Battle of the Bikes

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Introduction

- Create an entertaining one-on-one racing game to encourage gym members to work out and compete together
- Generate energy from the players' efforts in order to power the system
- Monitor and display users' speed and power generation to encourage competition
- Over course of the game, users will get "power-ups" that make pedaling harder for the other user to further stimulate competition

Motivation

- Create a system that is entirely self-sufficient
- Promote cardiovascular health
- Encourage male gym goers to engage in cardio
- Make cardio fun through competition

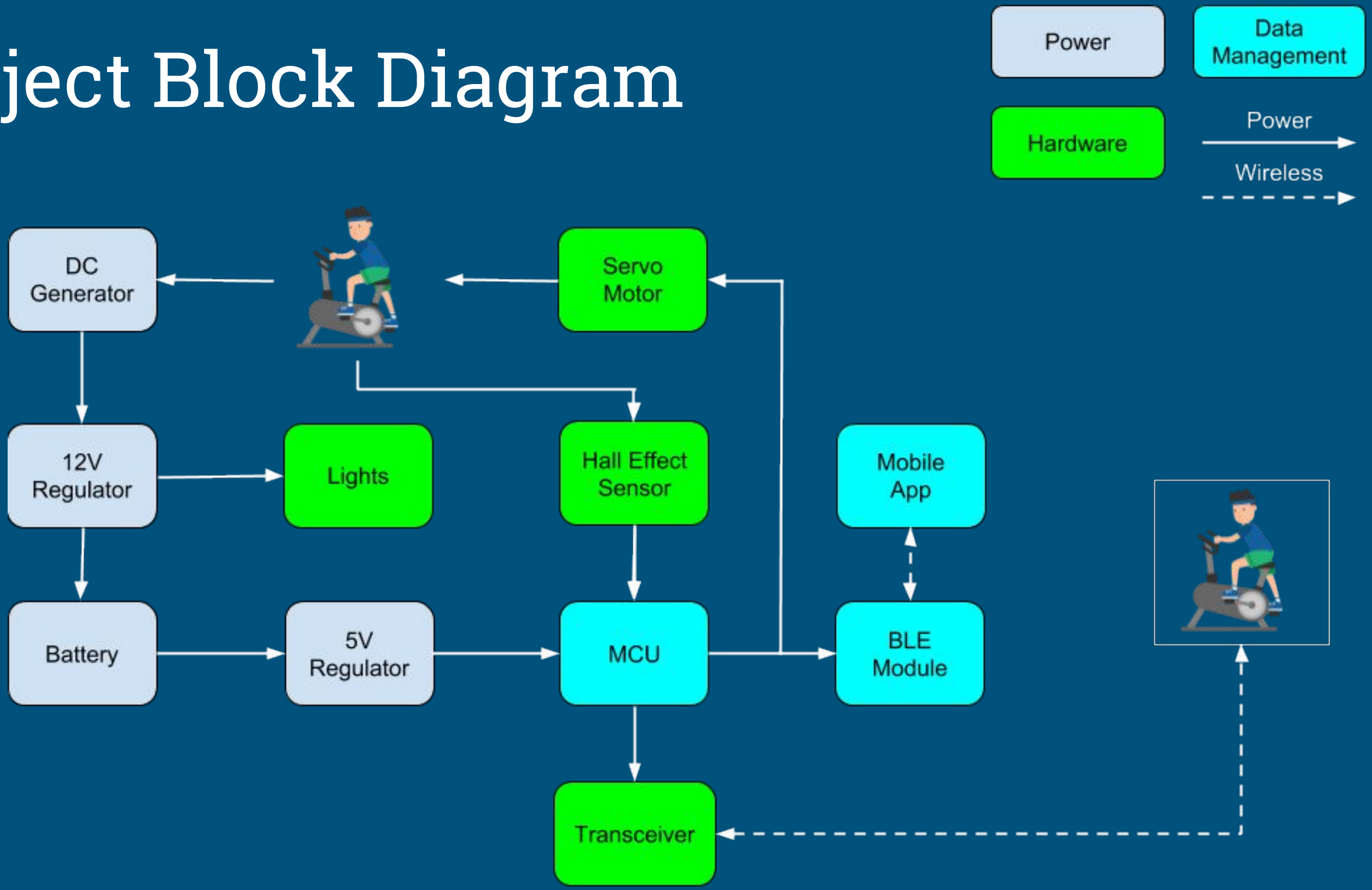
Project Goals and Objectives

- Entire system powered by human effort
- Wireless communication between two bikes and two phones
- Direct and automatic control of bicycle tension
- Excess power is directed to lights; faster = brighter
- Charging outlet for accessories

Specifications and Requirements

Feature	Parameter	Design Specification
Wireless Connectivity	Minimum Range	6 feet
Distance Travelled	Accuracy	+/- 4.45 feet
Speed	Accuracy	< 2 mph
Electronics Box	Size	5 ft x 1 ft x 1 ft
Battery	Output Power	At least 30 W

