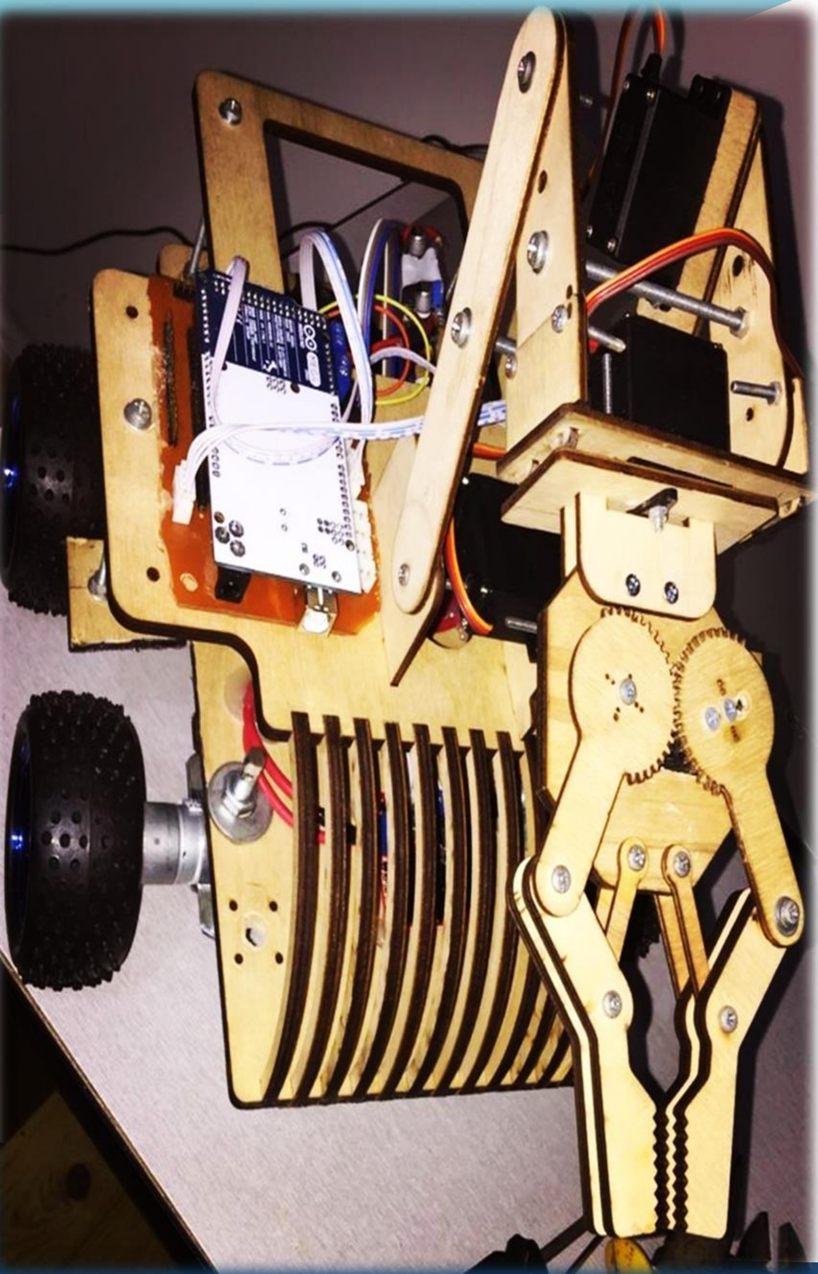
RAPTOR

LMR
TECHNICAL REPORT

OCTOBER 3, 2019

ALEXANDRIA,EGYPT



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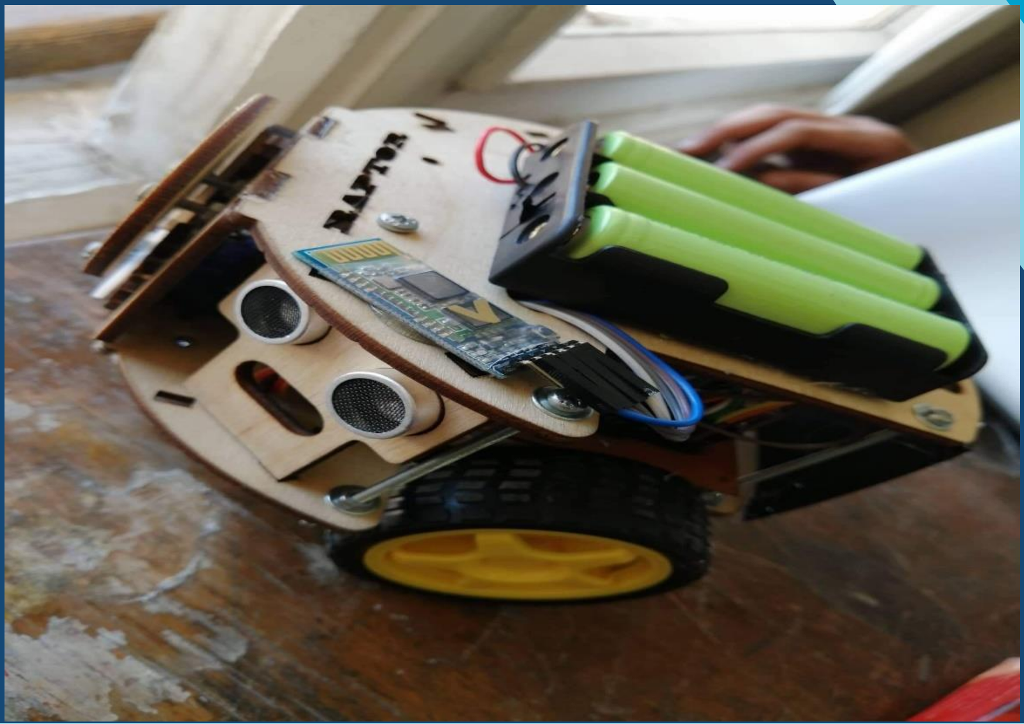
I- Abstract

It’s big challenge for everyone of us to enroll at this competition ; we all glade And very exciting to get the first place ; **RAPTOR** are 11 participant from different academic year have ambitions and seeking for science and modern technology .

LMR gave us the chance to apply the theoretical and written science to something physical we would build & fabricate .

We enrolled at this competition to get science and discover how this robot we see moving and do some tasks , the design , how coding , how the pilot controlling and how to fabricate & build all of these at the real .

Getting some soft skills like team working , communication skills , problem solving , working under pressure and leadership skills .



Figure(1) Mini robot

Contents

II – Design judicious

II-I – Design Prosses

While designing the first robot (mini robot) , we focused at the size to get the bonus less than (15x15 cm), then at the shape to look cool and well-designed look .

The second one (big robot) we tried to maintain the balance as there is an arm will be putted at, as well the design.

After establishing the outlines of design, electrical team members estimated the space needed for the electrical components in their enclosure. By receiving the dimensions of the electronic components, solid modeling by (CAD) & (SolidWorks) used to design and simulation the two robots.

II-II – Design constraints

The size limits for mini robot (figure 2) move at 15cm diameters

For the big robot (figure 3) not exceed 35x35 cm

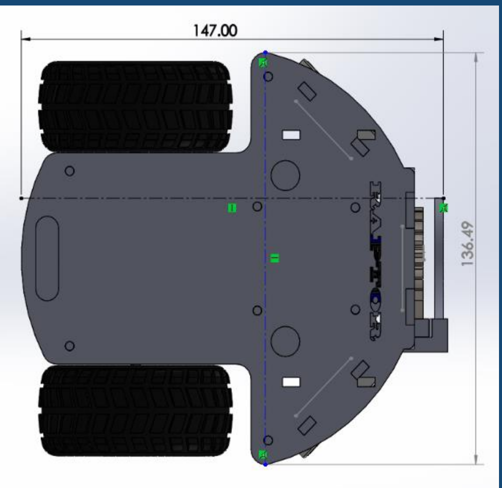


Figure (2)

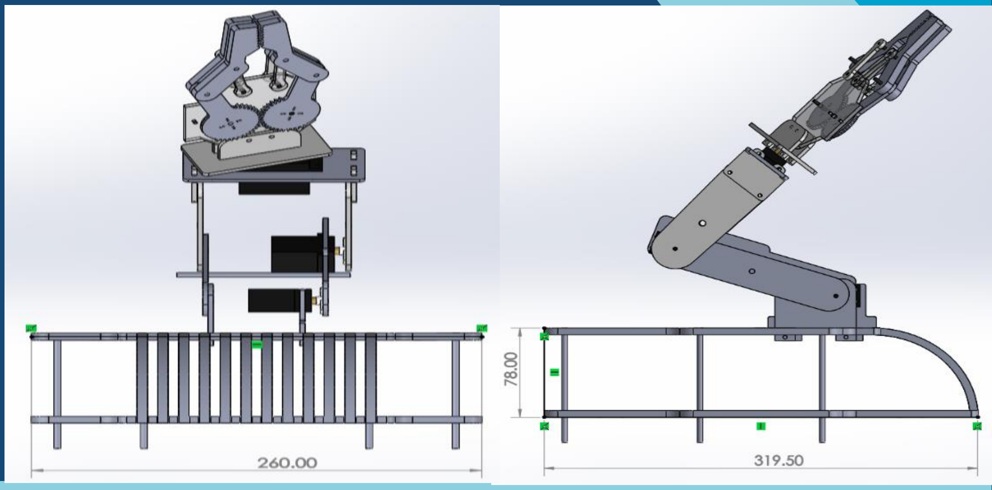


Figure (3)

II.III – Mechanical design

II.III.I – Cad Design

When designing the two robots, our priority was to build a lightweight, high strength base

with plenty of space for the payloads and necessary tools, the base of robots made of 6mm-thick laser cut transparent wood sheet. The wood was also selected due to relatively low density and will not make high mass. The base are used to correctly mount the all components on their supposed places .

