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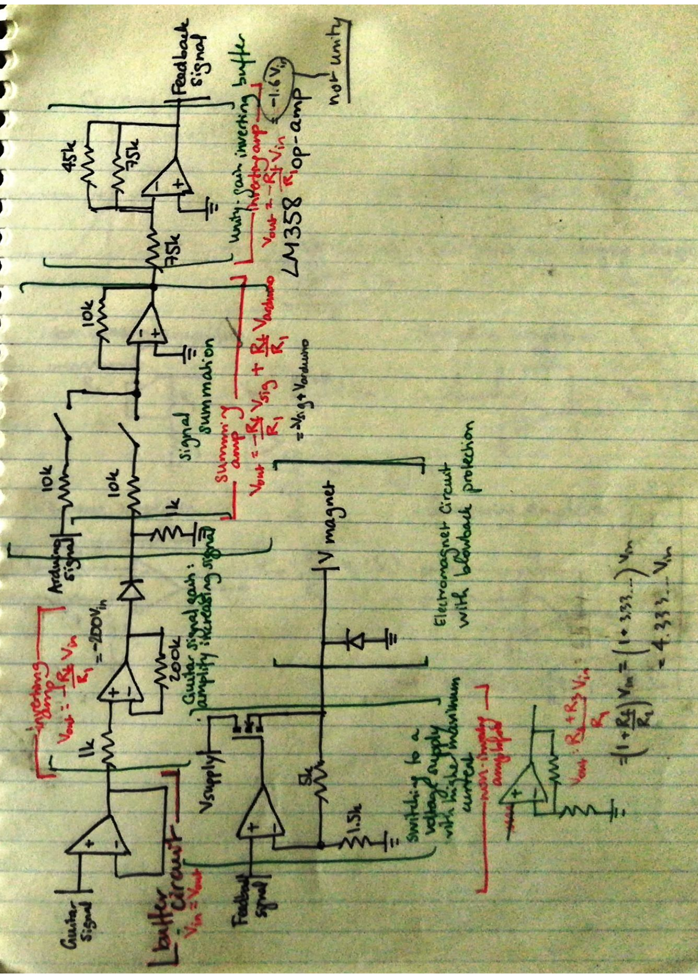
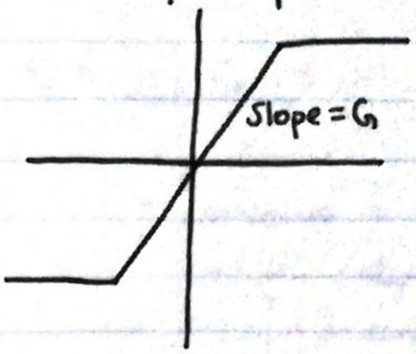
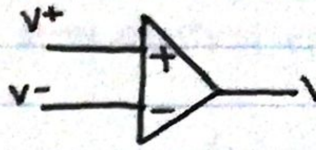


# Op-amp Review

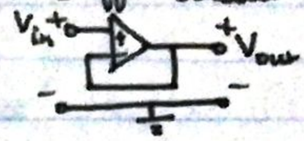



$V_{out} = G V_{in}$




$V_{out} = A(V_+ - V_-)$

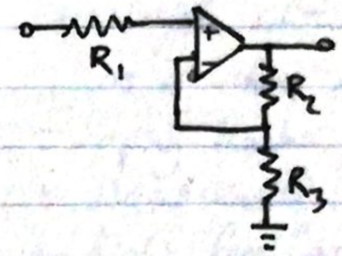
Buffer circuit (boosts power w/o changing waveform)



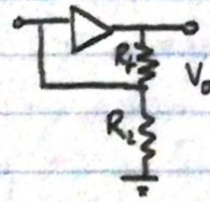

$V_{in} = V_{out}$

$G = 1$

Non-inverting amplifier

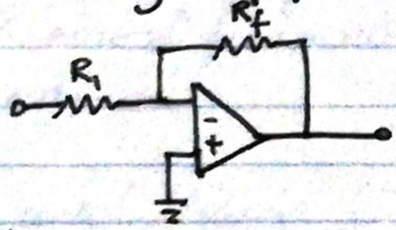



$V_{out} = \frac{R_2 + R_3}{R_1} V_{in}$



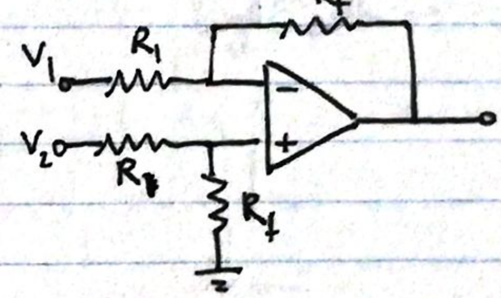

$V_{out} = \left(1 + \frac{R_f}{R_2}\right) V_{in}$

Inverting amplifier



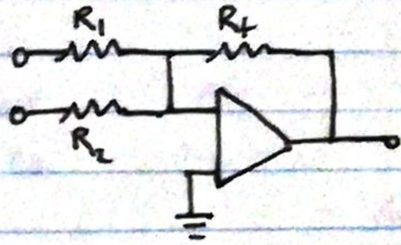

$V_{out} = -\frac{R_f}{R_1} V_{in}$

Difference amplifier




$V_{out} = \frac{R_f}{R_1}(V_2 - V_1)$

Summing amplifier




$V_{out} = G_1 V_1 + G_2 V_2 = -\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2$

# UI brainstorm

## * "TRADITIONAL" APPROACH → MAKING MORE CLASSICAL MUSIC *

- sostenuto pedal feature : sustain the keys that are currently selected / depressed. Multiple tracks are available
- pressure-sensitive buttons
  - o horizontal (traditional) button membranes

    OR
  - o ergonomic diagonal "flex sensors" on springs
- muscle control (shoulders, arms) for musical parameters such as volume, vibrato, pitch bend, wah-wah ] opt. add-on for future
- looping tracks
- ~~[illegible]~~ → or dancing, leg control / balance
- light feedback → when a string is played, it lights up

  light intensity → volume

  light color → track, or volume

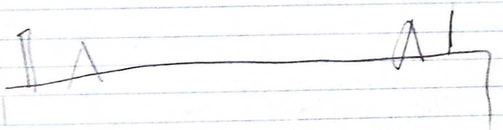
| * light tubes * | PRO | CON |
|---|---|---|
| - LED light tubes : | cool light effect | need diffuser tube or look cheesy, harder to set up |
| - acrylic rods : | simple, cheaper | looks more basic |
| - LED strips on rods | similar to LED light tube but less cheesy | |

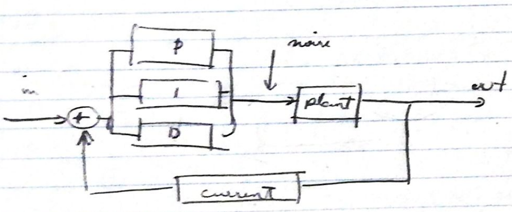
* look into I2C bus *

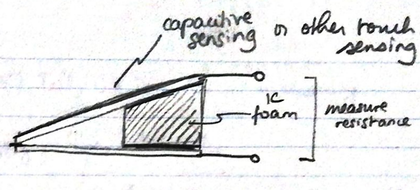
* "PLAYFUL" APPROACH → MORE ACCESSIBLE & FUN, LESS CONTROL

- Twirly stick with capacitive buttons, loop control, accelerometer/ gyroscope (like last year Guthman entry)

* PROBLEM: a separate UI will destroy coheaveness and will be difficult to justify



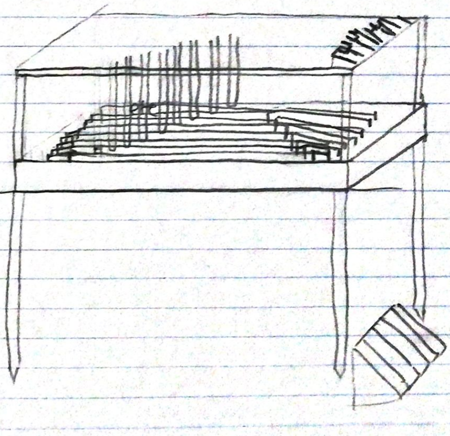


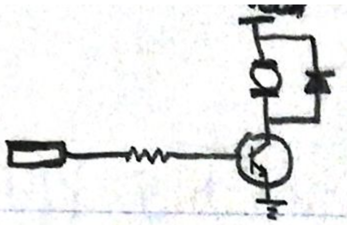




If strings are spaced 1 cm apart, "white" keys will be 1.7cm apart. ✓
Instrument will be 36 cm wide from leftmost to rightmost string.

<u>Musical Features</u>

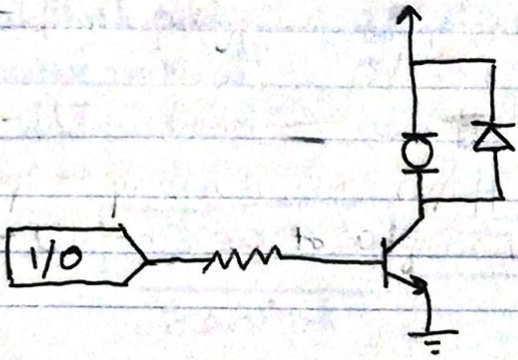
* Volume → vibrato, pitch bend, etc. ] pressure sensing
* Harmonic slide ] pedal (pressure s.)
* Sostenuto ] pedals (buttons)



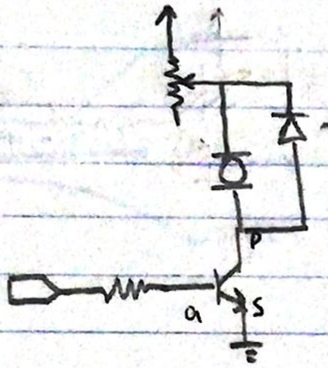


[redacted]

Electromagnet Circuit



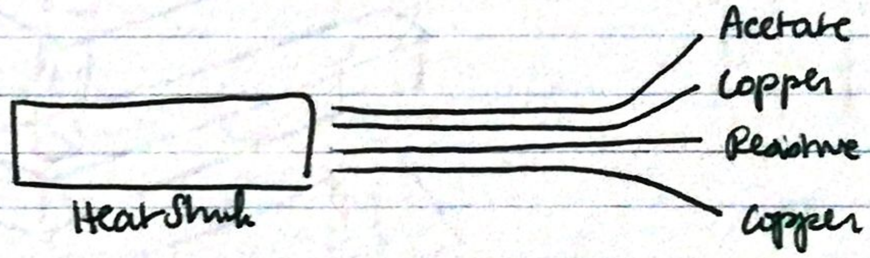

Test Circuit




blue pots - 10k

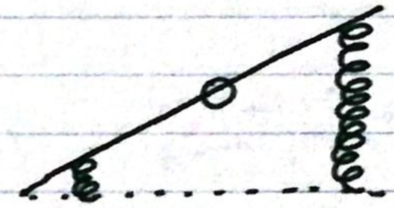
# DIY Bidirectional Flex Sensor

| | | |
|---|---|---|
| Copper foil laminate | 1/4" × 4.5" | ⟶ Aluminium foil |
| Acetate | 1/4" × 4.5" × .010 | |
| Heat Shrink tubing | 3/8" dia × 5" | |
| Resistive material | 5/16" × 5" | |

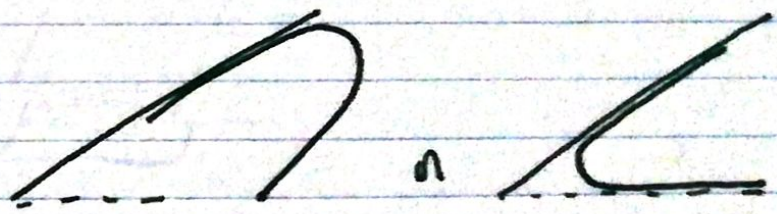



## Possible Sensors

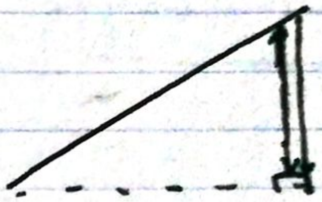
* Potentiometer



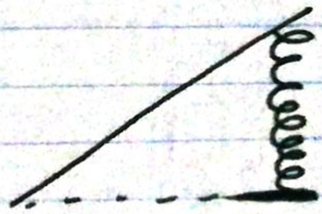
* Bend sensor



* Light / Optical Sensors



* Force Sensors

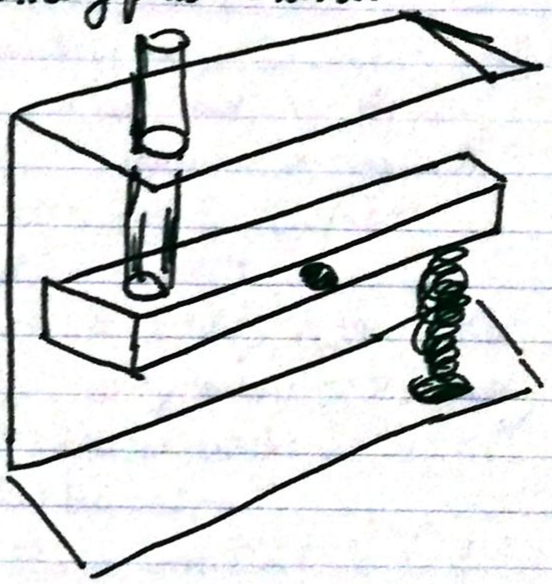


* Hall sensor

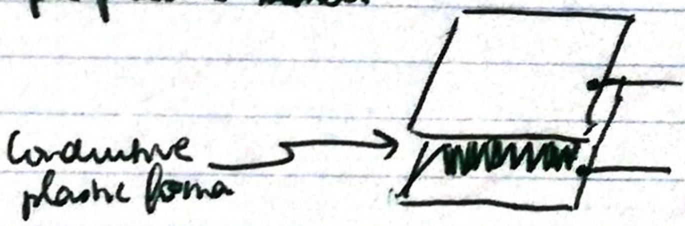
* Conductive Foam

Engineer Mini-Notebooks
555 Timer IC Circuits
Basic Semiconductor Circuits
Communications Projects
Digital Logic Projects
Environmental Projects
Formulas, Tables, Basic C.
Magnet & Magnet Sensor P.
Op Amp IC Circuits
Optoelectronic Circuits
Schematic Symbols
Science Projects
Sensor Projects

* Analog pressure sensor

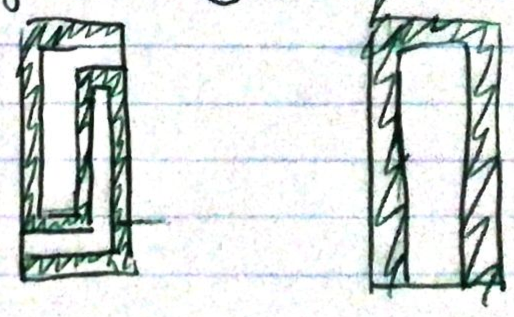


* Simple pressure sensor




* Strain sensor

High sensitivity: Single Ended



Making the harp

## UI (Physical)

Button keys → pressure sensitive, on-off
↝ use conductive foam + capacitive sensing
⇒ VOLUME, ON/OFF

Pedals → 4 pedals
↝ use latching buttons OR tilting switches OR 2 momentary
⇒ Sustain tracks

Other buttons →
⇒ HARMONIC SLIDE knob ~~button~~

## UI (lights, etc.)

Acrylic / fiber optic rod with LED

## SOUND ACTIVATION

Electromagnet (1 per string)

Feedback system to stop
↳ pickup
} solenoid

$\boxed{\text{37 notes}}$

serial input from ... usb

Teensy 36

TI microcontroller

MSPD432

keyboard matrices

Arduino Due

Harp

UI

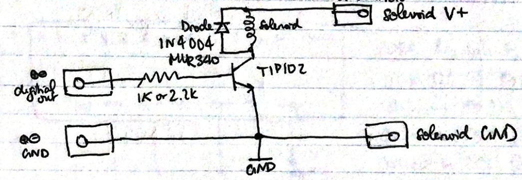
try
-> t- - - -
vs
-> wdding

11

## Comparison

| Teensy 3.6 | | Arduino Due | Arduino MEGA |
|---|---|---|---|
| 62 I/O Pins | | 54 I/O (12 PWM) | 54 I/O (15 PWM) |
| 25 Analog In. (13 bit res) | | 12 Analog In | 16 Analog In |
| 2 Analog Out | | 2 Analog Out | – |
| 20 PWM Out | | 84MHz | 16MHz |
| 180 MHz ARM | but combined | 3.3V | 5V |

