MAE 189 Capstone Design Midterm Presentation

Team 20: PathFollower

Project definition:

UCI Samueli
School of Engineering

In a 2D environment with circular obstacles, construct a robot that can track a predetermined collision-free path with a maximum inaccuracy of 10%. The robot should be able to do turn maneuvers and pass through any two obstacles that are close to one another when the path follower gives the order. The robot must be self-contained, self-sufficient, and able to operate for at least 30 minutes without requiring recharging.

Project Overview and Objectives:

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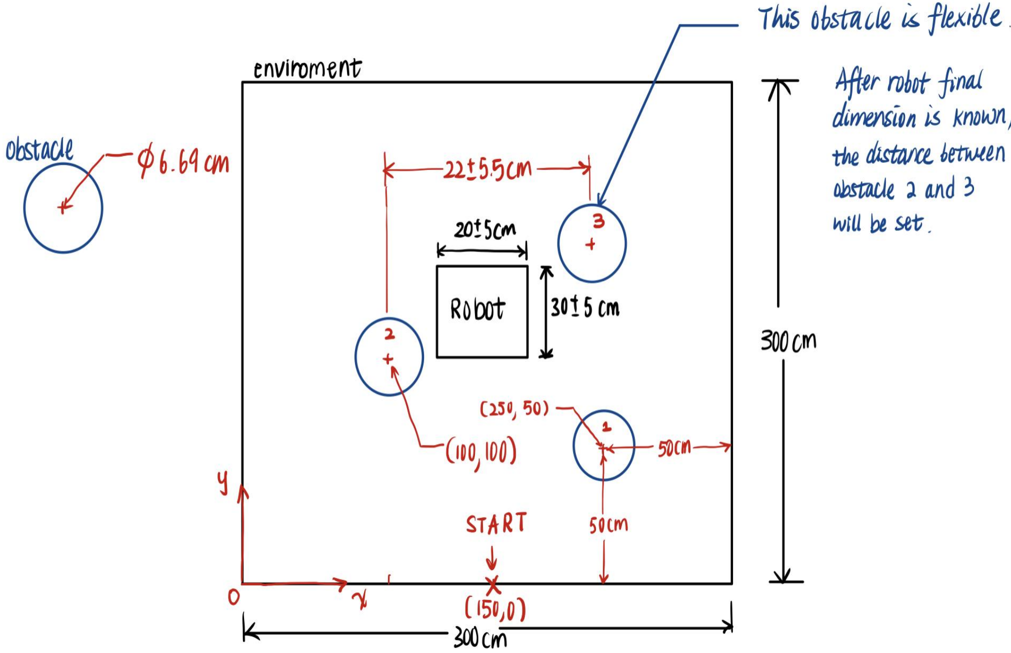
In a environment of **300cm x 300 cm,** our goal is to create a robot that has a base size of **20cm x 30cm** that are capable to turn and run autonomously. To ensure that the robot follows the pre-planned path within a maximum error of 10%, the obstacles are placed at distance of **22 cm** apart,measured from the surface of the obstacles. The autonomous robot needs to pass through any two closely obstacles to demonstrate its precision in following the path planned.



Rong Tian

Rong Tian

Design attributes and requirements

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-quality of robot: able to run and turn without break

-steering system and power system controlled by code

-able to run 30 minutes without recharging

-precision to follow path with max. 10% error

-budget $500

-project time: 10 weeks

Concept Design: Mechanical

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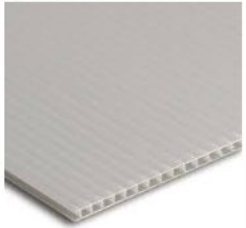
Material for the frame:

	pros	cons	why choose it
Lego 	- Light and sturdy - Very easy to change it's shape	- Expensive - Hard to get	We choose lego since we want to use a light and sturdy source that is easy to work with. We consider adding some wood and plastic too to reduce the cost.
wood 	- Sturdy - Easy to buy	- Heavy	
plastic 	- Light and sturdy	- Hard to change it's shape or cut them.	

