

Ballistic Chronograph

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ECE 480 – Design Team 3



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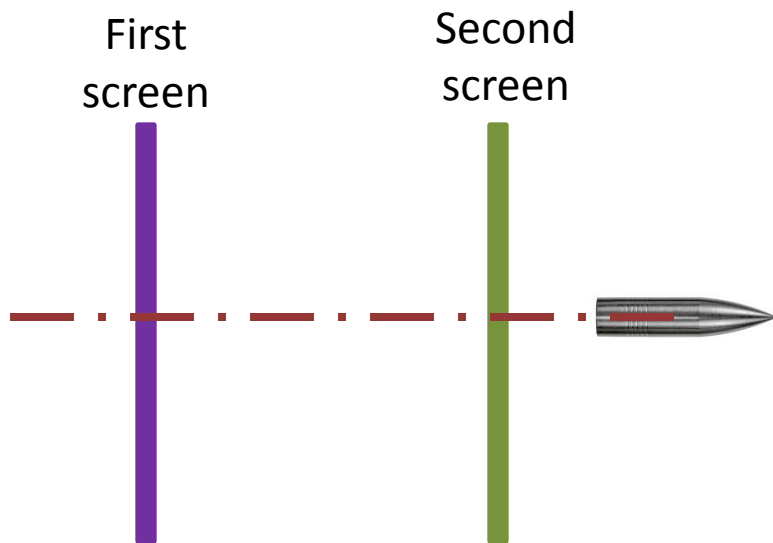
What is a Chronograph?



Caldwell Ballistic Precision Chronograph

- A chronograph measures projectile velocity
- The most common application is measuring the velocity of bullets on a shooting range.

Basic Chronograph Function



Detect Projectile at First Screen

Detect Projectile at Second Screen

Calculate Velocity

Presentation Outline

Commercial Options

Specifications

Concept Design

Development

Testing and Validation

Budget

Video Demonstration

Live Demonstration

Commercial Options



Caldwell Ballistic Precision Chronograph



CED M2 Chronograph Set



The Pact Professional XP Chronograph w/ IR Sensors

Primary Specifications

- *Projectile Velocity* → The chronograph should be able to detect and accurately report velocities up to 3500 feet per second
- *Wireless Reporting* → The user should be able to receive data from the chronograph without having to interact with it
- *Data Storage* → The user should be able to access and store the data acquired by the chronograph

Secondary Specifications

- *Environment Variables* → The chronograph should record environment variables relevant to projectile flight such as: temperature, humidity, pressure and altitude
- *Detection Scheme* → Explore the effectiveness of a laser-based detection system
- *Portability* → The chronograph should be portable and have a dedicated power supply

Concept Design

Screen #1
Laser powered
LED Bank

Screen #2
Laser powered
LED Bank

Peripheral
sensors



Microcontroller



LCD display

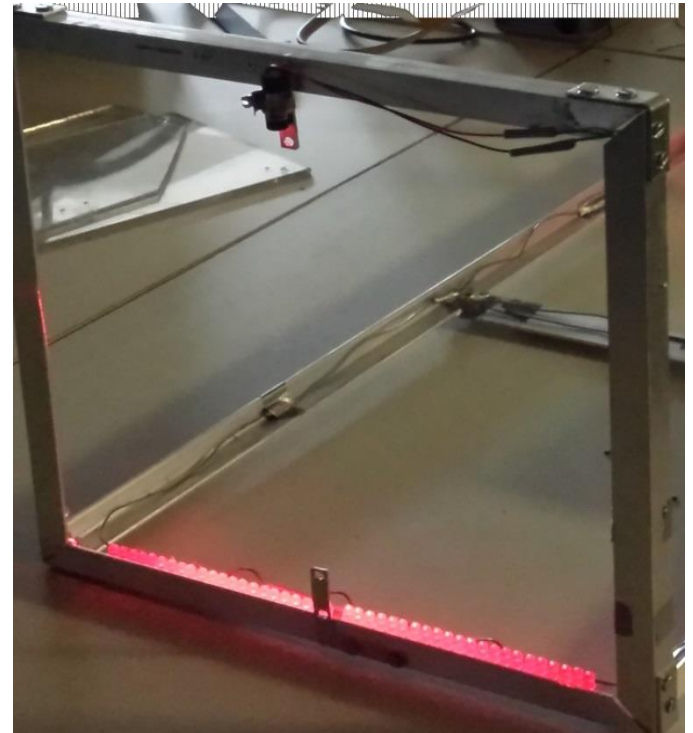
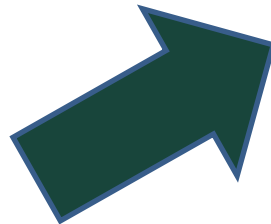
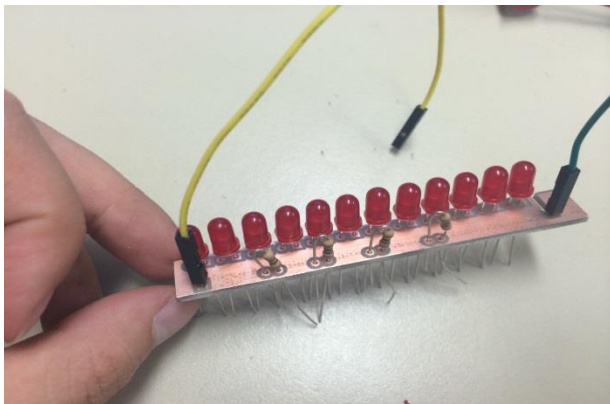
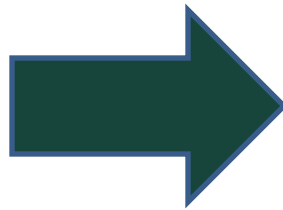
Bluetooth
Package



