Team 11
Robo-Weeder

Interim Design Review

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Presentation Overview

- Background & Motivation
- Objectives & Constraints
- System Overview
    a. Mechanical Features
    b. Electrical Features
- Current Status
- Challenges
- Future Work
- Summary

Organic vs. Conventional Farming

Conventional:

- Marginally higher Crop yield
- Synthetic pesticide/herbicide usage
- Harmful environmental effects
- Microbiology decline
- Soil Erosion
- Genetically modified organisms

Organic:

- Improve fertility, reduce nitrate leaching & weed, pest and disease problems
- Doesn’t use synthetic pesticides
- Higher antioxidant level in crops
- Utilize crop rotation technique to improve soil health

Happy Earthworm = Nitrogen = $$$

Figure 1: “Lumbricina” or Earthworm is organic farmers dream.

Ideal Conditions

Secretes Nitrogen as a waste product

Biological pistons that aerates soil as it borrows downward.

This movement is conducive to mineralization nutrients and their uptake of vegetation

Lives approximately 10-30 cm below surface

Less Than Ideal? Labor Intensive Weed Control

Figure 2: Closeup of Mulching technique implemented at Orchard Pond.

weed: any undesirable plant that grows on cultivated ground to the exclusion or injury of the desired crop.

- Tillage
- Mowing Cutting Weeds
- Flame/ Thermal Weeding
- Mulching

Need Statement

Is organic farming more beneficial?

Scientific study is inconclusive

Sponsor, Jeff Phipps M.E. and owner of Orchard Pond wants to,
"*commercialize a robotic system that will house several weeding implements to facilitate organic farming*."

Goal Statement:

"Develop a 'proof of concept' robotic machine that will enhance the production of organic crops."

2014-2015 Design

Motor Attachment:
Chain-Sprocket System with 1:1 ratio.

Autonomous Operation:
Camera with visual recognition software that identifies plants

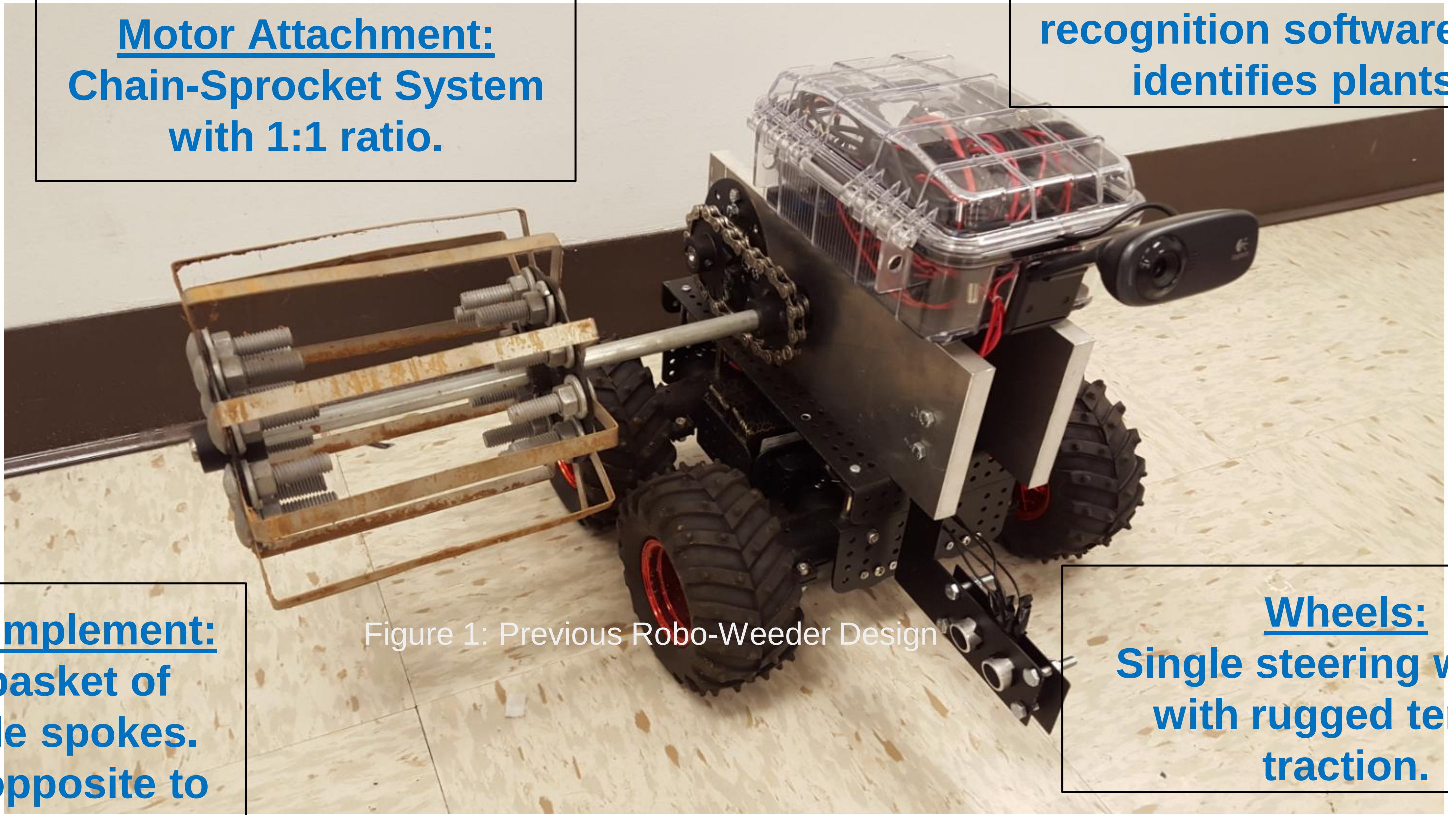


Figure 1: Previous Robo-Weeder Design

Shearing Implement:
Single basket of removable spokes. Revolve opposite to direction of motion.

