# E-BIKE CHARGING & DOCKING STATION

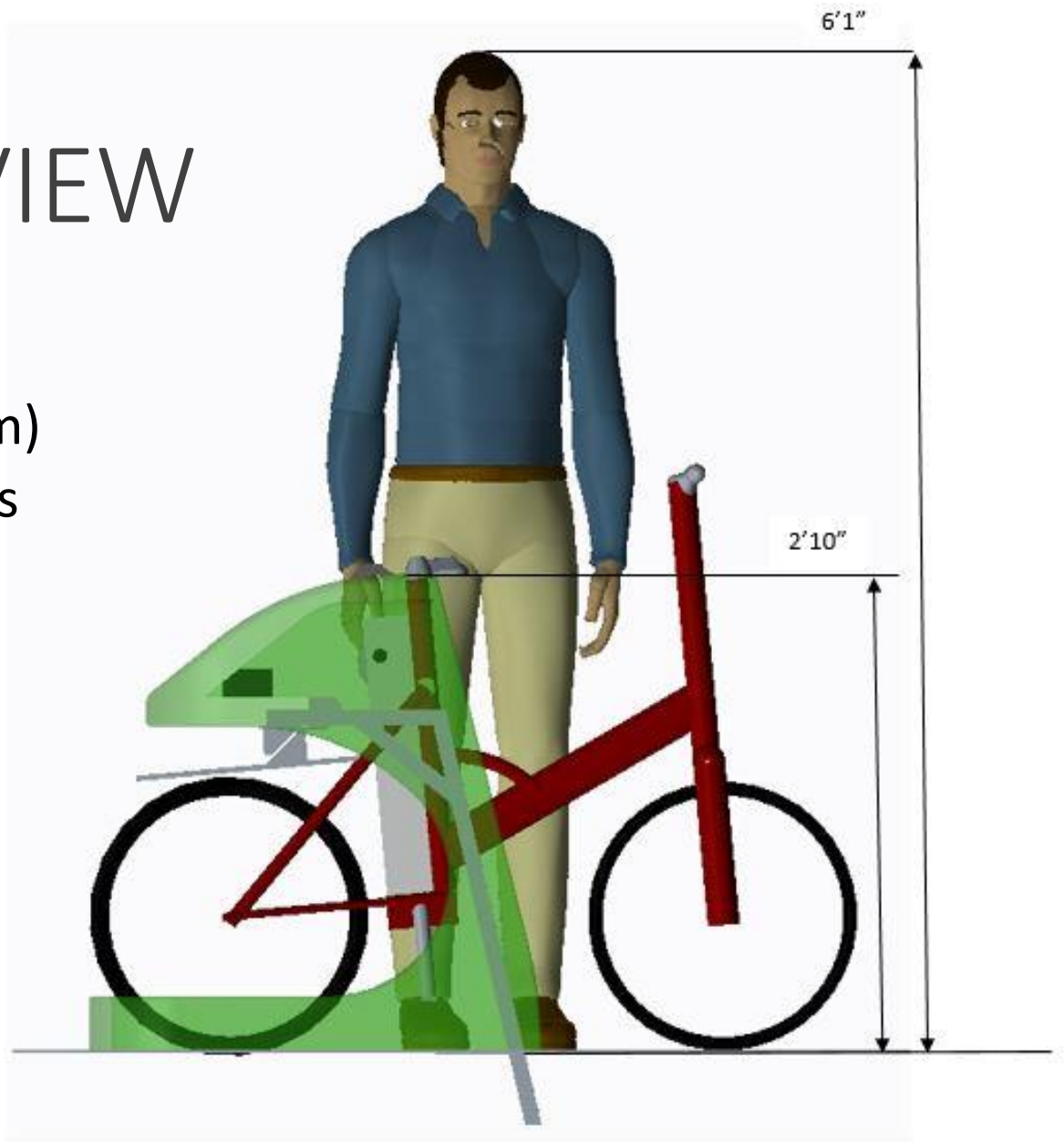
## SYSTEM LEVEL DESIGN REVIEW

BRYAN CASTRO
JUSTIN JOHNSON
SEVE KIM
JACOB KNOBLAUCH
BILAL RAFIQ

# MECHANICAL COMPONENTS

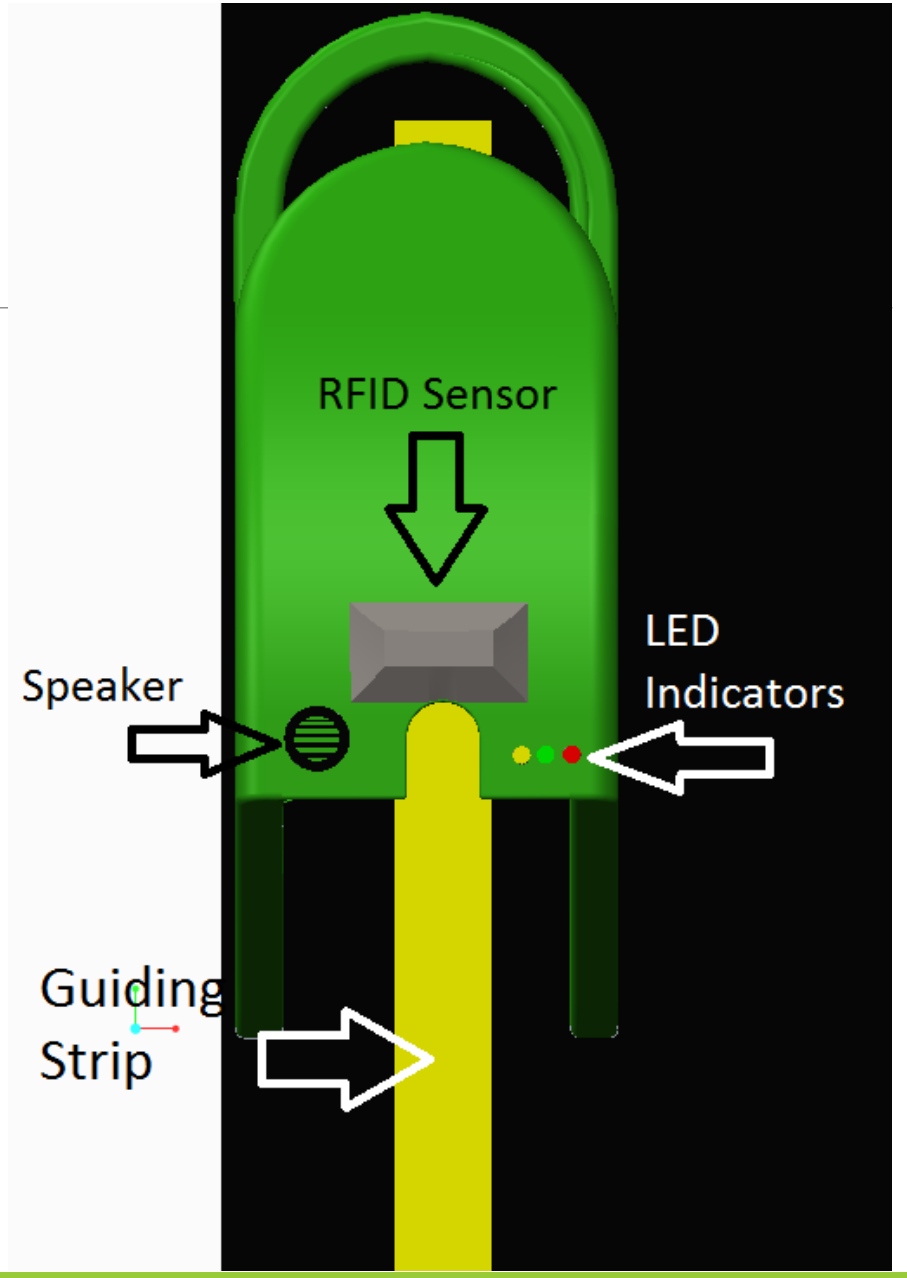
# STRUCTURAL OVERVIEW

- Galvanized Sheet Metal 15 Gauge(1.803 mm)
- A500 Steel Support Square Beams Thickness 4.7625 mm
- Designed to Meet IP4 – Splash of Water