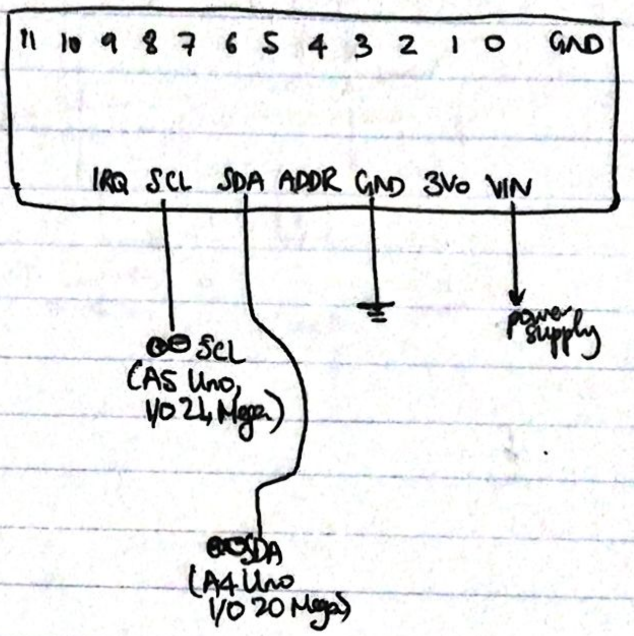
How to use a solenoid




* Diode : Schottky is better

* heat sink on transistor

## Adafruit 12-Key Capacitive Touch MPR121




ADRR: by default, pulled to GND with 10K Ω for I2C @ 0x5A

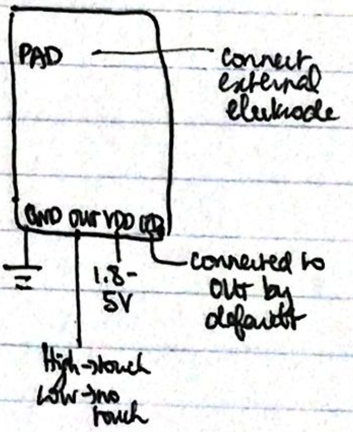
Connect to 3Vo for I2C @ 0x5B

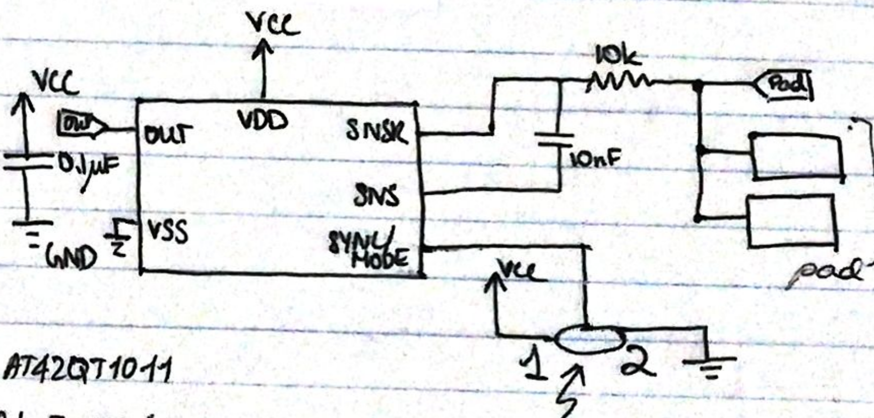
Connect to SDA for I2C @ 0x5C

Connect to SCL for I2C @ 0x5D

IRQ: interrupt request, pulled to 3.3V, goes to 0V until data is read

## Sparkfun AT42QT1011




1: Fast, 1ms delay, 200µA - 750µA

2: Slow, 80ms sleep at end of sample, auto switch to fast at detection, 15µA - 75µA

Parts: AT42QT1011

0.1µF capacitor

10nF capacitor

10k resistor

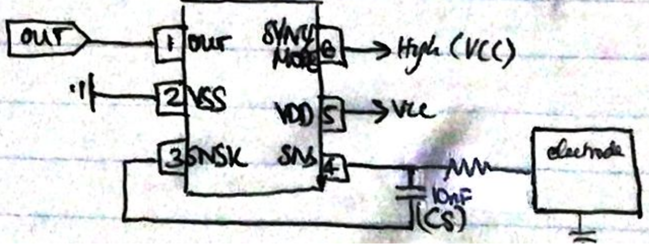
+ . . .

comes in SOT23-6 or 1CH 8-UDFN packaging

From Digikey: order 50 → 27.3005

From Arrow: order 50 → 27.03

SOT23-6 Packaging Circuit:




Cs ≫ Cx (5-20pF)

(increase sensitivity → increase Cs)

Standalone inputs

- → harmonic slide knob (potentiometer?) → slide pot? touch based? or knob?) ≋ depends on max frequency.
- → sustain vs. damping (toggle)
- → pedals (toggle)

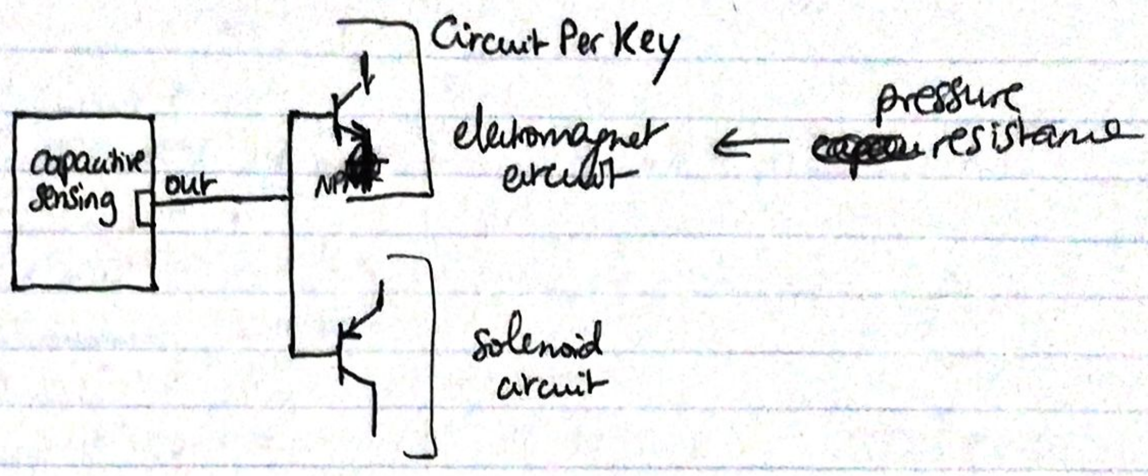
| Test |
| --- |
| How to control individual volume → using potentiometer ok? |
| See page 7 ~> meh I guess? |

If (sustain vs. damping) is set to <u>sustain</u>:
    electromagnets turn on/off with keys
If (sustain vs. damping) is set to damping:
    key on → solenoid down, electromagnet on
    key off → solenoid up, electromagnet off

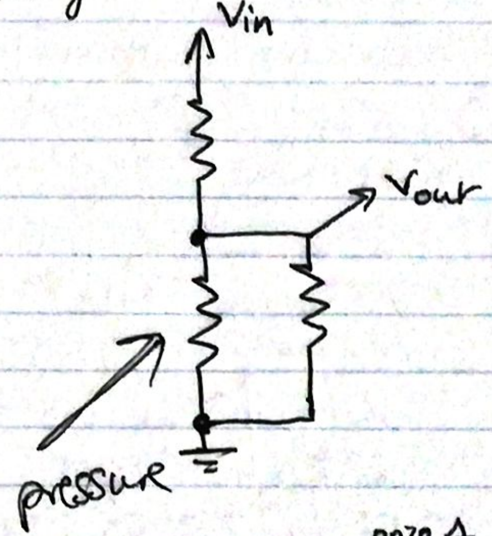
Circuits per key

Key (capacitive touch) ⟶ switch for electromagnet
Key (capacitive touch) ⟶ inverse switch for solenoid
sustain vs. damping switch ⟶ inverse switch for solenoid

Key (pressure) ⟶ voltage regulator for electromagnet




Voltage divider:




more resistance → more voltage

price 1

<u>Cost</u>

Cap Sensor AT42Q1011 (SOT23):

Resistors (4)

Capacitors (2)

Transistors : PNP (1) :

~~MOSFET~~ NPN(1) :

N-MOSFET :

Diode (2) :

Parts List

→ Conductive foam
→ copper tape? something to act as an electrode for conductive foam
→ LED strips
→ power supplies
→ electromagnets ✓
→ solenoids
→ string ✓
→ pins ✓
→

~~3700(...)~~
37m, assume
1m perkey

Sourcing Components

Solenoid

LED strip → come in 5m packs
Adafruit EL tape, 1m $8.95
Adafruit EL wire, 2.5m: $12.00
Amazon (Amicc) EL Wire, 5m: $10.99
Aliexpress ELWire ( ) 50m → $32.20
100m → $62.56
Sparkfun EL wire 3m: $9.95, tape 1m: $8.95
Chasing EL wire 3m: $9.95
$6.95 for Chasing Inverter (up to 5m)
If using Chasing EL wire from Sparkfun, total cost: $154.25 (14 packs of wire, 8 pack of inverters)

From AliExpress:
LED strip as cheap but...
(~$5, 5m strip)
EL tape: 1m, ~$5
~~(...)~~:
*EL wire requires inverter! *

Sparkfun Community Sponsorship
Application

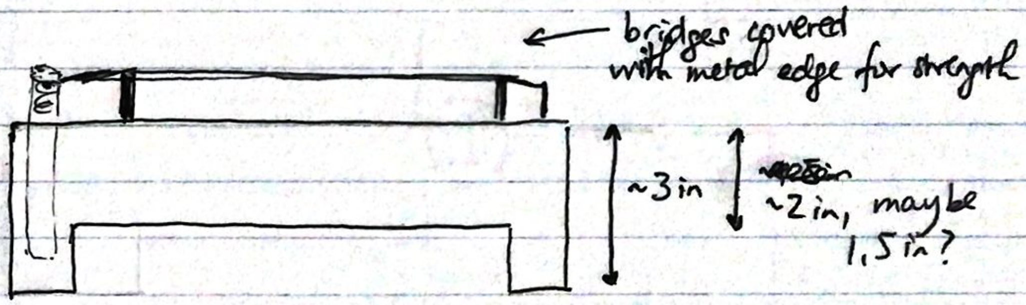
* What is the mission of your organization, program or project?
* What type of technology will your organization/program/project be using or teaching?
* What do you hope participants in your project/program/event walk away with?
* Describe the amount/type of hardware donation needed

# String Length Calculations

$$L = \frac{\sqrt{Kt}}{df}$$

K: depends on density/material, approx. 20000
t: tension of string (pounds)
d: diameter of wire in cm
f: frequency in hertz
L: length in cm

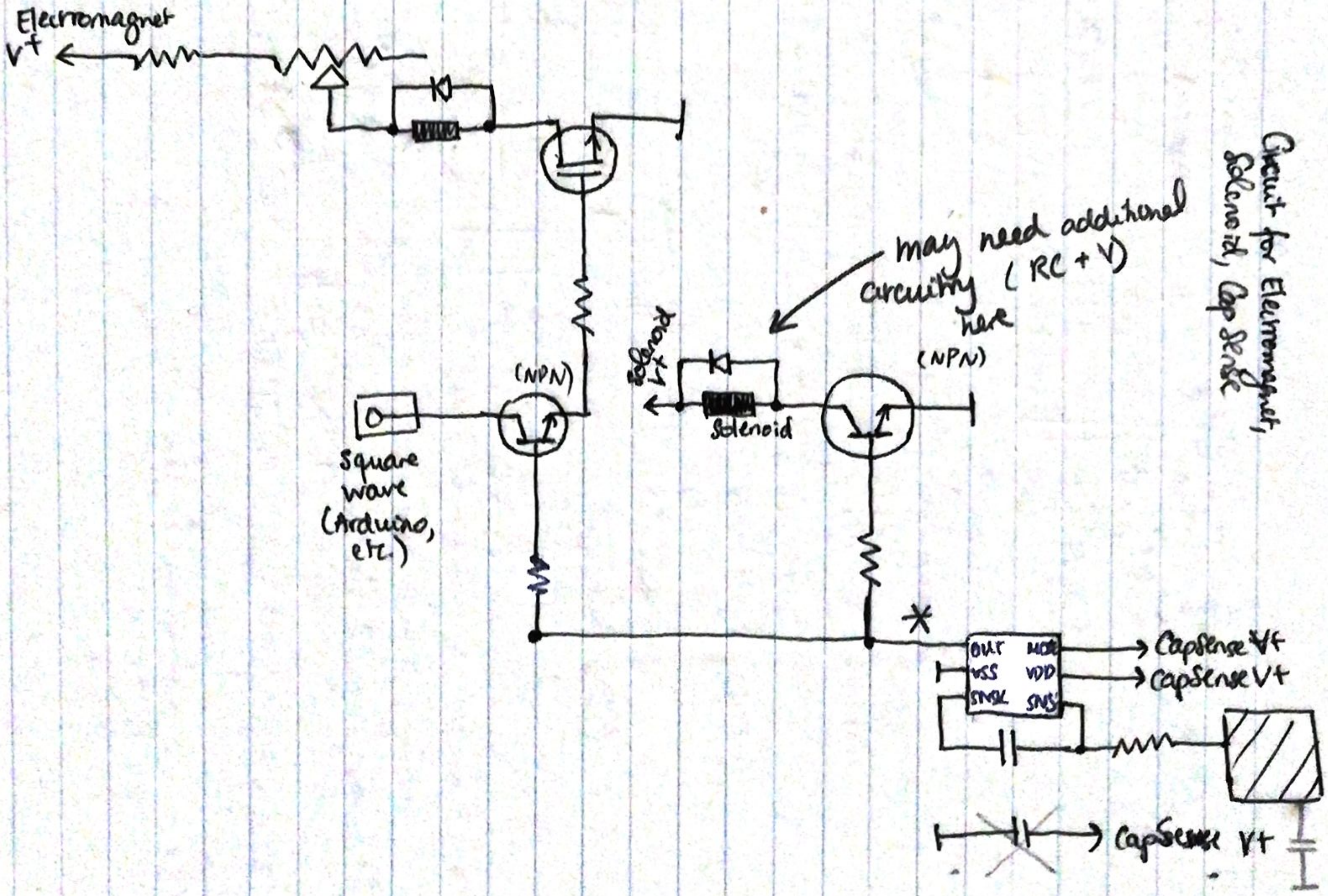
Our prototype (1 string):
$L = 53$ cm. Size 21, $d = 0.11938$. f: G3, 196 ish. $K = 20000$
so, $t = \frac{(fLd)^2}{K} = \frac{(196 \cdot 53 \cdot 0.11938)^2}{20000} = 76.89$.




New prototype (1 string): May 29th
(should be 247)
$L = 47$ cm Size 21, $d = 0.11938$. f: B3 240 ish. $K = 20000$
so, $t = \frac{(fLd)^2}{K} = \frac{(\cancel{240}\,247 \cdot 53 \cdot 0.11938)^2}{20000} = 115.29$

Circuit for Electromagnet, Solenoid, Cap Sense

modification: the signal at * will be coming from an arduino, which has MPR121 from I2C.



## Wood Discussion

Woods with high stiffness: (>2.00Mpsi)
- Yellow birch
- Hickory
- Bubinga (2.48)
- Purpleheart

pretty high stiffness: (>1.70 Mpsi)
- Ash
- Beech
- Hard Maple
- Oak
- Yellow Pine

Woods with high hardness: (>2000 lb)
- Bubinga
- Rosewood

pretty high hardness: (>1000 lb)
- Ash
- Beech
- Yellow Birch
- Hard Maple (1450)
- Oak
- Walnut
- Purpleheart (1860)

We want a wood with
- → high stiffness } board
- → low density } board
- → hardness } peg hole
- → high compressive strength } peg hole

Spruce : great tone
(Stiffness: 1.57, hardness: 510, spec. grav.: 0.40

X Mahogany : dark tone, good for e. guitars
(stiffness: 1.40 hardness, 830 spec. grav: 0.42)

Walnut:
(Stiffness: 1.68, hardness: 1010 spec. grav: 0.55)

Maple:
(stiffness: 1.83, hardness: 1450 spec. grav: 0.63)

*Young modulus*

# Let's Calculate!

~~Suppose~~

* Stiffness coeff, in Mpsi, gives us max. $t$

Spruce: 1.57 Mpsi ($\approx$ 1570000 lb/in$^2$) (wut?)

Materials:
soundboard: spruce
pinblock: plywood → laminate?
bridge: plywood or hardwood (maple)

Size 14.5: 0.034"
0.08636 cm

Size 21: 0.047"
0.11938 cm

$K = 20000$

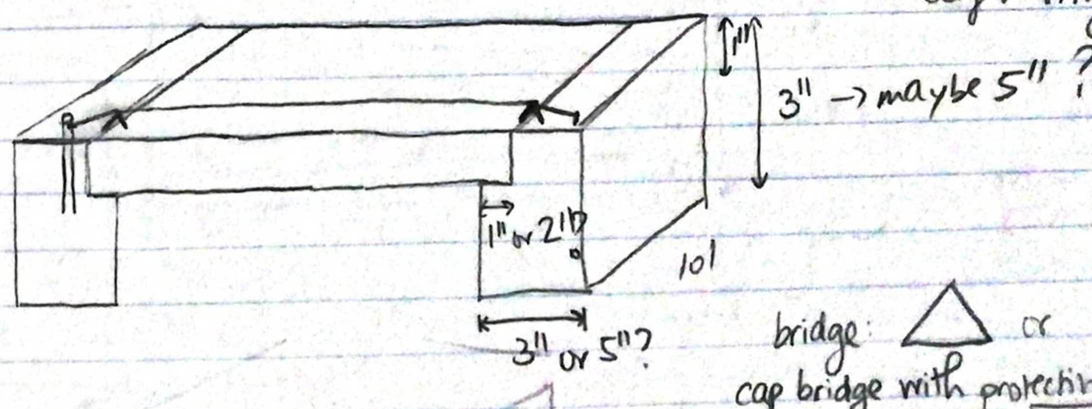
$$L = \frac{\sqrt{KT}}{df}$$

According to Wikipedia:
Good softwood tonewood: $\boxed{\text{spruce}}$
hardwood tonewood: maple.

Spruce from home depot:
→ 2in × 6in × 10 ft $9.70
→ 1in × 20in 4 ft $15.36 (laminated)
Plywood for tuning pin block

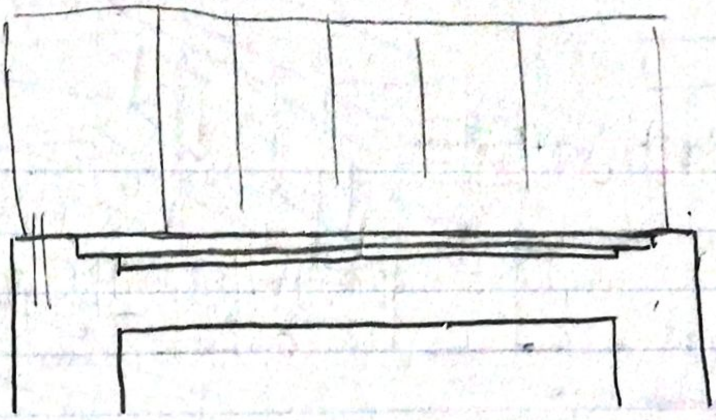
Pin height: 2.5 inch

Assume 100 lb tension per string.
Then: shortest string is 15cm
longest string is 110cm (125,



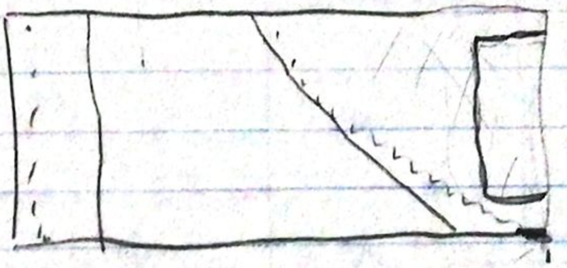

bridge: 

cap bridge with protective coating, or plastic/rubber piece? or not.



