Vehicle Energy Capture

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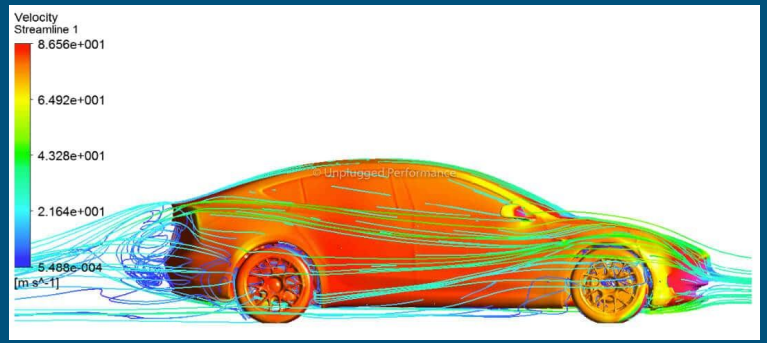
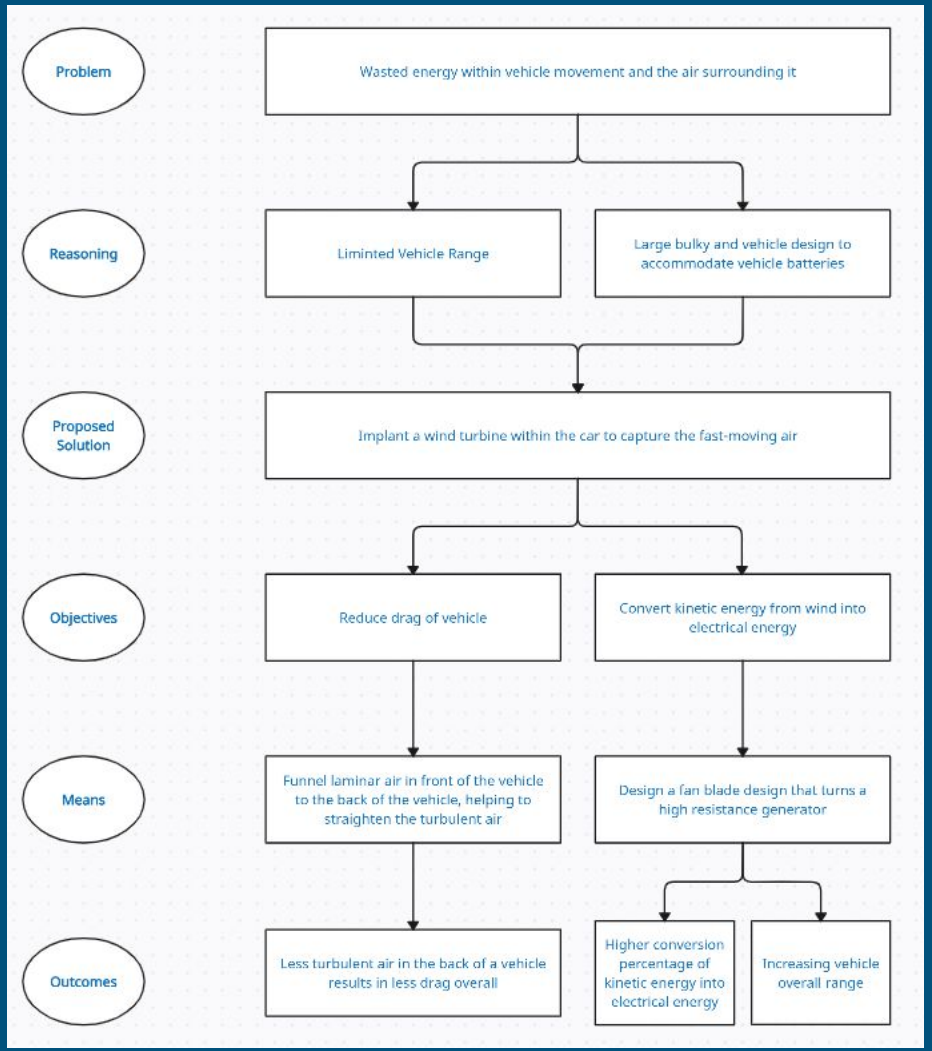
Introduction

- Harness energy from turbulent flow around moving vehicles



Background

- Every Vehicle Experience Drag
  - Avg. Drag Coefficient is .4 for modern vehicles
  - Rear and Front
  - Turbulent and Laminar
- Aerodynamics of the Vehicle
  - Impacts Factors such as grip, stability, handling, efficiency, etc.



