# Robo-Weeder Team 11

Sponsor: Jeff Phipps
Advisor: Dr. Gupta

<u>Student Members:</u>
Aquiles Ciron (EE)
Steve Miller (ME)
Chris Murphy (ME)
Arriana Nwodu (ME)
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October 22, 2015

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# Objectives

Design and create a Remotely Operated Vehicle (ROV) that houses interchangeable shearing implements.

- The Interchangeable Shearing Implement System will aid in the removal weeds by applying a shear force that minimally disturbs the soil ensuring the survival of beneficial microorganisms.

The ROV should be able to be operated wirelessly and be splashproof.

# Background

Conventional farming techniques:

- Genetically Modified Organisms
- Herbicides
- Pesticides
- Fertilizers

Controversial due to low nutritional value of crops, and unknown harmful effects after consumption.

Organic farming steers away from these methods, but with great difficulty.

- Must  remove weeds by hand.

# Previous Design

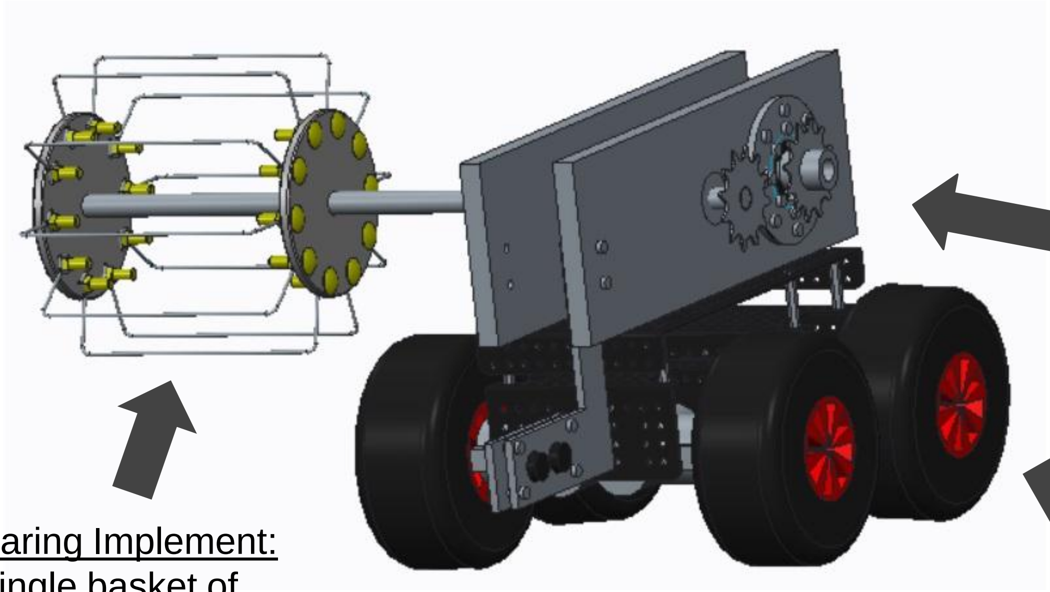


Figure 1: Previous Robo-Weeder Design

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

Wheels:
Single steering wheels with rugged terrain traction.

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

# Chassis Design Concepts

# 1st Design Concept

**Key Design Points:**

All Wheel Drive

180 Degree Front Wheel Steering

Vertical Auger Adjustment

Auger Style Shearing Mechanism

- Chevron Pattern

Note:  Chevron Augers are opposite handed. Front most auger forces material outward, Rear Auger pulls material back to center.

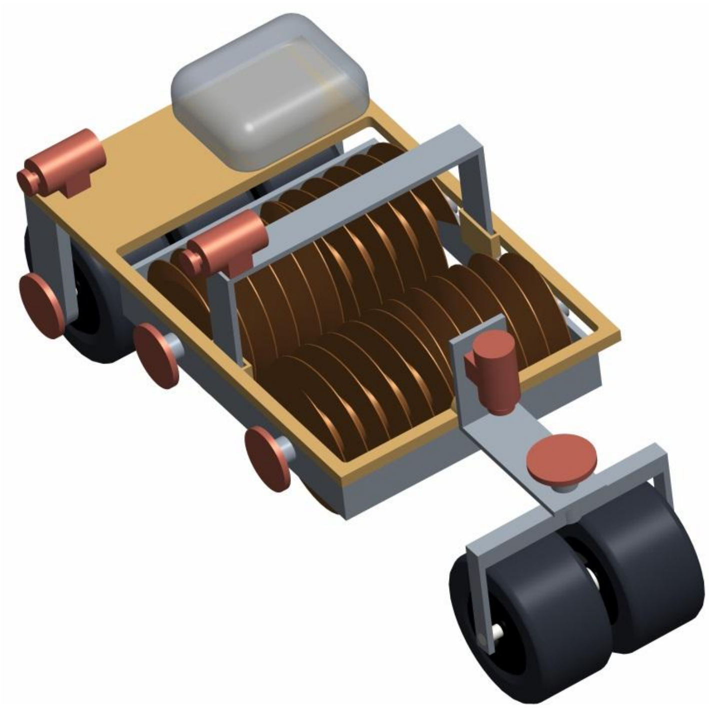


Figure 2: Concept 1 Robo Harvester

# 1st Design Concept

All dimensions are in inches.

