FAMU-FSU Engineering

SoutheastCon 2020 Hardware Competition

Virtual Design Review 5

Team Introductions

Isabel Barnola
Lead Software Engineer

David Bowen
Lead Robotics Engineer

Diego Campos
Lead Signal Process Engineer

Alex Ndekeng
Lead Power Systems Engineer

Abiel Souverain
Lead Design Engineer

Sponsor and Advisor

FAMU-FSU College of Engineering

Engineering Mentor
Jerris Hooker, Ph.D.

Academic Advisor
Bruce A. Harvey, Ph.D.

Objective

The objective of the project is to build an autonomous robot with the capabilities of completing at least one of the two challenges set for the 2020 SoutheastCon hardware competition.

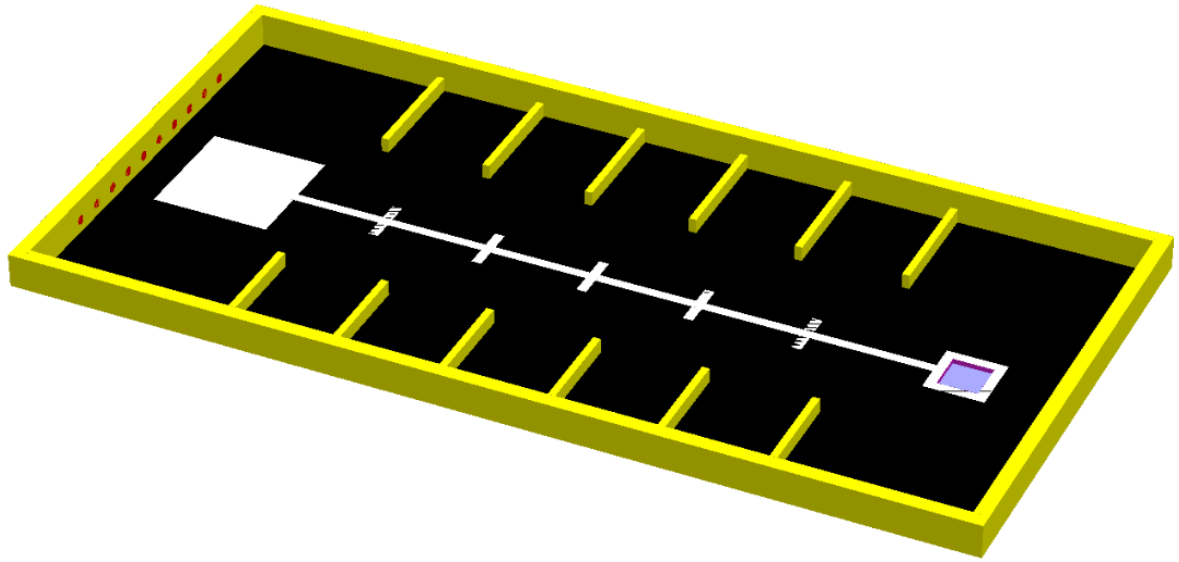
Alex Ndekeng

Project Background

Alex Ndekeng

2020 Southeast Con hardware competition

- 1st challenge: accurately stack Lego
  Duplo blocks representing the digits of pi.
- 2nd Challenge: push buttons in an order that represents the digits of pi



Description	Number of points
Total stack sequenced correctly	20 * N * N
Additional stack not sequenced correctly	N * N
Total button presses sequenced correctly	10 * N
Additional button presses not sequenced correctly	N (max of 100 counted)

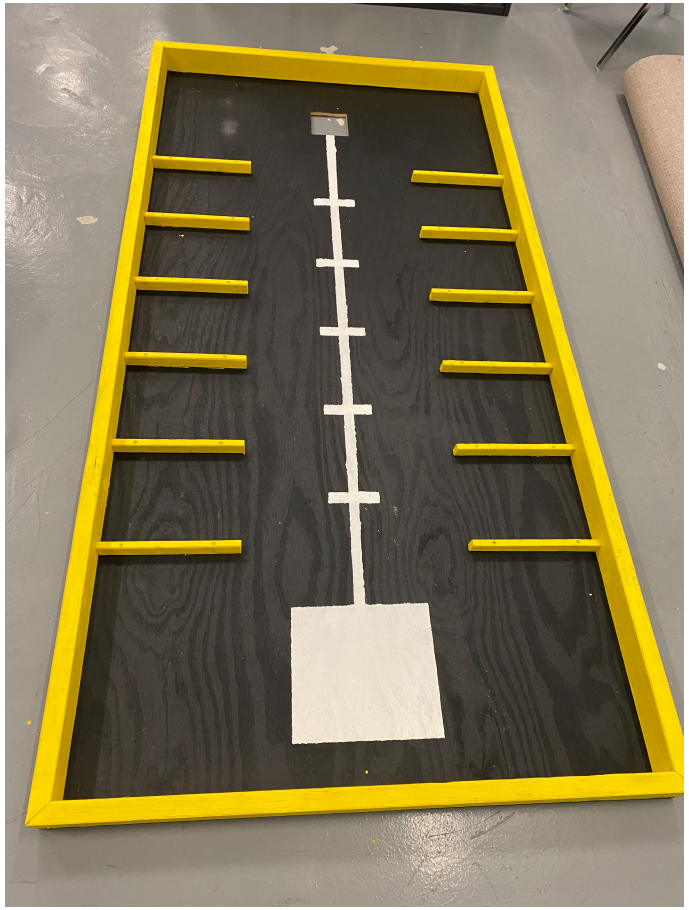
Alex Ndekeng

Customer Needs

- We're having our customers be the same as our primary and secondary markets as well as our stakeholders
- 12"x12"x12" autonomous Robot
- Ability to pick up to pick up Lego blocks and stack them
- Ability to stack Legos or push buttons in the order of the numbers of pi
- Navigate through the arena

Alex Ndekeng

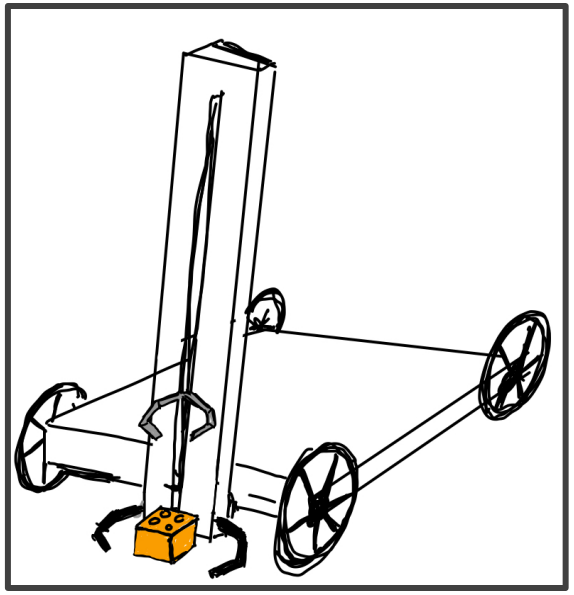
Built Practice Playfield

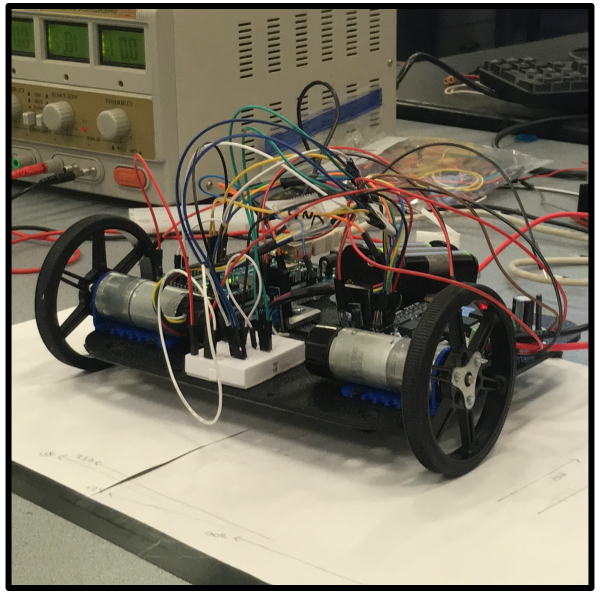


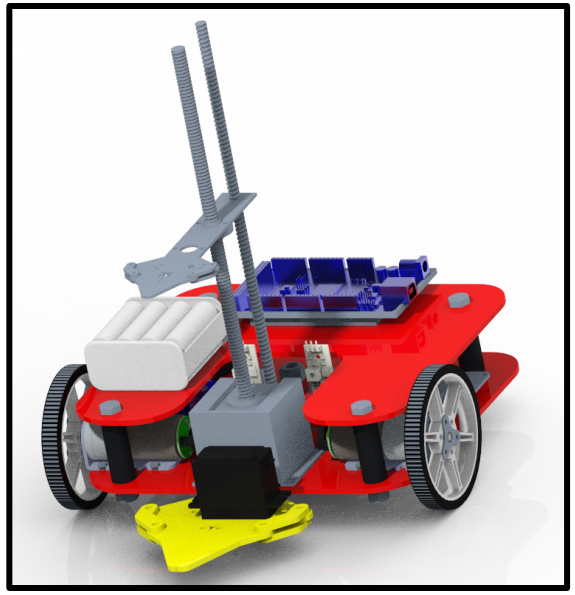
Components

Abiel Souverain

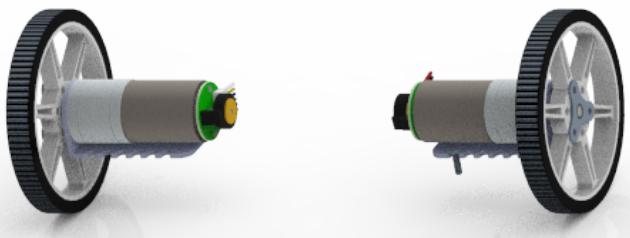
Ezio







Components



- Driving Motors – 99:1 gearbox
- Wheels – 80x10mm
- 6V
- 6.5A Stall Current
- 1A Running Current

