Laser Harp-CDR

Group 10
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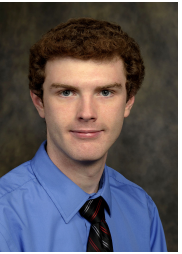
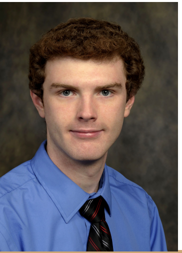


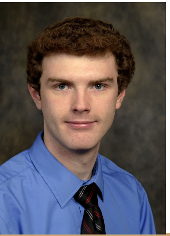
Motivation

- Our intent is to create an instrument that could use lasers as a string to be plucked to make sound
- Plenty of other instruments use electronics to create sound
- MIDI is a useful interface to pair with this instrument for electronic keying



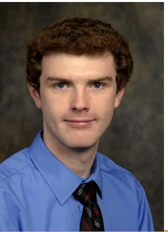
Goals and Objectives

- Design and construct a laser harp with built-in expression for performance
- Interface with external gear via Musical Instrument Digital Interface (MIDI)
- Utilize multiple types of sensors for note detection and distance sensing
- Implement a scale mode and transpose functions to maximize flexibility and ease-of-use

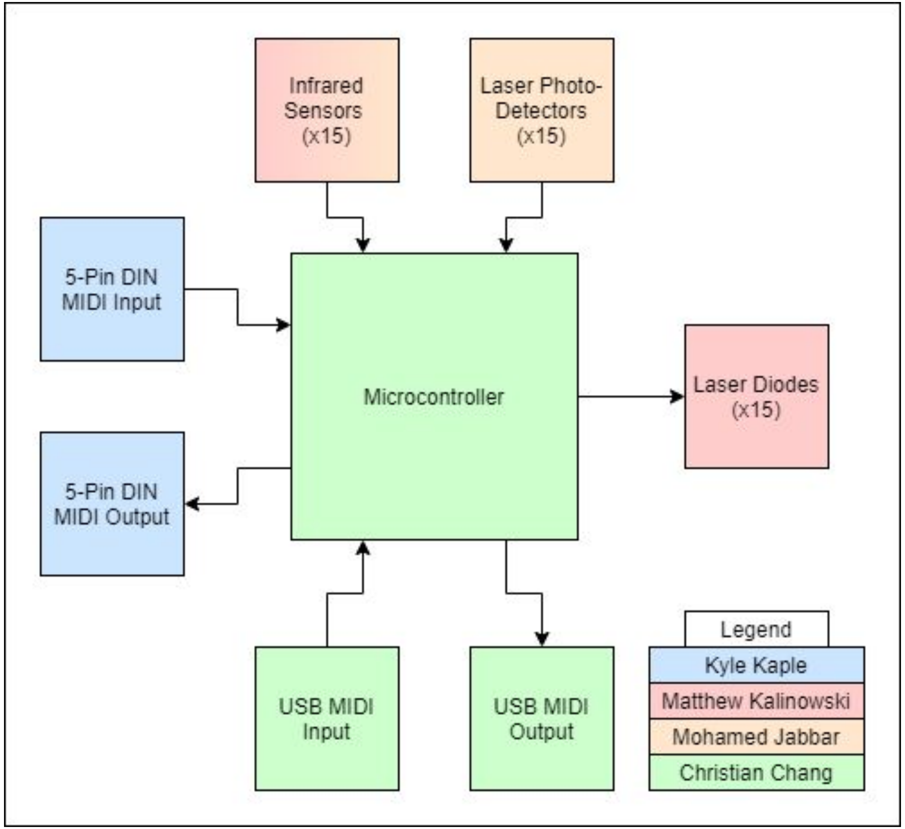


Specifications & Requirements

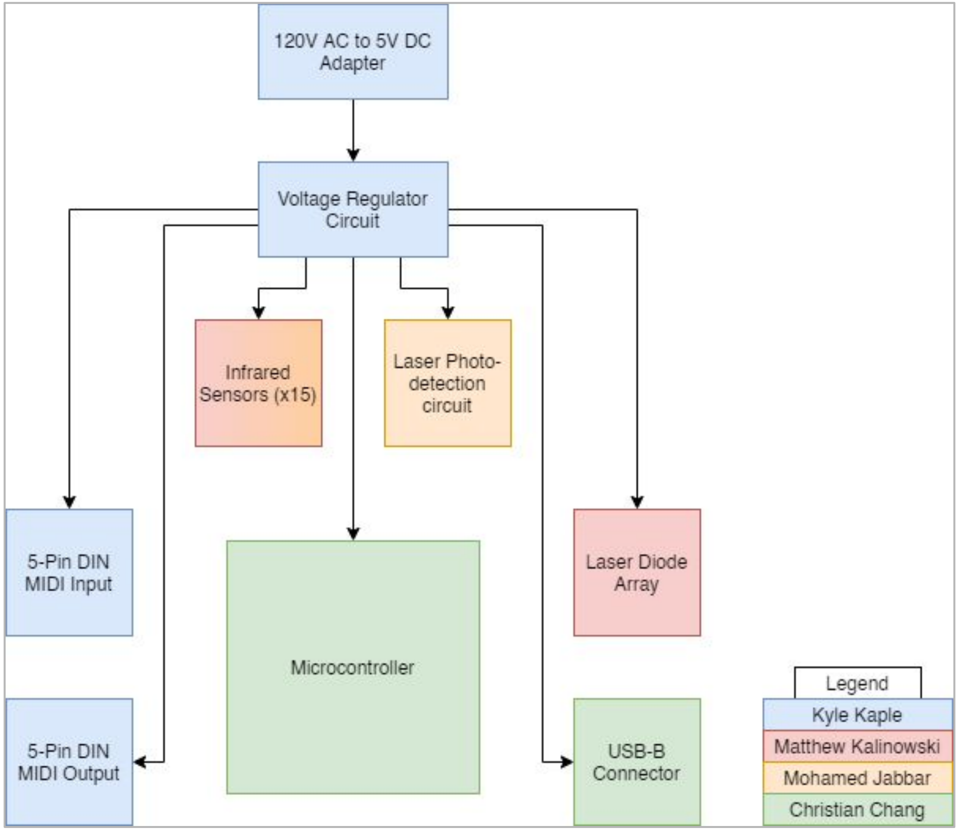
- The harp will have 15 independent laser “strings” with full polyphony
- The distance sensors will need to detect a range of 1-11 inches
- The harp will transmit MIDI data via UART at a baud rate of 31.250 kbps
    - 5-pin DIN and USB
- By MIDI, the harp will transmit both note on/off messages and Continuous Control (CC) messages for distance detection.
- Microcontroller will need at least 15 analog inputs for the analog distance sensor inputs. And at least 15 GPIO pins for the note on/note off detection