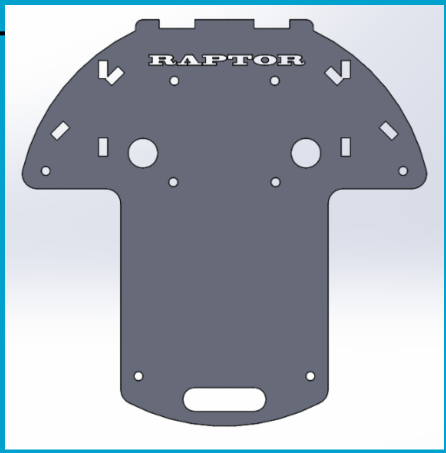


Figure (4)

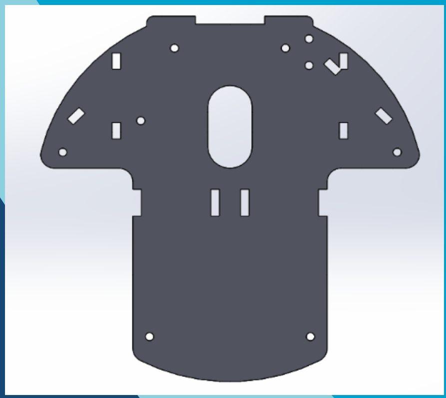


Figure (5)

The above base of mini robot figure (4)

The below base of mini robot figure (5)

Rack and pinion used for hooking the ring at the task and pull it using servo to move this part at figure (6)

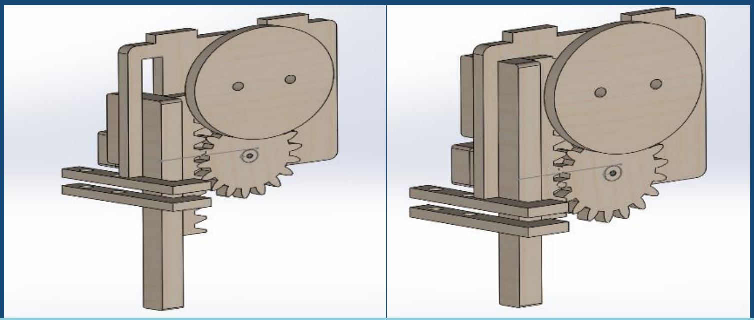


Figure (6)

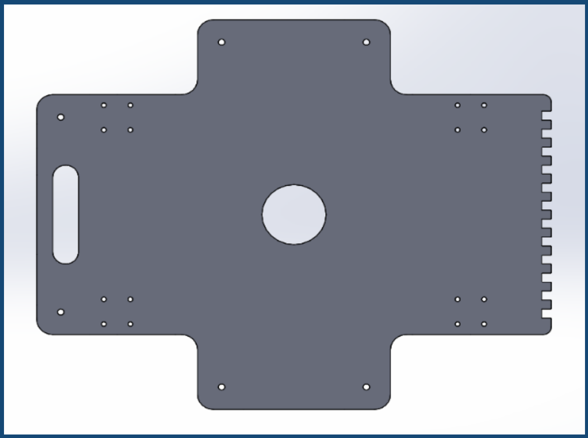


Figure (7)
Below base of big robot with
320x260mm

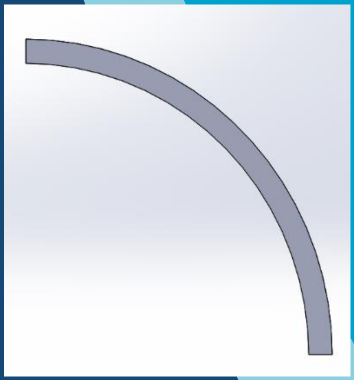


Figure (8)
link connected the above base
and below base

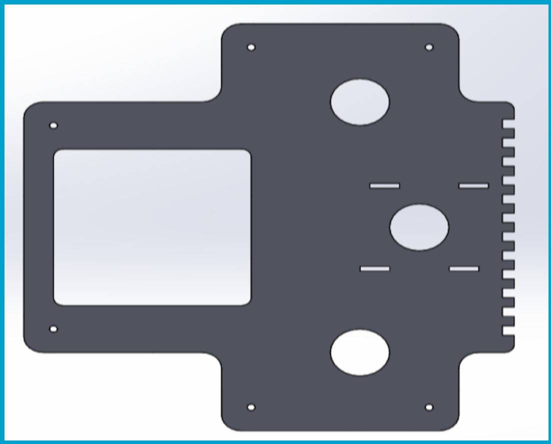


Figure (9)
above base of big robot with
248x260mm

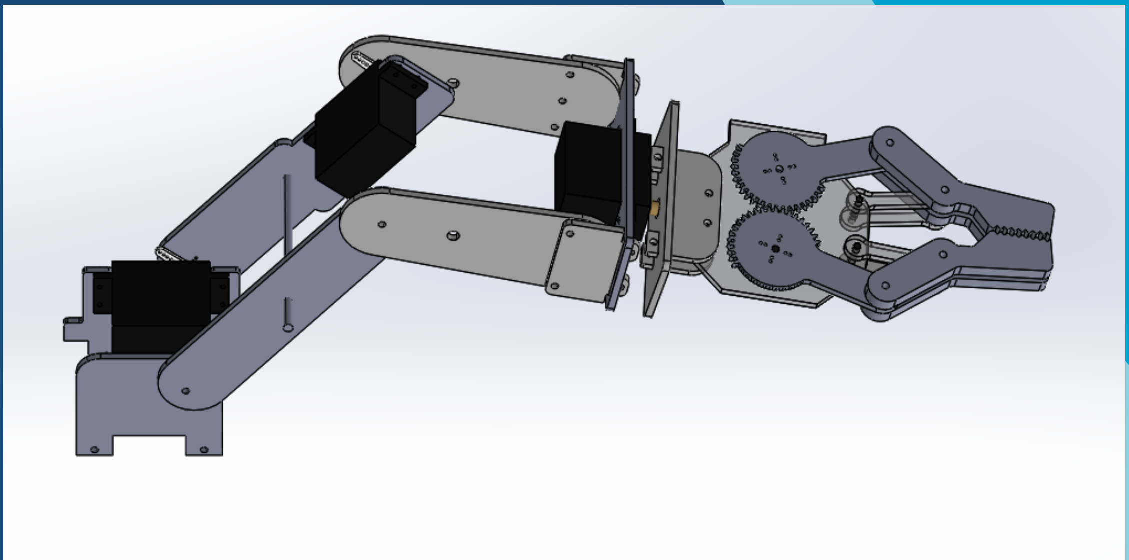


Figure (10)

The base of arm has no rotation movement as robot would be rotate aroung itself.

The arm has 4 servos motor ; as it gives motions which would do the tasks, 4 Mobility index

, 3 degree of freedom and 1 degree of flexibilty .

With working space maximum 413mm.

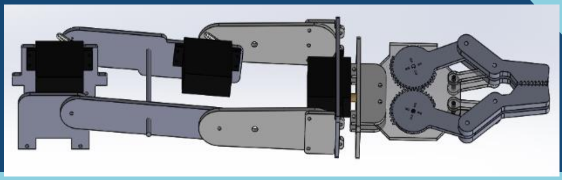


Figure (11)

