

ECE Senior Design

Team P.V.I.R

Lukas

10-1-2018

Project Advisor: Lukas
Graber

Project Name: Underground Power Vault
Inspection Robot

Contact Info:

Adrian Munoz

Phone #: (478)-973-1989

e-mail: am262601@gatech.edu

Team Members:

★ Stephanie Chan
(678)-972-0273
schan40@gatech.edu

★ Elizabeth Fuller
(478)-919-4407
efuller3@gatech.edu

★ Lemex Robinson
(678)-808-9046
lrobinson61@gatech.edu

★ Nelson Raphael
(678)-595-3833
nraphael7@gatech.edu

Link to Folder w/ Links for reference

<https://docs.google.com/document/d/>

★ GitHub links to find software
★ Mechanical Arm

[GitHub.com/H012GraberSeniorDesign2019](https://github.com/H012GraberSeniorDesign2019)

Table of Contents Second Pg

John

Date

Title

10-1-2018

1/08/19	Group meeting w/ Dr. Graber	23
1/8/19	meeting cont'd	24
1/9/19	meet w/ Group	25
1/10/19	Mechanical Arm CAD design	26
1/14/19	Group Meet Prep for Presentation	27
1/15/19	Blank Pg	28
1/15/19	Advisor Presentation/1st half	29
1/15/19	Advisor Presentation/2nd half	30
1/18/19	Mechanical Arm Sketch	31
1/22/19	Blank Page	32
1/22/19	weekly meeting w/ Dr. Graber	33
1/22/19	Arm design Considerations	34
1/22/19	Robot Motor Research	35
1/24/19	Things to consider	36
1/25/19	Parts Considered	37
1/25/19	Solutions Pros/Cons	38
1/25/19	Block sketches / Ideas	39
1/29/19	Group Meet w/ Dr. Graber	40
1/29/19	Group Meeting w/ Dr. Graber	41
2/06/19	Personal Meeting w/ Dr. Graber	42
2/07/19	Meet w/ Dr. Graber	43
2/8/19	LEF + Blank	44
2/8/19	Robot Arm Parts	45
2/8/19	Robot Arm Parts	46
2/12/19	Group meet w/ Dr. Graber	47
2/12/19	Group Meet w/ Dr. Graber	48
2/13/19	Mechanical Arm design sketch	49
2/16/19	Design Sketch	50
2/22/19	Group Meeting Lab Work	51
2/25/19	Intentionally left Blank	52
2/25/19	Hive Group Meeting	53
2/25/19	Mechanical Arm Design	54
2/26/19	Meet w/ Dr. Graber	55
2/26/19	Mechanical Arm Update	56
2/27/19	AE Machine Shop Visit	57
3/5/19	Blank Page	58
3/5/19	Blank Page	59
3/5/19	Blank Page	60
3/5/19	Meet w/ Dr. Graber	61
3/5/19	Meet w/ Dr. Graber	62
3/10/19	Power Schematic	63
3/12/19	Blank page	64

Table of Contents Third Page

3-14-19

Date	Title	Page #
3-12-19	Group meet w/ Dr. Graber	65
3-12-19	Group Meet w/ Dr. Graber	66
3-12-19	Group Meet w/ Dr. Graber	67
3-13-19	Invention Studio	68
3-13-19	Blank Pg	69
3-13-19	Group Meet w/ Elizabeth	70
3-13-19	Group Meet w/ Elizabeth	71
		72

Spring 2019
★ Robot Name
(PUIR)

Group Meeting w/
Dr. Graber

1-8-2019

★ Scheduling

★ Preparing for presentation and proposal

Dr. Graber's Proposal Feedback

★ Show how the communication works

For example, communication between
raspberry Pi and Tango Tablet

(emex)
Side: Tango Tablet is difficult to communicate
Kinect Camera issues

- processing
- power

Dr. Graber asked us whether we want to buy the
The mechanical arm or pursue a design

★ The Islot design sounds most appropriate

★ Design the arm so that it can reach
and inspect a vault at a height range
between maybe 1 m - 7 Ft.

For demonstration,

★ Print out a board that simulates the
Vault conditions

★ Expand the (Project Demonstration)
section of the Proposal

★ Expand

★ State everybody's role on the team
- documentation
- website
-

Make a chart of the roles

1-8-19
★ Add a Column to the tasks list

How can Dr. Graber help?

★ Schedule weekly meeting

Tuesdays 4:30 - 5:30

Plan to have the presentation by
Tuesday 1-15-18

★ stop using bit map pictures
and use vector graphics format

★ Any questions we can ask Tony From
Bunger Henry
To do list:

★ Finalize Proposal 1-9-19

★ Prepare Presentation 1-9-19

Files to access throughout
semester in location
drive: Google.com/drive/folders

Group Meeting w/ Group 1-9-19 (1-9-2018)
Update Project proposal - Goal

Identify the different roles each group member will take on in robot

Expand Project Demonstration Section

Adrian will focus on Mechanical Arm design and write about his approach on the Final Presentation report.

Attached a tasks list

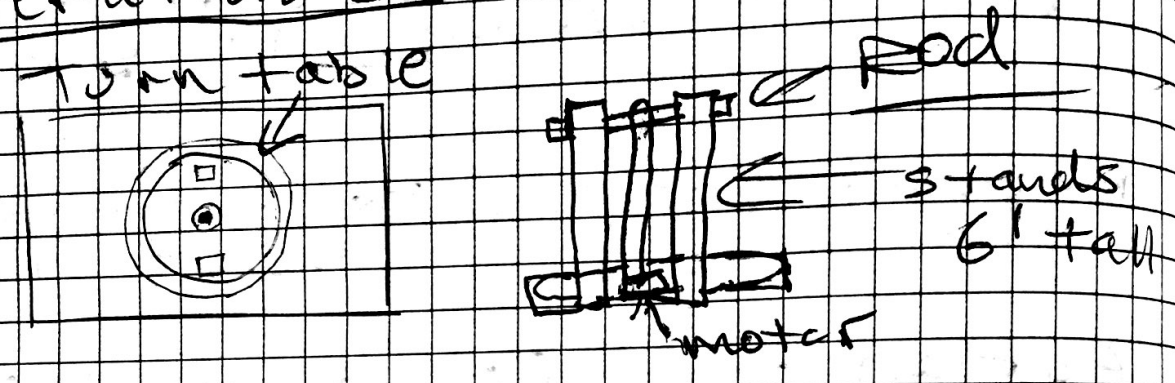
Made a chart w/ the different roles w/in the team

Presentation made according to tasks on Project Proposal

Practice Presentation 1-11-19

1-10-10
Blair


Mechanical Arm CAD design Iteration 1 design



Researched Parts that
could be used and compared
to potential

Group Meeting Preparation For Presentation

1-14-2019

* Proposal Presentation For 1-15-19 meeting / Presentation

- Introduction
- Goals
- Specifications (Mech. Arm, Sensor Package, GUI Specs)
- Design Approach Overview
- Design Approach (GUI)
- Design Approach (Control System)
- Design Approach (Mechanical Arm)
- Testing Procedure and Criteria
- Schedule
- Status

To Do List

1-14-19

☒ Practice Presentation skills

☒ Dress appropriately

1-15-19

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left Blank

1-15-19
Adams
12

Advisor Presentation (CDr. Graber)

1-18-19

* Add expo presentation

~~Alum~~

* Add Final Report

⇒ Upload presentation to website

Speed Controller has a low freq.