Electronics/Data Transfer Block Diagram



Power Block Diagram

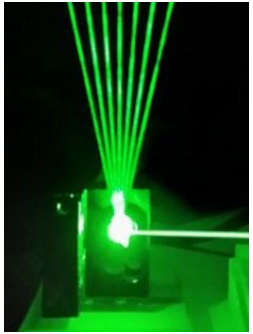


Design Constraints

- Size
    - Should be small enough to be considered portable.
    - Will need to big large enough to hold an entire scale without being too heavy from materials.
- Safety
    - There are laser diodes on this project and it is important to take precautions when designing the frame so that the user and any person nearby does not receive a beam to their eyes.
    - The beams will need to point downward and be covered by building materials to avoid unwanted eye contact.
- Economic
    - No sponsors so we are trying to make this a budget friendly project.

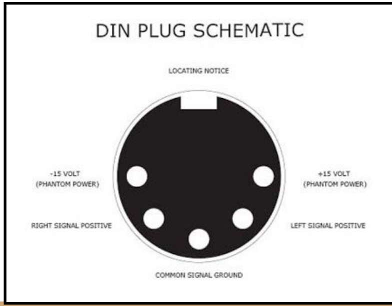
Framed vs Frameless

- Framed laser harps mount the lasers to a frame, and detect the beam from the opposite side
- Framed laser harps are safer
  - Less chance of accidental exposure to laser beams
- Framed laser harps are more sensible for home use
  - No infinite lasers pointing into the sky
- Frameless laser harps use a mirror attached to a stepping motor
  - Motion is imperceptible to human eye
- Frameless laser harps have limited number of strings
- Framed laser harp is the best option for our case



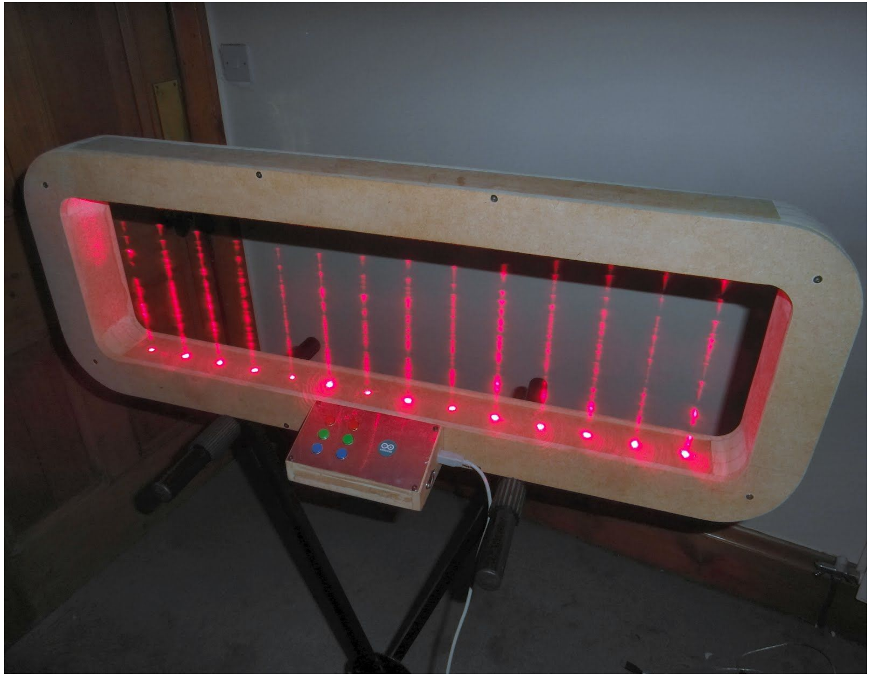
Musical Instrument Digital Interface (MIDI)