Objective Tree

Problem: Cars waste energy as they move and push through air

Why it matters: This limits how far they can go and makes cars bigger to hold batteries

Solution: Put a wind turbine inside the car to catch fast-moving air

Goals: Make the car use less energy and create extra electricity

How: Guide air smoothly through the car and use a smart fan design

Results: Less air drag, more power made, and longer driving range

Testing Method

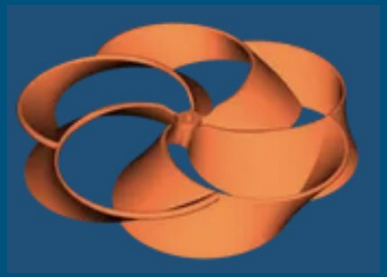
Two Parts

1. Test turbine blades and designs
2. Test selected turbine system on a moving RC Car

Turbine Background and Designs

Multi-blade turbine

Toroidal turbine



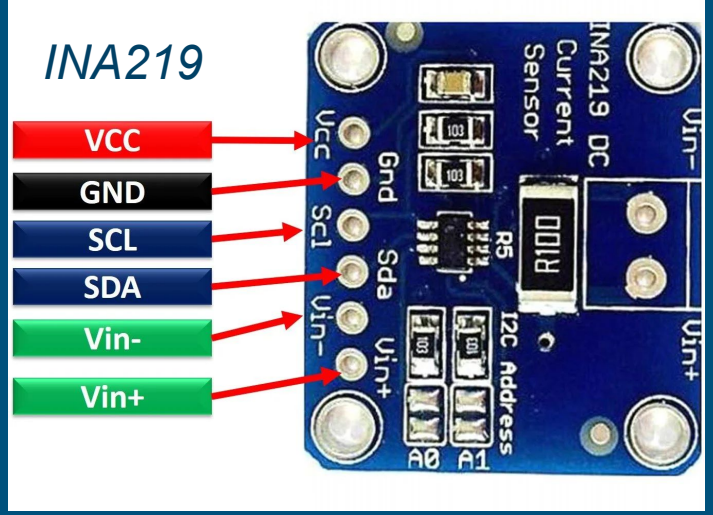
Vertical turbine

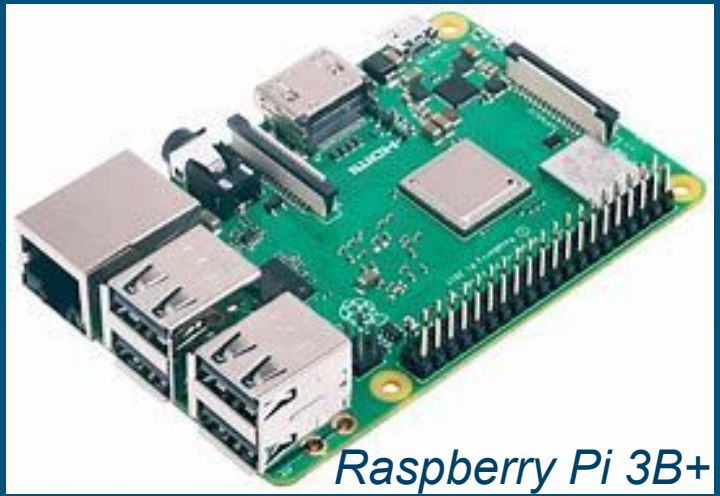
What do we want in a fan?

