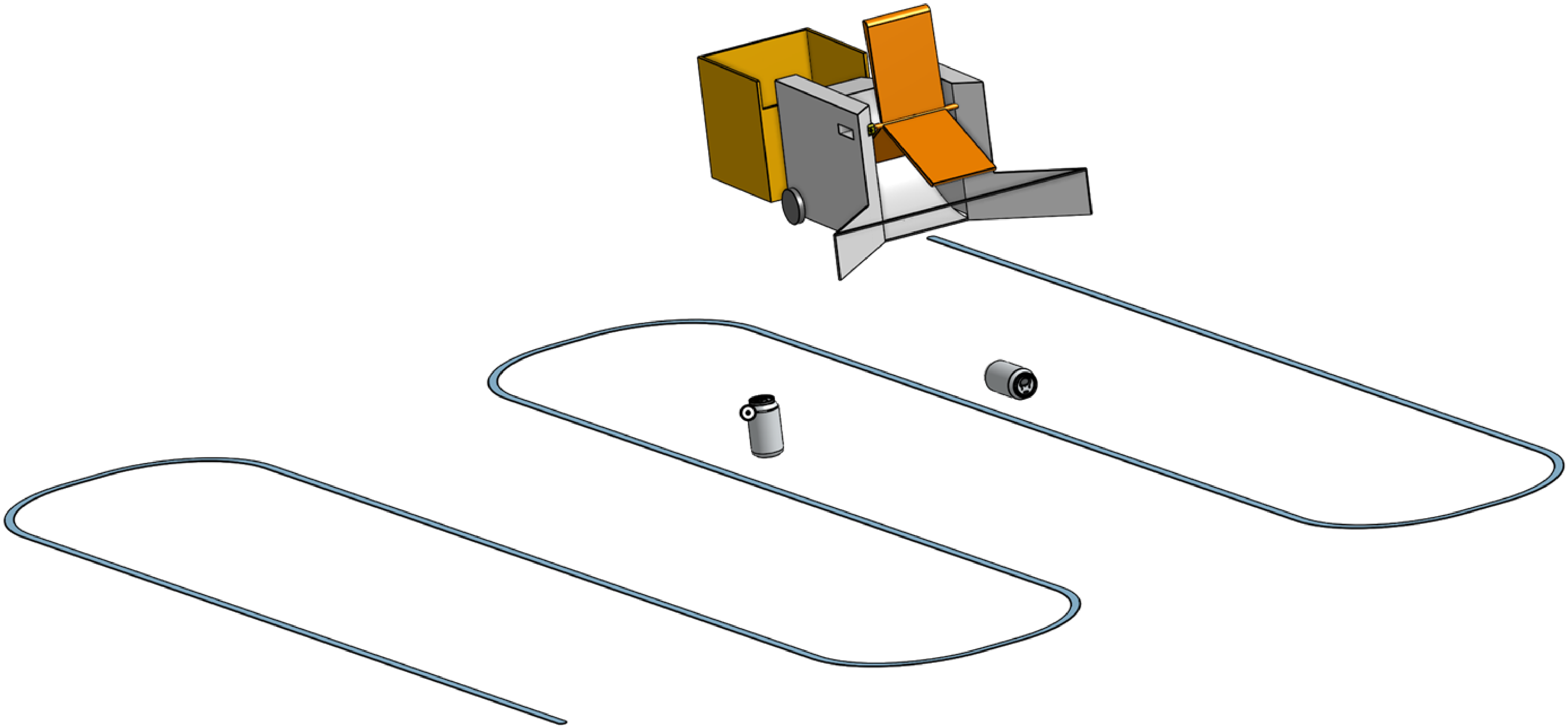




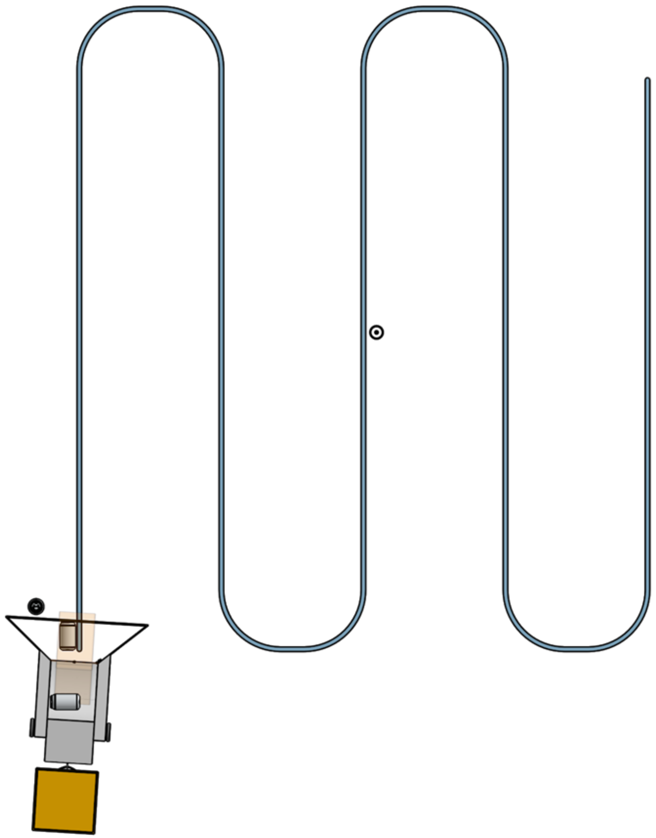


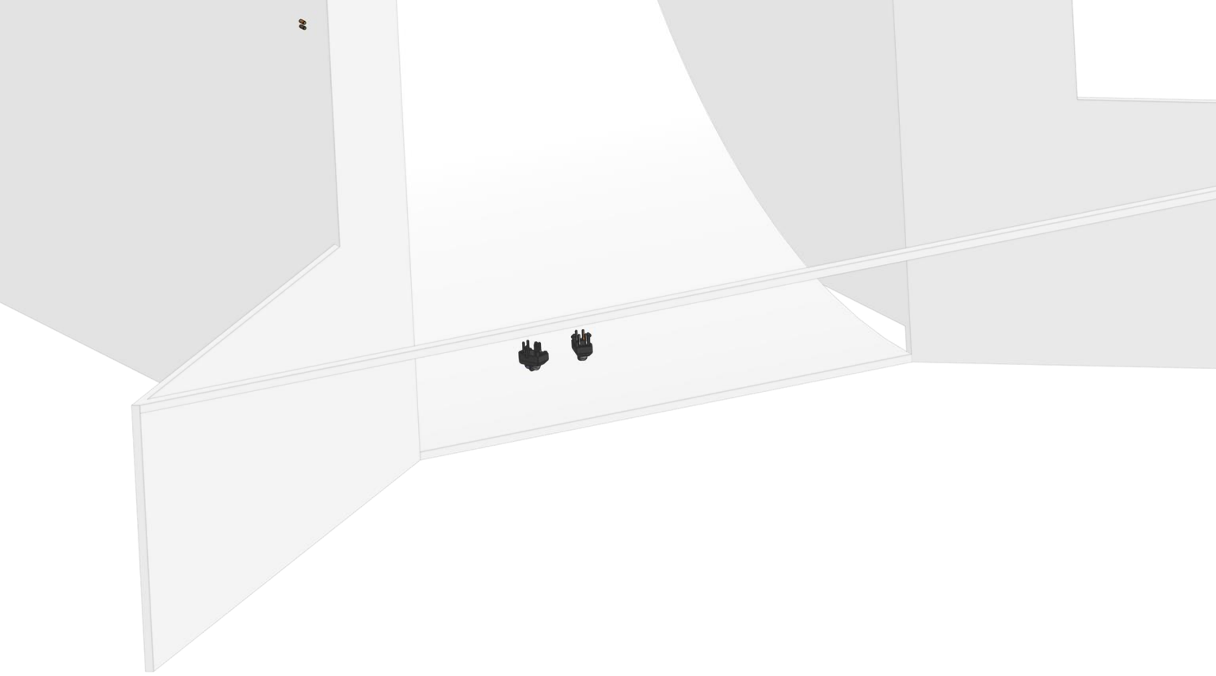


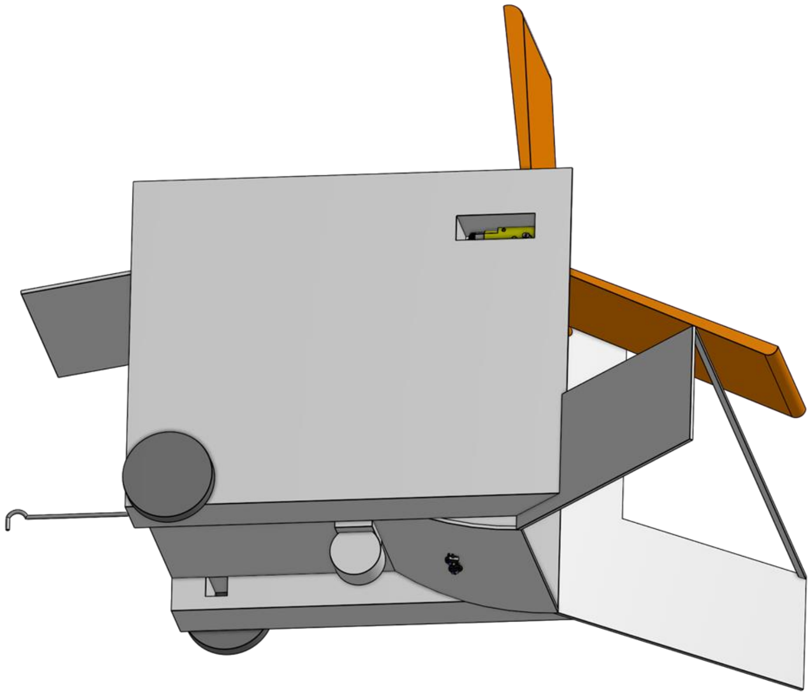
Prototype 1: The Combine



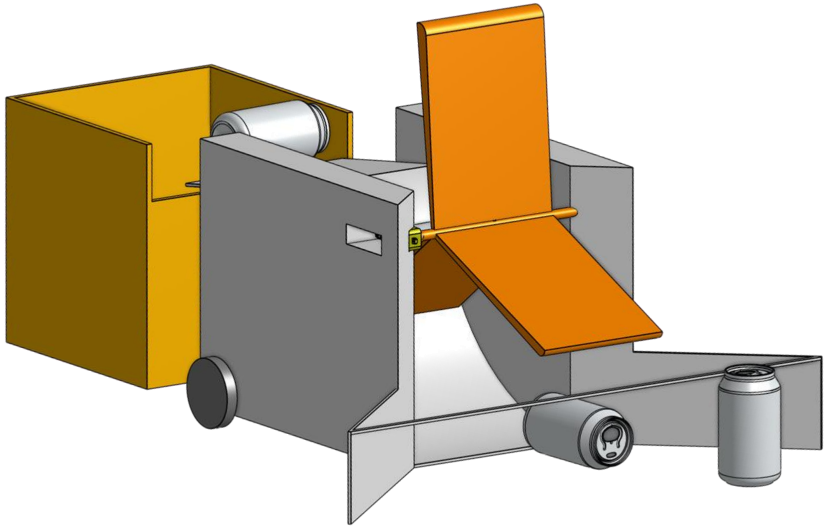
Navigation

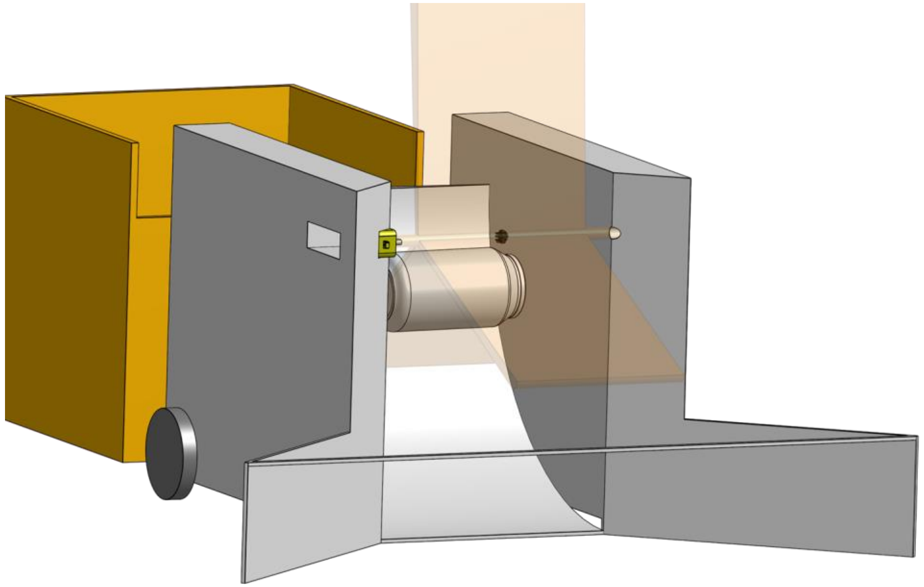


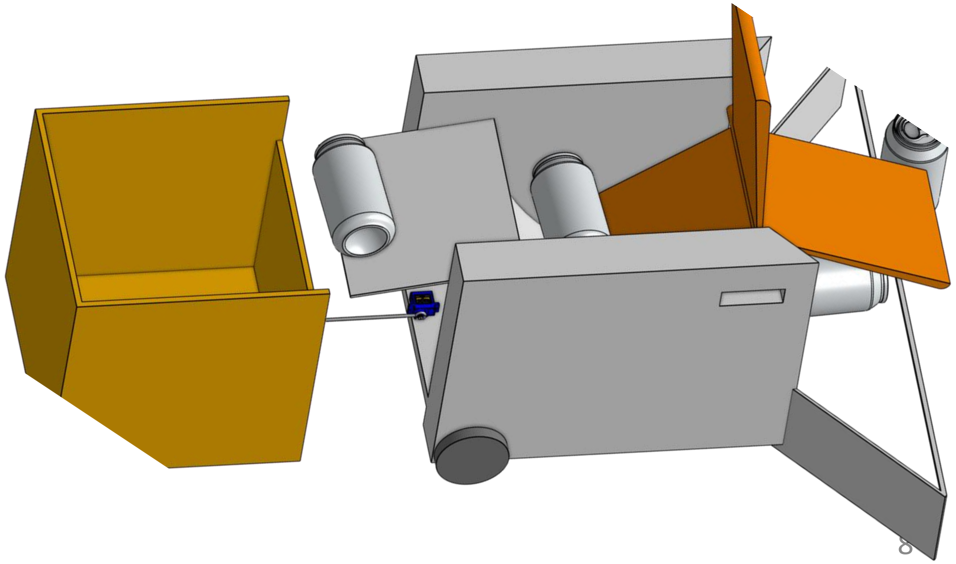




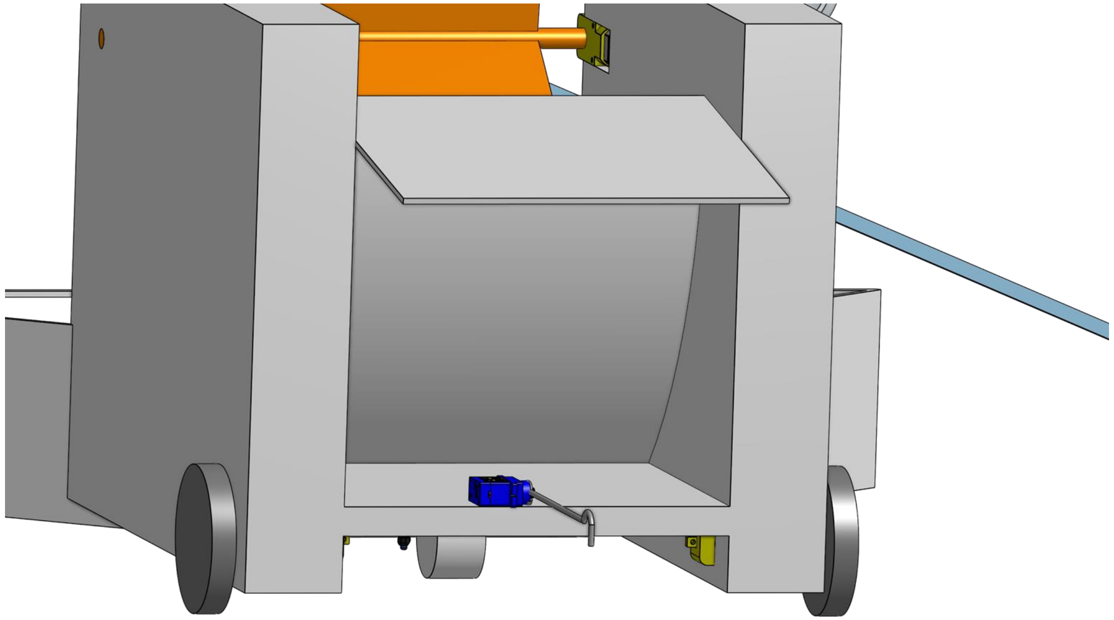
Can Collection

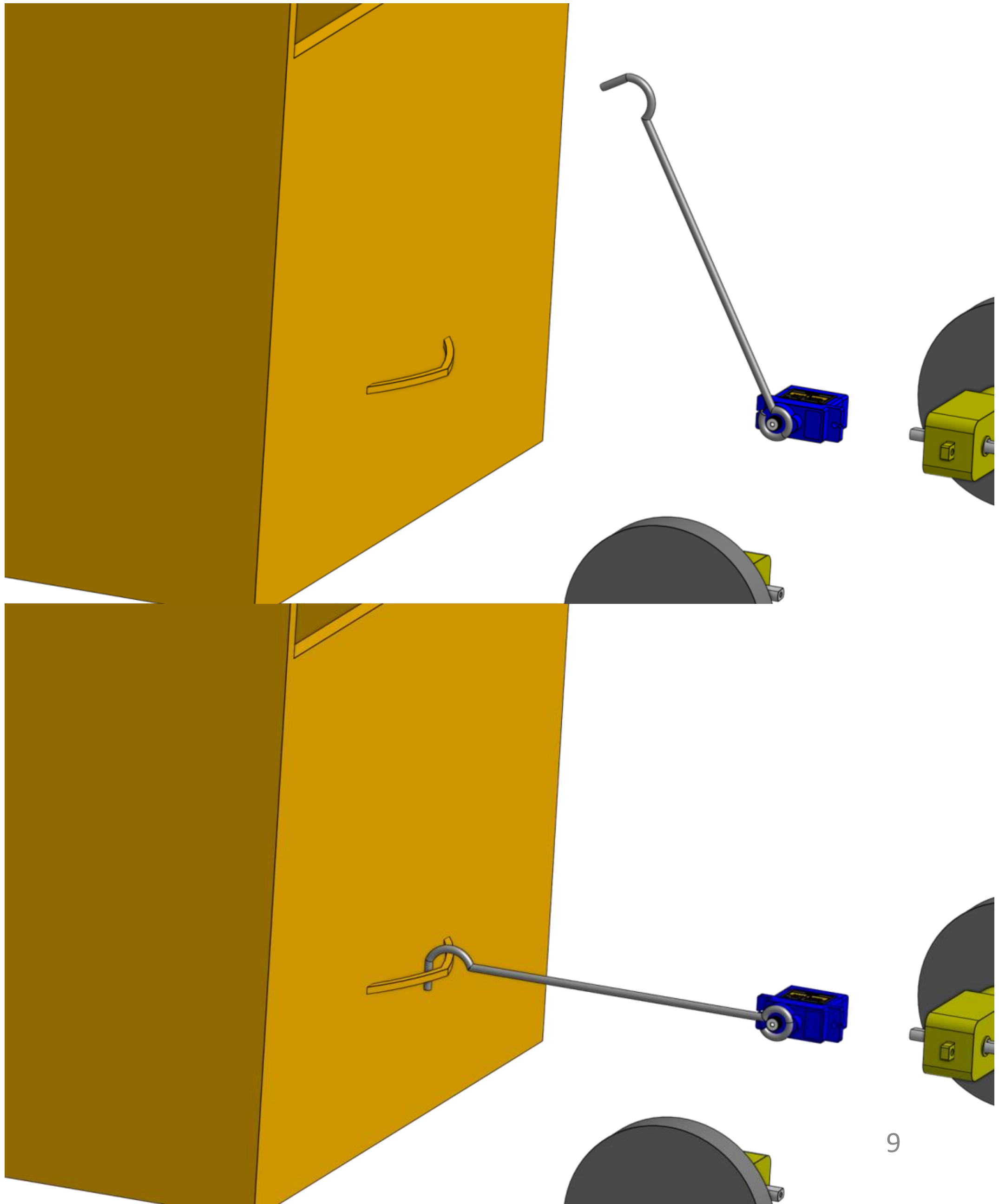




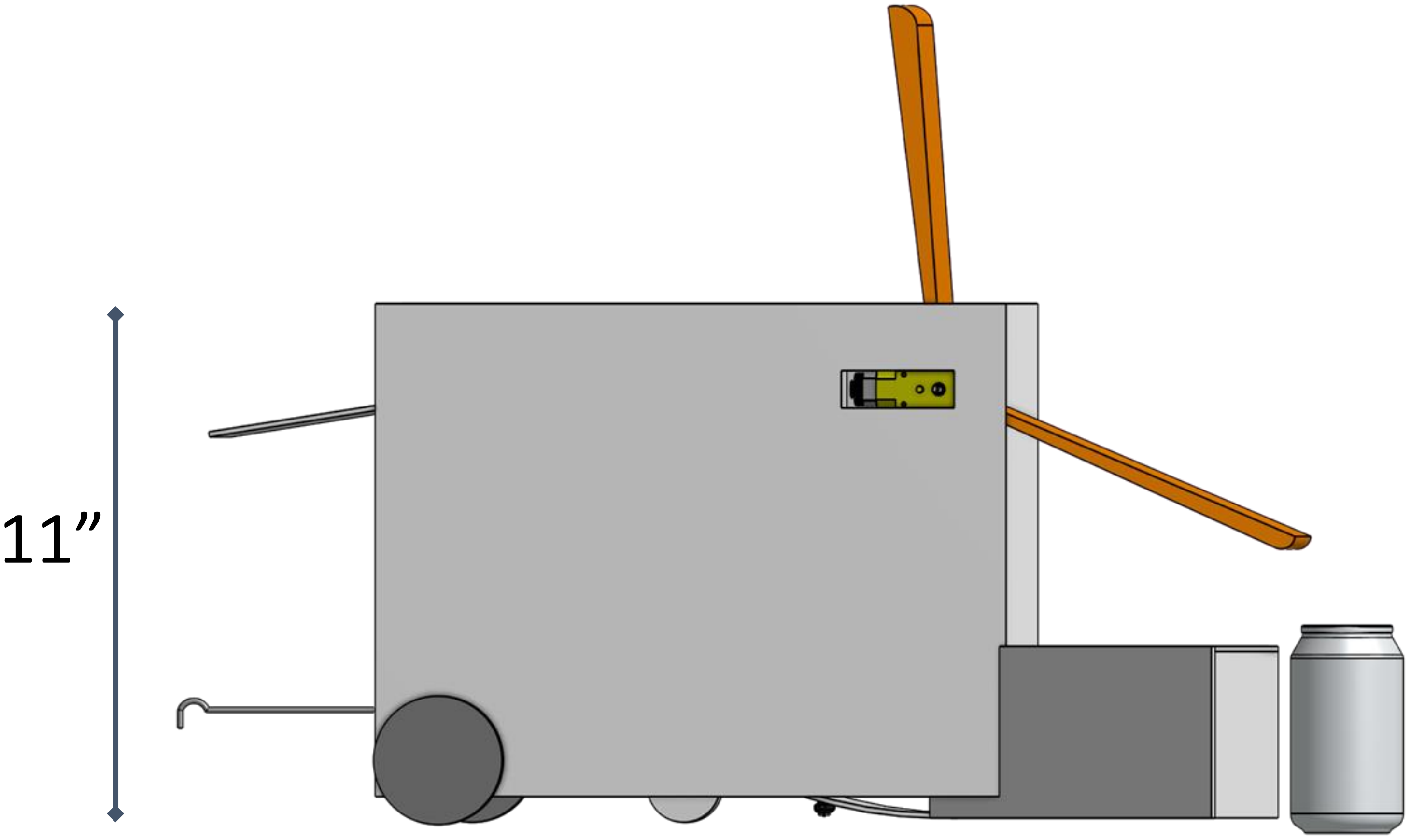


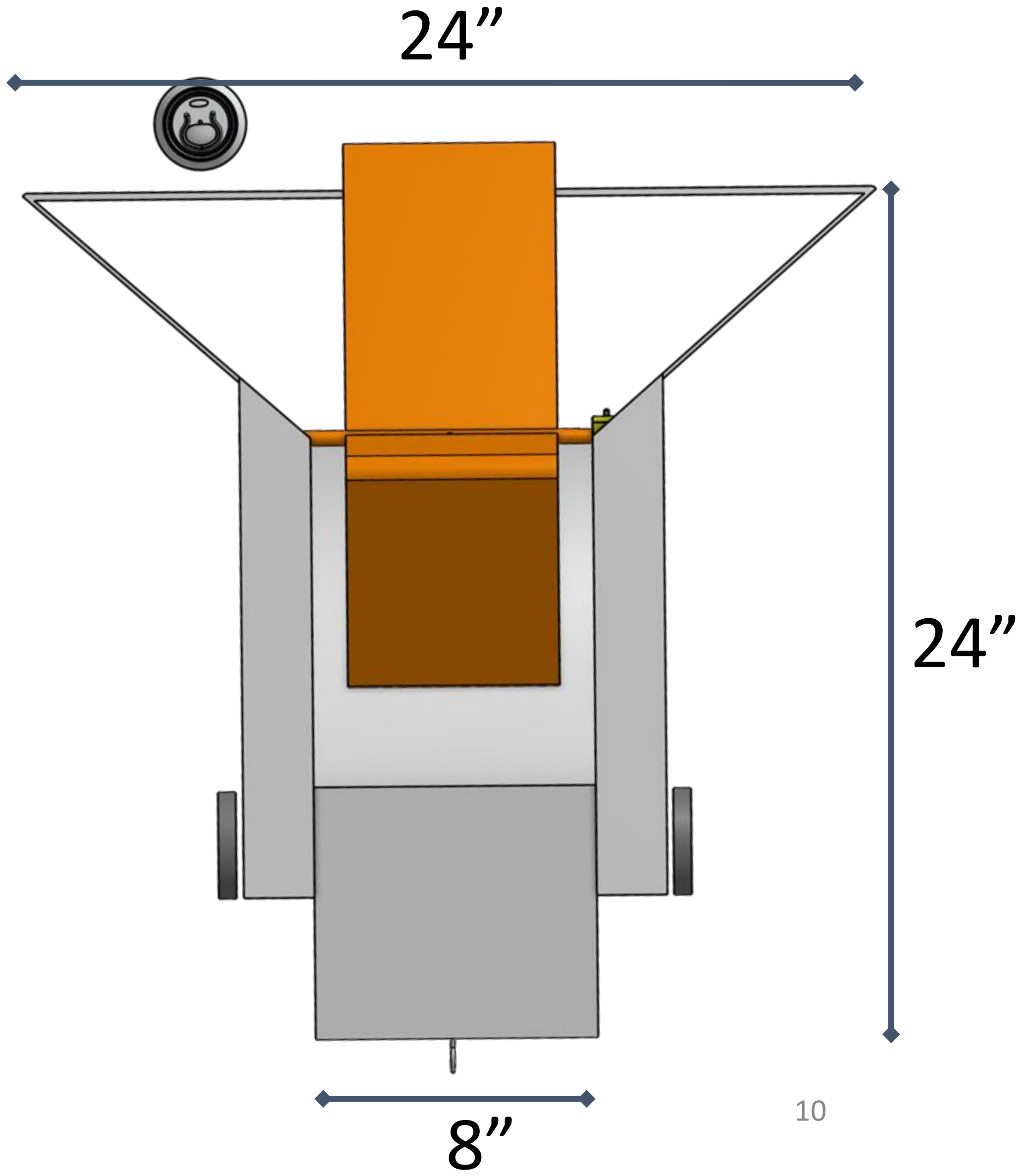
Can Storage



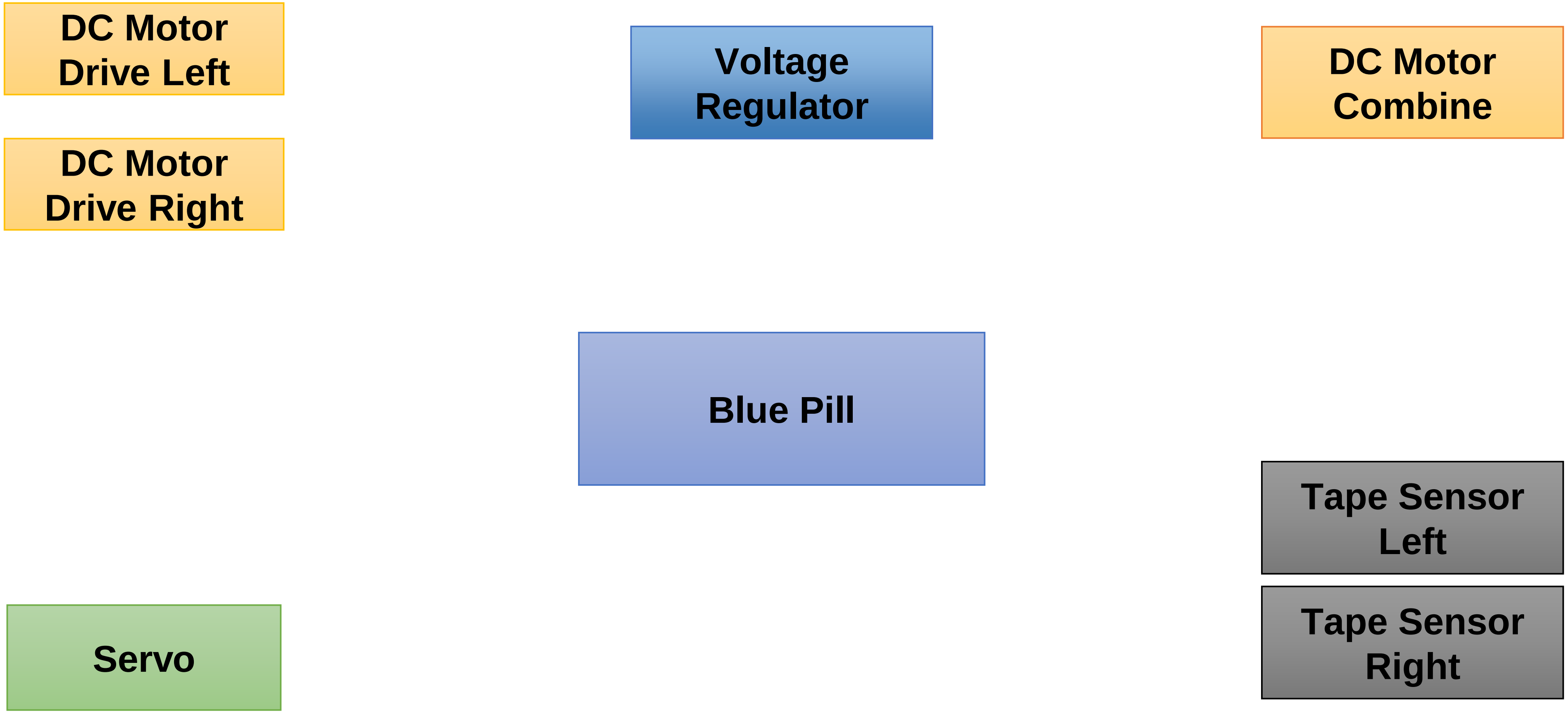


Dimensions





Circuit Block Components