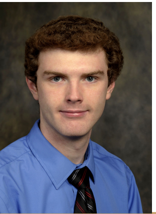
- Serial communication protocol standard in almost all synthesizers and samplers released since the 1980's
- Utilizes UART with a baud rate of 31.25 kbps
- Transfers messages for note on/note off and continuous control (CC) for parameter modulation
  - When laser is blocked, send corresponding "note on"
  - When laser is released, send corresponding "note off"
  - While laser is being blocked, send continuous "pressure" modulation via MIDI CC to modulate any modulatable parameter
- Will send and receive by both 5-pin DIN and USB



Light Source

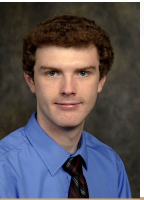
- Laser diodes used to create strings of harp
- Using low powered and low cost diodes to keep budget down
- Having small diodes allows easy mounting
- Can be ran in parallel sharing a single power supply and ground node





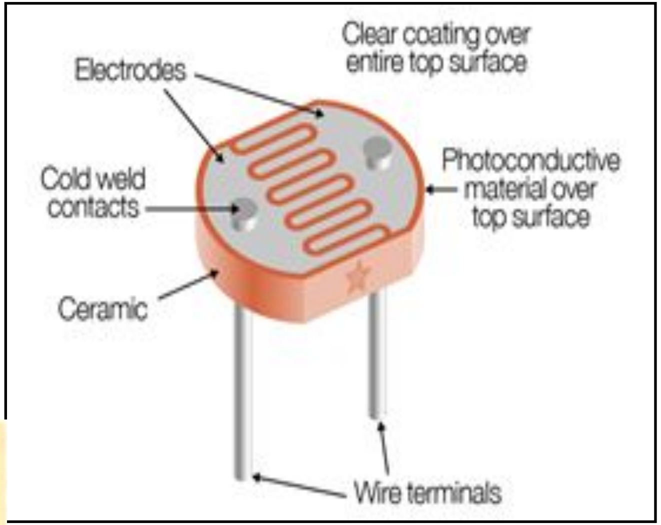
Light Source

Dimension	6.5 x 18mm
Cost	$5.99 10 pack
Wavelength	650nm
Voltage	5VDC
Operating current	>20mA
Manufacturer	HiLetgo



Light Detection

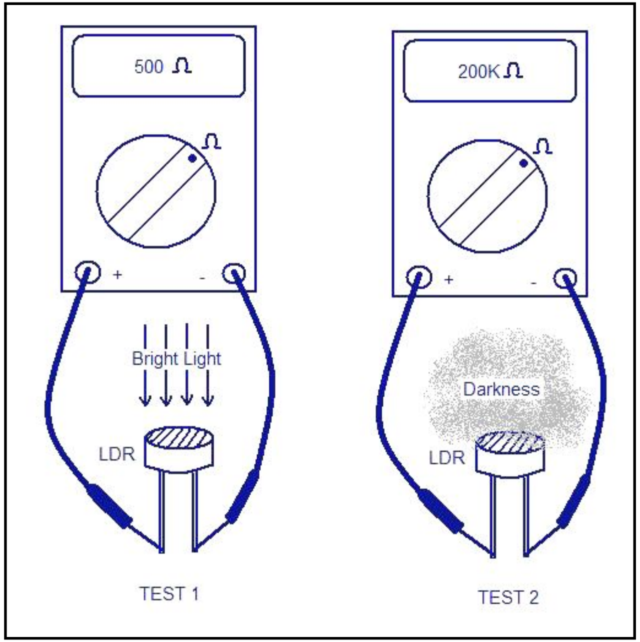
- Light-Dependent Resistor
  - Easy to install
  - Budget friendly
  - Simple integration into system



Dimension	Round 5mm
Cost	<$1.00
Resistance Range	200kΩ- 10kΩ
Sensitivity Range	400nm-600nm
Manufacturer	EBOOT

Light detection

- Is used to detect when the light is blocked
- The lasers will provide a low resistance
- The blocking will cause a high resistance
- Using this we can determine when and which laser diode is blocked allowing notes to be played

