Robotic Trash Cart
Team 311

Entrepreneurial Senior Design Project

Department of Electrical and Computer Engineering
Department of Mechanical Engineering

FAMU-FSU Engineering

Team Members

Jacob Emerson

Mechanical Engineer

Oscar Flores

Computer Engineer & Electrical Engineer

John Williams

Electrical Engineer

Bishoy Morkos

Mechanical Engineer

Oscar Flores

Sponsor

Dean's Office of the College of Engineering

Oscar Flores

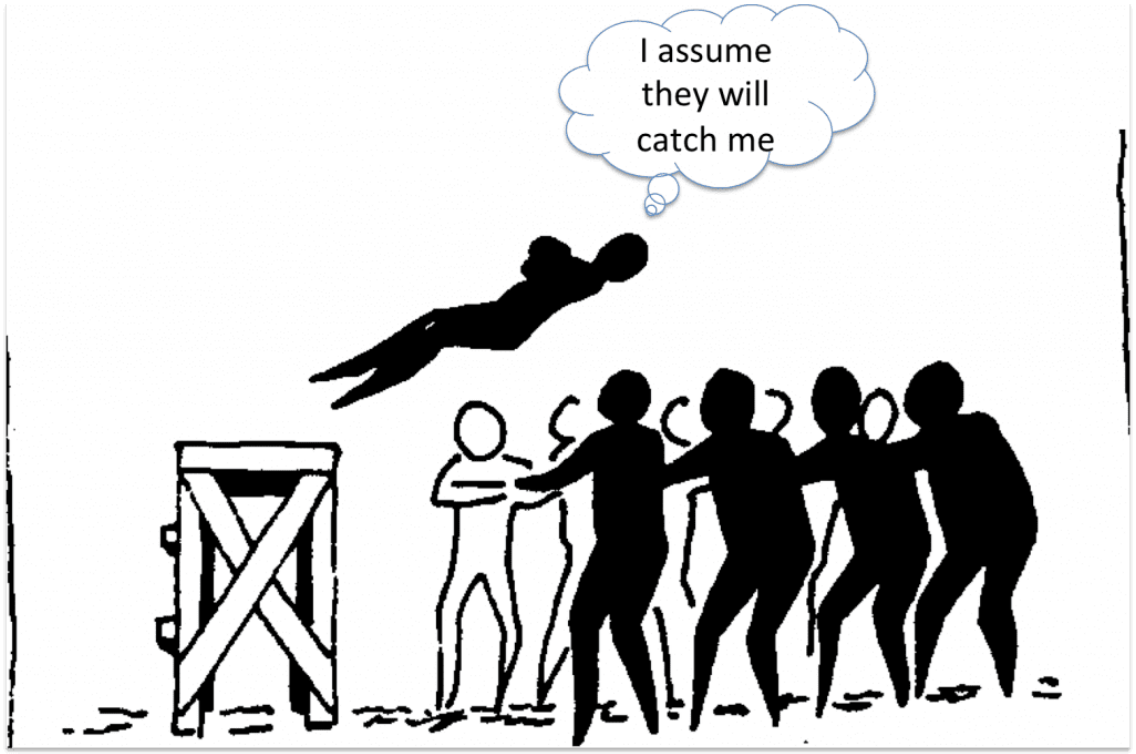
Customer Needs & Requirements

- Minimize the effort of taking out the trash
- Traverse a 5 degree incline
- Hold the waste bins securely
- Easy access to waste containers
- Weatherproof
- Impact proof

Oscar Flores

Assumptions

- Largest gradient that will be traversed is 5 degrees of incline (ADA)
- South Florida Weather: rain, humidity, and wind
- RTC will be stored outside on the side of the house
- Pathway is paved
- Waste Engineers will return the bins to the RTC



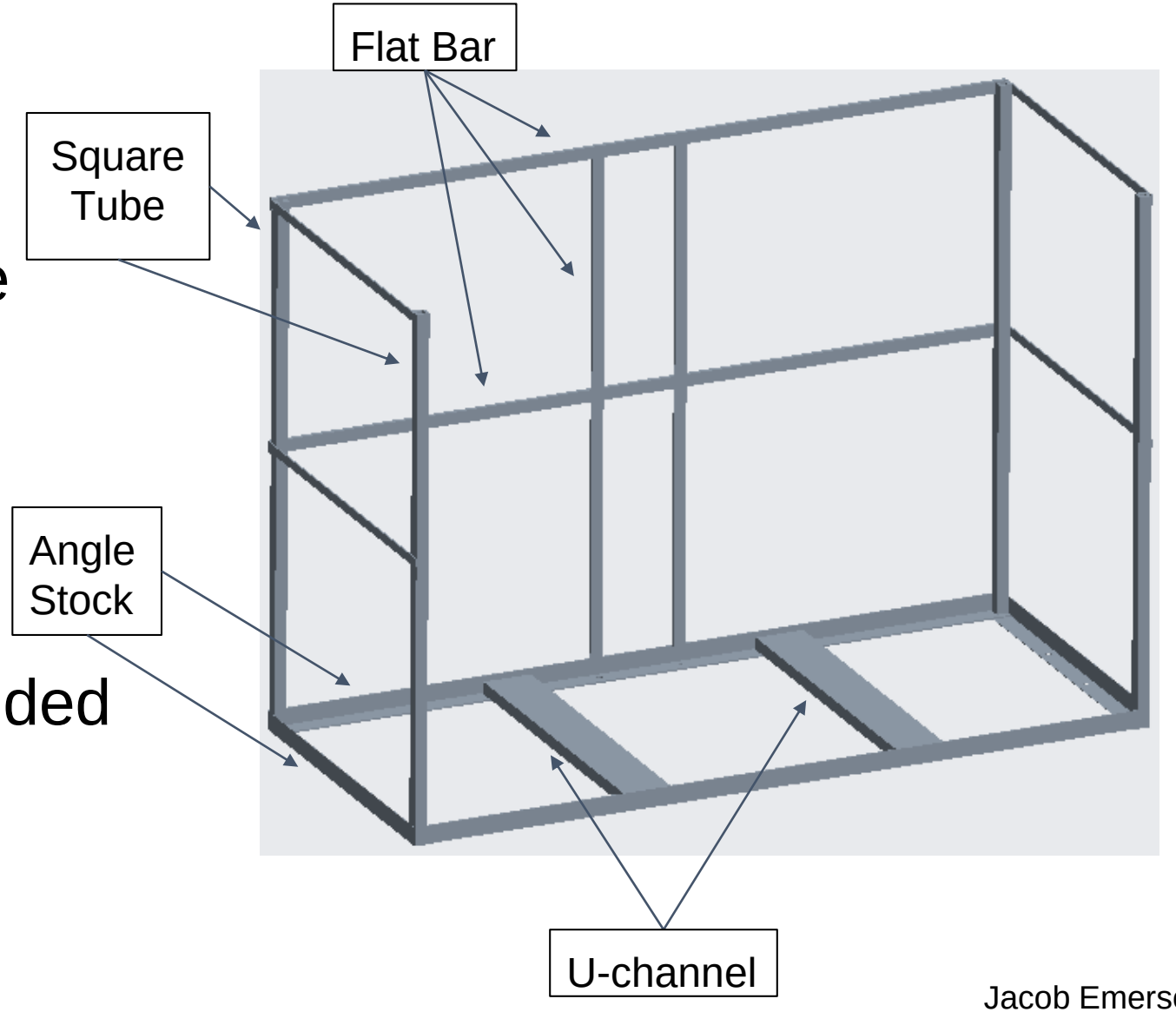
Oscar Flores

Frame

Rectangular aluminum frame

- Lightweight
- Anti-corrosive
- High strength
- Weatherproof

Aluminum U-channel was added for extra support.