- Blade length
- Surface area
- Blade count 3-5
- Low noise generation

Data Collection Instruments

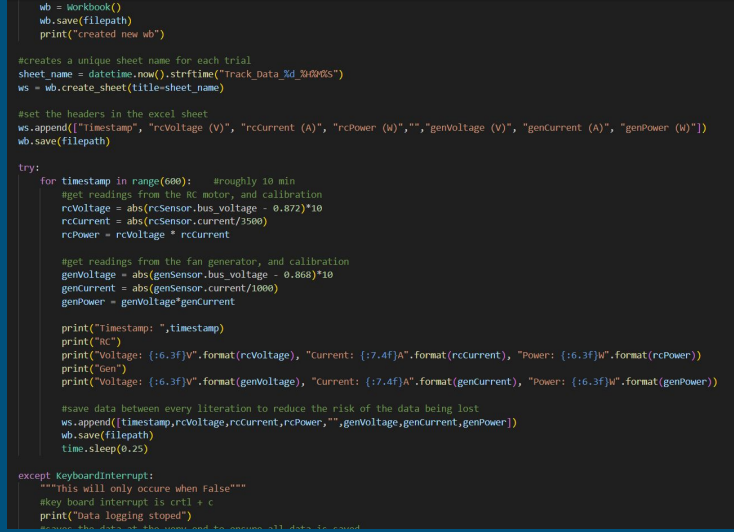
- Adafruit INA219
- Raspberry Pi
  - Hotspot SSH Capabilities
- PiSugar S Plus





Python Code Aspects

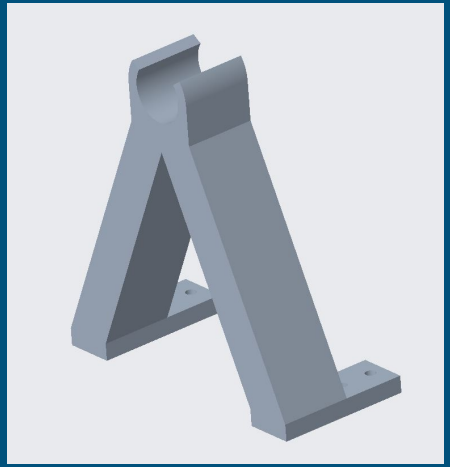
- Utilized libraries:
  - Adafruit_ina219 (Sensor Reading)
  - Openpyxl (Excel Recording)
  - Busio/Board (I2C Configuration)
  - DateTime/Time (1 hz)
  - OS (Save File)
- I2C bus configuration.
- ADC Resolution Configuration (32 samples of 12 bits)
- Calibration: match voltage and current from a DC power supply
- Repeat for 10 min:
  - Read sensor data
  - Write and display sensor data
  - Pause so the whole process takes 1 sec
- Save file, and close



```
    wb = Workbook()
    wb.save(filepath)
    print("created new wb")

#creates a unique sheet name for each trial
sheet_name = datetime.now().strftime("Track_Data_%d_%H%M%S")
ws = wb.create_sheet(title=sheet_name)

#set the headers in the excel sheet
ws.append(["Timestamp", "rcVoltage (V)", "rcCurrent (A)", "rcPower (W)","","genVoltage (V)", "genCurrent (A)", "genPower (W)"])
wb.save(filepath)

try:
    for timestamp in range(600):    #roughly 10 min
        #get readings from the RC motor, and calibration
        rcVoltage = abs(rcSensor.bus_voltage - 0.872)*10
        rcCurrent = abs(rcSensor.current/3500)
        rcPower = rcVoltage * rcCurrent

        #get readings from the fan generator, and calibration
        genVoltage = abs(genSensor.bus_voltage - 0.868)*10
        genCurrent = abs(genSensor.current/1000)
        genPower = genVoltage*genCurrent

        print("Timestamp: ",timestamp)
        print("RC")
        print("Voltage: {:6.3f}V".format(rcVoltage), "Current: {:7.4f}A".format(rcCurrent), "Power: {:6.3f}W".format(rcPower))
        print("Gen")
        print("Voltage: {:6.3f}V".format(genVoltage), "Current: {:7.4f}A".format(genCurrent), "Power: {:6.3f}W".format(genPower))

        #save data between every literation to reduce the risk of the data being lost
        ws.append([timestamp,rcVoltage,rcCurrent,rcPower,"",genVoltage,genCurrent,genPower])
        wb.save(filepath)
        time.sleep(0.25)

except KeyboardInterrupt:
    """this will only occure when False"""
    #key board interrupt is crtl + c
    print("Data logging stoped")
    #saves the data at the very end to ensure all data is saved
```