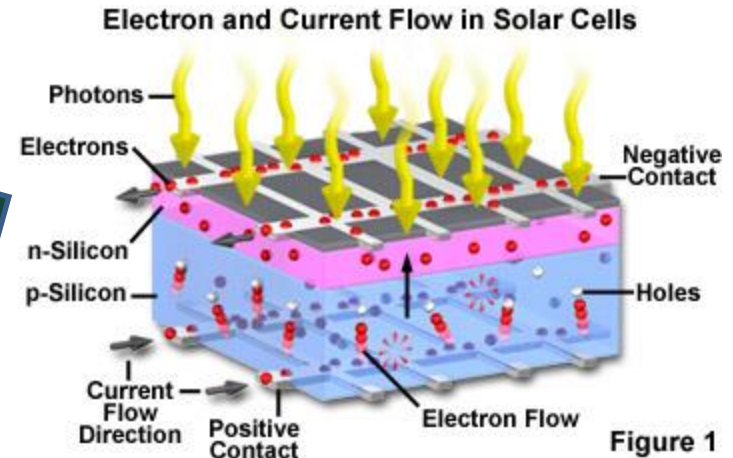
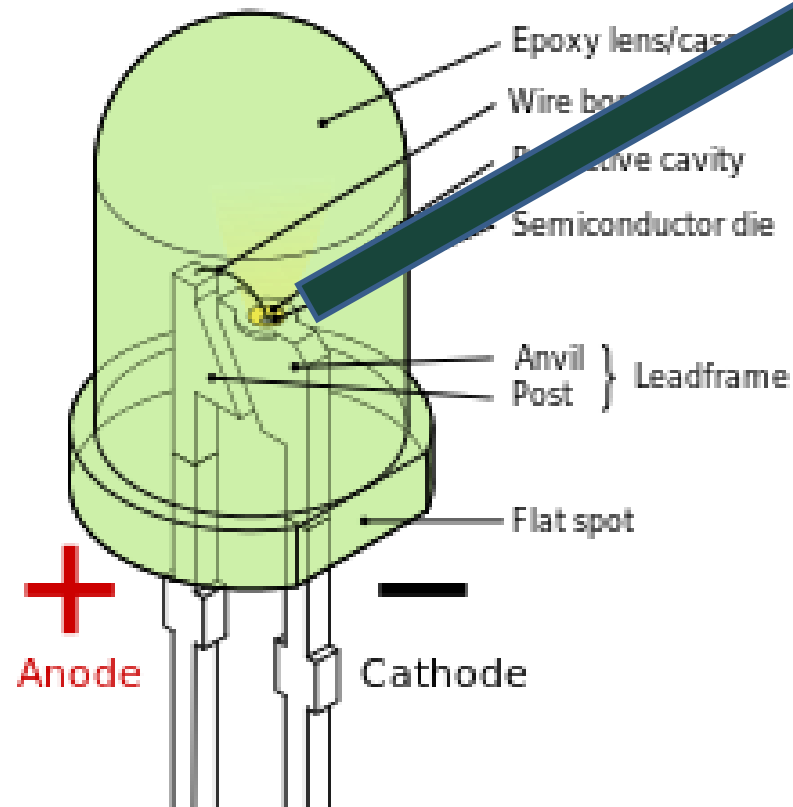
Android smart
phone