→ If you can produce the signals of the servos and motors to the Arduino then keep that.

Find the current input needed for Robot motors.

1-22-19

Look up

3D Printer
Rep Rap.me
Parts

2 ways to make robot move

* RC Servos

* Stepper Motors - super cheap

Think of the 3D Printer Design

* Lead screws

* Rails

* Bushing Motors 12mm rail bearings

* Pulleys

* Lead screws (For either T-slot bars or linear bearings)

* Coupler b/w the shaft and the

Aluminum turn table

Lazy Susan Design (Amazon)

Power into the Robot what?

1-15-19
Adrian
we

Keep in mind For example,
1 Stepper Motors use ~1.2 Amps
Currently we have 2 batteries

2 Parallel Designs Currently
For Robot Arm Design
1) T-Slot Design

2) Lazy Susan Design

Next Meeting,

✓ Test ~~the~~ Old Parts

1-18-19

✓ Start
Sensor Package Schematic

1-22-19

□

✓ Have updated Proposal submitted by
end of week

1-18-19

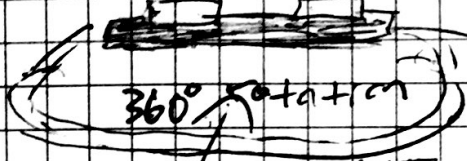
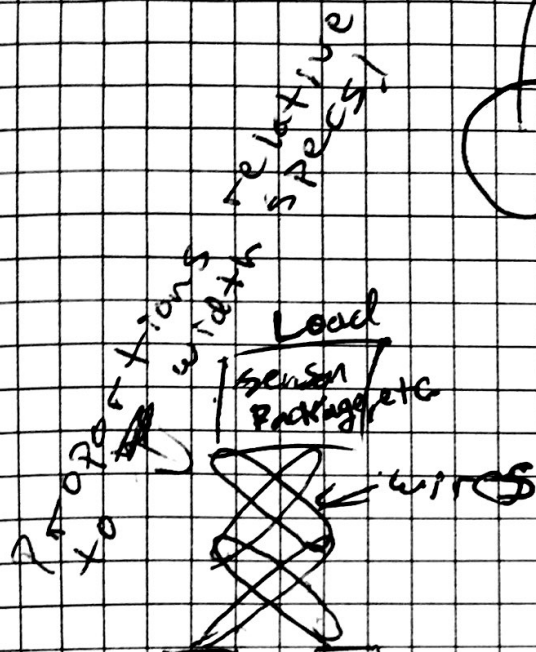
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Mechanical Arm Sketch

Servo Motor

1-18-19

Blank



THK linear Bearings

Robot

Movement

Intentionally Blank

Intentionally
Left Blank

11-22-19
Adams
MD

Weekly
Meeting w/ Dr. Gruber

1-22-18

Almas
M

Bring Presentation slides for upcoming meetings

* Project Updates

* Plans

* Gantt chart

Game Controller Mapping (Elizabeth)

List of Robot Functions

* Turn lights on/off

* General movement

* Rotate "Lazy Susan"

* Tilt movement

* Lift/lower camera

* "Reset" brings the camera back to a default position

* Toggle speed control -

* Capture an image - useful

Suggestion: have both Joy sticks
controlling each motor independently

* Have a Feedback mechanism to know
where the camera is located vertically

Arm design Considerations

1-22-19

Notes
AM

* Ball screw instead of Lead screw

* Continue w/ T-slots as structure

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Robot Motor type research (1-22-19)

DC Motors

- * Cheap
- * Robust
- * High gear reduction
- * Torque is slower
- * Less current used
- * Back speed control
- * ~~micro-controller~~ connection is easier

Brushless Motors

- * Higher torque/speed
- * Costlier/expensive
- * Lasts longer
- * Higher current used
- * Less Robust
- * ~~lasts~~ LESS maintenance

Servo Motors (S.V.)

- * 3 terminals (Power, Gnd, Control (PWM))
- * Very Fast relative speed
- * Has Feedback mechanism (b/c of Potentiometer inside mechanism)
- * Takes more current
- * Limited angle of rotation
- * Fast Response
- * Less holding torque

Stepper Motors

- * Move in steps
- * Take less current
- * More holding torque
- * No F.B. mech
- * Unlimited angle of rotation
- * Slower than servomotor
- * Need just a pulse to move a step

Vinh T. Nguyen

Vnguyen43@gafech.edu

Double Major
EE/ME

does machining
w/ Robot
Arm

Truy:

D.R. Roberts

Prof. (MRDC)

Top Floor

1 ϕ motor

$$P = VI \cos \phi$$

$$1 \text{ HP} = 746 \text{ (W)}$$

Learn. adafruit.com

11-24-19
Adrian
MD

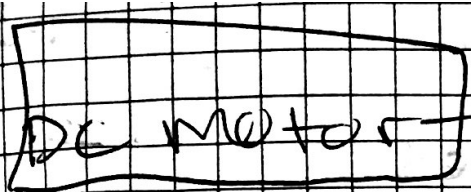
Things to Consider

- ★ Have two micro-controllers
- ★ CAN Protocol for comm between both controllers
- ★ b/c connected over 6' or 9' or 12' etc
- ★ Sensors talk I²C to microcontroller

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ALNSE
LANSE

M



large: small
w/ a gearbox and encoder

stepper ex -

servo motor - don't spin forever
- cannot spin

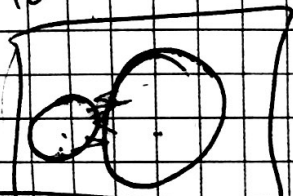
Form factors

potter.com

robotshop.com

Macmaster-Dowell

Turn table w/ gears
on edges



1675 (mm)