Abiel Souverain

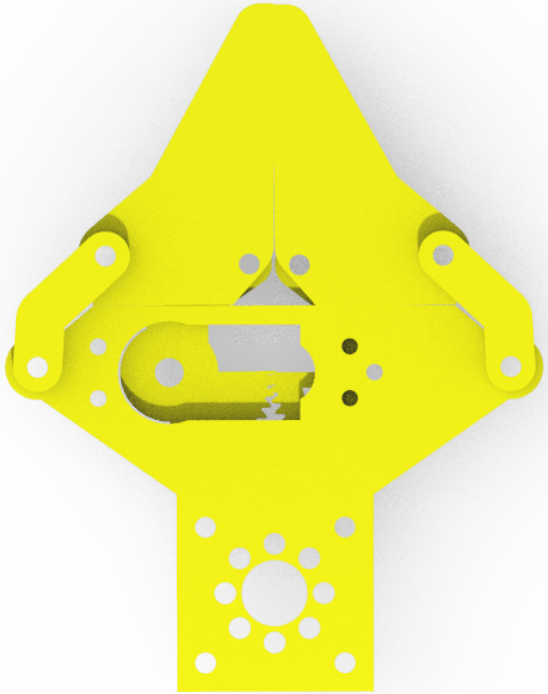
Parallel Gripper

- Model is based on this gripper from Servo City

Abiel Souverain

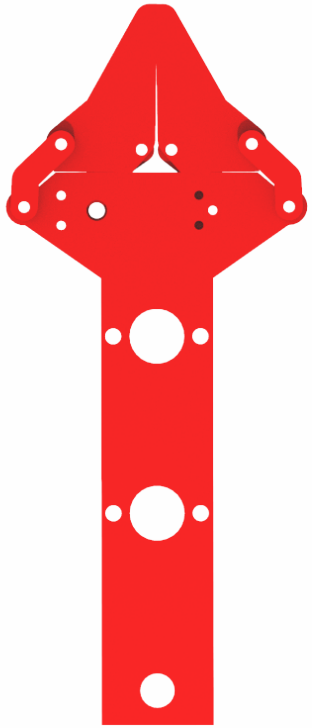
Components

5.23 in



Lower Claw

5.30 in

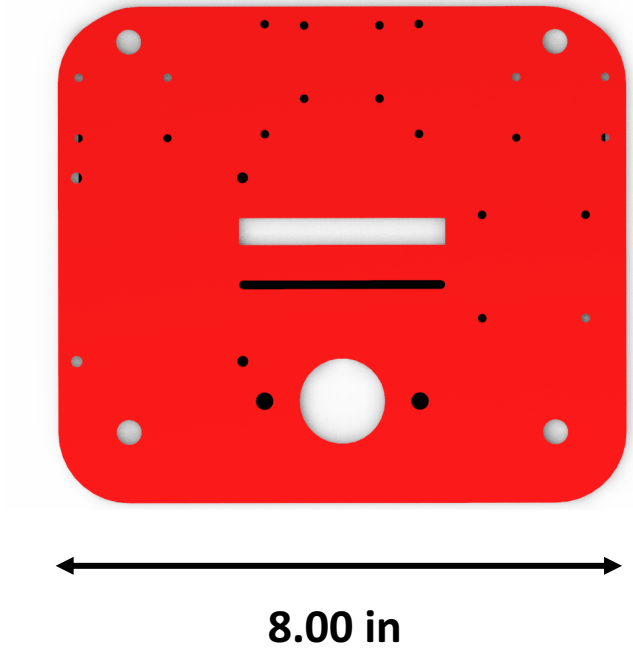


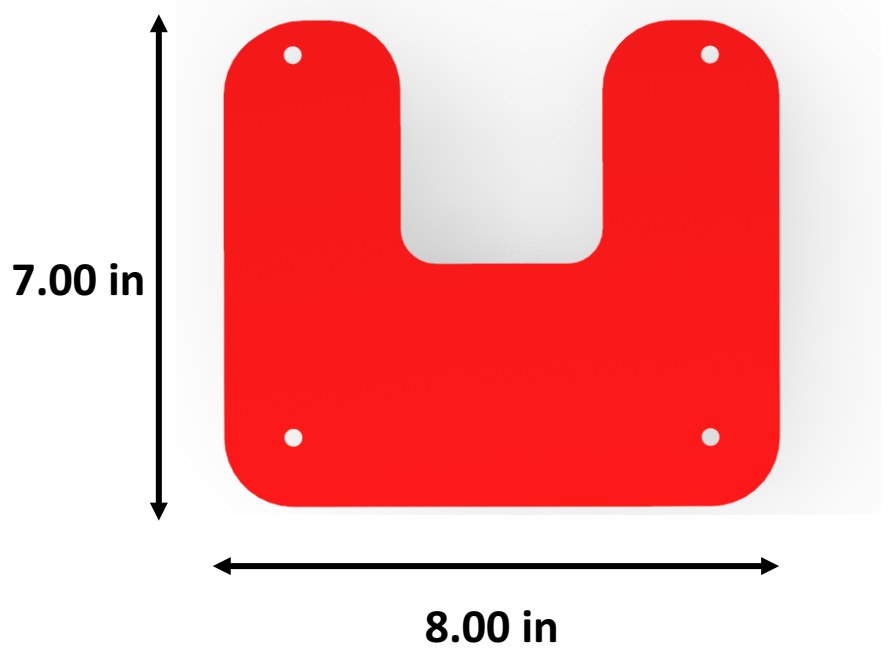
Upper Claw

Abiel Souverain

Components – Laser cut bases

Lower Base