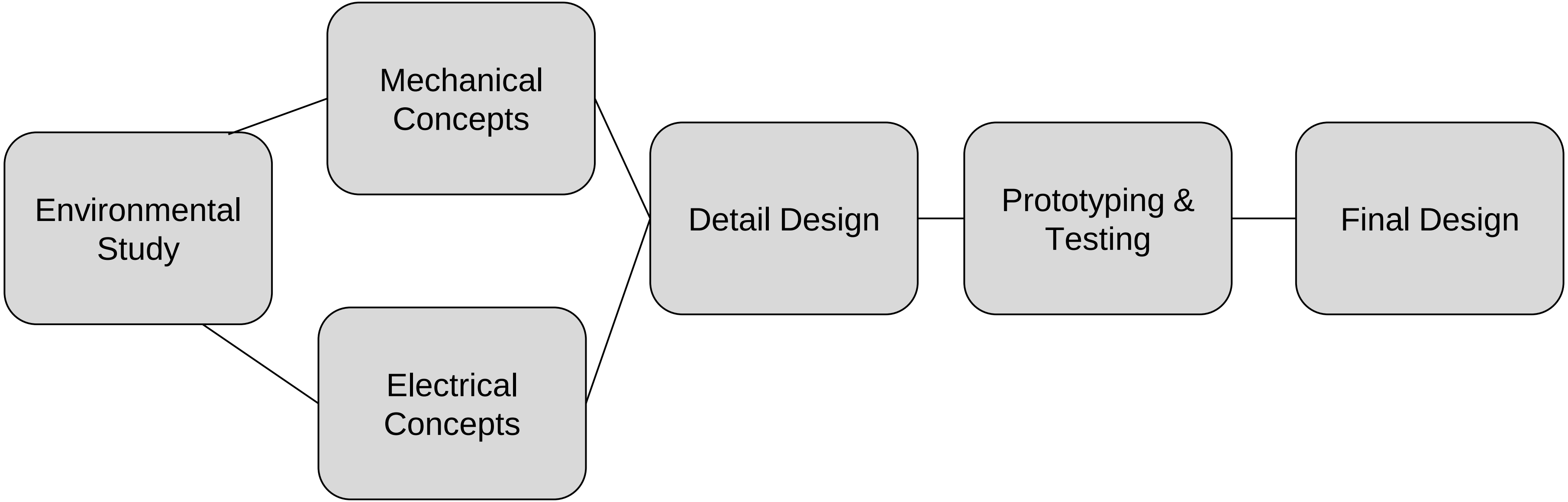
Wheels:
Single steering wheels with rugged terrain traction.

New Constraints

Figure 3: Organic Crops.

- Mobile
- 8” Auger provided
- Remotely Operated
- No till
- 1” soil interruption
- No wider than 12”

Project Scope



Design Modifications

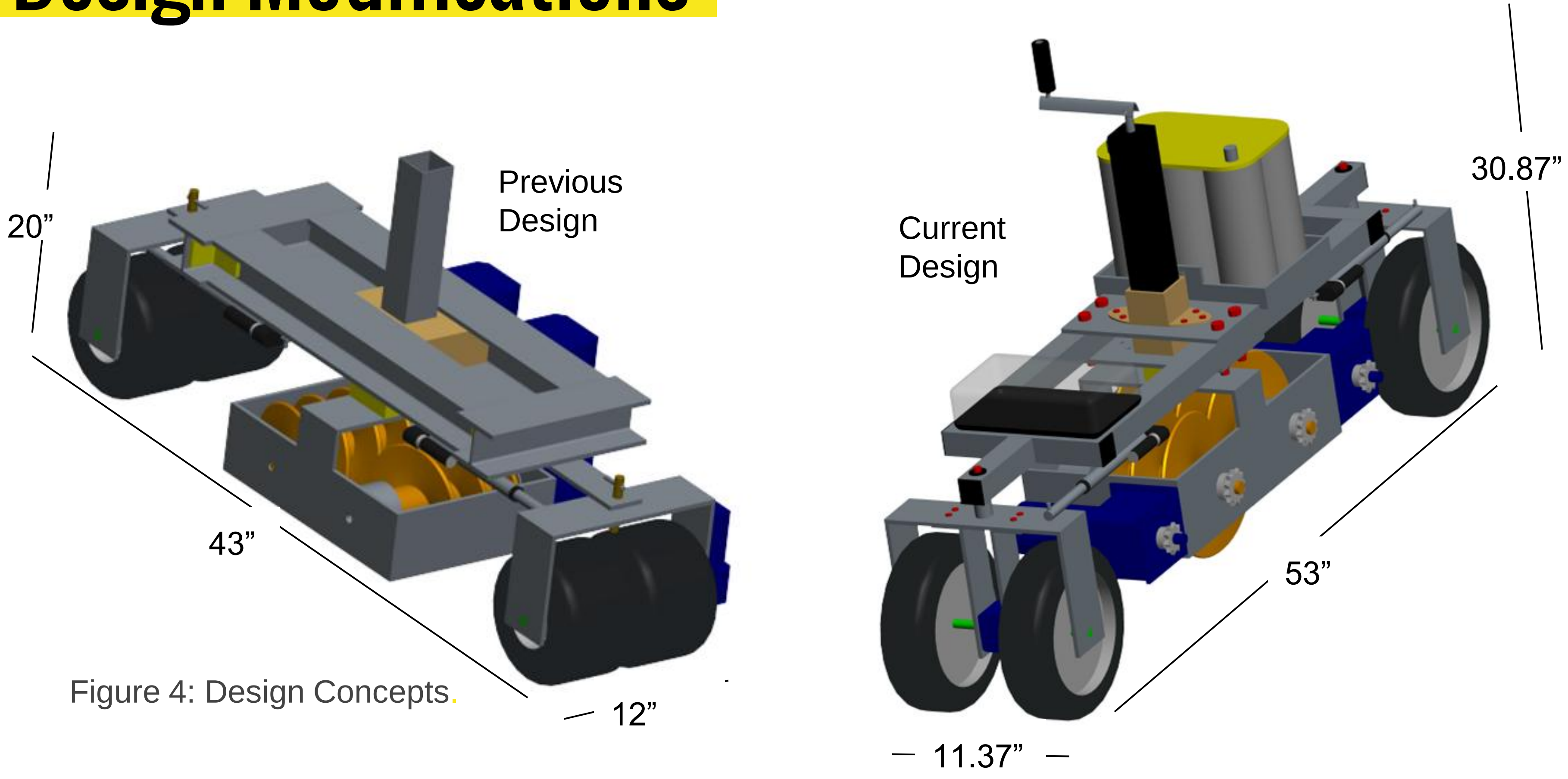
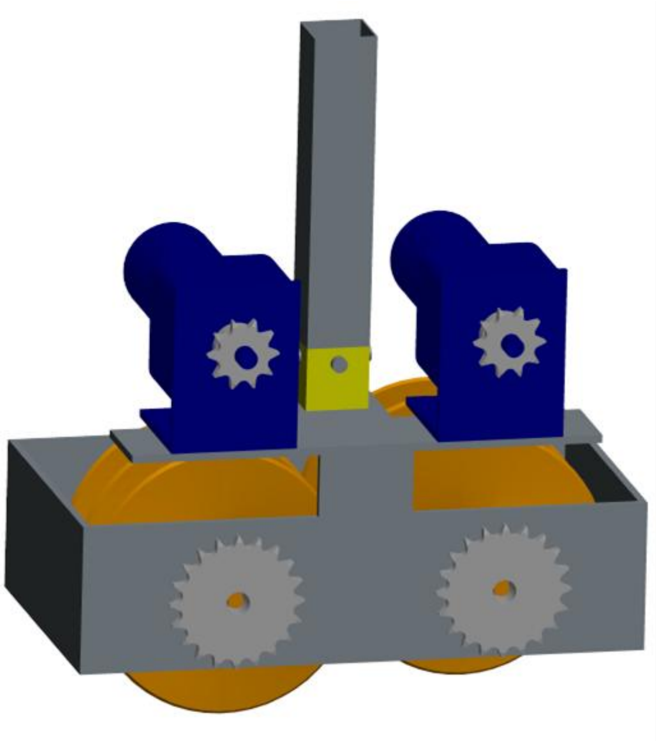


Figure 4: Design Concepts.