Development

Laser & LED Screens



Laser and LEDs Concept



Voltage produce

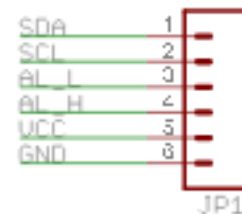
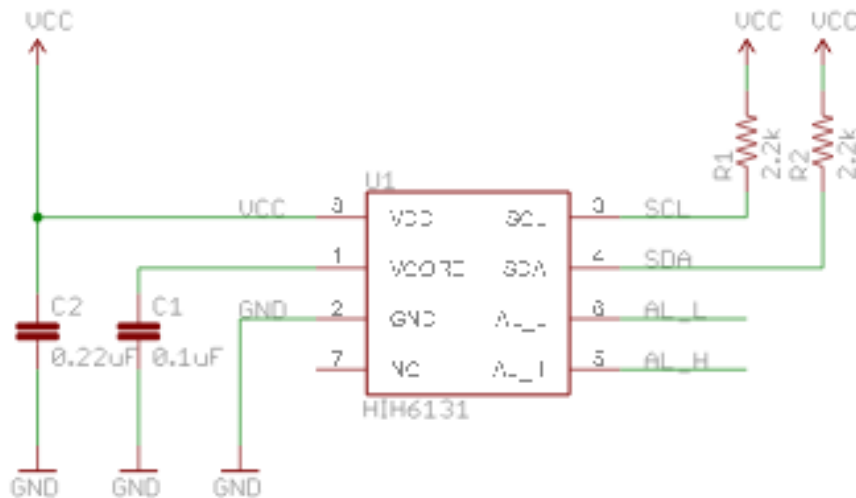
Temperature and Humidity Sensor



- HIH-6130
- Humidity range: 10-90% RH
- Temperature range: 5°C - 50°C
- Operating Voltage: 2.3 V - 5.5 V

Temperature and Humidity Sensor

- I2C bus with SCL and SDA hooked up to microcontroller
- SCL (clock) is high, start transmitting data via SDA pin
- Using Bluetooth temp/humidity outputs to smartphone



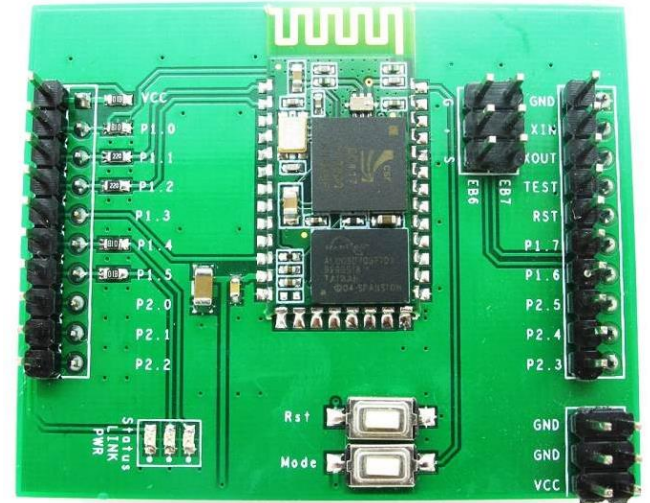
Altitude and Pressure Sensor

- Altitude/Pressure Sensor - MPL3115A2
- 1.6 V to 3.6 V Digital Interface Supply Voltage
- Pressure: 20-bit measurement (Pascals)
- Altitude: 20-bit measurement (meters)
- I2C bus to transfer data to microcontroller
- **Dead on Arrival**



Wireless Transmission

- Bluetooth sensor
- ITEAD BT Boosterpack
- Breakout board for the HC-05
- BlueTerm application
- Open source



Texas Instruments MSP430 LaunchPad



- Original choice for microcontroller
- Did not support our I/O requirements

Programming the Arduino

Initialize Screens

Detection Loop – 10 Sample Averaging

Detection Loop – 3 Sample Averaging

Fetch Sensor Data

Report Over Bluetooth

```
chronograph_code_v1 | Arduino 1.5.6-r2
File Edit Sketch Tools Help

chronograph_code_v1 $
// -- Detection code

//time variables
long time1 = 0;
long time2 = 0;

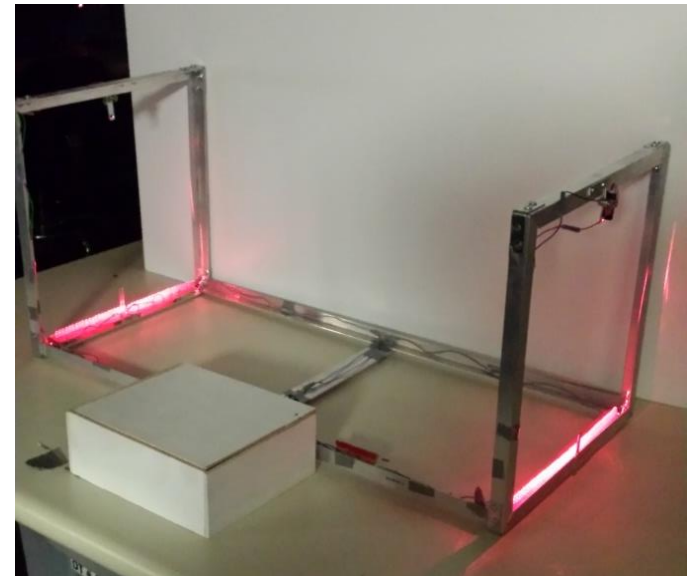
float threshold1 = (float)(led_screen1_min-led_ambient)*95.0/100.0;
float threshold2 = (float)(led_screen2_min-led_ambient)*95.0/100.0;

//screen1
while (1) {
  sensorValue = averagePin(A0, 10);
  if ( (sensorValue-led_ambient) <= threshold1 ) {
    time1 = micros();
    break;
  }
} //end while

//screen2
while (1) {
  sensorValue = averagePin(A1, 3);
  if ( (sensorValue-led_ambient) <= threshold2 ) {
    time2 = micros();
    break;
  }
} //end while
```