Design Specifications

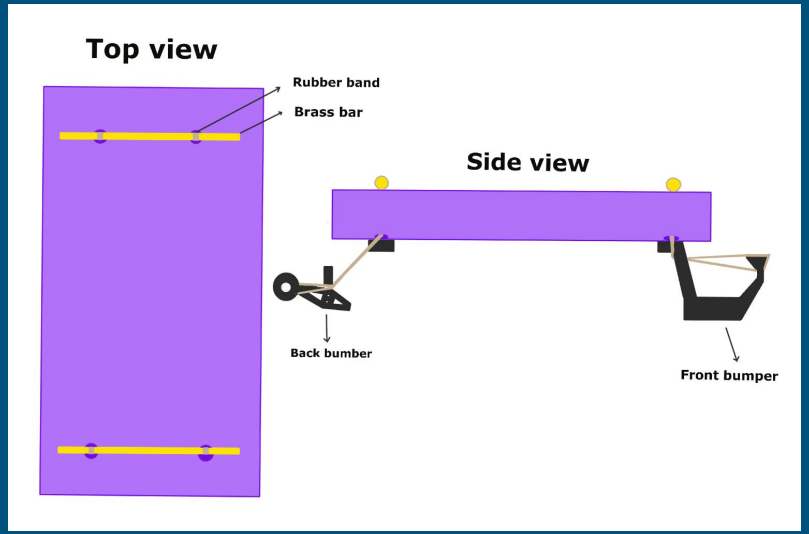
- Final Generator Mount



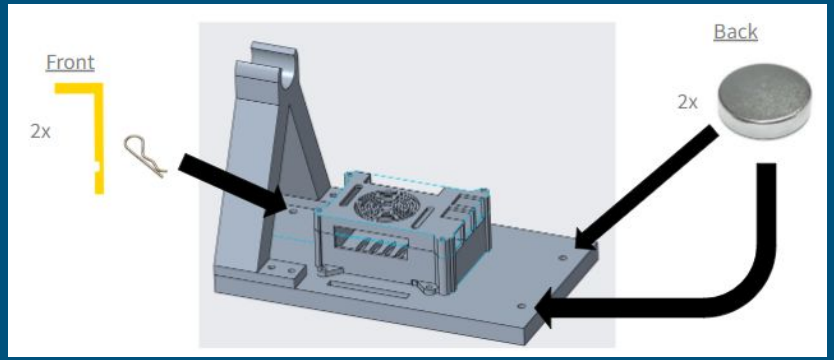
- Toroidal Fan design
  - Enclosed tips
  - 5 blades
  - Propulsion
  - Inertial rotation