2 - T slots

1 - Solid

rotating
rod

1 - Package Plate

0" - Solid-surface
Positioning

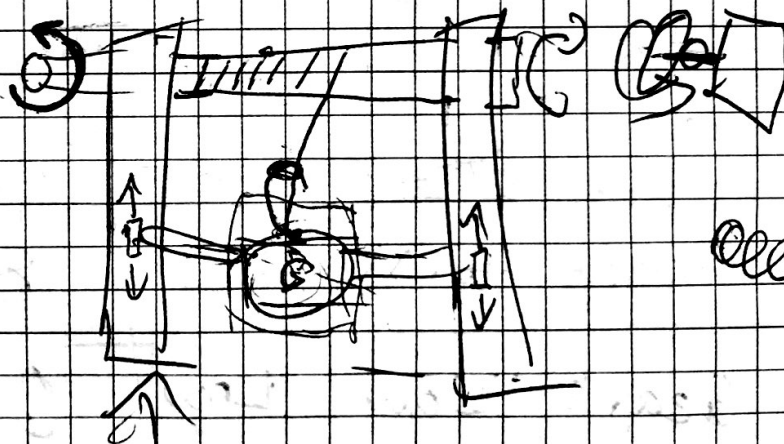
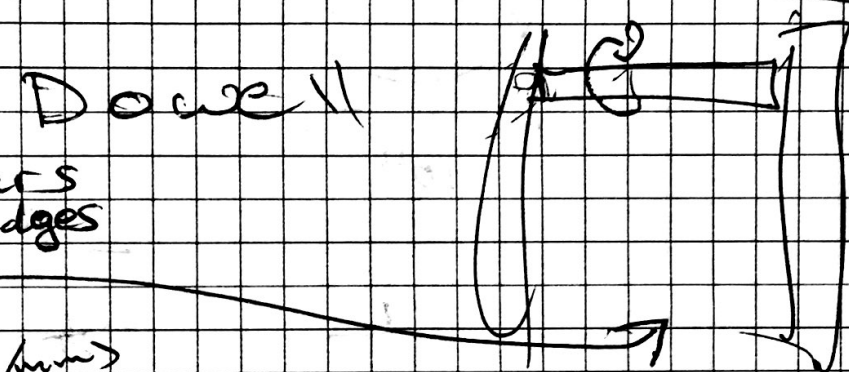


9.215

13.268



Base



0.000

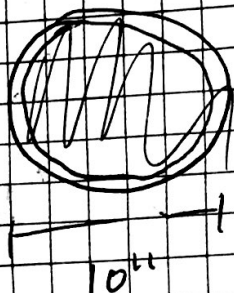
T-slots

Adrian

Pg. 37

Gear Rod Stock Solutions & Prices

Price
\$26.21 1-20
 Admin
 MW

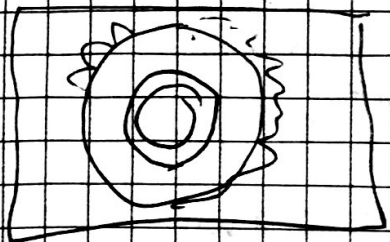


Sol.	Effect	Cost	Pts. / 10 pts
Turntable	High	Low	8
Gears	Low	Low	6
Hinge mech	Low	High	4

Solid Surface
 Positioning Turntable - 1

Sketches / Ideas

11-25-11

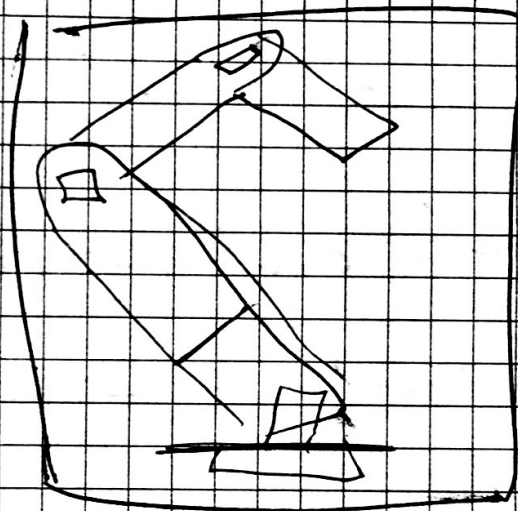


~~Abhin~~

~~me~~

attached

~~part~~



Inner Diameter

146.05 (mm)



Sketches

Outer Diameter

8.5" = 215.9 (mm)



19.88" = 505.09 (mm)

1" = 25.4 (mm)

1-29-0

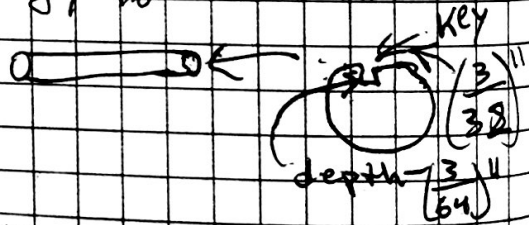
mount holes .75 (in) = 19.05 (mm)

T-S lots mounted to → .281" holes = 7.1374

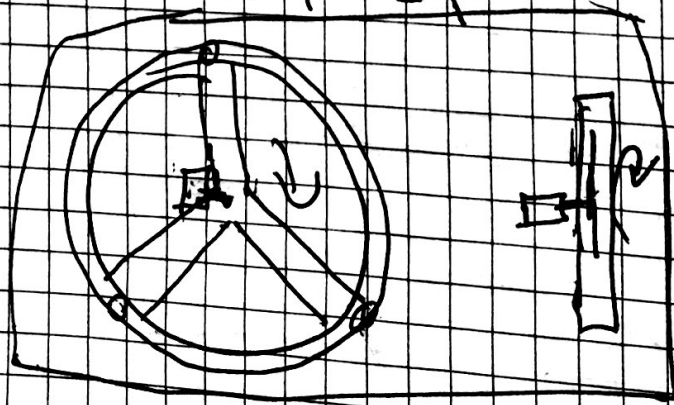
T-S + O + S 6 Ft.

motor - 2.2" = 55.88 (mm)

Keyed Rotary Shaft - 12" Long, $\frac{5}{16}$ " Diameter



Platform
To 7 Idea



Group meet w/ Dr. Graber | 1-29-2011
Adrian

- Parts (update) order

- 1.) First order will be sensors and test material
- submit first order on 1/30
- First order form presented in meeting

2.) Parts to Consider / recommend

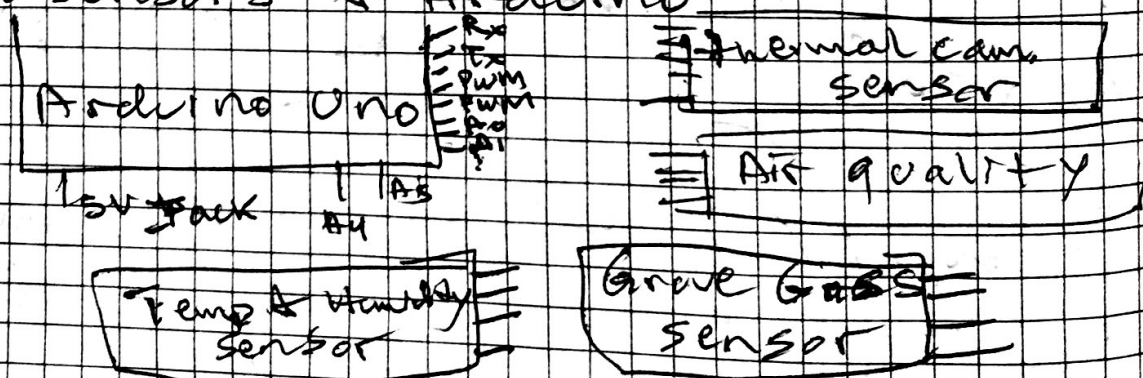
⇒ RPi Night Camera

- Good For low light areas
- smaller and lighter
- need to figure out how to mount