Riko Takahara

Concept design: Mechanical

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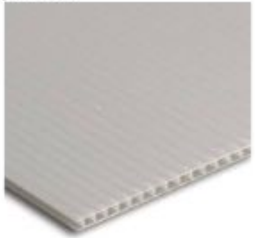
Lego

wood

plastic



Riko Takahara

Yield strength of material

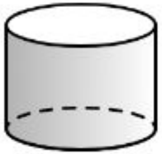
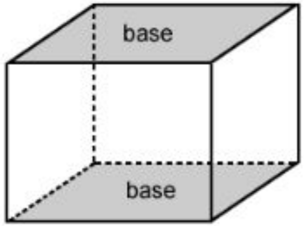
ABS plastic: 1.85*10^7 - 5.1*10^7 Pa ≈ 2700-7400 psi

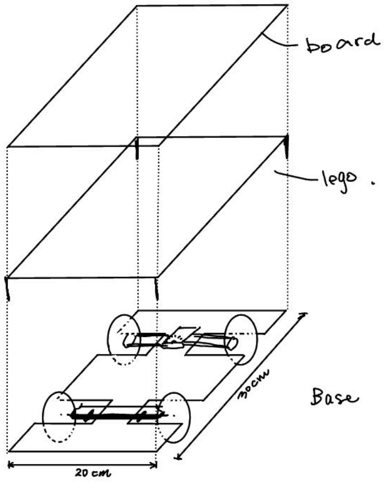
Lego can resist 1000N force from hydraulic press machine

Depend on species 800,000–2,500,000 psi and 5,000–15,000 psi

Polypropylene is around 9000 psi

Even Though lego's yield strength is the lowest of all, by comparing it to other cons that lego have, and since the yield strength fall under our needed condition since all the yield strength it is going to experience is the mass of the robot, we choose lego as the main material for the frame.

	pros	cons	why choose it
Circular base 	- Can turn quicker	- Very hard to make a circular base - Round base cause in shorter distance between wheels - Small area	
Rectangle 	- Easy to form te shape with lego - Farther the wheel is going to be apart and more sturdy	- Smaller area - Need more times to turn compare to circular base	- Its the basic shape and it's easier to make. It is also more sturdy than the circular shape.



Concept design: Mechanical

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Estimated Dimension:

Length: 32 cm

Width: 20.8 cm

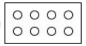
Calculated Estimated Weight:

For 2 Deck + 2 Axis +Connection Only

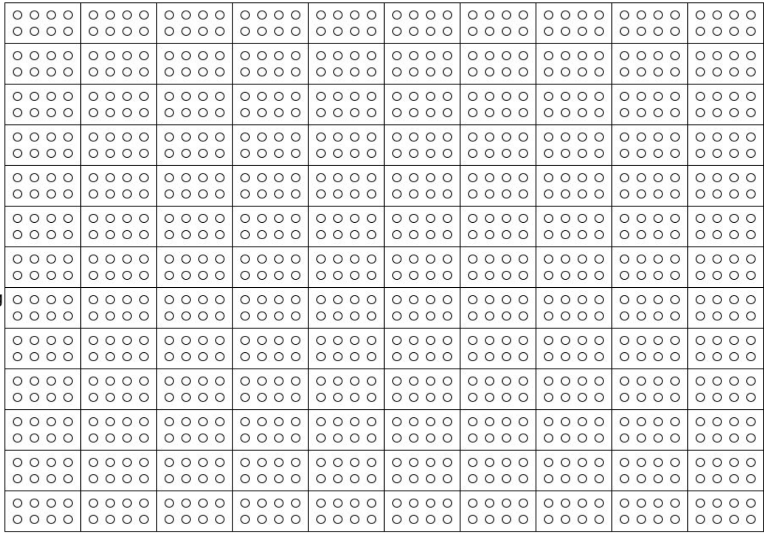
898.8 g

Weight Estimate For Base + Front&Rear Axis

3.2 cm

1.6 cm 

Base



Dimension:

3.2*10 = 32 cm

1.6*13 = 20.8 cm

Weight:

13*10*2.32

=301.6 g

Rear Suspension: 50 g

Front Steering: 60 g

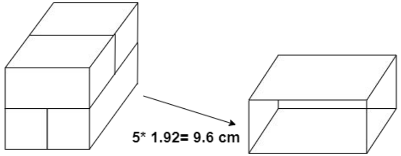
Connection&2nd Base:

Dimension:

3.2*1 = 3.2 cm

1.6*2 = 3.2 cm

0.96*2 = 1.92 cm



Total Weight = 2*Base + Front&Rear Axis + Connection
= 2*301.6 g + 50 g+ 60 g+ 80*2.32 = 898.8 g