II.III.II – Force & moment calculation&amp ; motor selection

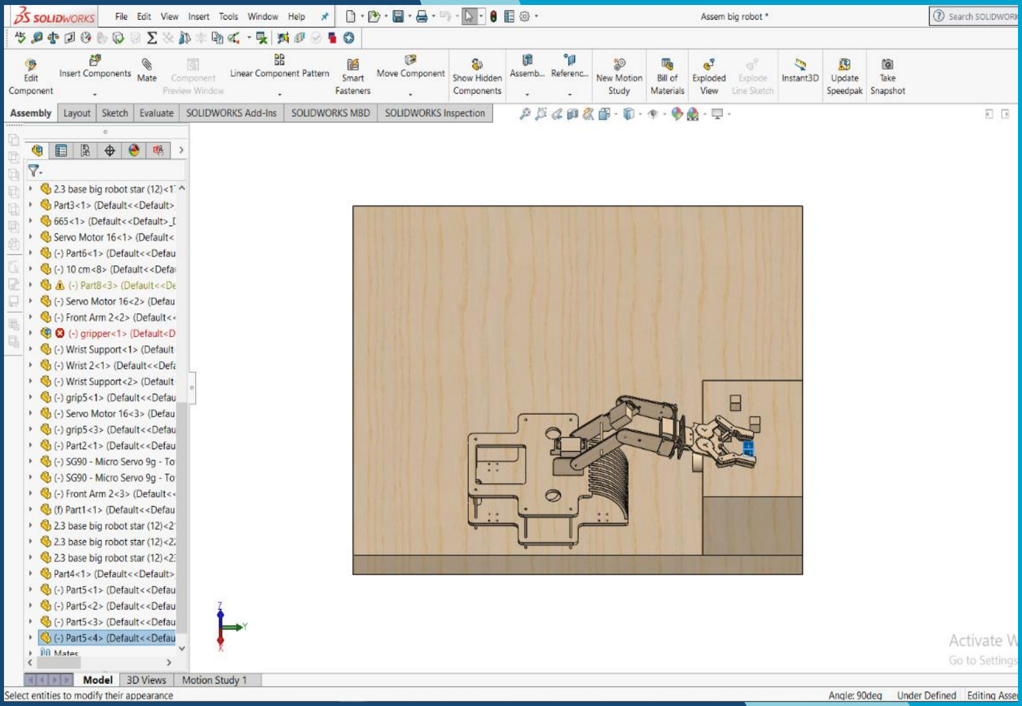


Figure (12)

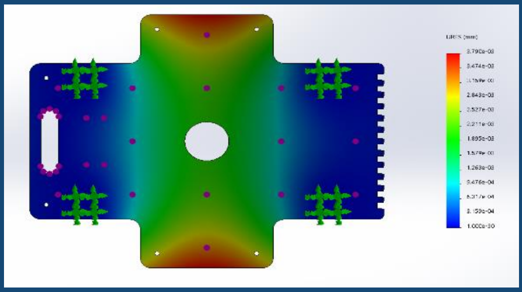


Figure (13)

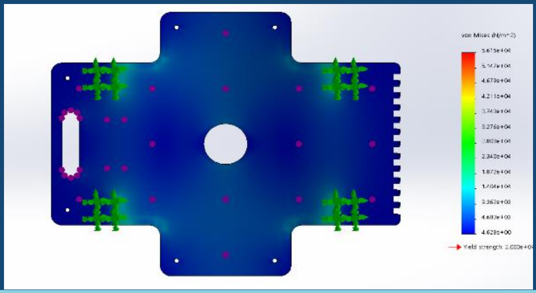


Figure (14)

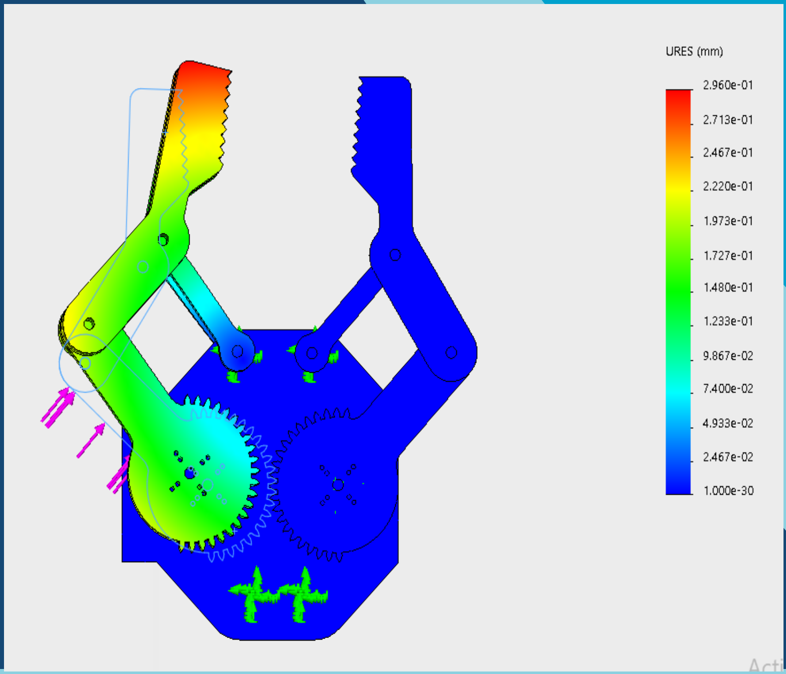


Figure (15)

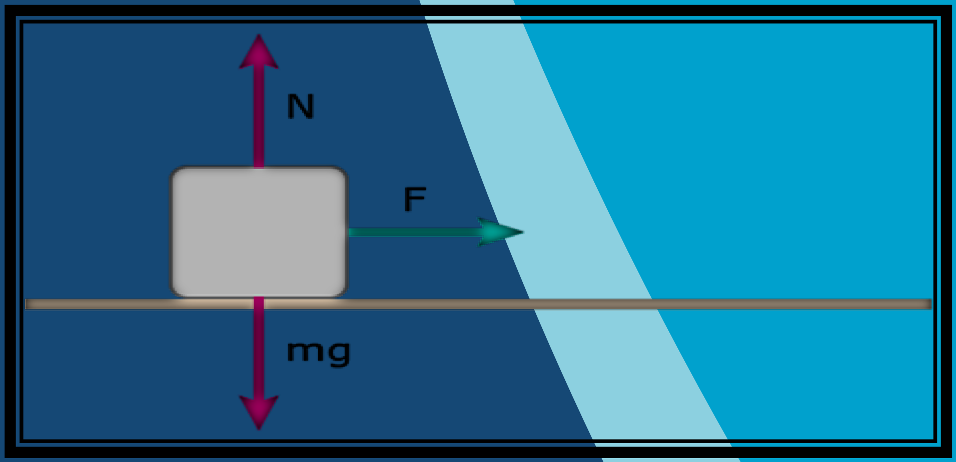
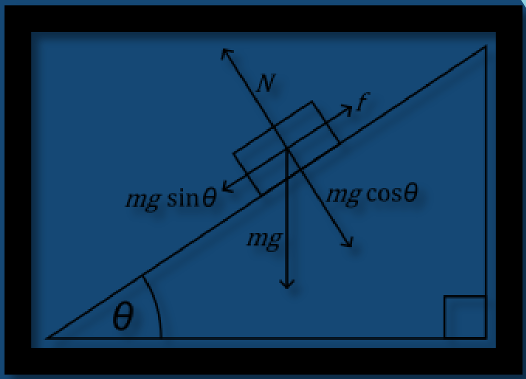


Figure (16)

N=0.5mg
N=0.5$* 1920 * \mathbf{10{-}3}$ = .96 kgf
Friction force = .96 $* \mathbf{0.9}$ = .864 $\boldsymbol{kgf}$
Torque = .864$* \mathbf{7}$ = 6.048 $\boldsymbol{kgf.cm}$



Torque= $\boldsymbol{F * R}$

Figure (17)

T= $(\boldsymbol{friction} + \mathbf{0.5}\boldsymbol{mgsin}14) * \boldsymbol{R}$
T= $(\mathbf{0.5}\boldsymbol{mgsin}\mathbf{15}+ \mathbf{0.9} * \mathbf{0.5}\boldsymbol{mgcos}\mathbf{14}) * \boldsymbol{R}$
T= $(\mathbf{0.5} * 1920 * \mathbf{10{-}3} * \boldsymbol{sin}\mathbf{15}+ \mathbf{0.9} * \mathbf{0.5} * 1920 * \mathbf{10{-}3} * \boldsymbol{cos}\mathbf{15}) * \mathbf{7}$
T= 1.189 $\boldsymbol{kgf.cmm}$

II.III.III – Dimensions & weight & C

<u>For mini robot</u>

not exceed 15x15 cm

<u>For big robot</u>

not exceed 35x35 cm

```
Mass properties of Assem big robot
     Configuration: Default
     Coordinate system: -- default --

Mass = 916.78 grams

Total weld mass = 0.00 grams

Volume = 916641.14 cubic millimeters

Surface area = 410616.30  square millimeters

Center of mass: ( millimeters )
        X = 90.56
        Y = 348.64
        Z = 354.57

Principal axes of inertia and principal moments
Taken at the center of mass.
         Ix = (-0.03,  0.96,  0.29)     Px = 49
         Iy = (-0.99, -0.06,  0.09)     Py = 18
         Iz = ( 0.10, -0.29,  0.95)     Pz = 19
```

Figure (18)