Jacob Emerson

Floor Grating

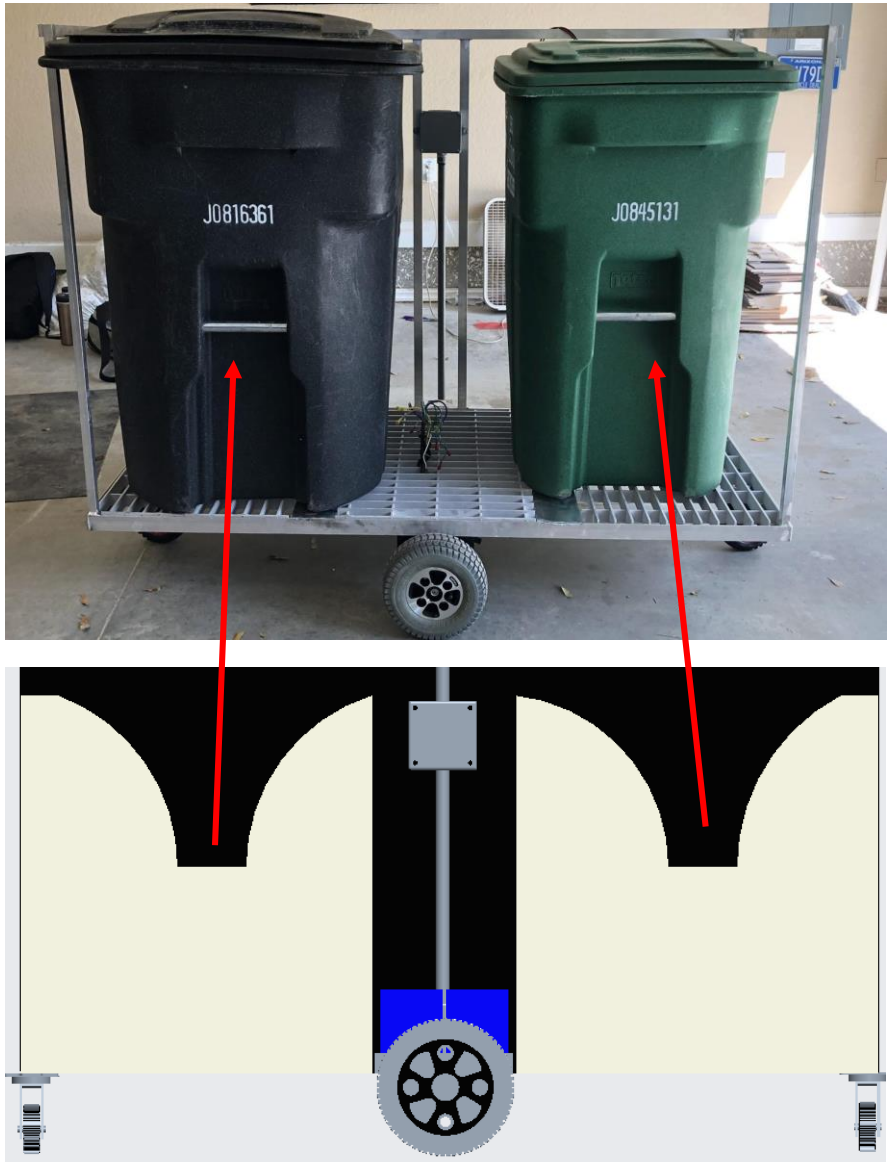
The base floor of the RTC was chosen to be a Light gray Rigidex Moltruded grating based on:

- High strength to weight ratio
- Corrosion resistant
- Lightweight
- Permeable Design

Jacob Emerson

Features & Safety

- Gate and ramp allow easy access to waste bins
  - ➢ V-shape pattern design for automatic garbage disposal
- Aluminum flat bar will surround the RTC to secure the bins from possible tipping



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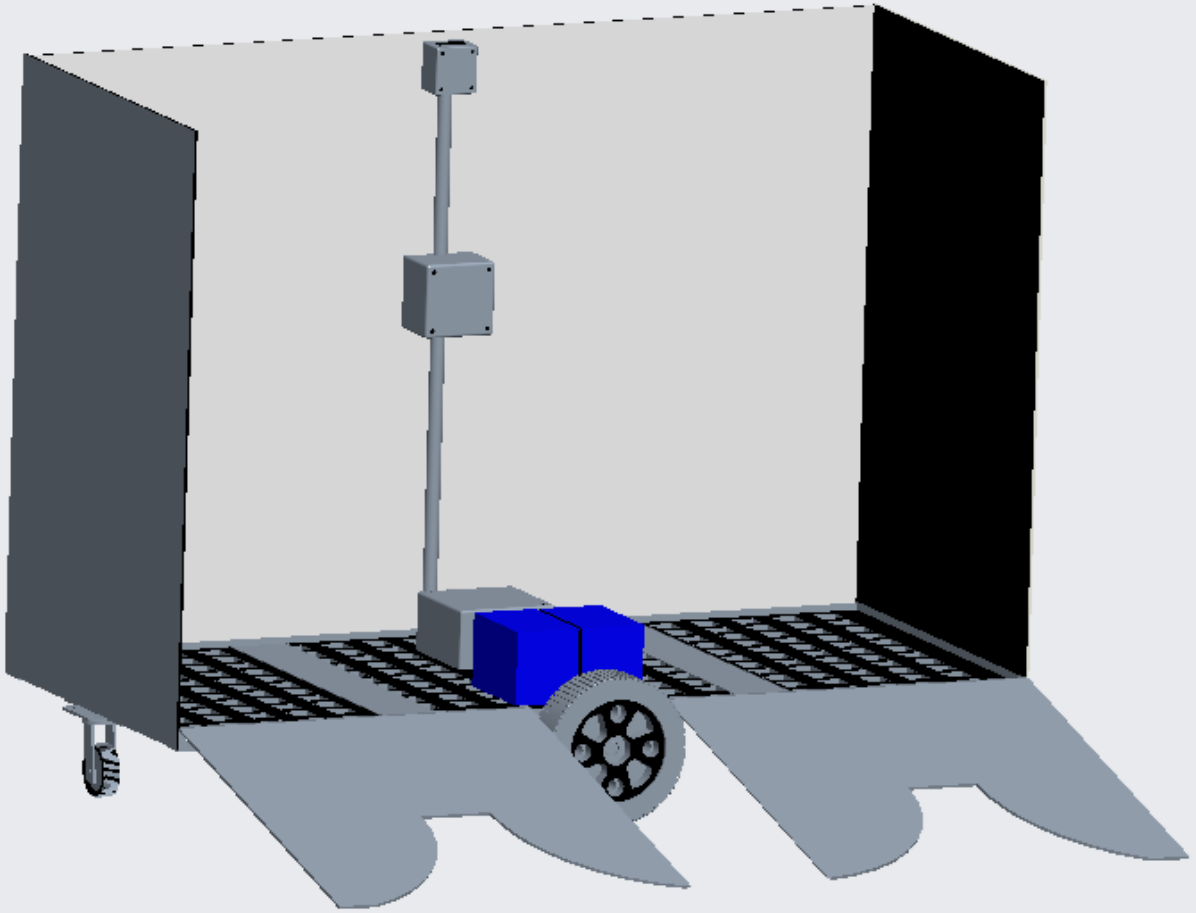
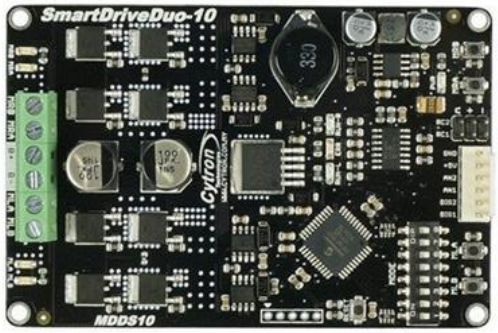
Robotic Trash Cart