Pin Resources

	Pins Available	Pins Required
Analog	10	2
PWM	15	7

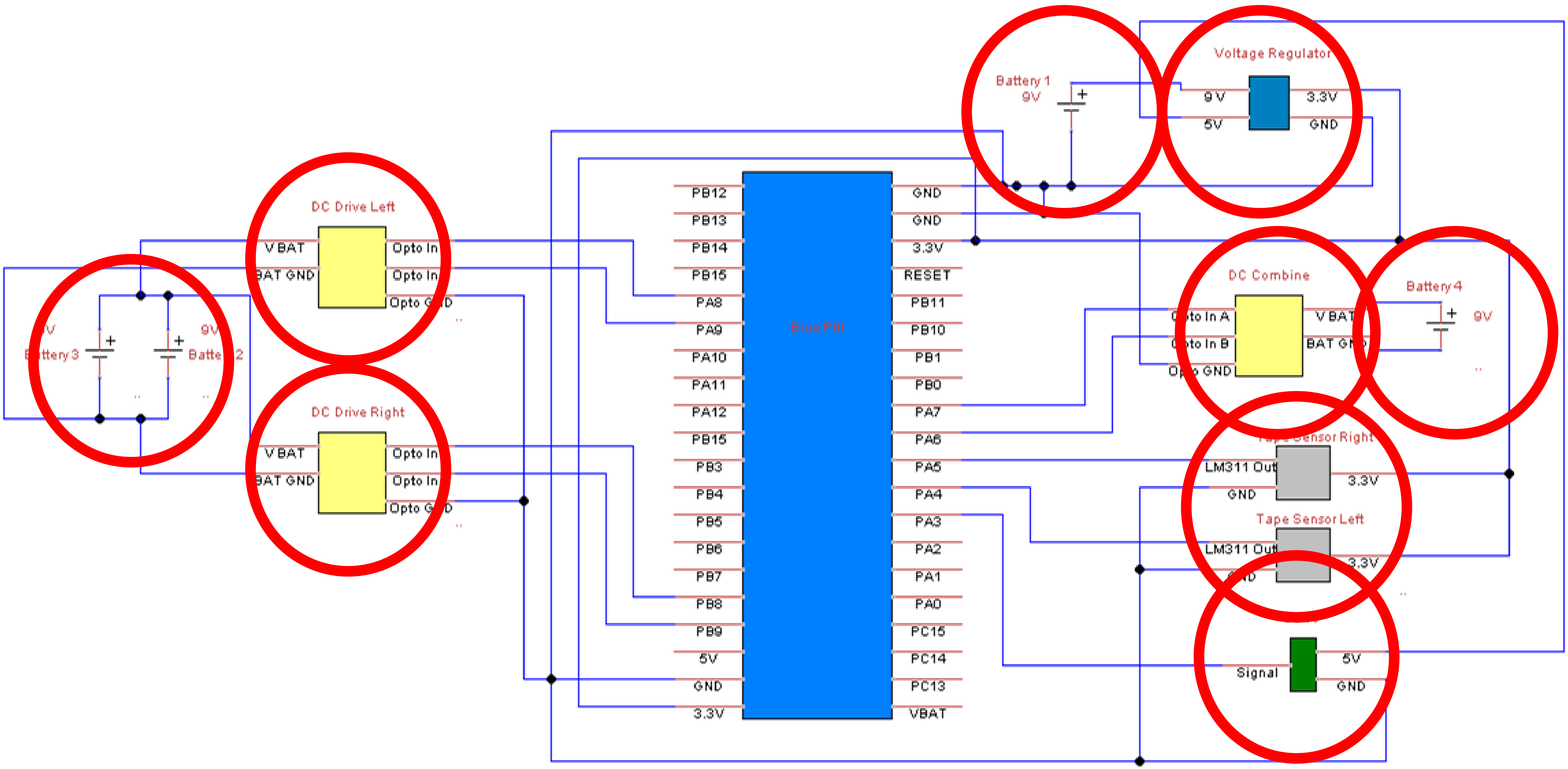
Timer Separation

Pin	Connection	Timer
PA8	DC Left A	1
PA9	DC Left B	1
PB8	DC Right A	4
PB9	DC Right B	4
PA6	DC Combine A	3
PA7	DC Combine B	3
PA3	Servo	2

Battery Planning

Battery 1	Batteries 2 & 3 in Parallel	Battery 4
Voltage Conversion Circuit and Blue Pill	2 DC Drive motors	DC Combine Motor
2 Tape Sensor Circuits		
1 Box Attachment Servo		
250 mA	500 mA	250 mA
2 hours	2 hours	2 hours

See appendix for detailed calculation



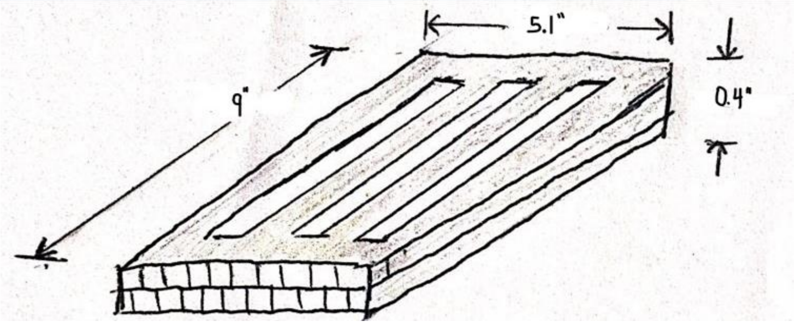
Battery 1
9V
Voltage Regulator
9 V
5V
3.3V
GND