⇒ Sensors

- will not use I2C ports
- will use Analog signal ports
- Made by Arduino

Overall System Schematic 4 sensors & Arduino Version 1.0



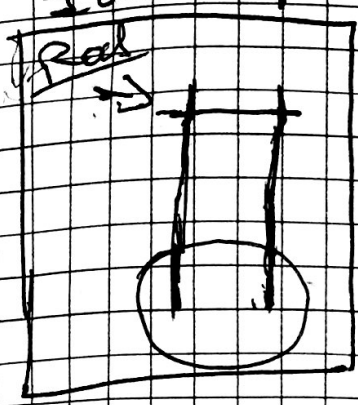
Action Items

- Stephen - Place order for parts, get locker
- Elizabeth - Mount for RPi camera
- Nelson - Finish CAD drawing for lead screw
- Adrian - work on CAD drawing for arm
- Lemek - Continue working on GVI

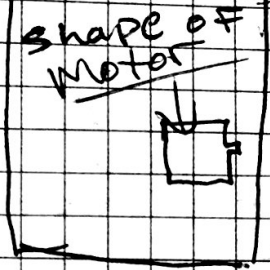
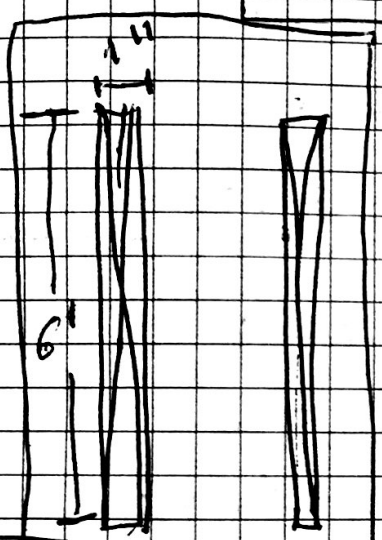
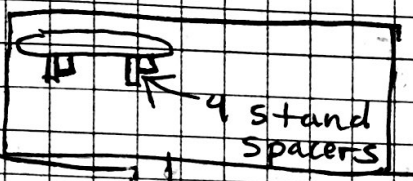
Pg. 42 | GROUP: Scrap old Robot (1-30-11)

Personal Meeting w/ Dr. Graber
 Mechanical
 Arm
 Ideas / Specs

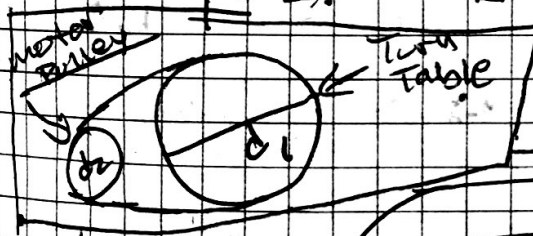
2-03-2019
 222



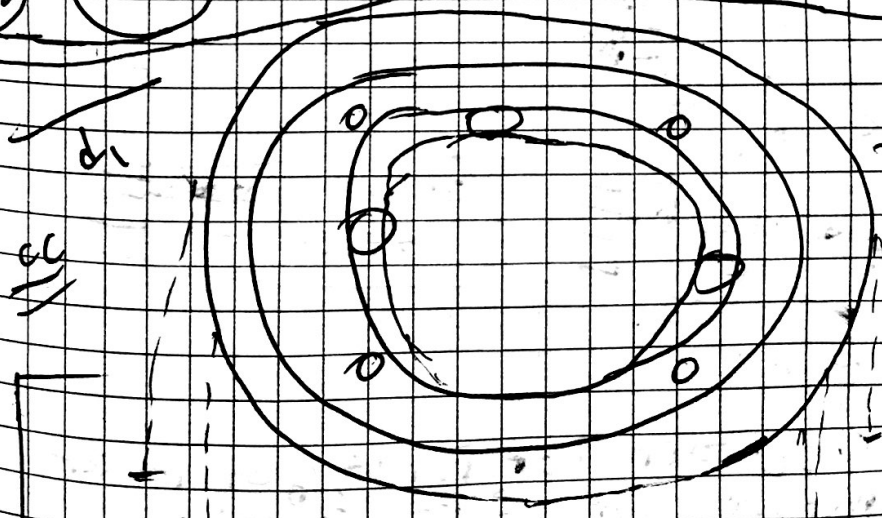
- ★ 1" T-slots, 6ft tall
- ★ Round-Belt pulleys
- ★ Nema 17 Motor (stepper)
- ★ D-shaft



- ★ Smooth Round rubber belt
- ★ V-belt pulley (research)



- ★ Aluminum Plate (1/8" or (water-jetted) Platform
- ★ Motor pulley for top platform



Turn-table w/ standoff spacers

Robot Top plate

2-06-19

General Meeting w/ Dr. Graber

2-6-19

* Try to include Fault control scheme or add it if scheme was removed

* Gas sensors

Nelson's Visit: Next Monday (2-11-2019)
(Neetrack)

* Include linear regulators

* CO sensors pin-out from ~~schematics~~ Data sheets hard to figure out

* remember, it is hard to implement

* GUI - working on implementation to raspberry pi.

* Include histogram and update to GUI

Motor w/ retraction

Personal Action Items

Adrian - work on Arm design (2-6-19)

Schedule a meeting w/ Dr. Graber and Nelson.

* Send Dr. Graber an e-mail to schedule.

Planned Action Items

- Lemek - continue to work on GUI, Test G5 sensor w/ RPI
- Stephanie - submit order forms for arm parts and power supply
- Elizabeth - calibrate gas sensor and temp sensor
- Adrian - Finish CAD drawing and submit a bill of materials for Arm
- Nelson - Help Adrian with arm CAD design and maybe work on communication Pg. 43

Ctrl 7/ISO

2-8-19
Address
RD

Intentionally
left blank

Robot Arm parts

LxWxH

2-8-19

③ ~~Star~~ T-slots - 6" x 1" x 1" → 6" x 1" x 1"

McMaster
\$17.68/ea

④ ~~Star~~ Round Turntable (AU) OD=12.8"

McMaster
\$37.03

⑤ ~~Star~~ 1" Pulley

\$13.12

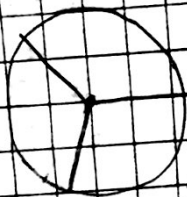
⑥ ~~Star~~ Round Belt Diameter: 1/4" AC=52"

\$14.75

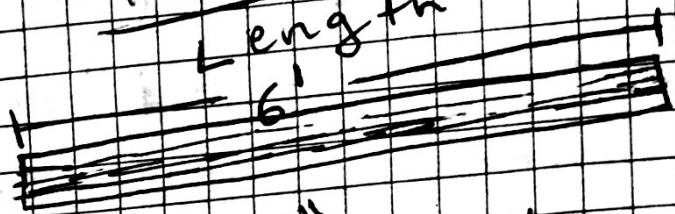
⑦ ~~Star~~ 6061 Aluminum Sheet 12" x 24"