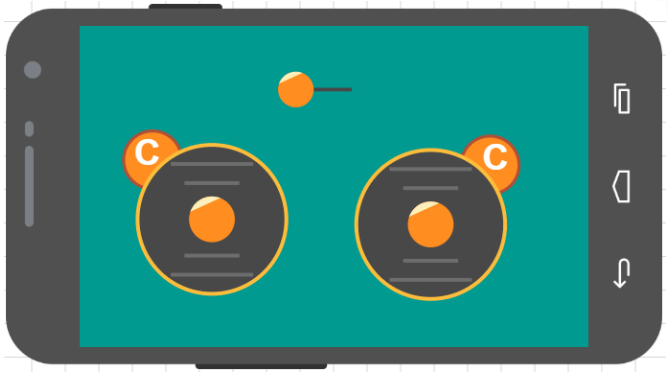


- Aluminum frame
- Impact resistant
- Fiberglass grated base
- Mid-wheel drive
- Zero-point turning

Jacob Emerson

Control System

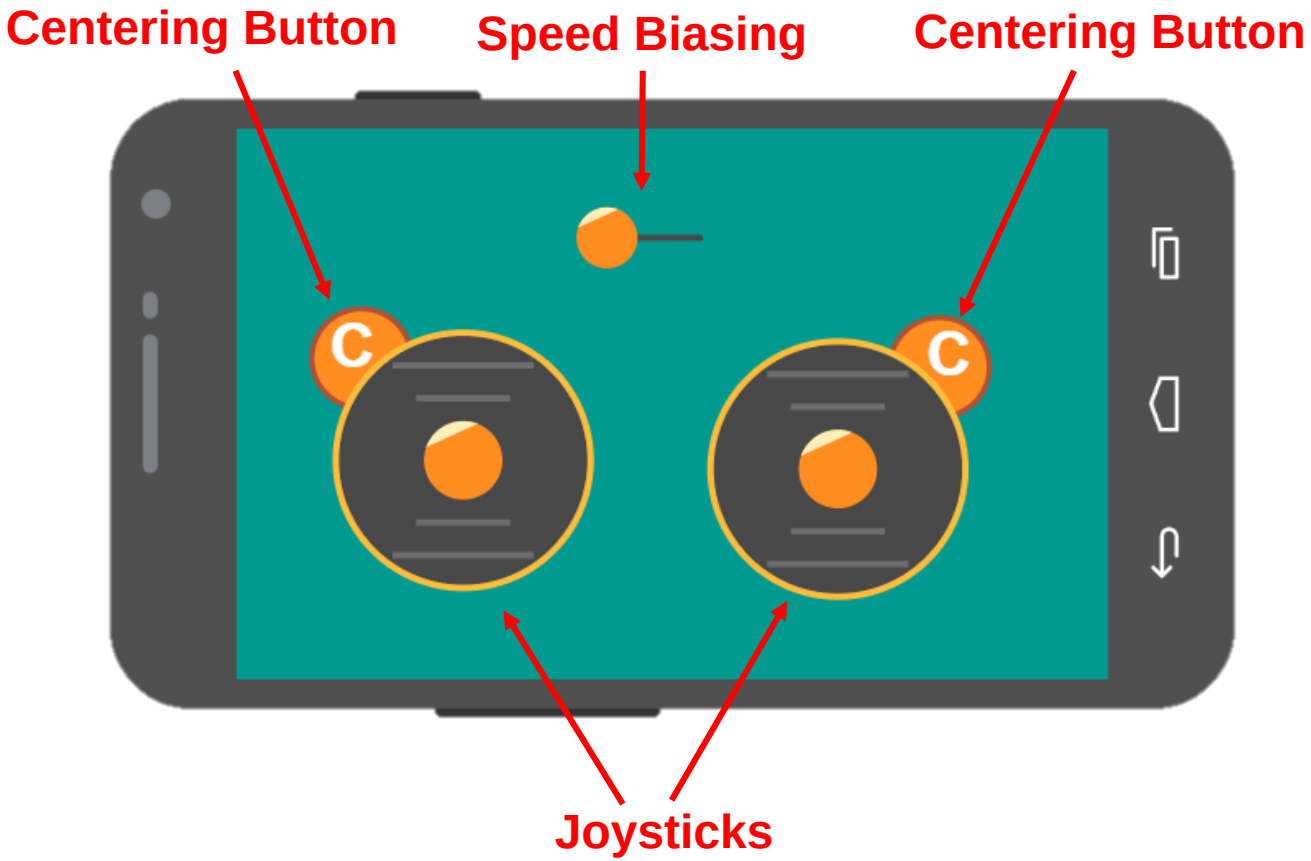




- Cytron SmartDriveDuo
  - ➢ PWM
  - ➢ Dual channel
- ESP32 SOC
  - ➢ Arduino compatible
  - ➢ BLE & WiFi capabilities
- RemoteXY App
  - ➢ Bluetooth capabilities
  - ➢ Minimizes effort to dispense waste bins

Oscar Flores

Mobile Application



- Free application for smartphones
- iOS & Android supported
- Arduino compatible
- Portable