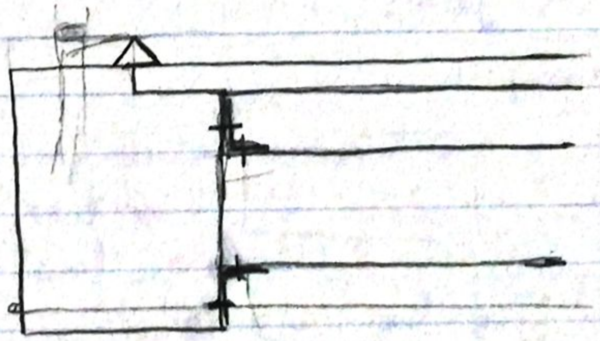
Weight (Kiln-dried)
2×4 11lb 13ft.

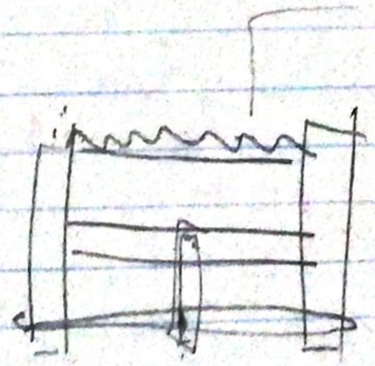
6 billion

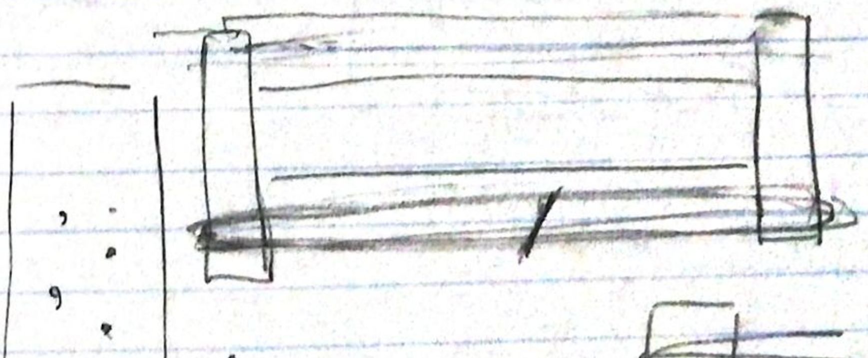


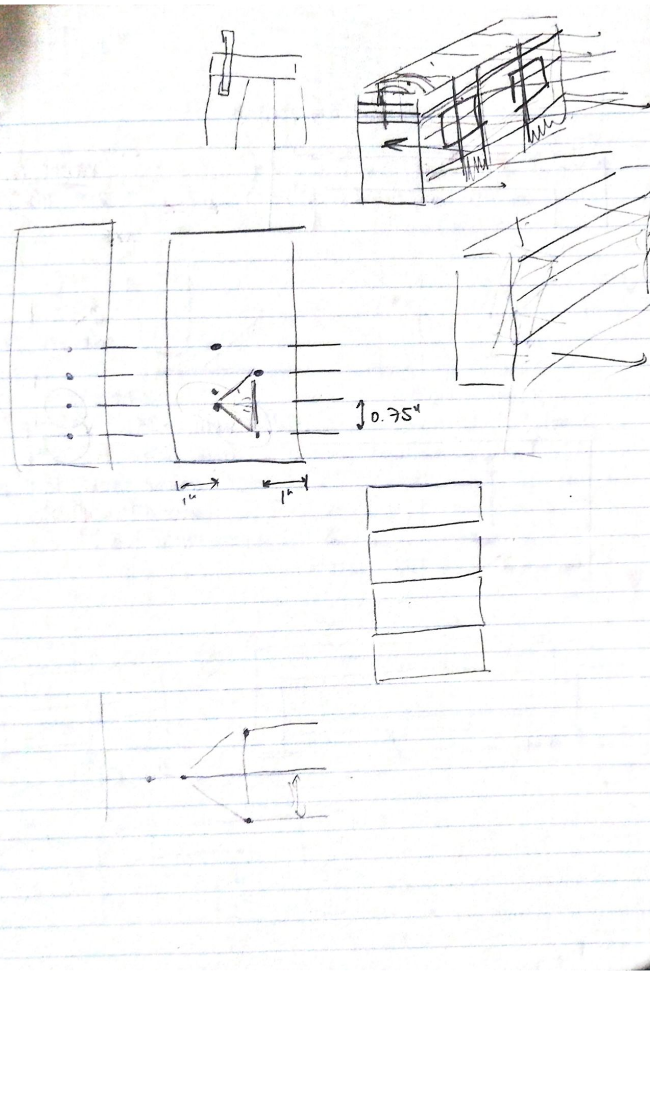
golden ratio: 1.618

37 strings
width: ~34 in. = 2.83 ft (space: 0.7
+6"
length 55in. = 4.58 ft
assume speaking length is
max 47" = 119.38 cm
We're fine!!!










## Pedal Problems

Pedal ON → If key ON → Key permanently ON

Pedal OFF → → Key goes OFF
*but only that key that was set to permanently on *

*OFF not neutral.

One possible solution: use a seperate microcontroller, which has the following requirements:

37 + pedal I/O pins ;(+) 37 I/O pins

But if we use 12-pin adafruit board → total of max 48 cap. touch, connected to I2C bus. $\boxed{\text{MPR121}}$

## Pseudocode

If CapSense ON → Key ON

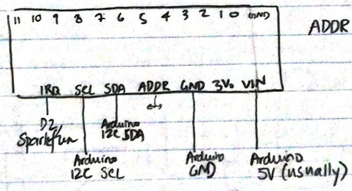
If Pedal ON → If CapSense ON → Key ON

If Pedal OFF → Pedal note array goes OFF

*Pedal note array*

Arduino MEGA would suffice

MPR121




ADDR → GND (default) 0x5A
→ 3Vo 0x5B
→ SDA 0x5C
→ SCL 0x5D

# Autoharp

$f = \frac{\sqrt{KT}}{dl}$ $\quad T = \frac{(fld)^2}{K}$

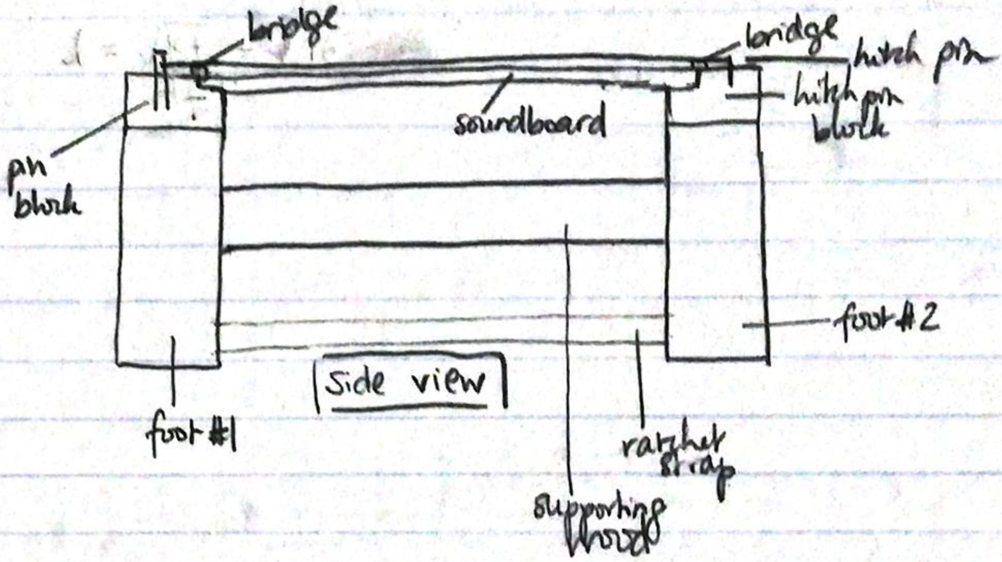
$K \approx 20000$

f in Hz
d in cm
l in cm
T in lbs

lower tension → lower pitch

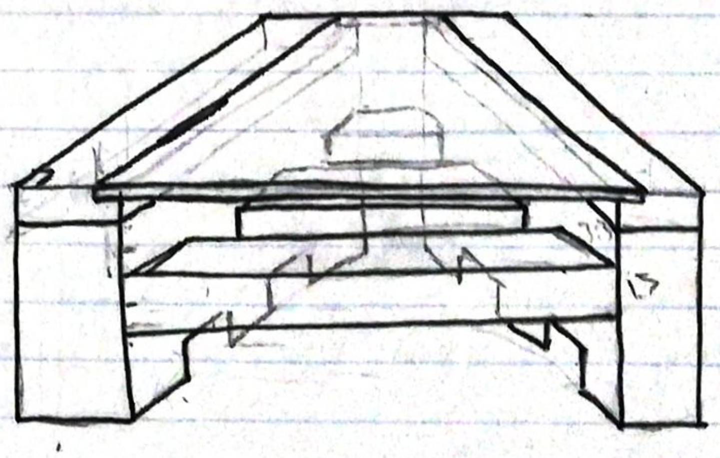
Prototype Size: 13 strings
middle range: C4 - C5

For $t = 100$ lbs, $f = [261 - 523]$: $d = 0.08636$ (size 14.5) → $l = [63, 31]$ → diff 30
$d = 0.11938$ (size 21) → $l = [45, 22]$




$l = \frac{\sqrt{KT}}{df}$

Isometric View



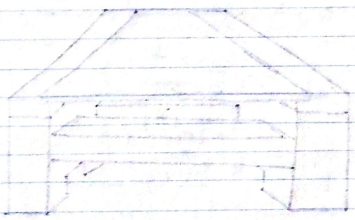
with ratchet straps going around the side notches

keys, etc. go here

List of Stuff to Get
for Harp Prototype

* Wood (beams, 2x4?) for body
* Wood for pinblock
* Wood for bridge
* Graphite paint
* Hitch pins
* Tuning pins
* String
* Ratchet Strap

* tool for twisting string around hitch pin

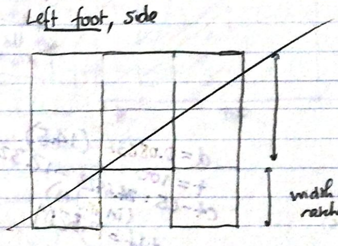


Prototype #1

13 strings (middle octave)
0.75" spacing between string → width between total strings = 9"
Length of string: range between ~31 cm and ~63 cm
→ 12" and 24"

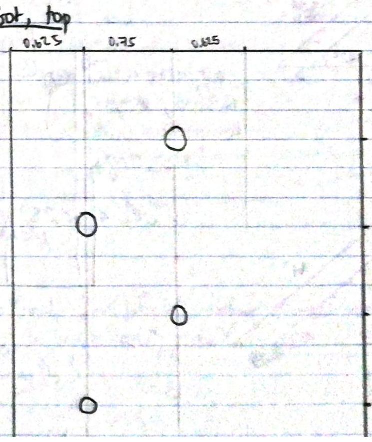
Dimensions
of 2x4 1.5x3.5
For prototype, use 3x2 blocks/pinbl
(breathing room: 0.75/side

Left foot, side



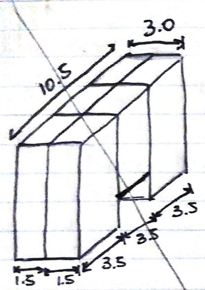

Left foot, top

* coat bridge with graphite spray

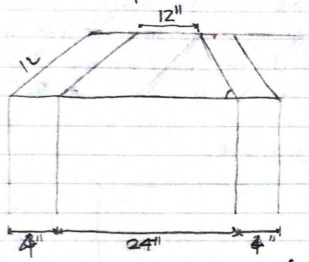


$T = \frac{(f\lambda)^2}{K}$

~1" length more per 10 lbs tension added

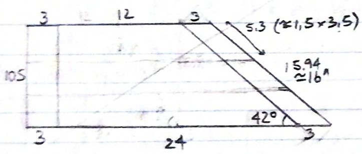



Left pin block



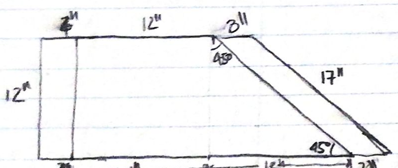

100 lbs tension

$d = 0.08636$ (14.5)
$t = 100$
C4 - C5 : 24.6423 - 12.3214
(in inches)
diff = 12.3209



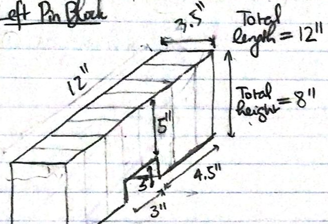

42 = 0.67

But using a 42° angle is hard, so we compromise with a 45° angle.

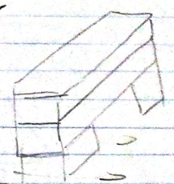



use either 4" or 2.5" wide blocks

Left Pin Block

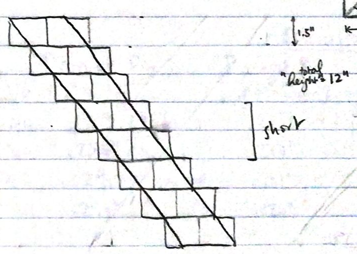


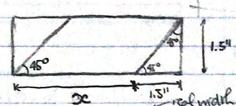

Option 1: width = 3.5" → as 2×4 width
Option 2: cut off round edges of 2×4 to 2", make 4" wide block or equivalent



Right Pin Block

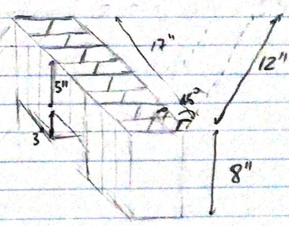
top view



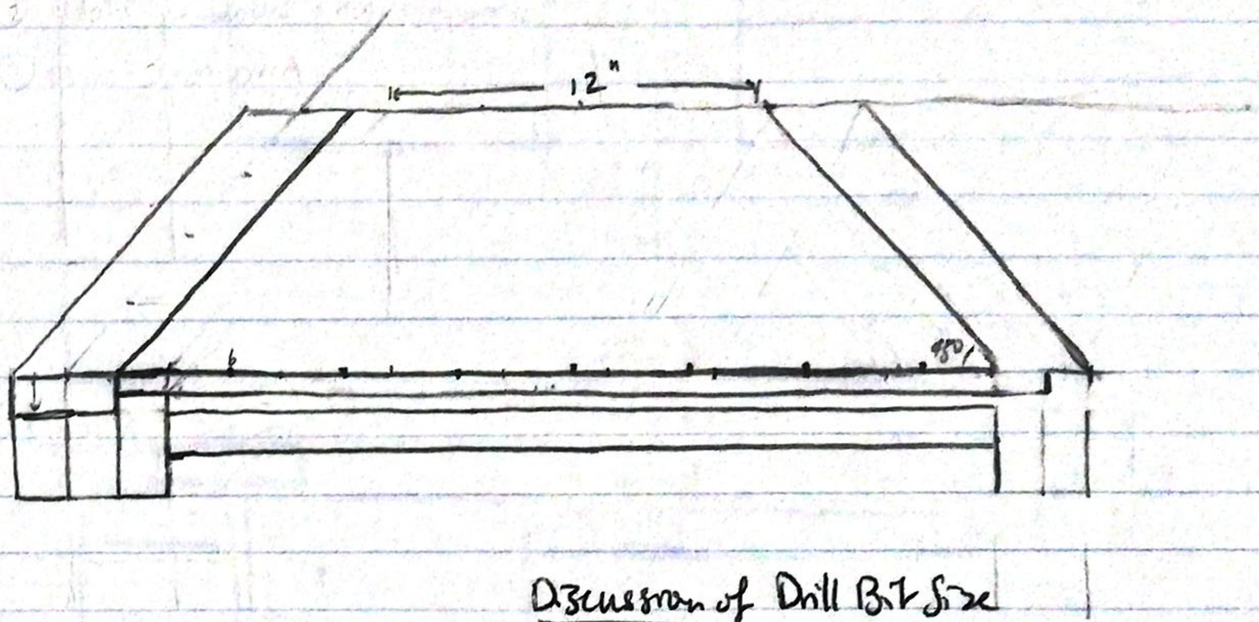

real width

If width of right pin block is smaller than 2", we can use just 1 2×4.