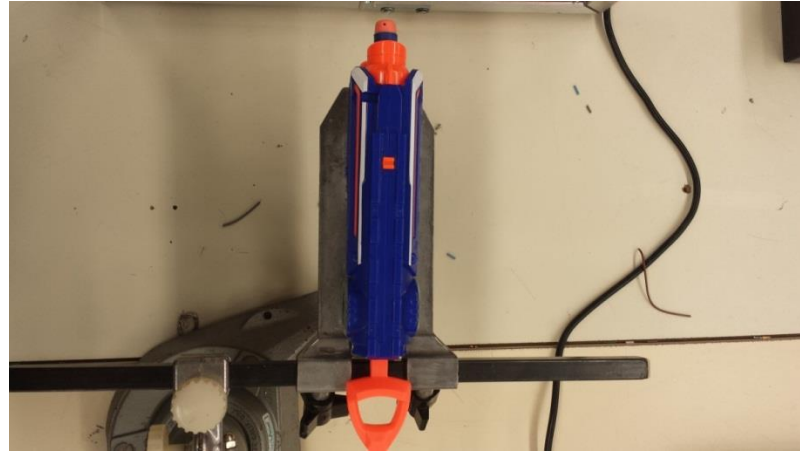
The Construction

- Aluminum frame with steel brackets
- Dimensions
 - 14 inch width x 14 inch length with 30 inch depth
- Wooden box that houses components
- Isolated ground (voltage changed)