Oscar Flores

Drive System

CIM 24 V DC motors and controller

- Provides the torque needed to get up a 5 degree incline with 200 lb load

Two 12 V (SLA) batteries

- 35 Ah
- Deep cycle

John Williams

Drive System Testing

Local push button operation

- Each motor functions in forward and reverse

No load test

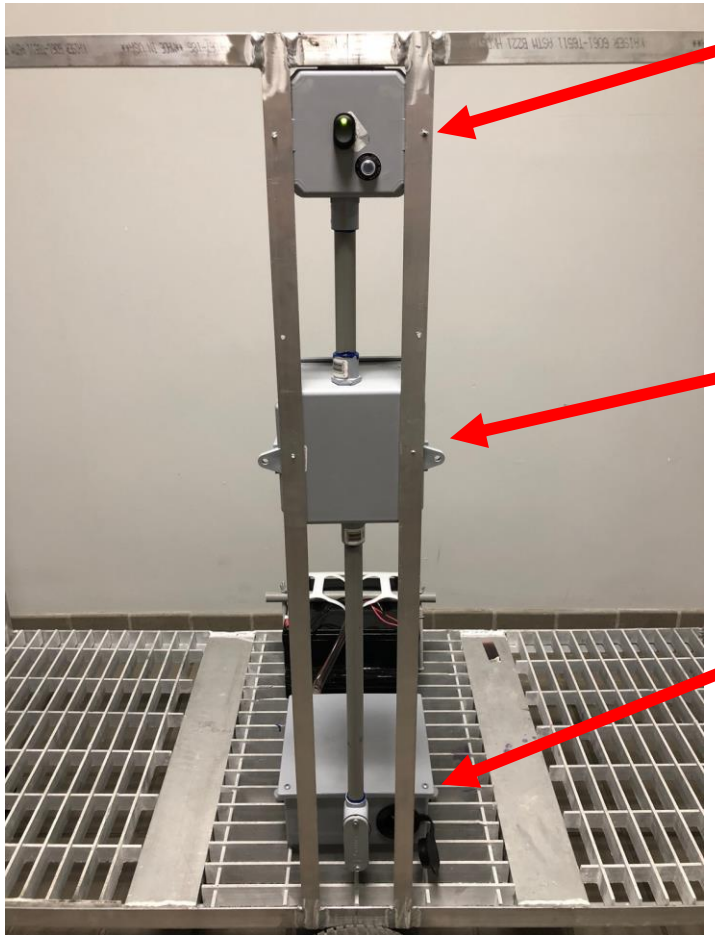
- Current is nominal at 2.79 amps

Local voltmeter

- Fully charged 25.4 V

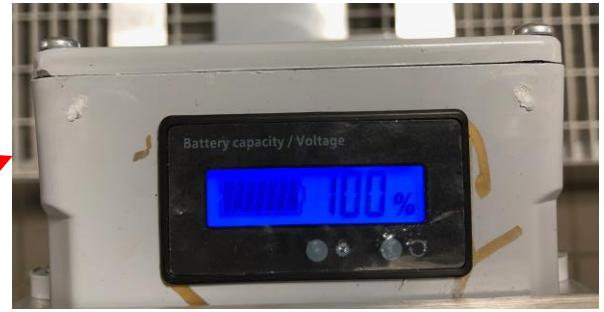
John Williams

Control and Drive System



Junction Box 1

- Toggle switch
- Circuit breaker
- Fuel gauge display

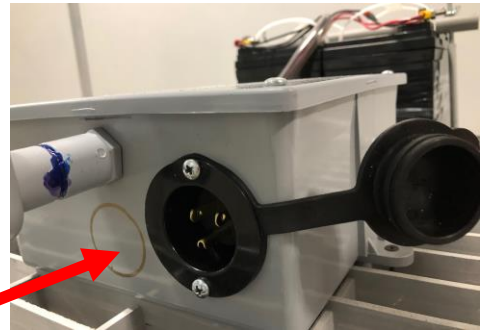


Junction Box 2

- Cytron SmartDriveDuo
- ESP32 SOC

Junction Box 3

- Motor connections
- Battery connections
- On-board charging



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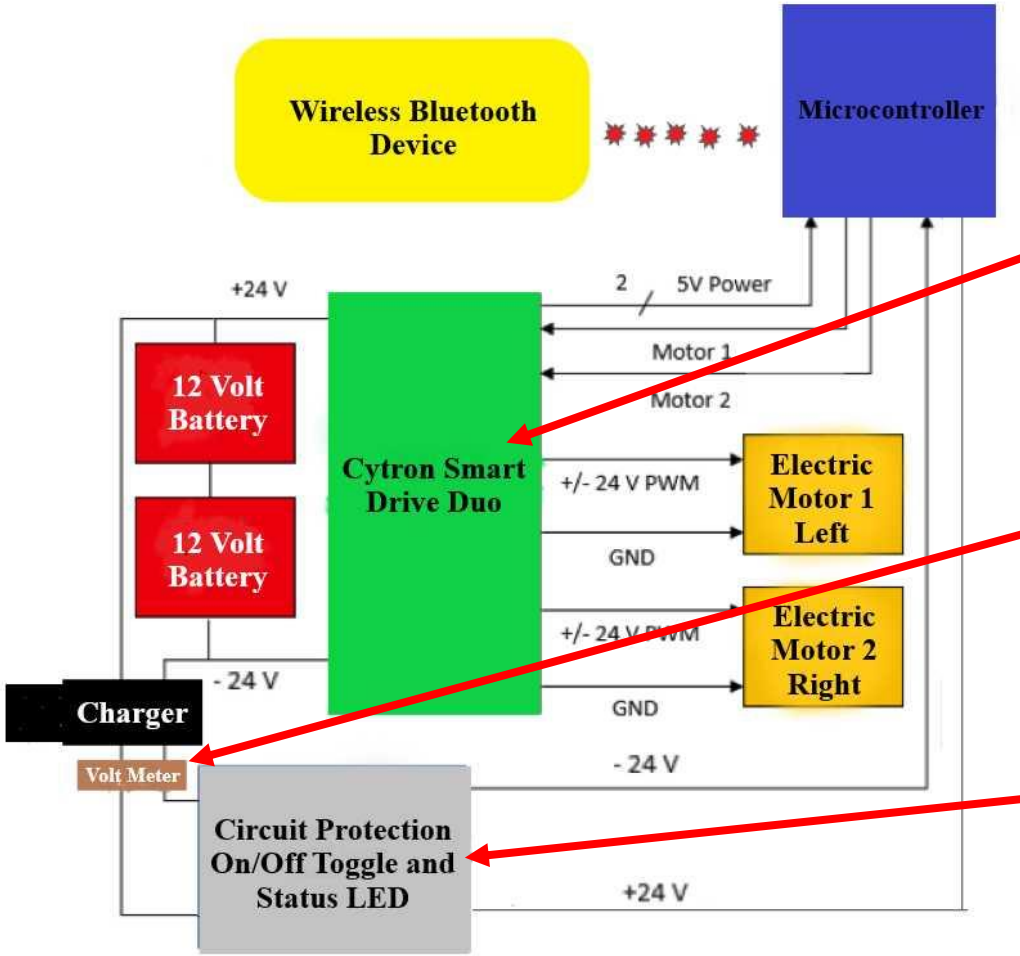
Control and Drive System