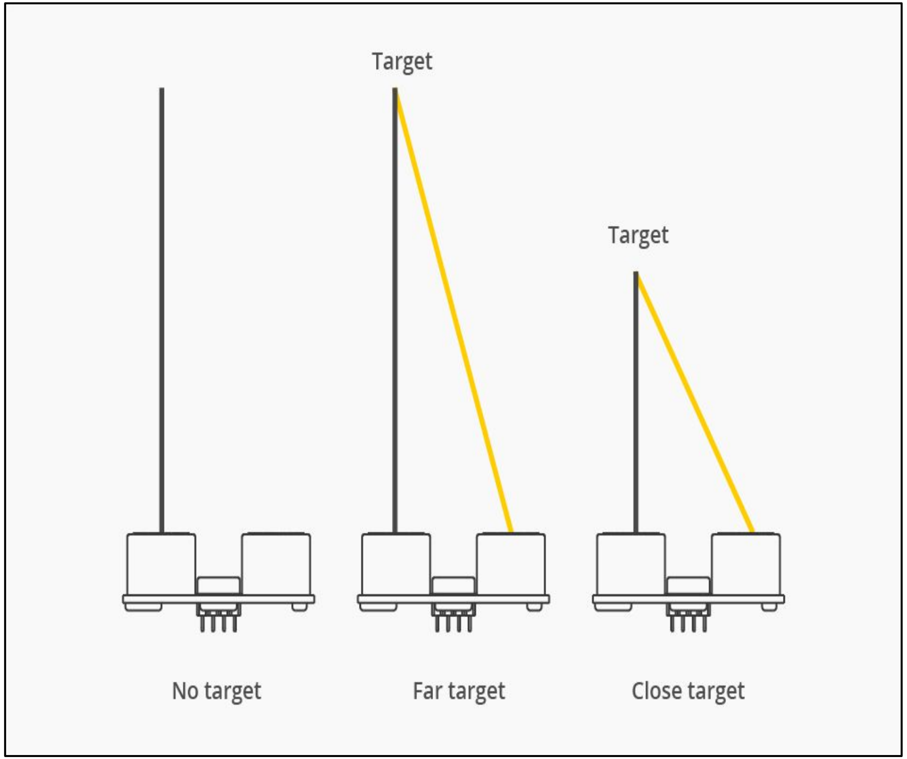


Distance Detection

Dimension	0.25 x 0.25 x 0.23 inches
Cost	$10.99 each
voltage	3.3-5VDC
Detection distance	2-30cm
Manufacturer	sharp-AIMELIAE

Distance Detection

- Uses triangulation to determine distance
- Can be used in light or dark settings
- Other alternative such as ultrasonic have low resolution and refresh rates or is too costly to use for this budget

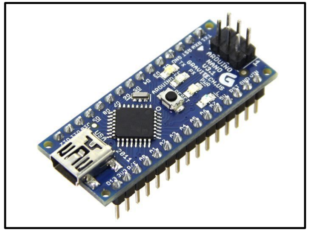


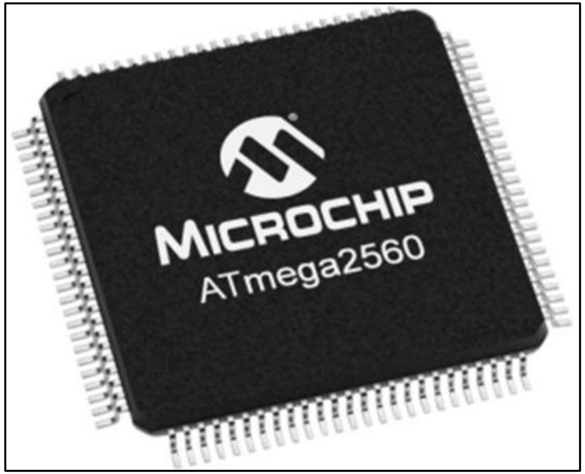
OLED Display

- Need a way to communicate with the harp to change scales
- Better viewing angles and contrast compared to LCD
- Uses the same voltage as the equipment 3.3-5VDC
- Design is important and and LCD looks old school
- Using Frieda OLED at 0.96 inch

Microcontroller Selection

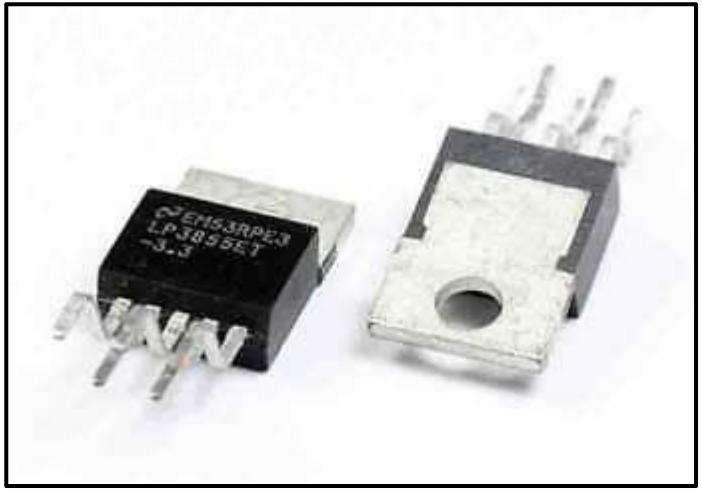
- Arduino Nano (based around Atmel ATmega328)
  - 14 GPIO pins
  - 6 analog input pins
  - Prototyping and small-scale testing only
- Atmel ATmega2560
  - 86 GPIO pins
  - 16-channel 10-bit A/D converter
  - 1.8V - 5.5V operating voltage
  - 4 UART channels