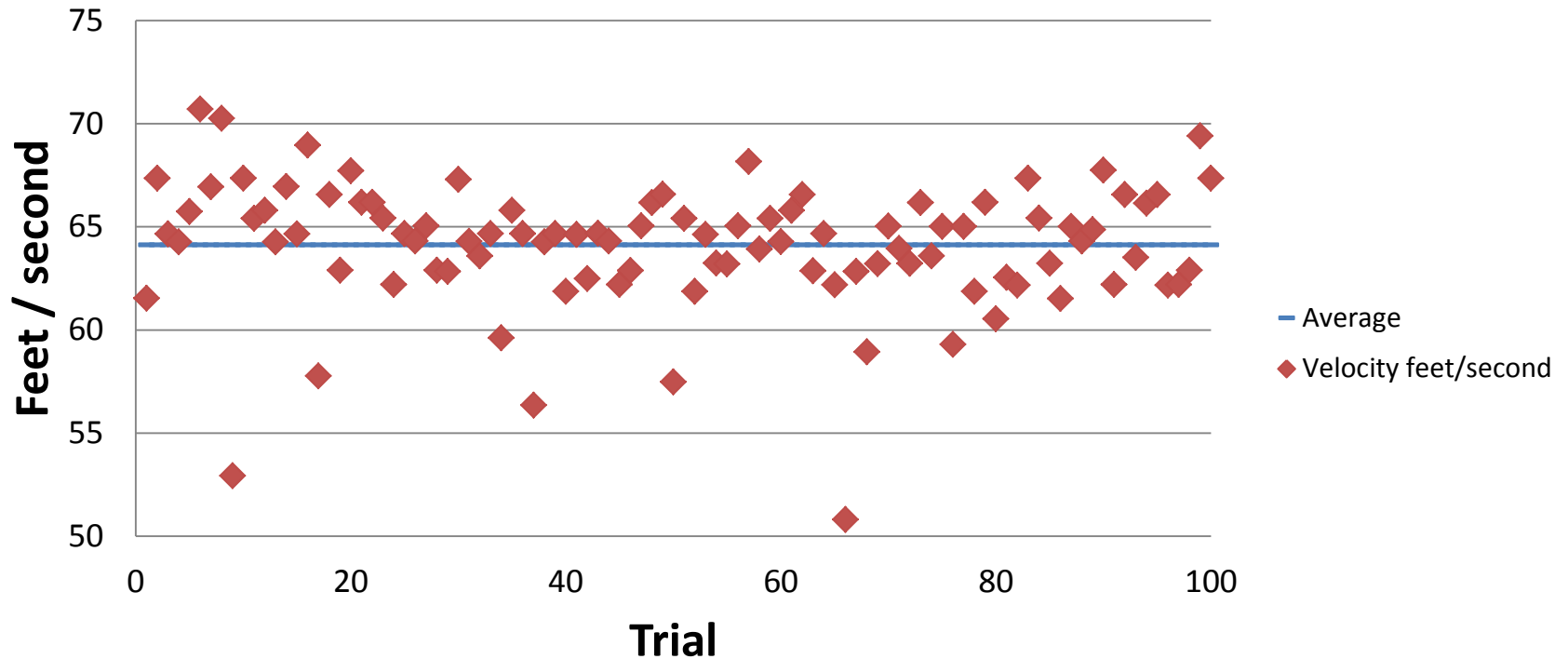
Testing and Validation

Data Collection



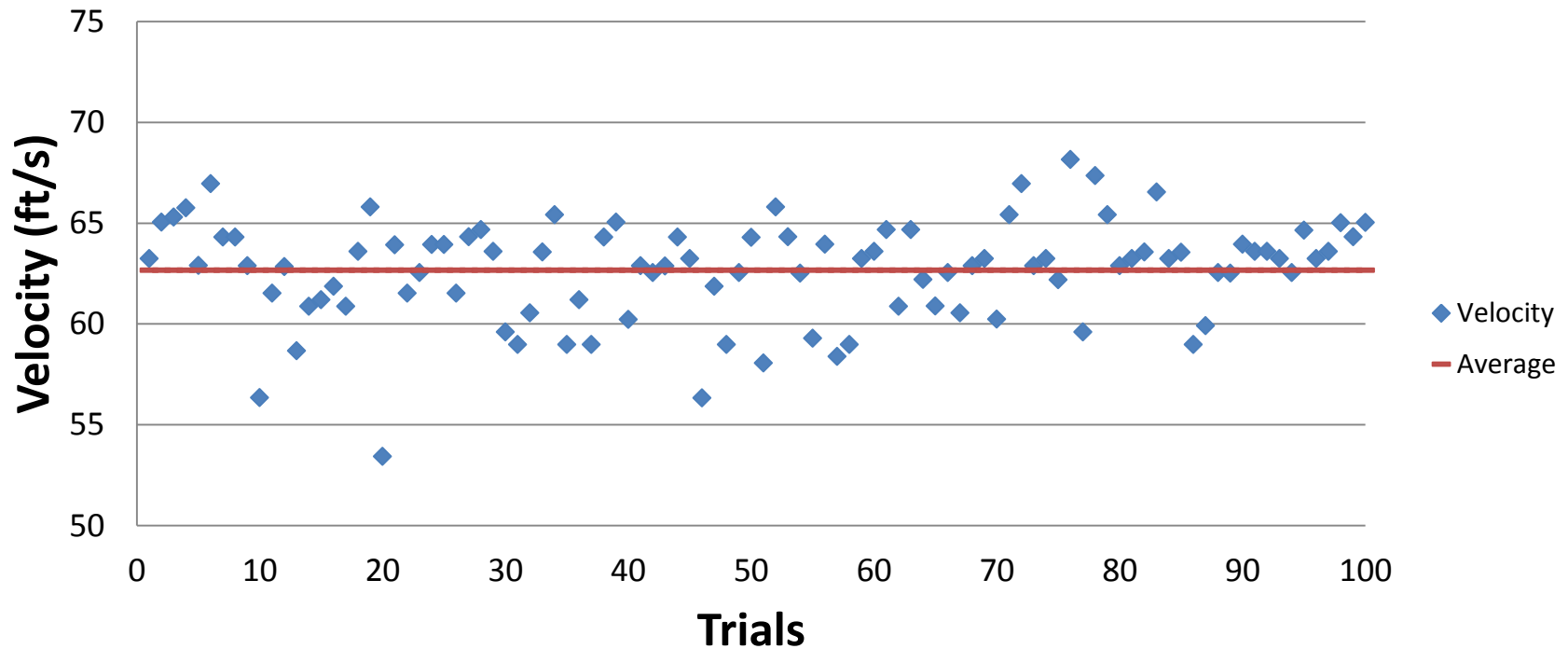
- Mounted Nerf gun in a fixed position
- 100 samples with lights on
- 100 samples with lights off

Chronograph Velocity - Indoor - Ambient Lighting



Average Velocity: 64.1 ft/s
Range: 50.8 ft/s – 70.7 ft/s

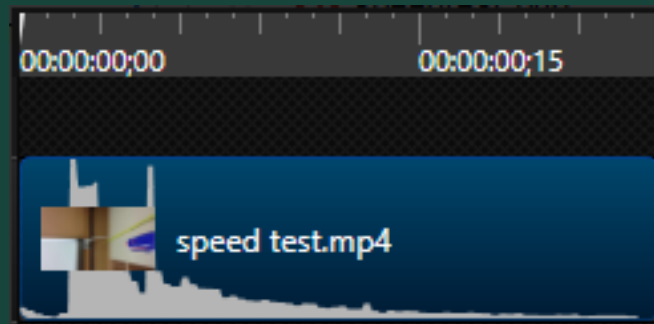
Chronograph Velocity - Indoor - No Ambient Lighting



Average Velocity: 62.6 ft/s
Range: 53.43 ft/s – 68.16 ft/s

Validating Results

- Precision
 - The chronograph behaved the same in both ambient light and darkness
- Accuracy
 - Caldwell Chronograph → 50 ft/s to 70 ft/s
 - Sound Test → 62.5 ft/s