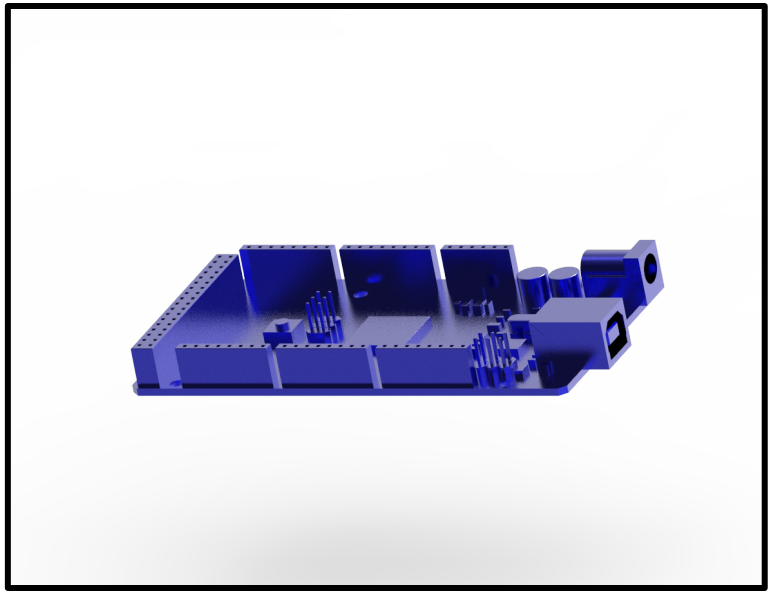




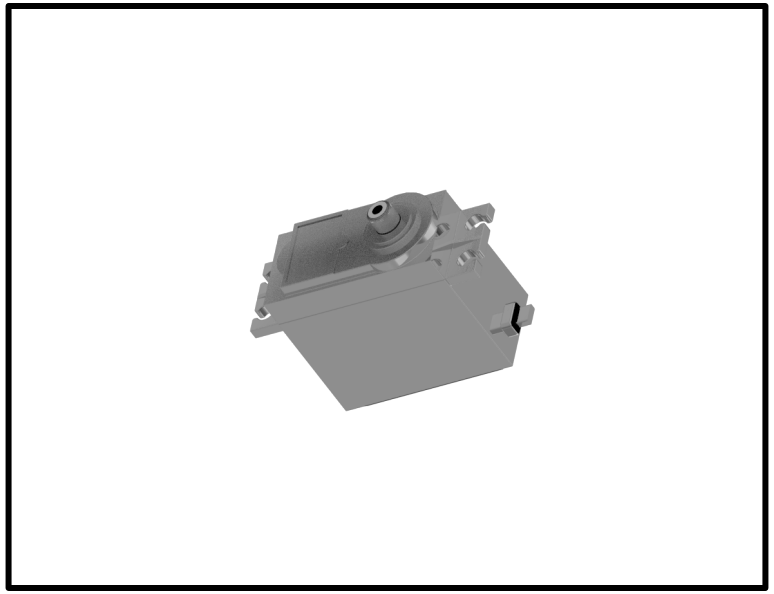
Upper Base

Abiel Souverain

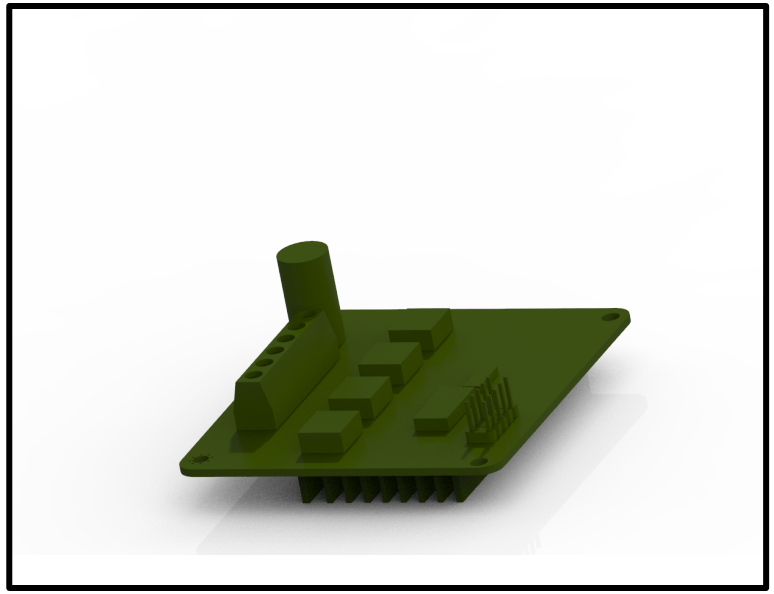
Components



Arduino Mega

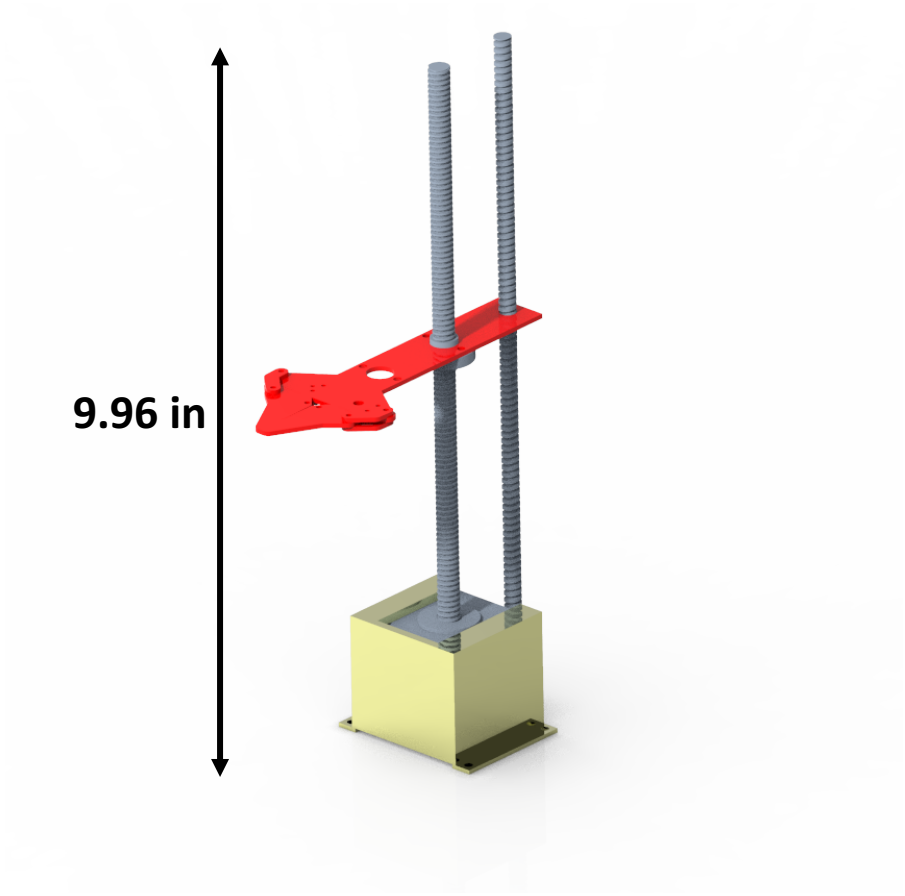


Servo Motor



DC Motor Driver

Components – Elevator Assembly



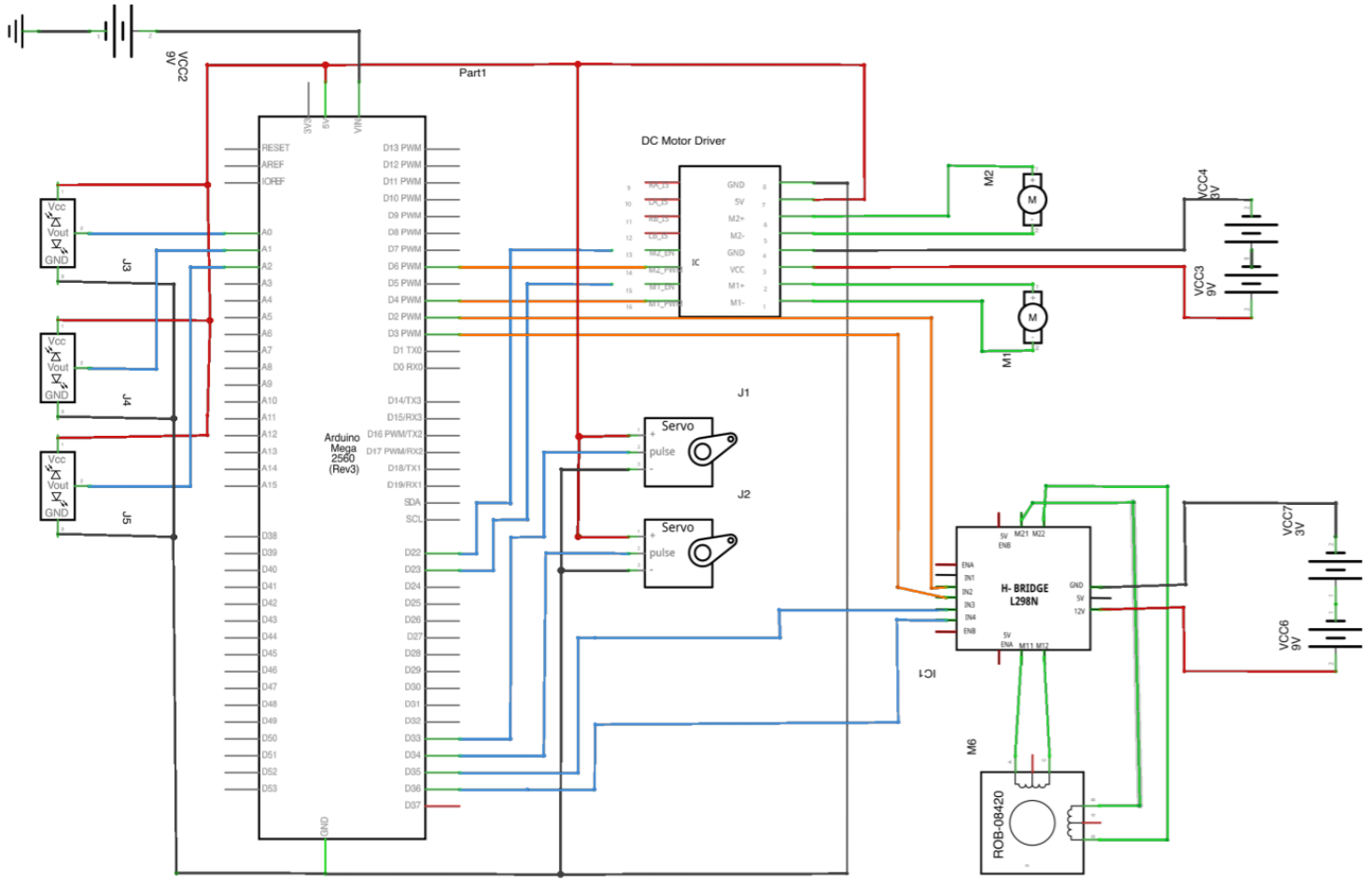
- Stepper motor with lead screw
- Geared Claw – servo controlled
- Guide Rod