**Total design size:**

Length = 30”

Height = 14”

Width = 13”

**Auger Size:**

Length = 10”

Diameter = 6”

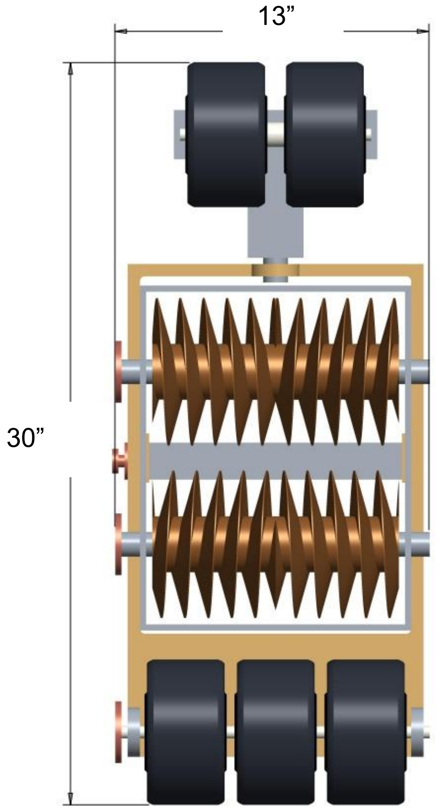



Figure 3: 1st Design Concept Bottom View

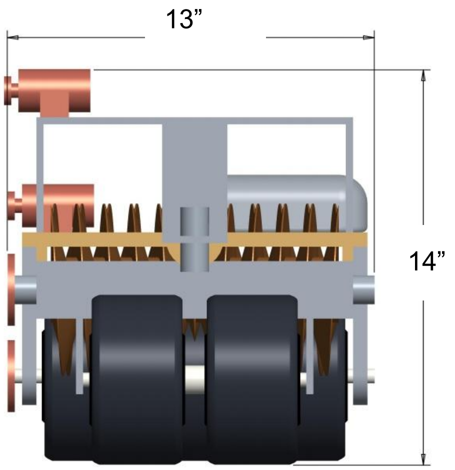



Figure 4: 1st Design Concept Front View

# 2nd Design Concept

**Key Design Points:**

Independently Driven and Steered Wheels

Vertical Auger Adjustment

Pivoting Auger Connection

Auger Style Shearing Mechanism

- Chevron Pattern

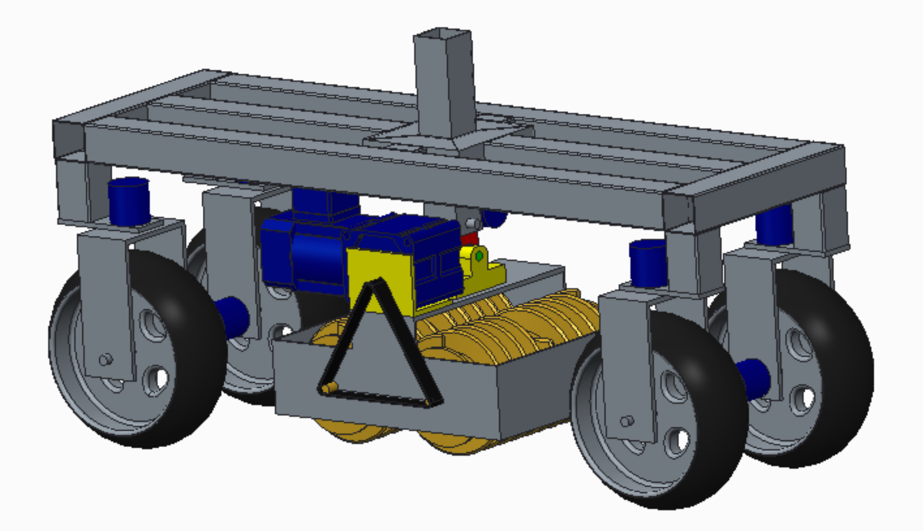


Figure 5: 2nd Design Concept

# 2nd Design Concept (cont)

All dimensions are in inches.

**Total design size:**

Length = 43 ’

Height = 22”

Width = 15”

**Auger Size:**

Length = 12 ”

Diameter = 6”