The mass includes only the wood we use adding about 1~2 kg for the components

II.III.IV – Reliability & manufacturing finishing

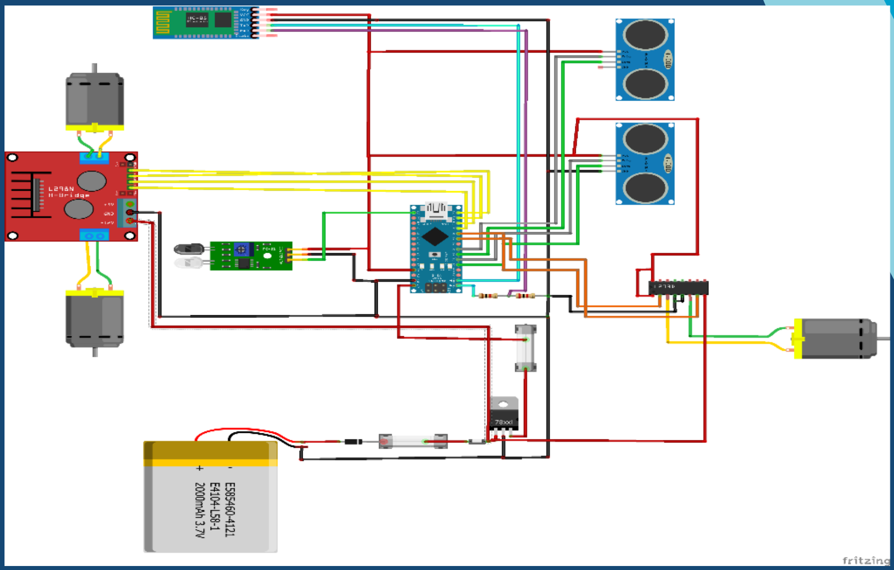
- using CNC laser cutting machine, and we have used tools like (drills, screwdrivers, bolts, nuts and chainsaws and wax gun) to build our robot

- It was a very important thing to make sure that our design was manufactured well to avoid any unexpected problems in the competition and to make work well and giving it a good shape

III – Electrical Evaluation

III-I – System Interconnection Design (SID)

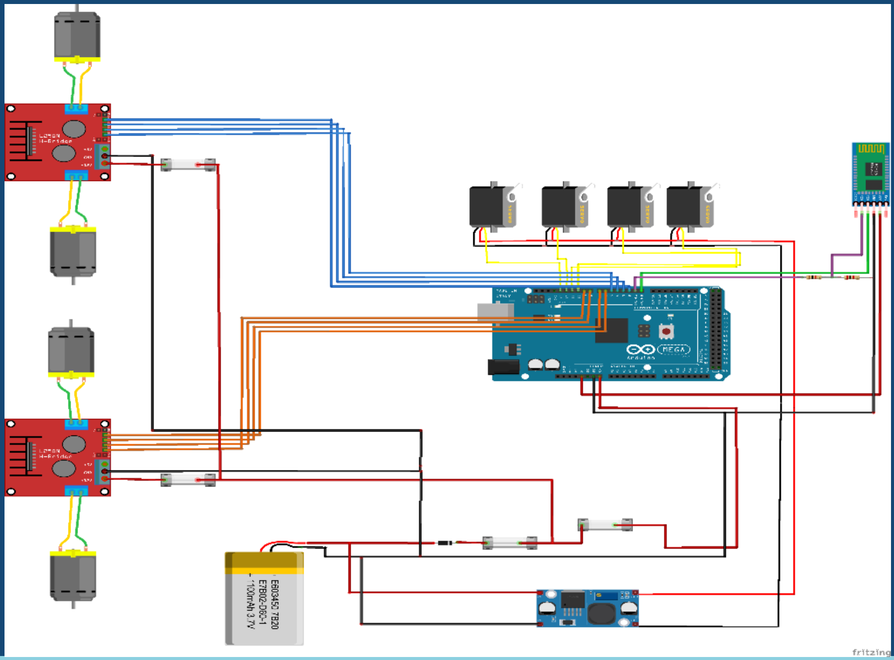
For ~ Mini robot



➢ Figure (19)

Using 2 motors, 2 ultrasonic ,1 IR,
1 Bluetooth module, Arduino nano,
1 motor driver, battery and dc motor

Big robot



➢ Figure (20)

Using 4 dc motors, 2 motor drivers,
battery, 4 servos, Bluetooth module
, buck convertor And Arduino mega.

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III-II – PCB Design

For mini robot

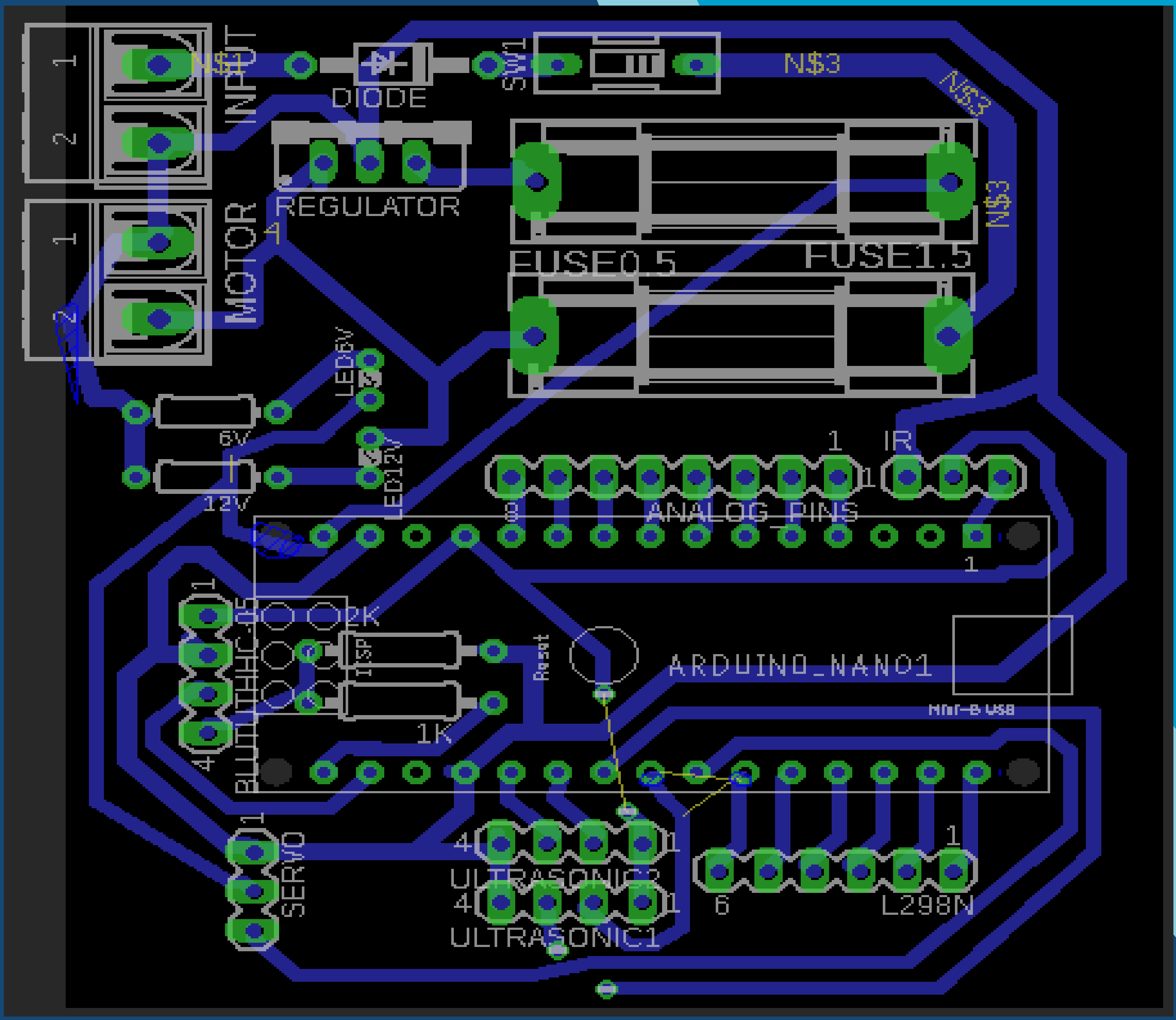

Figure (21)

For big robot

Power supply, supplies 5V for Arduino mega / 12V for buck converter

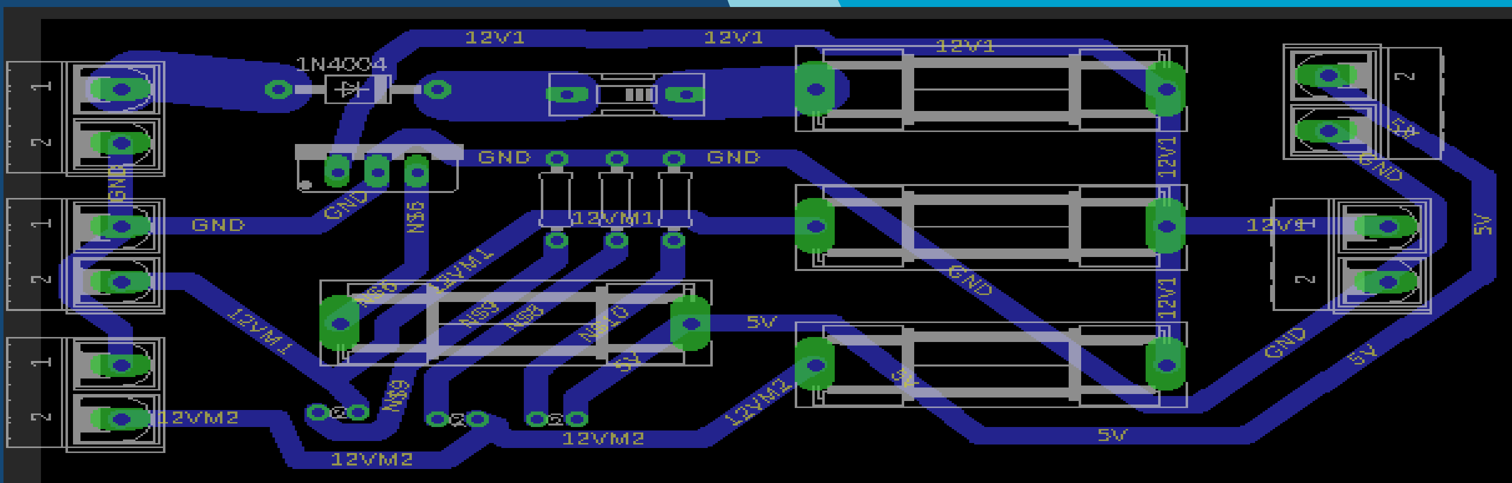

Figure (22)