Tianhao Zheng

Concept design: Mechanical

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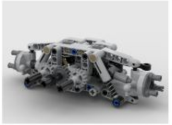
Comparison between Steering System

- We will choose Metal Steering System for:
  - Highest Strength to Bear Torque Given by Servo Directly
  - Acceptable Cost
  - Ackermann Steering that avoids slip

	pros	cons	why choose it
Alloy Front Steering Rod Link Pole Wheel Axle for 1/14 RC Tamiya Tractor Truck 	Simple Structure Easy Access (Amazon) Solid and Stable (Alloy) Cheap ($18)	Not Flexible in Size (7.05 x 2.68 x 1.02 inches)	Most Stable, Eco & Durable Choice and at same time Most Simple One.
Lego Front Axle With Suspension Steering and Driving 	Multiple Functions (Suspension mechanism fit with off-road environment) Relative Flexible Size Fit for Lego Frame Medium Cost ($20-80)	Weak Structural Strength Not Easy to Assemble on normal base	
3D print rack and pinion steering system 	Flexible in Size (Depends on need) Easy to Access (3D printer) High Potential for More Functions (Depends on Design) High Cost (Depends on yield and Crafting time. 3D print– $8 per hour and may take more than 5 hours)	Relatively Weak Structure Strength Long Period for Replacement If Broken and High Cost Long Period for Design & Crafting	

Tianhao Zheng

Concept design: Mechanical

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Comparison between Suspension System

- We will choose Lego Suspension System for:
  - Convenient to Assemble with Lego Base
  - Multi-Function with Suspension System and Differential System
  - Relatively Acceptable Cost

	pros	cons	why choose it
Technic Parts Rear Suspension System for Off-Road compatible with LEGO 	Easy Access (Amazon) Multiple Functions (Differential & Suspension mechanism) Adaptable for Multiple Landscapes Easy to Replace Components $20-$60	Weak Structural Strength (Assembly) Not Easy to Assemble on normal base (Irregular Shape) Not Flexible in size (7.5*3.3*1.53 inches)	With Differential System that Fits Power System the Most
RC Base 	Finished Product Easy Access and Use Most Durable (Unibody) Completed Base, Suspension, Power, and Steering $230-$1000	Not Flexible in size Difficult to modificate Difficult to add more sensor and other electrical components Relatively Expensive	
Rod and Gear System 	Finished Product Easy Access and Use Durable (Alloy body) Cost Efficiency ($7) Easy to Assembly (Fixed in a hole)	Single Function and Single Power input (Without Differential) Fixed Size	

Tianhao Zheng

Concept Design: Electrical

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- 2 different choices for power output for robot.

- Went with DC motor with 3000 rpm and 30W due to high power output

- Can adjust torque output through gear ratio.

DC Motor

DC Motor (3000rpm, 30W) 	- High RPM and High power output - Uses 12v - Should be powerful enough for worse case scenario	- requires gear ratio to increase torque	
DC Motor (30rpm, 6kg*cm) 	- 30rpmspeed can be adjusted to go slower, not faster - Decent torque, 6kg*cm. Torque can be adjusted by changing gear ratio (increase in gear ratio would cause more torque but less rpm) - Current .6Amp	- may not produce enough torque for our application - low power (.018W)	For back wheel driving https://www.amazon.com/dp/B071KFT4P7/ref=sspa_dk_detail_0?pd_rd_i=B072R5G5GR&pd_rd_w=YZps1&content-id=amzn1.sym.88097cb9-5064-44ef-891b-abfacbc1c44b&pf_rd_p=88097cb9-5064-44ef-891b-a

Hugo Martinez

← friction coefficent

μ of Hard rubber on dry concrete = .6

Normal force = 3 kg · 9.81 m/s² = 29.43 N

Friction force = (29.43)(.6) = 17.66 N

radius from center axis of wheel to floor = 2.875 in = .073 m

torque needed = (17.658)(.073) = 1.28 N·m

P = Power (W), T = Torque (N*m), w = speed (rpm)

3000 RPM, 30 W

$$P = \frac{(T)(w)}{9550} \rightarrow T = \frac{P(9.55)}{w} = \frac{(30)(9.55)}{3000} = .1 \text{ N}\cdot\text{m}$$

P = Power (W), T = Torque (N*cm), w = speed (rpm)