\$25.23

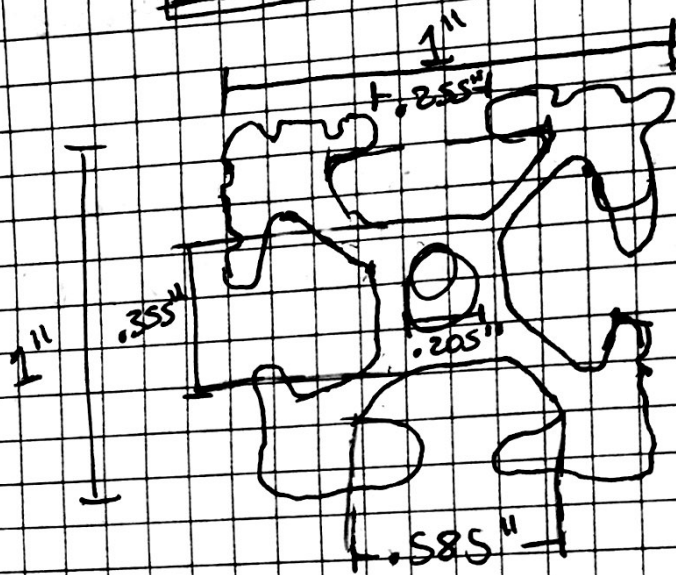
TOP View



TS to S 1" x 1" x 6"
Length



2-08-10
Actual
22



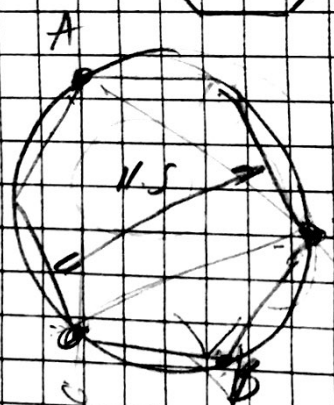
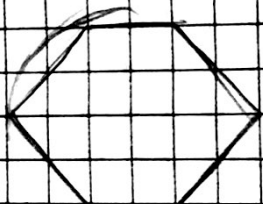
G T2-A1
Bracket

Item # 652 055
Series 10

Sliders

We have/Found $\rightarrow .31$ H

Need Slider $\rightarrow .255$ H

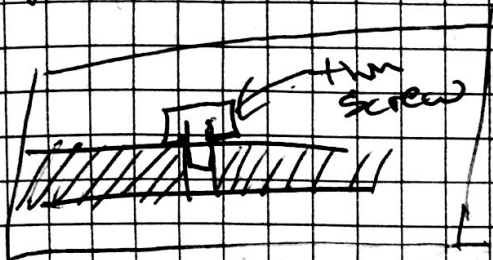


Weekly Meeting w/ Dr. Gruber

2-12-19

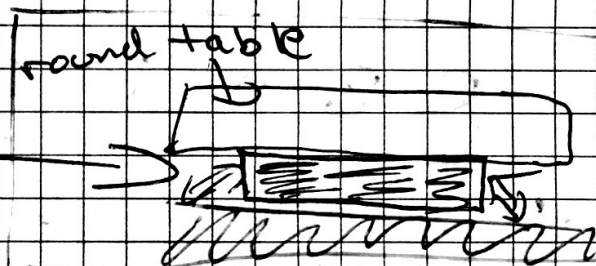
★ ~~Al 6061~~ too thin to bend (Mechanical Arm)

$\frac{1}{4}$ " Al sheet on top of Robot



★ look into screw size for Platform

use Epoxy resin

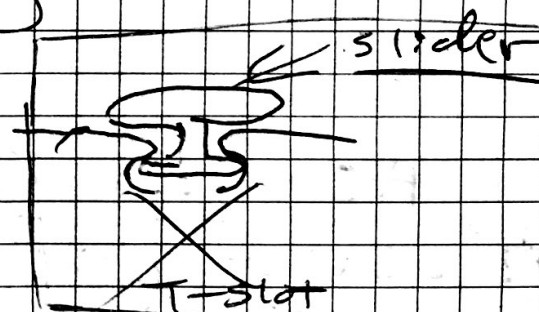


$(\frac{1}{8}) \times 12" \times 24"$ (Al sheet)

★ Tensioner (For belt strength)

★ AGTZ timing Belt

↳ Connects to the sensor Platform



Task - Stephanie

★ Order T-slots (2-14-19)

Parts Tested

★ Grove Gas Sensor

★ SV / Analog Signal

★ Now, need to test in presence of alcohol

IR Temp sensor in °Celsius

2-12-19
Adrian
2019

* 5V has 2 Analog inputs

→ Not reaching temperature
on surrounding Temp - Yellow Analog

RPI Camera

* IT WORKS, but has glare

* IR are self-activated on low light

RPI MQTT Comm

* ADC acts as broker

- manage subs / Publish messages

Action Items

2-15-19

✓ Nelson will test serial comm w/ Lemex
regarding the RPI and Due

✓ Stephenie will order new parts and
create way to display gauge for
air quality

2-15-19

✓ Adrian will make improvements to arm
and take into consideration recommendations

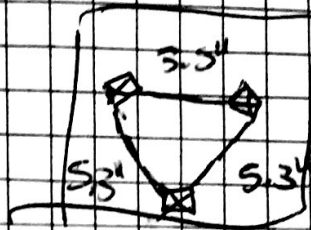
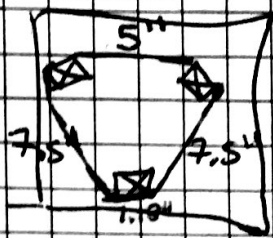
2-13-19

✓ Elizabeth will work on sensor schematic

3-5-19

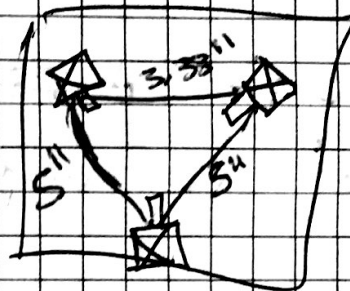
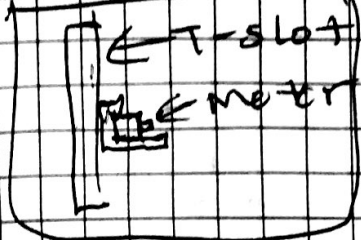
Mechanical Arm Design