Prototype Capability

Complete Specifications

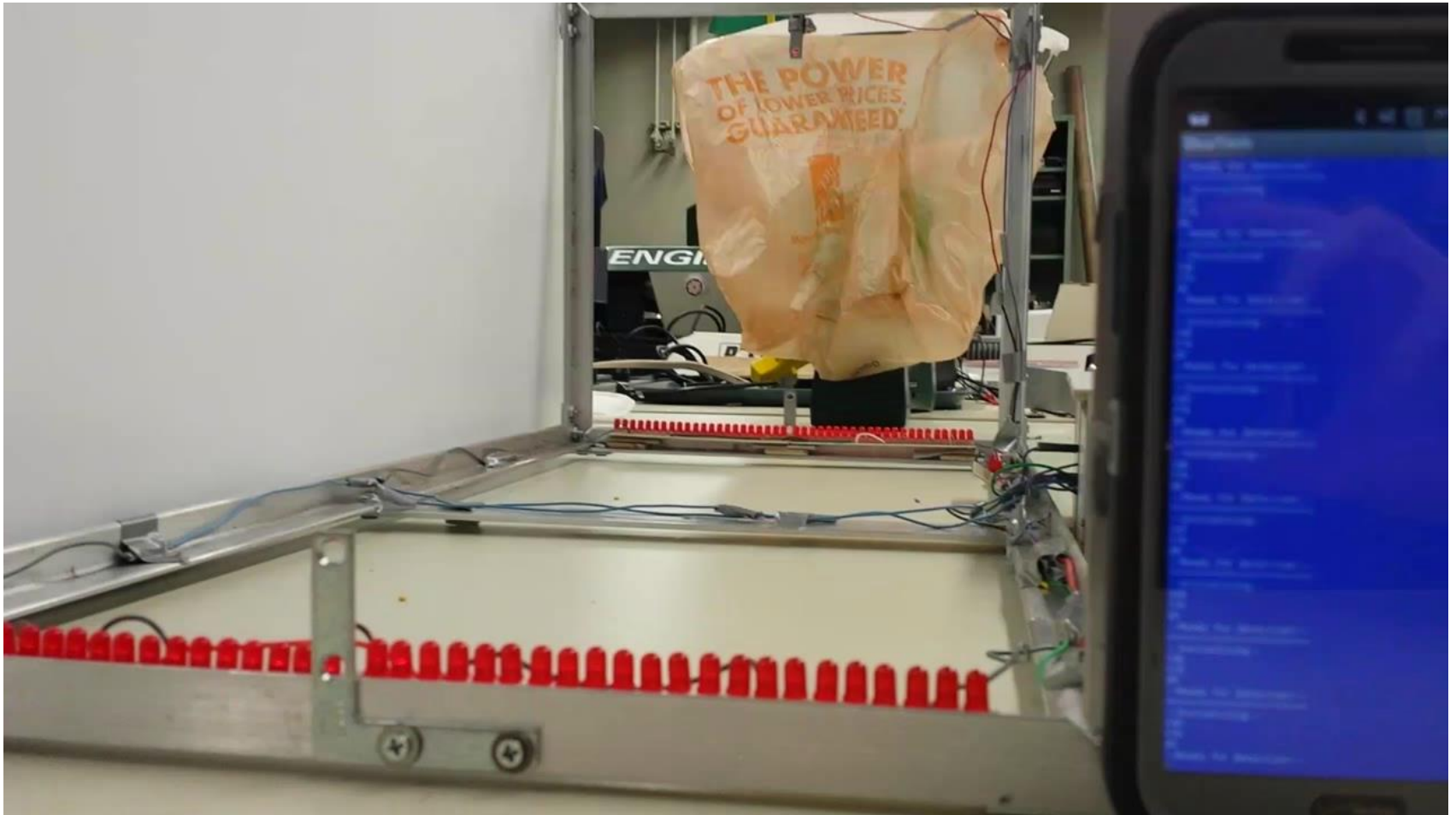
- Calculate Projectile Velocity up to 70 feet per second
- Temperature and Humidity
- Wireless Data Transmission

Unmet Specifications

- LCD screen
- Altitude and Pressure
- Data storage
- High Speed Velocity (untested)