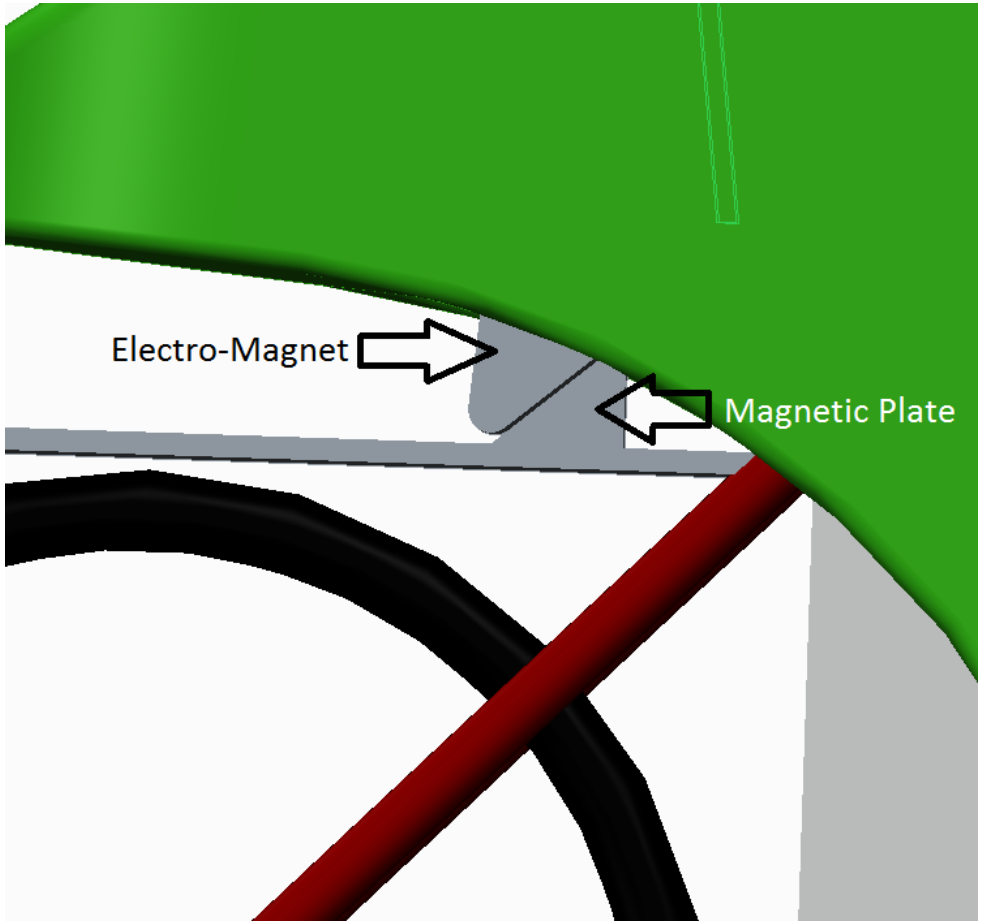
# KEY FEATURES

- RFID Sensor
  - Unlock and Lock the E-Bike
- Speaker
  - Alert User in Certain Situations
  - “Bike Not Placed in Locking Position”
  - “Please Swipe Your ID Card”
- LED Indicators
  - Red – Bike Locked
  - Green – Fully Charged/Available
  - Yellow – Bike Out Of Service/Charging
- Guiding Strip
  - Assist Users in Placing Bike at the Correct Position



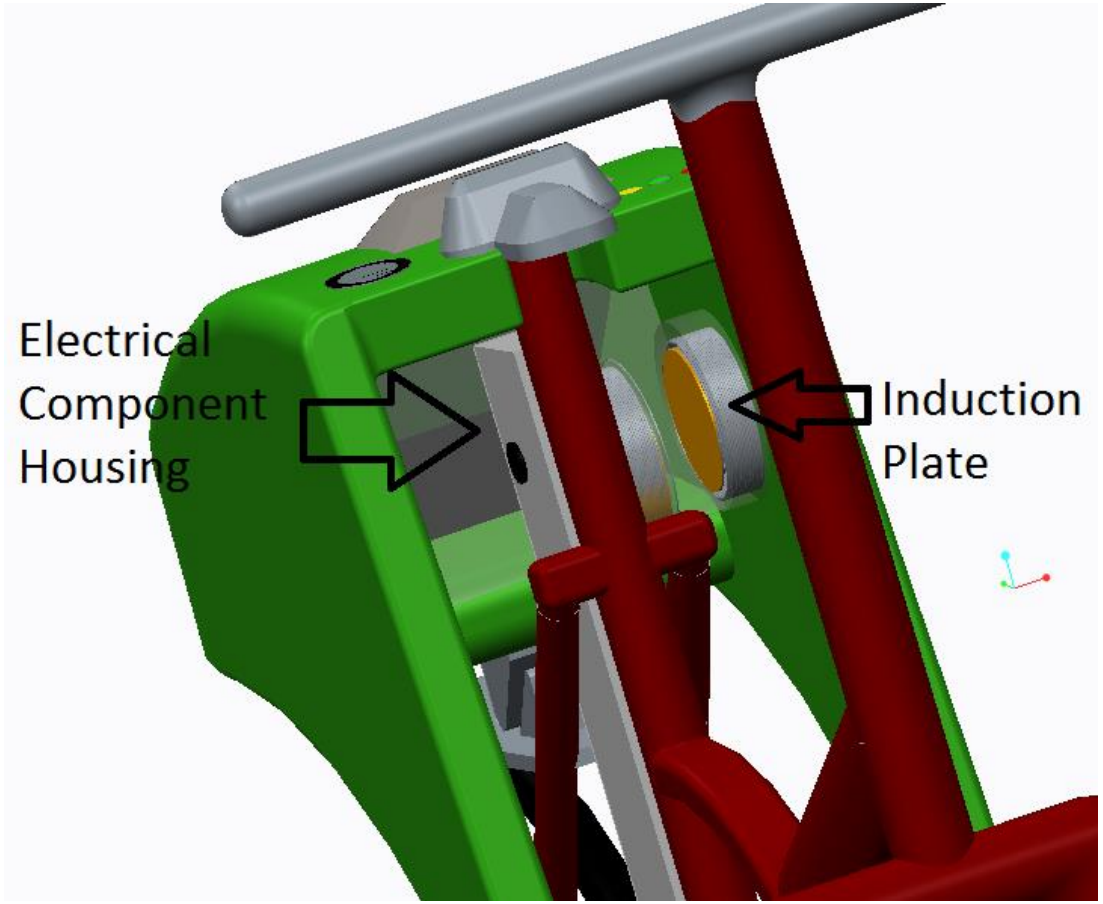
# Electro-Magnetic Lock

- EM and Plate make contact at 45 degrees
- Optimizes Distribution Forces throughout structure
- Rated 800 lb-f Magnetic Force



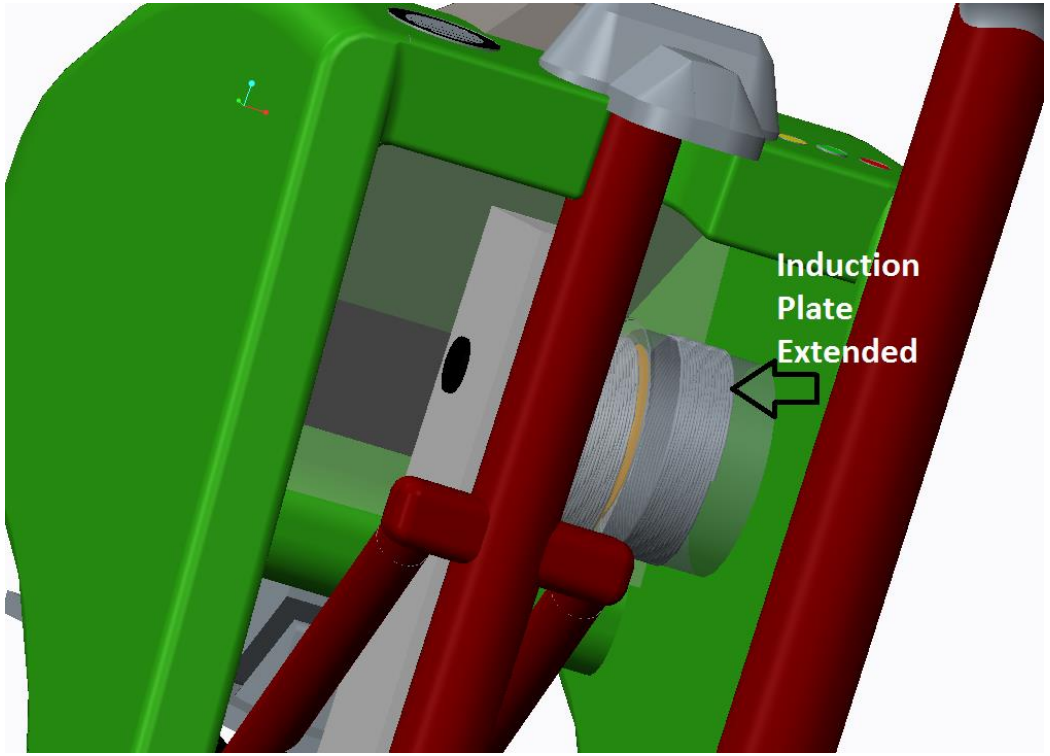
# CLOSE UP VIEW

- **Latched Door**
  - Encloses All Components
  - Easy Access for Installation and Repairs
- **Induction Plate**
  - Located on the Side
  - Kept Away From Bike for Protection During Docking