On top of each "pin block", glue a real pin block (or scrap wood, on right side), with holes for pins, and cut for soundboard

Approx
½" → 3"
$\boxed{1:6}$



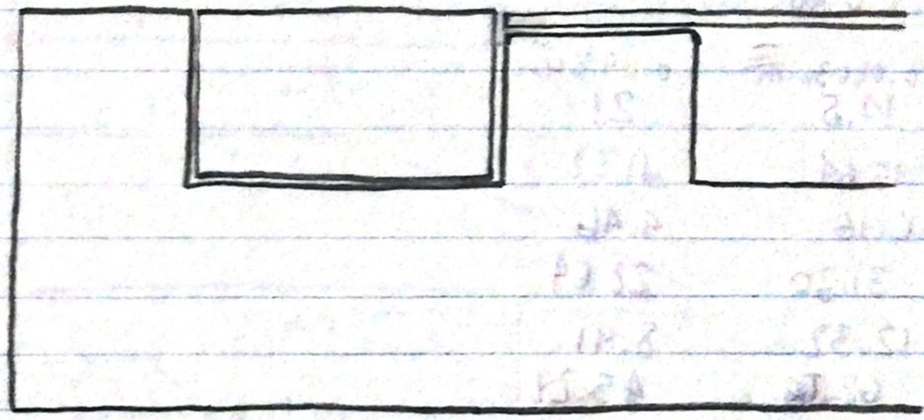

## Discussion of Drill Bit Size

| | Diam. of Pin | Diam of Drill |
|---|---|---|
| 1/0 | .276" | .009 under diam. of pin |
| 2/0 | .282" | .273" (or .272") |
| 3/0 | .286" | .277" |
| 4/0 | .291" | .281" |
| 5/0 | .296" | .286" |

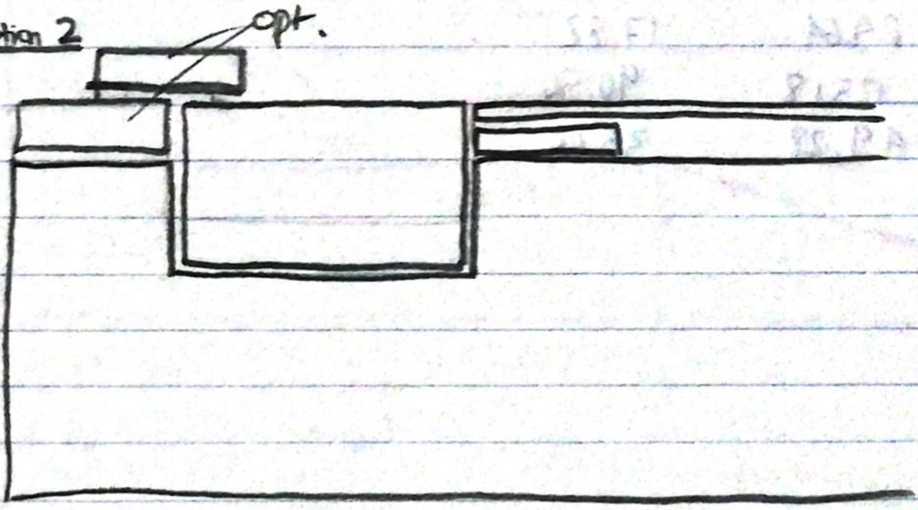
9/32 = 0.28125

## LEFT SIDE, SIDE VIEW

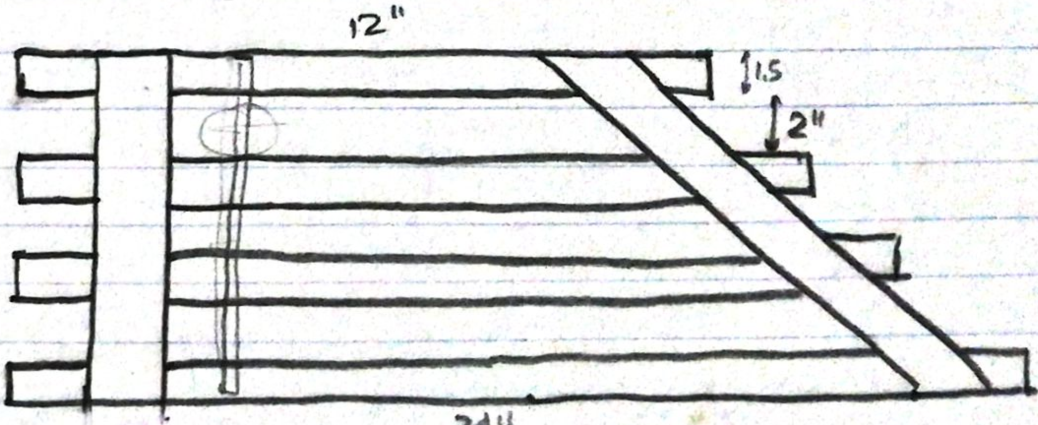
Option 1



Option 2



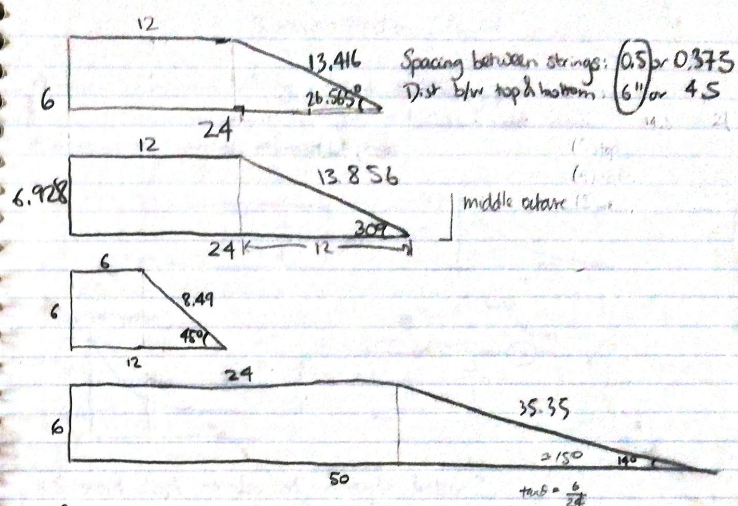

## TOP VIEW



$$L = \frac{\sqrt{KT}}{dT} = \frac{1419.210}{dT}$$

Under 100 lbs...

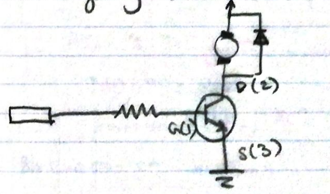
| | Freq. | 0.08636cm 14.5 | 0.11988cm 21 |
|---|---|---|---|
| C6 | 1046.5 | 15.64 | 11.32 |
| | | 6.16 | 4.46 |
| C5 | 523.251 | 31.30 | 22.64 |
| | | 12.32 | 8.91 |
| C4 | 261.626 | 62.59 | 45.28 |
| | | 24.64 | 17.82 |
| C3 | 130.813 | 125.18 | 90.56 |
| | | 49.28 | 35.65 |




Spacing between strings: 0.5 or 0.375
Dist b/w top & bottom: 6" or 4.5

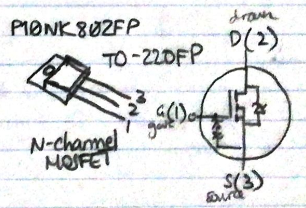
middle octave

This is getting ridiculous...



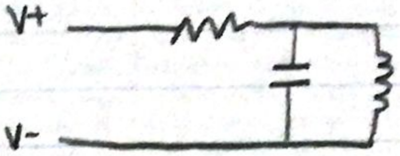

P10NK80ZFP

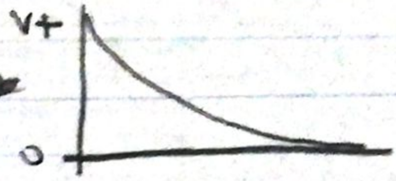
TO-220FP



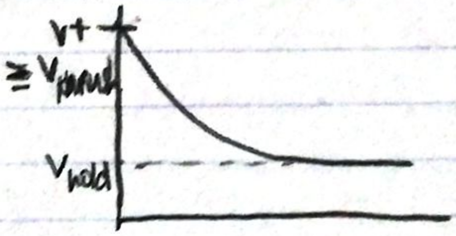
Continuous Hold on Solenoid

* measure minimum holding voltage = $V_{hold}$
  maximum inrush voltage = $V_{inrush}$
* measure resistance of solenoid = $R_{sol}$

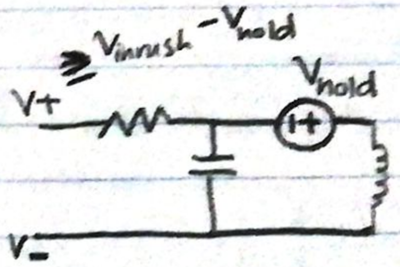



But we want




So...




* Solenoid Lock → also ok, maybe better?

Asimm's Testing:

740 $\mu$F capacitor. 3.6 $\Omega$ resistor,

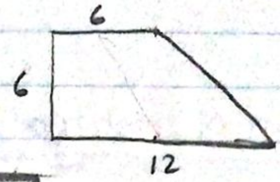
PWM @ 30kHz, 40% duty cycle → 275mA inpull

Sustain on 3% → 43mA

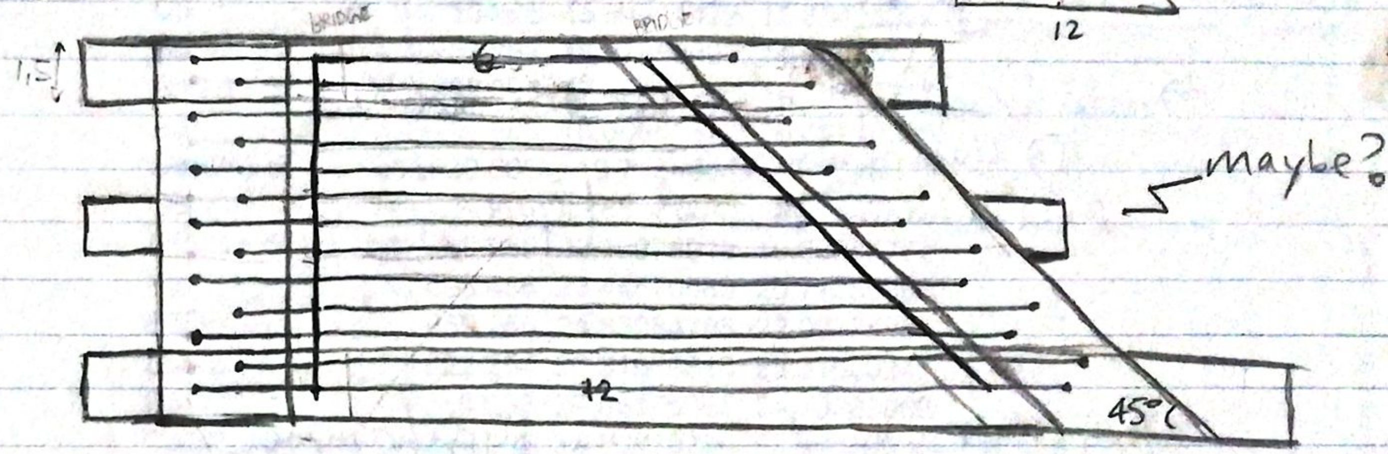
$\sqrt{2} \approx 1 + \frac{13}{32} = 1 + \frac{3}{8} + \frac{1}{32}$

$\sqrt{3^2 + 6^2}$

Prototype #2

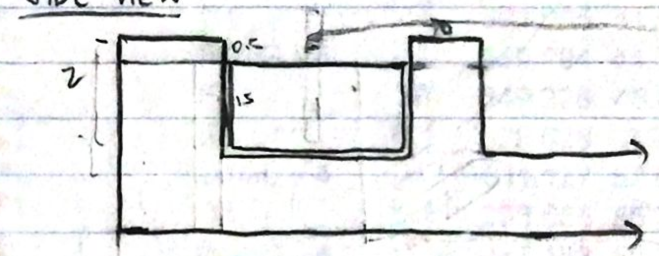



TOP VIEW - DRAFT

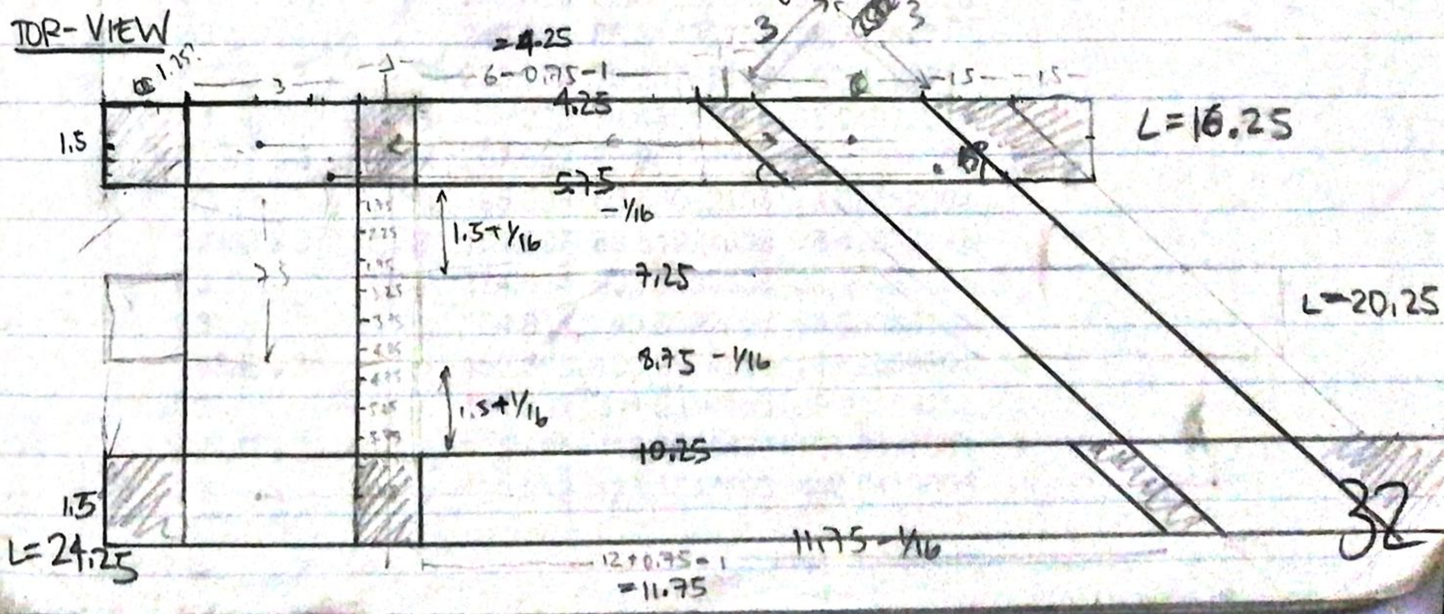



11.75
+4.25
16.00

SIDE VIEW




TOP-VIEW



Results of Prototype #2 (7/31/2018)

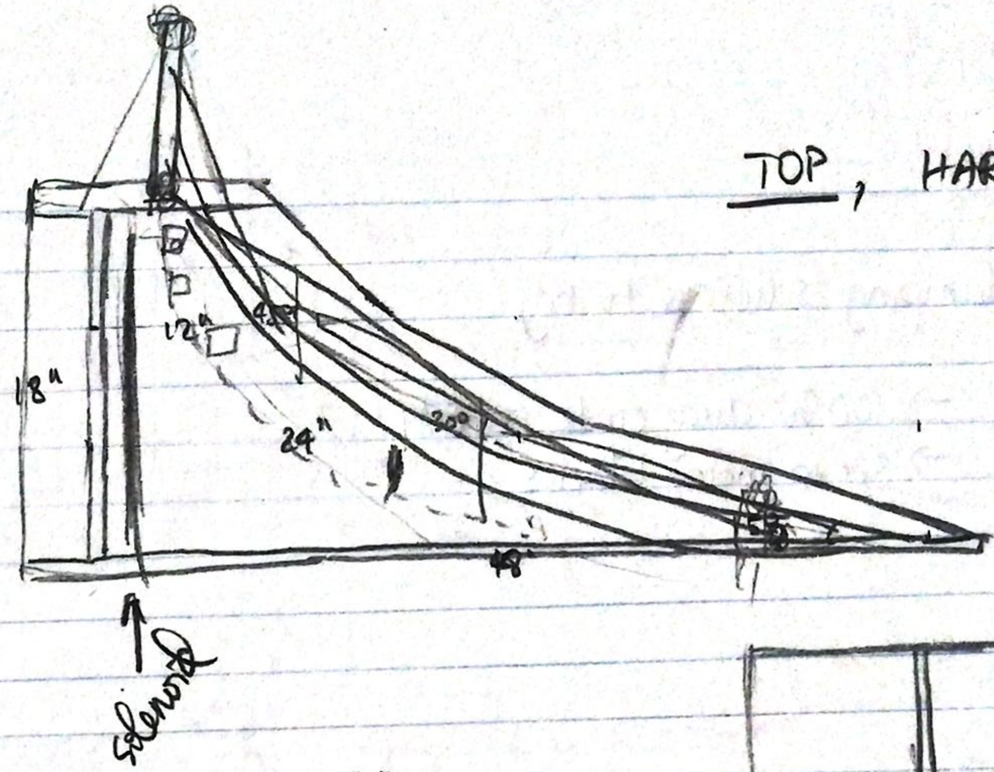
- → wood beams split on left side while
  1) hammering down
  2) achieving desired frequency

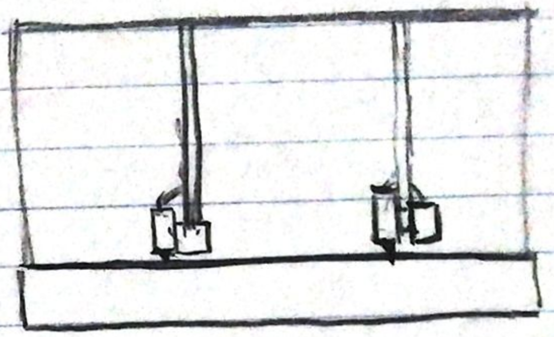
- → Things that worked: using a sledgehammer
- → Improvement in workmanship in general
- → Other things that worked: slightly underestimate dimension of cuts.