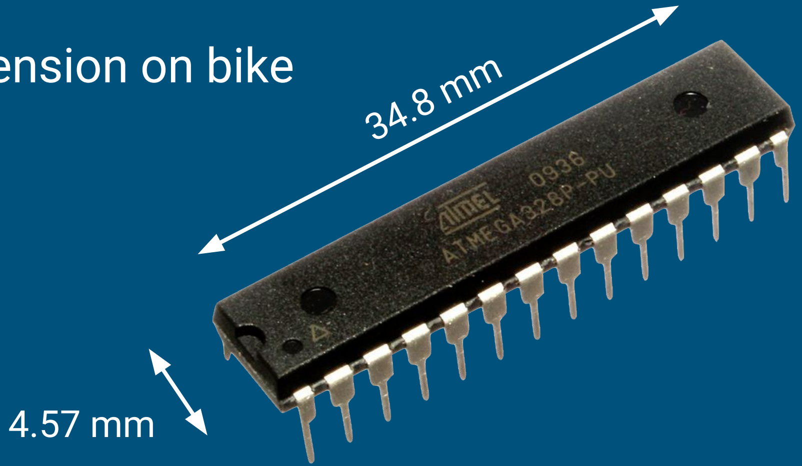
Project Block Diagram



ATmega328P

- Will be the brain of system
  - Hold information to send to app
  - Take power-up signal to change tension on bike

Manufacturer	Atmel
Voltage	1.8 - 5.5 V
Processor Speed	20 MHz
Memory	32 KB



Arduino Uno R3

- Program in C
- Many libraries for hardware
- Open source
- Has IDE for ease of programming

Manufacturer	Arduino
Operating Voltage	5 V
IO Pins	14

Wireless Communication

Wireless Connectivity

- Bluetooth
  - Connect system to smartphones
  - Bi-directional
  - Easy to use with smartphones
- Transceivers
  - Send data between bikes
    - Other user’s speed, power generated
    - Power-up
  - Allows bikes to be used independently for single player games

Selection of Wireless Communication

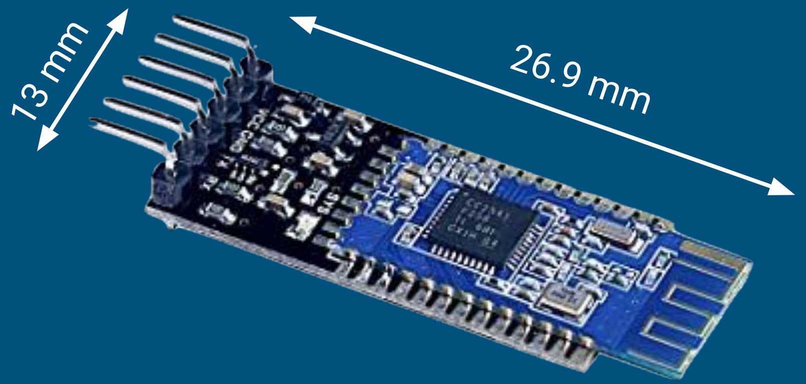
- Factors:
  - Low cost
  - Low power usage
  - Ease of implementation

	BLE	Wi-Fi
Transmit Power	2.5 mW	100 mW
Throughput	270 kb/s	900 Mb/s
Price	$10	$7

HM-10 BLE Module

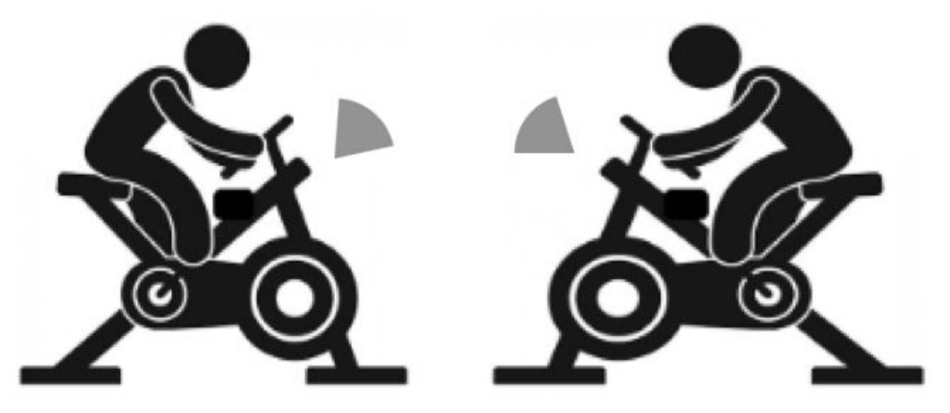
- Connect mobile device with microcontroller
- Allows back-and-forth communication to pass info