Previous Shearing Design Analysis



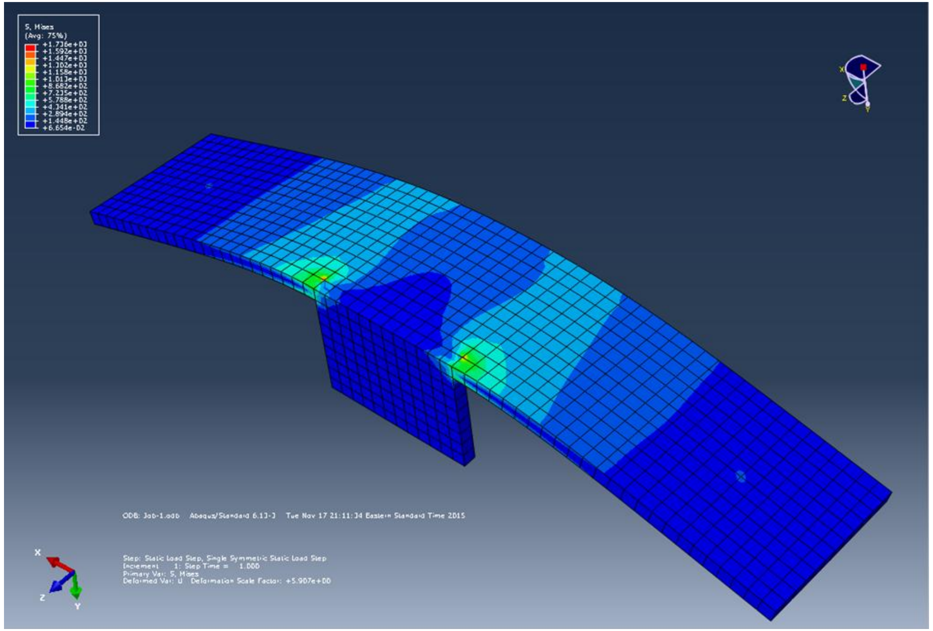


Figure 5: FEA Results.

Shearing Feature

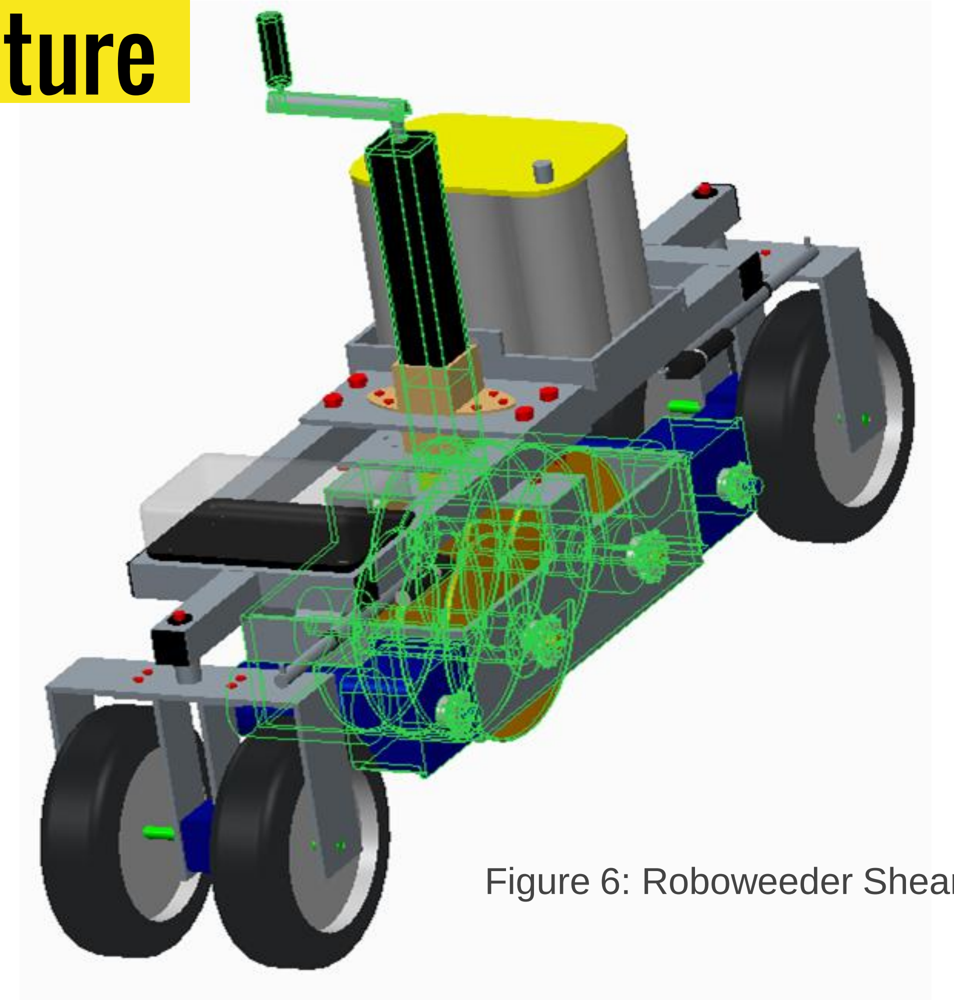


Figure 6: Roboweeder Shearing Mechanism

Shearing Feature

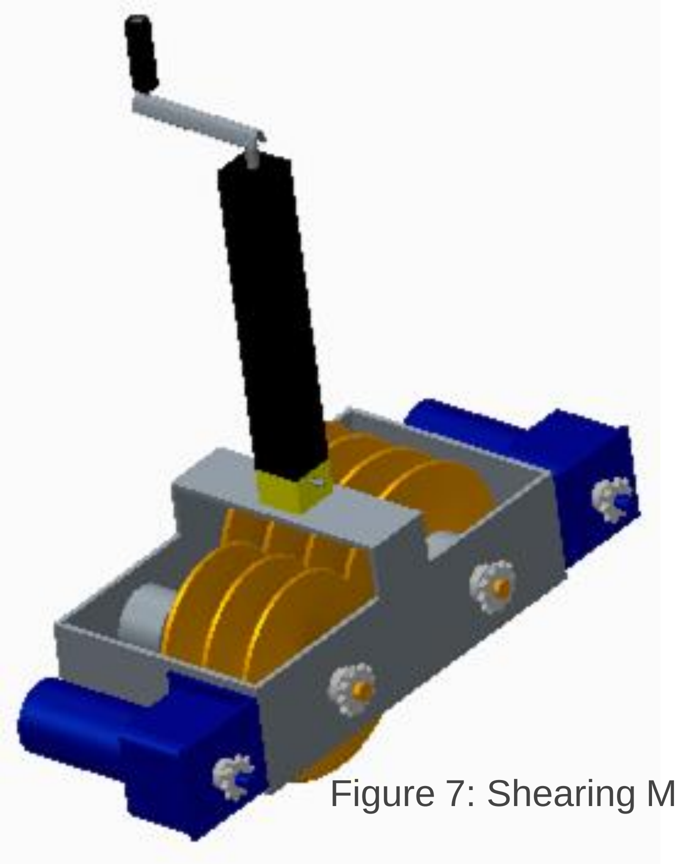


Figure 7: Shearing Mechanism.