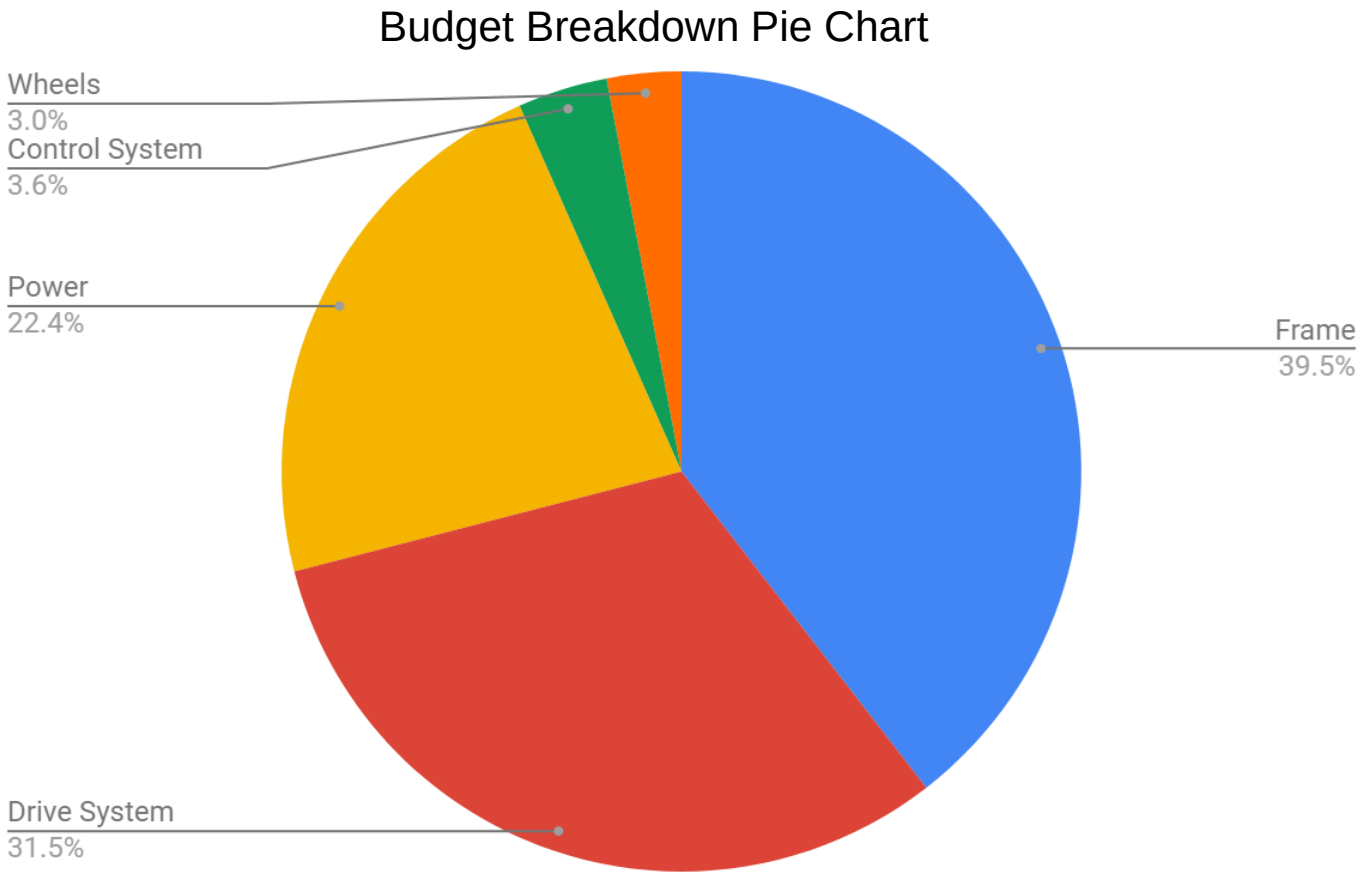
- One drive controlling two motors
- On-board charging with volt display
- Circuit protection 10 A

John Williams

Budget Update

Total Budget - $1,900.00

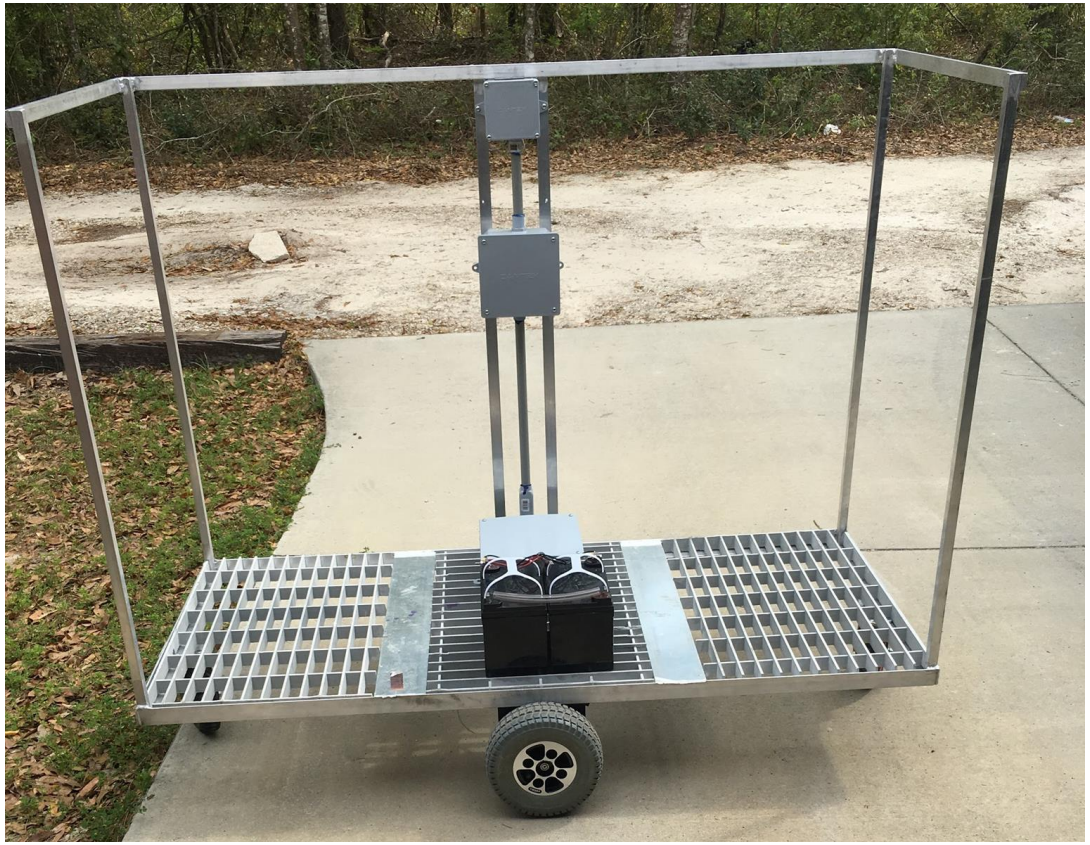
- Motors, controller, drive wheels - $529.00
- Aluminum - $163.00
- Fiberglass grating - $201.00
- 12V SLA battery (2) - $130.00
- Cytron & ESP-32 - $70.78
- Miscellaneous - $332.18



Total Spent = $1,579.49 Remaining = $320.51

Bishoy Morkos

Current Work



- Complete gate integration and any stabilization needs
- Complete wireless controller interface and testing
- Engineering Shark Tank

Bishoy Morkos

Special Thanks

Dean’s Office of the CoE
Dr. Christopher Edrington
Dr. Michael Devine
Dr. Jerris Hooker

Bishoy Morkos

QUESTIONS?