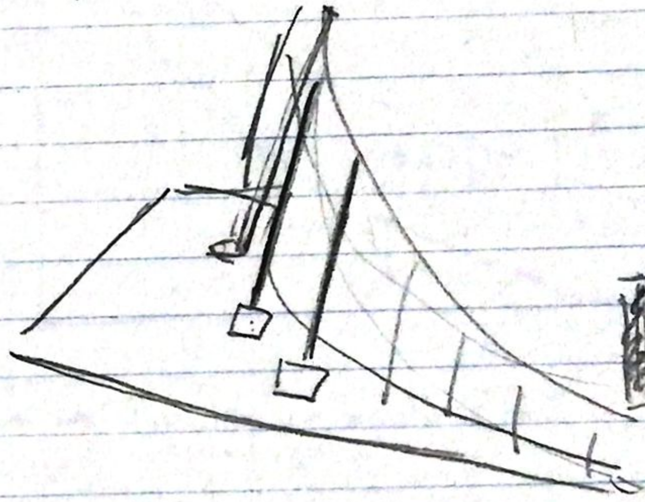
| | | | 100lbs | 180lbs Sheet1 | |
|---|---|---|---|---|---|
| | | | Size 14.5 | Size 21 | |
| | | | 0.034" | 0.047" | Length on prototype |
| | | | 0.08636 | 0.11938 | |
| | | Frequency in | Length in cm: | Length in cm: | |
| C6 | 1040 | 1046.5 | 15.64815472 | 13.86404056 | 6.16" 4.75" 60lbs |
| B5 | 968 | 987.767 | 16.57859993 | 14.68840166 | |
| A#5/B♭5 | 9 | 932.328 | 17.56441286 | 15.56181777 | |
| A5 | 860 | 880 | 18.60885672 | 16.48718005 | |
| G#5/A♭5 | 805 | 830.609 | 19.7154063 | 17.4675671 | 7.76" |
| G5 | 740 | 783.991 | 20.88773202 | 18.50623086 | |
| F#5/G♭5 | 722 | 739.989 | 22.12978019 | 19.60666772 | 7.825" 80lbs |
| F5 | 690 | 698.456 | 23.44570583 | 20.77255896 | |
| E5 | 646 | 659.255 | 24.83984788 | 22.00774881 | 10.96" |
| D#5/E♭5 | 623 | 622.254 | 26.31689618 | 23.31639241 | |
| D5 | 580 | 587.33 | 27.88175968 | 24.70283902 | |
| C#5/D♭5 | 544 | 554.365 | 29.53973269 | 26.17177932 | 12.32" |
| C5 Tenor C | ~~497~~ 511 | 523.251 | 31.29624963 | 27.72802812 | 11" 80lbs |
| B4 | 475 | 493.883 | 33.15723342 | 29.37683306 | |
| A#4/B♭4 | 457 | 466.164 | 35.12882572 | 31.12363555 | |
| A4 | 410 → 420 | 440 | 37.21771344 | 32.97436009 | |
| G#4/A♭4 | 415 | 415.305 | 39.43076513 | 34.93509214 | |
| G4 | 388 | 391.995 | 41.77551732 | 37.01250894 | |
| F#4/G♭4 | 364 | 369.994 | 44.25962019 | 39.21338844 | |
| F4 | 348 | 349.228 | 46.89141167 | 41.54511792 | |
| E4 | 325 | 329.628 | 49.6796204 | 44.01543085 | |
| D#4/E♭4 | 290 295 | 311.127 | 52.63379235 | 46.63278482 | ?? |
| D4 | 288 | 293.665 | 55.76351936 | 49.40567804 | |
| C#4/D♭4 | 261 → 266 | 277.183 | 59.07935881 | 52.34346422 | |
| C4 | 258 | 261.626 | 62.59237963 | 55.45595026 | 24.64 |
| B3 | | 246.942 | 66.31433257 | 58.75354716 | |
| A#3/B♭3 | 230 | 233.082 | 70.25765144 | 62.2472711 | |
| A3 | 213 | 220 | 74.43542688 | 65.94872019 | |
| G#3/A♭3 | 207 | 207.652 | 78.86172015 | 69.87035252 | |
| G3 | 190 | 195.998 | 83.55082151 | 74.02482904 | |
| F#3/G♭3 | 180 | 184.997 | 88.51924039 | 78.42677688 | |
| F3 | 173 | 174.614 | 93.78282333 | 83.09023584 | |
| E3 | 161 | 164.814 | 99.3592408 | 88.03086171 | |
| D#3/E♭3 | 150 | 155.563 | 105.2679231 | 93.2658694 | |
| D3 | 145 | 146.832 | 111.5274185 | 98.81169256 | |
| C#3/D♭3 | 140 [illegible] | 138.591 | 118.1591439 | 104.6873061 | |
| C3 | 131 | 130.813 | 125.1847593 | 110.9119005 | 49.21 |

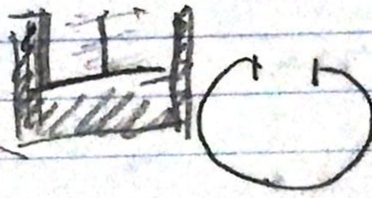
$T = \frac{(f[illegible])^2}{k}$

TOP, HARP.

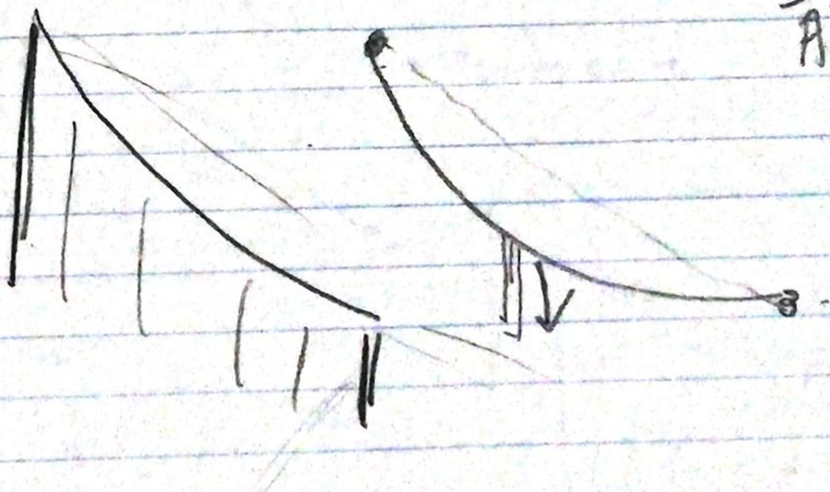


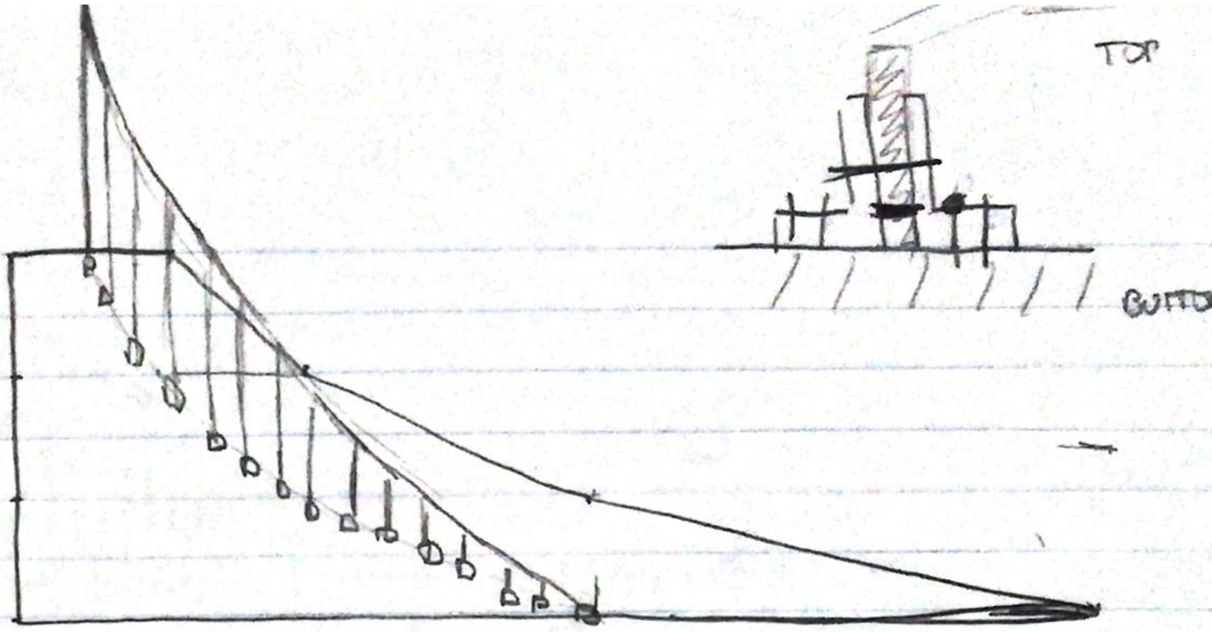


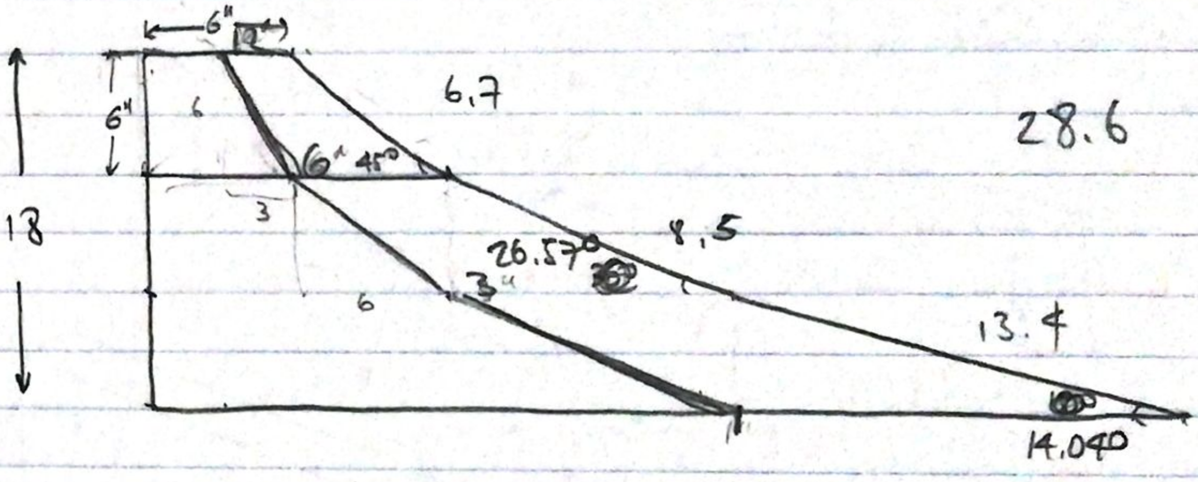


静力

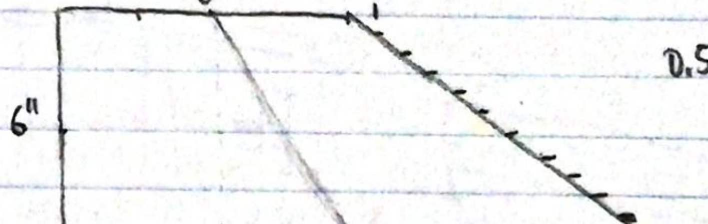


→ bridges
→ modern furniture
→ architechure
→ color palettes
→ fabrics
→ Jackson Pollok
→ sculpture



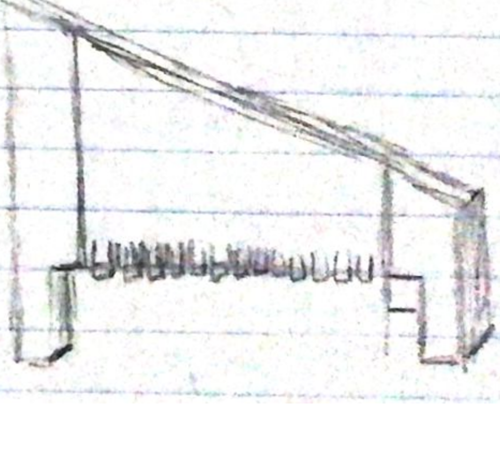



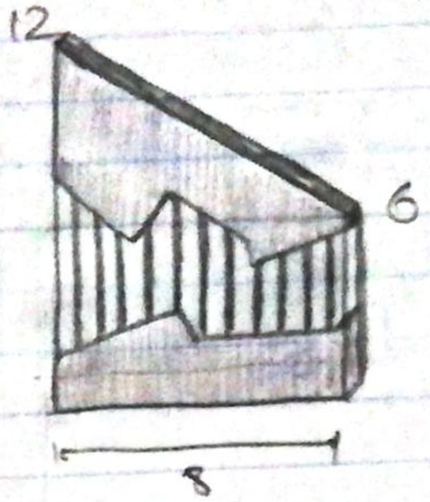

Top part → definitely use smaller (14.5 strings)



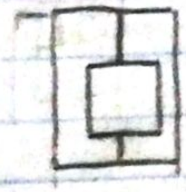

0.5" between strings

| Height: | | | |
|---|---|---|---|
| | 12 | | 12 |
| | 6 | or | 8 |
| | 3 | | 4 |
| | 1 | | ~0 |
| | ↑ | | |

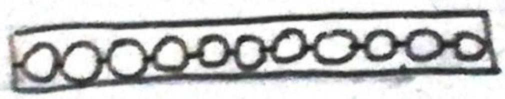


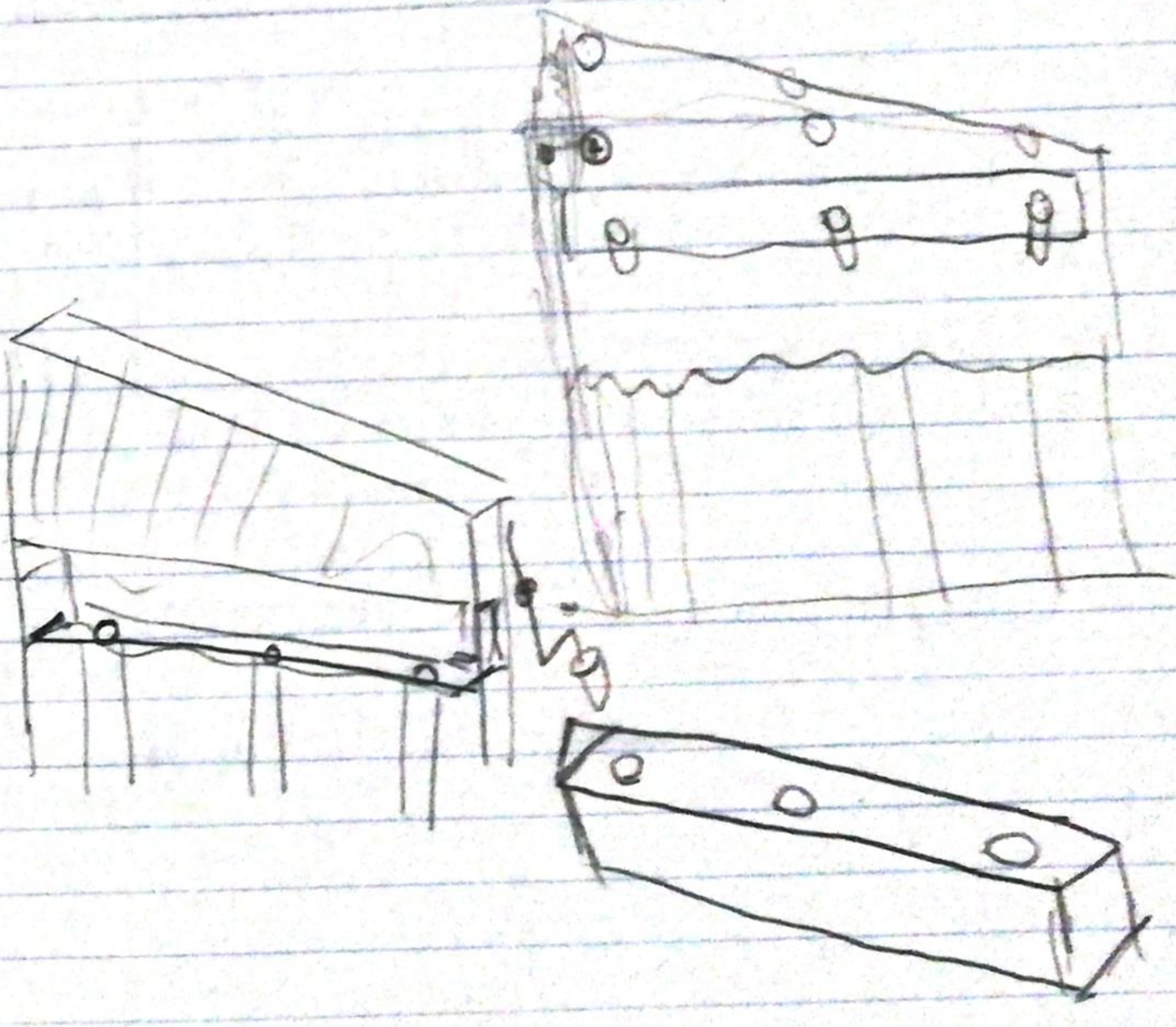


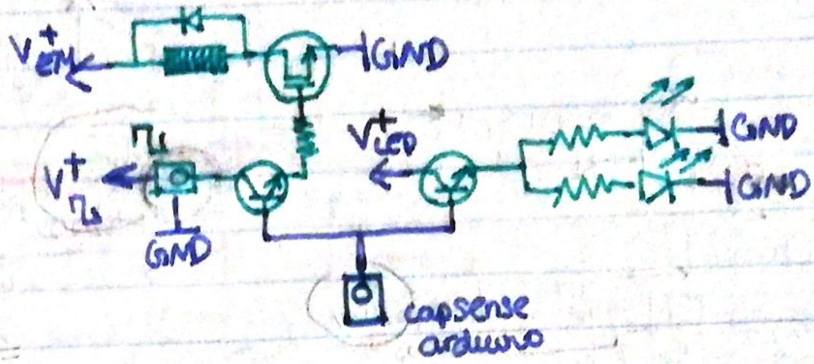

two pieces, with side view



and bottom view:



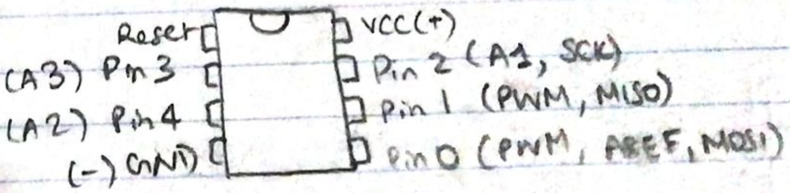





common wires

unique to each note

Explore ATTiny85 per electromagnet




| | UNO | MEGA | TINY |
|---|---|---|---|
| SCK | 13 | ~~50~~ 52 | 2 |
| MISO | 12 | 50 | 1 |
| MOSI | 11 | 51 | 0 |
| RESET | 10 | SS 53 | Reset |

Notes on programming ATTiny 45 with Arduino MEGA:

1) Upload ArduinoISP to MEGA, and be sure to change the default pin values

For highest C, 1046.5Hz. theoretically delayMicroseconds(478)

1046.5 Hz. Reality → 984Hz

delayMicroseconds(452) → 1043Hz.