Manufacturer	DSD Tech
Power Supply	3.3 V
IO Lines	RX, TX, GND, VCC

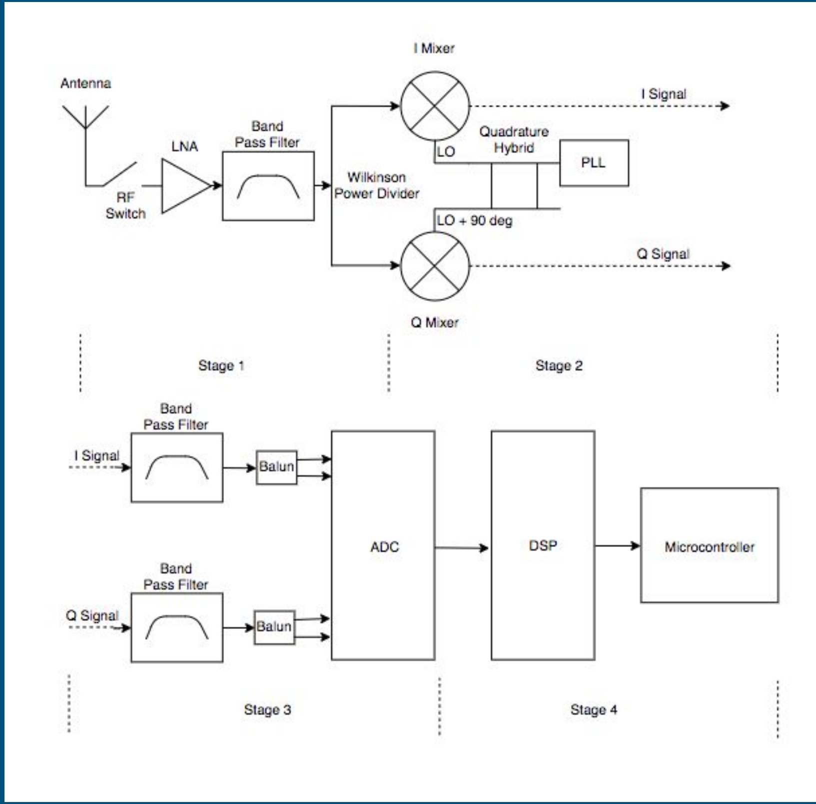


Transceivers

- QAM
  - I/Q Data
- Operating at 2.4GHz
  - Does not abide by any protocol
  - Transmitting under 1 Watt
- Transmit and Receive Paths
- Design Focuses
  - Impedance matching
  - Phase conservation



Transceiver Receive Path



Bike Hardware

Tension Control

- Adds competition to the game
- Controlled by the game
- Gear on a servo used to move a rod up and down to apply tension to wheel
- Precise control over tension on bike
- Keeps tension on wheel by keeping servo locked in position

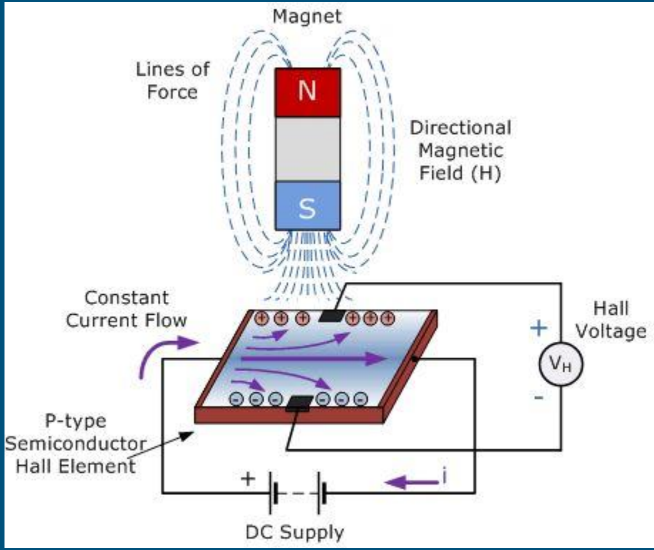
Servo Motor

- Adjusts bike tension
- Controlled by MCU and opposite bike

Specification	Rating
Torque	20 kg*cm
Working Voltage	6-7.4V

Wheel Rotation Monitoring

- Hall Effect Switch Sensor
- Magnet + sensor
- Measures each revolution
- Calculate speed and distance of bicycle



Power

Power Generation

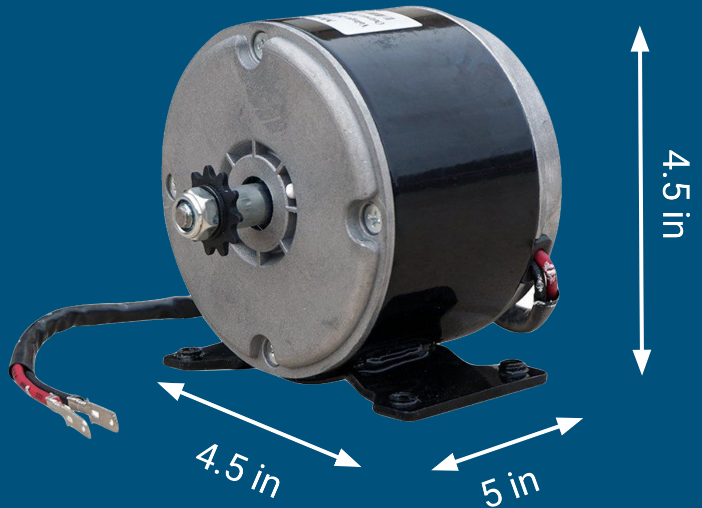
- Rubber belt on axle of stationary bicycle connected to the shaft of motor
- Typical use generates about 60W of power
- Peak generation of 12.5V at 5A
- Power unused by the battery will be diverted to a light - brighter means faster