- Attachable Generator Mount

Mounting Specifications



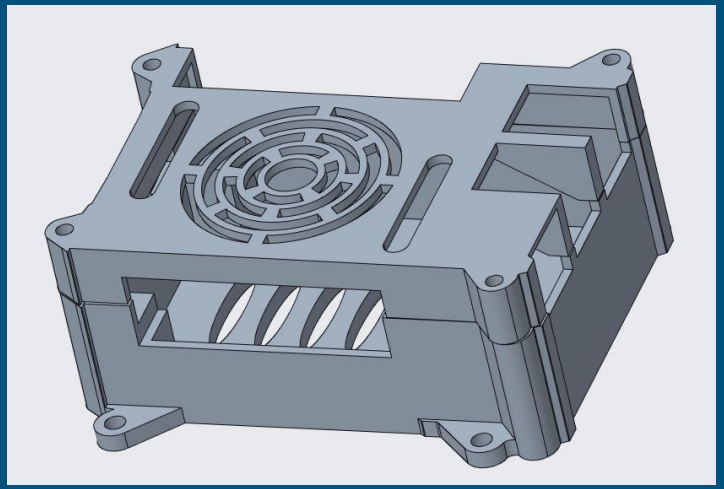
Elastic Holding Concept



Final Holding Concept

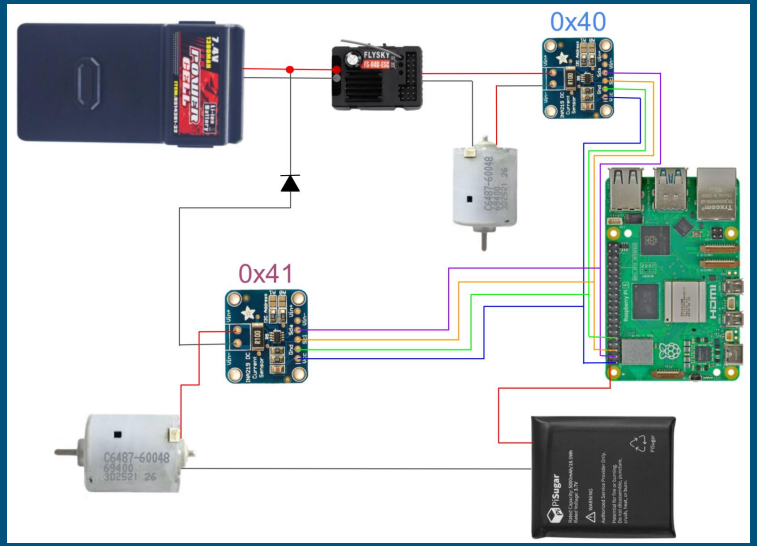
Protective Design Specifications

Original Raspberry Casing

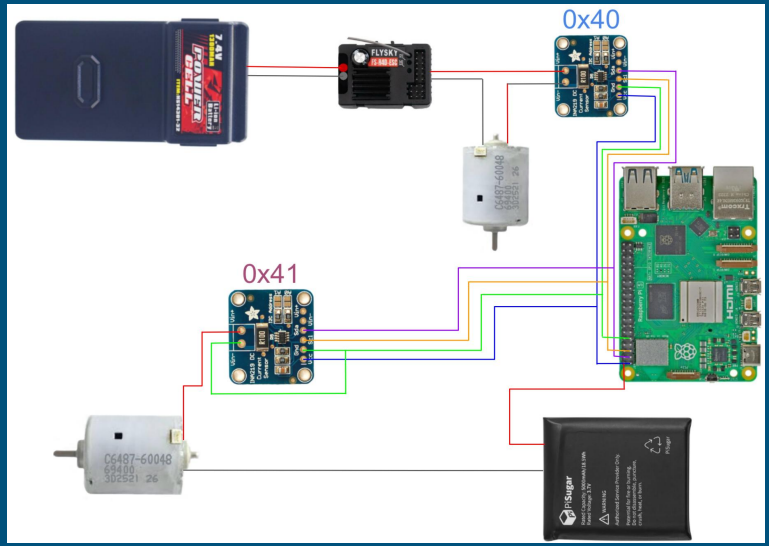


Redesign Raspberry Pi Casing

Electrical Specifications



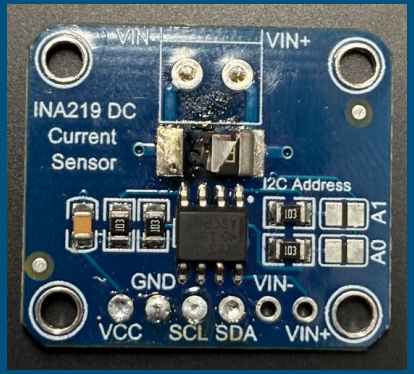
Ideal Electrical Diagram



Physical Testing Electrical Diagram

Design Changes and Challenges

- Securing to the Platform
- Raspberry Pi Holder
- Existing RC Car Structure
- Motor Stalling
    - Resistor blown on INA 219
- Testing in Real Conditions



Results: Baseline

Category	RC Voltage	RC Current (Amps)	RC Power (watt*second)
Average	**3.1440**	**0.4564**	**1.5775**
Standard Deviation	1.8547	0.3843	1.6853
95% CI (-)	-0.5653	-0.3122	-1.7930
95% CI (+)	6.8533	1.2249	4.9481

RC Car without Turbine Assembly, Low Power

Category	RC Voltage	RC Current (Amps)	RC Power (watt*second)
Average	**3.0987**	**0.4920**	**1.6021**
Standard Deviation	1.7024	0.3842	1.6174
95% CI (-)	-0.3061	-0.2764	-1.6326
95% CI (+)	6.5036	1.2603	4.8369

RC Car without Turbine Assembly, High Power

Results: With Turbine Assembly

Category	RC Voltage	RC Current (Amps)	RC Power (watt*second)	Fan Voltage	Fan Current (Amps)	Fan Power (watts*second)
Average	3.4108	0.5021	**1.8136**	1.0705	0.1508	**0.1619**
Standard Dev	1.8833	0.3799	1.7416	0.3925	0.0079	0.0606
95% CI (-)	-0.3558	-0.2577	-1.6696	0.2855	0.1350	0.0406
95% CI (+)	7.1775	1.2619	5.2968	1.8555	0.1666	0.2831
Efficiency (Fan Input/RC Output)=	**8.9253%**					