# INDUCTION COIL EXTENSIONS

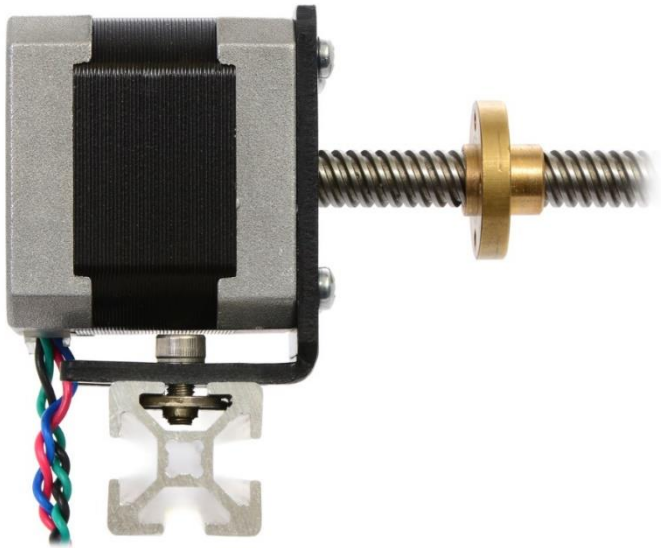
- Induction Coil Extension Required for optimization of Power Transfer



# INDUCTION COIL EXTENSIONS

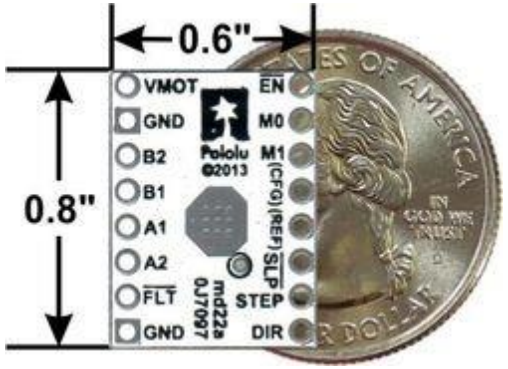
**Stepper Motor with 28cm Lead Screw**

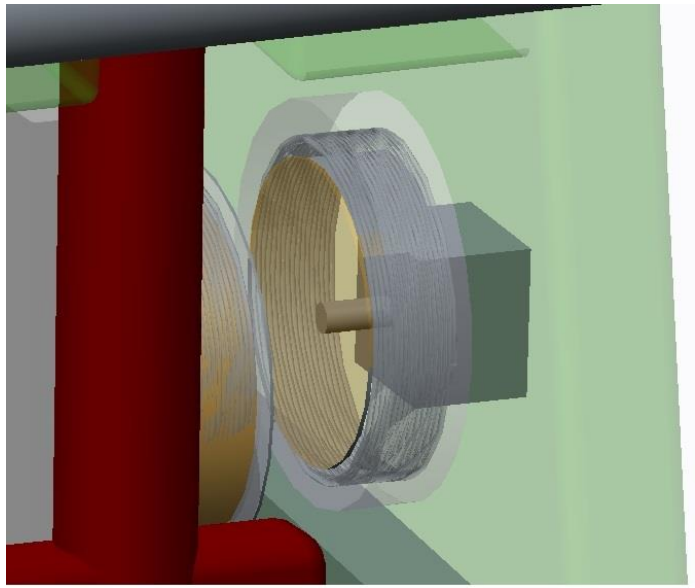
- Max Torque 36.72 kg-mm
- 1.7 Amps/Phase
- 2.8 Volts
- L xWxD = 42 x 42 x 38 (mm)



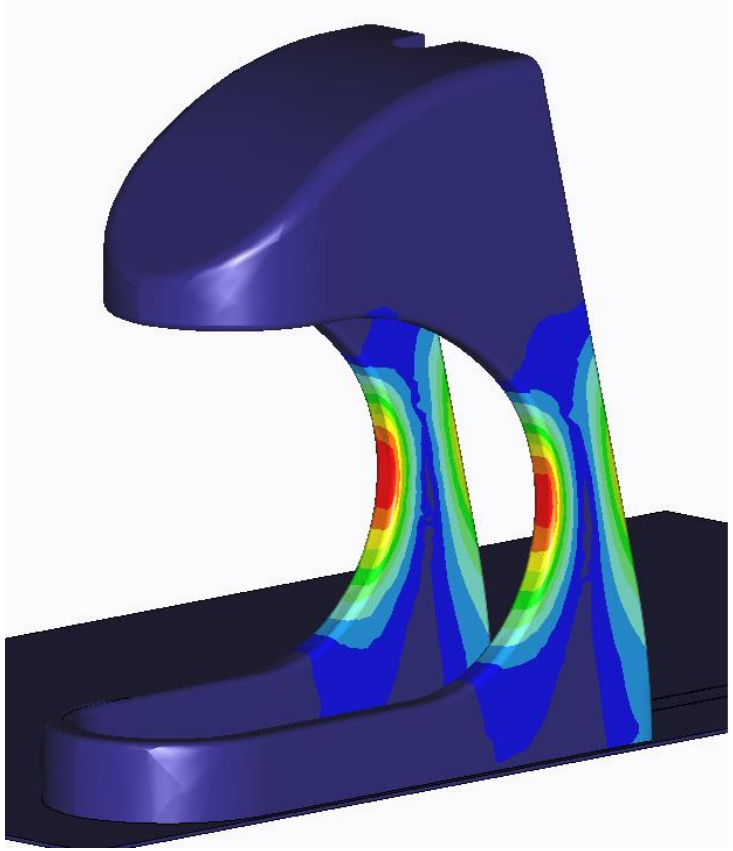
**DRV8834 Low-Voltage Stepper Motor Driver**