Generator Selection

- Alternator
  - Produces alternating current
  - Only used for external device power
  - Would require transformer for increased voltage
- DC Motor
  - Produces a direct current
  - More ideal as most systems will use DC
  - Voltage can be more easily manipulated

DC Permanent Magnet Motor Generator

- 12V/24V Generator
- Rated current: 16 A
- Rated speed: 2750 RPM
- Outputs DC
- Output power: 300 W



Battery Selection

- Factors
  - Size - Smaller is better to reduce the overall footprint of this project
  - Capacity - Battery must be large enough to receive all generated power without being damaged
    - Amps
    - Voltage
  - Rechargeable - Idea of project is creating a self-sustainable system
  - Temperature - Must operate in temps ranging from 50º F to 90º F
  - Cost

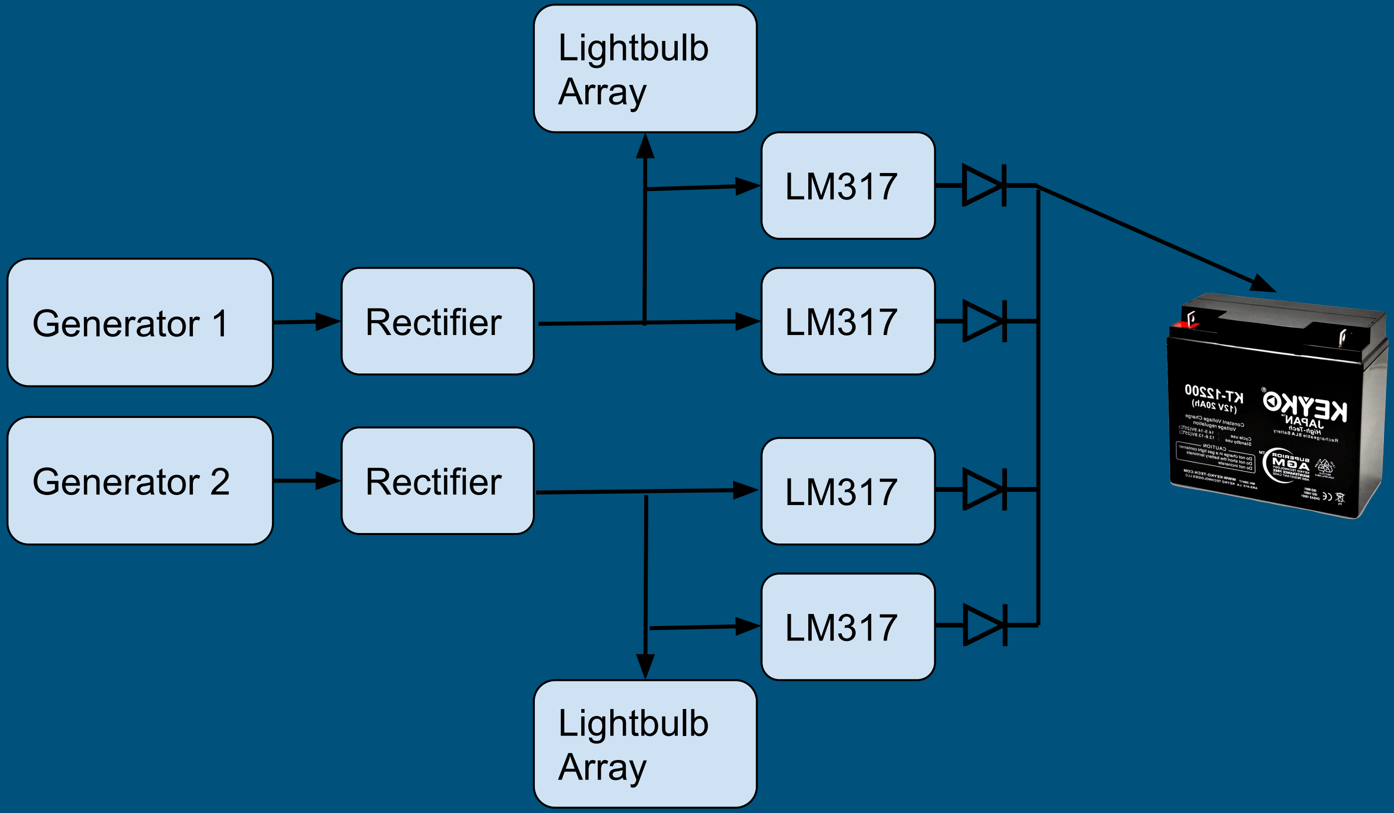
Comparison of Batteries

- Sealed Lead Acid
  - Advantages
    - Cost Effective
    - Charge
    - Life Span
  - Disadvantages
    - Temp
    - Weight
- Lithium Ion
  - Advantages
    - Weight
    - Lifespan(idle)
    - Capacity
  - Disadvantages
    - Cost
    - Lifespan(active)
    - Temperature

Lead Acid Battery

- 12 Volt
- 20 Ah
  - Charges at up to 14.9V
  - Higher voltages charge faster
  - Max recommended charge rate of 4A for battery longevity