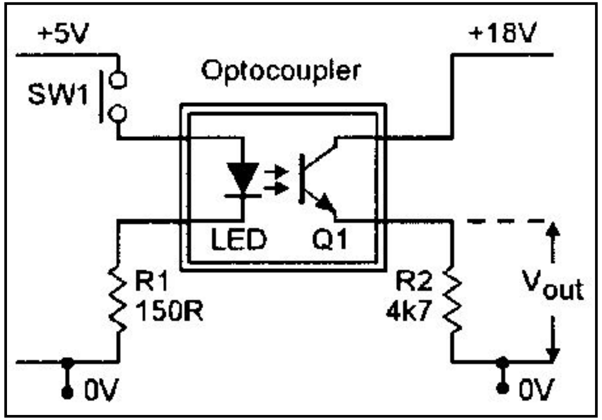
Voltage Regulator

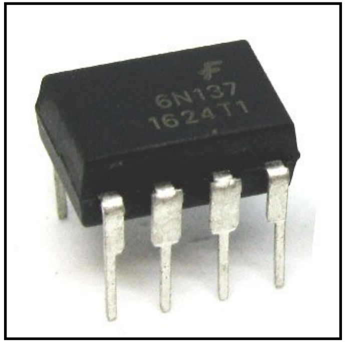
- To ensure consistent voltage input supply to the microcontroller, we need to add a simple voltage regulator circuit at the power supply input of the MCU
- Texas Instruments LP3855 linear voltage regulator
  - Low noise (improve infrared sensor accuracy)
  - TO-220 format with standard heatsink



Optocoupler

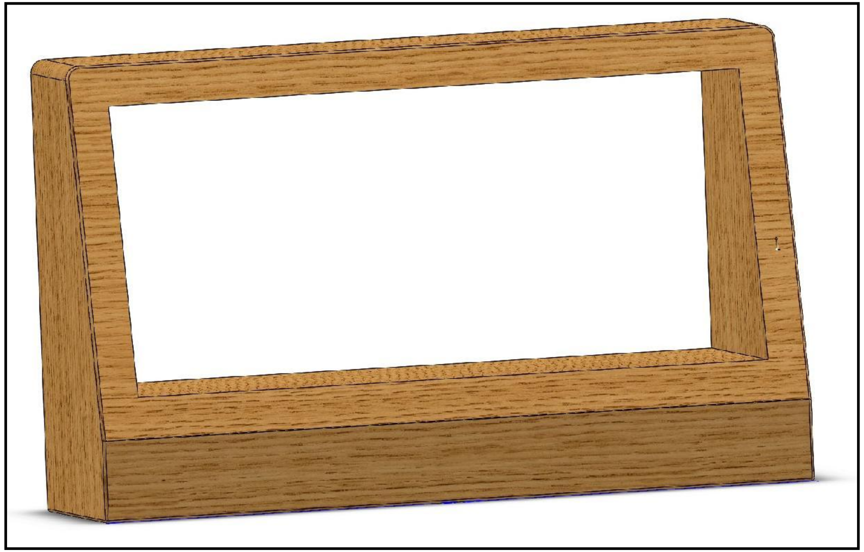
- Optical device that transfers electrical current between wires without direct connection
  - Similar to a transformer
- Included to isolate MIDI connection between external devices to remove any ground loop feedback hum
- Inexpensive and small
- 6N137 selected due to high switching speed

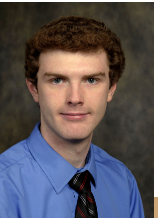




Frame Design

- We chose to make a framed laser harp for both safety purposes and to allow for a small device with equal “string” spacing
- Approximate dimensions of 27”x16.5”x7.5”
- Will be constructed with wood and aluminum rod
    - Cost-Effective
    - Can be built without metal machining tools or plastic molds



