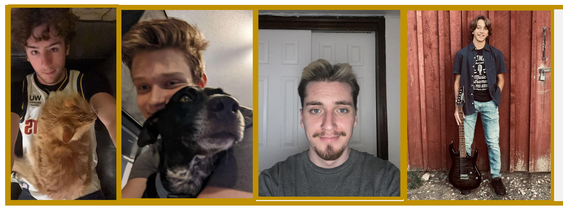


Accessible Ukulele

Joule Jugglers: Kaleb Keller, Ryan Loar, Kameron Lund, and Dominic Pedavoli
Piket-May - ECEN1400 Section 100 First Year Engineering Projects – Fall 2023
Engineering
UNIVERSITY OF COLORADO **BOULDER**

Project Background

Mission Statement: Our mission is to provide an equal musical playing experience for everyone, irrespective of physical ability, and to harmonize the world of music through the expression of the ukulele, for the love of music.

Our Clients: Amputees and individuals with motor control disabilities.

Solution: An accessible design that allows for the simple push of a button to be converted into linear motion that presses down different chords.

Design Inspiration

Beginner Guitar Gadgets

Beginner Chord

Guitar Hero

EZ Fret

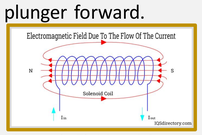
Our team noticed that these devices allow the user to play a full chord at the press of a button. We were inspired to create a similar device for the ukulele using solenoids.

What is a Solenoid?

A solenoid is an electromagnetic device that generates a magnetic field which pushes a plunger forward.

$B = \frac{\mu_0 NI}{L}$ $P = I^2R$

B = magnetic field strength;
μ0 = permittivity of free space;
N = number of turns;
I = current;
L = length of solenoid;
P = power;
V = voltage;



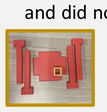
Magnetic Field and Current

Solenoid Render

Prototyping

Initial Housing

- Initial solenoid housing prototypes proved to be weak and did not fit correctly on the neck of the ukulele



- Solenoid Housing Prototype 1 (Left)
- Solenoid Housing Prototype 2 (Right)

Solenoid Testing

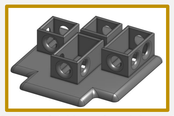
- The 5V solenoids did not have the force output required to press the string while running 5V through them
- Explored bigger solenoid that worked however it was too big

- Finally tested overdriving 9V through the 5V solenoid and it worked

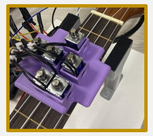
Engineering Design & Process

Solenoid Housing

- Solenoids are held in a 3D printed unit that precisely places the 6 solenoids over their respective strings and frets
- Housing is detachable via Velcro
- Holes in sides of solenoid ports to allow cooling



Solenoid Housing Model

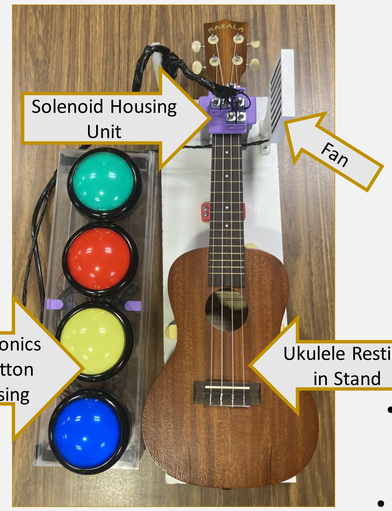


Solenoid Housing

Electronics & Button Housing

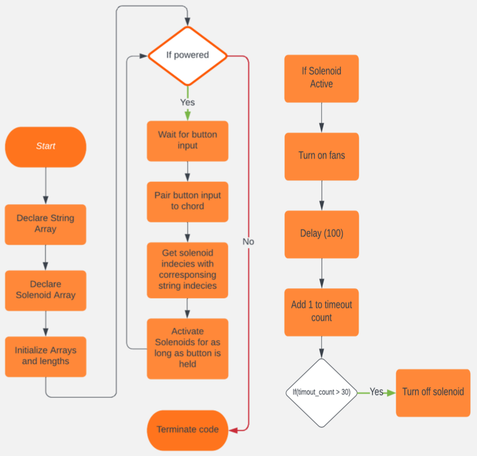
- Box is made of 1/8" laser cut acrylic
- Box houses the Arduino mega, circuitry, and buttons
- Port in back for wire access