DC Drive Left
VBAT
BAT GND
Opto In
Opto In
Blue Pill
PB12
PB13
PB14
PB15
PA8
PA9
PA10
PA11
PA12
PB15
PB3
PB4
PB5
PB6
PB7
PB8
PB9
5V
GND
3.3V
GND
GND
3.3V
RESET
PB11
PB10
PB1
PB0
PA7
PA6
PA5
PA4
PA3
PA2
PA1
PA0
PC15
PC14
PC13
VBAT
DC Combine
VBAT
Battery 4
9V
9V
DC Drive Right
VBAT
BAT GND
Opto In
Opto In
LM311 Out
GND
3.3V
Tape Sensor Left
LM311 Out
3.3V
Signal
5V
GND

Torque

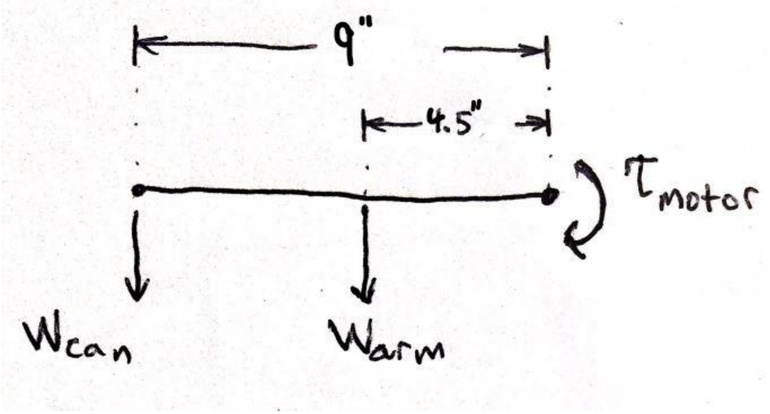
- Plastic density: 0.0036 lb/cu in
- Arm weight: Density*Volume = 0.033 lb
- Can weight: 0.029 lb

- Maximum motor torque: 0.69 inlb
  - Torque from arm: 0.41 inlb < 0.69 inlb

Motor can lift the arm + a can!