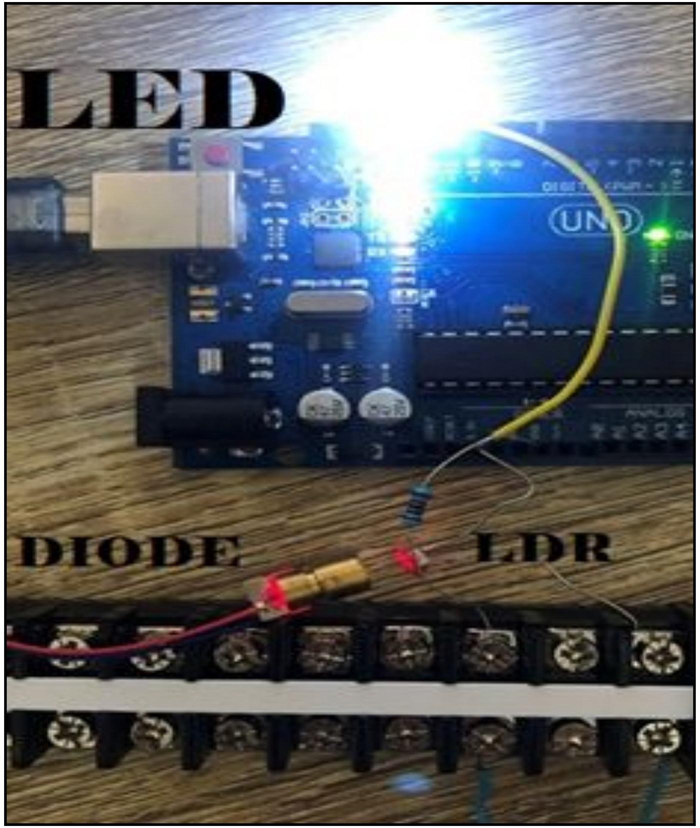


Laser Diode Mount

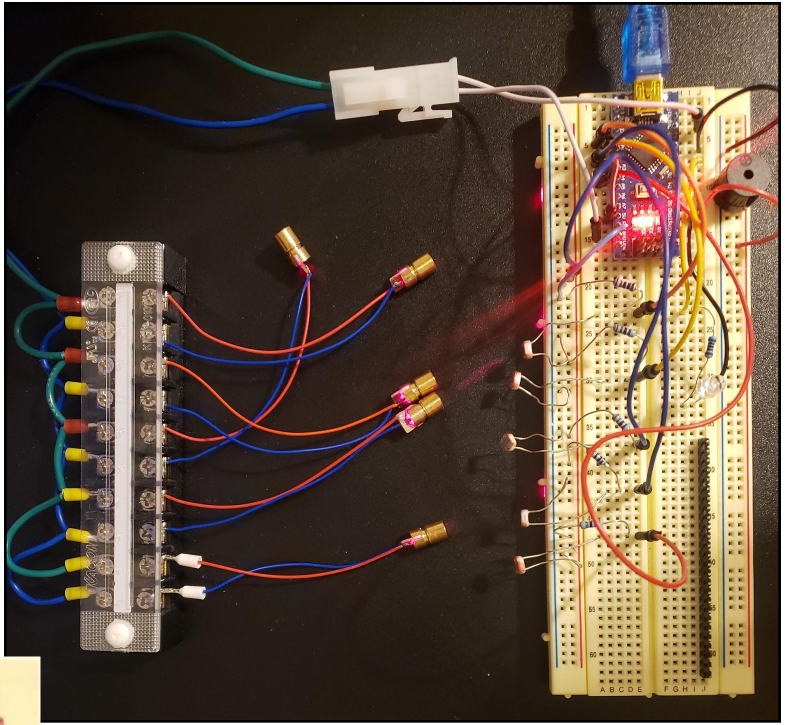
- Will pre drill holes to the dimensions of the laser diode
- Have threaded holes on the sides to hold the diodes with set screws
- The diodes should be easily mountable and able to align using set screws
- Having them held by screws rather than glue makes it easier to change broken parts

Prototyping- Single string

- Using a single laser diode and a single LDR hooked up to a microcontroller and breadboard for initial testing
- The goal was to ensure that a musical note could be played by interfering the path of the beam
- Arduino has a way to define musical notes based on code