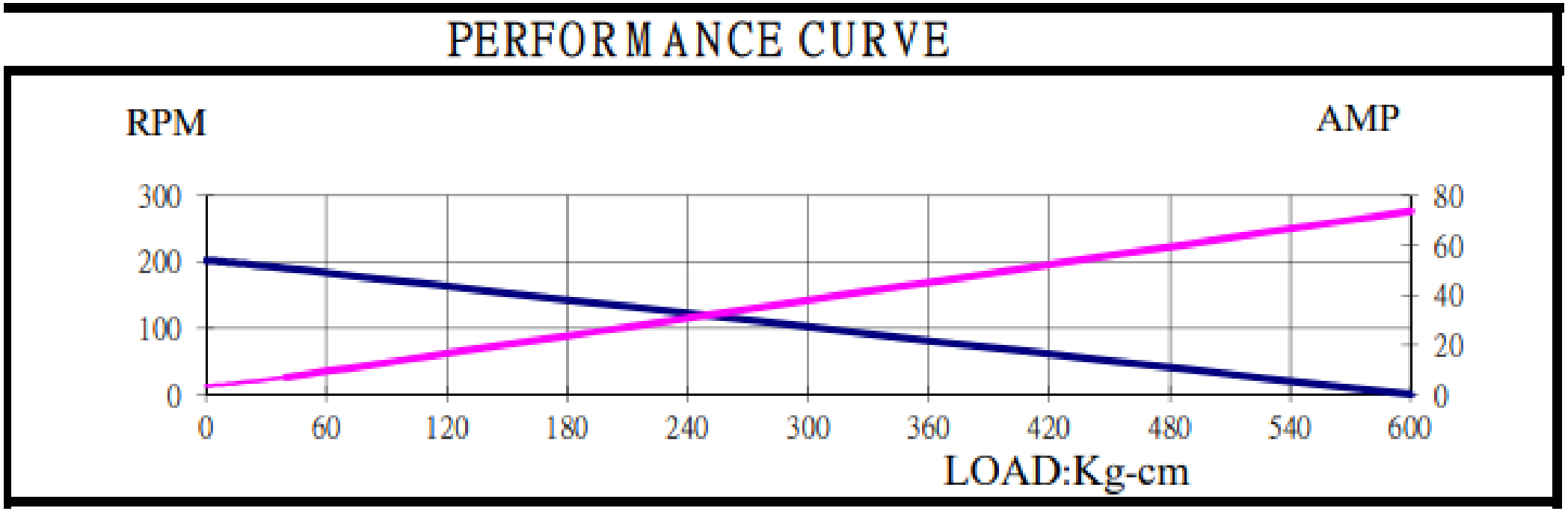
Current Progress

John & Oscar

Torque Calculation

200lbs = 90.7 kg
torque = radius*force*cos(theta) = 0.127m * 90.7 kg(9.8m/s^2) cos(5) =112.56 Nm
112.56Nm = 1147.79kg-cm

Motor Performance Curves



Current Progress

Concept Selection

Improvement Direction		↑	↓	↓	↓	↑	↑	N/A	↑	N/A	↓
Units		N/A	kg	Dollars	Seconds	Meters	mAh	kg/m^2	cm	m/s	N/A
Customer Requirements	**Importance Weight Factor**	**Material Durability**	**Weight**	**Price**	**Time**	**Transportation distance**	**Battery life**	**Weight Distribution**	**Drive over obstacles**	**Speed**	**Size**
Waterproof/ Weatherproof	4	9		3			3				1
Impact Proof	3	9	1	3			3				1
Easy Access to Waste Containers	4	3			3						
Recharging RTC	3	3		9	9		9				
Perform Consistent Transportation	5	9	1	3	3	9	9	3	3	9	3
Ensure RTC doesn't topple	5		3			3		9	9	9	3
RTC must be able to Traverse Incline	4		3	3		3	3	3	9	3	9
User Friendly	3			9		1	1			1	1
	Raw Score	129	35	102	54	75	108	72	96	105	76
	Relative Weight %	15.14	4.11	11.97	6.34	8.80	12.68	8.45	11.27	12.32	8.92
	Rank Order	1	10	4	9	7	2	8	5	3	6

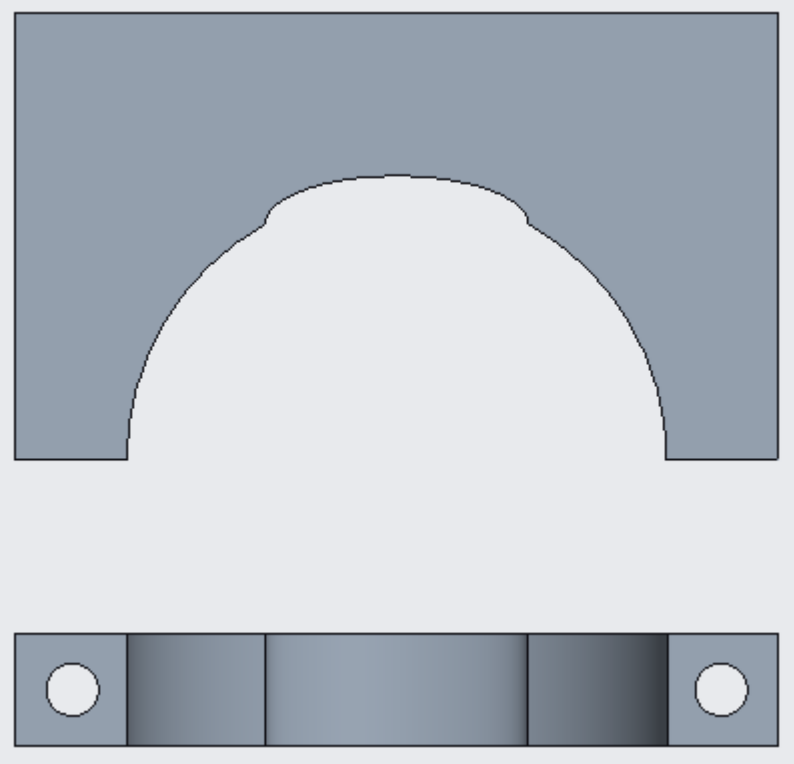
Targets

Target No.	Need	Metric	Imp.	Units	Marginal Value	Ideal Value
1	Transport	Within Destination Target Area	5	meters	1	0.5
2	Battery Life	Capacity V.S. Runtime	5	mAh	3000	4500
3	Transit Stability	Speed V.S. Wind	5	m/s	0.10	0.10
4	Drive over Obstacles	Obstruction Height	3	cm	1	2

Waste Container Capacity

	Garbage Bin	Recycling Bin
Capacity	95 gallons	65 gallons
Bin Weight	35 lbs	28 lbs
Overall Expected Weight including Waste	90 lbs	66 lbs

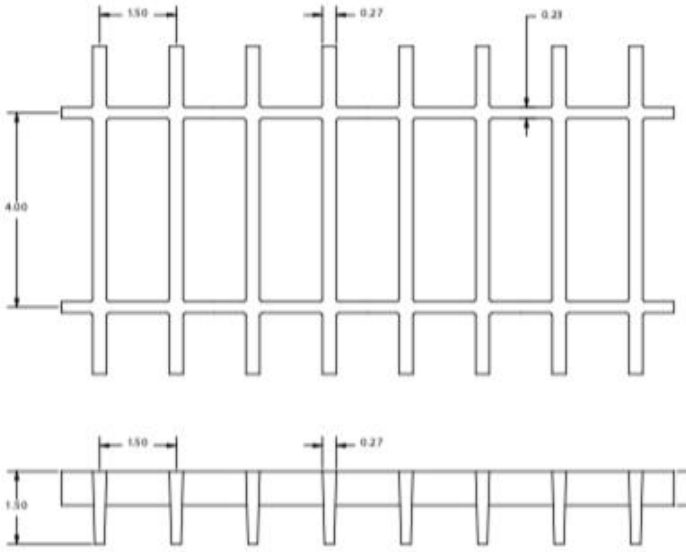
Motor Supports



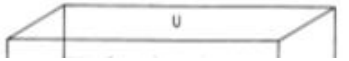
Fiberglass Grating Details

Product Details and Load Tables

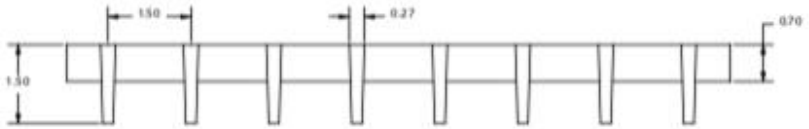
Product Details



Depths:	*1-1/2"*
Mesh Pattern:	*1-1/2" x 4"*
Panel Size:	*4'x 8'*
Resin System:	*Corvex*
Surface:	*Grit*
Color:	*Light Gray*
Flame Spread:	*25 or less*