Battery Charging



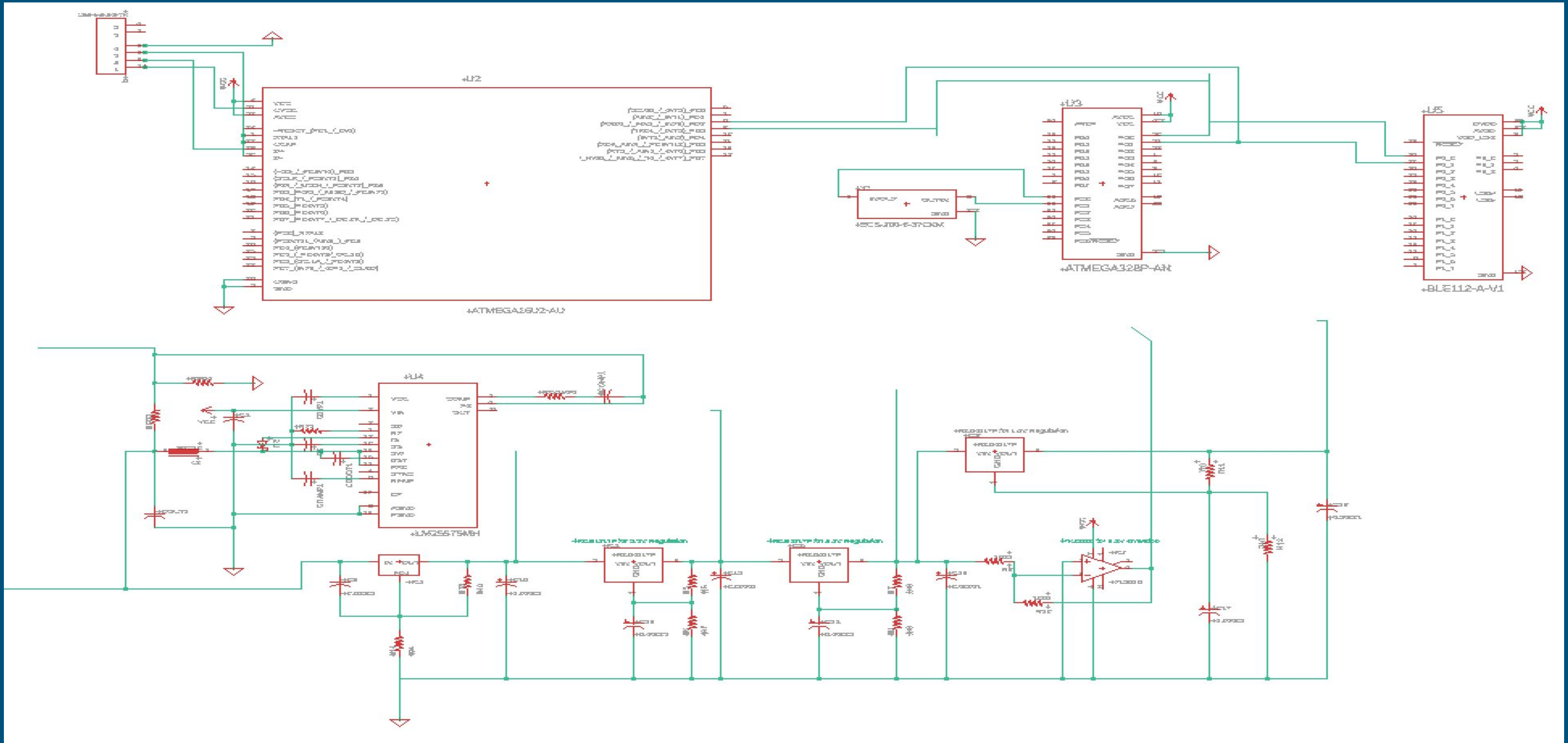
Excess Power

- Excess power generated by the system will be diverted into lightbulbs
- Keep the circuit from heating up too much and causing damage to components