Abiel Souverain

Wiring Diagram

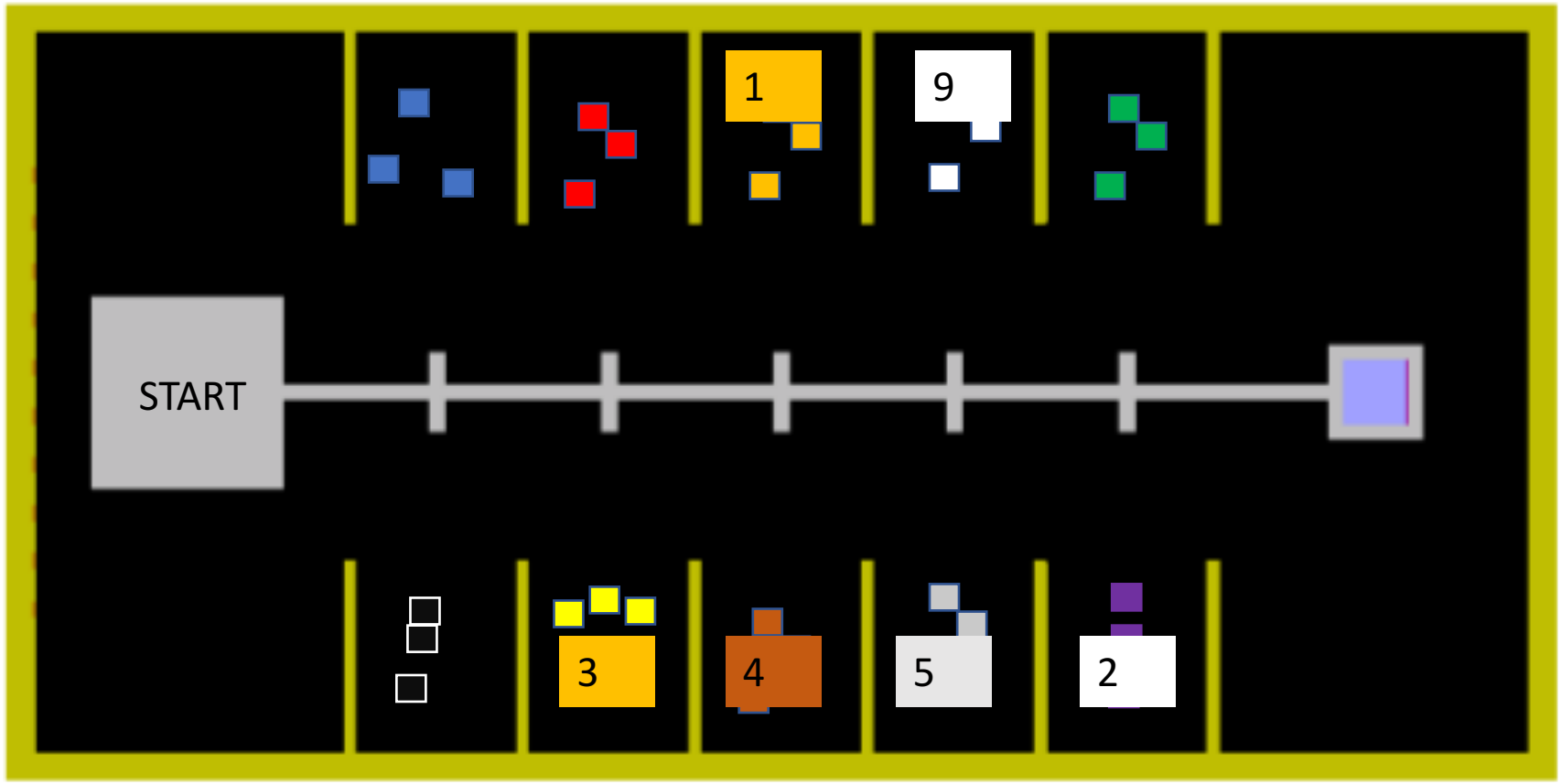
Diego Campos

Wiring Diagram



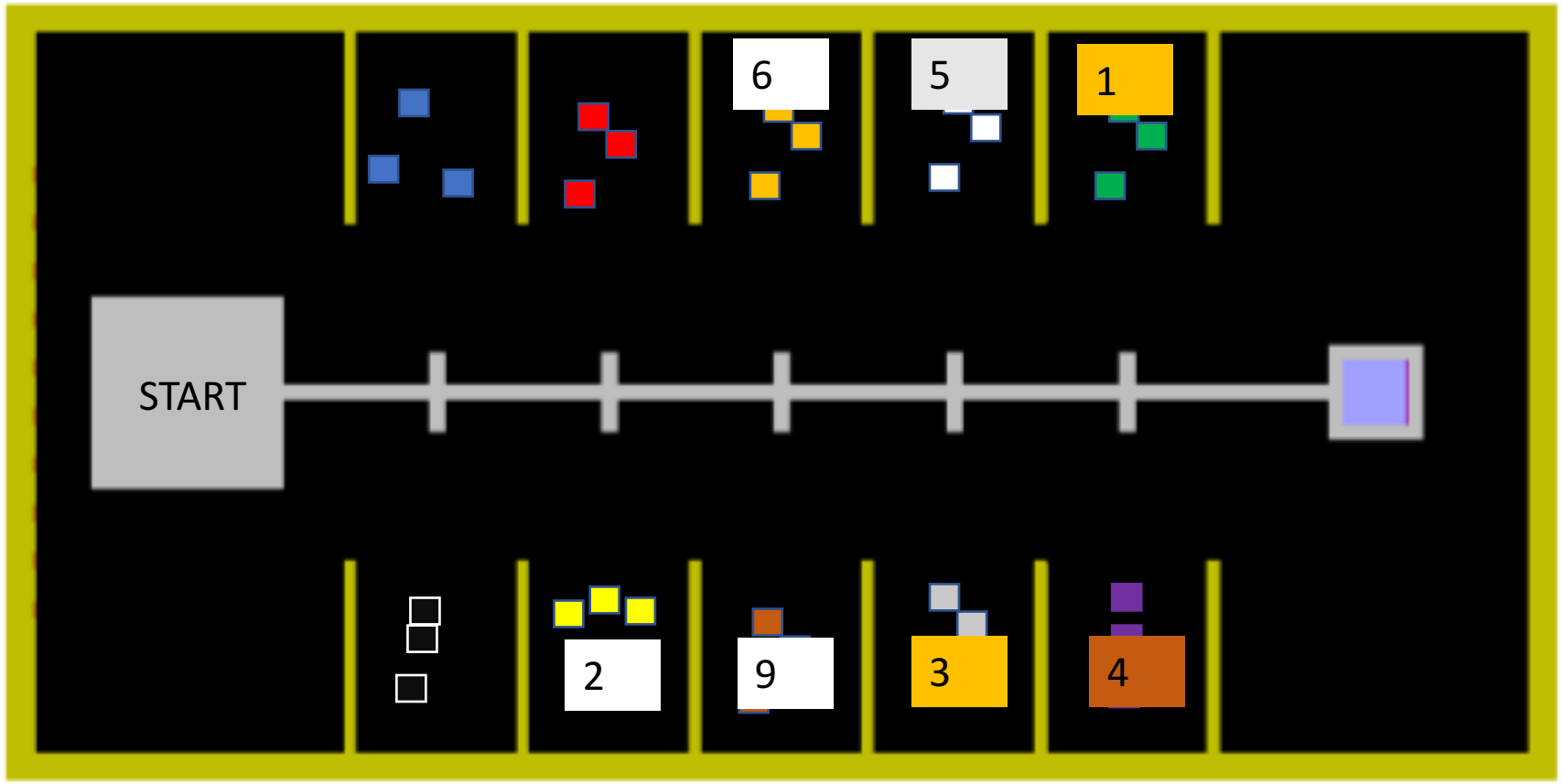
Diego Campos

Block Layout for 7 numbers



Diego Campos

Block Layout for 10 numbers



Diego Campos

Code

Isabel Barnola

Pseudocode – 7 blocks

```
stacking_challenge()
{
    // Block 3
        line_following(n = 2) // navigate over n white lines
        turn(right)           // rotate - 90 degrees
        stacking()            // Stack lego - Value = 3
        position = 2
    // Block 1
        turn(left)
        line_following(1)
        turn(left)
        stacking()
        position = 3
    last_stack(position,left) //  check if time == deadline - go to end
    // Block 4
        turn(right)
        turn(right)
        stacking()
        position = 3
    last_stack(position,right) //  check if time == deadline - go to end
    // Block 1
        turn(left)
        turn(left)
        stacking()
        position = 3
    last_stack(position,left )//  check if time == deadline - go to end
    // Block 5
        turn(right)
        line_following(n = 1)
        turn(right)
        stacking()
        position = 4
    last_stack(position,right ) //  check if time == deadline - go to end
    // Block 9
        turn(left)
        turn(left)
        stacking()
        position = 4
    last_stack(position,left ) //  check if time == deadline - go to end
    // Block 2
        turn(right)
        line_following(n = 1)
        turn(right)
        stacking()
    //END
        turn(left)
        line_following(n =1 )
        stacking()
        drive_backwards()
}
```

Isabel Barnola

Pseudocode – Main functions

```
line_following(int num_lines)
{
    // follow line
    // count vertical lines
    // stop when count = num_lines
    // uses turn_l, turn_r,
    //      advance and stop
}
turn (int direction) // right or left
{
    // turn 90 degrees to direction
last_stack(int position,int dir )
{
    // not enough time - stack at the goal
    turn(dir)
    line_following(5-position)
}
```

```
stacking()
{
    // aproach block until its detected
    go_to_block();
    pick_block()
    {
        // activate claw1
        // lead screw - down
        // deactivate claw2
        // lead screw - up
        // activate claw2
        // deactivate claw1
        // lead screw - up
    }
    // drive back to vertical line
    drive_backwards( num_turns)
}
```

Isabel Barnola

Main functions What is done?

What is done?

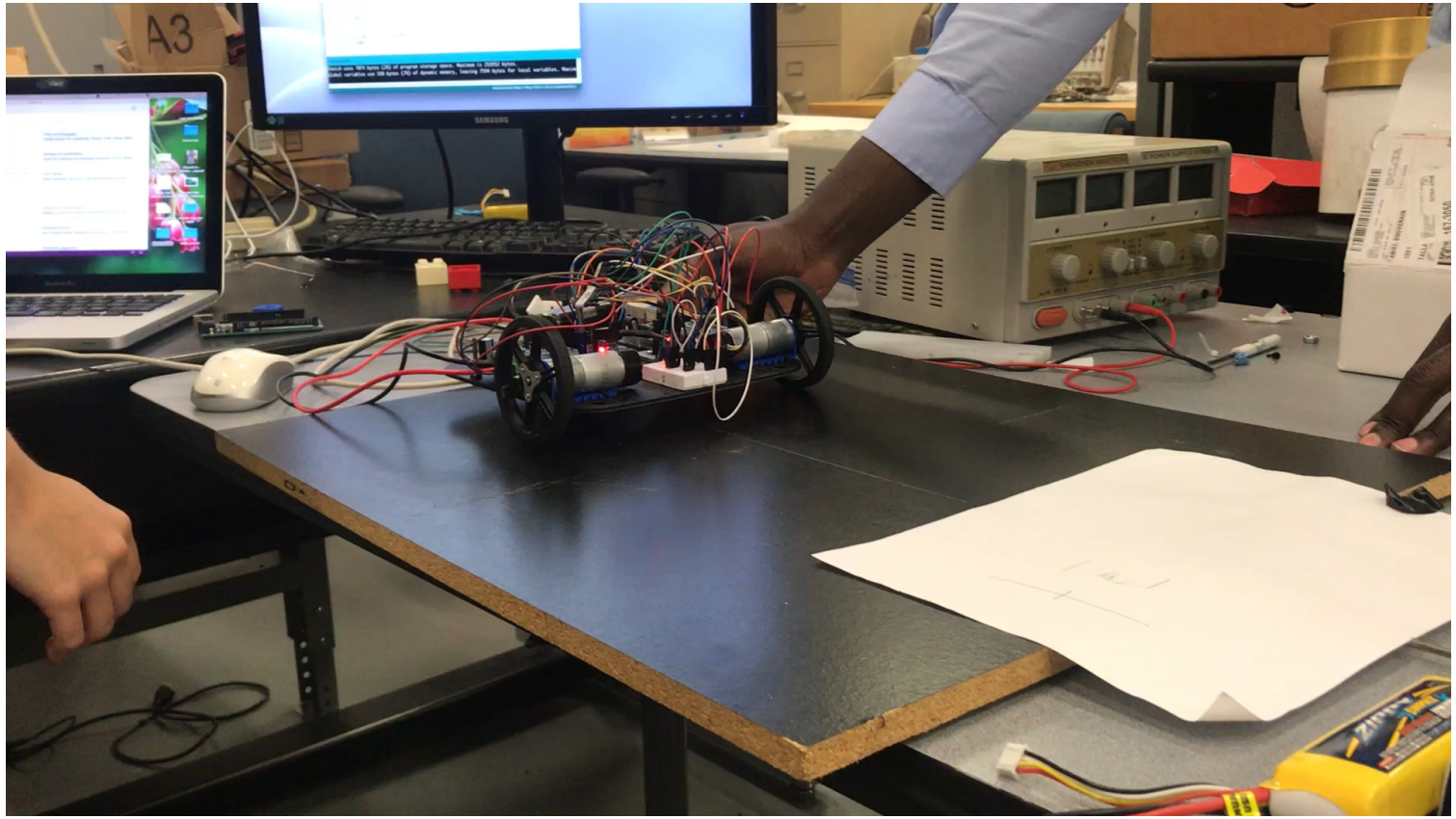
- Line_following ✔
  - Robot stops after line
    - Velocity has to be slowed down
    - IR sensors must be attached to interrupt
- Turn ✔
  - Robot turns very close to 90 degrees
- Last_stack() ✔
  - Combination of turn and line_following