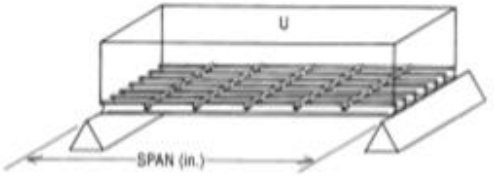


Fiberglass Grating Details



Uniform Load Table - Deflection in Inches

U Uniform Load - psf
ΔU Uniform Load Deflection - in

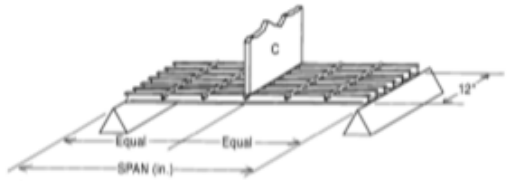


CLEAR SPAN (in)	STYLE		UNIFORM LOAD (psf)							MAXIMUM RECOMMENDED LOAD (psf)	ULTIMATE CAPACITY (psf)
	DEPTH (in)	MESH (in x in)	50	65	100	200	300	500	1000		
12	1-1/2	1-1/2 x 4	<.01	<.01	<.01	<.01	<.01	0.01	0.03	1644	8220
18	1-1/2	1-1/2 x 4	<.01	<.01	0.01	0.02	0.04	0.06	0.12	1180	7080
24	1-1/2	1-1/2 x 4	0.02	0.02	0.04	0.07	0.11	—	—	482	3855
30	1-1/2	1-1/2 x 4	0.04	0.06	0.08	0.17	0.25	—	—	306	2450
36	1-1/2	1-1/2 x 4	0.08	0.11	0.17	0.34	—	—	—	211	1690
42	1-1/2	1-1/2 x 4	0.15	0.20	0.31	—	—	—	—	154	1233
48	1-1/2	1-1/2 x 4	0.26	0.33	0.51	—	—	—	—	117	938
54	1-1/2	1-1/2 x 4	0.41	0.53	—	—	—	—	—	88	704
60	1-1/2	1-1/2 x 4	0.62	0.81	—	—	—	—	—	68	540

Fiberglass Grating Details

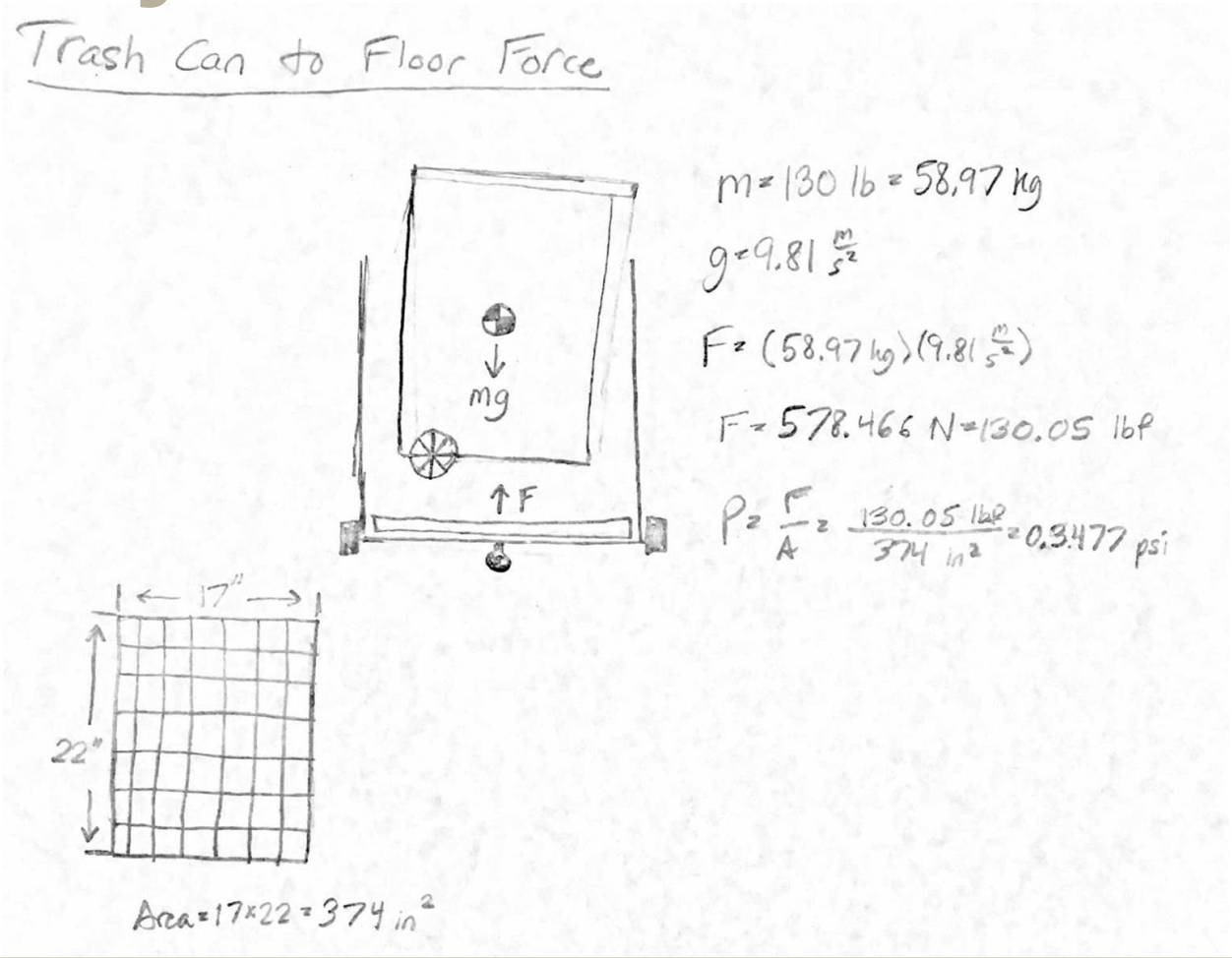
Concentrated Line Load Table - Deflection in Inches

C Concentrated Line Load - psf of width
ΔC Concentrated Line Load Deflection - in