Top Platform

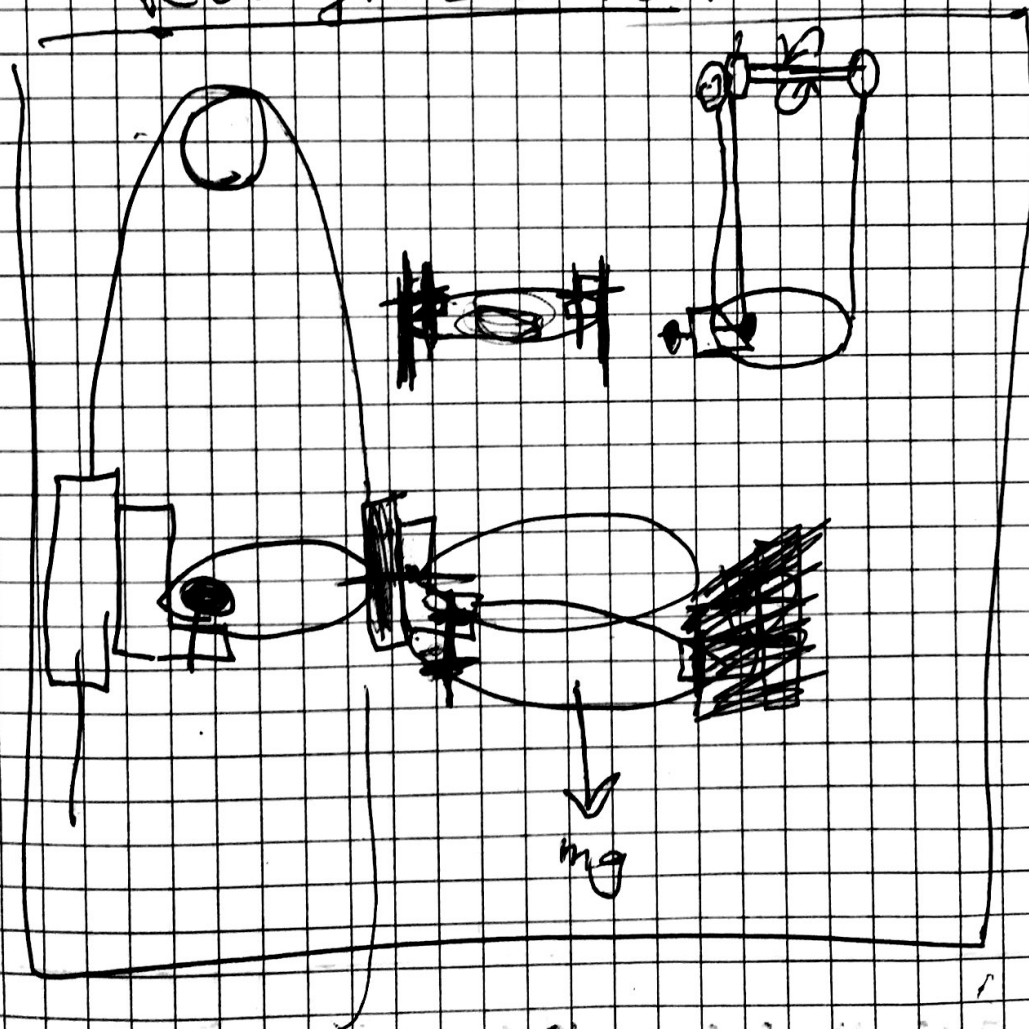


2-13-19
Turn table
5 screws
6mm

Stepper Motor



Rough sketch



~~Notes~~
Pg. 49

Stepper Motor w/Pulley

5 mates

- Coincident - Pulley / Motor
- Concentric - Motor shaft / Pulley
- Coincident - Plate / Motor
- Concentric - Motor screw / Plate hole
- Concentric - screw / hole

Adjust different mates
to make sure every aspect considered
for joining parts.

Unable to meet during official
weekly meet due to
Job interview

12-19-19

Group meeting / Lab Work | 2-22-19

Adm. ~~W~~

* Testing Batteries soldered in series

DCV 4+4+4+4=16 (V)



* measure turntable screws holes
screw hole ≈ 6 (mm) (outer, & inner ring)

* Placed order link on drive for Top Lid screws

Previous screws used = 30 #6-40 $\frac{3}{8}$ " = Length
Found 1 pack of 100 #6-32 $\frac{7}{16}$ " = Length
on McMaster-Carr.

- Screws will be replacing the 30 #6-40 and
will be screwed using the same holes i.e. 70 extra

Intentionally
LCF Blank

☒ Meet Monday to solder other set of
batteries

2-25-2019 - Goals

2-28-19



Intentionally left blank

12-25-10
Hans
2010

25.57

2-25-

HIVE Group Meet

2-25-19

- ★ Removed Solder from Battery holder
- ★ Removed Battery Contacts and got new 12 Gauge contacts for battery holders.
- ★ Tested Arduino contacts @ HIVE
- ★

★ Test + MQTT Comm

★ Test + Sensors

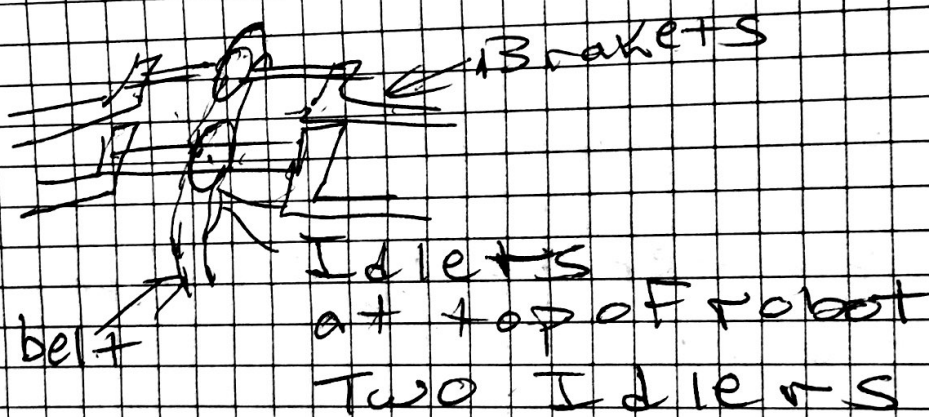
★ Test batteries again for conductivity

Mechanical Arm Design

12-28-19
Adams
~~me~~



Design in Solidworks



ACCESS CAD Solidworks
parts and
drawings / Assembly
on Drive / sensor design
drive. [google.com/drive/folders/](https://drive.google.com/drive/folders/)

Meeting w/ Dr. Graber

12-26-19

UNO can run ~~480~~ but, the DUE req's 1kHz
The PWM signal for the DUE was decreased.

PWM ^{signal} goes to the Speed Controller.

★ Went over Controller Functions

★ Have two controllers
1st Include in Final Report For Future
Pilot Controller 2nd Camera/Sensor Controller
Implementations

Toggle sticks control each individual motor

★ Voltage Schematic updated

G.U.I

★ Adding a toolbar, perhaps add events

★ Format changed

★ Full screen mode button added

★ Connection status created

★ Gauge Graphic Update
- Can have 360° rotation

Note

★ Dr. Graber would like to see the robot/GUI and the features.

★ Motor cannot move or the camera not allowed ~~to~~ until the RESET button is pressed.

Controller Functions discussed

★ Take Photo

★ Toggle Speed Control

★ Motor Controls

★ etc.