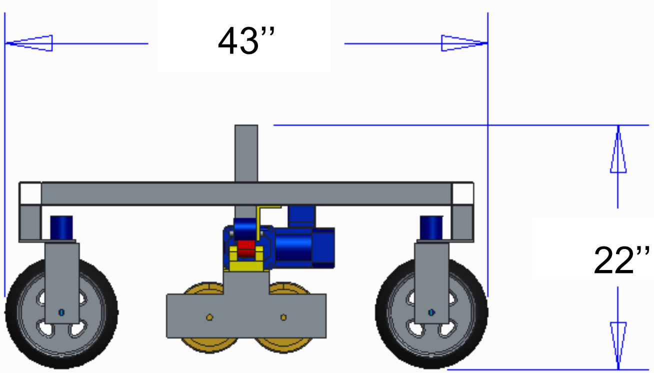



Figure 6: 2nd Design Concept Side View

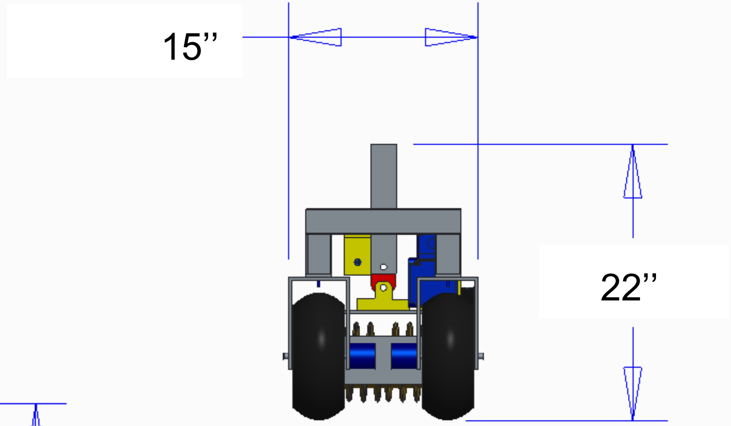



Figure 7: 2nd Design Concept Front View

# Potential Exciter: Shearing Implement

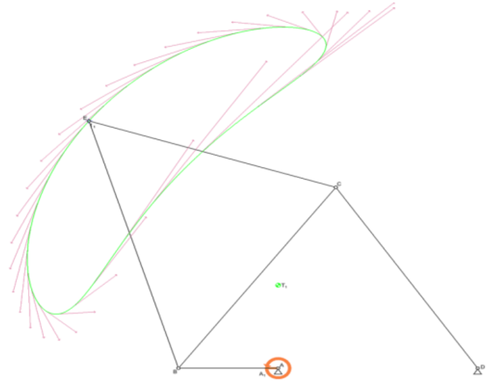


Figure 8: New Shearing Implement

Sponsor wants to use helical auger with varying cutting angle

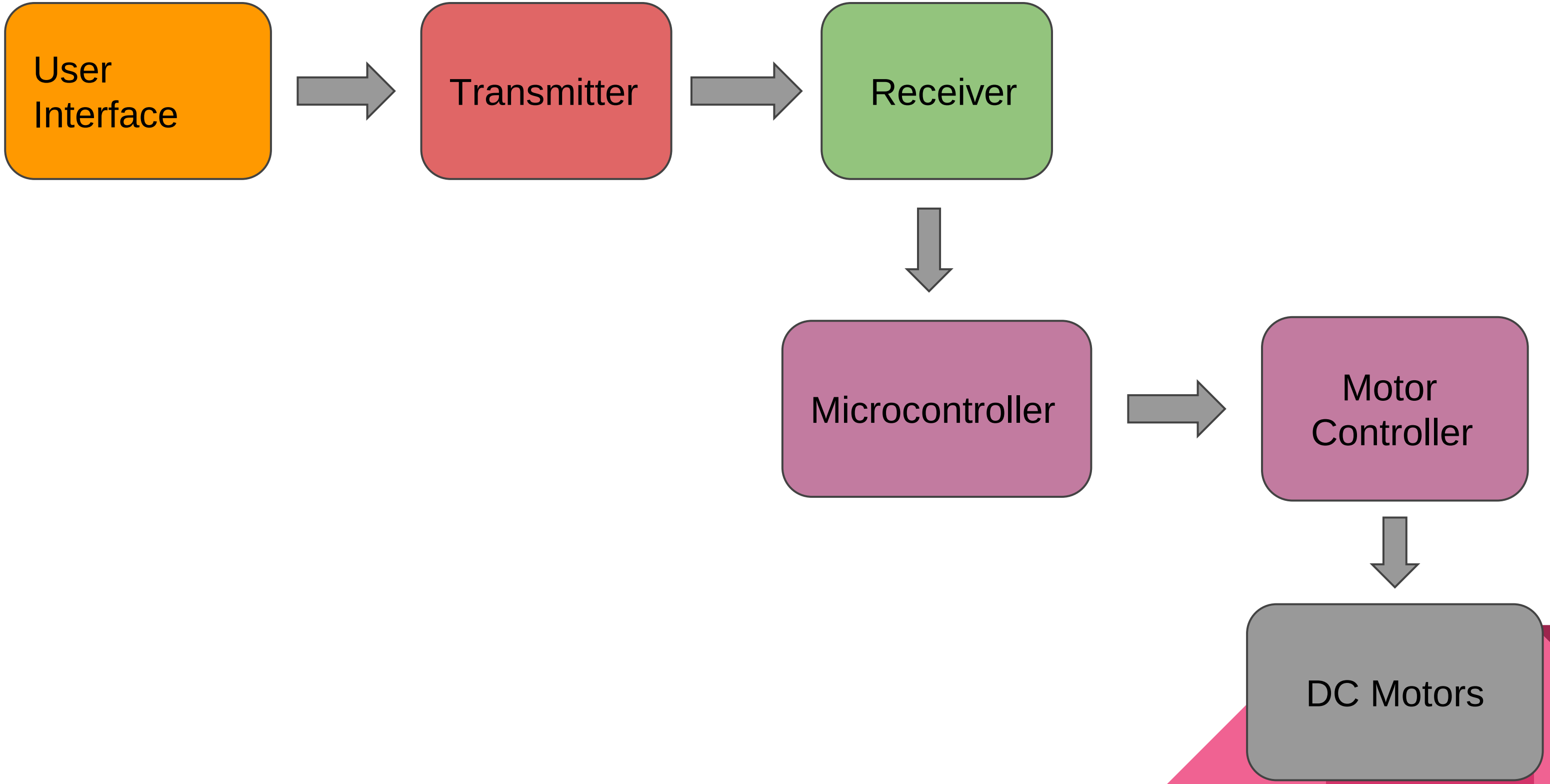
- Cons:
  - Heavy
  - Applied surface pressure can damage crop root system
  - Removed material can accumulate at wheels or other components causing slippage at wheels or other form of blockage.

New Shearing Implement:

- 4-Bar Coupler that shears root system to a required depth via slow downward shear stroke, and quick return stroke to avoid material build up.