Proposal for the arm: cut out 50% of material to save weight, and layer plastic to increase stiffness.



Free body diagram of windmill arm. The can is treated as a point mass at the farthest end.

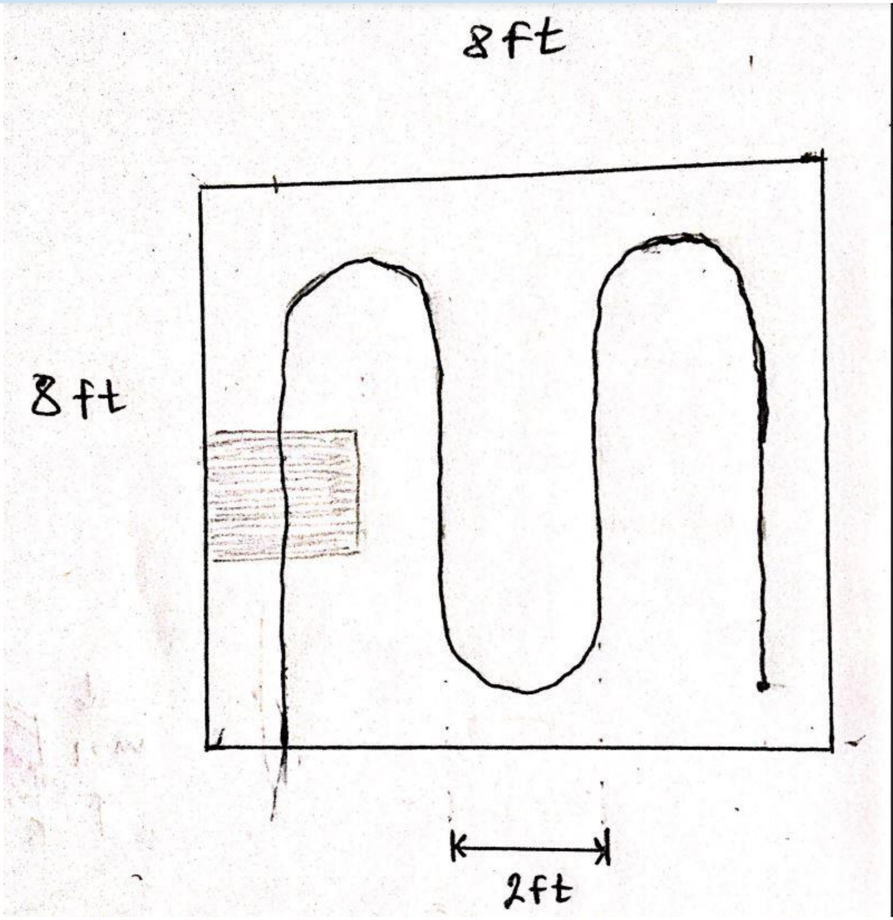
Speed

- Robot travels roughly 38ft in 50 seconds
  - Speed = 0.76 ft/s

- Angular speed : 100 rpm
- v = w*r
  - r = 0.9 in

So the wheel radius must be at least 0.9”

Make it 1.6” to be safe.

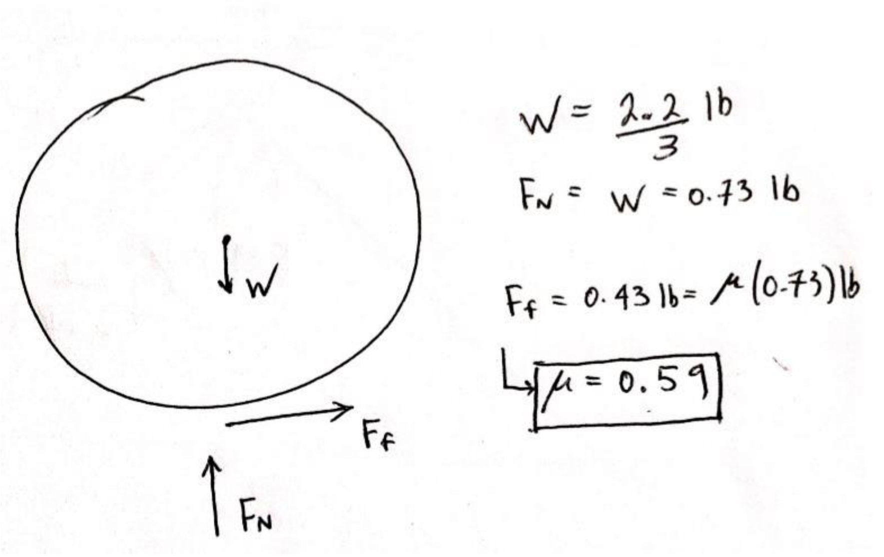


Rough layout of robot trajectory. Total path length is roughly 38 ft.

Friction

- Robot weight : 2.2 lb (estimated from PCBs, motors and plastic)
  - Assume weight is split between 3 wheels
- Wheel provides accelerating force of 0.69inlb / 1.6in = 0.43lb

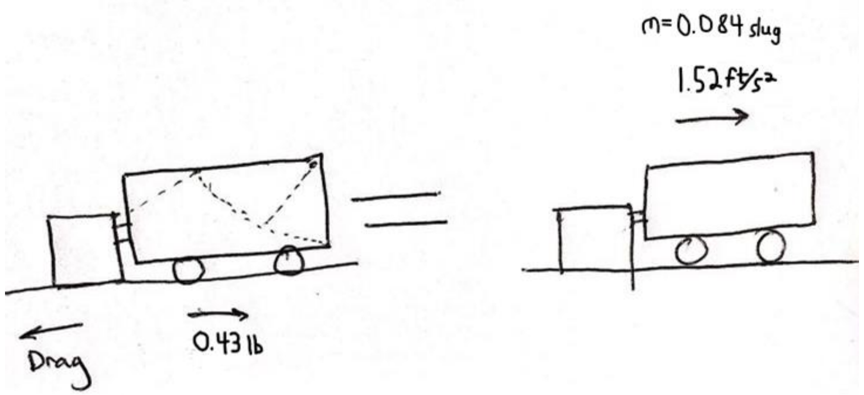
- Coefficient of friction: mu = 0.59
  - This is high, but within reason for rubber



Force Diagram of wheel during acceleration. Angular values not shown.

Acceleration

- Reach max speed in 0.5 s: a =1.52 ft/s^2
- Robot + box: 2.7 lb
- F = m*a = 0.13lb
  - Net force to accelerate system



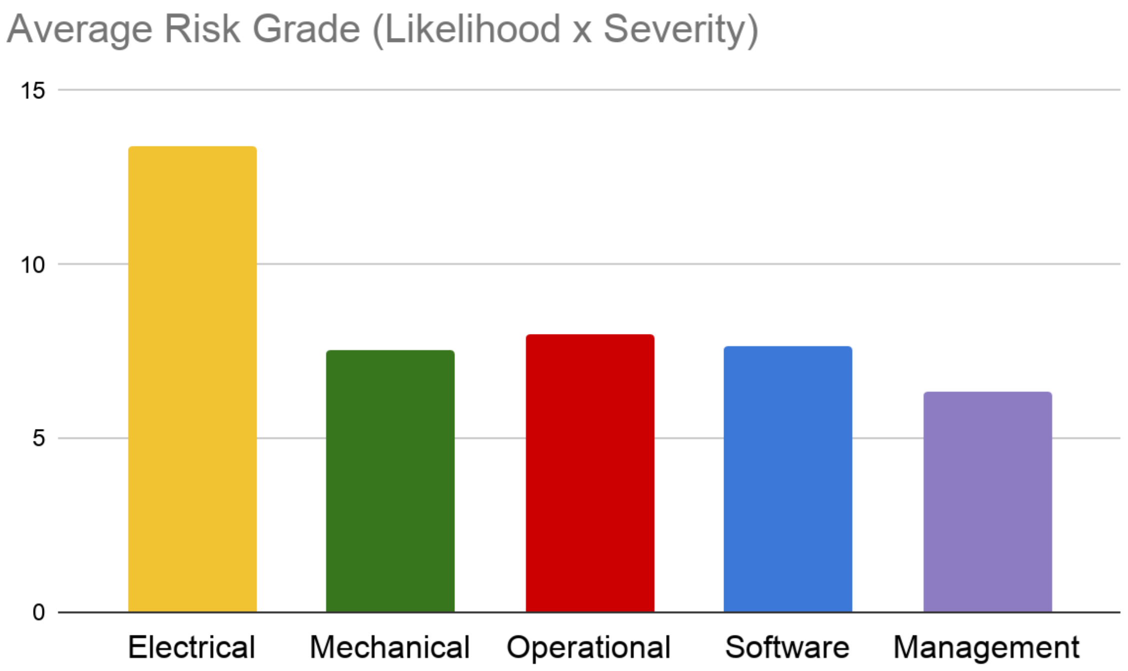
Kinetic diagram of robot + box system during acceleration. Only horizontally-acting values are shown.

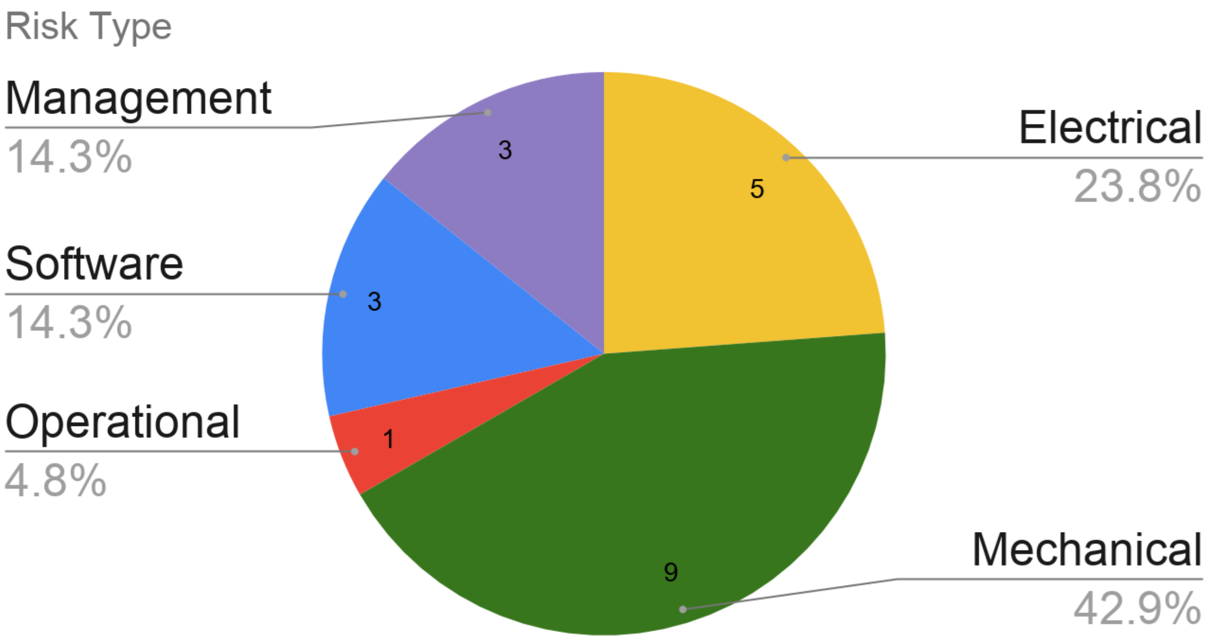
- Net force = 0.43lb - drag = 0.13lb
  - A drag of 0.3 lb is much more than the light box can provide

System will accelerate!

Risk Analysis

Risk matrix in appendix on slide 34





Risk Analysis

Risk matrix in appendix on slide 34

Risk Category	Example Risk	Mitigation Strategy
Software	Robot doesn’t know it left competition surface	Line competition surface with bumpers or tape
Electrical	Noise from motors resets Blue Pill	Use optoisolators and shield wires
Mechanical	Box doesn’t slide	Test box and robot friction extensively
Operational	Damage components and they are unavailable	Order spares now

Progress Tracking

Daily 2 minute anonymous form

- Hours worked
- Productive hours
- Sleep
- Happiness
- Team functionality
- Tasks completed
- Tasks to do

Timeline

•Initial prototyping	June 22 - June 26
•Build chassis	June 24 - June 30
•Prototype circuits	June 29 - July 10
•Code navigation system	June 26 - July 16
•Finish mechanical side	July 6 - July 16
•Integrate motors and solder circuits	July 8 - July 17
•Code entertainment system	July 10 - July 23
•Fine tune robot	July 16 - August 5

Appendix

- Our Questions
- Circuit Schematics
- Detailed Project Timeline
- Risk Analysis Chart
- Other Designs

Questions

Connecting Blue Pill ground externally - ground loop?

Strict 2’ size limit?