To do

- Stacking()
  - go_to_block()
  - Pick(block)
- drive_backwards

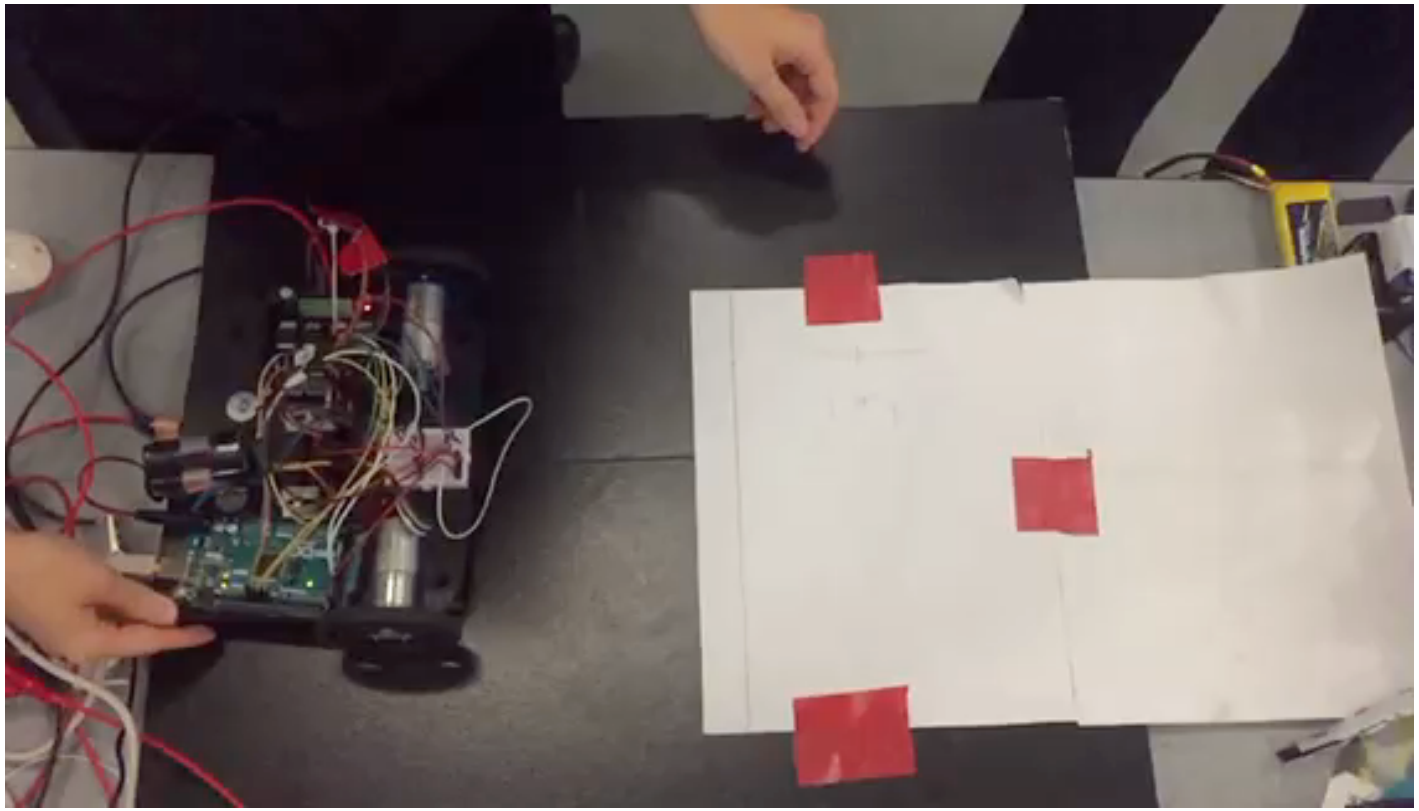
Isabel Barnola

Line following - Testing



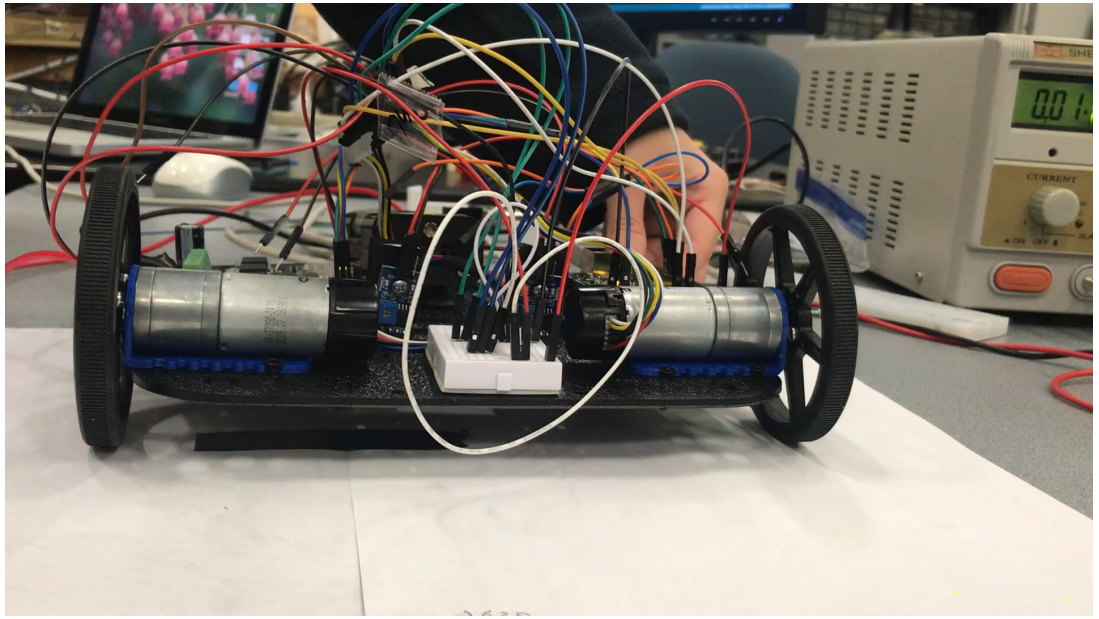
Isabel Barnola

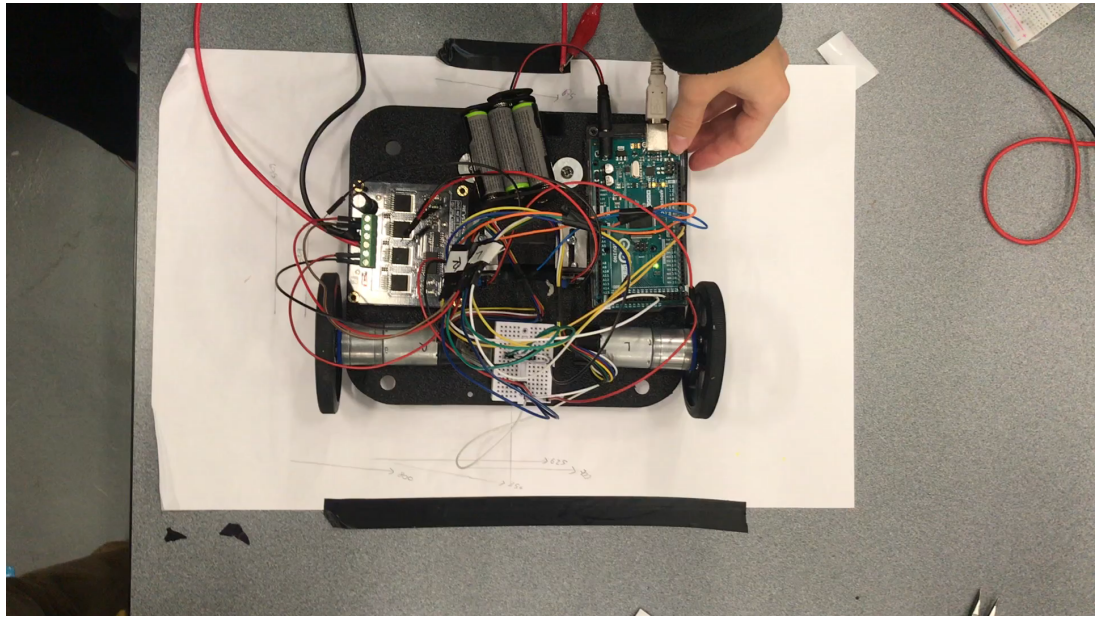
Line Following - Testing



Isabel Barnola

Programming



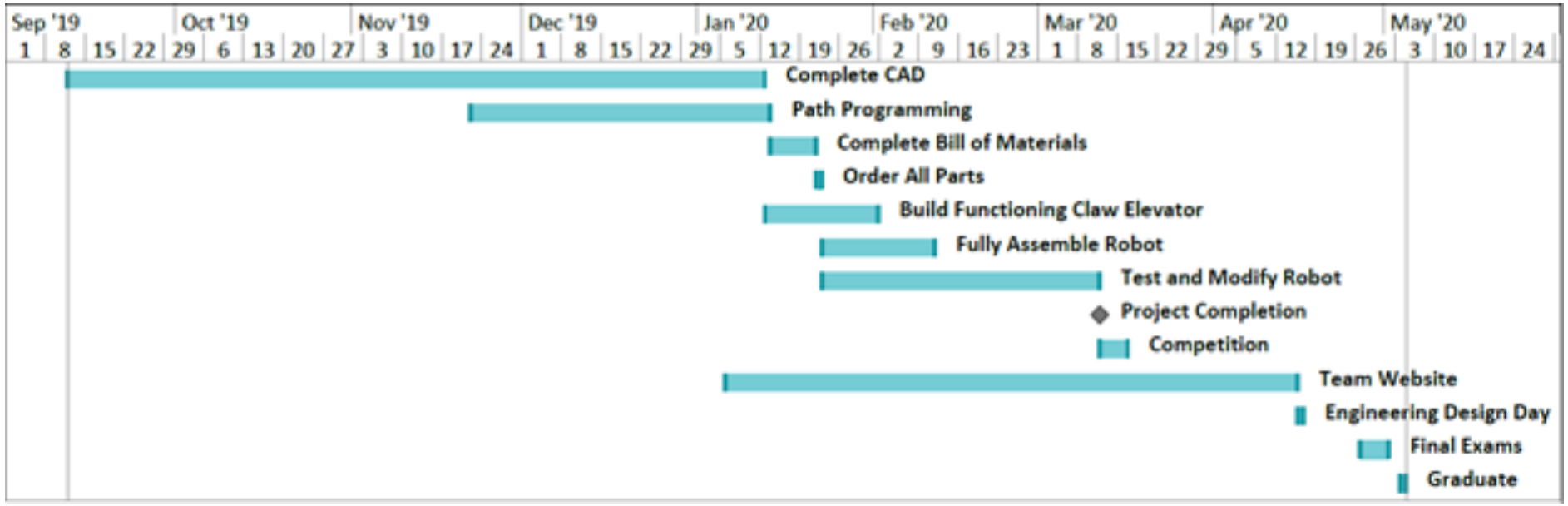


Isabel Barnola

Timeline

David Bowen

Timeline



David Bowen

Revised Timeline

1. Programming – March 1, 2020
2. Functioning claw elevator – 1 week after parts arrive
3. Completed CAD – February 23, 2020
4. Fully assembled robot – Dependent on 2.
5. Competition – March 12-15, 2020

David Bowen

Obstacles

- Power/Batteries
- Path Programming
- Parts being shipped
- Encoders
- Motor speed

David Bowen

Parts Ordered

- Stepper motor with lead screw
- ABS sheets
- DC motor driver
- 12V High current battery pack
- 9V Batteries
- Hardware

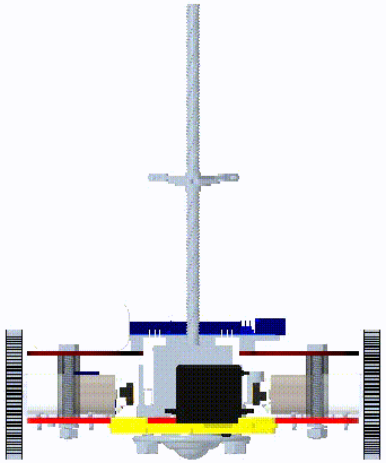
4 Most Important Points

1. Discussed physical components
2. Discussed wiring and programming
3. Obstacles/revised timeline
4. Waiting on parts to arrive

David Bowen

Thank you for your time.