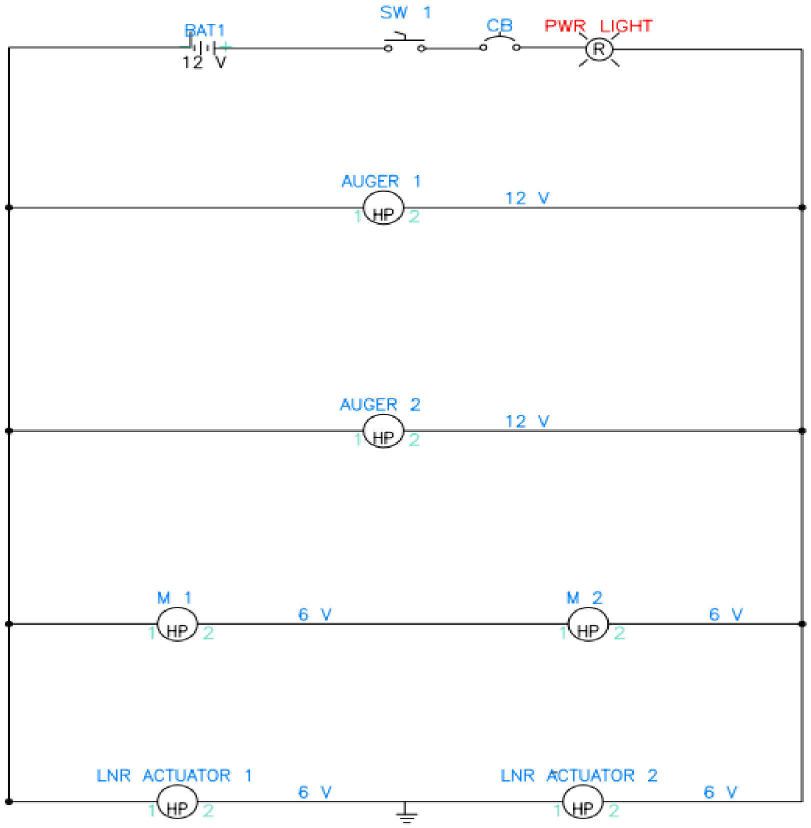
# Electrical Components

# EE Flow Chart



# Unit Schematics

- 12 V Power System
- 6V – 12V DC Motors/Linear Actuators
- Fuse (CB) for circuit protection
- LED for power indication



# Remote Control User Interface

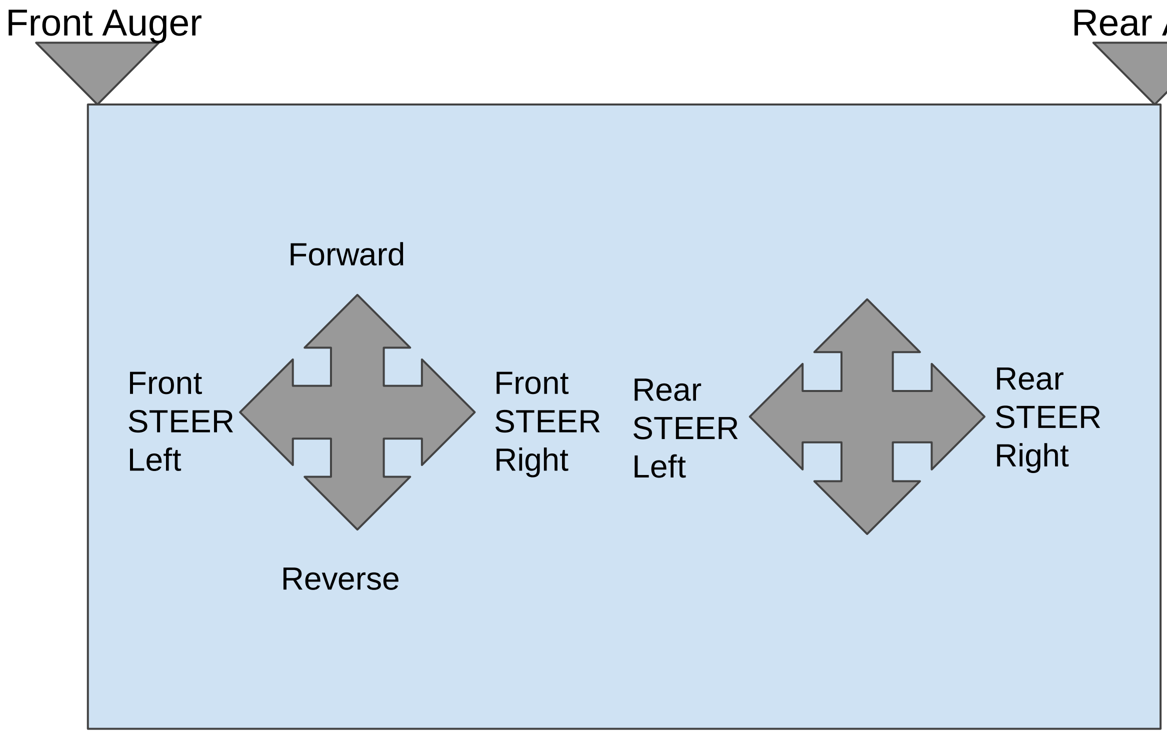



Figure 9: Control Schematics


Figure 10: Remote Control

## Transmitter

- 5 Channels
- Left and Right joystick has 2 Axis of movement (Up/Down, Left/Right)
- Controlling forward, reverse, independent (front/rear) wheel steering and the auger's operation
- Channels:
  - Channel 1: Forward/ Reverse (L. joystick)
  - Channel 2: Front Steering (L. joystick)
  - Channel 3: Rear Steering (R. joystick)
  - Channel 4: Auger 1 - front (switch # 1)
  - Channel 5: Auger 2 – rear (switch # 2)