The geared motors are rated for 4.5V - how do they behave at 9V?

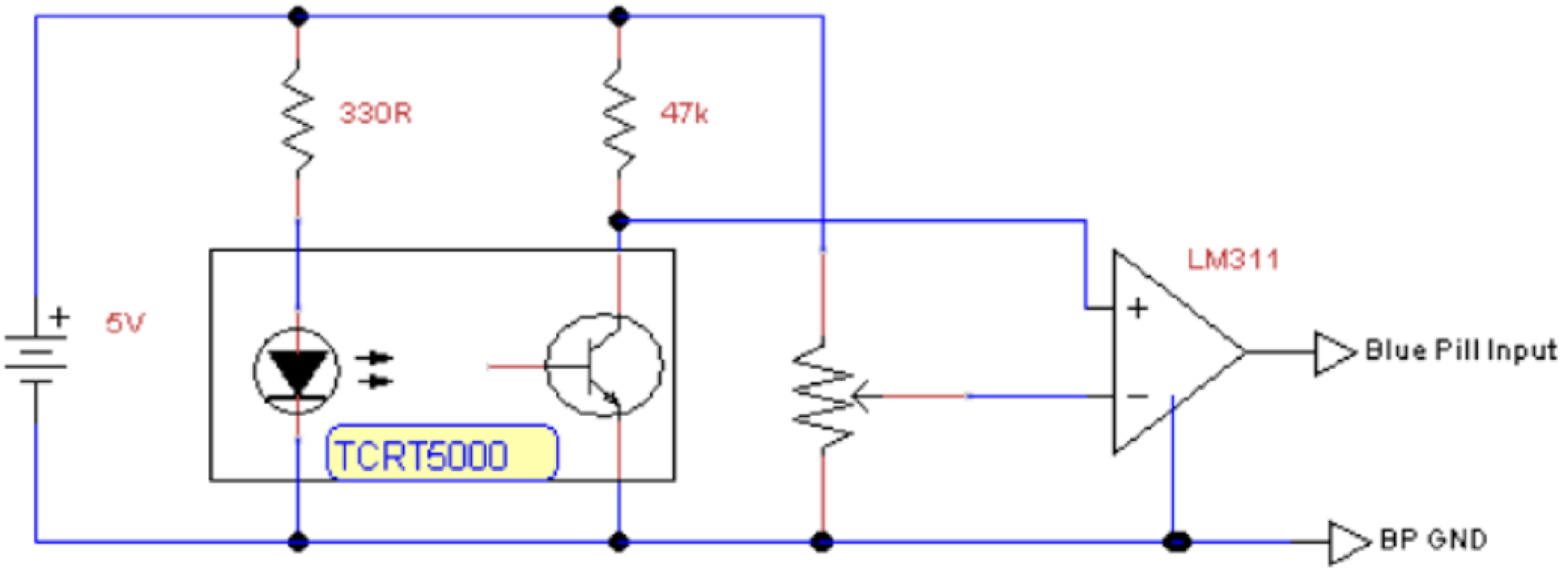
linear relationship between load and rpm

max T - rpm = 0

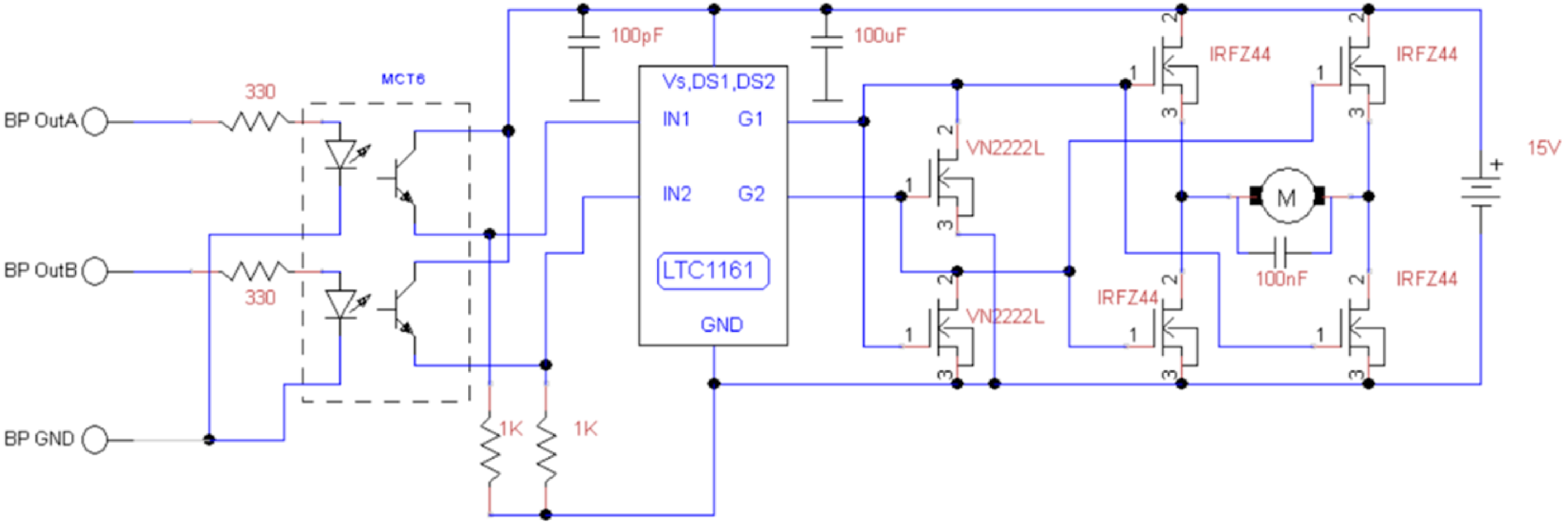
Is there a set material for the recycling bin?

tape following limits speed

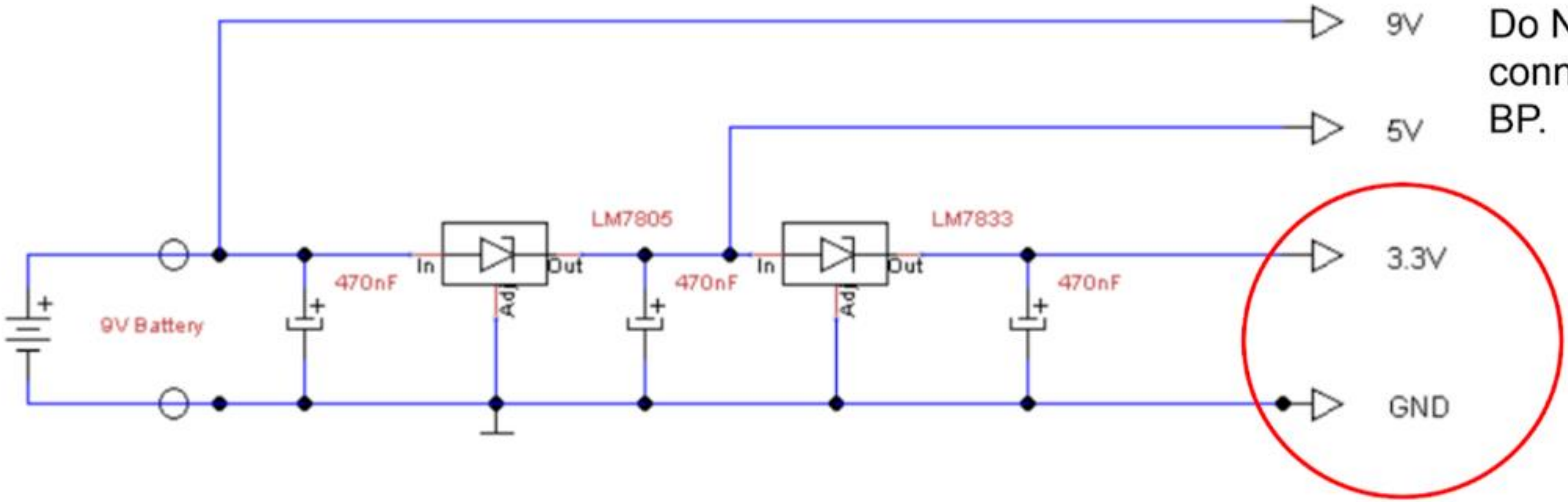
Tape Sensor Schematic



H-Bridge Schematic



Voltage Regulator



Do NOT connect to BP.

Connect to all GND, 3.3V and VBAT

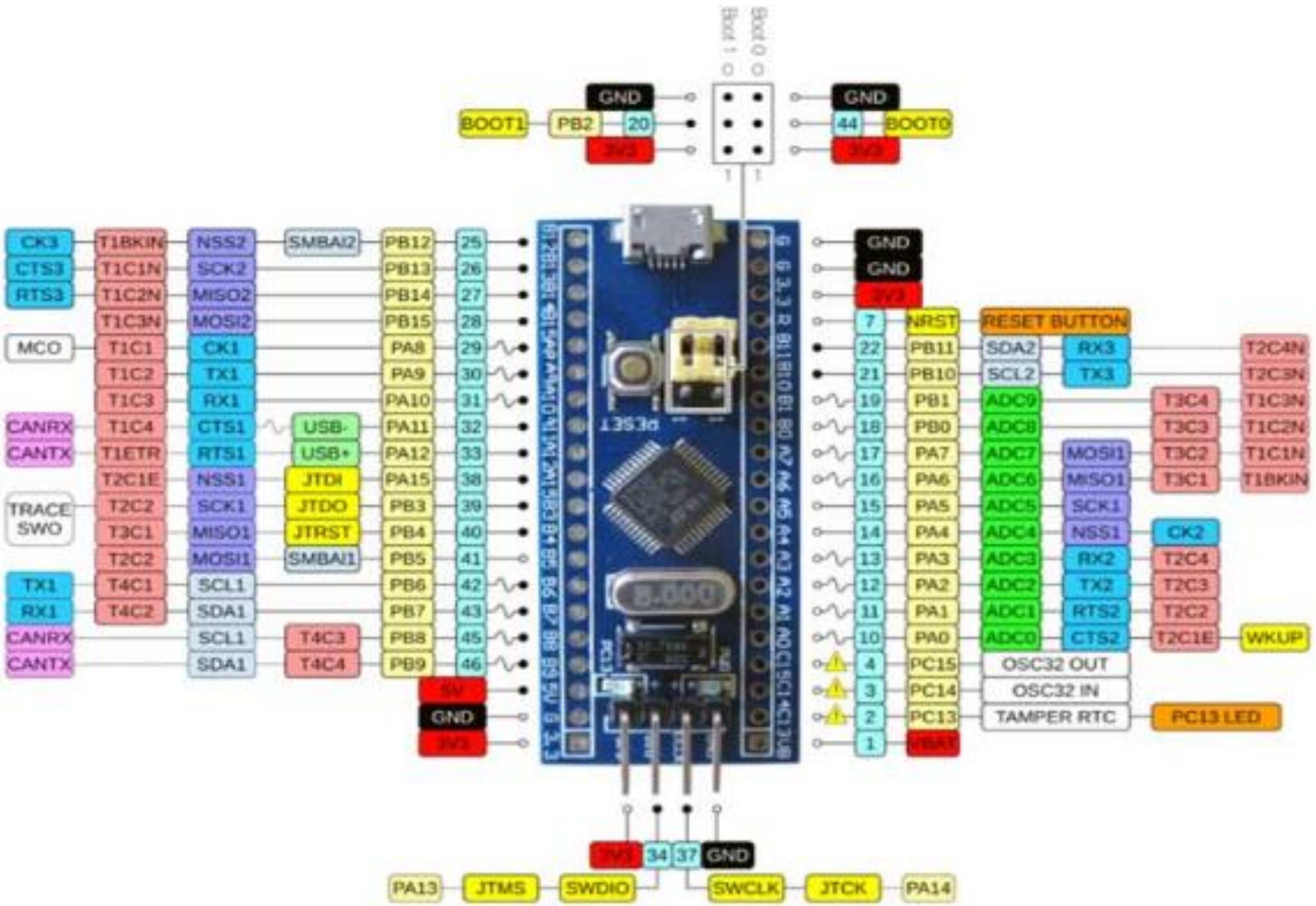
Power Calculations

Battery 1	Current	Batteries 2 & 3 in Parallel	Current	Battery 4	Current
Voltage Conversion Circuit and Blue Pill	5 mA	2 DC Drive motors	500 mA	DC Combine Motor	250 mA
3 Tape Sensor Circuits	45 mA				
1 Box Attachment Servo	200 mA				
TOTAL current	250 mA	**TOTAL current**	500 mA	**TOTAL current**	250 mA
Lifespan	2 hours	**Lifespan**	2 hours	**Lifespan**	2 hours

Battery is rated for 500 mAh
All batteries have approximately same maximum current draw
Parallel batteries on drive motors adds redundancy
Separate battery on combine motor removes noise from other circuit - always running

Pin	Connection	Analog	PWM	Timer
PA8	DC Left A	No	Yes	1
PA9	DC Left B	No	Yes	1
PB8	DC Right A	No	Yes	4
PB9	DC Right B	No	Yes	4
PA6	DC Combine B	Yes	Yes	3
PA7	DC Combine A	Yes	Yes	3
PA3	Servo 1	Yes	Yes	2
PA5	Tape Sensor Right	Yes	No	none
PA4	Tape Sensor Left	Yes	No	none