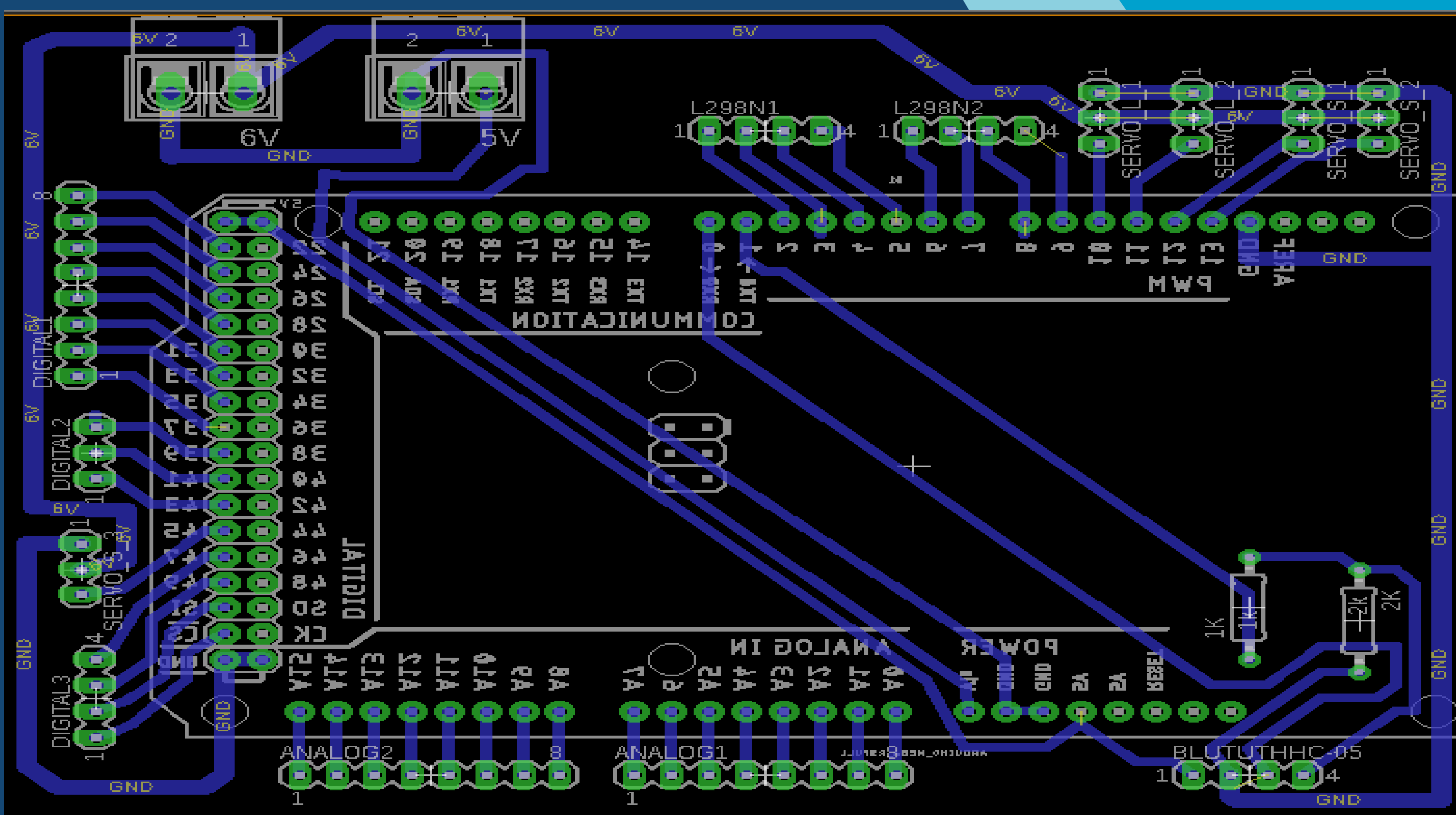

Figure (23) control pcb

III-III – System Components with Material Selection Reasons

Servo Motor Controllers

Figure (24)

Servo motors have been around for a long time and are utilized in many applications.
They are small in size but pack a big punch and are very energy-efficient. These features allow them to be used to operate remote-controlled or radio-controlled toy cars, robots and airplanes. Servo motors are also used in industrial applications, robotics, in-line manufacturing, pharmaceutics and food services

The servo circuitry is built right inside the motor unit and has a position able shaft, which usually is fitted with a gear the motor is controlled with an electric signal which determines the amount of movement of the shaft.

What's inside the servo?

Inside there is a pretty simple set-up: a small DC motor, potentiometer, and a control circuit. The motor is attached by gears to the control wheel. As the motor rotates, the potentiometer's resistance changes, so the control circuit can precisely regulate how much movement there is and in which direction .

When the shaft of the motor is at the desired position, power supplied to the motor is stopped. If not, the motor is turned in the appropriate direction. The desired position is sent via electrical pulses through the signal wire. The motor's speed is proportional to the difference between its actual position and desired position. So if the motor is near the desired position, it will turn slowly, otherwise it will turn fast. This is called proportional control. This means the motor will only run as hard as necessary to accomplish the task at hand, a very efficient little guy.

How is the servo controlled?

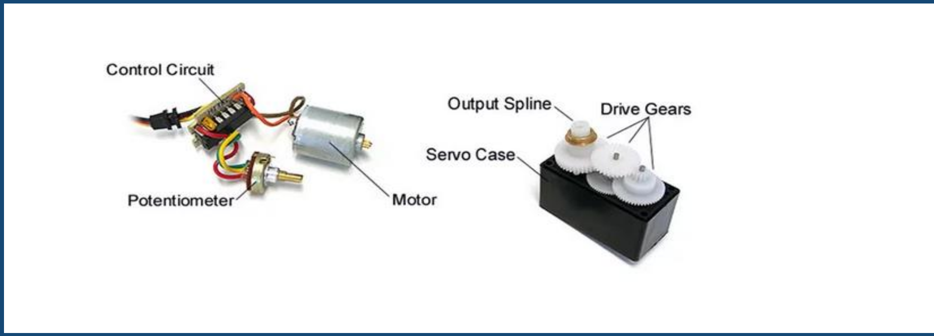

Figure (25)

Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of

180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor expects to see a pulse every 20 milliseconds (MS) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position. Shorter than 1.5ms moves it in the counter clockwise direction toward the 0° position, and any longer than 1.5ms will turn the servo in a clockwise direction toward the 180° position.

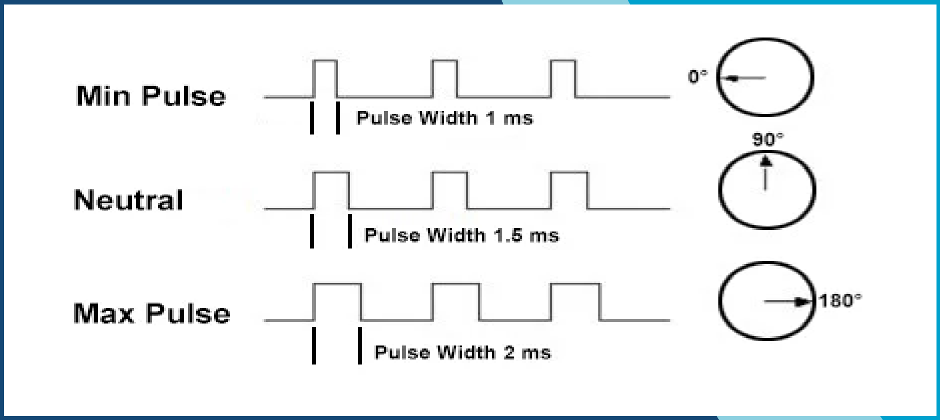

Figure (26)

When these servos are commanded to move, they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is called the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position

Types of Servo Motors

There are two types of servo motors - AC and DC. AC servo can handle higher current surges and tend to be used in industrial machinery. DC servos are not designed for high current surges and are usually better suited for smaller applications. Generally speaking, DC motors are less expensive than their AC counterparts. These are also servo motors that have been built specifically for continuous rotation, making it an easy way to get your robot moving. They feature two ball bearings on the output shaft for reduced friction and easy access to the rest-point adjustment potentiometer

For mini robot

Small robot **Arduino nano :** we used Arduino nano because its pins are Enough to control the small robot .