Button and Electronics Housing



Final Accessible Ukulele Design

Software flow charts



Main Code – Block Diagram Safety Mechanism – Block Diagram

Electrical Design

Buttons:

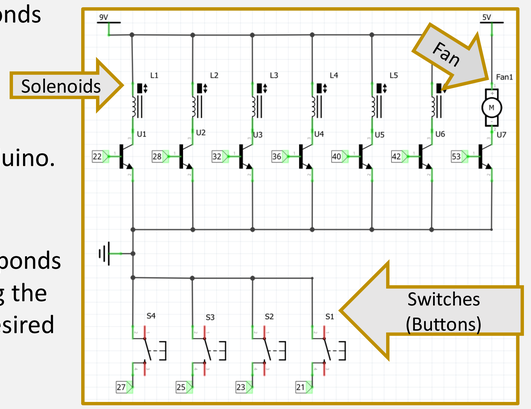
- Each button corresponds to a chord.

Fan:

- Fan is connected and controlled by the Arduino.

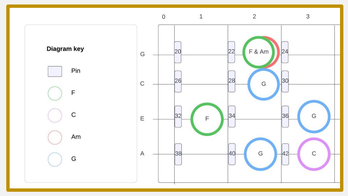
Transistors:

- Each transistor corresponds to a solenoid, allowing the Arduino to activate desired solenoids.



Electrical Schematic

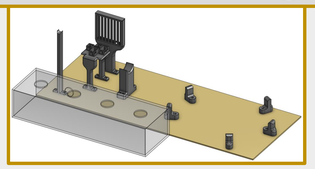
How it works



Solenoid to Chord Reference Sheet

- Each button is linked to a set of solenoids which correspond to a specific chord.
- Press a button and strum the ukulele to achieve the same effect of playing a chord in a typical way.
- All the logic and timing is handled by an Arduino mega in the clear box, which also provides the power through a 9V wall plug.

Housing



Complete Housing CAD Model

Dimensions

- Overall Footprint: 10 " X 26"
- Height: 7"

Lessons Learned

Technical Development: All Members learned CAD, Laser Machining, Soldering, and 3D design to help put the project together and ensure its success.

Team Development: Each member came forward and displayed one or more of their strengths/talents to help complete what needed to get done on time while making sure their work is up to standard.

Future Developments

-Implement additional solenoids allowing the user to play more chords

-Finding alternative solenoids that are similar in size, yet output the minimum force required without being overdriven

Budget

Quantity & Product	Price Per Item	Total Cost
6 5V Solenoids	$5.50 each	$33.00
6 13.2 x 12.1 mm Copper Heatsinks	$1.95 each	$11.70
6 Transistors	$0.00 each	$0.00
4 Buttons	$12.95 each	$51.80
1 Arduino Mega (ELEGOO)	$21.00 each	$21.00
1 30 x 30 mm fan	$3.50 each	$3.50
1 9V DC Power Supply	$14.00 each	$14.00
Total	-	$135.00
Margin	-	$165.00

Testing

- Our main concern was with the heat of the solenoids.
- Below is the data we gathered (three trials) on the effect of fan cooling on the surface temperature of solenoids.

Seconds Activated	Temperature °F (No Fan)	Temperature °F (With Fan)
0	72.34	74.71
22.5	75.55	79.99
45	87.02	85.26
67.5	95.22	89.66
90	103.70	93.17

Surface Temperature Data

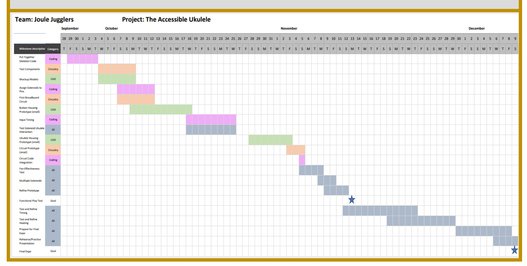
Safety Concerns

- Potential exposure to live wires (as few as possible with our constraints).
- Solenoids are prone to producing a large amount of heat.

Heat Dissipation

- Fan engages when the solenoid(s) are active, ensuring that the solenoid never reaches above 100° F.
- Fans use convection cooling to push air past the solenoid housing, dispersing the heat.

Gantt Chart



Acknowledgements

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