Unique components

EM + diode

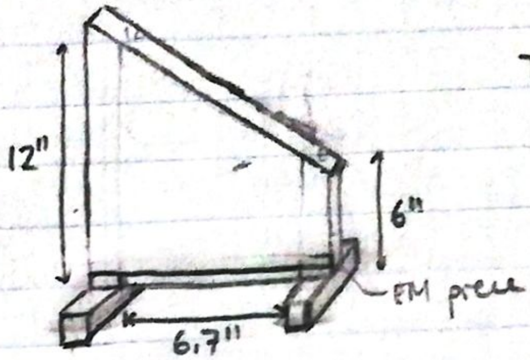
mosfet

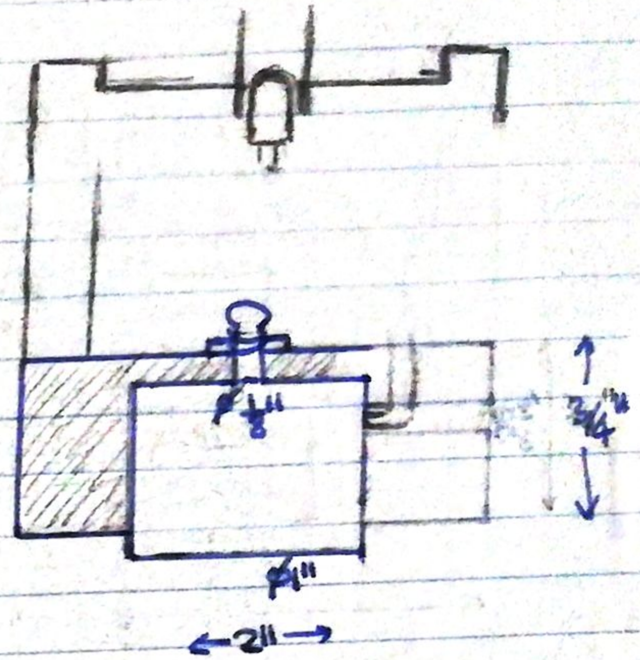
NPNs

⎍ generator

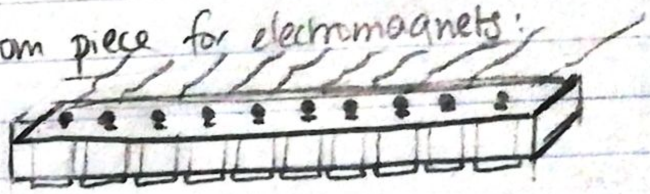
LEDs

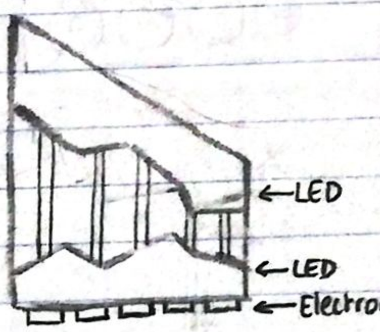
Thickness: 3"




Bottom piece for electromagnets:






## Electromagnet Dimensions


Wire: 300mm. Weight: 57g

Temp: -20°C~130°C. DC12V@ 1.5W

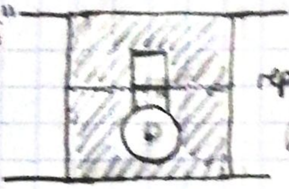
8kg force.

$5mm = 0.197''$
$\approx 3/16''$
use $\frac{1}{4}$

Acrylic tubes: OD $3/8''$ $= 0.375''$, ID $1/4''$, tolerance $\pm 0.020''$ 6ft long.

Top View

$\frac{1}{2}cm = \frac{1}{4}''$

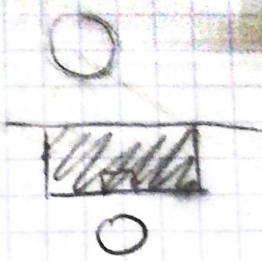


repeat

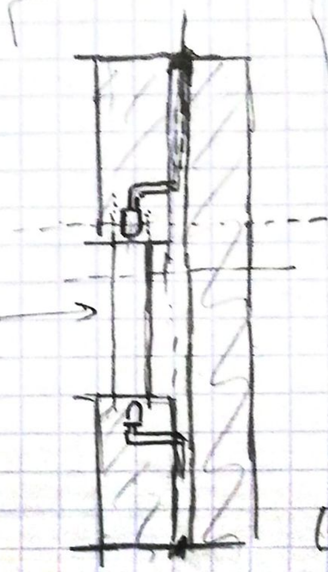
hole for light tube, depth $= \frac{1}{4}''$

old

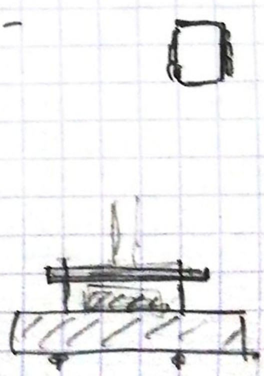
wires are LED → GND → signal



old

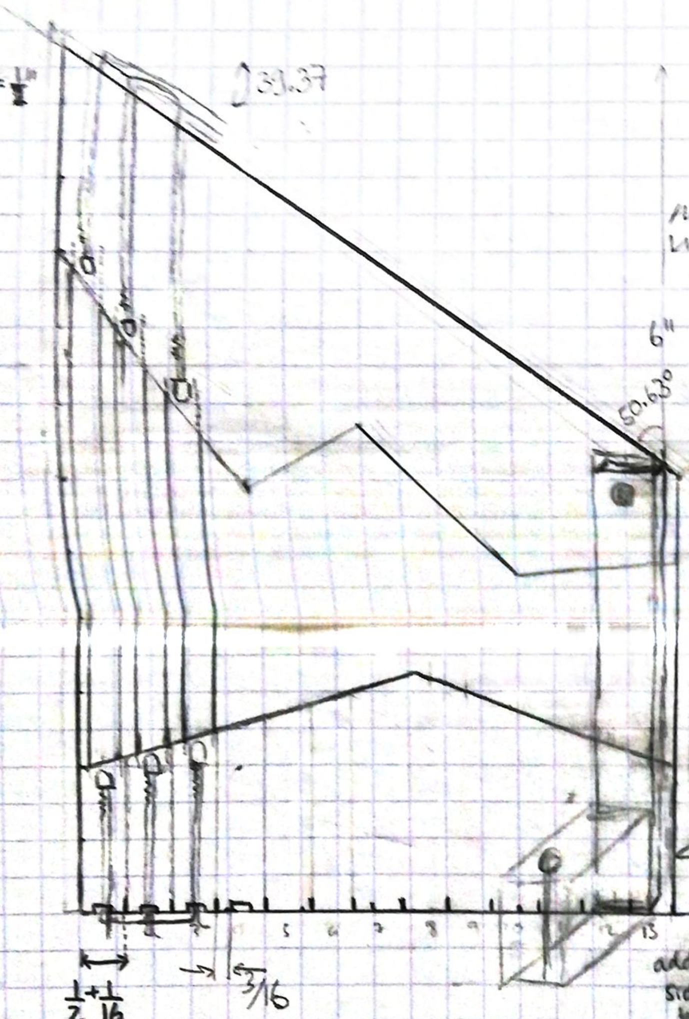


no wood



Side View

$\frac{1}{2}cm = \frac{1}{8}''$




on back
$0.5 + \frac{1}{16}$

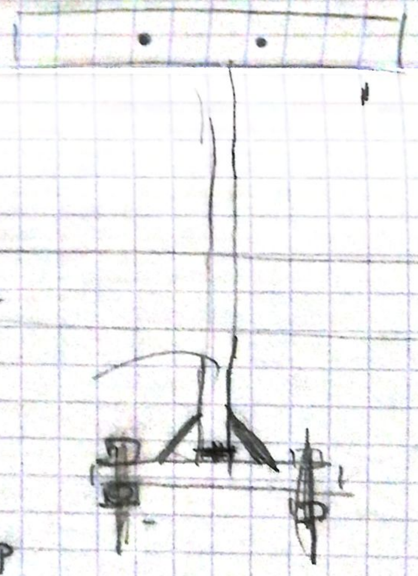
add $\frac{1}{2}''$ to each side for tolerance

$\frac{1}{2} + \frac{1}{16}$
$= 0.5625$

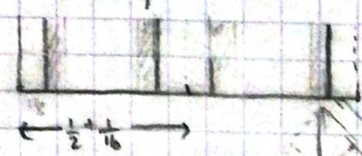
$3/16$

width: 7.3125

new

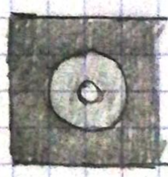


Blowup

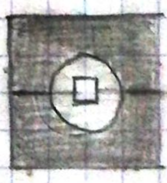


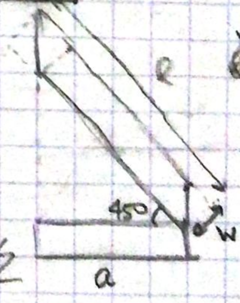

Top View

Option 1

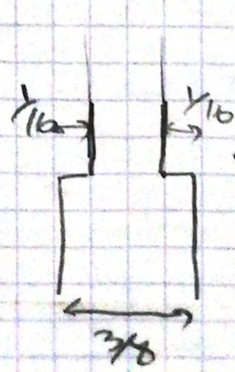


Option 2






$l \cos 45° = a$




$V = IR$

$5 = 10mA \cdot R$

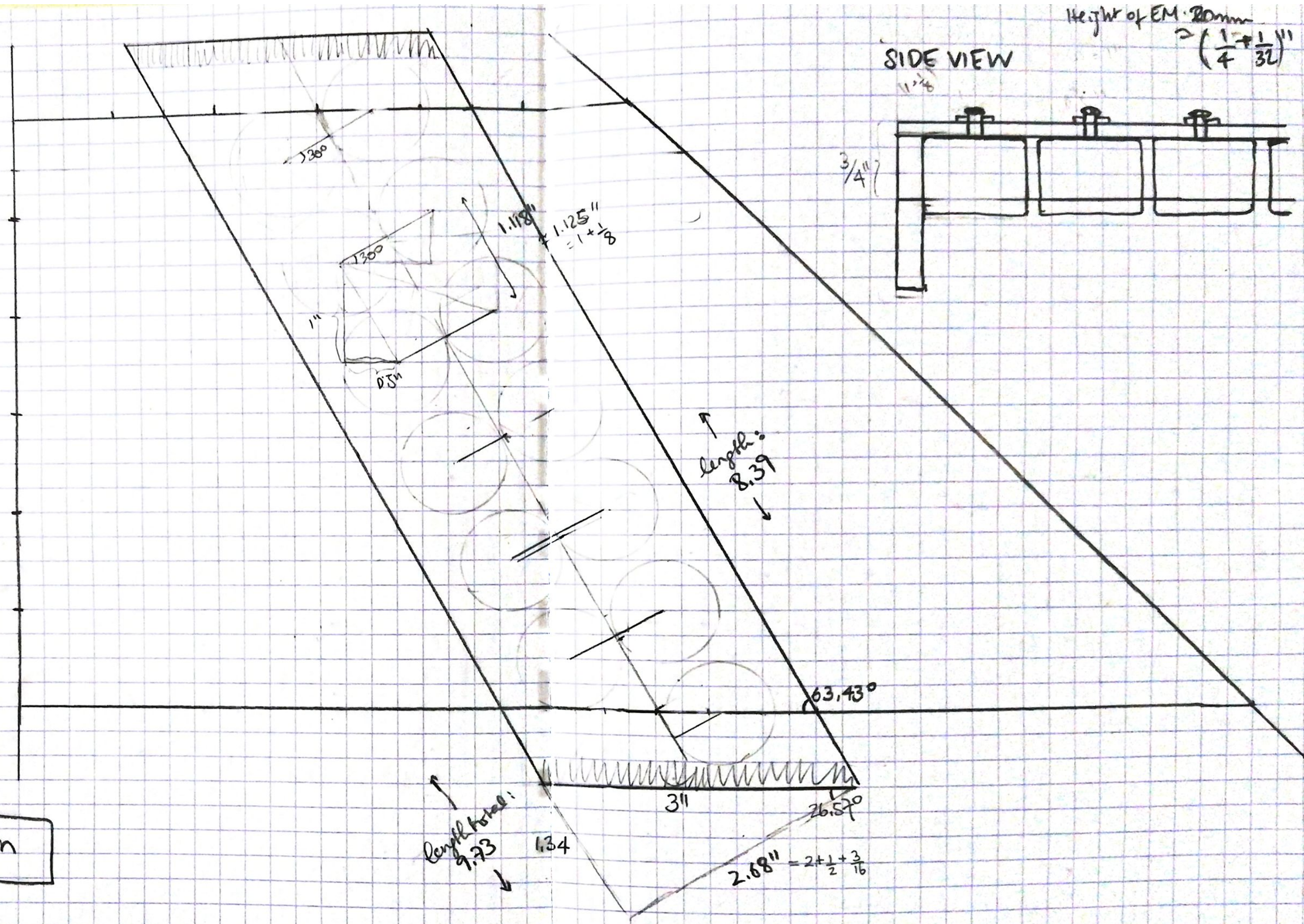
$\Rightarrow R = \frac{5}{0.01} = 500\Omega$

$l = \frac{a}{\cos 45°} + w$

$= \frac{9}{\cos 45°} + 4 \approx 16.73$

$\approx 17$

TOP VIEW

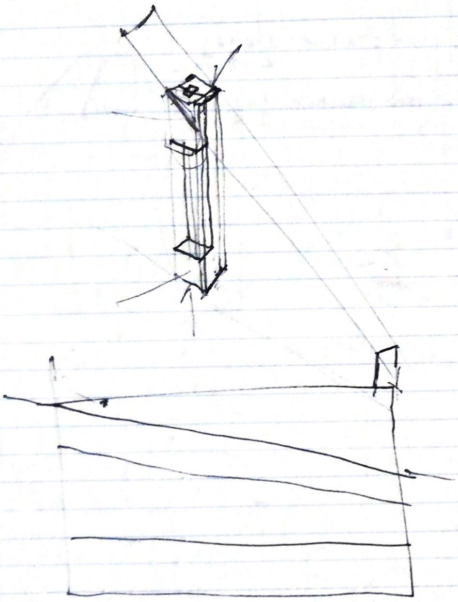


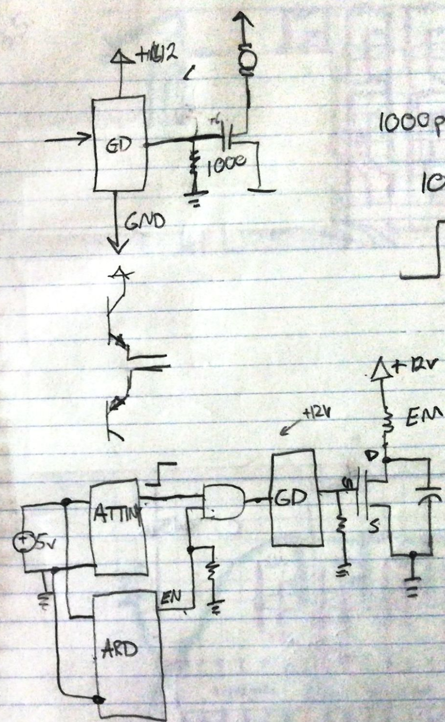

1cm = 1/2 in

Height of EM: 8mm = (1/4 + 1/32)"

SIDE VIEW

3/4"






1000pF ≈ 1nF

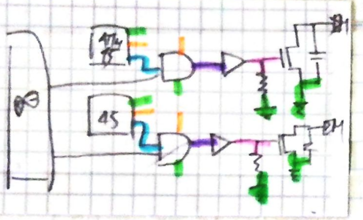
$10^{-9} \cdot 10^{3} =$

11ms →

GND
5V
12V
ATTiny45 → AND gates
AND gates → Gate driver
Gate driver → MOSFET
solder

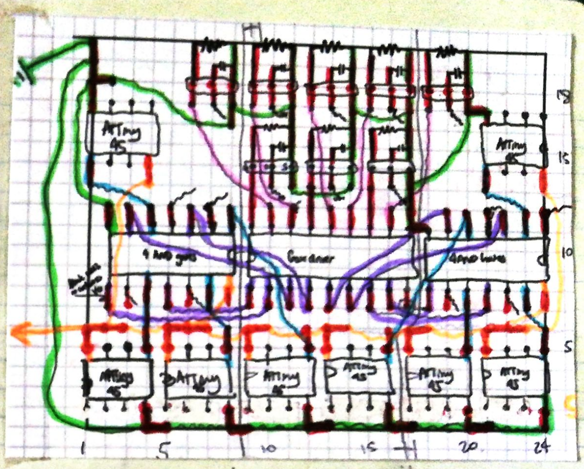
Total number of keys: 13

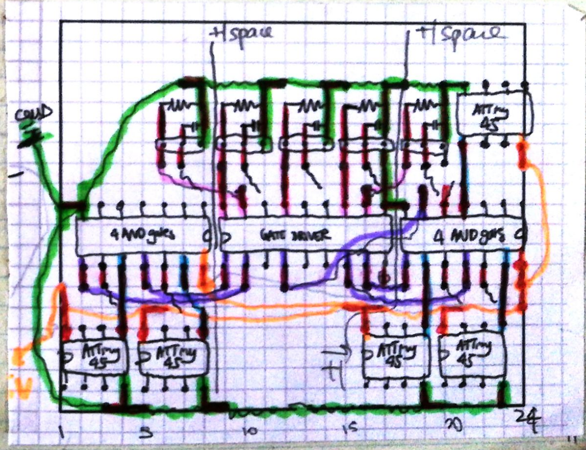
- 1 Arduino MEGA
- 2 CAP1188
- 4 Quad AND gates
- 2 MIC2981/82 (gate drivers)
- 13 ATTiny45 → in holders
- 13 MOSFET
- 13 1kohm resistors
- 13 capacitors (330uF)




