King Abdul Aziz-University
Faculty of Engineering-Girls Camps
Industrial engineering Department
Introduction to Engineering Design II (IE202)
Spring 2015

Progress Report

Designing a Robotic Car

Team (7)

Team Email:
Section:XBG

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Submitted to: Prof. Ibrahim Olwi

Submitted on: Tuesday, April 14

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Introduction

We believe that there are big goals in our lives that might seem impossible until we dissect them into small goals. Our big goal is to make a difference in this world and not leave it the same way we found it; our first small goal is to play the role of the designer in our project by collaboratively working in a team and extracting every bit of knowledge and experience we can from the course of IE202: Introduction to Engineering Design II. We intend to give our best effort in every step we take to successfully achieve great progress in our project. This progress report aims to show the advancement in our project to ensure satisfactory results. The processes we will undertake are shown step by step in accordance to what we have learned in the course of IE202.

First of all this all, this project report will focus on managing the project by providing an in depth *literature review.* This will provide us with a deep understanding of various concept to correctly state the *revised problem statement*. To ensure high quality work and effective collaboration between members, the *project chart* will be set. Tasks will afterwards be listed in a *work breakdown structure (WBS)* to break major tasks into manageable ones. These tasks will be divided among members using the *linear responsibility chart (LRC)* which will be reflected on a *Gantt chart* and then a *percent complete matrix (PCM)* to make sure the project meets its schedule on the course calendar.

The second aspect this progress report will cover is defining the problem. This will be achieved by taking several steps. First of which will be determining the *initial design attributes* followed by the *design objectives and the objective tree*. *Realistic constraints* will also be determined and taken into consideration. Finally, *metrics* to measure the achievement of the objectives will be identified

After managing the project and defining the problem, we will be able to specify the design requirements by producing a *black box* that accounts for all the inputs and outputs. These inputs and outputs will then be further explained in the *transparent box*. At last, Qualitative and quantitative *performance specifications and design requirements* will also be identified in order to develop the *function-means tree.*

We will do our best to develop a well-rounded progress report by summarizing the key points in the *conclusion* and including *citations* and *appendices*.

✓ Managing the Project:

1. Literature Review

The main concern upon perfecting this project is applying the most suitable method of programming on an effectively designed robotic vehicle. For this reason, this report's literature review focuses on researching vehicle designs that optimize speed and force in addition to methods used to program robotic vehicles. This will ultimately give us a deeper understanding on how the project will function.

Robotic Vehicles:

Designing the robot is a very crucial step to be taken because it forms the basis of our project. There are many aspects to be considered when designing the robot such as the frame, the motor, the wheels, etc. For a better constructed design, it is best to put screws and sensors on everything to save a lot of time and money such as shown in figure1. The best technique to follow when building is to use fewer and simpler parts. Fewer and simpler designs mean less chances to make mistakes, less

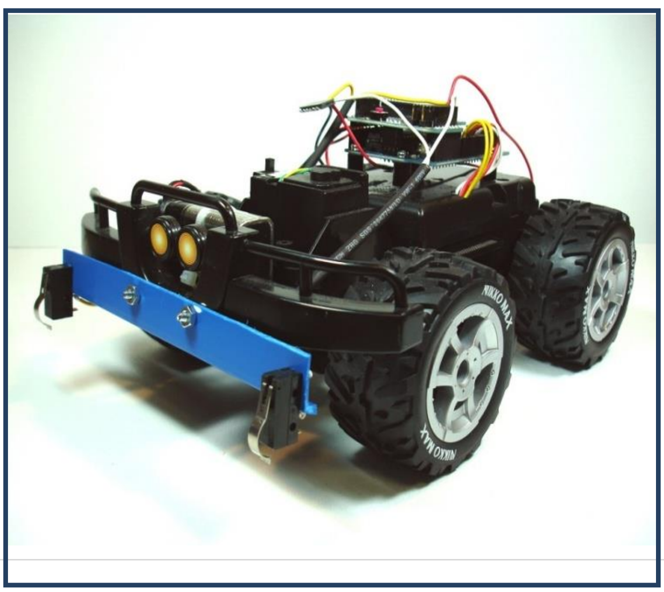


Figure 1: robotic vehicle.

designing, and less cost.