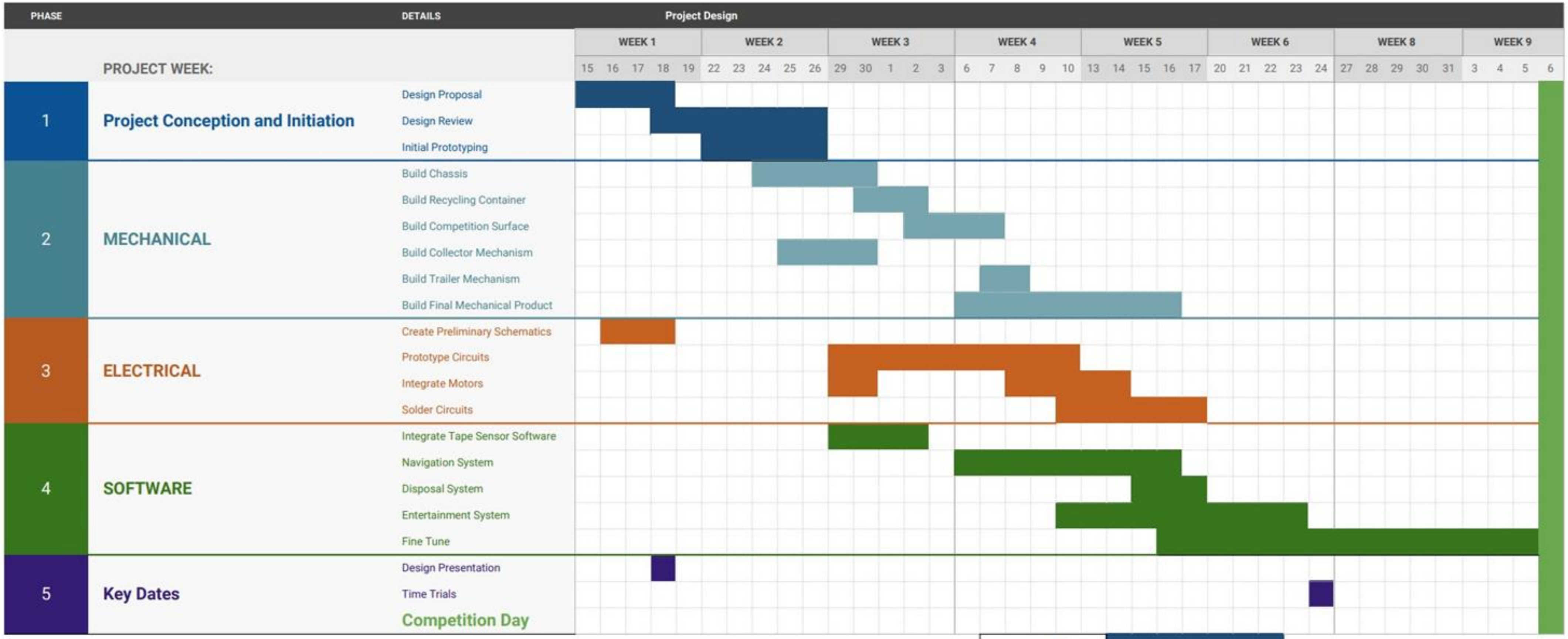
	PB12		GND	Battery 1 GND
	PB13		GND	Battery 1 GND
	PB14		3.3V	3.3 Voltage Regulator
	PB15		RESET	
DC Left A	PA8		PB11	
DC Left B	PA9		PB10	
	PA10		PB1	
	PA11		PB0	
	PA12		PA7	DC Combine A
	PA15	Blue Pill	PA6	DC Combine B
	PB3		PA5	Tape Sensor Right
	PB4		PA4	Tape Sensor Left
	PB5		PA3	Servo 1
	PB6		PA2	
	PB7		PA1	
DC Right A	PB8		PA0	
DC Right B	PB9		PC15	
	5V		PC14	
Battery 1 GND	GND		PC13	
3.3 Voltage Regulaor	3.3V		VBAT	

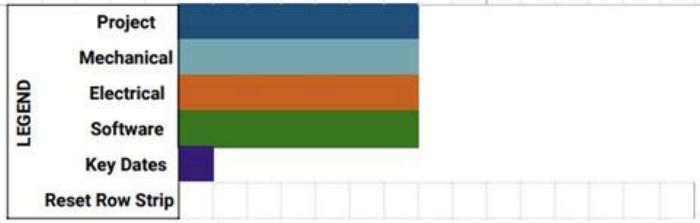


- https://components101.com/microcontrollers/stm32f103c8t8-blue-pill-development-board

ROW-BOTS PROJECT TIMELINE

PROJECT TITLE	Row-Bots	COURSE NAME	ENPH 480
PROJECT TEAM	Holden, Lewis, Mykal, Nick	DATE	6/15/20





https://docs.google.com/spreadsheets/d/1uhVeTAalDqOoHRtqT7lvaWu6vt07k7P0X9toSj-yvIo/edit#gid=1709744959

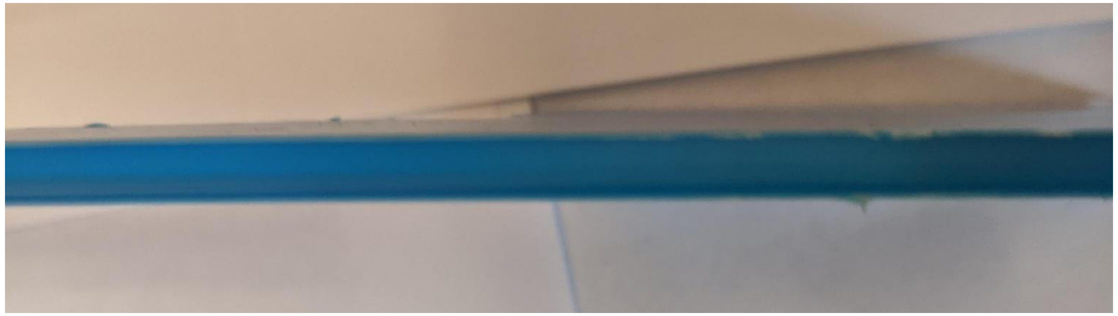
Risk	Risk Type	Likelihood	Consequence	Grade	Acceptable?	Mitigation
Batteries die	**Electrical**	3	5	15	No	Back up batteries supply
Box doesn't slide	**Mechanical**	2	5	10	No	Test trailer mechanism extensively
Box tips	**Mechanical**	2	5	10	No	Pull box at correct angle to avoid moments in wrong direction
Can jams in collector	**Mechanical**	2	4	8	No	Create algorithm to unjam can and test collector with many orientations and speeds
Can misses bin	**Mechanical**	2	2	4	Yes	
Cold solder joints	**Electrical**	2	4	8	No	Use best solder practice and test connections with multimeter
Combine breaks	**Mechanical**	1	4	4	Yes	
Combine stops turning due to can	**Mechanical**	4	3	12	No	Detect rpm of combine, reverse if stuck
Components Unavailable	**Operational**	2	4	8	No	Order spare components now
Entertainment system is lame	**Software**	1	5	5	Yes	
Hitch mechanism fails	**Mechanical**	1	5	5	Yes	
IC's blow	**Electrical**	5	4	20	No	Backup circuits

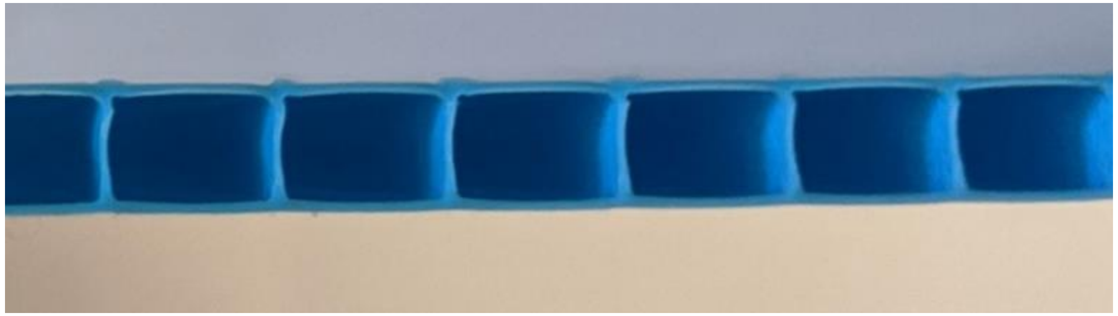
https://docs.google.com/spreadsheets/d/1OAZy4-wU5SI4BfNzQB1ZcYxA7Wh5FwU2rwSvHWz73AM/edit#gid=804378267

ENPH 480 ROW-BOTS		**Severity of Consequence**				
RISK ANALYSIS		1	2	3	4	5
Likelihood	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Mechanical Lessons – Cutting and Building

- Plastic has a strong direction and a weak direction – two layers at 90° are strong
- Cutting precise curves with utility knife is difficult
- Scissors work well for curves
- Filing curves with a metal file is effective

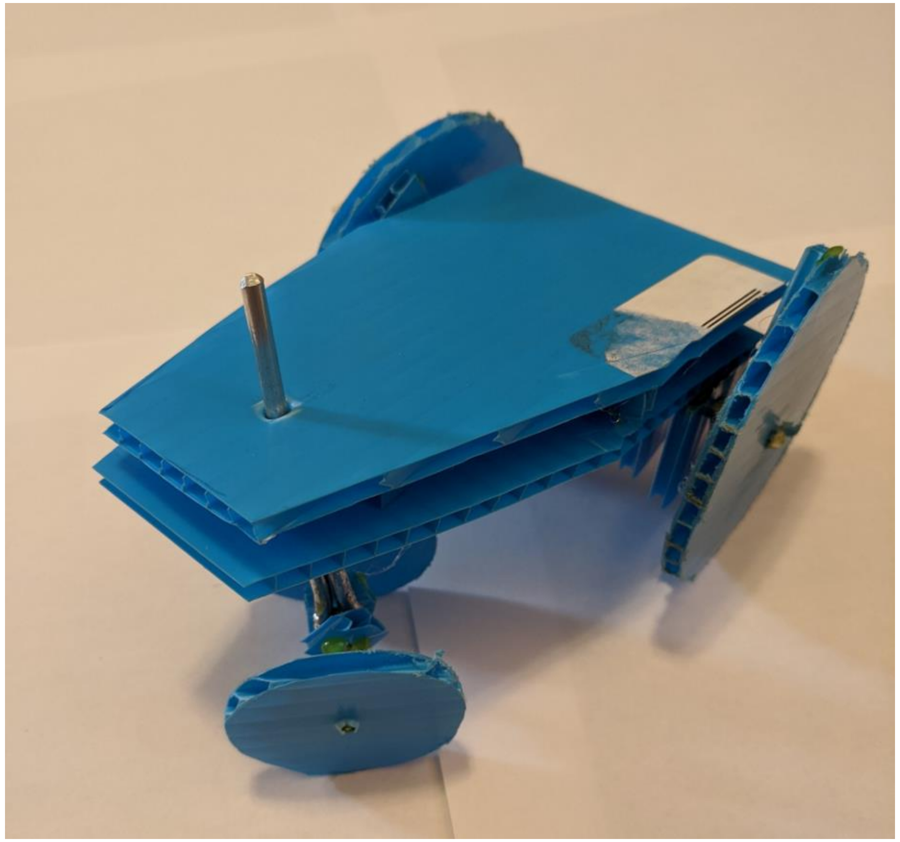




Figures showing the ribs in between the sheets of plastic. The plastic is strongest when these ribs are parallel to the loading axis

Mechanical Lessons – Attachment

- Riveting is not effective – plastic fails around hole while installing
- Hot glue is effective for permanent joints
- Zap straps and bolts work well for joints that could need to be removed
- Drilling holes before cutting out small pieces is easier, and using an awl helps a lot



Prototype I: built to test attachment and manufacturing techniques and tools

Mechanical Design

- Materials are cheap, abundant and easily sourced
- Manufacturing is quick and always available
  - No delays to use equipment
  - No delays for machinists or shop personnel
  - No shop hour restrictions
- Manufactured pieces can be easily modified
  - Plastic can still be cut when on robot
  - Plastic can easily be added with hot glue
- The learning from hands-on construction is effective
  - We learn fastest from working directly with the materials

Electrical Design

- Materials are expensive, limited and hard to source
- We have limited components (board space, Blue pills, etc.)
  - Shipping times are too long to wait for new components
- Manufactured pieces cannot be easily modified
  - De-soldering is difficult – removing an entire circuit is not reasonable
  - Building multiple iterations on the circuit boards is not possible
- Prototyping is available with protoboards
- Manufacturing resources are not limited
  - No delays to use tools
  - No shop hour restrictions

Critical Differences

Mechanical

- Materials are cheap, abundant and easily sourced
- Manufactured pieces can be easily modified

Electrical

- Materials are expensive, limited and hard to source
- Manufactured pieces cannot be easily modified