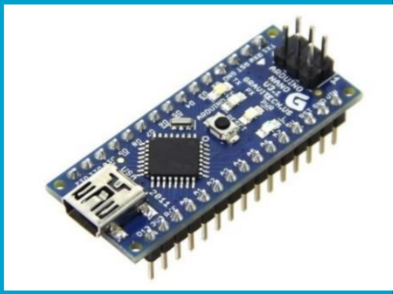

Figure (27)

Motor driver L298n : we used l298n MD because the motors of the robot uses 300mA for each motor and the L298n MD can give each one 600mA maximum

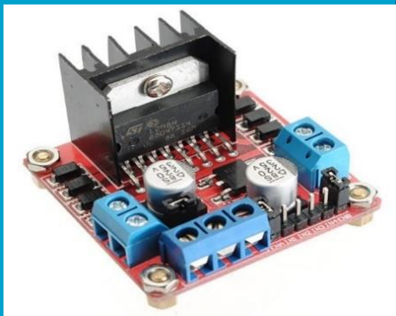

Figure (27)

Ultrasonic sensor : the US sensor is used to solve the maze , the sensor head emits an ultrasonic wave and receives the wave reflected back from the target , it measure the distance to the target by measuring the time between the emission and reception

Figure (29)

IR sensor : IR sensor is used to fix the blackline at the end of the maze to transform to manual control, As if it doesn’t read anything so it’s the black line else it is not a black color

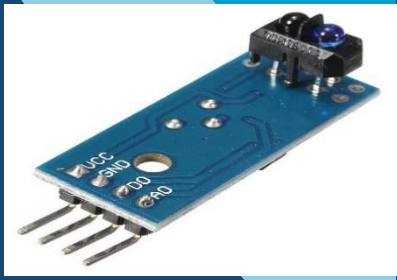

Figure (30)

Dc motor : a small dc motor with an l293 IC is used to control the robot arm up and down to catch the ring .

Figure (31)

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For big robot

Microcontroller:

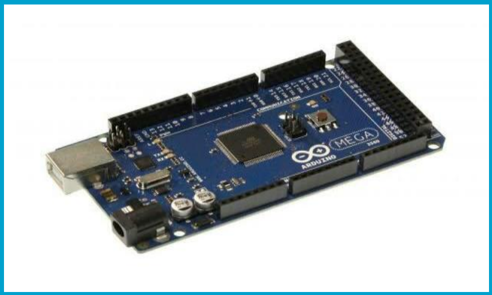


Figure (32)

We used an Arduino as our microcontroller , it's an open source platform used for built electronic projects .

Arduino Mega:

Based on our design we used Arduino Mega
As it has our suitable no. of PWM and I/O analog and digital pins , that allow us to make our needed connections.

Motor selection:

Motors and actuators are the devices which make the robot movable. Motors and actuators convert electrical energy into physical motion.
DC motors: DC motors are the simplest motors to use. They can reach a high rotational speed that is dependent on the input voltage. However, it cannot handle the position as

Figure (33)

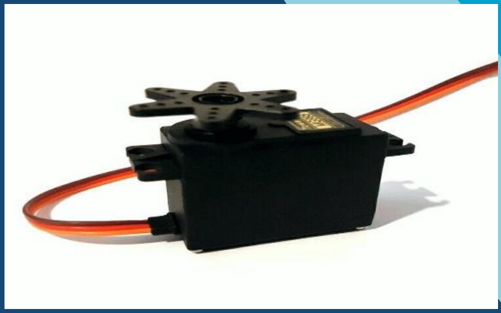


Figure (34)

one would with a servomotor or a stepper motor, but we use it for our wheels motion, also it's cheap, easy to drive, available in all size Robust, high gear reduction, best for competition robots.

So based on our design we decided to use 4 DC motors of 20kgf.cm torque to be sure that we are in safe mode.

Motor driver: "L 298N"

We used 2 motor driver " L298N " instead of building H-bridges as it is difficult to control the direction of DC motor .

As our dc motors needs :

Operating voltage : 12v & current : 700mA “ for every motor channel ”

Note : “ The max current the dc motor deal is 1.2A ” .

Arduino connection:

L 298N takes input voltage from motor and signal pulse from Arduino Mega to control motion of motor.

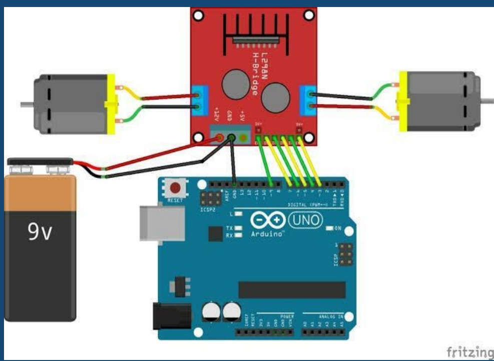


Figure (35)

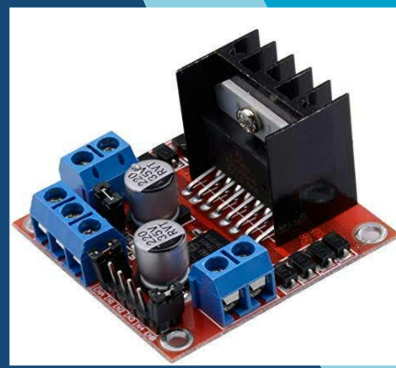


Figure (36)

Servo motors:

A servo motor is a rotary actuator that allows for precise control of angular position, it consists of a motor coupled to a sensor for position feedback, it also requires a servo drive to complete the system. So, based on our design we used 4 servo motors of 11 kgf.cm to rotate the arm weight.

Servo drive circuit:

Our servo is power by 1 A and 6 V after our voltage is regulated by passing through “7806” voltage regulator.

Arduino connection:

Servo takes input voltage and current from its drive circuit and PWM signal to control it’s angle from Arduino Mega.

communication protocol:

Bluetooth module” HC-05” is connected to Arduino by wiring,

As we can use software serial to communicate with Bluetooth module by using certain app. from Android operating system. So we can control robot through mobile for manual control for robot and arm.

Figure (37)

Battery selection:

We used a 12V. LI-polymer battery to drive our electronic and mechanical devices efficiently.

LI-polymer battery:

- Has a required capacity to perform task without need to recharge.
- used to Drive DC motors, servo motors and Arduino.

Figure (38)

IV – Safety

IV-I – Over Load Protection

For small robot

The electrical circuit pulls an average current of 1.5-2A.

The L298N Driver pulls an average current of 1200mA with a 14.4 Electric power,

The Arduino nano has an absolute limit of 40mA on each pin with a 2.5 Electric power.

The two Ultrasonic, Bluetooth module and the IR are fed by the Arduino,

With a current rate of 30mA for the two ultrasonic and a 0.75 Electric power,

20mA for the IR with a 1 Electric power and 30mA

for the Bluetooth module with a 1.5 Electric.

For big robot

The electrical circuit pulls an average current of 6-7A.

The two L298N Driver pulls an average current of 2400mA with a 28.8 Electric power,

The Two S3003 servo motor pulls an average current of 250mA for each one as max with a 1.2 Electric power,

The Two MG996R servo motor pulls an average current of 1200 for each one as max with a 6 - 10.8 Electric power and

The Arduino Mega has an absolute limit of 40mA on each pin ,and 200Ma in total for all pins , with a 2.5 Electric power.

The Bluetooth module is fed by the Arduino,

With a current rate of 30mA for the Bluetooth module with a 1.5 Electric power.

IV-II – Short circuit Protection

For mini robot

The battery produces a 12V with a 5A current so at the beginning of the circuit we used

a 1.5A Fuse that can stand up to 2A,

then after the 7806 regulator that feed the Arduino , using a 0.5A fuse that can stand up to 1A.

for big robot

The battery produces a 12V current so at the beginning of the circuit we used a 6A Fuse that can stand up to about 7A,

then we used three fuses two of them 1.5A fuse that can stand up to about 2A before the two L298N motor drivers and the last one stands up from 0.5A to 1A for Arduino mega

IV-III – Reverse Voltage Protection

- Reverse voltage protection circuits prevent damage to power supplies and electronic circuits in the event of a reverse voltage applied at the input or output terminals.
- Reverse voltage protection is implemented at the input of the power supply or onboard of the custom, multiple output redundant power supplies.
- The protection ensures that the components are not damaged by accidental swap of the power supply connections.

There are various methods that differ in operation, efficiency and complexity.

While some like a diode or circuit breaker provides only the reversal voltage protection, others such as the protection ICs provide the reverse voltage, over current, and overvoltage protections.

One drawback of the series diode is that it takes up board space and has high power dissipation at high load currents

Protecting reverse voltage using a diode

The diode is connected in series with the load and only allows power to reach the load only when in forward bias. If the voltage is reversed, it blocks the voltage and the reversed power does not reach the load.