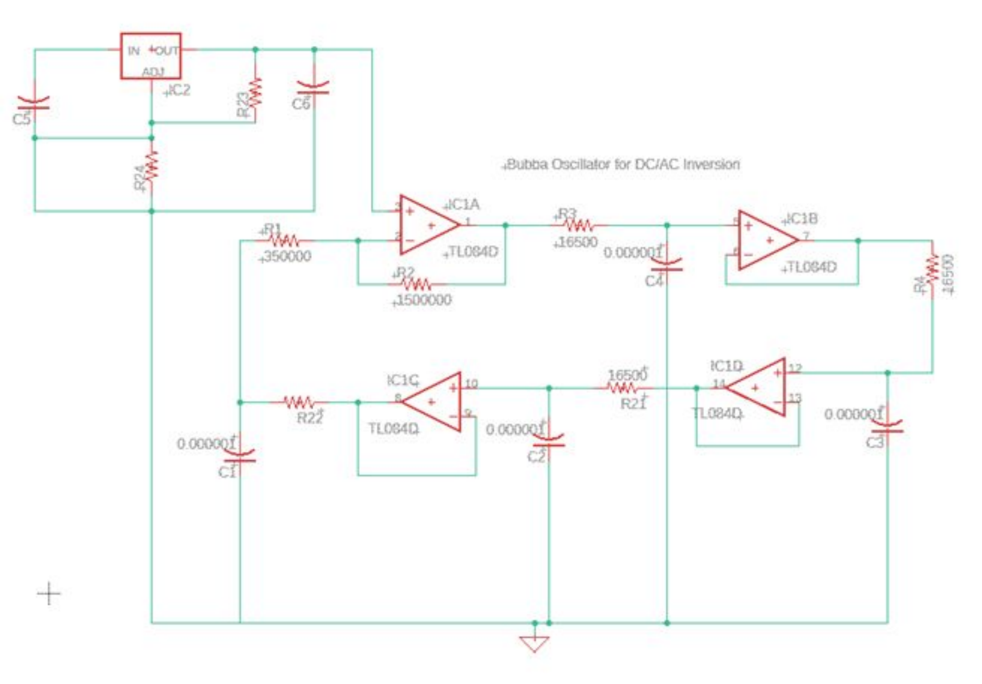
Voltage Regulators

- To obtain specific voltage requirements throughout the system several regulators will be required.
- 12V to 5V
  - LM25575 Switching Regulator
- Linear Regulators
  - 5V to 5V Linear
    - LM317
  - 5V to 3.3V
    - REG1117
  - 3.3V to 2.5V
    - REG1117
  - 2.5V to 1.8V
    - REG1117

PCB Schematic



Schematic - Bubba Oscillator



Electronics Enclosure

- Dimensions: 5 ft x 1 ft x 1 ft
- Allow heat to escape enclosure
- Used to hide and protect electronics
- Material: plastic
    - Don’t want to disrupt wireless communication

Mobile App

Android vs iOS

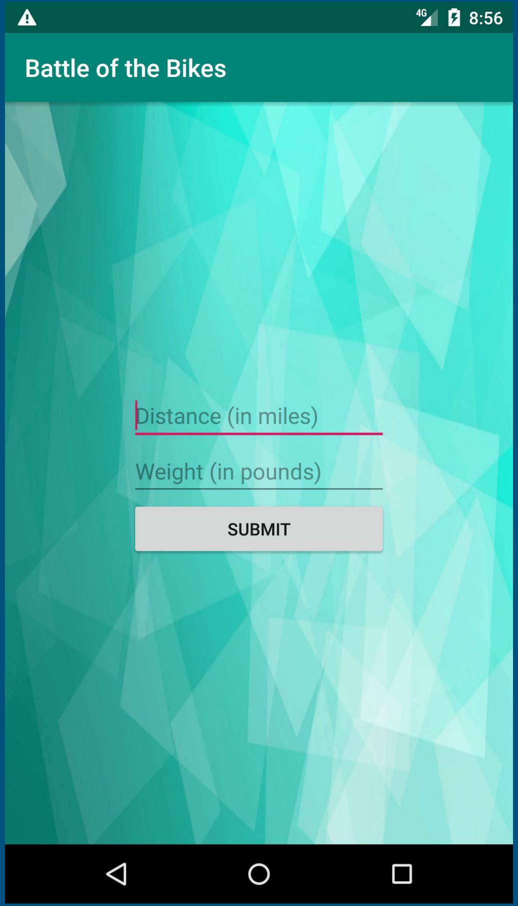
- Programmable on any operating system
- Java
- Open Source
- More users worldwide
- Cheap development and fast publishing
  - One time $25 fee vs yearly $100 fee for iOS
  - App on Google Play store in a few hours

- Devices are standardized
- More security
- More iOS users in North America

Startup Screen

Mobile App Features

- Easy to read displays during use
  - Speed
  - Distance
  - Calories burned
  - Competitor’s distance
  - Power-up
- Power-up button
- Graphical representation of ride at end of session



Calorie Calculations

- Use METs (Metabolic Equivalent of a Task) to keep track of Calories burned during use

MET	Description
4	Less than 10 mph on average
6	10 - 11.9 mph on average
8	12 - 13.9 mph on average
10	14 - 15.9 mph on average
12	16 - 19.9 mph on average
16	More than 20 mph on average

$$\text{Calories Burned} = 0.0175 * \text{MET} * \text{Weight(kg)} * \text{Minutes}$$