Mechanical Parameters:

- Vertically lifted via crankshaft
- Constraint Provided: 8” diameter auger
  - counter balancing effect with counter rotating augers to ensure stability
- Two 14 pound motors providing 110 in-lb to each auger
  - 1.2:1 Gear reducing Sprocket system

Steering Feature

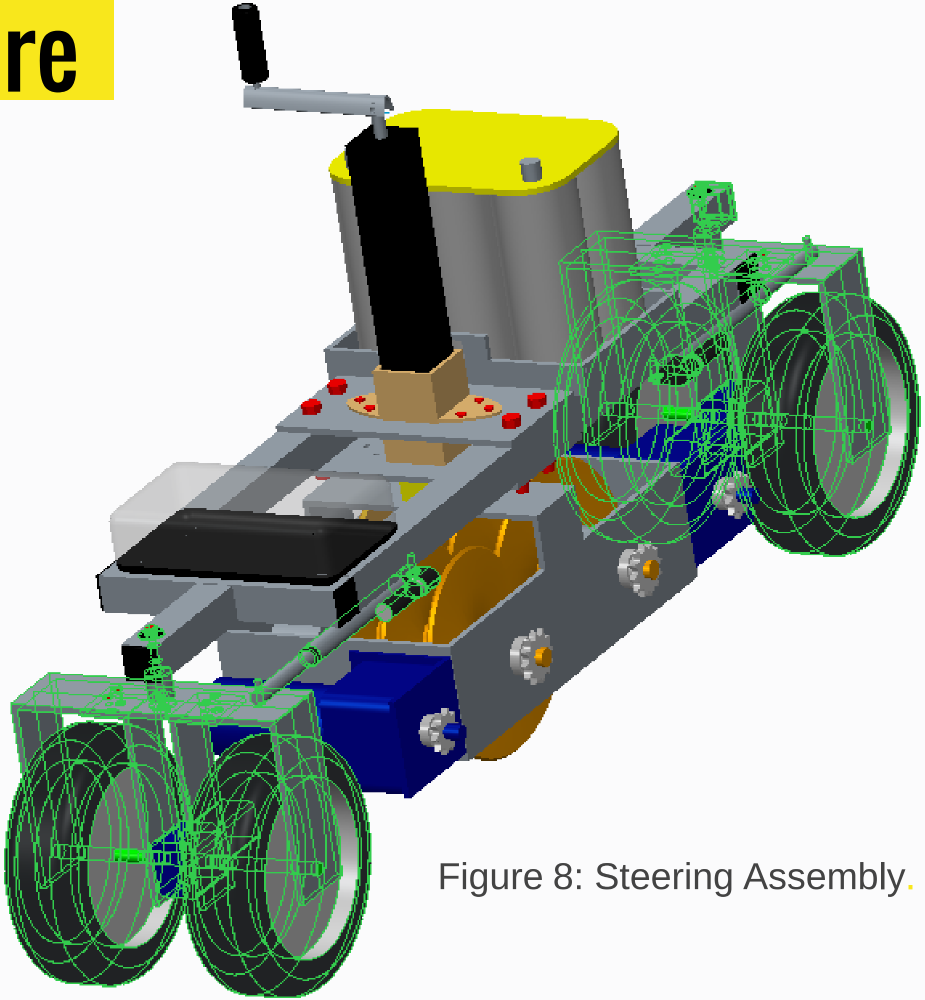


Figure 8: Steering Assembly.

Steering Feature

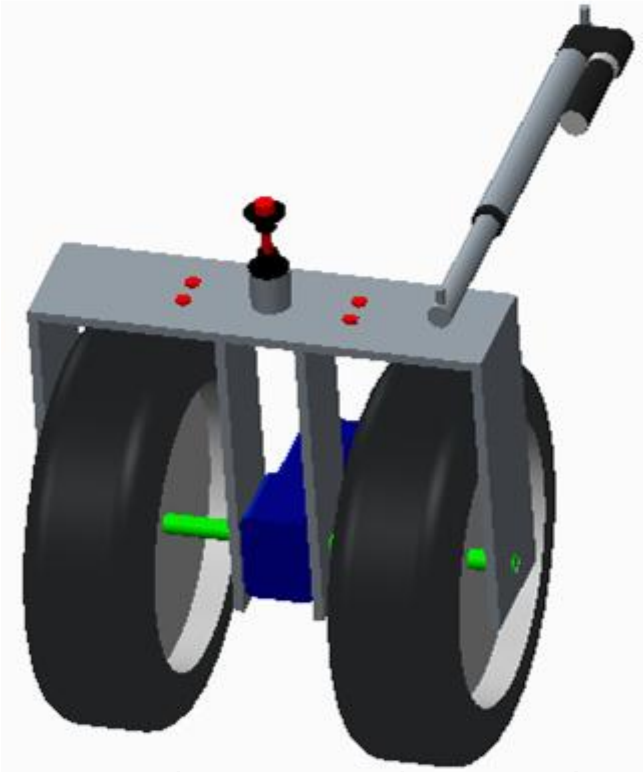
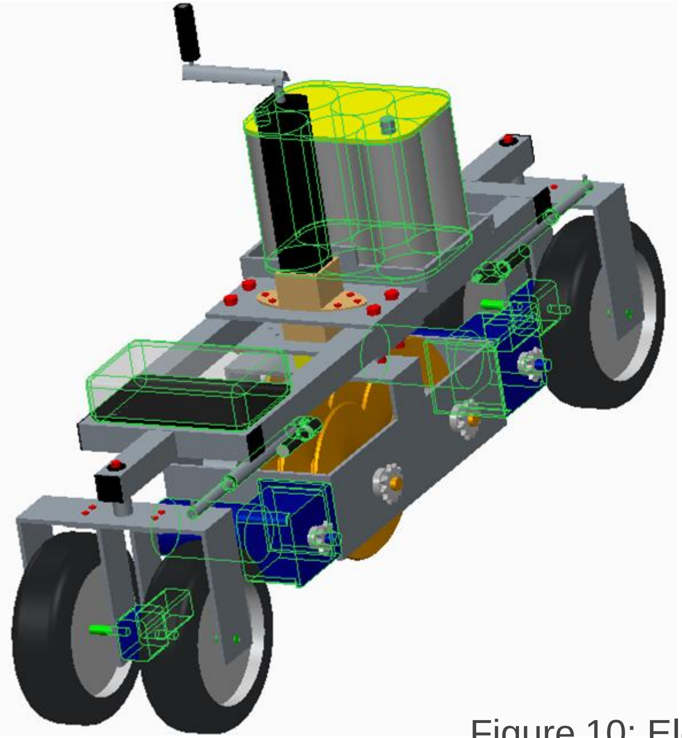


Figure 9: Steering Assembly.