Figure 11: Remote Control

## Microcontroller/Motor-controller

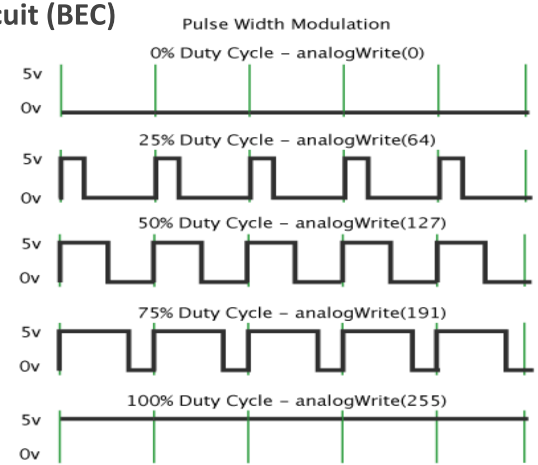
- Arduino Microcontroller (8 bit timer)
- Receive signals from the receiver as a PWM
- operational control:
- Speed: 6 to 12 inches / sec
- Auger: 30 to 60 RPM

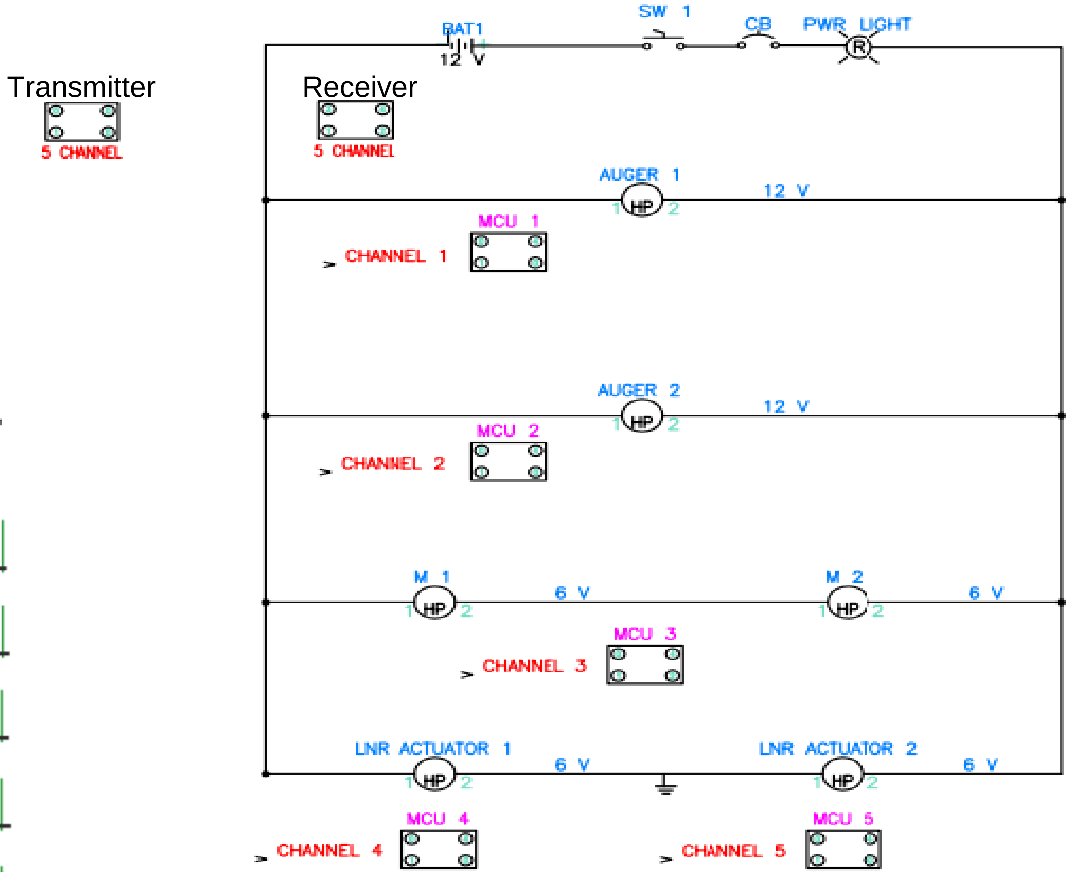

Figure 12: Microcontroller

Figure 13: Motor-controller

# Receiver

- 5 Channels
- Receive signals from the transmitter
- Each signal is transmitted to each
  Independent channels, designated
  for each microcontroller.
- The transmitted signal is a
  Pulse Width Modulation (PWM)
- The receiver is powered by a 5 V
  source, or a Battery Elimination
  Circuit (BEC)



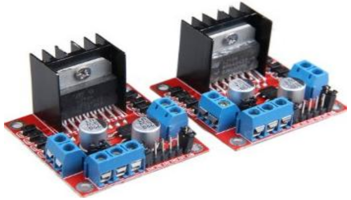
# Electrical Design Concept

**Parts: #**

| # | Part |
|---|---|
| 1 | Transmitter (5 Channel) |
| 1 | Receiver (5 Channel) |
| 2 | Microcontroller/Motor |
| 3 | Battery (12 V) |
| 1 | Fuse (CB) |
| 1 | LED (Power Indicator) |
| | 22 AWG (Copper Wire) |
| 4 | DC Motor |
| 2 | Linear Actuator |



Arduino Microcontroller



Motor-Controller L298 Dual H-bridge

Voltage step-down regulator (DROK)