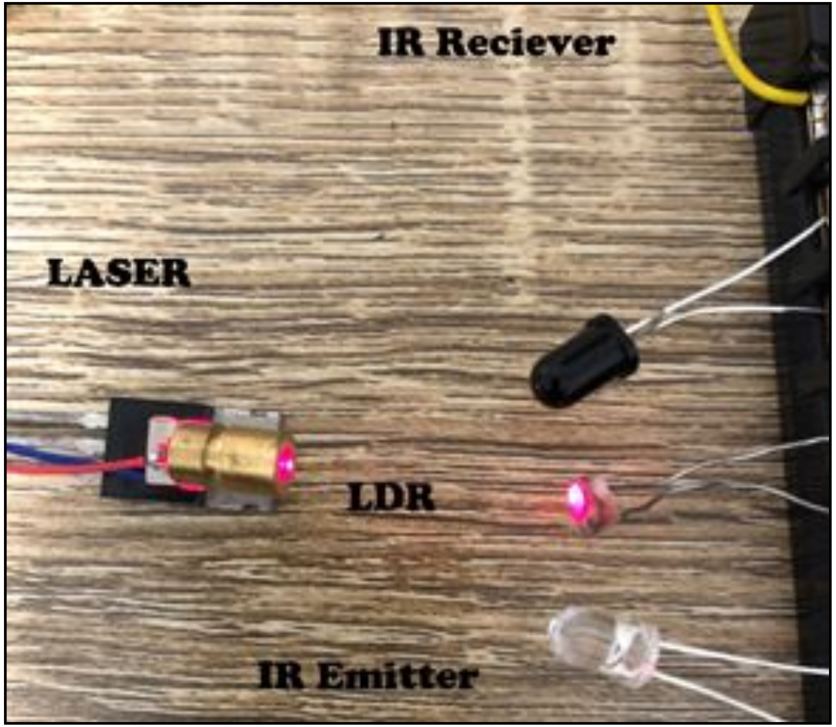
Prototyping multi string



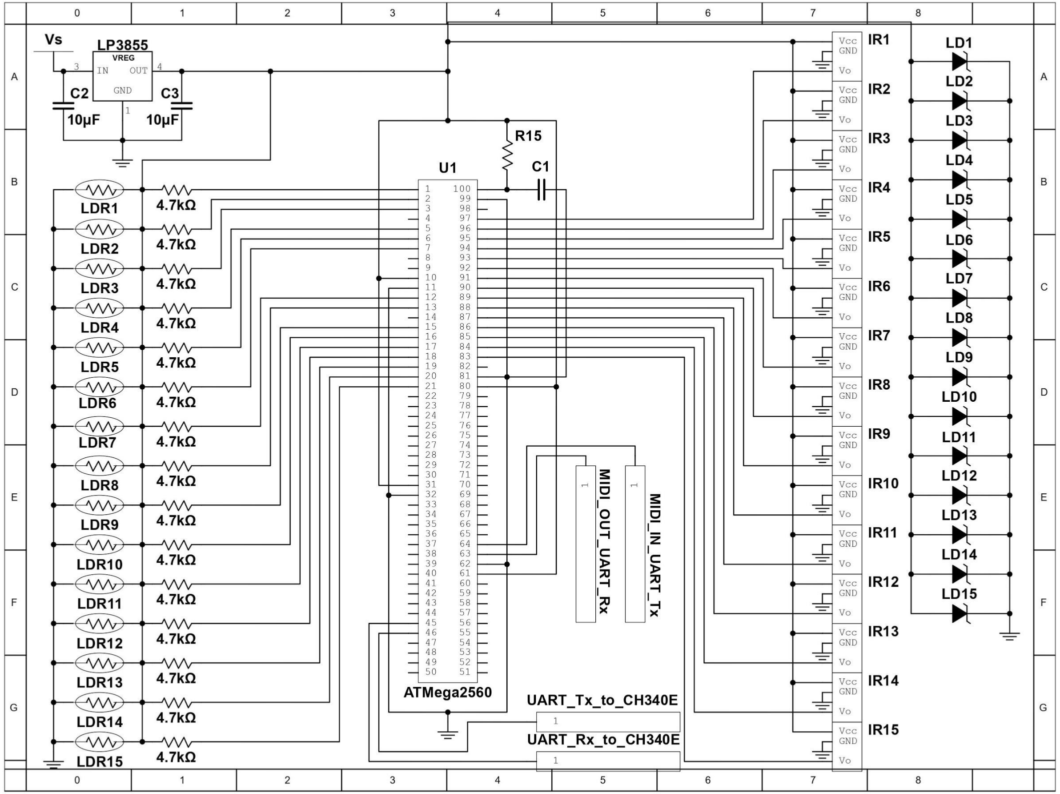
- Adding additional laser diodes and LDRs to the breadboard maxing pin outputs
- The test was to determine the amount of reasonable spacing for the system as a whole
- With twelve diodes we will need to create a rather long harp frame to account for the addition of distance detectors

Prototyping IR integration

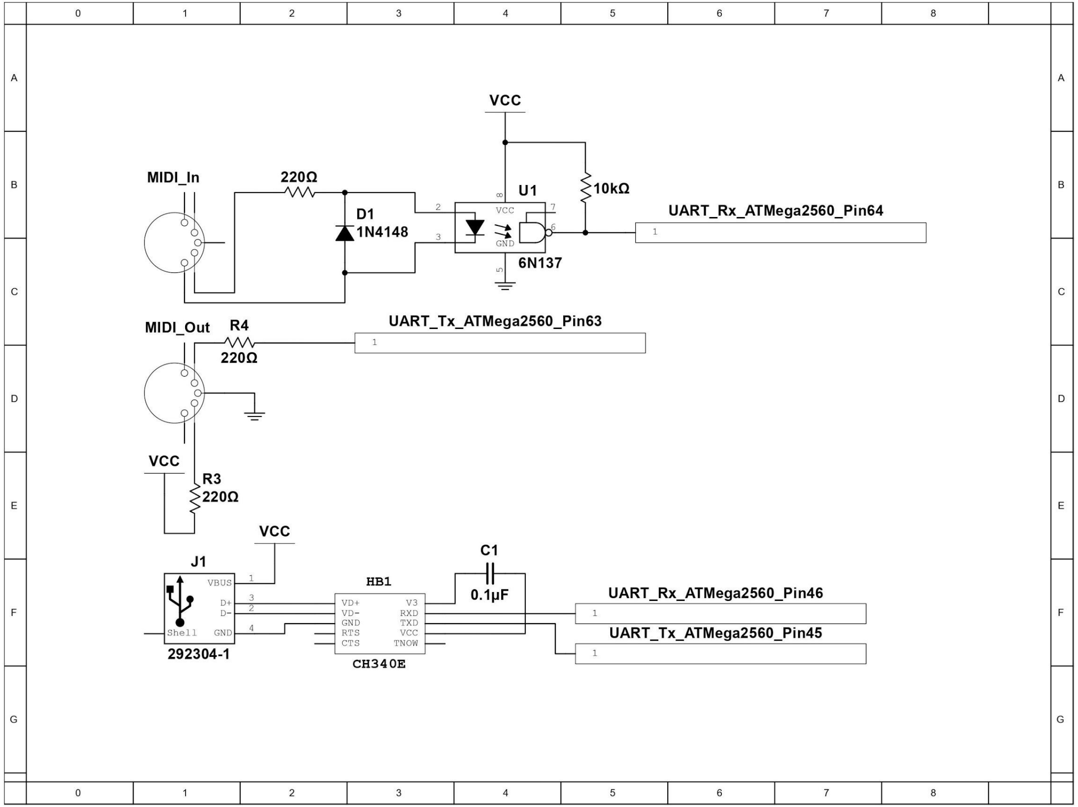
- Using basic IR LED and receiver to test distance integration
- Will be using a premade configuration rather than individual components from Sharp
- Uses triangulation to calculate the distance of the interfering object