Video Demonstration



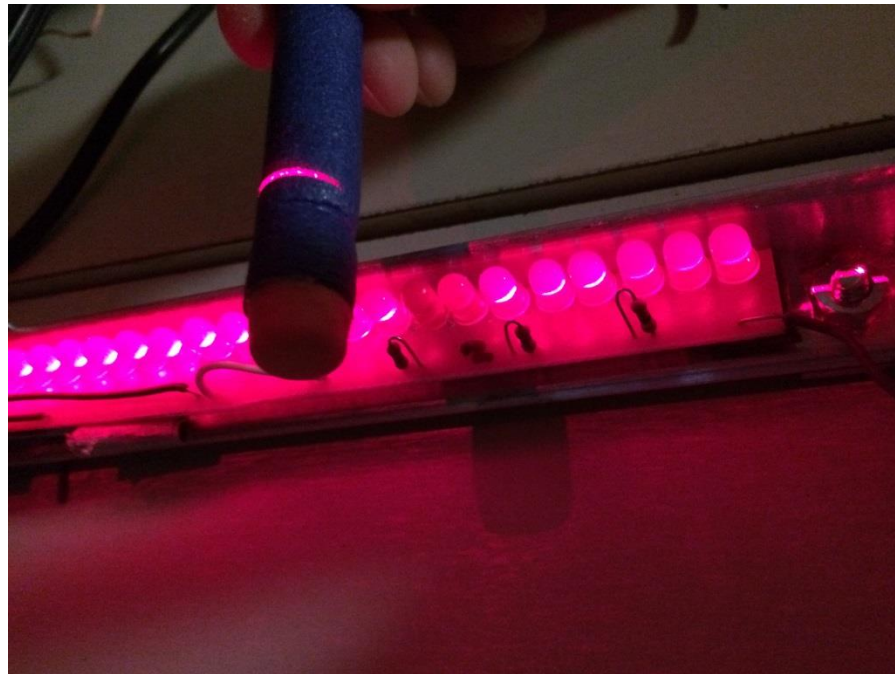
Design Issues and Future Suggestions

Detection Area



- Laser detection region is limited

Series LEDs

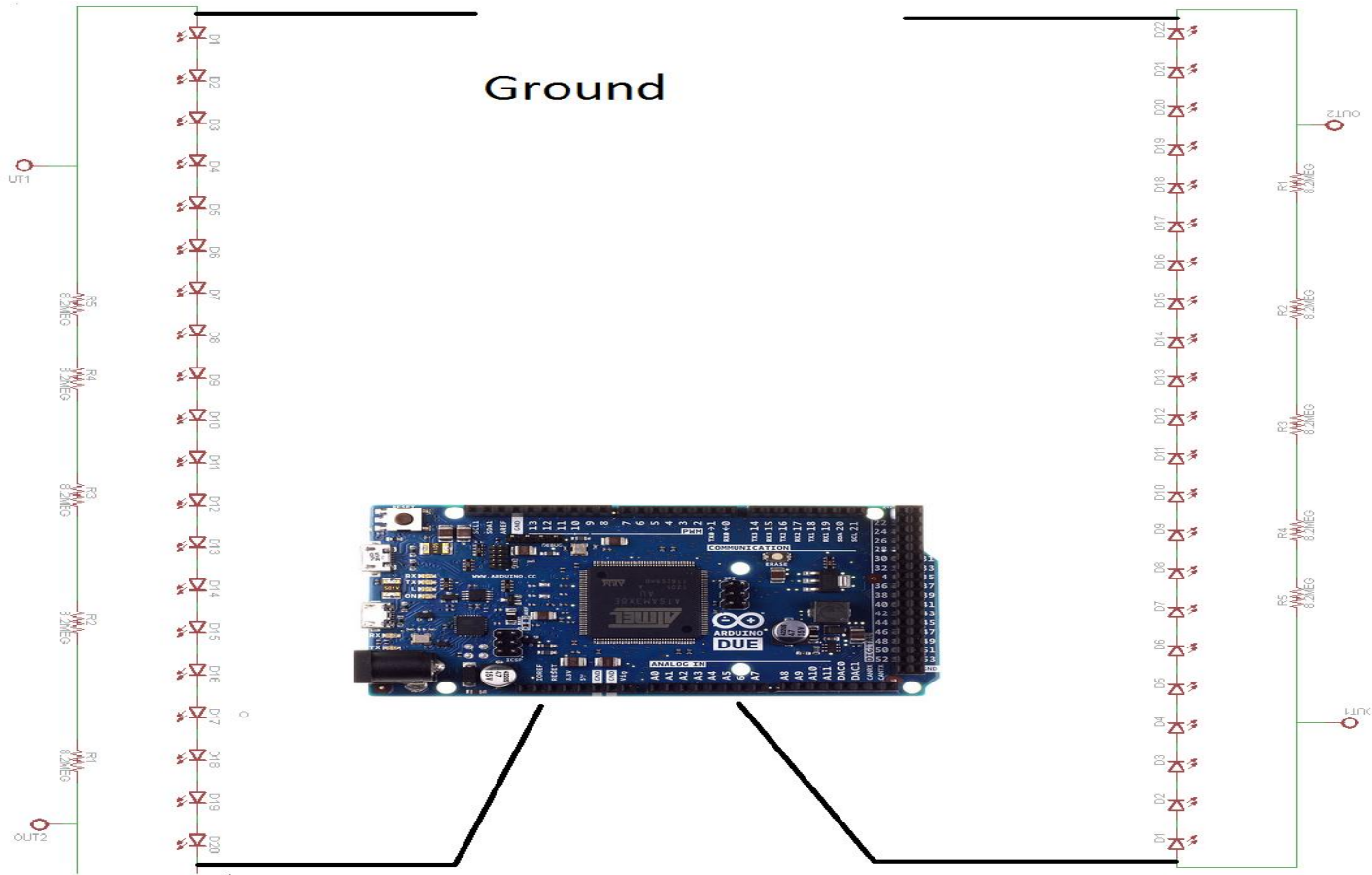


- LEDs are in series → They will charge neighbors if too few are blocked

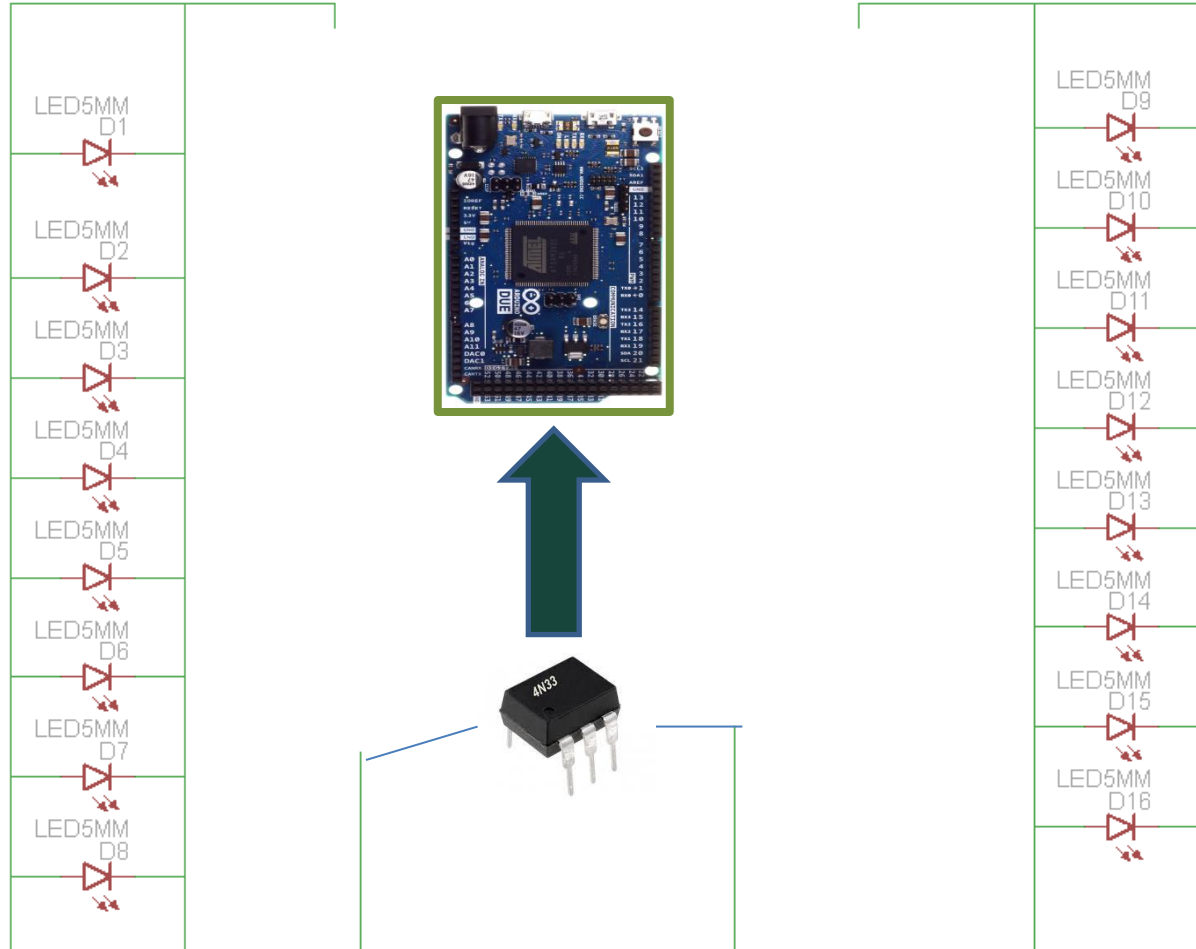
Future Design Improvements

- Increase the area of detection by using LED banks and using more line lasers
- Shield the LED banks from the sides(preventing the ambient light effect)
- LCD (better power supply)
- More sensors (altitude, air pressure, wind speed)
- More powerful microcontroller
- Parallel circuit design
- Opto-isolator

Current Schematic – Series LEDs



Improved Schematic design – Parallel LEDs



Budget

	Final Budget Per Unit		
	Part	Qty	Cost
	Line Laser Diode - 5mW 650nm Red	2	\$17.90
	Humidity and Temperature Sensor - HIH6130 Breakout	1	\$23.96
	Standard LEDs - Through Hole RED DIFFUSED	200	\$15.80
	Development Boards & Kits - ARM ARDUINO DUE	1	\$49.99
	2.2\" 18-bit color TFT LCD display with microSD card breakout - ILI9340	1	\$24.95
	ITEAD Bluetooth BoosterPack	1	\$14.00
Total:			\$146.60

Live Demonstration

Questions?