Figure 14: Electrical Components

# Final Conceptual Design

**<u>Chassis:</u> Mixture between the 1st & 2nd Design**

- Helical Auger Shearing Device
- Vertical Adjustment of the Auger
- Independently Driven Wheel Axles
- Independently Steered using Linear Actuators
- Radio Operated

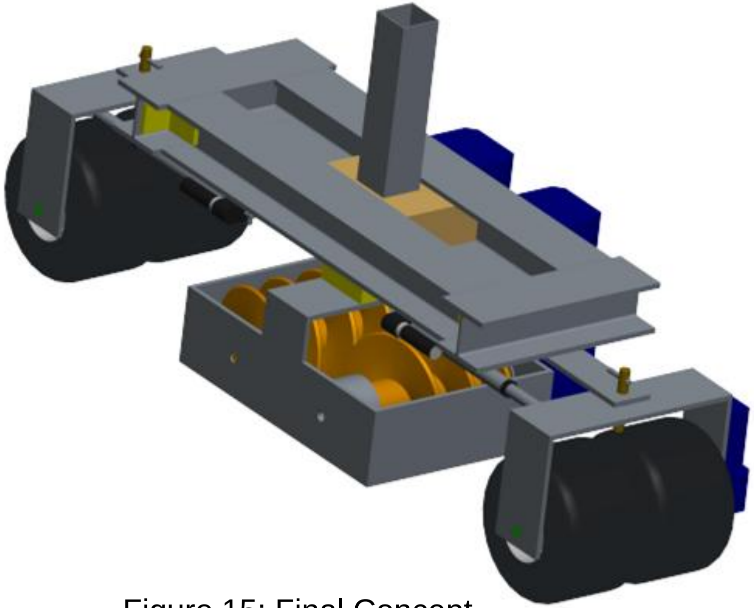


Figure 15: Final Concept

# Final Conceptual Design

All dimensions are in inches.

**Total design size:**

Length = 43”

Height = 20”

Width = 12”

**Auger Size:**

Length = 7”

Diameter = 6”

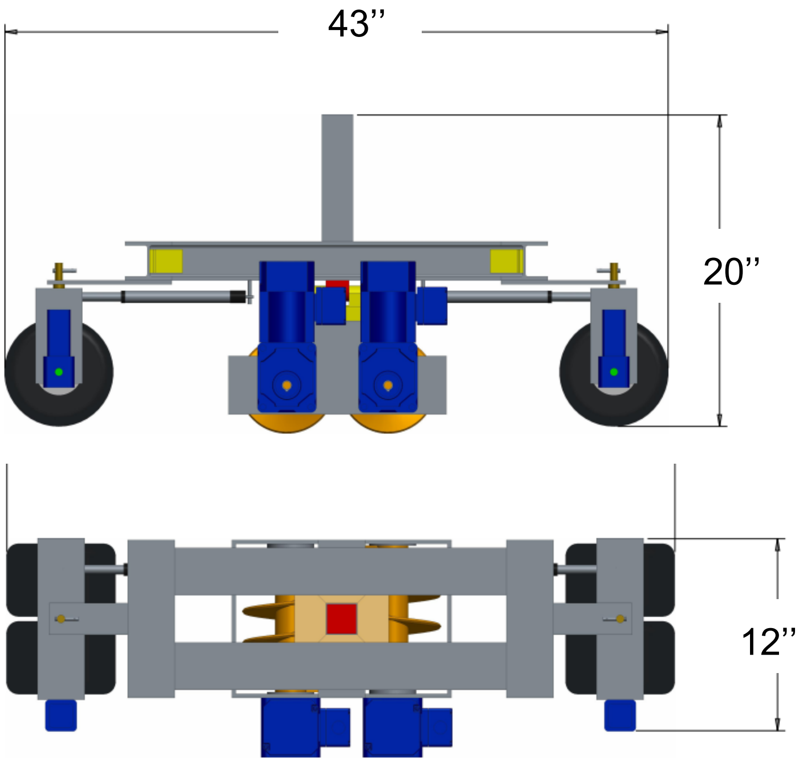



Figure 16: Final Concept

# Potential Challenges or Risks:

Safety:

- Shearing device will have a housing component around it
- FMEA will be done on the final concept
- Proper protective components must be installed to make the overall product safe

Splashproof:

- Steps must be taken to ensure electrical components are safe from water.

Machinability

- Ensure that fabricated parts have CAD drawings that accurately portray the component.

Maintenance

# Relevant Data:

Environmental Analysis: How much force is needed to shear the soil?

Consulted with the Civil Engineering Department Soil Mechanics professor Sal Arnaldo, P.E. and the Civil Department Professor and Chairman Kamal Tawfiq, Ph.D., P.E.

Recommended testing soil properties to determine exact forces needed.

- Shear force of soil in “Worst Case Scenario”
- Coefficient of Friction (μ) between the auger and soil.

Once the actual shear force is known, This force will be supplemented into the auger equations to determine the torque needed from the drive motors.