Using the diode is the simplest method and has the advantage of low cost

- The disadvantages of using the diode are; the forward voltage drop which can be significant in low voltage applications, the high-power dissipation in high load currents and low efficiency.
  A Schottky diode is sometimes used due to its fast response and low forward bias voltage drop

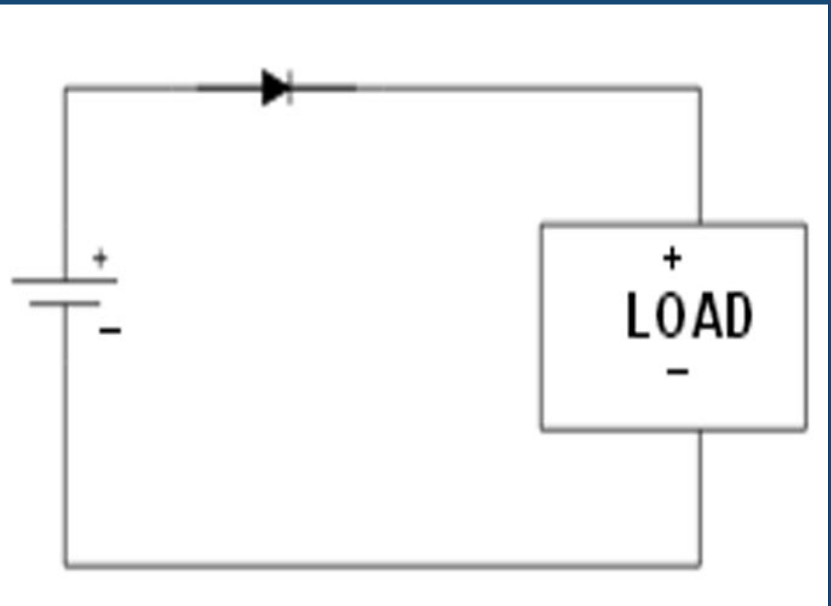


Figure (39) Diode in series with load

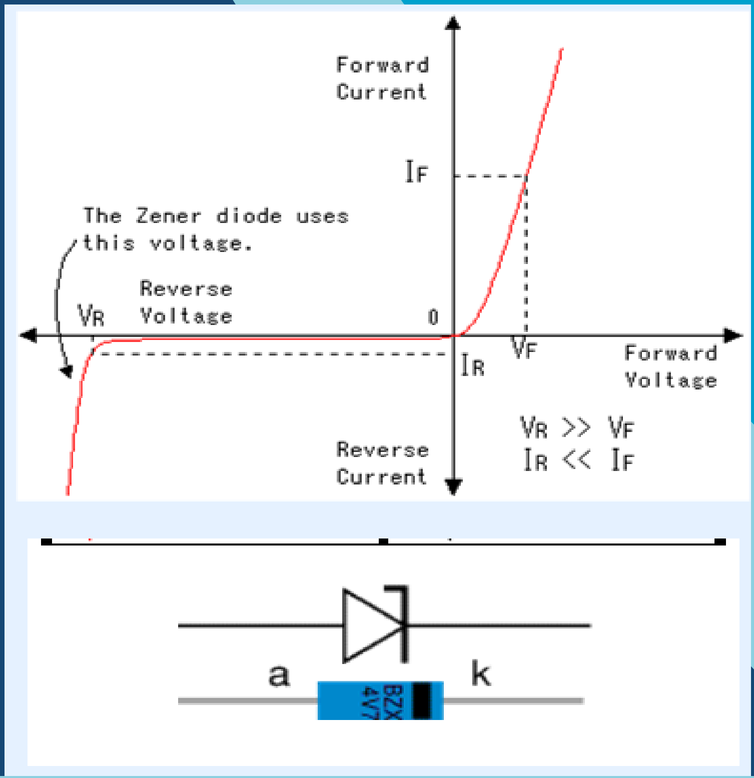


Figure (40)

IV-IV – Indication Elements

LEDs are commonly used for indicator lights (such as power on/off lights) on electronic devices

Figure (41)

Working Principle:

A light-emitting diode is a two-lead semiconductor light source.

It is a p–n junction diode that emits light when activated.

When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons

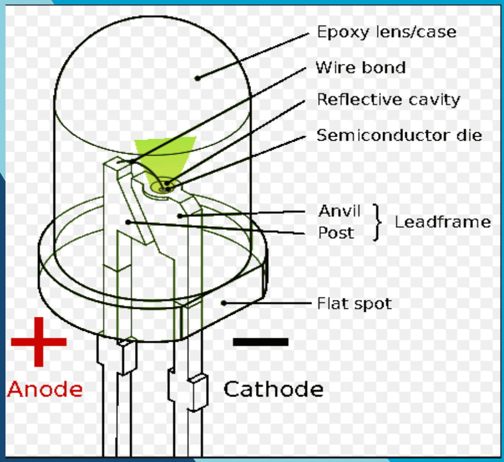


Figure (42)

LEDs are used to check the state of the circuit if it’s on or off.

For example:

o In Power circuit, we put a led connected in parallel after each fuse to check if the current in the circuit is interrupted or not by the fuse in case of short circuit or overload.

IV-V – Wires & Tracks Size Calculation

For mini robot

We used a 1.5mm track from the beginning to the 1.5A fuse so it can stand a 3A, then we use a 1mm from the 1.5A fuse to the Driver connector so it can stand a 2.5A, and the rest of the tracks are 0.8mm so it can stand a 2A.

Figure (43) **the battery**

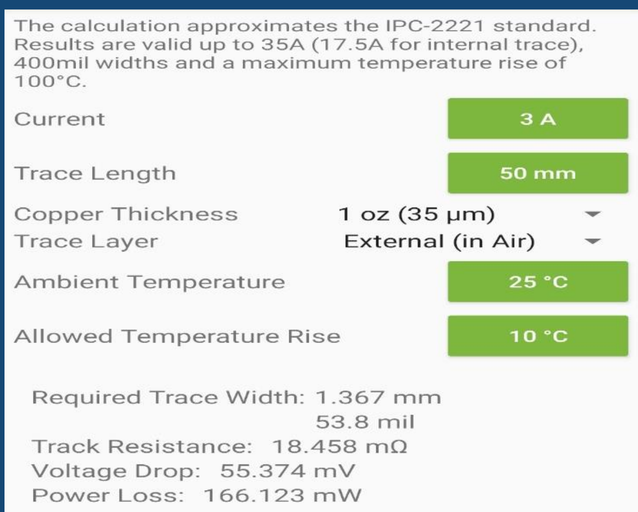
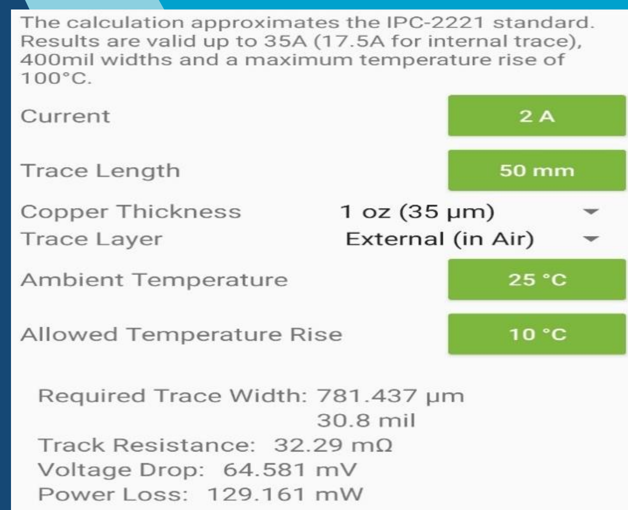


Figure (44) **DC motor**



For big robot

We used a 4.3mm track from the beggining to the 6A fuse so it can stands to 6-7A, then we used a 1mm from the 6A fuse to the two motor driver connecter and the buck converter so it can stands a 2.5-3A, and the rest of the tracks are 0.8mm so it can stands less than 1A.

Figure (45) battery

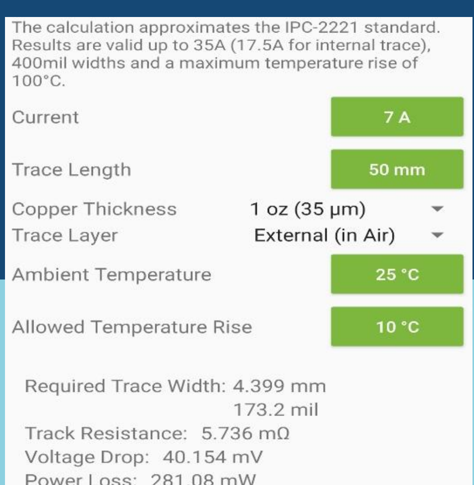


Figure (46) buck coinventor

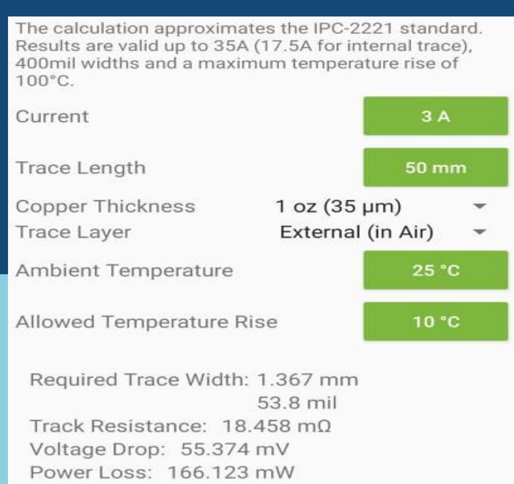
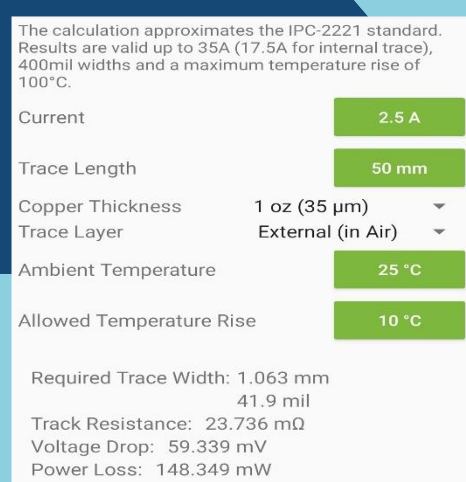