Mechanical Arm Update

(2-26-19)

- * Rods connect top rollers ~~to roller~~ ^{Adrian} purchased
- * GT2 belt will connect to 3 pulleys
- * For now 8" plate used at left and top plate

Stepper Motor Controller

- * Nema 17 is 2 phase
- * will use 2 motor controllers

MQTT Update

- * Successful communication (broker/robot)

Items discussed in depth

- * Task Status: Arm CAD design
- * Plates for the robot lrd slightly too short

Action Items/To do list

- ☒ Lemex will continue to work on GUI
- ☒ Stephanie will meet w/ Lemex to get gauge to change w/ time. 3-4-19
- ☒ Elizabeth and Adrian will work on Arm design and finish another list of parts to be ordered, as well as, work on CAD iterations. 3-2-19
- ☒ Nelson will work on the serial connection b/w the arduino and RPi. 3-4-19

AE Machine Shop Visit

2-27-19

Montgomery Knight
(welding)

Waterjet cutter ~~blow~~

Have USB w/ DXF (Files)

Dan stairs

2-wooden doors

ETT Wooden Plate

Intentionally
left blank

Intentionally left Blank

5-3
Adeline
ME

Intentionally left blank

3-5-19

~~John~~
~~John~~

3-5-19

Admiral
~~2/5~~

Intentionally

left
blank

Meeting w/ Dr. Graber

3-5-19

AM

Met Discussed the 20 Amp Fuse

~~Time~~
~~20~~

* Water Proofing Cable Solution

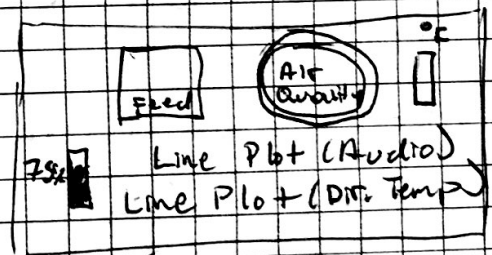
* Chose a standard ethernet

* Cant the turns that keeps track of the 360° location.

* Show the invention studio 03/06/19
the DXF Files and ~~ask~~ ^{specify} the date I need the Parts.
- Ask them if they provide suggestions.

* GUI Update

- Live Streaming
- Log-in Window
- Live Line Plot working
- Full screen camera
- Gauge Graphic



GUI design

GUI design Both Navigation Graphs on the same Graph, sharing the same x-axis (time)

MATI Communication

* tested serial communication between R Pi and DE

*

* Code Cleanup

* We will be using perf boards to connect sensors and etc.

* Design Notebooks submitted on (Cameras)

Pg. 61

Arduino Codes

★ Grab sensor data to Arduino

★ Arm movement code

★

Create a Software Component Schematic
Action Items / To do list

★ Raspberry Pi Case (slides 2, 5 - week 5 slide 12)

→ to be 3D printed - Adrian Munoz

(Amazon link w/ picture and dimensions)

★ Lemek will continue work on GUI

★ Elizabeth and Adrian will work on sensor code and schematic layout

★ Adrian will make DXF files of parts to be water jetted

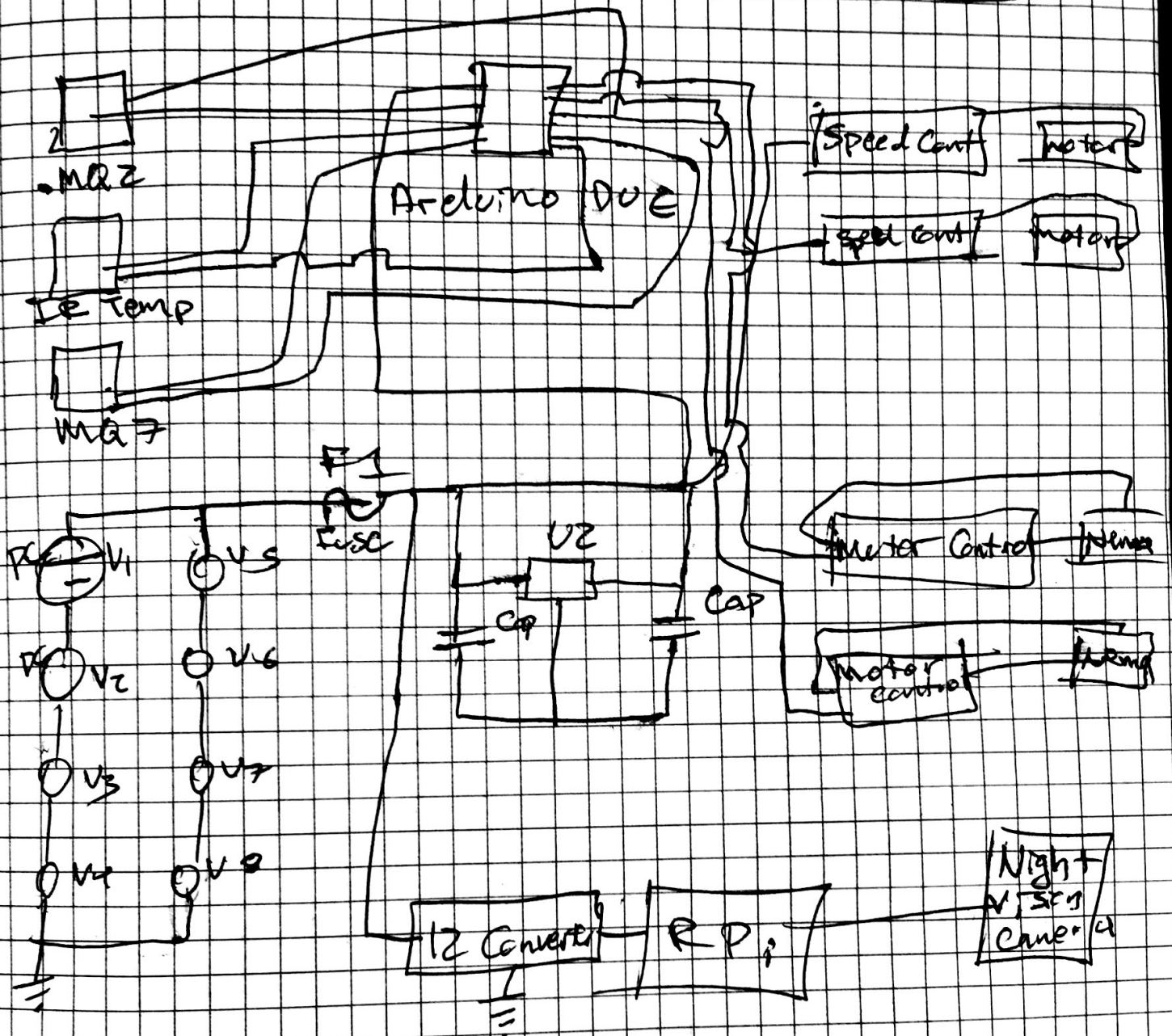
★ Nelson will work on code cleanup for communication code and test connection

★ Stephanie will create bar graph on GUI

Sensor/Power Schematic

13-10-19

Abhinav



Change From Multisim to Simulink in Matlab

Intentionally
left B blank

3-12
A
M

Solidworks

Group Meet

→ 3D-PDF

w/ Dr. Graber

3-12-19

For next meeting
Write comments on 2D drawing

★ Print the Motor mount so that it has a bridge design.