# Auger Force Analysis

**Axial Force of the Auger: (Shearing Force)**

$$F_{AA} = F_{AT} * \frac{\cos(\alpha) * \cos(\gamma) - \mu * \sin(\gamma)}{\cos(\alpha) * \sin(\gamma) + \mu * \cos(\gamma)}$$

**Tangential Force of the Auger: (Rotational Force)**

$$F_{AT} = \frac{2 * M}{d_1}$$

Location of Forces

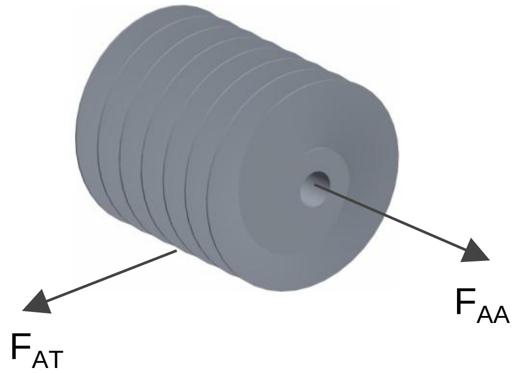
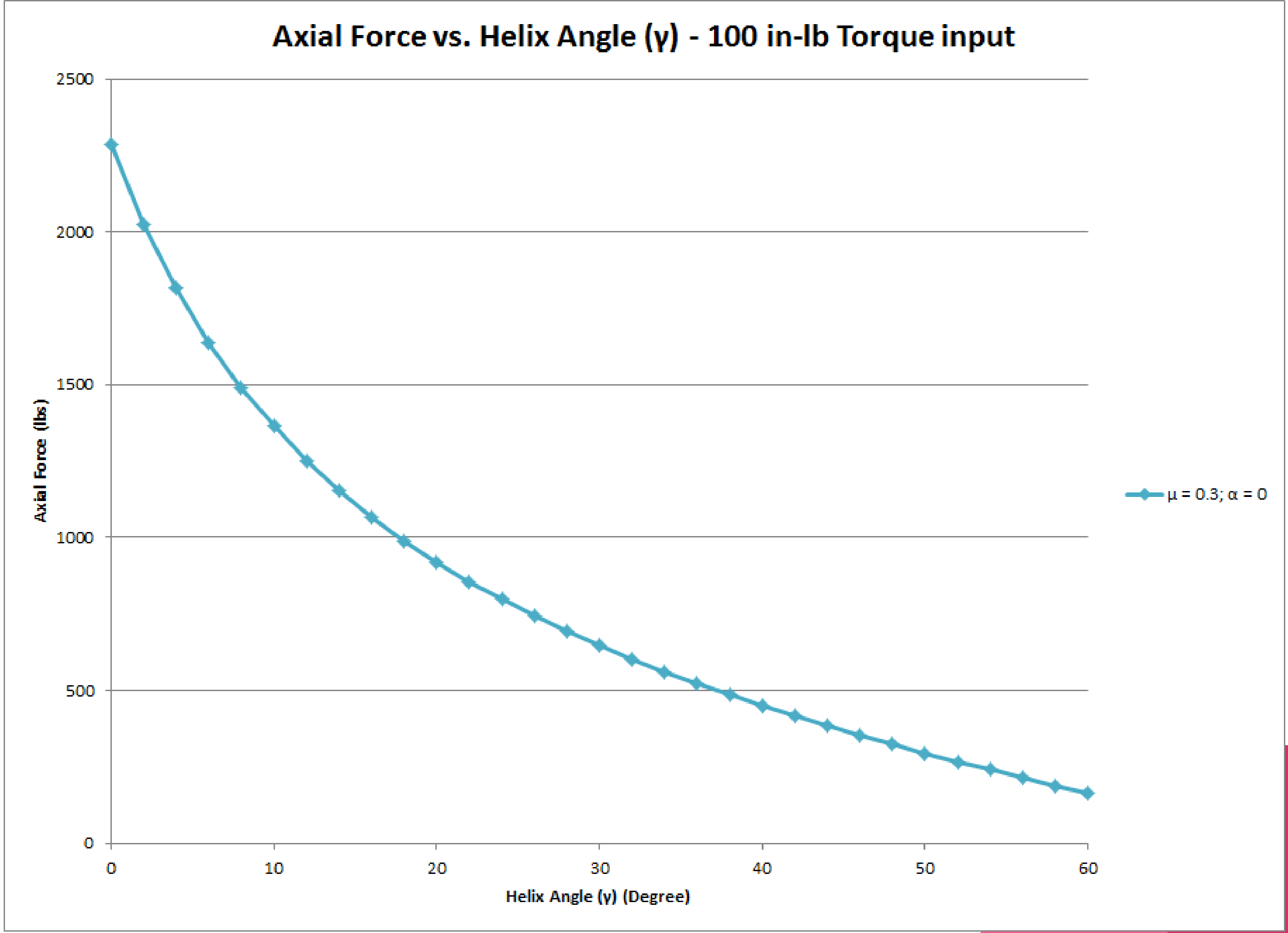



Figure 17: Auger Forces

**NOMENCLATURE:**

- $F_{AA}$: Axial Force on Auger
- $F_{AT}$: Tangential Force on Auger
- γ: Lead Angle
- α: Pressure Angle
- M: Auger Torque
- $d_1$: Reference Diameter
- μ: Coefficient of Friction


Axial Force vs. Helix Angle (γ) - 100 in-lb Torque input
2500
2000
1500
1000
500
0
Axial Force (lbs)
0
10
20
30
40
50
60
Helix Angle (γ) (Degree)
μ = 0.3; α = 0

# Current and Future Tasks:

**Current Project Tasks**

- Soil Sample Testing
- Design of Electrical System and Controls

**Future Project Tasks**

- Finite Element Analysis on Components of Final Design
- Failure Mode Effects Analysis
- Detailed Design & Prototyping
- Development of New Shearing Implement