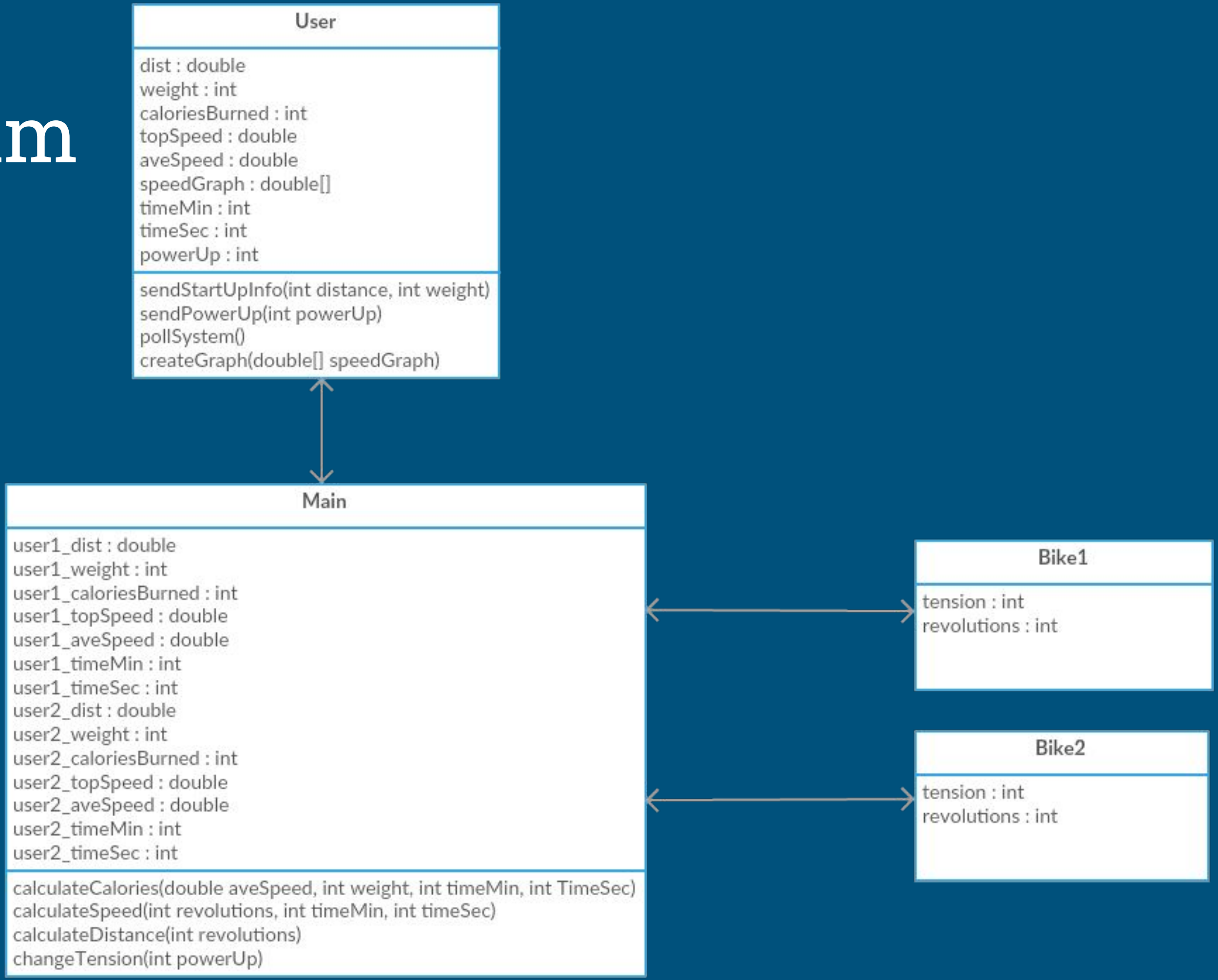
User Interaction with System

- Provide distance and weight for initialization of system
- Send power-up signal to change tension on other user’s bike

System Interaction with User

- Tension constantly changes throughout ride
  - Based off distance user has ridden
  - Gives feeling of riding on different terrain
- Constant updating of speed, distance, and calories burned to app
- Display of average speed through each “section” of ride at end in form of graph
- Cool down phase

Class Diagram



Administrative

Standards and Benefits of Our System

- IEEE 802.15.1
  - Bluetooth Standard
- ASTM F1250
  - Stationary Bike Safety Standard
- System is self reliant
  - Save on power bills
  - Reduce carbon footprint on our environment
- Promotes self health

Project Budget and Financing

Part	Item Count	Price/Unit	Total Cost
DC Motor	2	$65	$130
HM-10 BLE Module	2	$9.99	$19.98
Stationary Bike	2	$149.99	$299.98
12 V Battery	1	$42.95	$42.95
Servo Motor	2	$17.49	$34.98
Development Board	1	$24.37	$24.37
Magnetic Sensor	20	$0.50	$10
PCB	4	-	$0
Miscellaneous	-	-	$86.23
Total	**-**	**-**	**$648.49**