Problems are different:
We need different strategies

Our Strategy

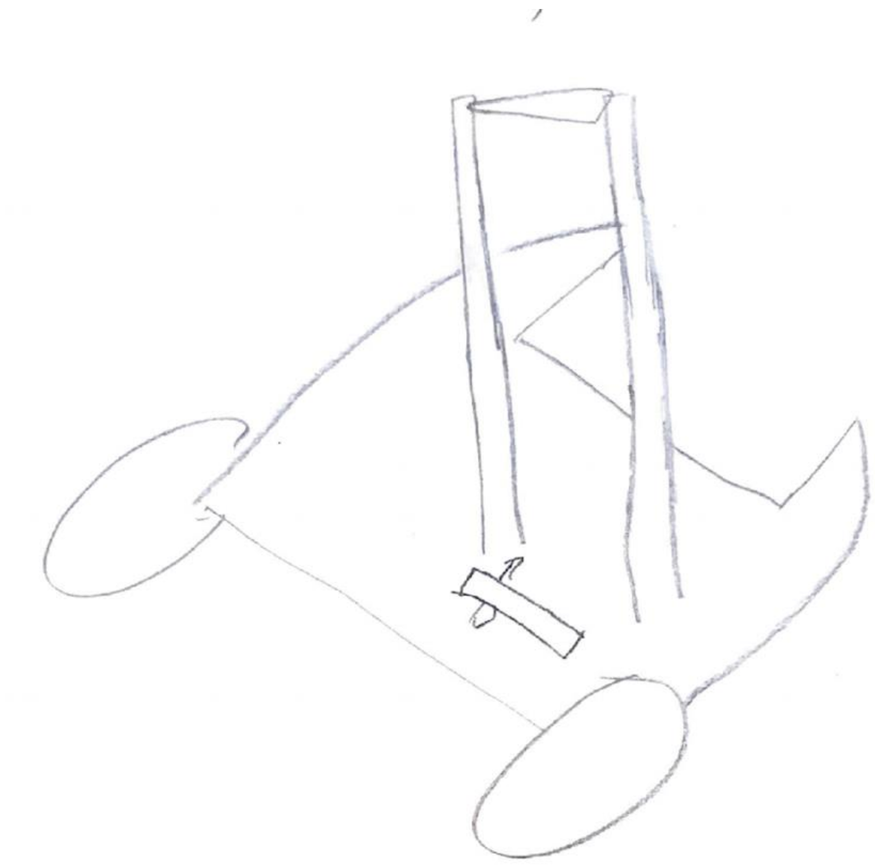
Mechanical

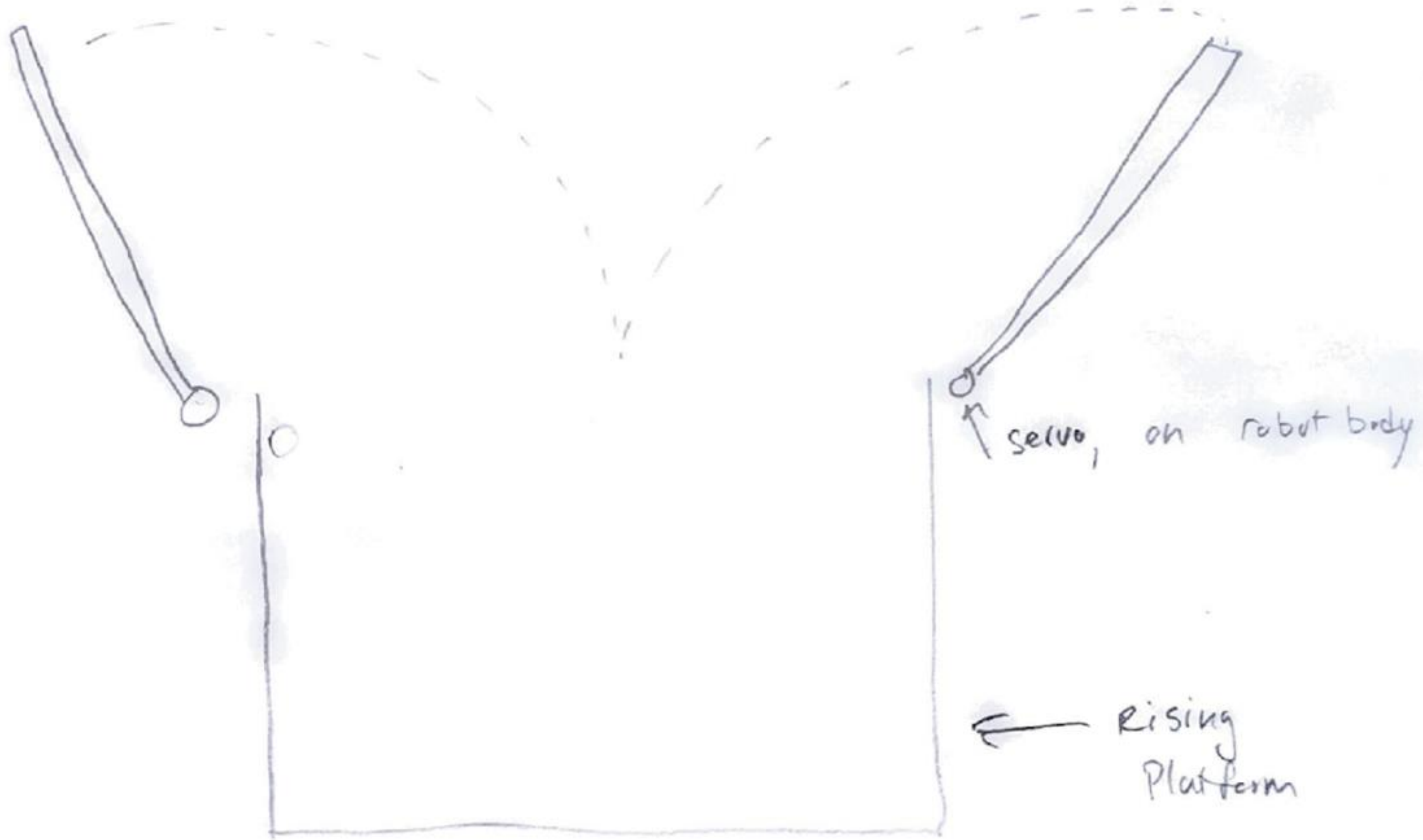
- Take advantage of easy and fast manufacturing
- Build prototypes, modify designs repeatedly

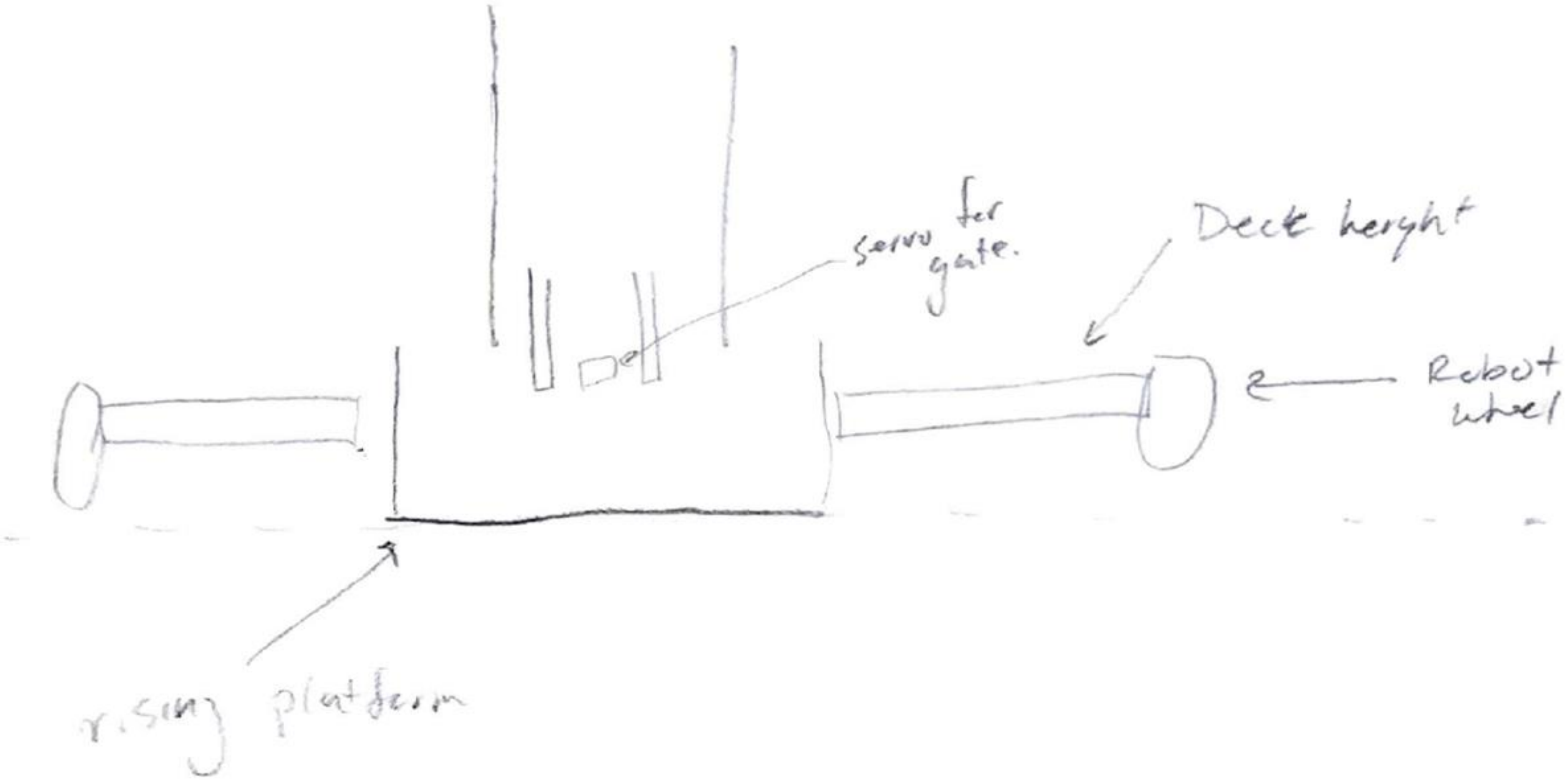
Electrical

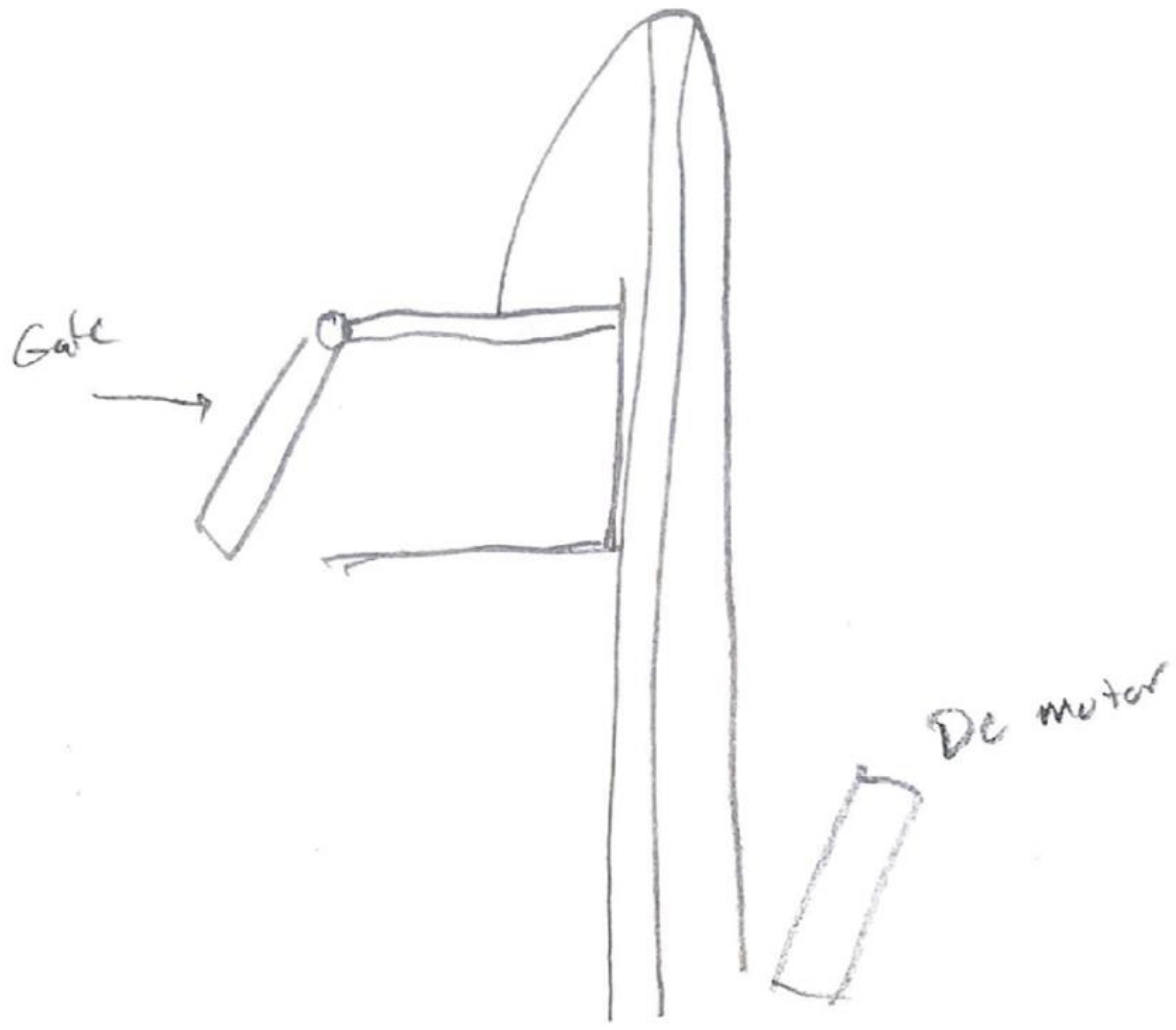
- Plan strategically to make sure circuits work when installed on circuit boards
- Use circuit schematics and plans to build precisely
- Test circuits on protoboards before installing on circuit boards