- 2.5-10.8 V supply voltage range
- Up to 2 A output current
- Small and Compact



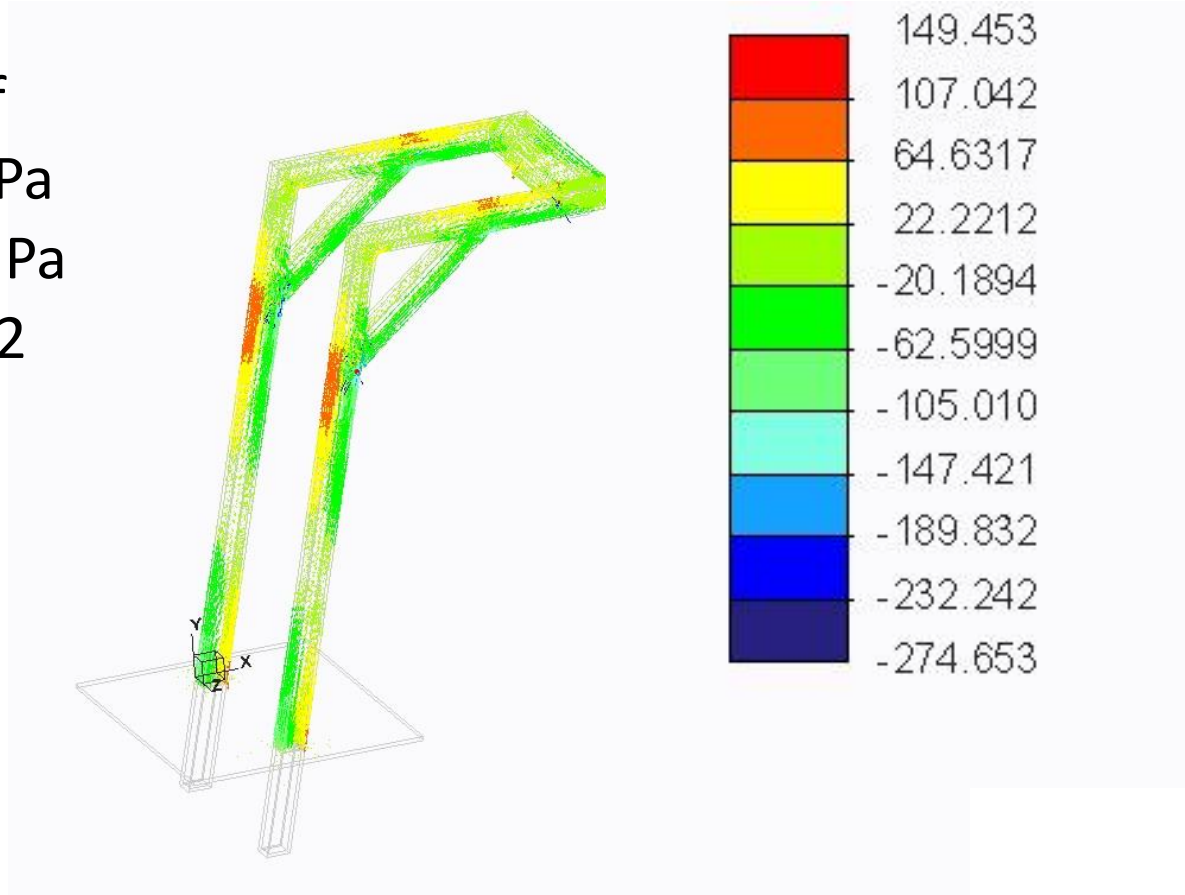



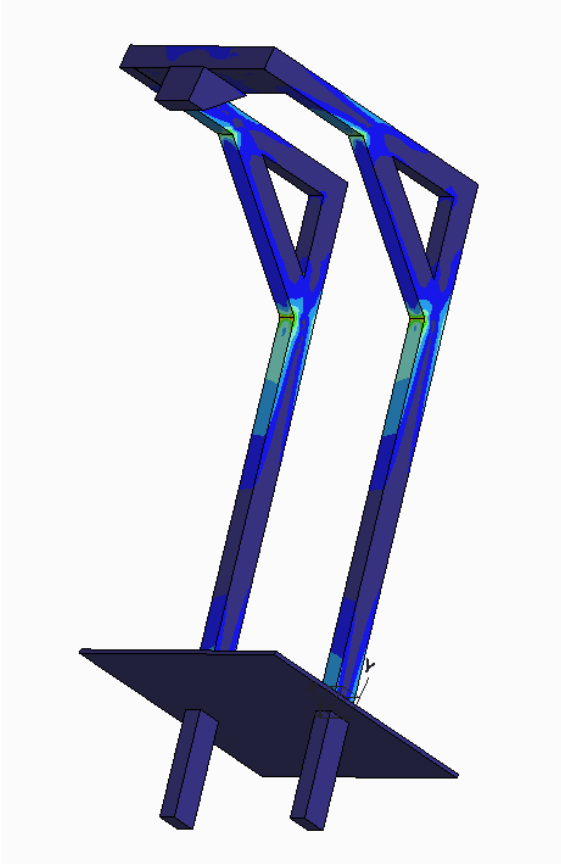
# STRUCTURAL ANALYSIS



# STRUCTURAL ANALYSIS

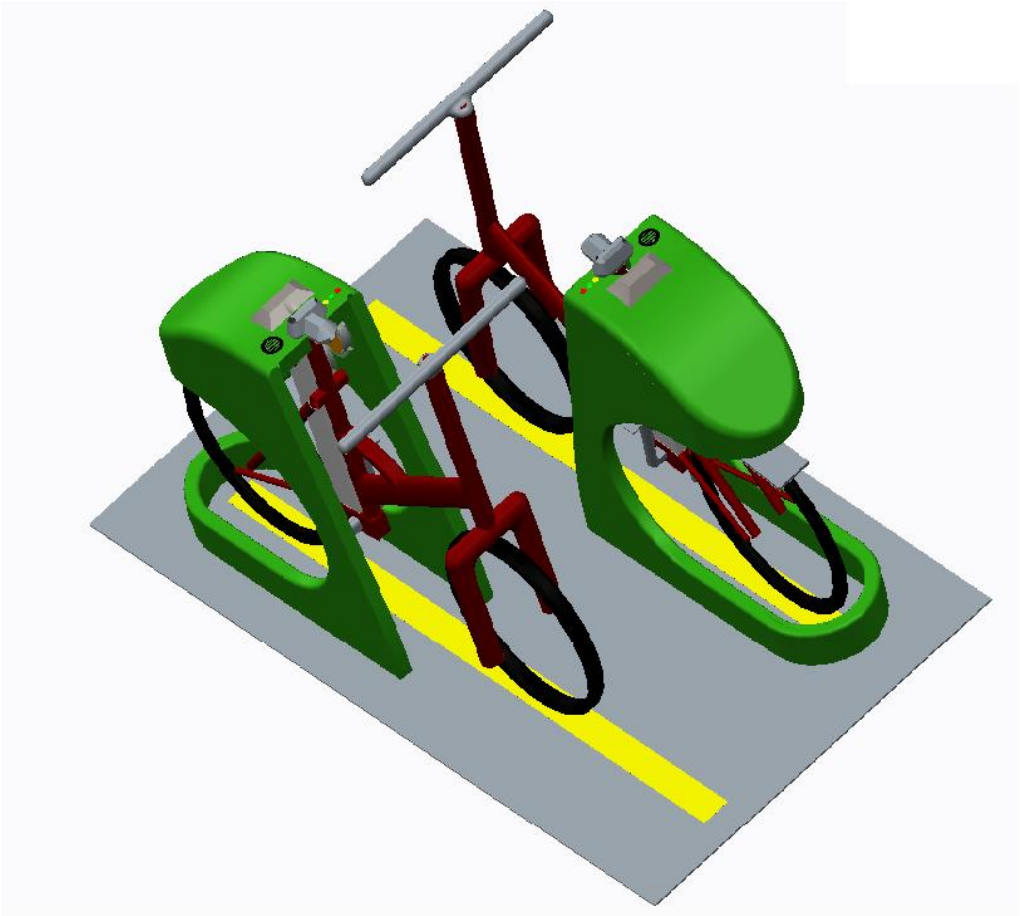
- Max Load 363 kg-f
- Max Stress 150 MPa
- Yield Stress 317 MPa
- Factor of Safety = 2