Category	RC Voltage	RC Current (Amps)	RC Power (watt*second)	Fan Voltage	Fan Current (Amps)	Fan Power (watts*second)
Average	4.1274	0.8851	**3.6504**	1.9055	0.2252	**0.4262**
Standard Dev	0.6207	0.0552	0.5847	0.6423	0.0149	0.1334
95% CI (-)	2.8861	0.7746	2.4810	0.6209	0.1953	0.1593
95% CI (+)	5.3688	0.9956	4.8199	3.1901	0.2551	0.6931
Efficiency (Fan Input/RC Output)=	**11.6752%**					

Overall Results

- 3.65 - 1.6 = 2.05 watts, an increase in power due to drag
- .43/2.05 = 0.21, 21% returned from the turbine
- Consumer Point of View:
  - 3.65 - 0.43 = 3.22
  - 1.6/3.22 = 0.497

- Turbine was a successful in capturing energy from turbulent air
- Turbine failed to produce enough power for consumer market

Future Improvements

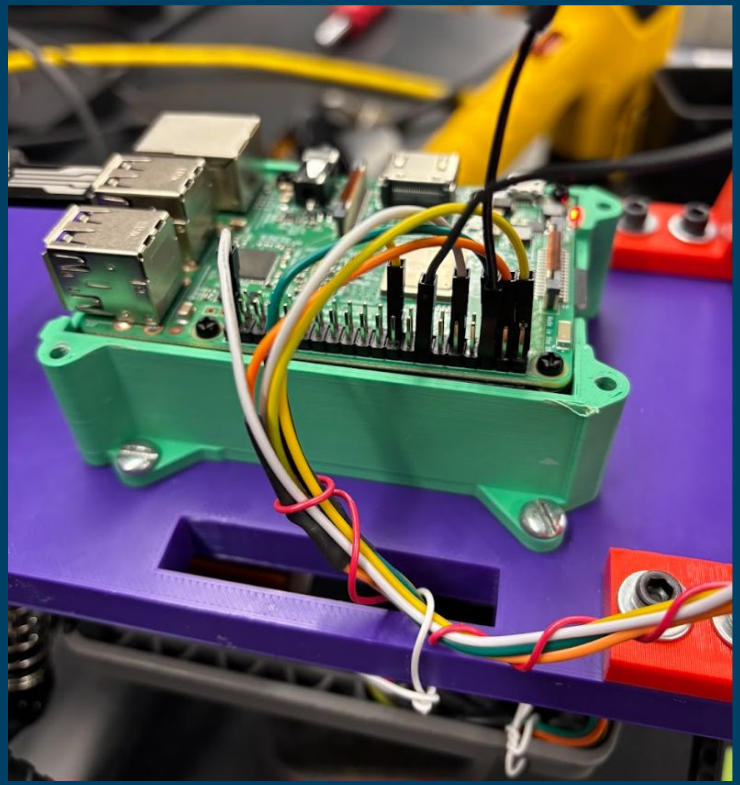
- Testing with actual vehicle designs
  - Electric vehicles
- Increase in scale
- Testing using realistic conditions
  - Increase in speed
  - Natural winds
  - Difference in terrains

Bill of Materials

- Cost Per Unit: $206.49
- Initial Budget $500

EGR Capstone: Scale RC Car Model				
Item	**Qty.**	**PP Qty.**	**Vendor**	**Total Cost (USD)**
Hatchbox 3D Filament 1kg	345g	$25.99	Amazon	$8.97
Auoshi RC Car	1	$89.99	Walmart	$89.99
Raspberry Pi Gen 3	1	$47.85	Amazon	$47.85
Hp Deskjet 5550 Carriage Assembly Motor	1	$9.99	Missingcord	$9.99
PiSugar S Plus Portable Battery	1	$29.99	Amazon	$29.99
USB Thumb Drive	1	$6.99	Amazon	$6.99
Notebook M2*8 Screws	8	$0.02	Amazon	$0.16
HiLetgo INA219 Sensor Module x2	1	$8.19	Amazon	$8.19
Socket Cap 8-32 Screw	4	$0.23	Bolt Depot	$0.92
Hex Nuts 8-32	4	$0.07	Bolt Depot	$0.28
Washer	8	$0.07	Bolt Depot	$0.56
Machine Screws 10-32 ⅞”	8	$0.12	Bolt Depot	$0.96
½” Magnets	4	$15.99	Amazon	$1.28
24-gauge wire	4ft	$8.99	Amazon	$0.36
Total Cost Per Unit				$206.49

Assembly



Questions