Mechanical Parameters:

- Each pivot point 30 degree turn radius
  - Independent/Parallel
- Desired motor will be centered between wheels
  - Stability
- Single linear actuator steering providing
- High Traction wheels

Electrical System:



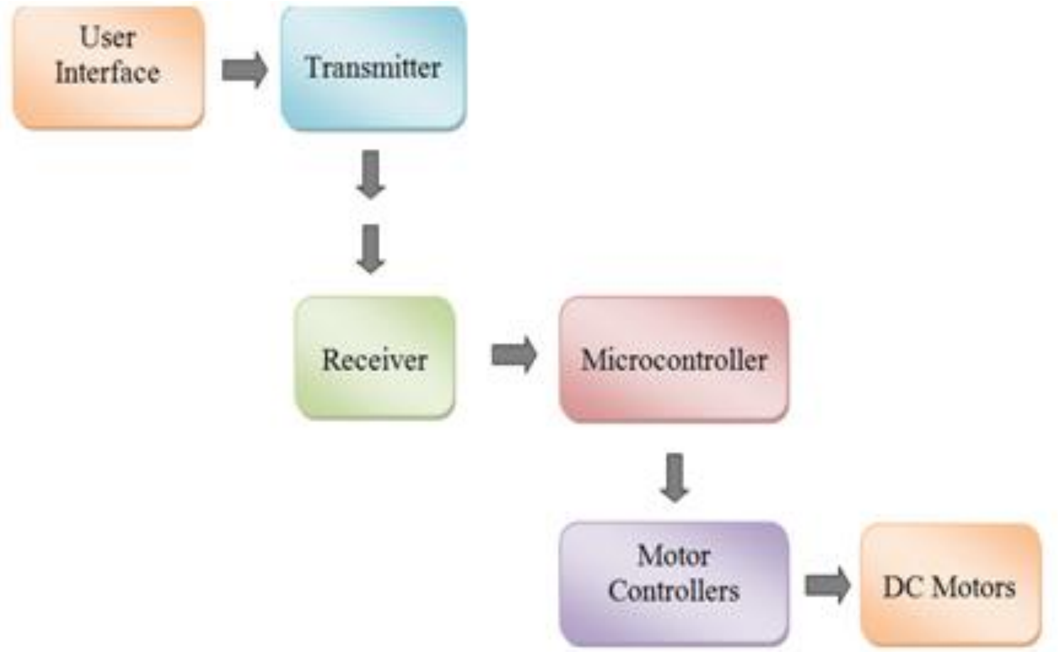


Figure 10: Electrical System Overview.

Design Needs

- 1 Transmitter/ Receiver
- 1 Microcontroller
- 2 Linear actuators
- 4 Motors
- 6 Motor Controller Channels
- 12V Battery