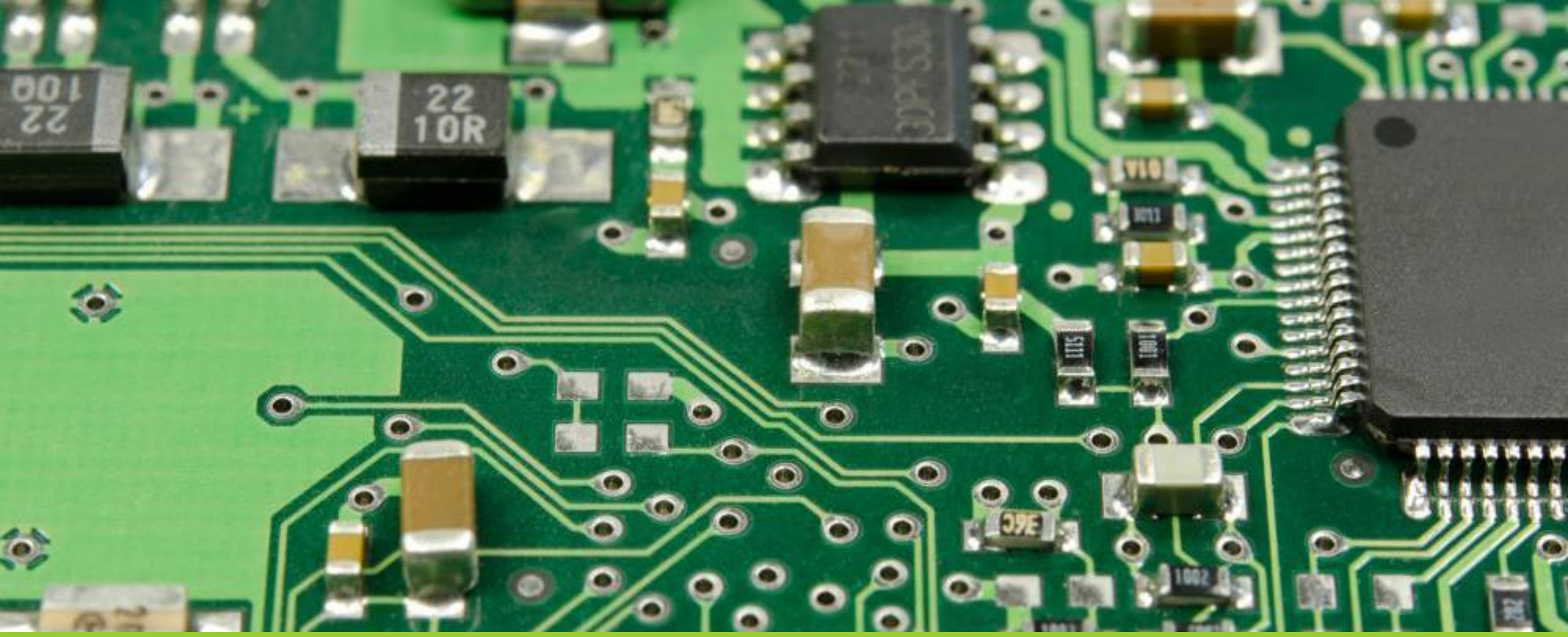


# SET-UP OF STATION

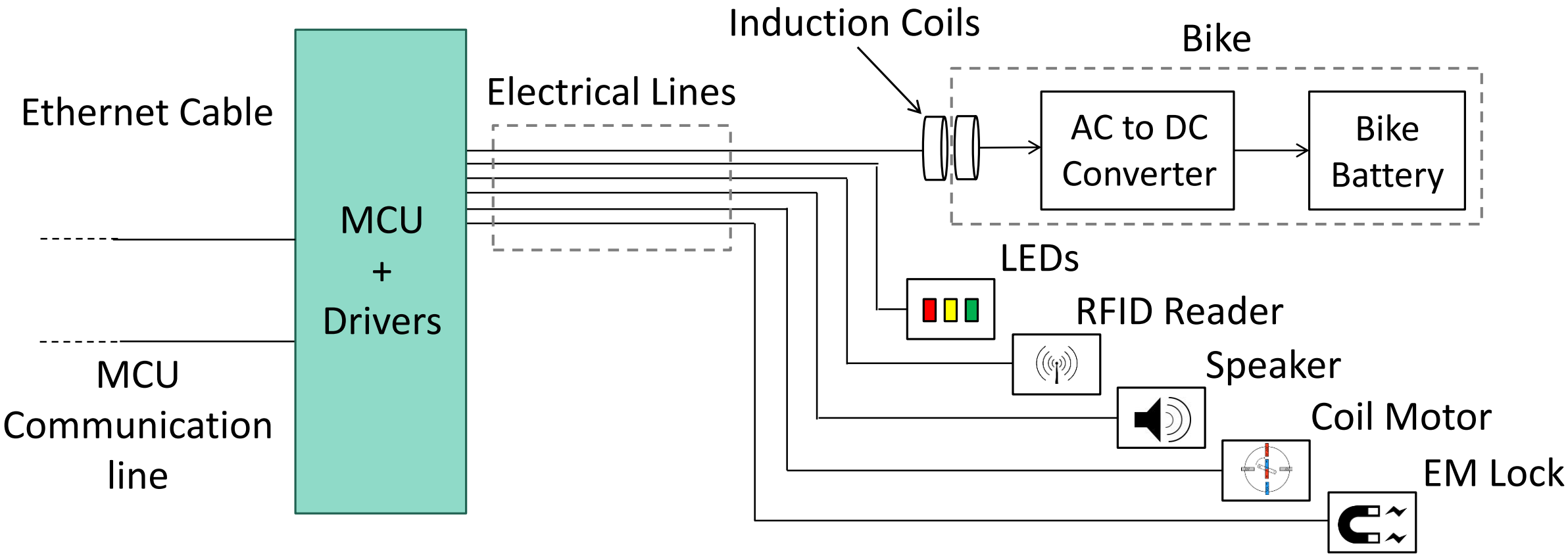
- Various Orientations





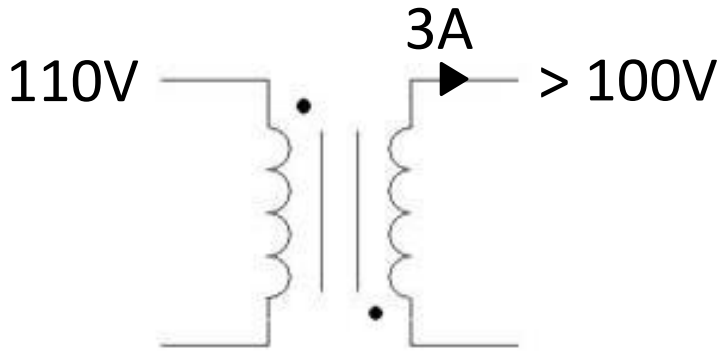

# ELECTRICAL COMPONENTS

# ELECTRICAL OVERVIEW



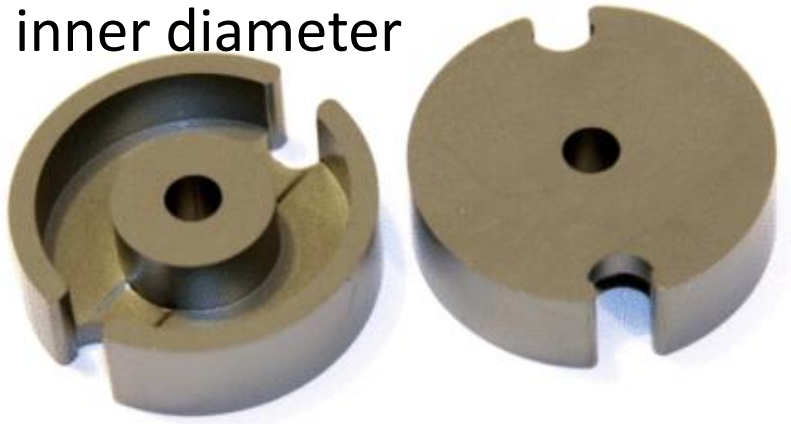
# INDUCTION COILS

- Small scale testing done: 19mm diameter
  - Will likely need larger diameter for full scale testing
- 14 American Wire Gauge (AWG) “Magnet Wire” will be used
- Need at least 100V on bike side
  - Approximately 1:1 turn ratio needed
  - Higher ratio if efficiency is less than 90%



# INDUCTION CORES

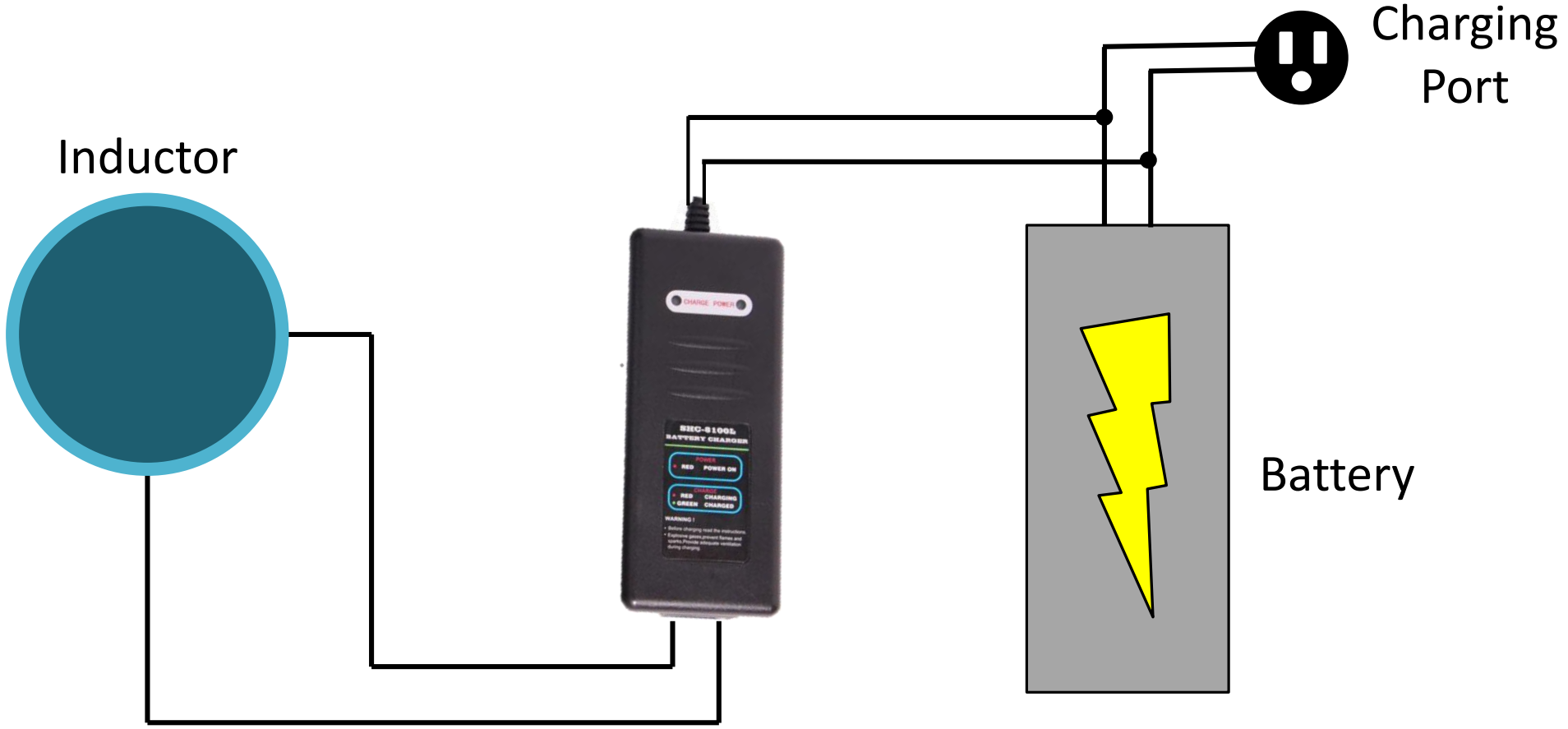
- Core needs to be adequate size and have number of coil turns to “carry” magnetic field
  - Smaller core/fewer turns result in a power bottleneck at higher voltages
- Current core for testing: pot core, 36 x 22mm, 19mm inner diameter
- 25 turns, 5V 60Hz, 86% power efficiency
- More likely later core diameter: 40-80mm