C 445μs

6235



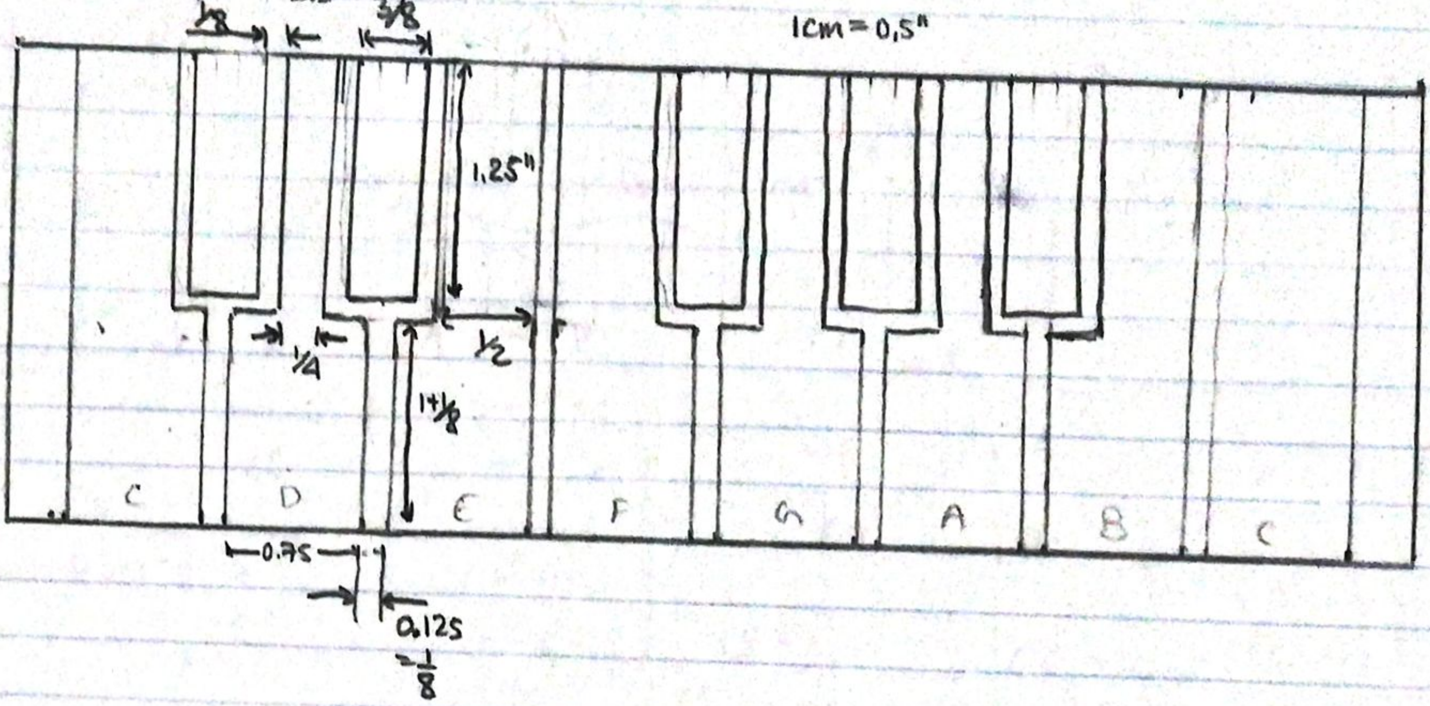



# Prototype UI

7.5×2 = 15

Dimensions: 7.5" × 2.5"

1cm = 0,5"




Width of keys: ~~0.75~~" white keys, $\frac{1}{8}$" between. $\frac{3}{8}$" black keys

Width of prototype keyboard: 6.875"

Space on sides: 0.3125 = $\frac{1}{4} + \frac{1}{16}$

Height: white keys:
black keys: ↑ + $\frac{1}{2}$"

CAP1188

AD → 3V  0x28 (top keys)

AD → GND  0x29 (bottom keys)

LED light, top (high → low)

Top6, 1 cable:

Orange Orange/White Green Green/White Blue Blue/White

SallenKey.R 1 – R5 $R_3 = R_2$

2 – R4

.C 1 – C2

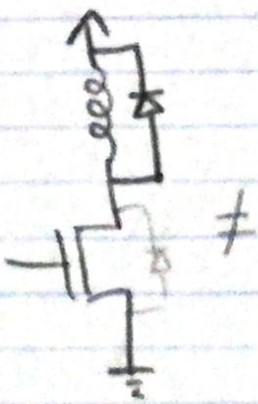
2 – C3 C9 - 220μF

RxOSC.R – R1

.C – C1 C8 - 1μF C6 = 10nF

R7 - 220 Ω

R6 - 0Ω



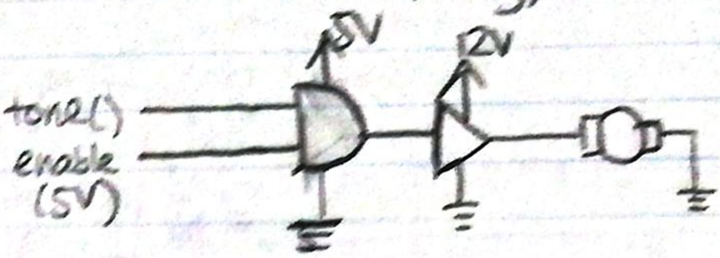
$\neq$

| | | R-OSC R | | | Sallen Key R2 | Sallen Key R1 | | | R-OSC C | Sallen Key C1 | Sallen Key C2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| fo | f-filt | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ | $R_6$ | $R_7$ | $C_1$ | $C_2$ | $C_3$ | $C_6$ | $C_8$ | $C_9$ |
| C6, 1046.5 | 1500 | 43k (43.2) | 52k | = 52k | ~~10k~~ 56 | 11k | 0 | 220 | 10n | 1μ | 0.01μ =10n | 10nF | 1μF | 220μF |
| * 987.767 | 1500 | ~~47k~~ 46.4 | 52k | 52k | 75 | 15k | 0 | 220 | 10n | 1μ | 10n | 10n | 1μ | 220μ |
| 932.328 | 1200 | ~~47k~~ 48.7 | | | 91 | 18k | | | 10n | 1μ | 10n | | | |
| 880 | 1100 | 51k (51.2) | | | 100 | 18k | | | 10n | 1μ | 10n | | | |
| 830.609 | 1100 | ~~56k~~ 54.9 | | | 100 | 20k | | | 10n | 1μ | 10n | | | |
| 783.991 | 1000 | 56k (58k) | | | 113 | 22k | | | 10n | 1μ | 10n | | | |
| 739.989 | 1000 | 62k (61k) | | | 113 | 22k | | | 10n | 1μ | 10n | | | |
| 698.456 | 900 | 68k (65k) | | | 127 | 24k | | | 10n | 1μ | 10n | | | |
| 659.255 | 800 | 69k (68.1k) | | | 140 | 28k | | | 10n | 1μ | 10n | | | |
| 622.254 | 800 | 73k | | | 140 | 28k | | | 10n | 1μ | 10n | | | |
| 587.33 | 800 | 77k | | | 141 | 28k | | | 10n | 1μ | 10n | | | |
| 554.365 | 750 | 82k | | | 150 | 30k | | | 10n | 1μ | 10n | | | |
| 523.251 | 750 | 86.8k | | | 151 | 30k | | | | | | | | |

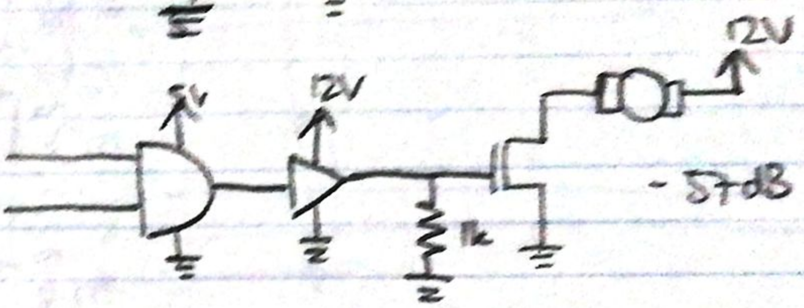
Circuit Testing, Nov 3 2018

tone(463)

electromagne
against speak
Measured wi
phone



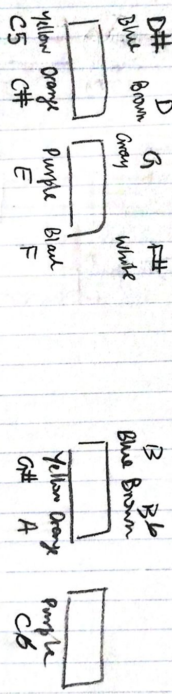

-75dB




-57dB

Definitely
use capacitor

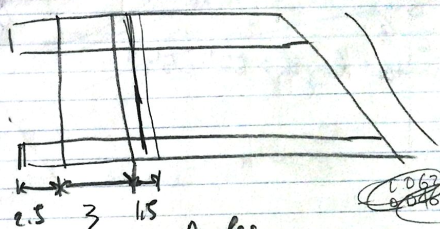
with capacitor
across MOSFET D/S : -55dB
less high freq.




Ben Steele - Westminster

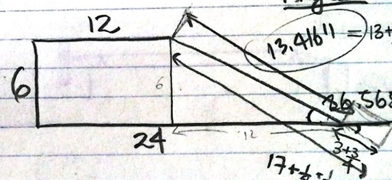
Innovative teaching showcase

Feb 8:30 - 9:30




0.0625
0.0469

## Angles




$13.416'' = 13 + \frac{1}{4} + \frac{1}{8} + \frac{1}{32} + \frac{1}{64} \approx 13 + \frac{3}{8} + \text{a bit}$

~~total length~~

$4 + \frac{3}{16} = 4 + \frac{1}{8} + \frac{1}{16}$

$17 + \frac{1}{8} + \frac{1}{32}$

$3 + \frac{3}{4}$

$4 + \frac{3}{16} = 4.1875$

$3 + \frac{1}{16} = 3.0625$

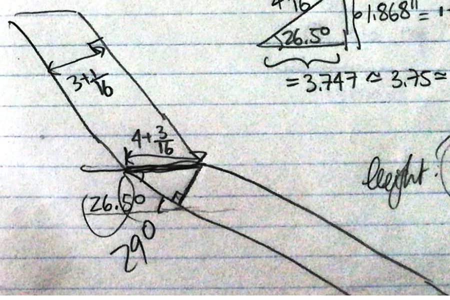
$\cos\theta \cdot 4.1875 = 3.0625$

$\theta = 43°$

$4 + \frac{3}{16}$, 26.5°, $1.868'' = 1 + \frac{3}{4} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64}$

$= 3.747 \approx 3.75 = 3 + \frac{3}{4}$

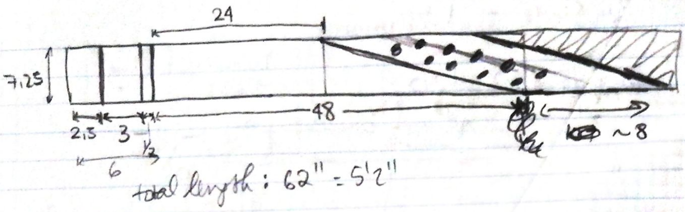
Current




length: $3 - \frac{3}{32}$

47

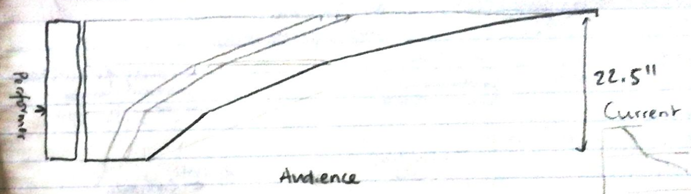
$$\begin{array}{r} 48 \\ +14 \\ \hline 62 \end{array}$$

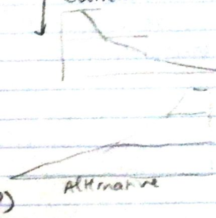


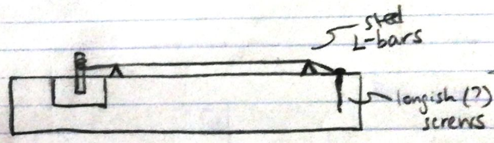

total length: 62" = 5'2"

New harp design

Top view - outline




Work plan

Harp body

① test new form idea

If OK

② redo top / middle octaves

UI

Keyboard

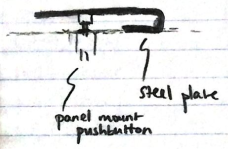
| | | | | |
|---|---|---|---|---|
| Jan 6-12 | Test/~~make~~ 3rd octave | ; | ~~order buttons~~ | |
| 13-19 | Remake octaves 1 & 2 | ; | ~~make keyboard~~ | ← MLK holiday |
| 20-26 | PCB ~~for octaves~~ 2&3 | ; | order lights stuff | |
| 27-2 | | ; | make lights/decoration | |
| Feb 3-9 | | | | ← away for audition |
| 10-16 | | | | |
| 17-23 | | | | |
| 24-2 | | | | |
| March 3-9 | | | | ← Guthman |

## Keyboard design

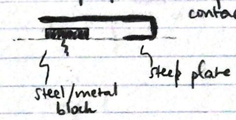
Use panel mount buttons
Digikey PS1024ARED
50ct. $31.11

Side view

1 option...




backup option - simple contact

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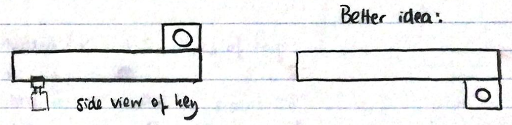
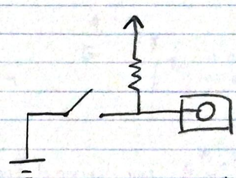
Better idea:



width of washer: $\frac{1}{32}$

total width of 37 keys:

$$\frac{36}{32} + 3\left(4\cdot\frac{1}{2}+3\cdot\frac{1}{4}+5\cdot\frac{3}{8}\right)+\frac{3}{4}$$

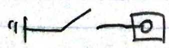
$$= 15.75$$

pinMode(buttonPin, INPUT_PULLUP)

buttonValue → low, button ~~pressed~~ released

→ high, ↓ → [illegible]

Using internal pull-up



Jan 19 Electronics Inventory

| | | | | |
|---|---|---|---|---|
| (6) | SN74F08N | Quad AND gates, | DIP | |
| (17) | RJH651 | | SMD | |
| (9) | 2426C/49T/C5L3 | | SMD | |
| (19) | LM324 | | SMD | and MISC LEDs. |
| (5) | ATTINY45 | Microcontroller | DIP | |
| (2) | MIC2981/82YN | Gate Driver | DIP | |
| alot | 1KOhm Resistor | | SMD | |
| alot | 1N4148 Diodes | | Through hole | |
| alot | 0.33μF Capacitor | | SMD | |
| (8) | 3LN80KS GK1JG | Mosfet | Through Hole | |

parts needed for next 2 octaves of harp:

| | | | |
|---|---|---|---|
| MOSFETS - | 26 | 20 | |
| ATTinies - | 26 | order: ~25 | |
| AND gates - | 8 | 4 | |
| Drivers - | 4 | 4 | |
| Multiplexers - (16 channel) - CD74HC4067 | 3 | 6 | } mount on shield |

multiplexers take 5 pins to make 16 pins. one multiplexer/octave

Arduino MEGA, 54 I/O pins

~~[illegible]~~

Drill Bit Sizes - Harp "final" octave
1/20/2019

Flat-head screws pre-drill in pin block : 13/64"
Flat head screws pre-drill in 10x2x10 : 11/64"
Pins in pin block : 9/32"
Head of flat head screws on pin block : 1/2"

Width of button slots (keyboard) : Dodo blades + $\underbrace{\text{4 rings/disks}}_{3/64"}$ + 4 thicker ones

height of bridge : 3/8"
height of bridge slot : 1/16"

predrill for philipp head screws (hitch pins) - 1/16"

"Final" ~ Guthman Harp Circuit

I. Keyboard/UI → single keyboard

INPUT
- 37 keys → 37 buttons → 37 Arduino I/O pins
  - → each connected to GND and a resistor to 5V.
- 2 switches → 2 Arduino I/O pins
  - → each connected to

OUTPUT
- 37 notes → 37 Arduino I/O pins

so total : 76 I/O pins

* Arduino mega : 54 digital I/O, 16 Analog Pins : 70
* so use GPIO expanders, MCP23008 (8 channels)
* Or use arduino nanos, 8 of them
* try TI board

II. Electromagnets → ~~modular units, one board per octave.~~

If 1 board : 5 gate drivers, 10 AND gates

If 3 boards : 6 gate drivers, ~~10~~ - 12 AND gates

MIC2981 - 8 channels

AND gates - 4 channels

use a connector for enable inputs

MODULAR UNITS, 1 per octave

Inputs from Keyboard switches → use INPUT_PULLUP

multiplexers ~~A1~~ U1: 2-6
U2: 8-12
U3: 14-18

circled → COM pin
uncircled → S0-S3

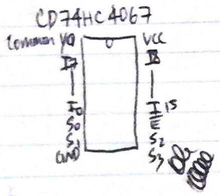
Outputs from MEGA to EM board

VGA connectors
U1: 22-~~34~~
U2: 38-50
U3: A2-~~A14~~ A14

Other stuff: switches for sustain (2): A0, A1

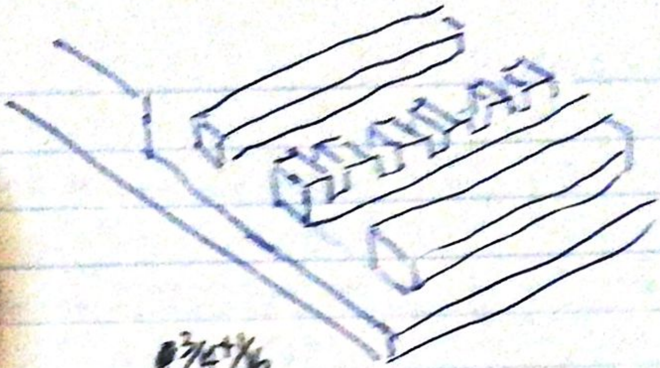
Essentially.. ① take input from the keyboard ~~switches~~ button by sweeping through the multiplexed inputs and storing the status of each button in an array.
② if switch is changed to on, push the button status array into a switch 1 array. Ditto for switch 2. If off, clear the array.
③ Combine the switch array and button status array into a play array with OR.
③ digital write that play array to the appropriate output pins.