- **Frame:**

The first part to be studied in this literature review is the frame. It is the basic structure that forms the fundamental attachment to everything else. It also comprises the largest part of the robotic vehicle; therefore, the frame has to be made of a rigid, light weight material i.e. Aluminum or HDPE.

- **Motors:**

The motor can be chosen from a very wide variety of options. For a simple vehicle, a basic DC motor is enough. Also, for maximum control, strength, and efficiency, it is preferred to have a gear box attached to the motor[1]. The speed of the motor can be determined by understanding that whenever the wheel rotates an entire revolution, the vehicle travels a distance that is equal to the circumference of the wheel. This means that if the circumference is multiplied by the number of rotations per minute, the distance travelled in a minute can be deduced as shown in figure 2 [2]:

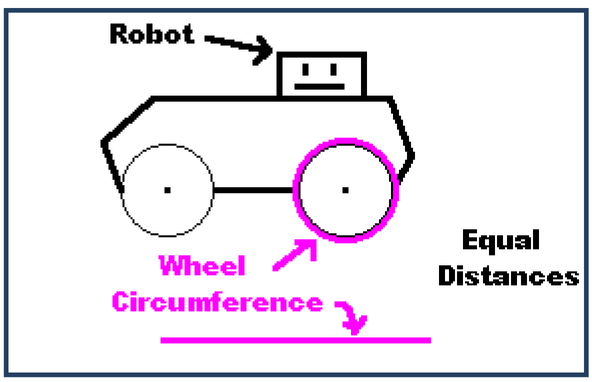


Figure 2: showing the wheel circumference

Velocity = circumference * rpm
Velocity = diameter * pi * rpm OR Velocity = 2 * radius * pi * rpm

The motor's force and torque are very important aspects when building a robot as shown in figure 3. For a robot to go uphill or to have high acceleration, high frequency is required. By knowing the wheel's diameter and torque, the force that the robot is capable of can easily be determine using the following formula:

Torque = Distance * Force
Distance = Wheel Radius
Force = Torque / Wheel Radius

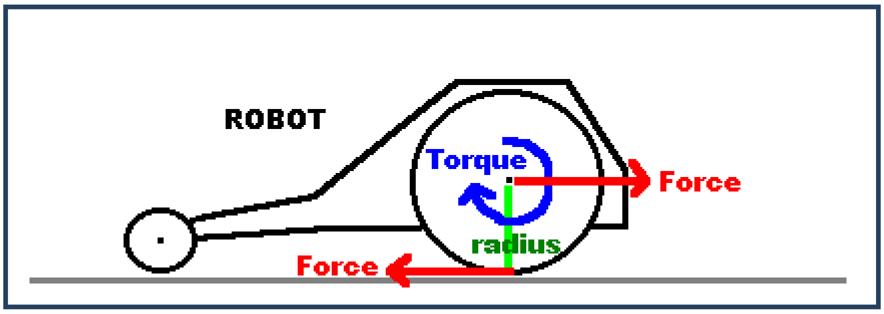


Figure 3: Torque vs. Force

Also acceleration must be taken into consideration when building the motor as shown in figure 4. Acceleration should be about half of the maximum velocity, and it increases if the plane is inclined due to gravity.

Force = Mass * Acceleration

acceleration for inclines = 9.81m/s^2 * sin((angle_of_incline * pi) / 180)