# AC/DC CONVERTER

- Input to be converted from 110V 60Hz AC to 36V DC
- Converter will be integrated into bike battery case
- Input will connect directly to induction coils
- Output will connect in parallel to charging port

# AC/DC CONVERTER

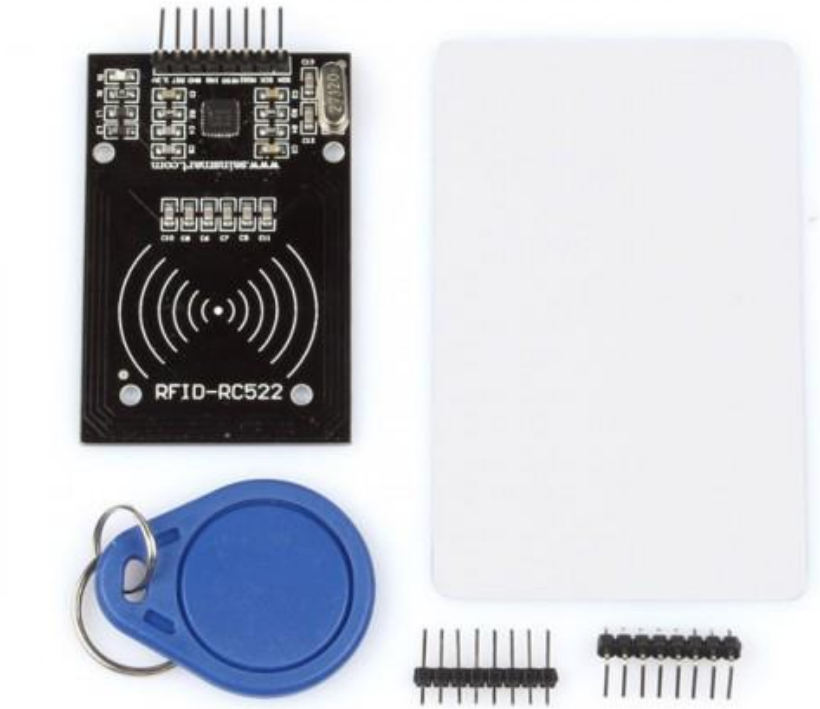


# ELECTRICAL LINES

- Electrical line to be routed through station
  - Induction coil (power)
  - LEDs
  - RF Reader
  - Speaker
  - Motor
  - Electromagnetic lock
- Wire sizes:
  - 12 AWG for induction coil
  - 22 or 18 AWG for other components

# RFID Reader/Writer

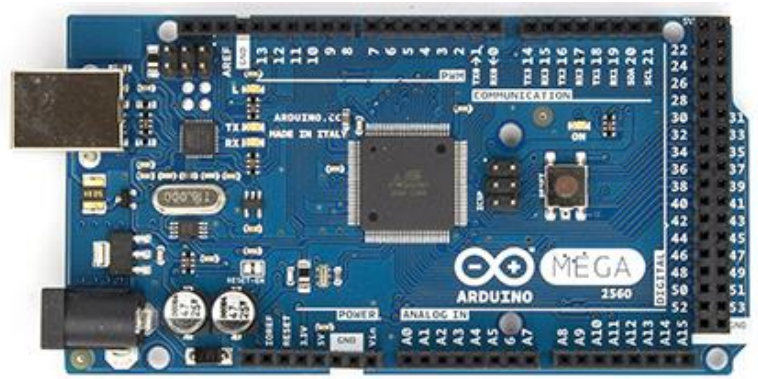
- Mifare MFRC522 RFID Reader
- Reading user RFID:
  - Check against online database, unlock if ID found
- Reading bike RFID:
  - Smaller pool of IDs, store on microcontroller
  - If valid ID, lock bike, attempt to charge, alert if not charging properly

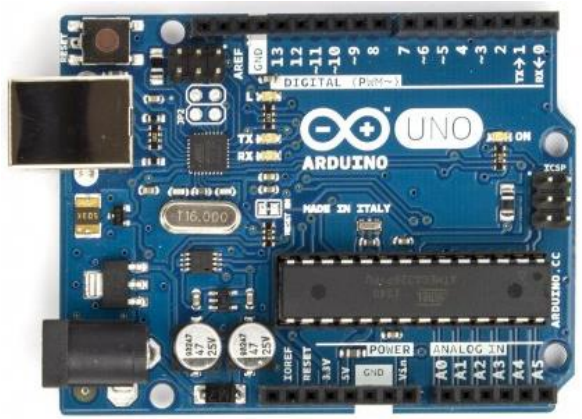


# MICROCONTROLLER

One microcontroller will be used per station

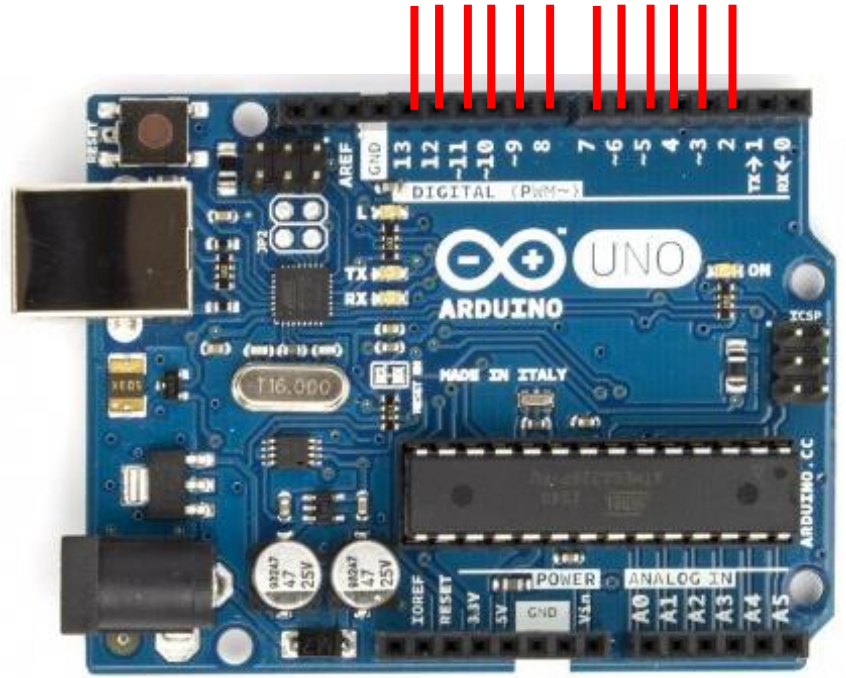
- First station: Arduino Mega
- Second station: Arduino Uno Rev3
- First station will have Arduino Ethernet Shield, all stations to have RFID reader
- Communication between MCU's using I2C



# Peripherals

- LEDs
  - 3 I/O ports needed (2 with encoder)
- RF Receiver
  - 5 I/O ports needed
- Speaker
  - Single I/O port needed
- Motor
  - 2 I/O port with driver
- Electromagnetic Lock
  - 1 I/O port with switch



# OVERALL RISK ASSESSMENT

# ELECTROMAGNETIC LOCK FAILURE

## RISK

- Power failure
  - Faulty wiring
  - Power shortage
  - Power surge
- Bike security compromised

## SOLUTIONS

- Back up power source
  - 800 lb. EM Lock requires 12VDC
    - Internal battery source
    - Connect to building power generator

# RF-ID FAILURE

## RISK

- User RF-ID tag
  - Station will not unlock when user wants to use e-bike
- Bike RF-ID tag
  - Bike misplacement will jeopardize locking and charging
    - Locking will not activate without tag
    - Battery will not charge without tag

## SOLUTIONS

- Alert user about malfunction through speaker
- Highly impact resistant and protective casing for RF-ID failure

# INDUCTION PLATE MISALIGNMENT

## RISK

- Plates do not line up properly
  - Charging is not fully operational
  - Bikes can not be used

## SOLUTIONS

- Ensure alignment
  - Seat-post clamp with spring terry clip
  - Magnetic lock is used to help set in place
- Alert user via speaker until bike is in proper position