5 RPM

$$P = \frac{(T)(w)}{9550} = \frac{(10)(5)}{9550} = .005 \text{ W}$$

30 RPM

$$P = \frac{(6)(30)}{9550} = .018 \text{ W}$$

50 RPM

$$P = \frac{(3.97)(50)}{9550} = .0207 \text{ W}$$

550 RPM

$$P = \frac{(.7)(550)}{9550} = .0403 \text{ W}$$

Concept Design: Electrical

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- We will go with 20kg servo motor as it is cheaper and is powerful enough for our applications
- Will need a 12v to 5v convertor to operate

Servo Motors			
	pros	cons	why choose it
20kg servor motor 	- operates on low voltage 4.8-6.8 - cheap - lightweight (2.12 oz)	- needs a convertor - can't produce a force greater than 20kg, would maybe not be optimal for back wheel driving	- for front wheel steering https://www.amazon.com/ANNIMOS-Digital-Waterproof-DS3218MG-Control/dp/B076CNKQX4/ref=sr_1_8?crid=19SBFI4YU08RG&keywords=servo+motors&qid=1665364586&qu=eyJxc2MiOiI1LjQxIiwicXNhIjoiNC43OSIsInFzcCI6IjQuNTkifQ%3D%3D&sprefix=servo%2Caps%2C166&sr=8-8
35kg servo motor 	- operates on average voltage 5-7.4 - lightweight (2.12 oz) - Heavy amount of torque	- a bit too powerful for our applicatoin	- for back wheel drive (depending on how heavy the overall robot will be) https://www.amazon.com/ZOSKAY-Coreless-Digital-Stainless-arduino/dp/B07S9XZY

Hugo Martinez

Concept Design: Electrical

- Battery (36800 mAh = ~44 mins)

10 x Battery Capacity in amp hours / appliance load in watts

Mass of robot: 1451 g
5v servo = 5 watts
5v arduino = 0.29 watts
Gps module = .024 watts
DC motor = 30 watts

10 x 36.8 mAh / 2118.6 watts = 1.7 hrs robot life (102 mins)

battery			
	pros	cons	why choose it
(10000 - 40000) mAh portable battery 	-large battery supply -cheap -constant voltage	-may not be enough power -a bit bulky (300-400g)	-Battery energy capacity is flexible -would be enough to power our robot for 30 mins -least expensive -most energy efficient
Lithium-ion 	-lightweight -stable voltage -high energy density	-expensive -may need to have multiple batteries in a pack	
Lithium polymer 	-super lightweight -cheap -comes in a range of Voltages (3.7V - 44.4V)	-can be dangerous if handled improperly -requires a smart charger -must be stored and maintained properly	

Michael Punaro

Concept Design: Electrical

- Voltage Converter (12v to 5v)
  - to prevent overcharging our servo motors

Michael Punaro

Concept Design: Electrical

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Microcontroller Board			
	pros	cons	why choose it
Arduino UNO REV3 	- team is very comfortable using this product - has everything we need to complete the project	- limited amount of pins	- cheaper and doesn't require WiFi/Bluetooth applications to complete the tasks https://www.amazon.com/Arduino-A000066-ARDUINO-UNO-R3/dp/B008GRTSV6/ref=sr_1_3?crid=1U8AV3JBBXS1M&keywords=arduino&qid=1665364347&qu=eyJxc2MiOiI2LjAwIiwicXNhIjoiNS4yMCIsInFzcCI6IjUuMDIifQ%3D%3D&s=electronics&sprefix=arduino%2Celectronics%2C156&sr=1-3
ARDUINO UNO WiFi REV2 	- Able to connect to WiFi and bluetooth - Able to do everything that Arduino UNO REV3 can do and more!	- A lot more expensive	

- Chose the Arduino UNO REV3
- Has sufficient input / output pins
- Only using one sensor so a simple and cheap microcontroller would be best

Michael Punaro

Concept Design: Position sensor

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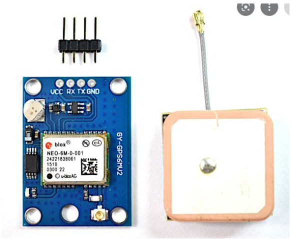
	Pros	Cons	Reason
Position (GPS) 	-gives **longitude+latitude** -one is enough to **determine position** -output is easier to work with when **calculates desired direction**	-output in **NMEA format**, needs to be decoded (use arduino library) -**wait about 1 min** to have stable output -transfer to **x,y coordinate**	**Doesn't choose it:** Have to violate one of the design attributes: precision or budget.