Team Email: southeastcon@admin.my.fsu.edu



Review | Current Progress | Revised Timeline | Future Work

David Bowen

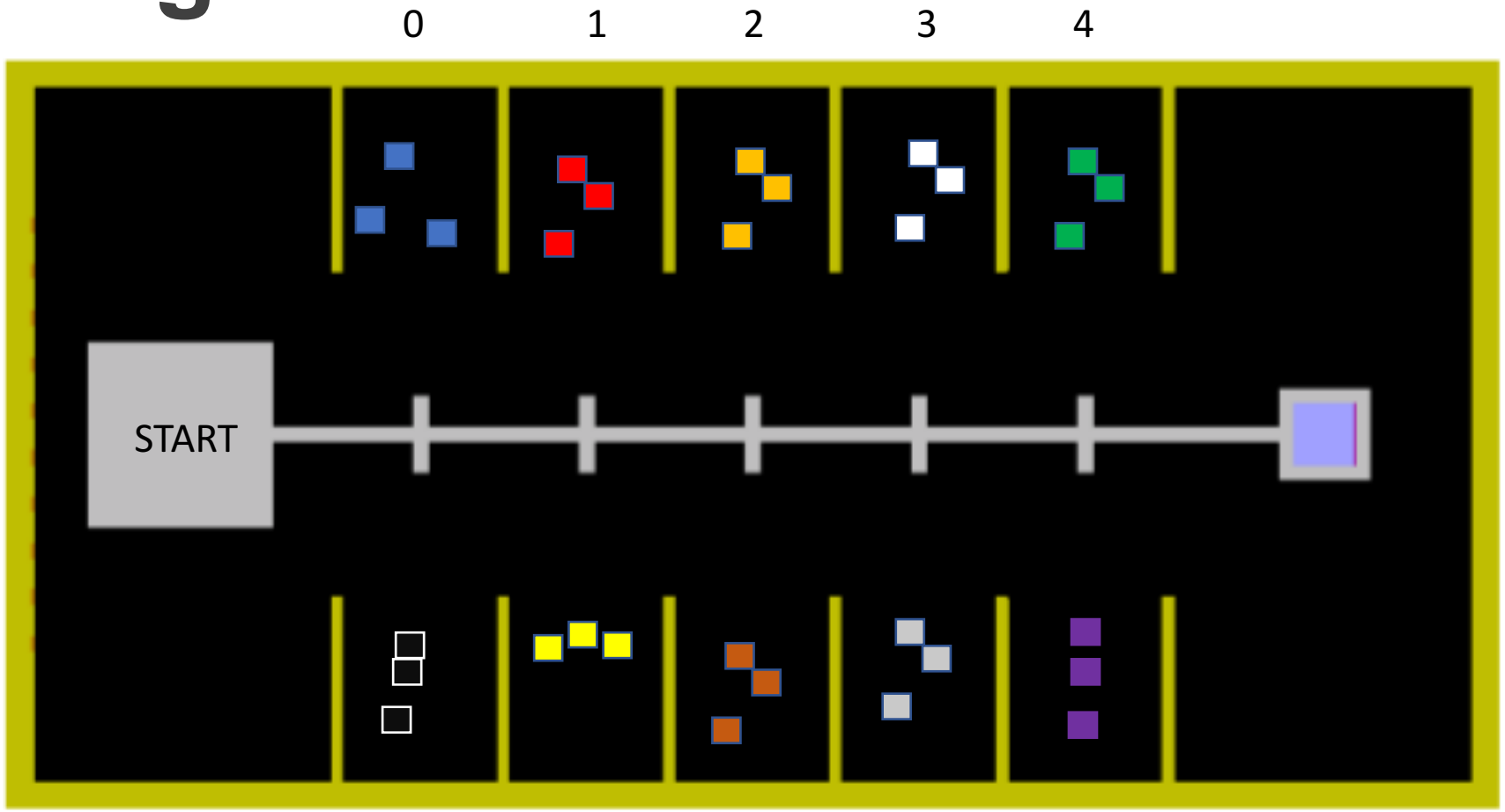
Backup Slides

Functional Decomp Backup

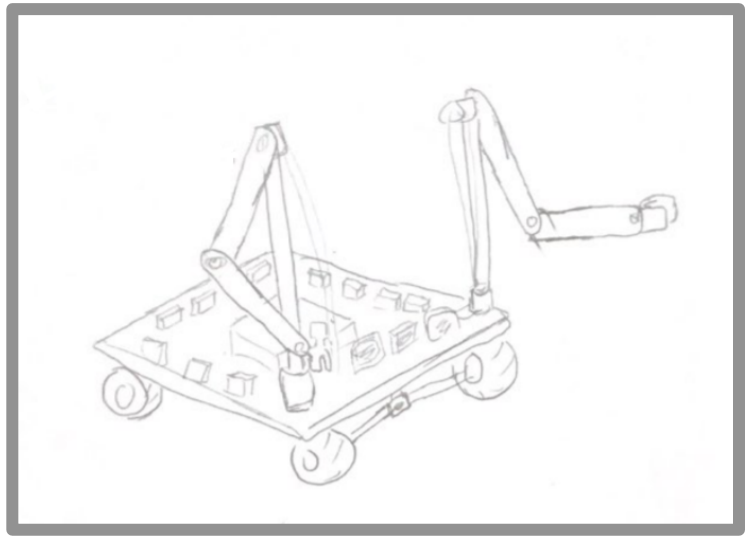
Concepts

Challenge

180 Seconds

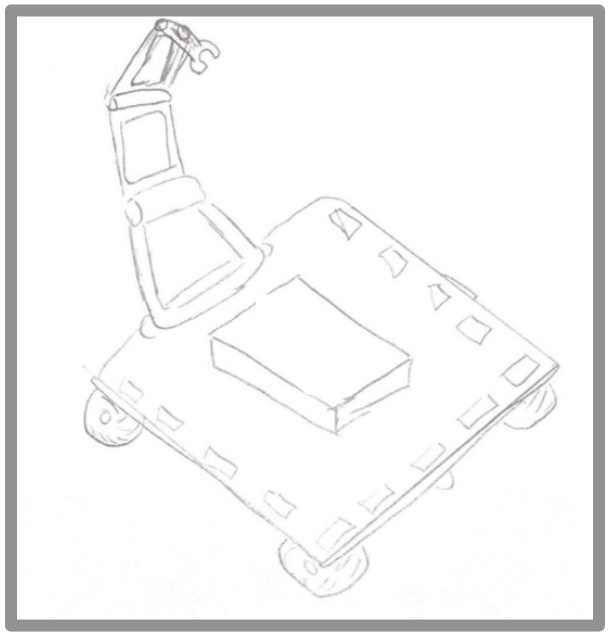


Concepts 1-2



Robot with two arms

- 2 arms to hold the Lego and stack it and has a
- Hammerlike appendage on top of one arm.

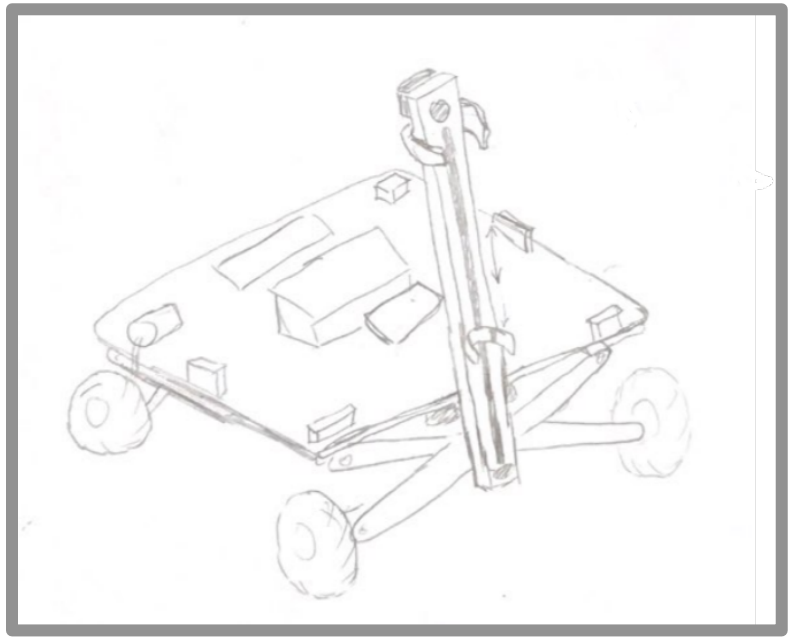


Scorpion

- 4 motors in the “tail.”
- Individual motors in wheels

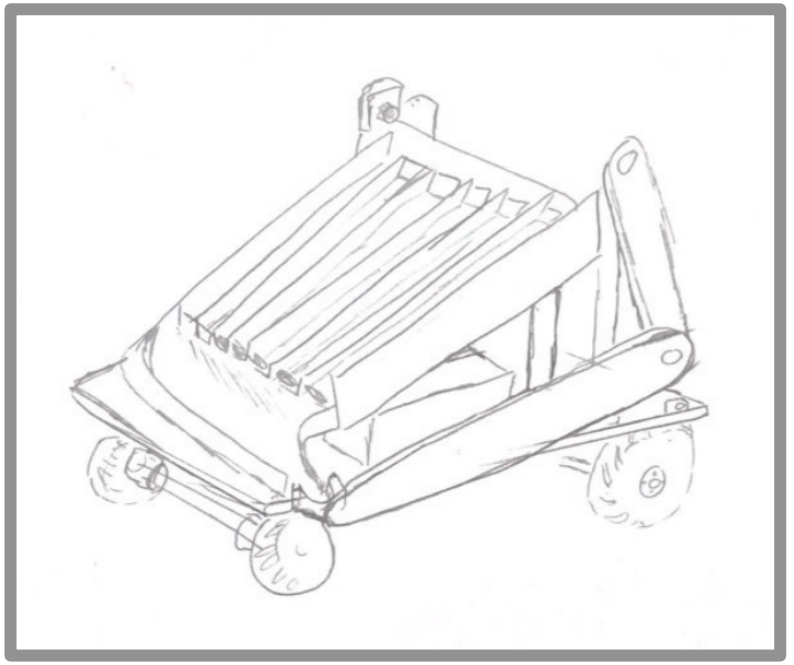
Isabel Barnola

Concepts 3-4



Robot with 2 claws and lift kit.

- Two claws to raise and lower blocks.
- It will find blocks using sonar.
- Lift kit.