Microcontroller ➡ Motor Controller

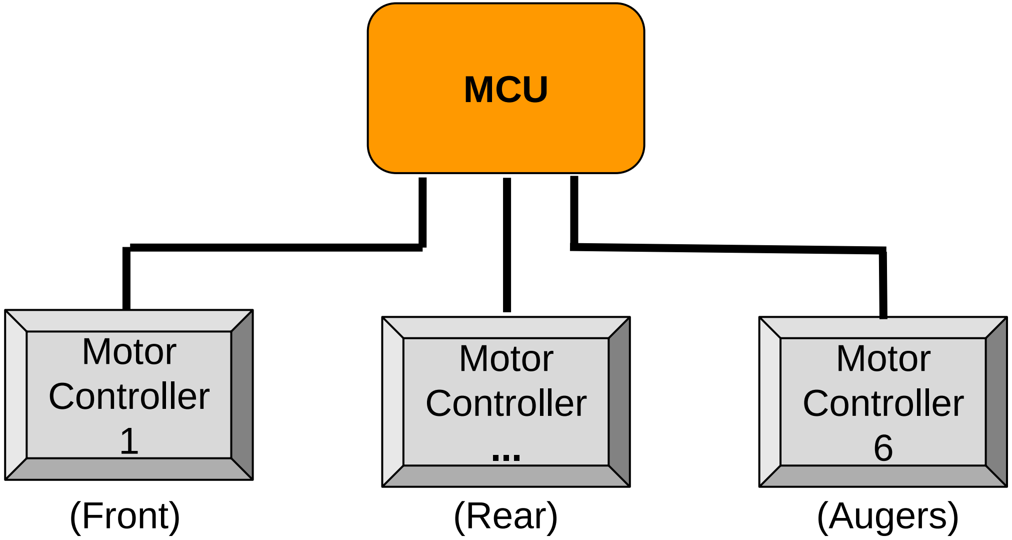


Figure 11: Motor Controller Diagram

Shearing Components

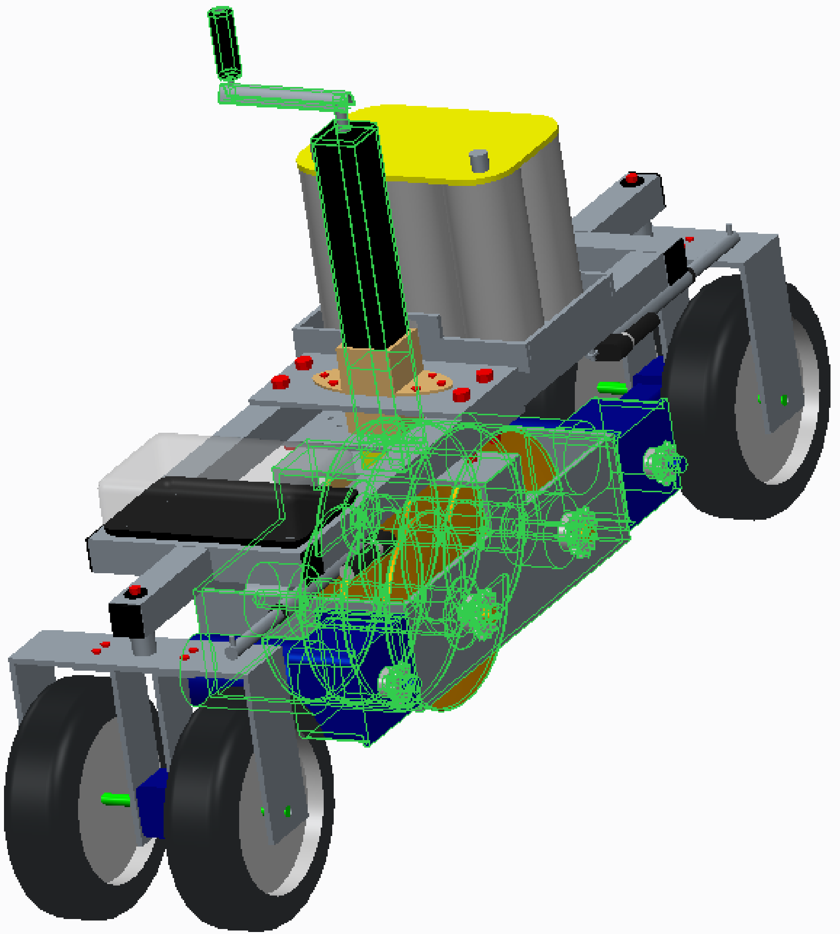


Figure 12: Roboweeder Shearing Mechanism

Shearing Feature

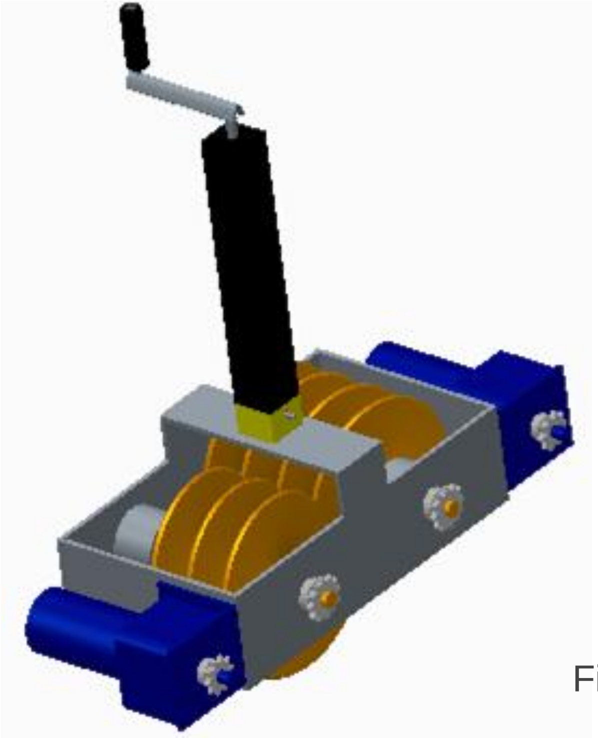


Figure 13: Shearing Mechanism

Electric Parameters:

- 2 Motors
- ~110 lb-in Torque (per Auger)
- 60-100 RPM (per Auger)

Steering/Drive Components

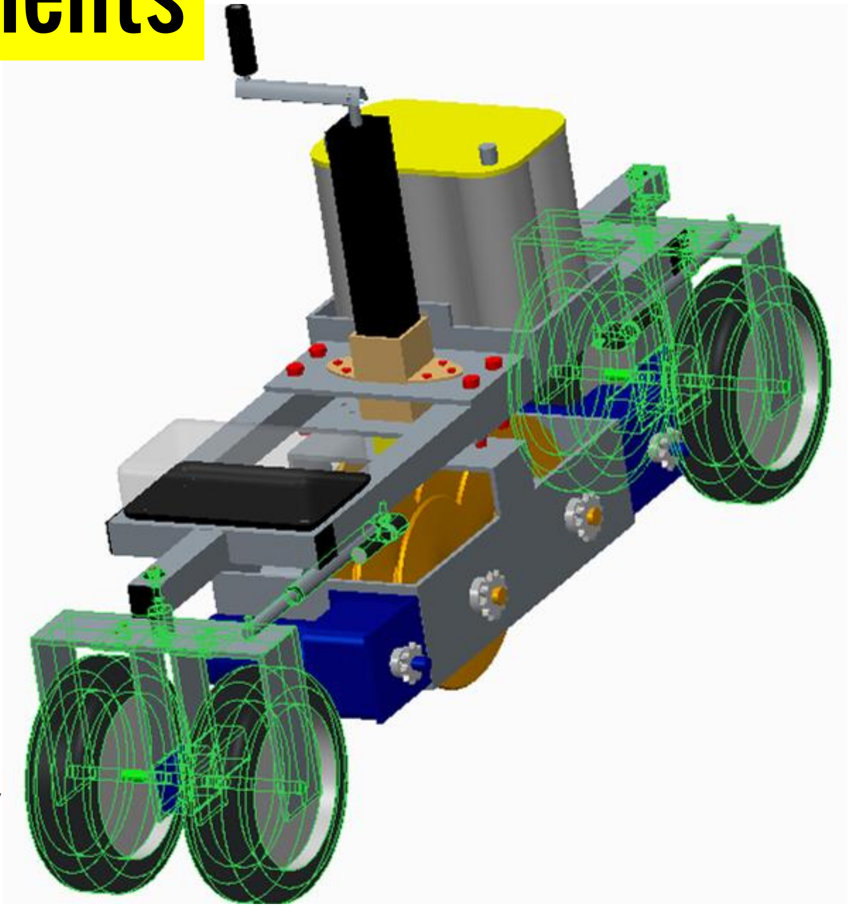


Figure 14: Roboweeder Steering Assembly

Steering/Drive Feature

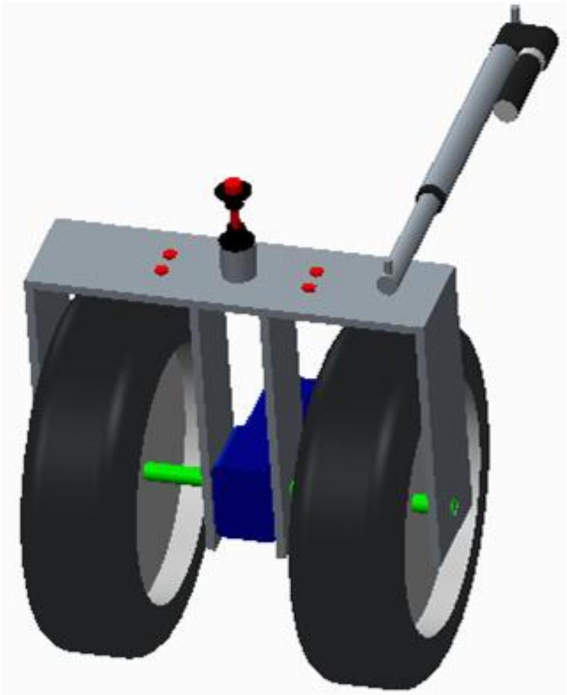


Figure 15: Steering Assembly

Electric Parameters:

- 2 Drive Motors
- 2 Linear Actuators
- ~100 lb-in Torque (Drive Motor)
- ~25 ±5 RPM (Drive Motor)

Prospective Motors

Drive Motor

Auger Motor

Motor	**LEESON M1135285**	**LEESON M1125219**
Cost	$312.77	$229.99
Speed	27 RPM	61 RPM
Torque	134 lb-in	113 lb-in
Amperage	14 A	10.4 A

Transmitter

Turnigy 6X FHSS 2.4Ghz Transmitter and Receiver ($30)

- Transmits through Radio Frequency
- 6 Channels
  - Augers
  - “Drive” Motors
  - Linear Actuators

Figure 16: Transmitter

Figure X

Microcontroller

Arduino Mega 2560 ($45)

- Processor: ATmega2560 @ 16 MHz
- 54 Digital I/O Pins
    - 14 PWM Pins
- 16 Analog Inputs
- 7V - 12V Operating Voltage