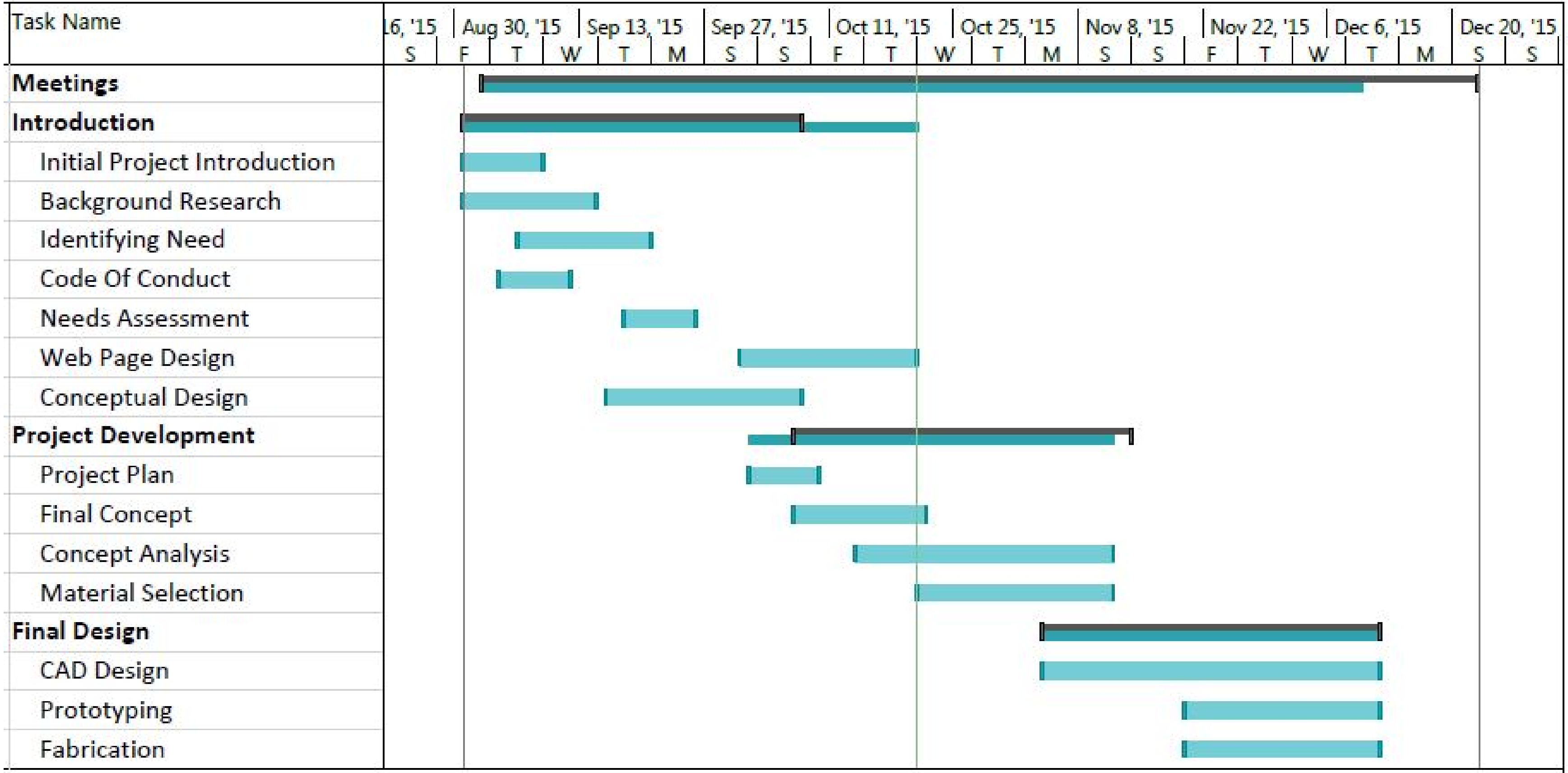
# Modified House of Qualities (HOQ)

| Importance/Weight | Customer Requirements | Mass | Material | Durability | Stability | Strength of Components | # of Tires/Tracks | # of Motors | Operation Mode (Wired, Radio, etc...) | Battery System |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Safe to Operate | 4 | 20 | 20 | 40 | 20 | 4 | 4 | 4 | 4 |
| 1 | Cost Efficient | 5 | 10 | 5 | 5 | 5 | 10 | 10 | 5 | 5 |
| 5 | Effective | 5 | 25 | 50 | 5 | 25 | 25 | 5 | 25 | 25 |
| 5 | Reliable | 5 | 25 | 50 | 50 | 50 | 5 | 5 | 5 | 25 |
| 2 | Simple to Operate | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 10 | 2 |
| 2 | Interchangable Implements | 20 | 10 | 10 | 20 | 10 | 2 | 2 | 2 | 2 |
| 3 | Weight | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 3 | 15 |
| 2 | Marketability | 2 | 2 | 20 | 20 | 10 | 2 | 2 | 10 | 2 |
| 4 | Irregular Terrains | 4 | 4 | 20 | 40 | 4 | 40 | 4 | 4 | 4 |
| Totals | | 77 | 128 | 207 | 212 | 156 | 120 | 64 | 68 | 84 |
| Rank | | 7 | 4 | 2 | 1 | 3 | 5 | 9 | 8 | 6 |

**Key Engineering Characteristics:**

1. Stability
2. Durability
3. Strength of Components

# Schedule/Gantt Chart



Questions?

# References:

[1] "Worm Gears." *Worm Gears*. 22 Jan. 2013. Web. 14 Oct. 2015.

http://www.roymech.co.uk/Useful_Tables/Drive/Worm_Gears.html

[2] http://12.000.scripts.mit.edu/mission2014/problems/ineffectiveinadequate-agricultural-practices

[3] http://www.ofrf.org/organic-faqs

[4] https://www.ocf.berkeley.edu/~lhom/organictext.html