Consider to
★ Make

★ Give Credit to Thingiverse for the 3D designs 3D-Printed

★ No updates on GUI

★ MQTT Communication

Create Obj

- broker
- Topic
- port

Gui Publisher

- Publish Data

Gui Subscriber

- Connect Sub

3-12-2019

* Give the Mechanical design a Priority over many other tasks in the Project. e.g., Website

Website Update

- * Expanded on the documents Pg 1
- D. will hold the following:
- Design notebooks
 - Finished proposals
 - weekly slides
 - Software tutorials
 - Video

Control System Design - TO DO:
(Testing to fill in details)

Motor Control	Control Feature
Speed Control Mode	
Stepper Motors	
Default Positions	

Schematic Updates

- * Added stepper motor controllers, Nema 17 and M47 Co sensor
- * Looking to convert Schematic over to Simulink in Matlab
- Add Decoupling capacitors to IC's

3-12-19

★ Take into account all the holes needed to be water jetted.
e.g., Coiled wire

Reminder, design notebooks are due this Friday!

Action Items For week

→ ASK if they prefer us to have the holes added first and or if we can go ahead and water jet the base shapes.

□ Start a document with links to files/paths where code is located.

★ Adrian, Elizabeth, and Nelson will test the sensor communication and work on getting plates waterjetted.

3-13-19

□ Lemex and Stephanie will keep working on GUI

Access Files on G I T H U B

Invention Studio

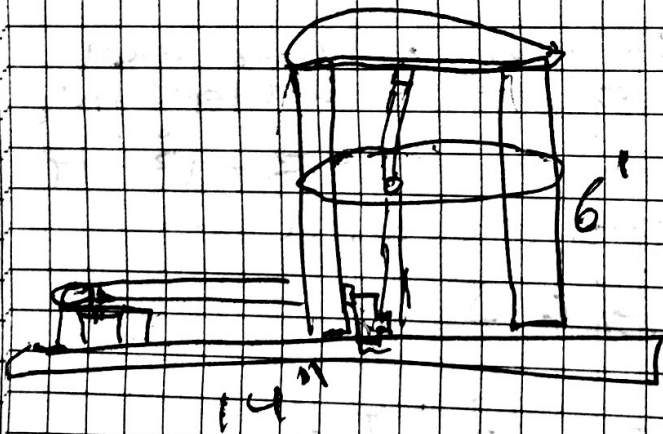
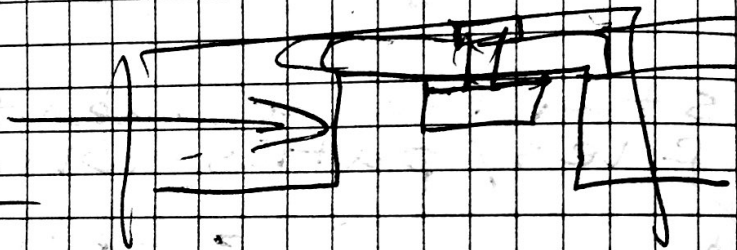
3-13
Admission
No

★ CAD model updated
on Solidworks

★ Should wait to get plates
water-jetted until all are
here.

★ 3D Printed Motor mount
once again using
new design

Bridge
design



(Not
drawn
to scale)

3D Printer Files
Resource website
used

www.thingiverse.com/mount motor

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3-13-19

Ami
Mc

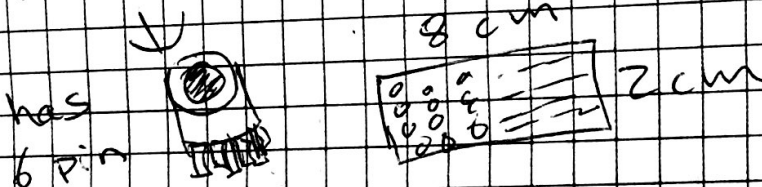
Group meet w/ Elizabeth

3-13-19
Alvin

Solder CO sensor to Perf board
Begin to structure the sensor layout on Perf board

Used connectors from sensor pins to Perf board Pin headers

MQ-7 Gas CO-sensor



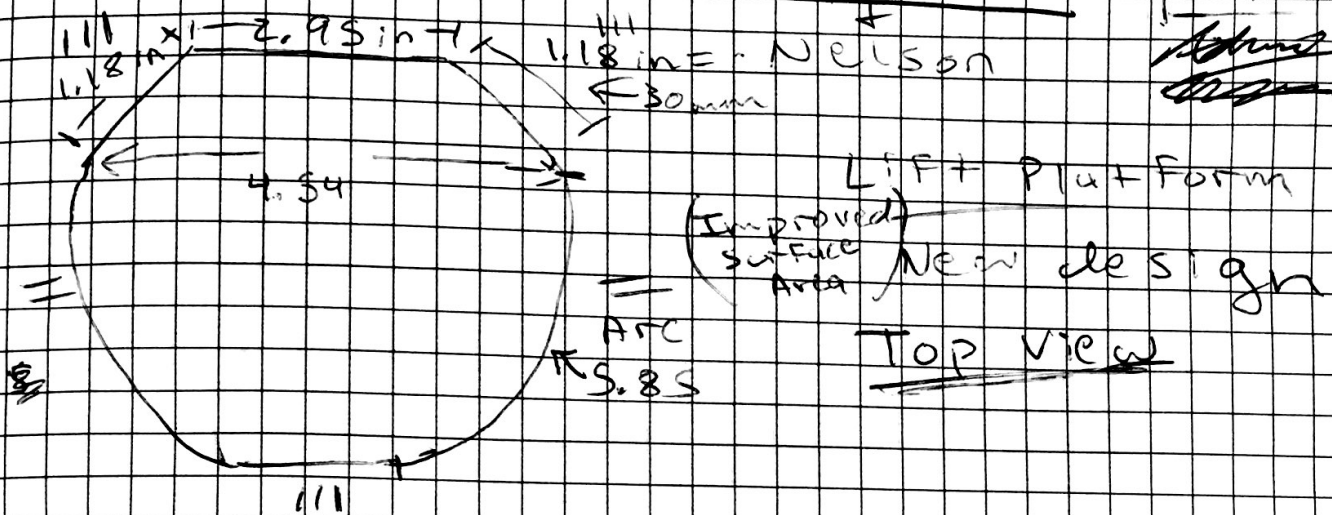
Arduino only uses 4 pins
Takes

A0 DO GND VCC

GROUP MEET w/ Elizabeth

3-13-19

~~Adrian~~
~~Adrian~~



New design For LIFT Plate

3-14-19

3D-Printed - Adrian Pick-up

Work on updating sketches
and CAD design