Sweeper Bot




servo, on robot body
Rising Platform

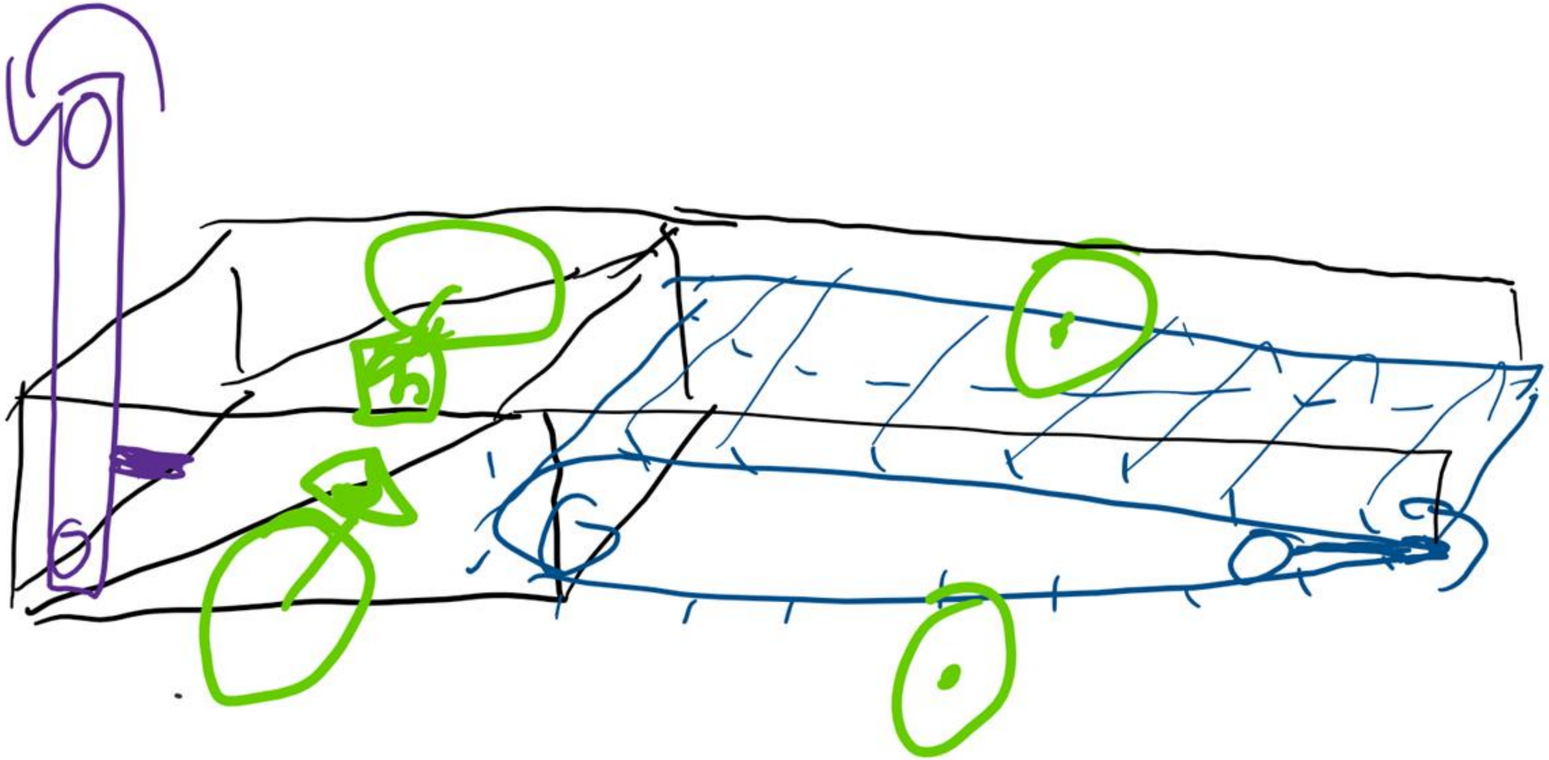

servo for gate.
Deck height
Robot wheel
rising platform

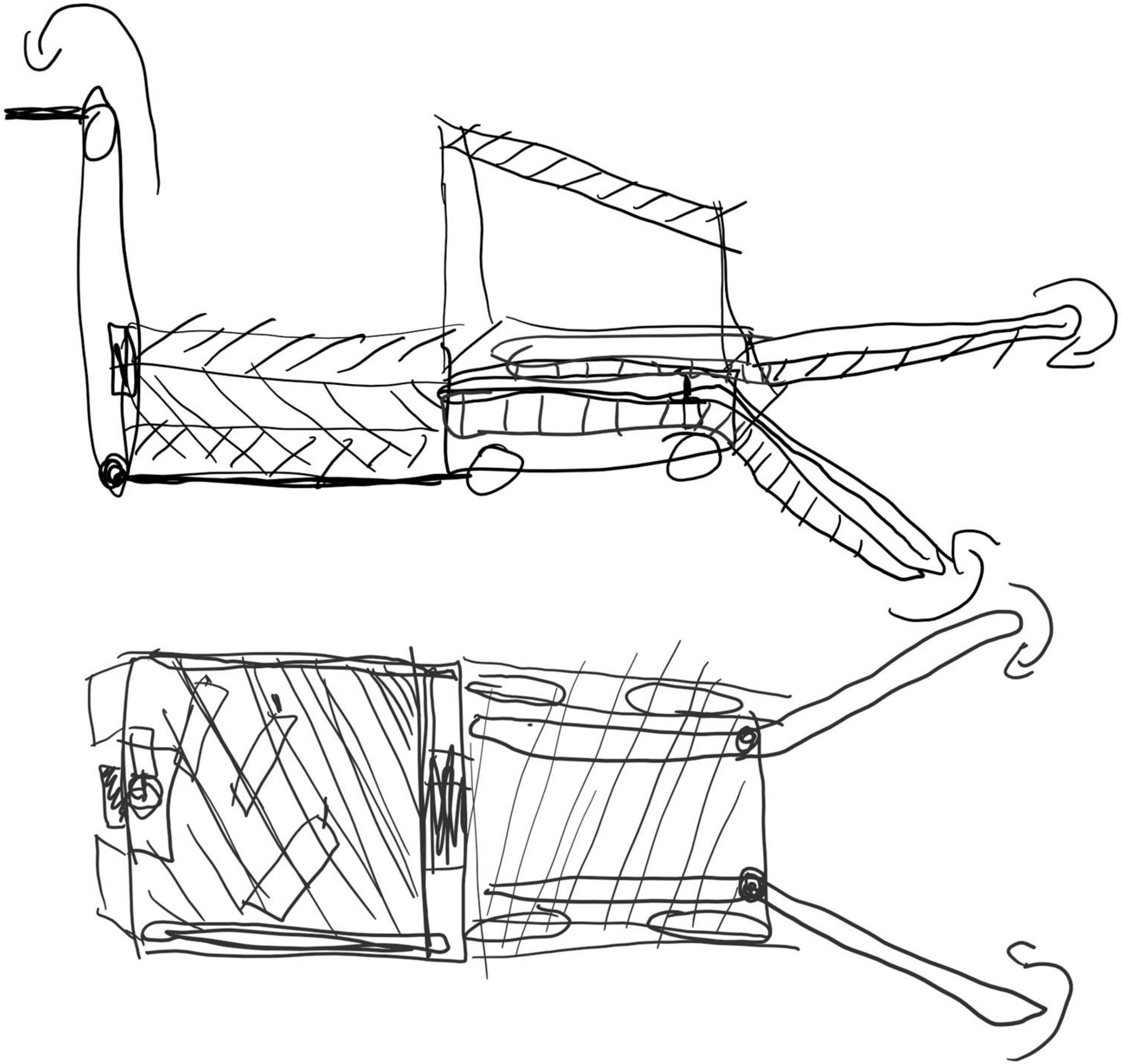

Gate
Dc motor

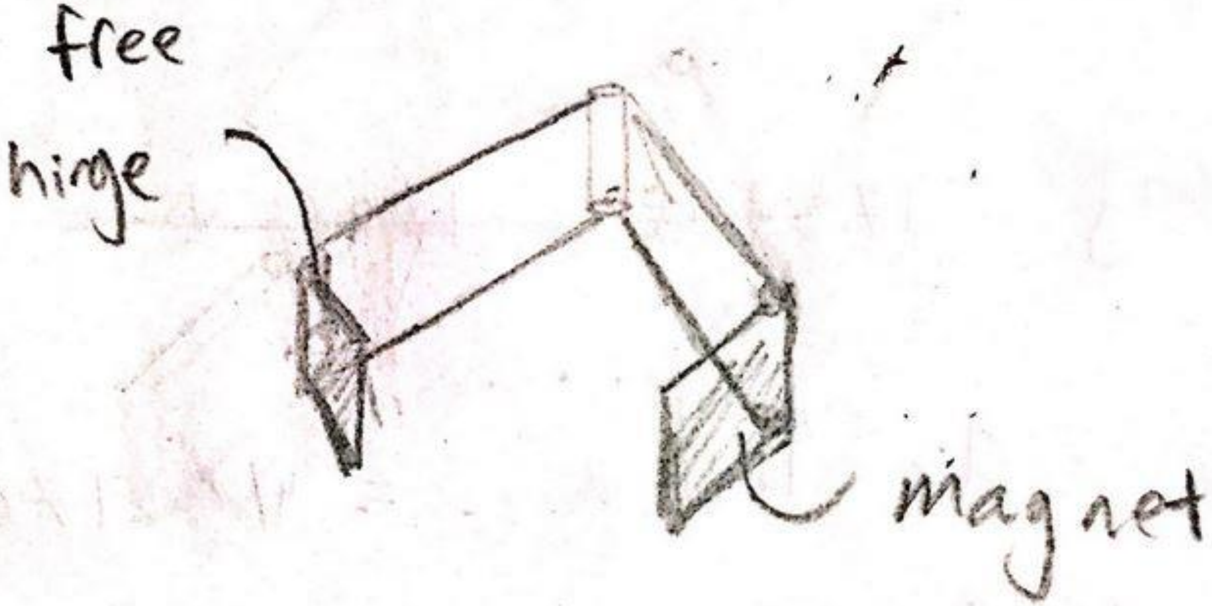
"GATOR"

Belt/Slanted/Vertical pully/ bi-roomwheel

1. Sweep
2. Centre
3. Hit Box
4. Dispose



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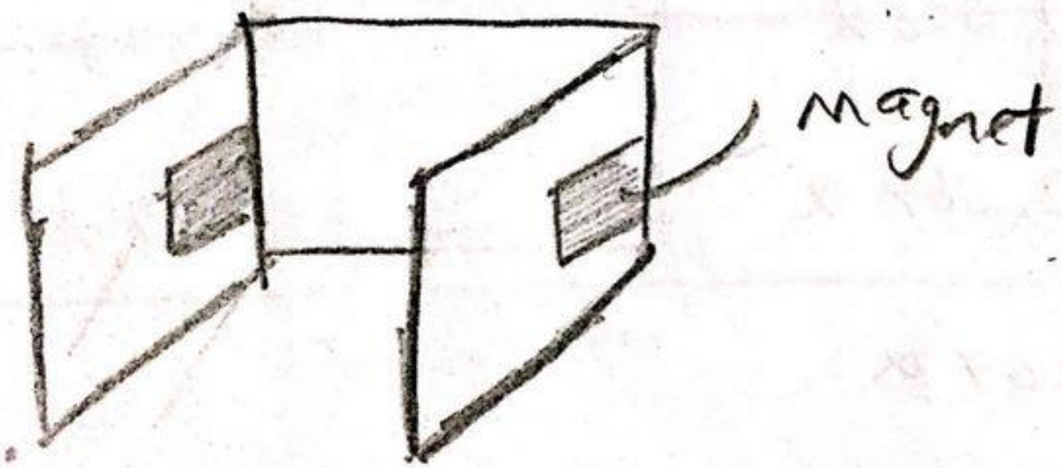
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