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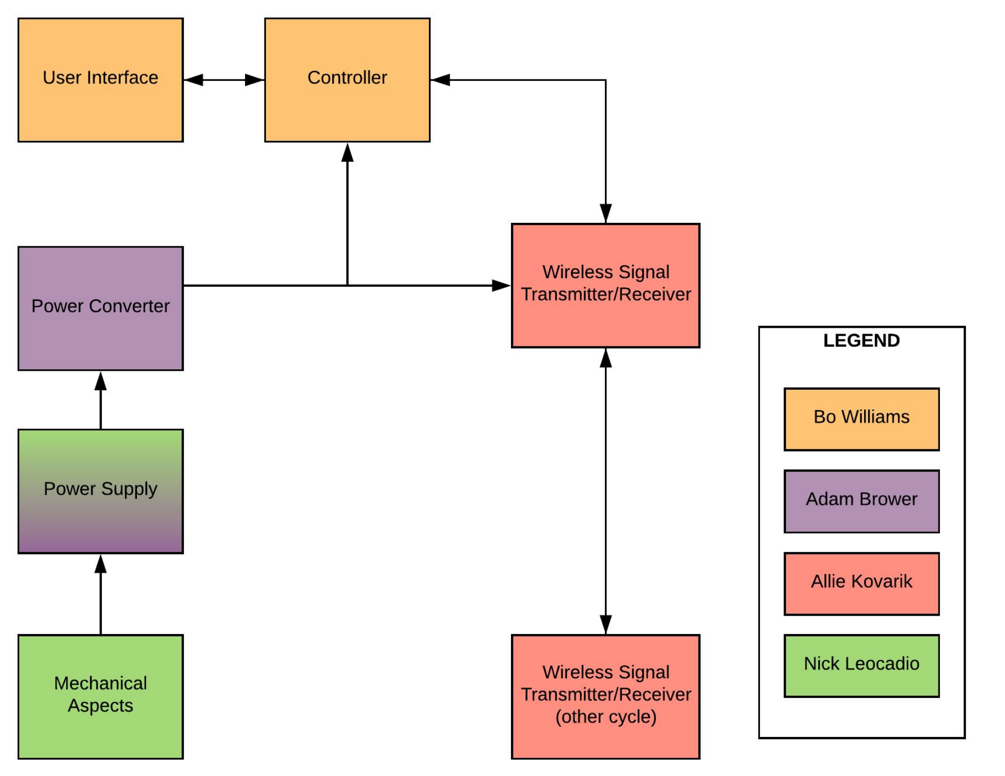
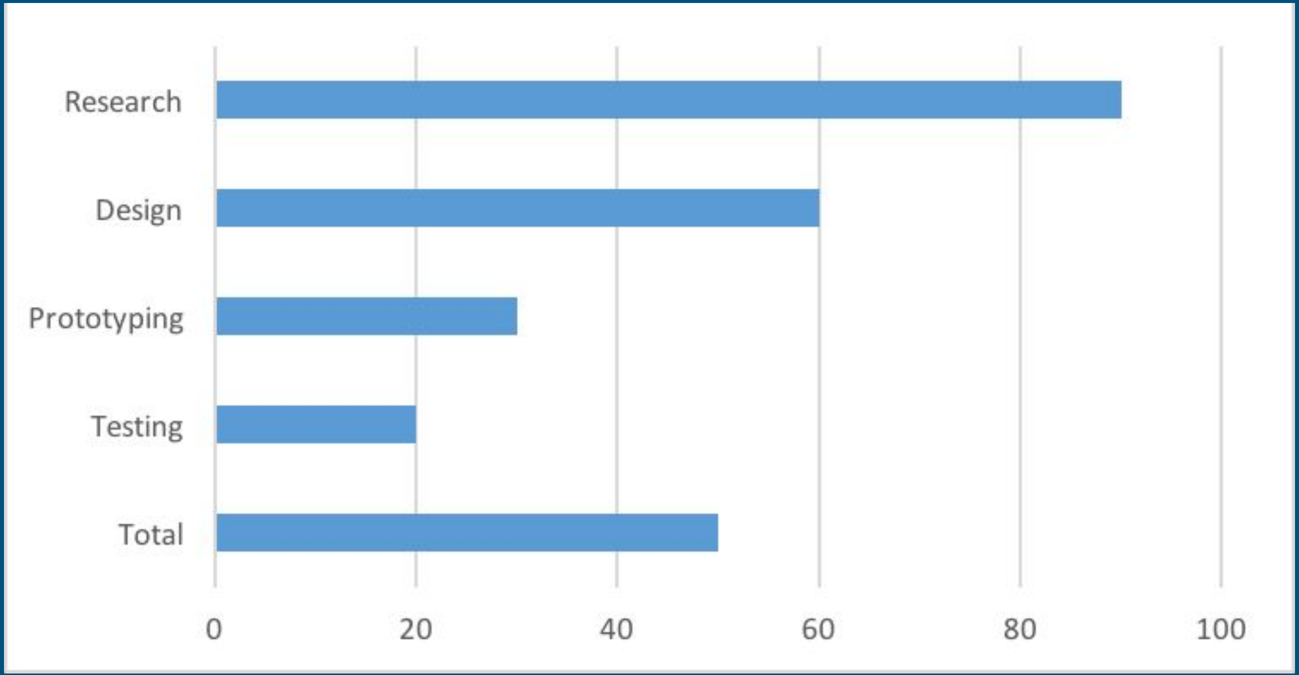
DC Motor	2	$65	$130
HM-10 BLE Module	2	$9.99	$19.98
Stationary Bike	2	$149.99	$299.98
12 V Battery	1	$42.95	$42.95
Servo Motor	2	$17.49	$34.98
Development Board	1	$24.37	$24.37
Magnetic Sensor	20	$0.50	$10
PCB	4	-	$0
Miscellaneous	-	-	$150
Electronics Housing	1		$50
Projected Total	**-**	**-**	**$762.26**

Project Workload Responsibilities



Progress Completion



Current Tasks

- Receive and test first PCB revisions
  - Power Regulation
  - Transceivers
- Finishing power system, prototyping tension system
- Testing power output and usage
- Bluetooth connection successful
  - Able to send information between each device

Project Difficulties

- First time developing a mobile app
- Handling excess power generated by system
- Staying within a reasonable budget
- Creating necessary mechanical components of system since none of us are ME
- Transceiver implementation

Immediate plans for completion

- Complete communication between transceivers
- Test power regulation PCB with the system
- Integrate all mechanical parts

Questions?