Figure 17: Arduino Microcontroller

Figure X

Budget Forecast

Total Budget: $3000.00

Upcoming Costs

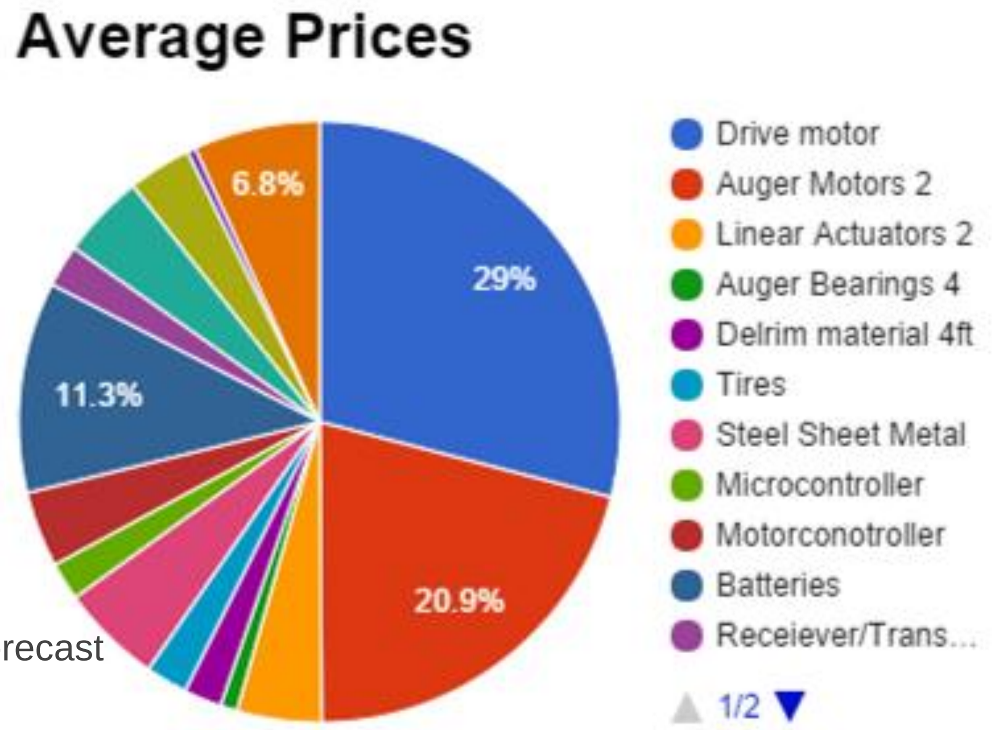
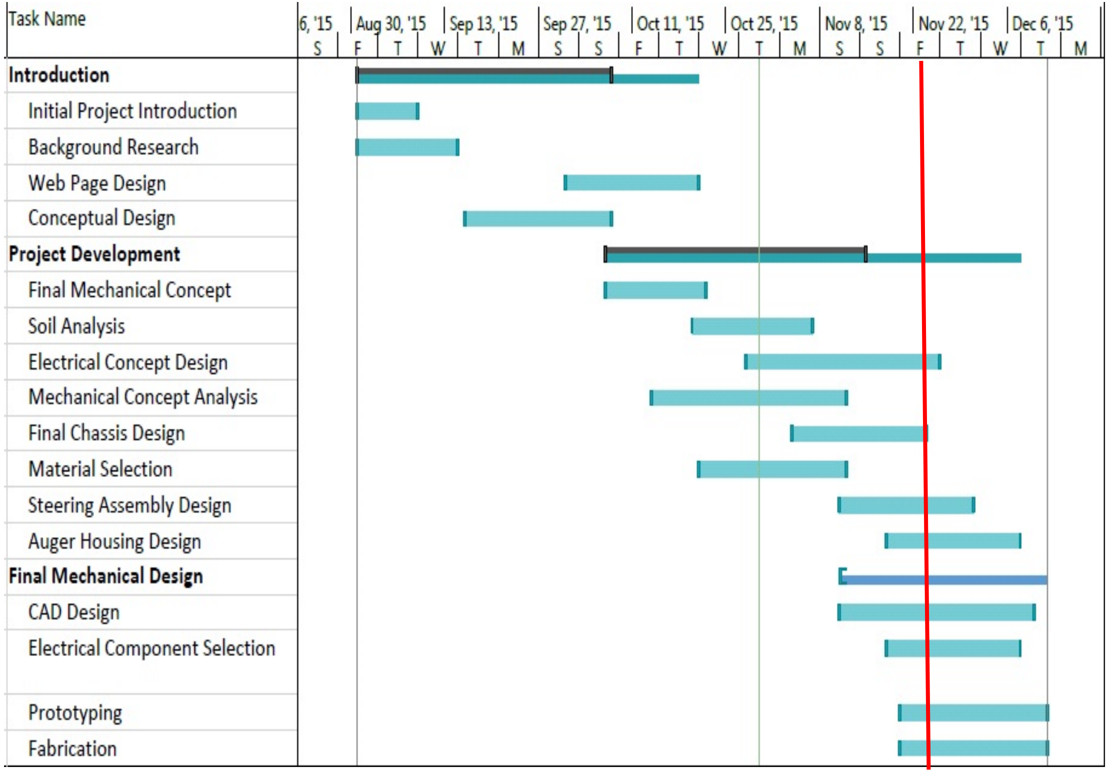


Figure 18: Budget Forecast

Current Status



Current Project Tasks:

- Electrical Concept Design
- Electrical Component Selection
- Steering Assembly Design
- Auger Housing Design
- Detailed CAD Design

Behind Schedule

- Fabrication

Future Work

- Electrical Components
  - Motor Controller based on final motor selection
  - Linear actuators pending on further force analysis
- Battery Type/Size
- FMEA

- Mechanical Components
  - Detailed CAD Design
- Fabrication
  - Chassis
  - Steering Assemblies

Challenges Ahead

Stability

Intended use of a lead acid battery may affect the center of gravity.

Connection of Materials

Connection between purchased and fabricated parts fit as intended.

Material Selection

Using the correct materials is important to keep the weight down, but to also maintain the strength of components.

Summary

Goal:

Develop a ‘proof of concept’ robotic machine that will enhance the production of organic crops.”

Robo-Weeder

Steering: Independent front and rear with parallel steering capability.

Shearing: Auger Style to minimize soil disruption.

Communication: Radio Controlled for ease of operation.

References

http://www.todaysdietitian.com/newarchives/040715p40.shtml
(organic vs conventional farming)

http://www.orchardpondorganics.com/images/gallery/original/1301371300_f7d5753c3bf1.jpg

http://www.ocia.org/sites/default/files/_documents/EN-QS-M-003_0.pdf
Organic standards

https://en.wikipedia.org/wiki/Earthworm
earthworms

https://www.arduino.cc/en/Tutorial/PWM (PWM Table, Microcontroller)

http://www.engineeringtoolbox.com/thermal-conductivity-metals-d_858.html thermal conductivity of gray cast iron

http://www.hobbyking.com/hobbyking/store/__24969__Turnigy_6X_FHSS_2_4ghz_Transmitter_and_Reciever_Mode_2_.html
(Transmitter)

Questions?