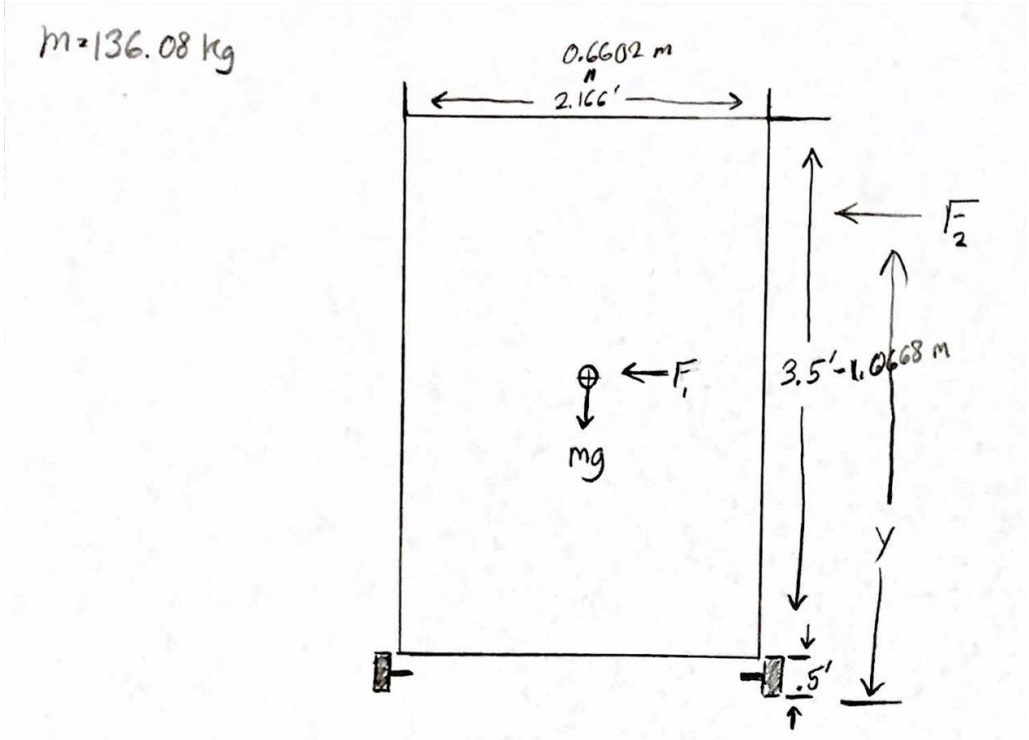


CLEAR SPAN (in)	STYLE		LINE LOAD (lb/ft of width)						MAXIMUM RECOMMENDED LOAD (lb)	ULTIMATE CAPACITY (lb)
	DEPTH (in)	MESH (in x in)	50	100	200	300	500	1000		
12	1-1/2	1-1/2 x 4	<.01	<.01	<.01	0.01	0.02	0.05	1644	8220
18	1-1/2	1-1/2 x 4	<.01	0.01	0.03	0.04	0.06	—	885	5310
24	1-1/2	1-1/2 x 4	0.01	0.03	0.06	0.09	—	—	482	3855
30	1-1/2	1-1/2 x 4	0.03	0.05	0.11	0.16	—	—	383	3063
36	1-1/2	1-1/2 x 4	0.04	0.09	0.18	0.27	—	—	317	2535
42	1-1/2	1-1/2 x 4	0.07	0.14	0.28	—	—	—	270	2158
48	1-1/2	1-1/2 x 4	0.10	0.20	0.41	—	—	—	235	1875
54	1-1/2	1-1/2 x 4	0.15	0.29	—	—	—	—	198	1583
60	1-1/2	1-1/2 x 4	0.20	0.40	—	—	—	—	169	1350

Force Analysis



Tipping Analysis



Ideal Case

Height where force like wind @ assumed max acceleration

$mg\left(\frac{0.66}{2}\right) = F_1(0.686)$ 2.25ft

$\frac{(136.08)(9.81)(0.33)}{0.686} = F_1 = 642.17\ N$

Any force applied

$mg\left(\frac{2.166}{2}\right) = F_2 y$

$(136.08)(9.81)(1.083) = F_2 y$

$1445.74\ N \cdot m = F_2 y$

Any force applied at $y = 3\ m$

Higher than average ($y > 3$) $F_2 = 481.91\ N$

Seat @ 18-20mph brick wall

1700 lbf

$\frac{1700}{19} = \frac{481.9}{x}$

$x = 5.3\ mph$

Mass of car: 1043 kg

4 mph = 1.788 m/s

Elastic collision

$\frac{1.788\ \frac{m}{s} \cdot 1043\ kg}{2\ s} = 583.04\ N$

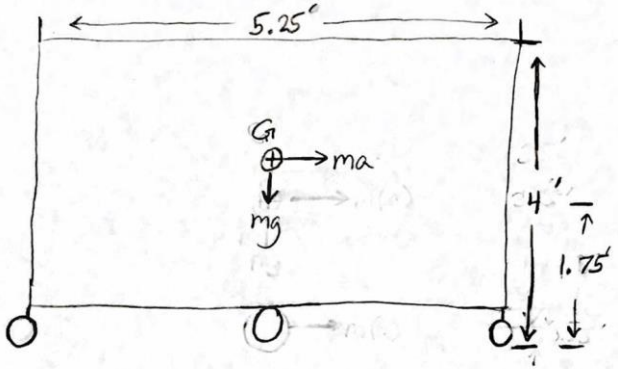
Could withstand a slow 2 second collision with

Tipping Analysis

$m = 300\ lb = 136.08\ kg$

$g = 9.81\ \frac{m}{s^2}$

Ideal Case



Maximum Acceleration

Without tipping: $mg\left(\frac{5.25}{2}\right) = ma(2.25)$

$25.75 = a(2.25)$

$a = 11.444\ \frac{m}{s^2}$

Average acceleration of a car: 3-4 $\frac{m}{s^2}$

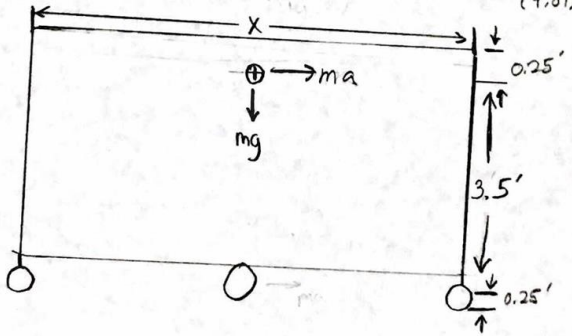
Tipping according to maximum possible acceleration:

$a = 0.1\ \frac{m}{s^2}$

Vertically

$\frac{mg}{a}\left(\frac{5.25}{2}\right) = \frac{ma}{a}y \rightarrow y = \frac{(9.81)(2.625)}{(0.1)} = 257.5'$ @ $0.1\ \frac{m}{s^2}$

$mgx = ma(1.75) \rightarrow x = \frac{(0.1)(1.75)}{(9.81)} = 0.0178'$ to tip $= 0.214''$



Where tipping occurs when CG is higher @ $0.1\ \frac{m}{s^2}$

$mgX = ma(3.75)$

$X = \frac{(0.1)(3.75)}{9.81} = 0.0382' = 0.4587''$

Markets

- Residential
  - Elderly living communities
  - Disabled residents
  - Homeowners

- Industrial
  - Waste Management Companies (WastePro)
  - Construction sites
  - Manufacturing facilities
  - Companies that have heavy amounts of waste or recyclables

Manufacturing & Revenue

Manufacturing Cost per unit: $300.00

Potential Revenue Streams:

- Selling directly to homeowners
  - Offering technical support
  - Warranty
- Leasing Contracts
- Service Contracts
- Licensing Contract

The Future of AWR

Single unit waste bins

- Sense when they are full
- Self-navigate to a central waste site
- Streamline waste disposal for businesses

Designed for locales with dense foot traffic

- Amusement Parks and Stadiums
- Universities and college campuses
- Local, state, and federal parks