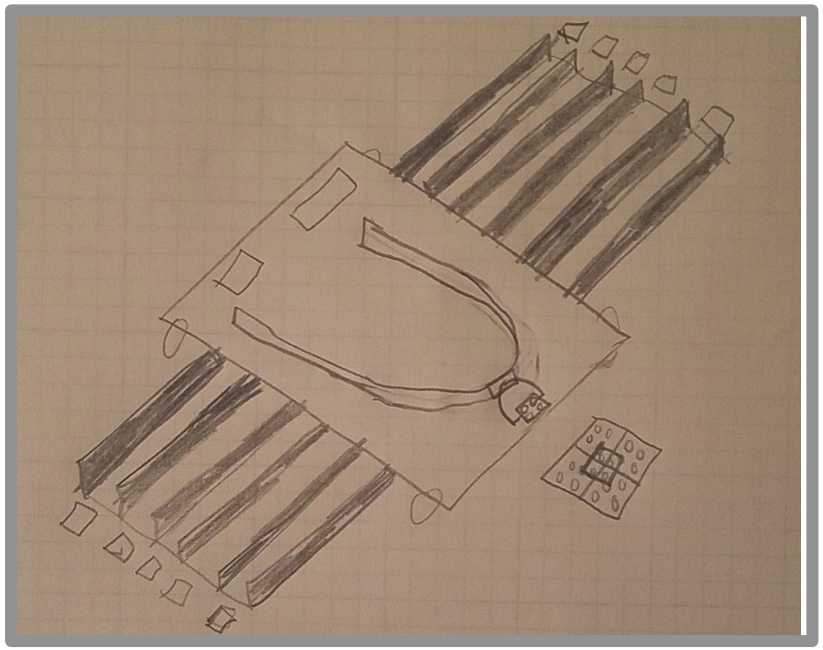


Color Sorting Robot

- Sorter on its body with blocks that slide in.
- Elevator and claw
- 3 DoF arm

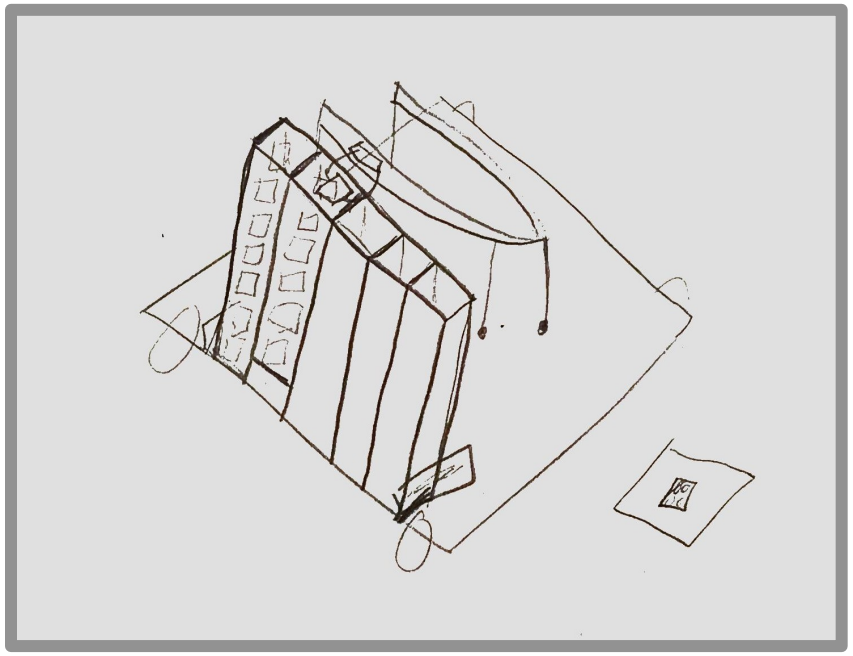
Isabel Barnola

Concepts 5-6



Slide System

- Slide system on either side to collect the blocks.
- Claw on a track to move grab the next block in the sequence and stack it.

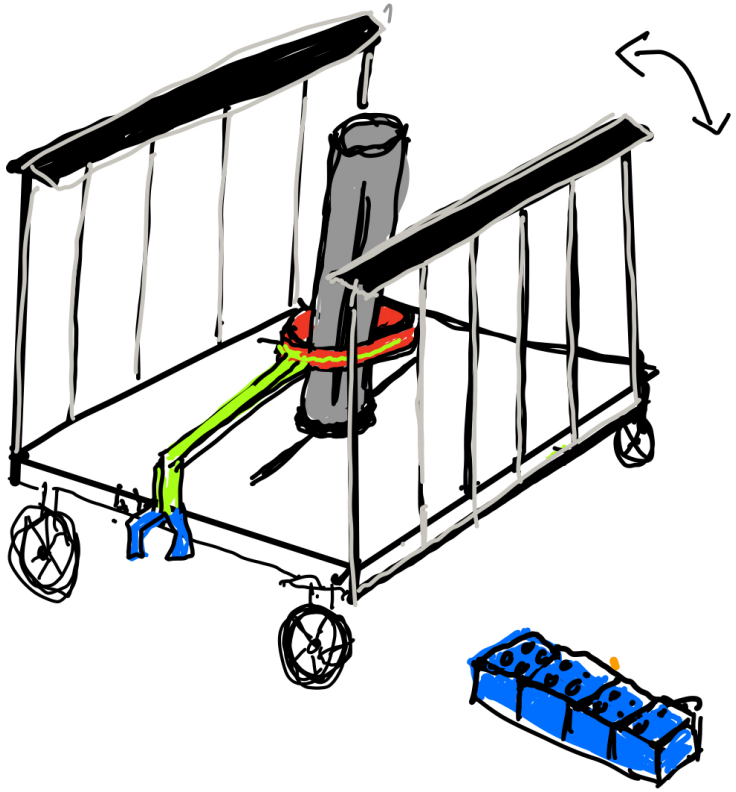


Spring Elevator

- spring-based elevator in 10 individual hoppers to store and supply bricks.
- It will have a claw track for stacking.

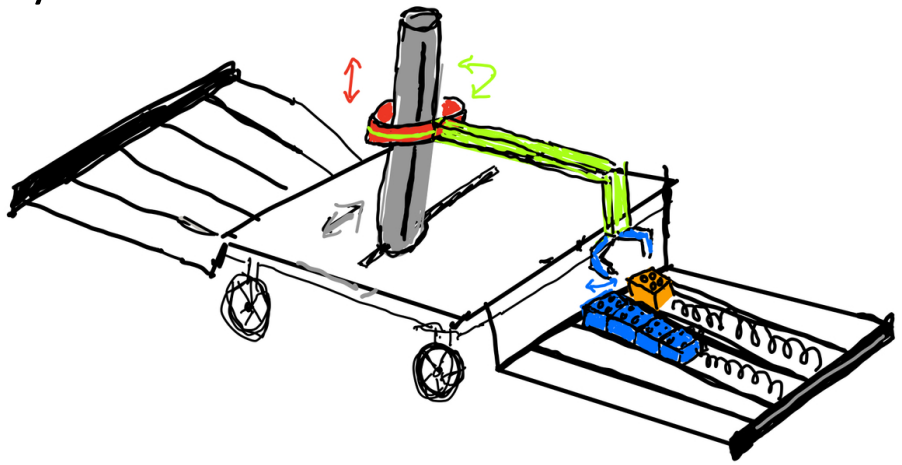
Isabel Barnola

Concept 7



Stingray

- Net-like arms.
- Arms used to drag the Legos from the bins in an organized fashion to the base.
- From there an arm, composed of a lift and a claw that moves 360 degrees pick up the Lego blocks and stack them correctly on the base.



Isabel Barnola

Concept Selection Backup

Pugh Matrix

Engineering Characteristics	Datum	Weights	Scorpion	Robot w/ two arms	Claws and lift kit	Slide System	Spring based elevator	Stingray
Acceleration	0	1	1	1	1	1	0	-1
Distance from Barrier	0	1	1	1	1	0	0	1
Block Height	0	2	0	1	0	0	0	1
Time to reach correct bin	0	1	-1	-1	0	1	-1	0
End time behavior	0	1	1	1	1	1	0	1
Time to locate block within bin	0	1	0	-1	0	1	0	1
Total Score	-	-	2	3	3	4	-1	4
Rank	-	-	5	3	3	1	6	1

Pugh Matrix

Engineering Characteristics	Weights	Datum(Scorpion)	Robot with two arms	Slide System	Claws and lift kit	Stingray
Acceleration	1	0	-1	-1	-1	-1
Distance from barrier	1	0	0	-1	0	0
Block height	2	0	1	0	1	1
Time to reach correct bin	1	0	0	1	1	1
End time behavior	1	0	0	1	0	1
Time to locate blocks within bin	1	0	1	1	1	1
Total	-	-	1	1	3	4
Rank	-	-	3	3	2	1

Criteria Weights

	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	End Time behavior	Time to locate block within bin
Acceleration	1.000	5.000	0.333	1.000	3.000	0.333
Distance from Barrier	0.200	1.000	0.333	0.333	1.000	0.200
Block height (raising and lowering)	3.000	3.000	1.000	1.000	1.000	0.333
Time to Reach Correct Bin (Color Determination)	1.000	3.000	1.000	1.000	5.000	1.000
End Time behavior	0.333	1.000	1.000	0.200	1.000	0.143
Time to locate block within bin	3.000	5.000	3.000	1.000	7.000	1.000
Sum	8.533	18.000	6.667	4.533	18.000	3.010

Criteria Weights

Criteria	Criteria Weights
Acceleration	0.157
Distance from Barrier	0.054
Block height (raising and lowering)	0.176
Time to Reach Correct Bin (Color Determination)	0.211
End Time behavior	0.065
Time to locate block within bin	0.337

Acceleration Ratings

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.200	0.333	0.200	1.000	0.333	1.000
Scorpion	5.000	1.000	1.000	3.000	5.000	5.000	3.000
Robot with two arms	3.000	1.000	1.000	0.200	5.000	1.000	3.000
Claws and lift kit	5.000	0.333	5.000	1.000	5.000	3.000	3.000
Slide system	1.000	0.200	0.200	0.200	1.000	0.333	3.000
Spring-based elevator	3.000	0.200	1.000	0.333	3.000	1.000	3.000
Stingray	1.000	0.333	0.333	0.333	0.333	0.333	1.000
Sum	19.000	3.267	8.867	5.267	20.333	11.000	17.000

Distance From Barrier Ratings

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.333	0.333	0.333	3.000	1.000	1.000
Scorpion	3.000	1.000	3.000	1.000	5.000	3.000	3.000
Robot with two arms	3.000	0.333	1.000	1.000	3.000	1.000	1.000
Claws and lift kit	3.000	1.000	1.000	1.000	5.000	3.000	1.000
Slide system	0.333	0.200	0.333	0.200	1.000	0.333	0.333
Spring-based elevator	1.000	0.333	1.000	0.333	3.000	1.000	1.000
Stingray	1.000	0.333	1.000	1.000	3.000	1.000	1.000
Sum	12.333	3.533	7.667	4.867	23.000	10.333	8.333

Block Height Capabilities (Raising and Lowering)

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	1.000	1.000	0.333	3.000	0.333	3.000
Scorpion	1.000	1.000	1.000	0.333	3.000	1.000	1.000
Robot with two arms	1.000	1.000	1.000	0.200	1.000	1.000	0.333
Claws and lift kit	3.000	3.000	5.000	1.000	3.000	3.000	1.000
Slide system	0.333	0.333	1.000	0.333	1.000	0.333	0.333
Spring-based elevator	3.000	1.000	1.000	0.333	3.000	1.000	1.000
Stingray	0.333	1.000	3.000	1.000	3.000	1.000	1.000
Sum	9.667	8.333	13.000	3.533	17.000	7.667	7.667

Color Determination

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	3.000	5.000	1.000	5.000	3.000	1.000
Scorpion	0.333	1.000	1.000	0.200	0.333	1.000	0.333
Robot with two arms	0.200	1.000	1.000	0.333	0.333	0.333	0.200
Claws and lift kit	1.000	5.000	3.000	1.000	3.000	3.000	0.333
Slide system	0.200	3.000	3.000	0.333	1.000	1.000	1.000
Spring-based elevator	0.333	1.000	3.000	0.333	1.000	1.000	1.000
Stingray	1.000	3.000	5.000	3.000	1.000	1.000	1.000
Sum	4.067	17.000	21.000	6.200	11.667	10.333	4.867

End Time Behavior

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	0.333	0.333	1.000	1.000	3.000	1.000
Scorpion	3.000	1.000	1.000	1.000	0.333	5.000	3.000
Robot with two arms	3.000	1.000	1.000	3.000	1.000	5.000	1.000
Claws and lift kit	1.000	1.000	0.333	1.000	1.000	5.000	0.333
Slide system	1.000	3.000	1.000	1.000	1.000	3.000	1.000
Spring-based elevator	0.333	0.200	0.200	0.200	0.333	1.000	0.333
Stingray	1.000	0.333	1.000	3.000	1.000	3.000	1.000
Sum	10.333	6.867	4.867	10.200	5.667	25.000	7.667