Appendix to follow

Appendix

Team 11: Robo-Weeder

Motor Torque Calculations

α	Pressure Angle			
γ	Lead Angle			
μ	Friction Coefficient			
z	Starts		4	
p_x	Axial Pitch		1.8125	46.04

α = 10 degree	0.174533
μ = 0.3	
p_x = 7.25 inch	184.15 mm
D_{ref} = 4.6875 inch	119.06 mm

$$F_{Axial} = F_{Tangential} * \frac{\cos\alpha * \cos\gamma - \mu\sin\gamma}{\cos\alpha * \sin\gamma + \mu\cos\gamma}$$

$$F_{Tangential} = \frac{2 * T}{D_{ref}}$$

$$T = \frac{F_{axial} D_{ref}}{2 * \frac{\cos\alpha * \cos\gamma - \mu\sin\gamma}{\cos\alpha * \sin\gamma + \mu\cos\gamma}}$$

$$\gamma = \frac{180}{\pi} * \tan^{-1}\left(\frac{z}{q}\right)$$ → 26.214 degree 0.457521

$$q = \frac{D_{ref}}{m}$$ → 8.124197

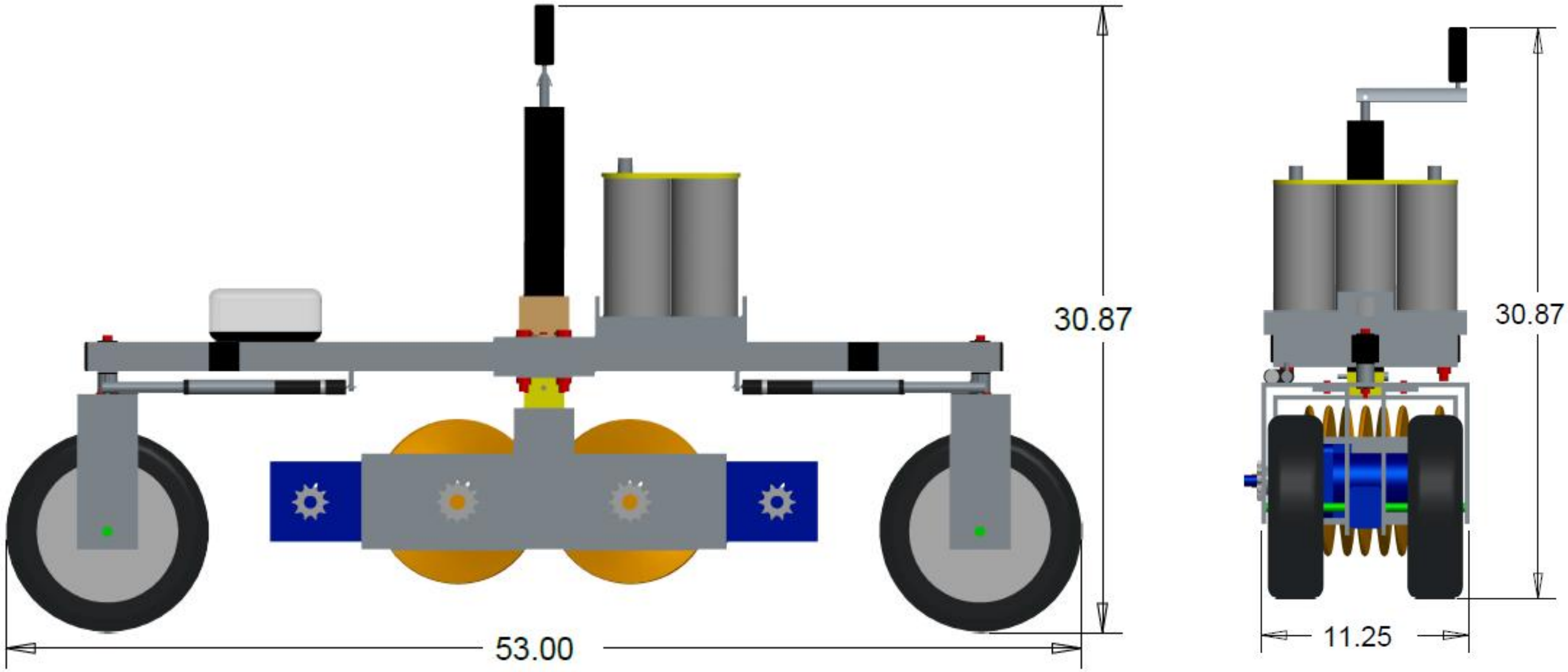
$$m = \frac{p_x}{\pi}$$ → 14.65499

Total axial force needed to shear soil:
F_{axial} = 50 lbs

Needed Auger Shaft Torque
110 In-lb

Supplied Rated Torque:
113 in-lbs @ 12V

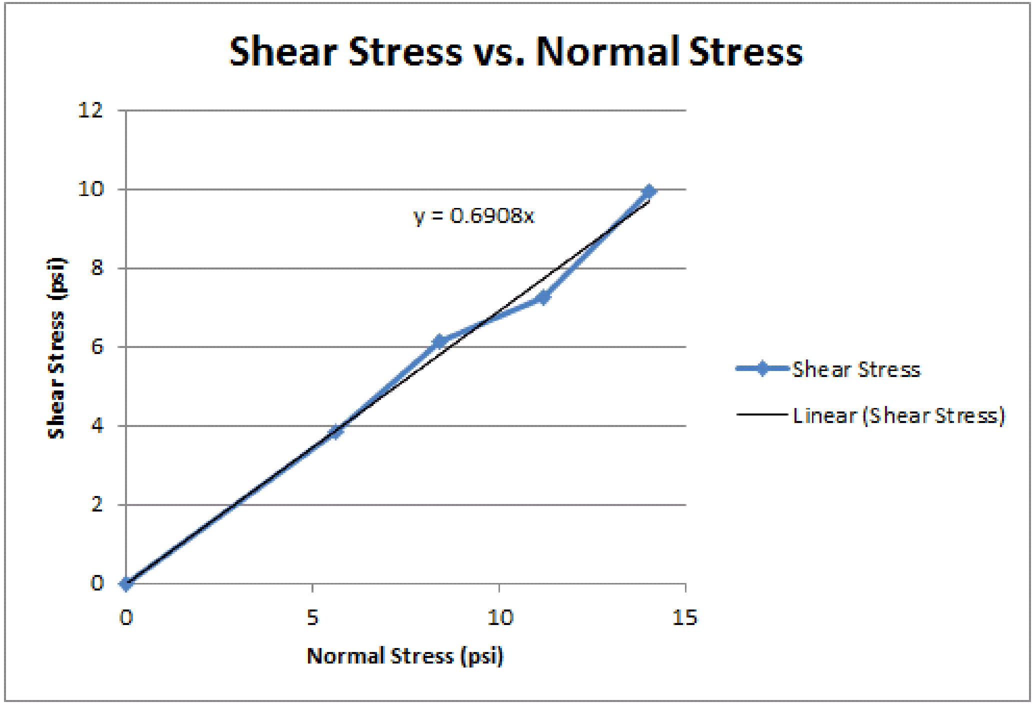
Dimensions



Organic Terminology

A pest is any living organism which is invasive or prolific, detrimental, troublesome, noxious, destructive, a nuisance to either plants or animals, human or human concerns, livestock, human structures, wild ecosystems etc. It is a loosely defined term, often overlapping with the related terms vermin, weed, plant and animal parasites and pathogens. It is possible for an organism to be a pest in one setting but beneficial, domesticated or acceptable in another

Soil and Shear Force Calculations



Maximum Normal force: 100 lbs

Normal Stress: 2.7 psi

Shear Stress: 1.86 psi

Shear Force: 6.75 lbs

Total Shear Force Needed: 50 lbs

Torque Needed: 110 in-lbs