# COMPONENT AVAILABILITY/DELIVERY

## RISK

- Out of stock
- Custom built parts
- Uncommon component
- Delays testing
- Incomplete report
- Shipping from a far location

## SOLUTIONS

- Various ordering options
- Order ahead of time
- Preference for readily available components
- Avoid custom built parts
- Order from nearby location

# CHANGE OF DESIGN

## RISK

- Delays completing tasks
- Reanalyze, retest and prototyping of design
- Lack of time to efficiently complete design process

## SOLUTIONS

- Thoroughly analyze design first time around
- Avoid changing design unnecessarily
- Efficiently appoint tasks if change occurs

# UNEXPECTED COMPONENT COSTS

## RISK

- Adds unexpected costs
- Incorrect quantity of components

## SOLUTIONS

- Assuring necessary components are on budget list
- Adding costs to budget ASAP

# BUDGET MISMANAGEMENT

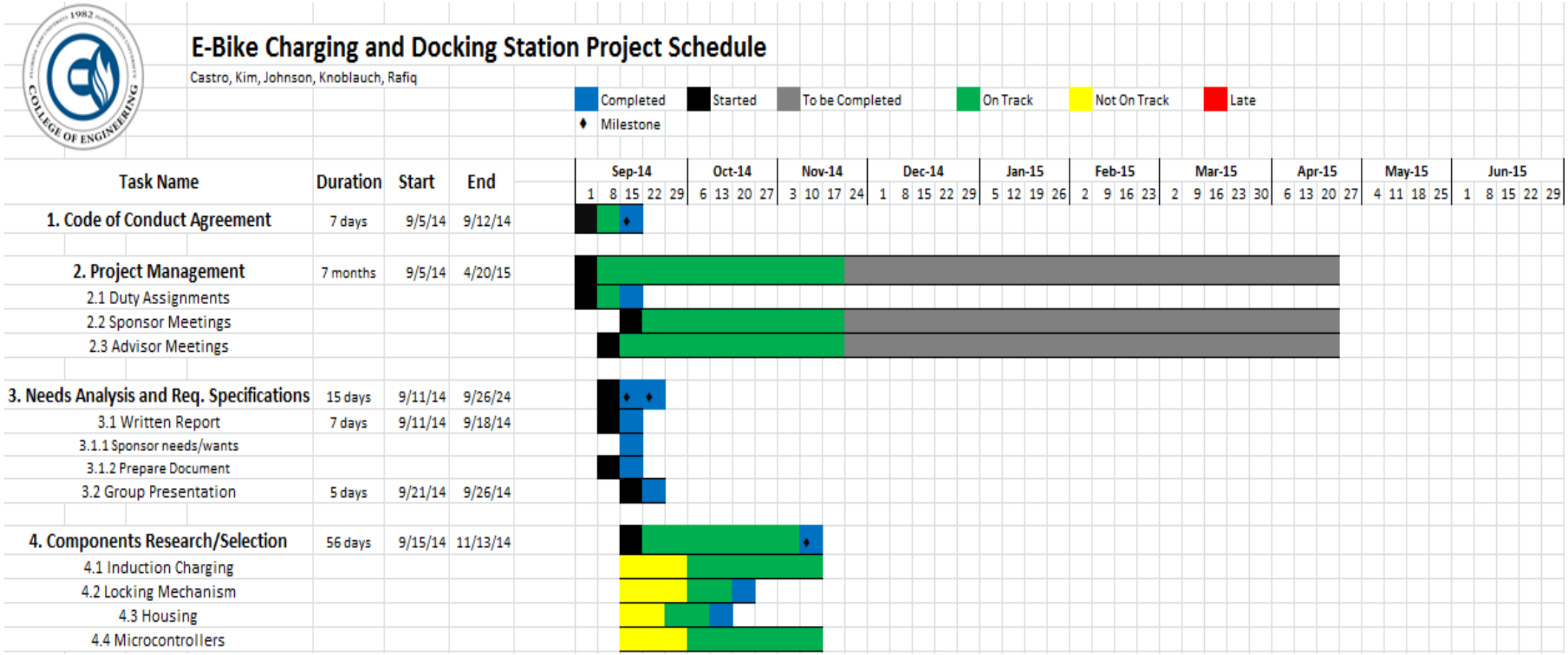
## RISK

- Insufficient funds for the project
- Incorrectly tracking costs
- Prioritizing unnecessary purchases

## SOLUTIONS

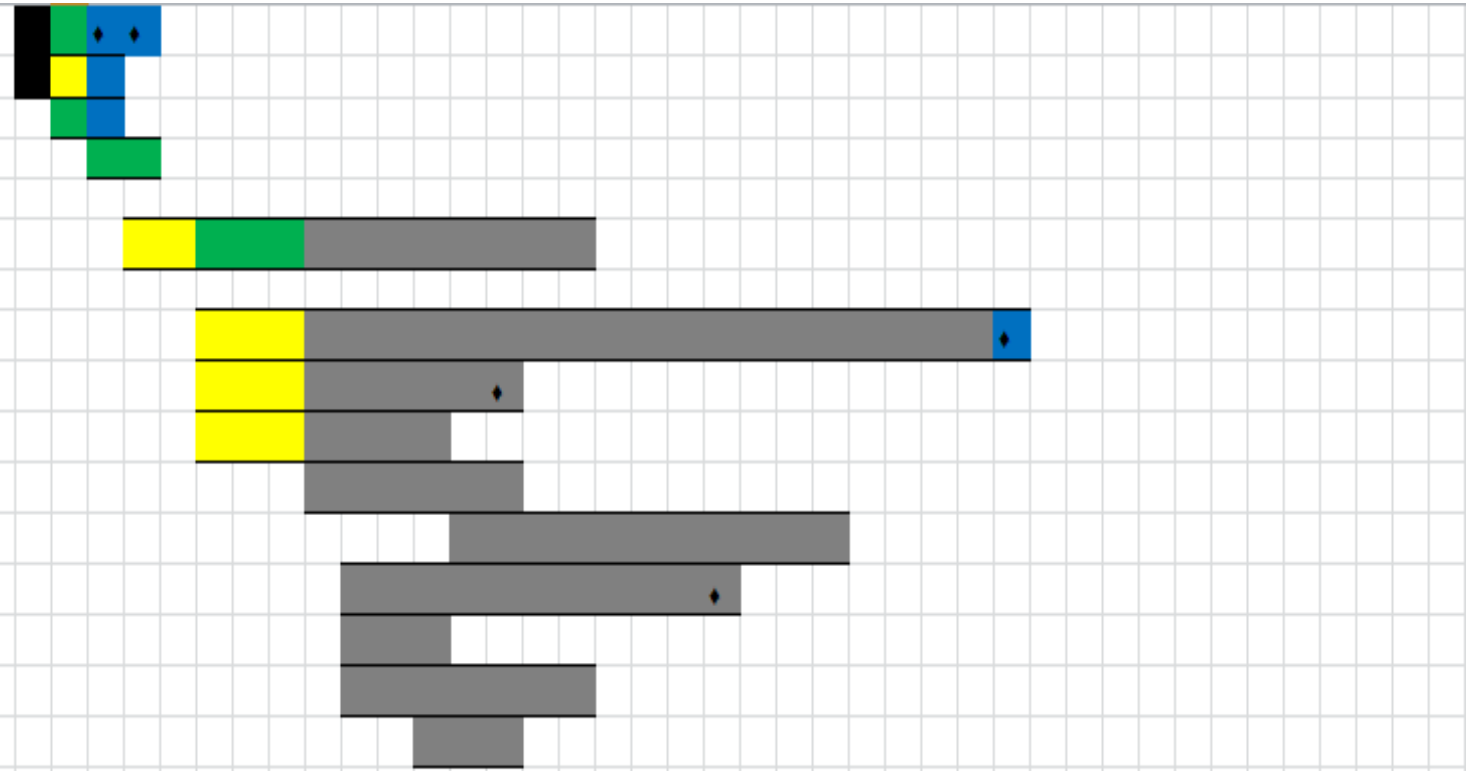
- Keeping itemized list to keep record
- Periodically check and update budget
- Discuss budget management with sponsor

# SCHEDULE


E-Bike Charging and Docking Station Project Schedule
Castro, Kim, Johnson, Knoblauch, Rafiq
Completed
Started
To be Completed
On Track
Not On Track
Late
Milestone
Task Name
Duration
Start
End
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
1. Code of Conduct Agreement 7 days 9/5/14 9/12/14
2. Project Management 7 months 9/5/14 4/20/15
2.1 Duty Assignments
2.2 Sponsor Meetings
2.3 Advisor Meetings
3. Needs Analysis and Req. Specifications 15 days 9/11/14 9/26/24
3.1 Written Report 7 days 9/11/14 9/18/14
3.1.1 Sponsor needs/wants
3.1.2 Prepare Document
3.2 Group Presentation 5 days 9/21/14 9/26/14
4. Components Research/Selection 56 days 9/15/14 11/13/14
4.1 Induction Charging
4.2 Locking Mechanism
4.3 Housing
4.4 Microcontrollers