CD74HC4067



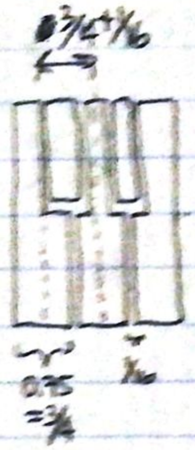

U1: C3-C4
U2: C4-C5
U3: C5-C6

| | | U1 | U2 | U3 | |
|---|---|---|---|---|---|
| Multiplexer pins | Common I/O | 2 | 8 | 18 | INPUT_PULLUP |
| | S0 | 3 | ~~10~~ 9 | 17 | OUTPUT |
| | S1 | 4 | 10 | 16 | |
| | S2 | 5 | ~~12~~ 11 | 15 | |
| | S3 | 6 | ~~13~~ 12 | 14 | |
| Output pins | Enable output | 22-34 | 38-50 | A2-A14 | OUTPUT |
| Sustain pedal switch | A0, A1 | | | | INPUT_PULLUP |



width of button 5/16" or 9/32"
length . 1/2" + 1/16 9/32"

[illegible]



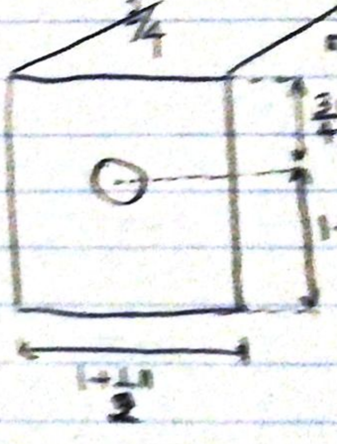


$\frac{1}{2}\left(\frac{3}{4}-\frac{9}{32}\right)=\frac{1}{2}\left(\frac{24-9}{32}\right)=\frac{15}{64}$

$=\frac{1}{4}-\frac{1}{64}$

let's approximate that to 1/4

height of rod support




2nd octave new pinblock:

$\left(7+\frac{3}{8}"\right) \times \left(3-\frac{1}{32}"\right)$

L W

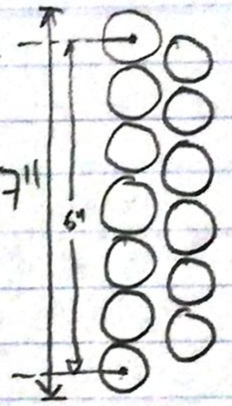
★ no weird angles! ★

# EM Bridges

PCB dimensions: $7+\frac{3}{8}$" × $2+\frac{3}{8}$"

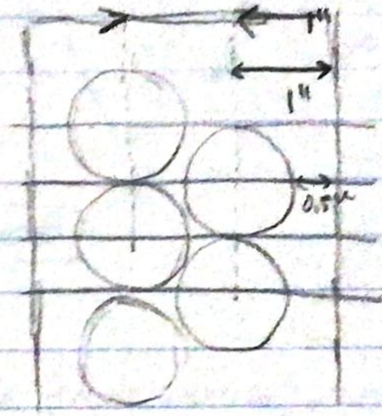
Bridge height: 1.5" (supporting side piece 1.5"×3")
dim: 8"×3"

13 strings:




EM diam: 1"

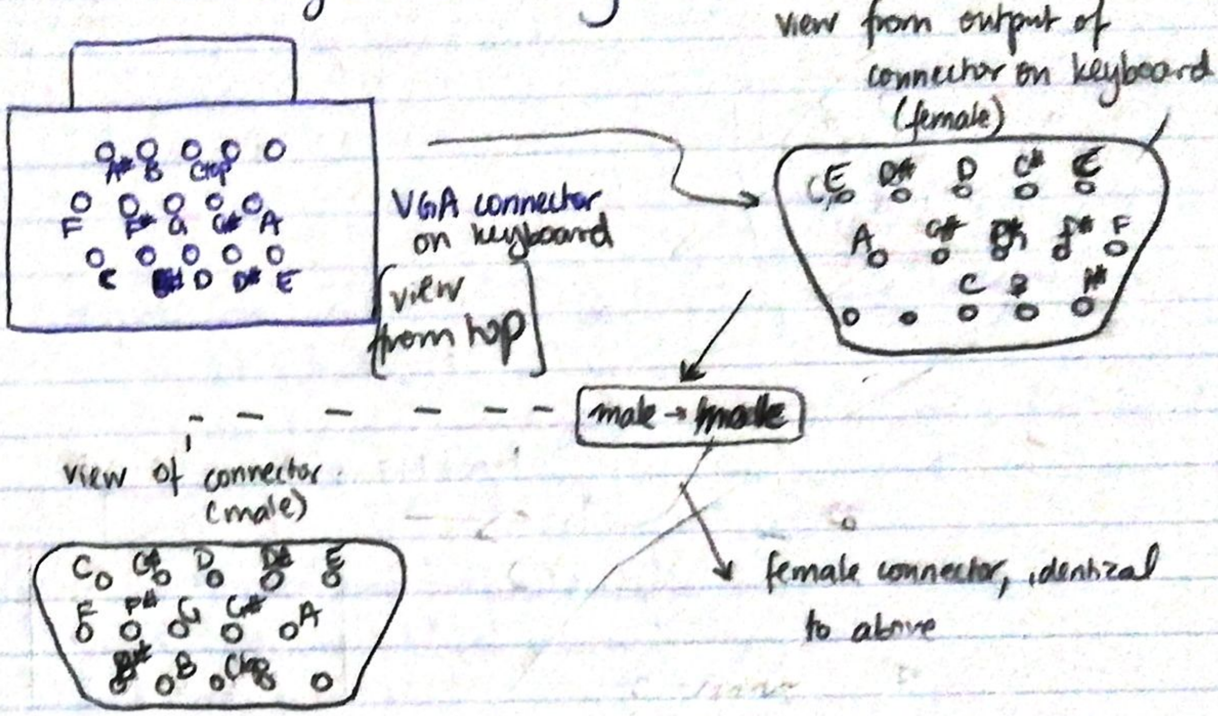
String spacing: 0.5"



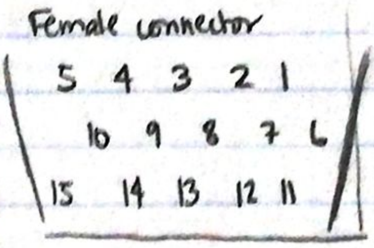

$\frac{5}{8} \cdot \frac{1}{2} = \frac{5}{16} = \frac{1}{4} + \frac{1}{16}$

Drill bit for EM mounting screws: 5/32"

# EM bridge connector wiring




Female connector




| | | |
|---|---|---|
| 1 green-red | 6 pink-red | 11 yellow single |
| 2 green-white | 7 pink-white | 12 orange single |
| 3 blue-red | 8 tan-red | 13 purple single |
| 4 blue-white | 9 tan-white | 14 silver-white |
| 5 red single | 10 gray single | 15 silver-red |

~~Monday~~ Monday progress: keyboard done

Tuesday progress:

→ VGA cable soldered to Coulomb octave

→ working notes: C, C#, D, G#, A, B — maybe? B3?

output from keyboard not working — connected to each other & to ground

E3, F3, ~~E#3~~, G3, (set to zero always)

input from keyboard OK

Inside the ~~Amazon~~ male-male cable:

singles: red, blue, black, green, brown, yellow

thick: red, green, blue

15 inputs on connector

9 wires    ~~12~~ notes ~~[illegible]~~

BECAUSE VGAs SUCK... (and because I was asleep)

Arduino shield board ] VGA female

wires [ EM board

must go to

male plug

so!

(breakout board?) male headers

female jumpers

male jumpers

or an extra set of wires here

female headers

breakout board (i.e. DIY connector)

female headers

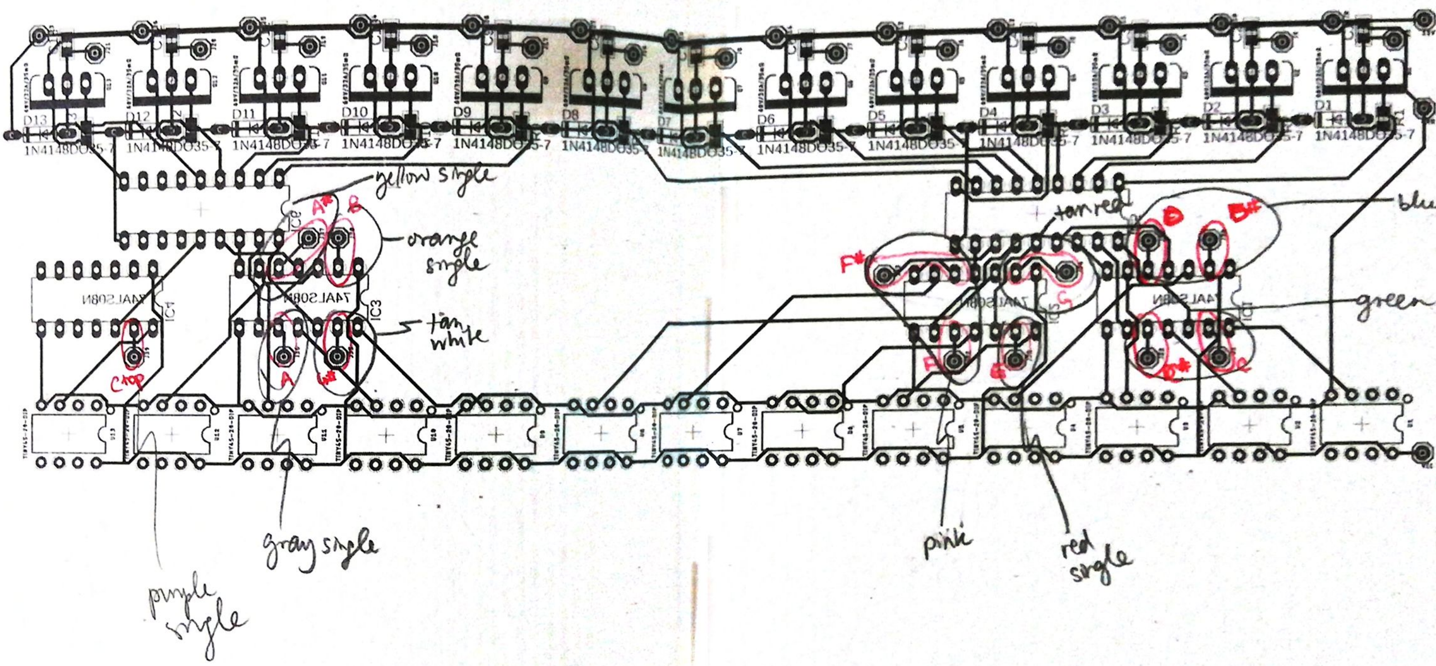
because a VGA plug cannot be soldered directly to a through-hole board.

Otherwise we make our own VGA breakout board to pin header...

OPTION 2

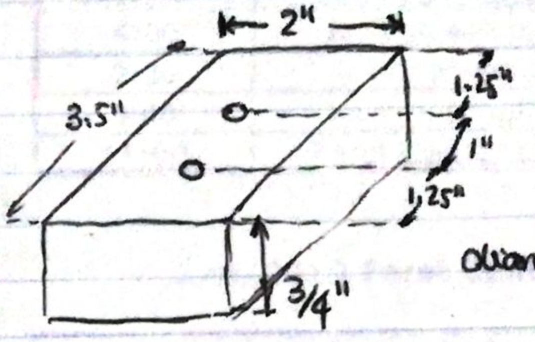
desolder VGA connector and replace with male jumpers to connector breakout board, which connects to EM board.

DIY the VGAs ~~for~~ with headers



D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
1N4148DO35-7
74ALS08N
IC1
IC3
yellow single
orange single
tan white
gray single
purple single
pink
red single
tan red
blue
green

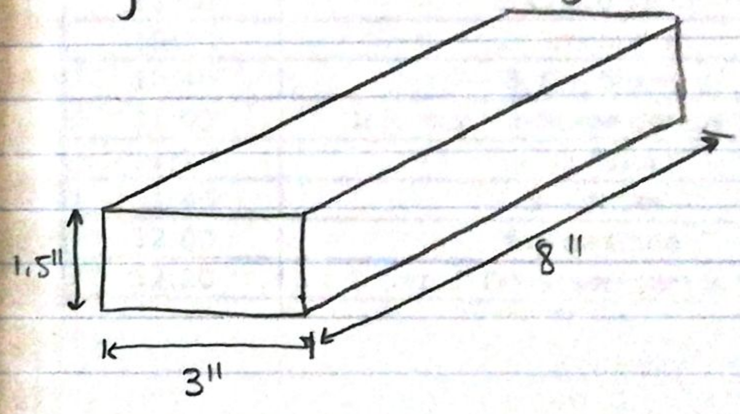
Pedal buttons on keyboard




height of switch: 1/2"

diameter of hole / drill bit size: 1/4"

Acrylic box on EM bridges



# 2019 MARGARET GUTHMAN NEW INSTRUMENT C

## DRAFT SCHEDULE

| TIME | PERFORMER/ EVENT | LOCATION |
|---|---|---|
| 4:00 | load-in, setup, and sound checks | main stage |
| 7:30 | Pamela Z concert | West Village 175 |
| 9:00 | load-in, setup, and sound checks | main stage |
| 11:00 | Ferst Center closes; setup ends | |

**3/8/2019 Ferst Center for the Arts**

| TIME | PERFORMER/ EVENT | LOCATION |
|---|---|---|
| 8:00 | continental breakfast available | back stage |
| 8:00 | load-in, setup, and sound checks | main stage |
| 9:45 | Welcome and General Information | main stage |
| 10:00 | 1. Chord Viola | main stage |
| 10:20 | 2. Arcontinuo | main stage |
| 10:40 | 3. GeoShred | main stage |
| 11:00 | Informal On-Stage demos (1,2,3) | main stage |
| 11:20 | 4. AirSticks | main stage |
| 11:40 | 5. Koritas | main stage |
| 12:00 | 6. The Glide | main stage |
| 12:20 | Informal On-Stage demos (4,5,6) | main stage |
| 12:40 | Break | |
| 2:00 | 7. SpiderHarp | main stage |
| 2:20 | 8. Hit-Strike-Play | main stage |
| 2:40 | 9. Biot-Savharp | main stage |
| 3:00 | Informal On-Stage demos (7,8,9) | main stage |
| 4:00 | Ge Wang Lecture | Reinsch-Pierce Auditorium |
| 5:00 | Break | |
| 8:00 | Roger Linn lecture / demonstration | Ferst Center Main Stage |
| 9:00 | load-in, setup, and sound checks | |
| 11:00 | Ferst Center closes; setup ends | |

**3/9/2019 Ferst Center for the Arts**

| TIME | PERFORMER/ EVENT | LOCATION |
|---|---|---|
| 9:45 | Welcome and General Information | Main Stage |
| 10:00 | 10. Kaurios | Main Stage |
| 10:20 | 11. Spinstruments | Main Stage |
| 10:40 | 12. QJin | Main Stage |
| 11:00 | Informal On-Stage demos (10,11,12) | Main Stage |
| 11:20 | 13. S.R.I Mrudanga | Main Stage |
| 11:40 | 14. Mission Control | Main Stage |
| 12:00 | Informal On-Stage demos (13,14,15) | Main Stage |
| 12:20 | break | |
| 2:00 | sound checks / tech setup as needed | |
| 5-6:30 | contestants meet w/ host and VIPs | |
| 6:00 | lobby opens | |
| 6:30 | house opens | |
| 7:00 | finals event begins | main stage |

Guthman Presentation Outline

Harp Performance
① Piazzolla
② New piece

* Demo performance - Piazzolla
5 * Demo performance - New piece ← all sounds are acoustically produced
* How the harp came to be - EMs as a way to actuate strings, give credit to PMC

THE BIOT-SAVHARP IS AN INSTRUMENT ENTIRELY DESIGNED AROUND ITS SOUND

① Engineering - how it works — modular design, by component/ by octave

Keyboard buttons / sost. buttons ] keyboard
↓
Arduino MEGA ] microcontroller enable signals
↓
5 EM boards : ATTiny squarewaves driver circuit ] generate square waves for EMs
↓
strings on harp damping system ] make sound

+ amplification

② Design - how it is played
Musicality
→ simulated vibrato with damping system
Special effects
→ plucking /
→ reverb/volume control
5 → harmonics

③ Place in music world

→ other EM based projects (Andrew McPherson) have shown this is a big thing

A dedicated instrument to the possibilities of EM-based string actuation

→ sound for film scores, classical, pop, etc.

ICONIC, INCOMPARABLE SOUND

The Biot-Savharp belongs to the unique class of instruments that have a sustained ~~[illegible]~~ & uniform sound.
As such, I also see a new repertoire created for it.

④ Future developments.
- individual note volume control
- wider range

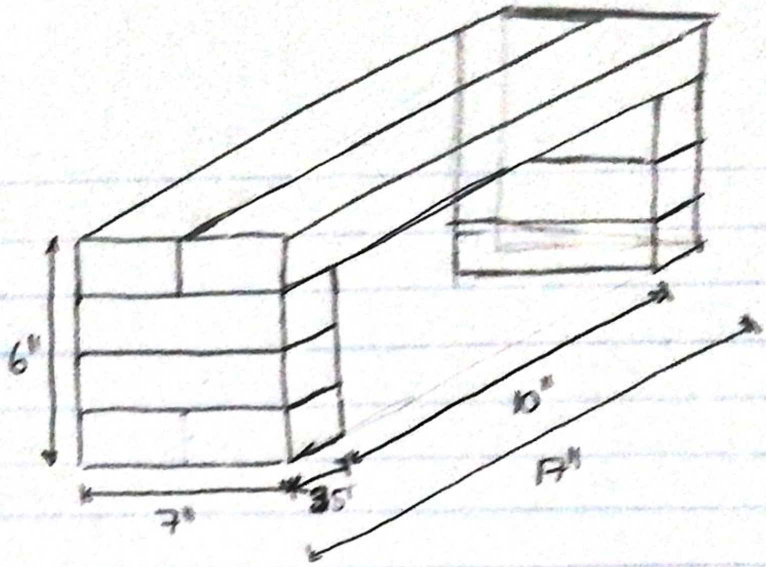
?

Biot-Savharp Guthman Presentation

- Entirely acoustic, designed entirely around the SOUND

HOW IT WORKS
- Underlying physical principle
- Keyboard (discrete), sostenuto switches
- Arduino MEGA (logical ANDing)
- 37 ATTinies, EM driver circuit
- Damping system
- Modular design, by component & by octave

HOW IT'S PLAYED – special effects
- simulated vibrato
- harmonics on plucking
- harmonics (EMs)


6"
10"
17"
7"
35"