Design attributes: maximum error of 10%
Budget of $500

	precision	price($)
GPS NEO-6M	5-7m Not precise	~13
RTK GNSS NEO-M9N	1.5m Not precise	~70
RTK GNSS ZED-F9P	1cm	~275 Too expansive

Rong Tian

Concept Design: Position sensor

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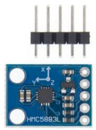
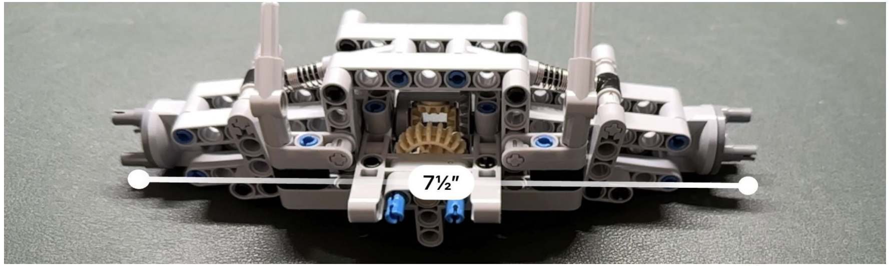
		Pros	Cons	Reason
Direction	**Magnetometer:** 	-measure **heading,** easy to use as direction -**high precision** with **low price** precise:1%, price:~$8	-**Large fluctuations and inaccuracy** in reading near magnet -**discontinuities** in heading from 360 to 0.	
	Gyroscope:	-**high accuracy,**(<1 degree) (frequently used with accelerometer) ~$7	-measure **angular velocity** -need to **calculate direction** from reading	-MPU 6050 (gyro+accel), ~$6 -arduino library to output in angle with respect to initial direction
Distance	**Reed switch:** 	-easy to install -cheap~$3-5	-**limited** in a certain speed range -**discrete distance** measured	
Rong Tian	**Encoder:** 	-**continuous measure** in distance -more accurate -**accuracy in 0.3 degrees** or less <$10	-convert rotational displacement to **electric signals** **-convert to linear displacement** -avoid slippage	-gives more precise distance measurement

Schedule after week 4

week	Task	Duration	Start Date	End Date
1	Team formation and meeting	4	9/27/2022	10/1/2022
2	Team organization Report	3	10/1/2022	10/4/2022
2,3,4	Concept design	20	10/3/2022	10/23/2022
2	week 2 status report	1	10/8/2022	10/9/2022
3,4,5	Solidwork Model	21	10/9/2022	10/30/2022
3,4	Pseudocode	14	10/9/2022	10/23/2022
3,4,5	Wire diagram	21	10/9/2022	10/30/2022
3	week 3 status report	1	10/15/2022	10/16/2022
4	Purchase order	6	10/17/2022	10/23/2022
4	Webpage	3	10/20/2022	10/23/2022
4	week 4 status report	1	10/22/2022	10/23/2022
5	Midterm presentation	2	10/23/2022	10/25/2022
5	Midterm report	6	10/24/2022	10/30/2022
6	week 6 status report	6	10/31/2022	11/6/2022
6,7	Electric verification	13	10/31/2022	11/13/2022
6,7	Robot fabrication	13	10/31/2022	11/13/2022
6,7	Code first draft	13	10/31/2022	11/13/2022
7	week 7 status report	7	11/7/2022	11/13/2022
8	Robot prototype	1	11/13/2022	11/14/2022
8,9	Test robot and fix problem	13	11/14/2022	11/27/2022
8	week 8 status report	6	11/14/2022	11/20/2022
9	week 9 status report	6	11/21/2022	11/27/2022
9	Final Robot	0	11/27/2022	11/27/2022
10	Final Presentation	5	11/27/2022	12/2/2022
10	Poster and design review	5	11/27/2022	12/2/2022
10	Design review	7	12/2/2022	12/9/2022
10	Final report	7	12/2/2022	12/9/2022

Purchase order submitted in week 5, expect to get component in week 6. Electrical and coding team will work on code before parts arrived.

Mechanical team already obtain some of the parts and works on it.(suspension+differential)



Tianhao Zheng

Questions and Concerns

- Find an accurate way to determine position with direction and distance measured
  - -curve line distance? Straight distance?
  - -frequency measured?