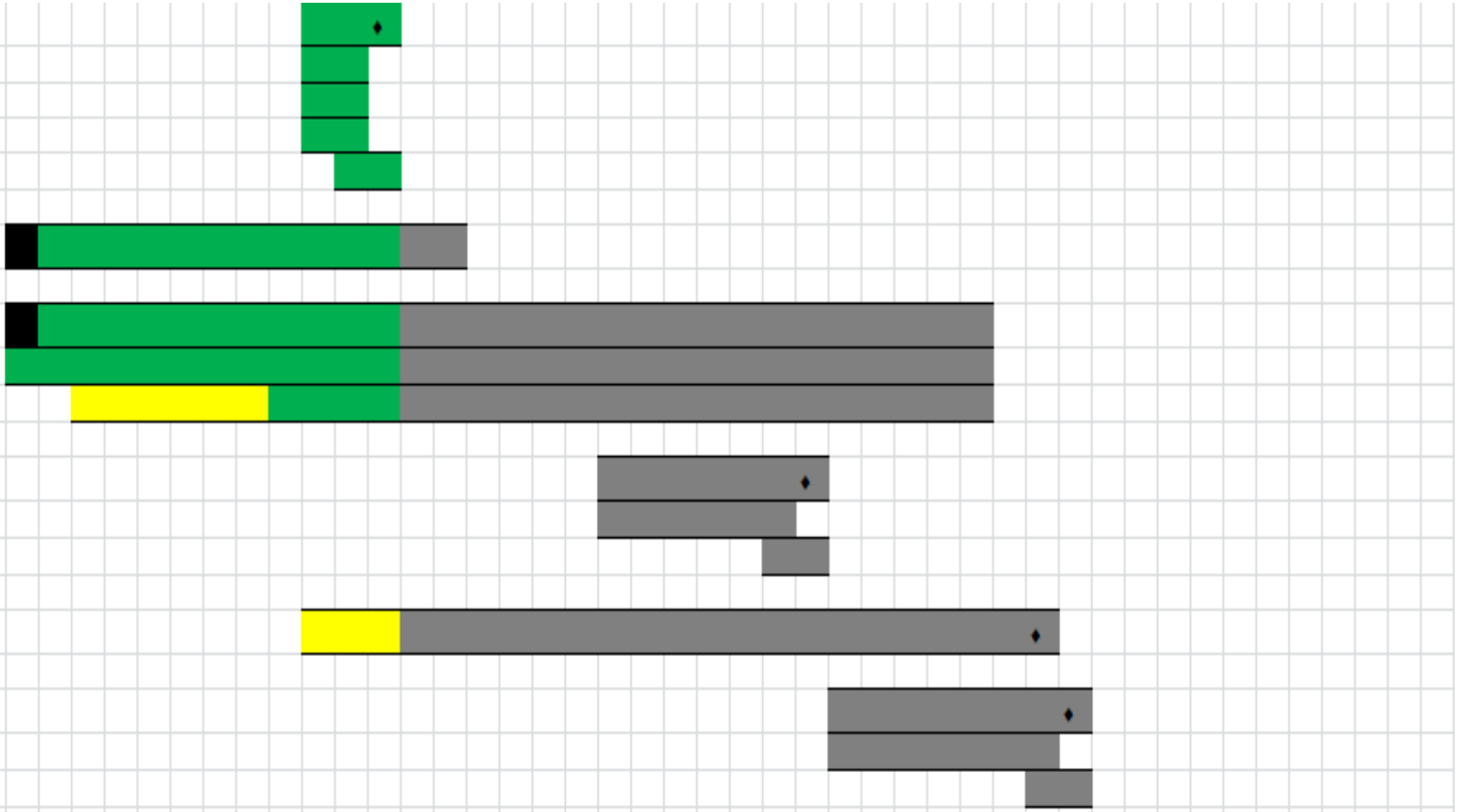
# SCHEDULE

| | | | |
|---|---|---|---|
| **5. Project Proposal** | 22 days | 10/2/14 | 10/23/14 |
| 5.1 Written Report | 15 days | 10/2/14 | 10/17/14 |
| 5.1.1 Design Proposal | | | |
| 5.2 Group Presentation | 5 days | 10/18/14 | 10/23/14 |
| | | | |
| **6. Order Components** | 82 days | 10/22/14 | 1/12/15 |
| | | | |
| **7. Test/Implement Components** | 5 months | 11/3/14 | 4/6/15 |
| 7.1 Test and Implement Induction charging | | | |
| 7.1.1 Test Induction Plates | | | |
| 7.1.2 Test charging circuit | | | |
| 7.2 Test and Implement Microcontrollers | | | |
| 7.3 Test and Implement Locking Mechanism | | | |
| 7.4 Implement guiding track | | | |
| 7.5 Test and Implement Housing | | | |
| 7.6 Implement seat aligner | | | |



# SCHEDULE

| | | | |
|---|---|---|---|
| **8. System-Level Design Review** | 15 days | 11/6/14 | 11/21/14 |
| 8.1 Written Report | | | |
| 8.1.1 Create detailed system designs | | | |
| 8.1.2 Update designs | | | |
| 8.2 Group Presentation | | | |
| **9. Self & Peer Evaluation** | 3 months | 9/5/14 | 12/5/14 |
| **10. Project Documentation** | 7 months | 9/5/14 | 4/20/15 |
| 10.1 Meeting Minutes | | | |
| 10.2 Team's Website | | | |
| **11. Detailed Design Review** | 35 days | 1/5/15 | 2/16/15 |
| 11.1 Written Report | | | |
| 11.2 Group Presentation | | | |
| **12. Test Prototype** | 5 months | 11/3/15 | 4/6/15 |
| **13. Final Presentation** | 49 days | 2/23/15 | 4/13/15 |
| 13.1 Written Report | | | |
| 13.2 Group Presentation | | | |



# BUDGET ESTIMATE

| A. Personnel | | | |
|---|---|---|---|
| **Engineer** | **Hours** | **Hourly Pay** | **Total Pay** |
| Bryan Castro | 348 | $30.00 | $10,440.00 |
| Seve Kim | 348 | $30.00 | $10,440.00 |
| Bilal Rafiq | 348 | $30.00 | $10,440.00 |
| Justin Johnson | 348 | $30.00 | $10,440.00 |
| Jacob Knoblauch | 348 | $30.00 | $10,440.00 |
| | | Personnel Subtotal | $52,200.00 |
| B. Fringe Benefits | | 29% of Personnel | $15,138.00 |
| **C. Total Personnel** | | | **$67,338.00** |

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| **C. Total Personnel** | | | **$67,338.00** |

# Budget Estimate

| D. Expenses | | | |
|---|---|---|---|
| **Item/Description** | **#** | **Price/Unit** | **Total Price** |
| Galvanized Steel Sheet Metal (1.41 $m^2$) | 1 | $88.48 | $88.48 |
| A36 Hot Rolled Steel (8 ft, 1 in Diameter) | 1 | $32.00 | $32.00 |
| FPC-SS800-G 800 lbs Outdoor and Gate Electromagnetic Lock CE Listed | 1 | $87.73 | $8 |
| Arduino UNO Rev3 | 1 | $24.97 | $2 |
| Arduino MEGA 2560 Rev3 | 1 | $43.70 | $4 |
| Arduino Ethernet Shield Rev3 (without PoE Module) | 1 | $36.21 | $3 |
| Mifare RC522 RFID Reader | 1 | $5.36 | $5 |
| Wall Adapter Power Supply (9VDC, 650mA) | 1 | $5.95 | $5 |
| 3” Diameter Speaker (8 ohm, 1 Watt) | 1 | $1.95 | $1.95 |
| Tool Storage Spring Terry Clips (1 in) | 1 | $10.19 | $10.19 |
| 18 AWG Copper Magnet Wire (1 lb, 201 ft) | 1 | $16.50 | $16.50 |
| 14 AWG Copper Wire (25 ft) | 1 | $14.00 | $14.00 |
| LED R/Y/G | 1 | $2.75 | $2.75 |

| | | | |
|---|---|---|---|
| | Expenses Subtotal | $388.75 | **Expenses Subtotal** | **$369.79** |
| E. Total Direct Costs | **E. Total Direct Costs** | **Personnel + Expenses** | **$67,707.79** |
| F. Overhead Costs | **F. Overhead Costs** | **45% of Direct Costs** | **$30,468.50** |
| **G. Total Project Cost** | **G. Total Project Cost** | | **$98,176.29** |

# QUESTIONS