Microcontroller and Sensing Subsystem Schematic



MIDI and USB Connector Schematic

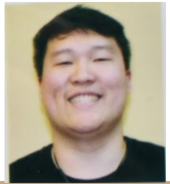


Coding

- Arduino Assets

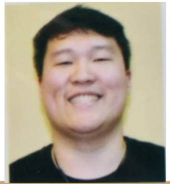
- C++
    - setup: Use it to initialize variables, pin modes, start using libraries, etc. which can execute the initial conditions of the code once
    - loop: which will work with setup to make it run infinite times and is the main function
    - input: : similar to an “if” loop, to take in our detectors
    - manipulate data: used to change the input

- Pins
    - 30 input pins
        - 15 digital photodetectors
        - 15 analog IR sensors



Lithium-Ion Battery

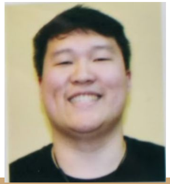
- Has the best energy storage 3000mAh
- Longest Lasting
- Fast Charging
- Low Self Discharge
- Durable



https://www.amazon.com/TalentCell-Rechargeable-3000mAh-Lithium-External/dp/B01M7Z9Z1N/ref=sr_1_4?dchild=1&keywords=lithium+ion+battery+pack+usb+5V&qid=1612287319&sr=8-4

Bill of Materials

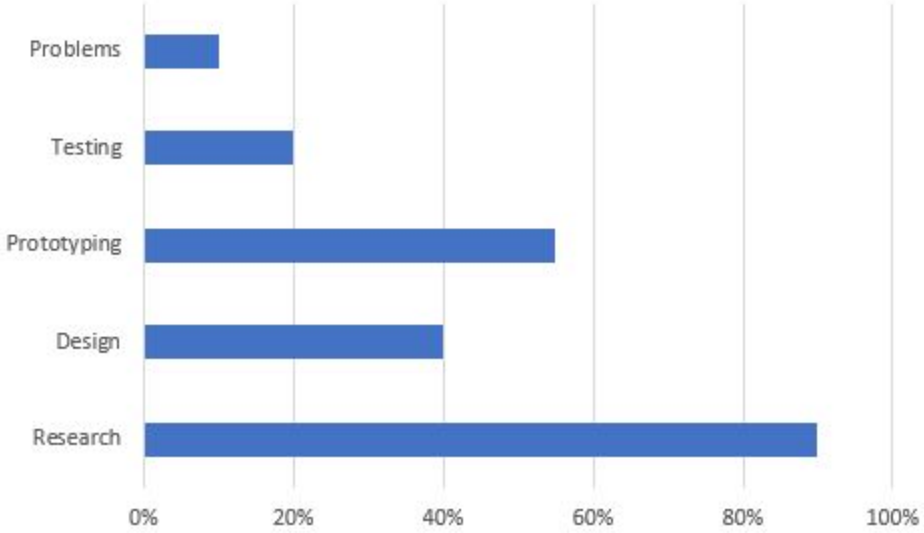
Part	Price per unit	Quantity	Cost
Laser Diodes	$0.39	15	$12.98
Photoresistors	$0.16	15	$4.95
Infrared Sensor	$8.74	15	$131.10
Optocoupler	$1.78	1	$1.78
OLED module	$4.00	1	$4.00
Microcontroller	$11.99	1	$11.99
Voltage Regulator	$4.90	1	$4.90
PCB	$2.66	5	$13.30
Frame lumber	$45.98	1	$45.98
Total cost			$240.83



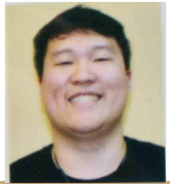
Work Distribution

Name	Software	Photonics	Electrical	Misc.
Christian	X			X
Mohamed		X	X	X
Matthew	X	X		X
Kyle			X	X

Progress

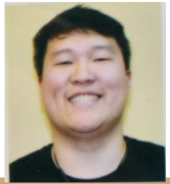


Problems
Testing
Prototyping
Design
Research
0%
20%
40%
60%
80%
100%



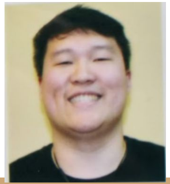
Complications

- Spacing out the infrared sensors so that they do not interfere with each other.
- Figuring out the best material to build
- Find a way to mount the laser diodes such that they are adjustable in the case that they need to be replaced.
- Debugging



Plan to complete on time

- Purchase missing components
- Use worksite to build frame and base including main components
- Wire the main components to the power supply
- Design and order the PCB
- Program the harp and begin to troubleshoot any possible issues



Questions?