Time to Locate Block in Bin

	Datum - Color Sorting	Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Datum - Color Sorting	1.000	1.000	0.200	1.000	0.333	1.000	0.333
Scorpion	1.000	1.000	0.333	1.000	0.333	1.000	0.333
Robot with two arms	5.000	3.000	1.000	5.000	3.000	3.000	0.200
Claws and lift kit	1.000	1.000	0.200	1.000	1.000	1.000	0.250
Slide system	3.000	3.000	0.333	1.000	1.000	1.000	0.250
Spring-based elevator	1.000	1.000	0.333	1.000	1.000	1.000	0.250
Stingray	3.000	3.000	5.000	4.000	4.000	4.000	1.000
Sum	15.000	13.000	7.400	14.000	10.667	12.000	2.617

Final AHP Matrix

Final Matrix Transposed						
	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	End Time behavior	Time to locate block within bin
Datum - Color Sorting	0.047	0.091	0.102	0.249	0.106	0.069
Scorpion	0.304	0.284	0.117	0.059	0.199	0.072
Robot with two arms	0.161	0.146	0.091	0.044	0.206	0.238
Claws and lift kit	0.259	0.213	0.318	0.209	0.118	0.074
Slide system	0.061	0.041	0.058	0.116	0.181	0.117
Spring-based elevator	0.116	0.103	0.151	0.104	0.038	0.076
Stingray	0.052	0.123	0.163	0.219	0.153	0.355

Concept Selection

Analytical Hierarchy Process

Concept	Alternative Value
Datum - Color Sorting	0.113
Scorpion	0.133
Robot with two arms	0.152
Claws and lift kit	0.185
Slide system	0.098
Spring-based elevator	0.100
Stingray	0.219

David Bowen

House of Quality

Engineering Characteristics								
Units		ft/s^2	in	in	s	s	s,in	s
Customer Requirements	Importance Weight Factor	Acceleration	Distance from Barrier	Block height (raising and lowering)	Time to Reach Correct Bin (Color Determination)	Design/Build Time	End Time behavior	Time to locate block within bin
Stack Duplo Blocks Correctly	6	1	5	9	9	9	1	5
Mobility	5	5	9	5	5	9	9	5
Robot Volume	7	1	5	5	1	1	1	5
Color Recognition	3	5	1	5	5	5	1	1
Speed	4	9	1	1	9	9	9	5
Automatic Shutdown	2	5	1	1	1	1	9	1
East of Implementation	0	5	5	9	5	9	1	5
Button Pushing	1	1	1	1	1	5	1	1
Raw Score		97	81	89	85	109	101	69
Relative Weight %		18%	15%	16%	15%	20%	18%	13%
Rank Order		3	6	4	5	1	2	7

David Bowen

Pugh Matrix

	Datum	Concepts					
Engineering Characteristics		Scorpion	Robot with two arms	Claws and lift kit	Slide system	Spring-based elevator	Stingray
Acceleration		+	+	+	+	S	+
Distance from Barrier		+	+	+	S	S	S
Block height (raising and lowering)		S	+	S	S	S	+
Time to Reach Correct Bin (Color Determination)		-	-	S	+	-	+
End Time behavior		+	+	+	+	S	S
Design/Build Time		S	-	+	+	-	S
Time to locate block within bin		S	-	S	+	S	+
Sum of Pluses		3	4	4	5	0	4
Sum of Minuses		1	3	0	0	2	0
Rank		4	3	2	1	5	2

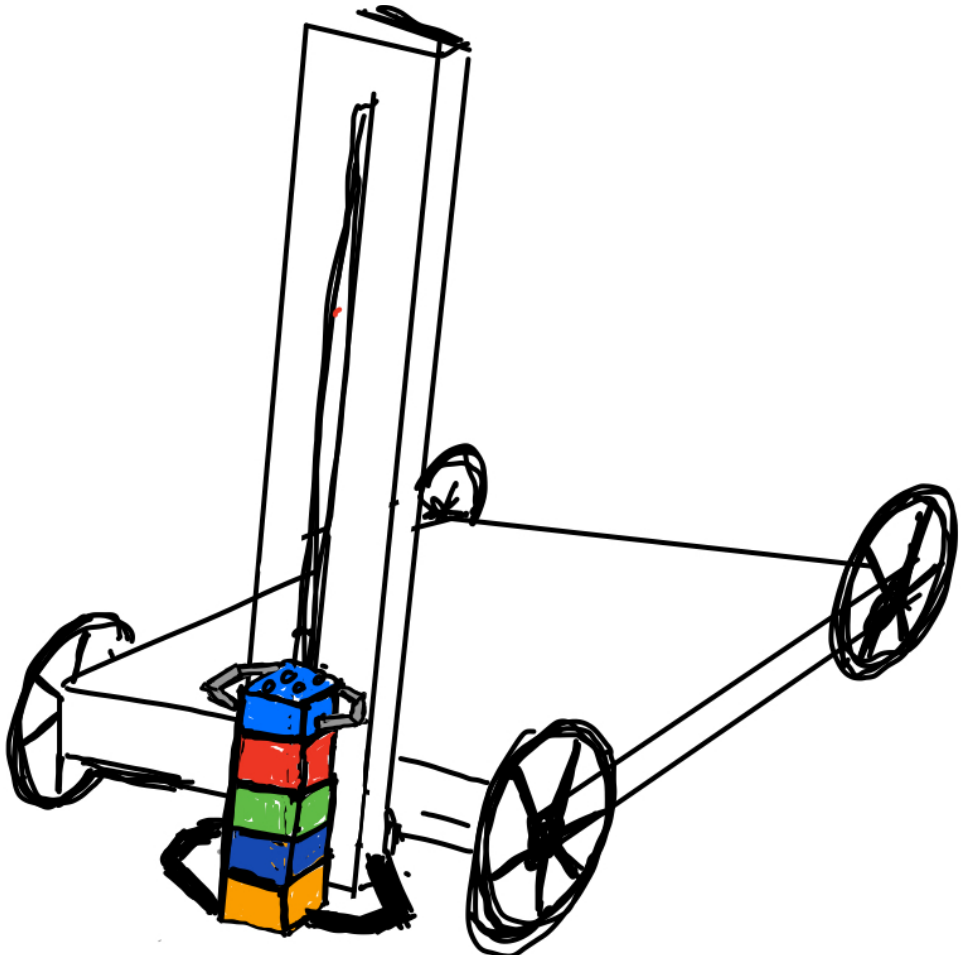
	Datum	Concepts		
Engineering Characteristics	Scorpion	Stingray	Slide system	Claws and lift kit
Acceleration		S	-	-
Distance from Barrier		-	-	S
Block height (raising and lowering)		+	S	+
Time to Reach Correct Bin (Color Determination)		+	+	+
End Time behavior		-	+	S
Design/Build Time		S	S	+
Time to locate block within bin		+	+	+
Sum of Pluses		3	3	4
Sum of Minuses		2	2	1
Rank		2	2	1

David Bowen

Analytical Hierarchy Process

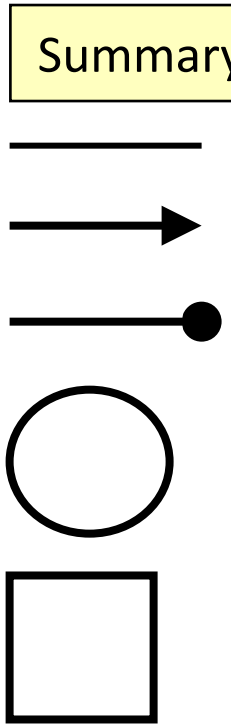
Concept	Alternative Value
Datum - Color Sorting	0.113
Scorpion	0.153
Robot with two arms	0.139
Claws and lift kit	0.190
Slide system	0.095
Spring-based elevator	0.095
Stingray	0.179

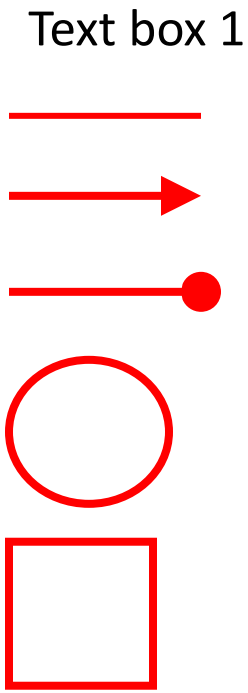
David Bowen

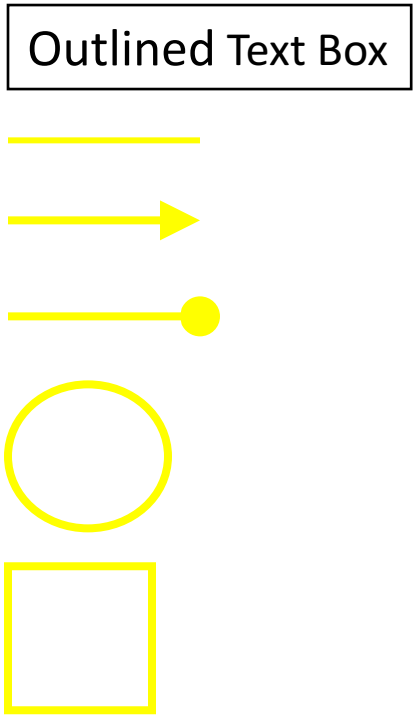


Detailed Math Backup

Standard Shapes







Approved Logos

FAMU-FSU
College of
Engineering

FAMU-FSU
Engineering

FAMU-FSU
Engineering

FAMU-FSU
College of Engineering

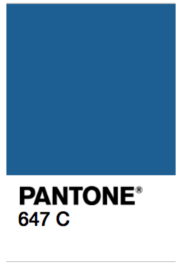
Color Palette

2299 C
Color values:
RGB 164 210 51
HEX/HTML #A4D233
CMYK 41 0 84 0

1788 C
Color values:
RGB 238 39 55
HEX/HTML #EE2737
CMYK 0 88 82 0

75% Black
Color values:
RGB 64 64 64
HEX/HTML
#404040
CYMK: 0 0 0 75

2239 C
Color values:
RGB 0 207 180
HEX/HTML #00CFB4
CMYK 59 0 39 0



647 C
Color values:
RGB 35 97 146
HEX/HTML #236192
CMYK 96 54 5 27

50% Black
Color values:
RGB 128 128 128
HEX/HTML
#808080
CYMK: 0 0 0 50

2199 C
Color values:
RGB 0 187 220
HEX/HTML #00BBDC
CMYK 77 0 16 0

7535 C
Color values:
RGB 183 176 156
HEX/HTML #B7B09C
CMYK 10 11 23 19

25% Black
Color values:
RGB 191 191 191
HEX/HTML #bfbfbf
CYMK: 0 0 0 25

APA Tables

Category 1	Category 2	Category 3	Category 4	Category 5
Item 1				
Item 2				
Item 3				
Item 4				

	Category 2		Category 3	
Category 1	subcategory 1	subcategory 2	subcategory 1	subcategory 2
Item 1				
Item 2				
Item 3				
Item 4				