Figure (47) DC motors



V – Overall Creativity (Robot design & Style)

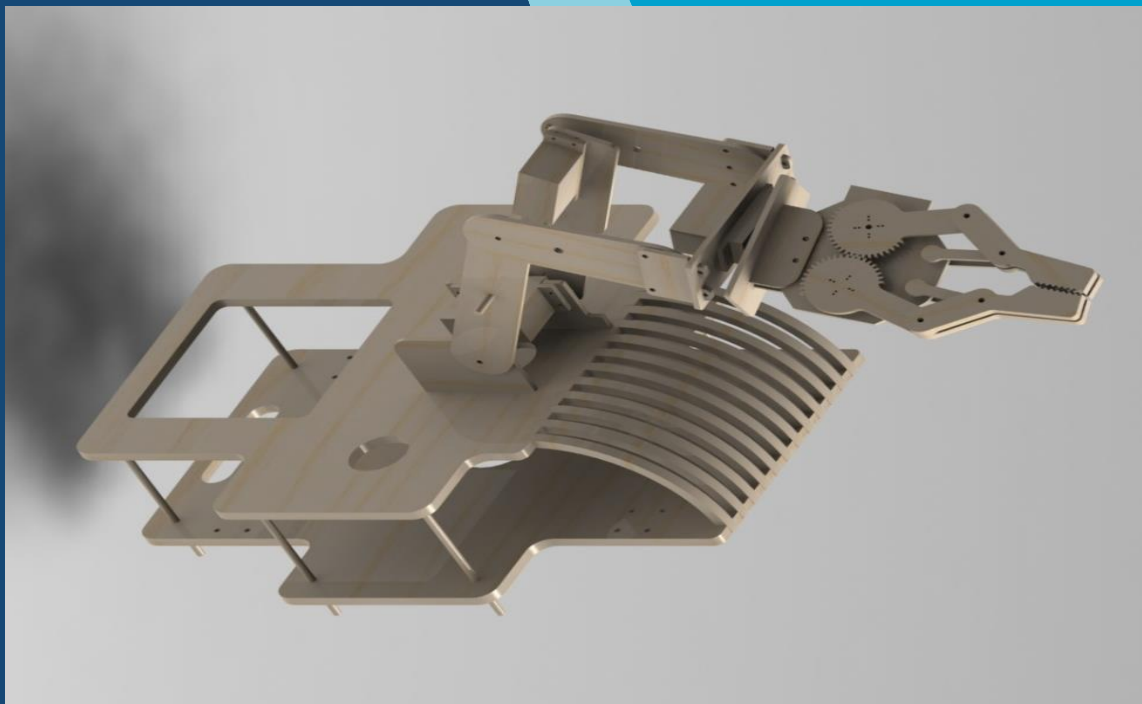


Figure (48) final assembly of big robot

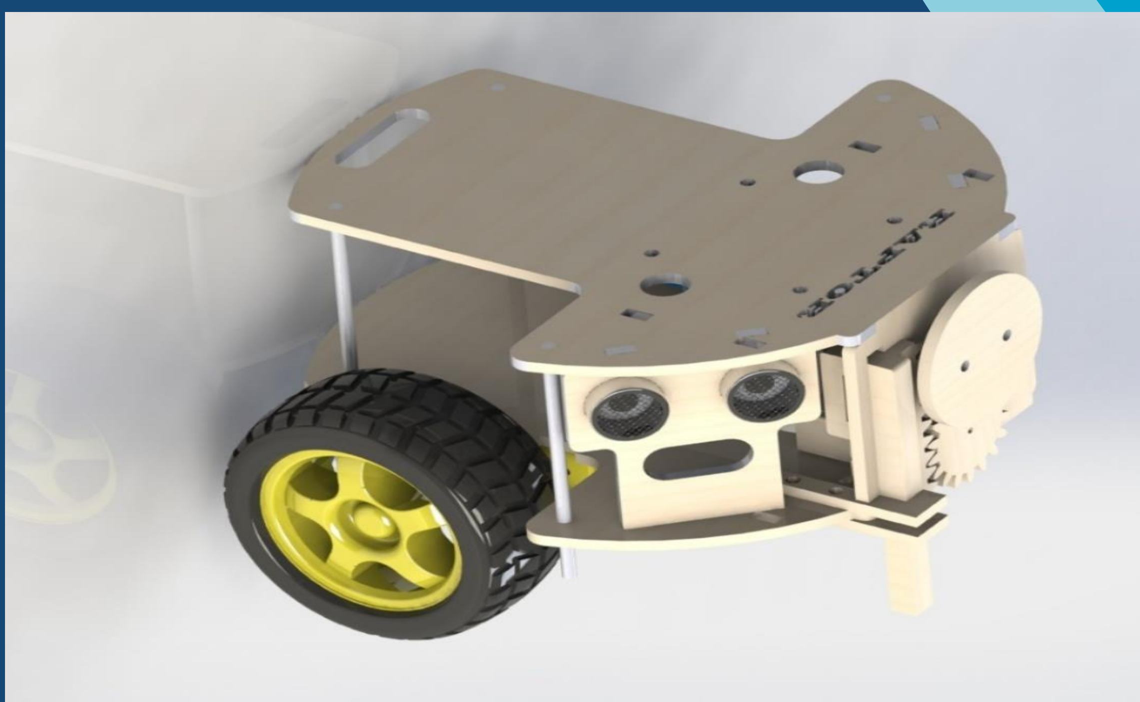


Figure (49) final assembly of small robot

VI – Lessons Learned

Technical lessons:

- ✓ Dealing with new sensors like IR & Ultrasonic sensors
- ✓ Fabrication the whole robot as mechanical or electrical
- ✓ Software programming

Interpersonal lessons:

- ✓ Teamwork
- ✓ Prioritization.
- ✓ Time management
- ✓ Leadership
- ✓ Research skills
- ✓ Critical thinking

Problem Solving and Trouble-Shooting:

- After connecting the wires, we found out that one of them is empty, so all wires had been checked before connecting by AVO
- While coding at Nano Arduino, the library of servo makes the code going wrong as Nano Arduino cannot afford many tasks, so we replaced the servo motor by DC gear motor

VII – Time Management (plan, timeline & real)

<u>Plan</u>

7/9~12/9
mini robot full fabrication

14/9~19/9
big robot full fabrication
& pre

21/9~26/9
test two robots & start at report

28/9~3/10
test, adding & Send the report

5/10~7/10
test all tasks & the competetion

Real

16/9~17/9
coding& solidworks design for small robot

18/9~19/9
printing & fabrication & pre

21/9~22/9
coding& solidworks for big robot

23/9
print the big robot & fabrication

24/9
start at report with testing the robot

25/9~1/10
testing the components

2/10~5/10
test the whole robot (motors & servo)

7/10~8/10
the competetion

VIII – Budget

Component’s name	Quantity bought	Price per component	Total price
	Mechanical	Components	
Free wheel	1	15	15
DC gear motor	3	20	60
wheel	2	20	40
Motor (20 torque)	4	250	1000
Wheel with coupling	4	100	400
Servo 14kg	2	250	500
CNC for mini robot			60
CNC for big robot			110
Coupling	4	7	28
Motor driver (L298)	3	55	165
Rivets			20
Total price for	Mechanical	components	2398LE
	Electrical	Components	
Arduino Nano / Mega	1/1	95/255	350
Ultrasonic / IR	2/1	45/25	70
Bluetooth module	1	110	110
LI-Battery	4		300
Holder / charger	1/1	10/20	30
cable	2	10	20

PCB	4	20/23/22/19	84
LI-PO	1	500	550
Total price for	**Electrical**	**components**	**1514LE**
Total price		**3912LE**	
Components that we already had	**2 servo 4kg**	**Breadboard**	

IX – Acknowledgements

The success and final outcome of this competition required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of the competition. All that I have done is only due to such supervision and assistance and I would not forget to thank them.

I respect and thank LMR COATCHES, for providing and giving us all support and guidance, which made me complete the ROBOT. I am extremely thankful to [her/him] for providing such a nice support and guidance.

I owe my deep gratitude to [Ragab], who took keen interest on our work and guided us all along, till the completion of robot design and fabrication by providing all the necessary information for developing a good system.

I would not forget to remember [Abdelrahman , motaaz ,], of [ST smart , old participant at lmr] for their encouragement and more over for their timely support and guidance till the completion of the competition.

X – Conclusion

At the end we value this good experience that we learned a lot from it,

we know that maybe we will not be the first team in this competition, but we know that we tried our best and that is more than satisfy for us.

RAPTOR