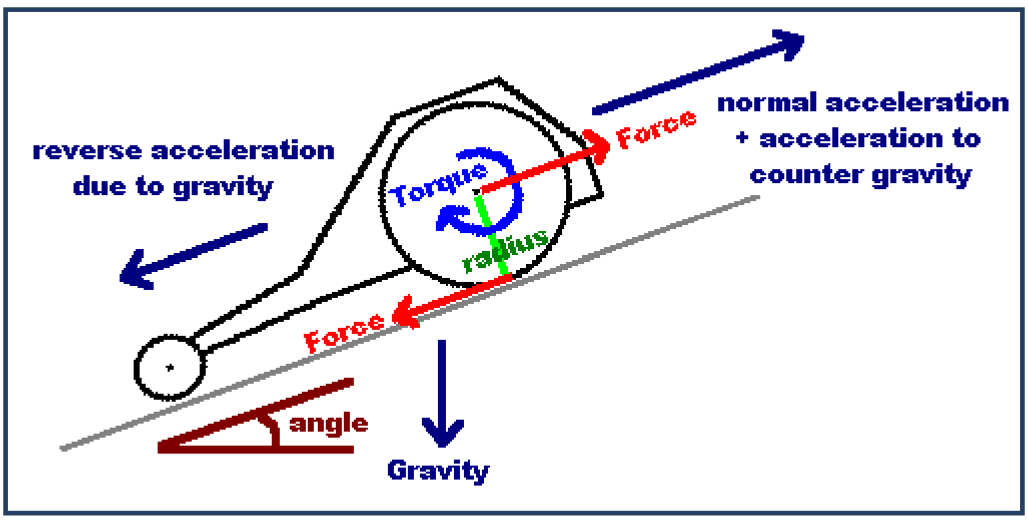


Figure 4: Inclination affecting the robot

- **Wheels:**

The wheel's basic features to take into consideration are its diameter, width, and texture as shown in figure 5. Torque and velocity are also important aspects of our project; wheels with large diameters provide more torque but less velocity. Large motor engines can handle large diameter wheels while small motor engines work better with a much smaller diameter wheel to provide it with enough torque to go up a hill. An often neglected aspect of the wheel is the texture. If the texture of the wheel is too smooth, its friction with the ground will be low. This will ultimately cause the vehicle to skid during acceleration and braking. On the other hand, if the wheel is too rough, the vehicle might experience inefficiency due to the increasing friction with the ground. To calculate the wheel diameter needed, a simple formula derived from the velocity formula can be used[2]:

velocity = diameter * pi * rps
OR
diameter = velocity / (pi * rps)

Figure 5: Wheels on the left and sensors on the right

- **Sensors:**

Sensors as shown in figure 5 are one of the main elements in any robotic vehicle. Attaching the sensor to the vehicle is a very risky process, because once it's attached, it will remain limited to functioning on the position it is at. Sensors have to be protected from noise, dirt, and collision with other cars. For example, if a color sensor was added to follow a line, the sensor would need to be put at an exact location such that it receives data sufficiently and is not affected by dust.

Robotic programming method:

There are numerous programming methods and electronic circuits that are dedicated to allowing the creation of robotic systems that are able to carry out tasks that conventional machines cannot achieve [3]. However when choosing which method to apply, the question should never be “which is the best method?”, but rather “which is the best method for MY project?” For simple robotic vehicles, either Lego Mindstorms or Arduino can perform the tasks.

- **Lego Mindstorms:**

Lego Mindstorms is a hardware and software kit that creates robots that are easily programmed and customized as shown in figure 6. The mechanical system is controlled using a brick computer, a set of sensors and motors, and Technic Lego parts. Lego Mindstorms is programmed using its command box programming instead of code programming. Lego Mindstorms is very easy to use; however, it has a few disadvantages. First of all, the designer is limited to the motors and sensors that Lego sells. Secondly, Lego Mindstorms is the most expensive compared to other methods, and each additional feature has an extra cost. Finally, the functions that happen in the Lego Mindstorms remain a black box to the designer.

Figure 6: A Lego Mindstorms robot

- **Arduino:**

Arduino is an open-source computer software and hardware kit that creates interactive objects and builds digital devices. Its function is based on a microcontroller boards that is either purchased preassembled or assembled by the user following the given instructions. Arduino provides a wide range of flexibility; it allows the connection to almost any digital or analog device. Its cost is fairly reasonable and much less than the Lego Mindstorms. However; Arduino requires soldering and fabrication. The programming language used with Arduino is C and

C++, but only two functions need to be known by the user to make an executable program:

- setup(): a program that utilizes settings is run once by this function.
- loop(): creates a cycle where the function is called repeatedly until the board is turned off.

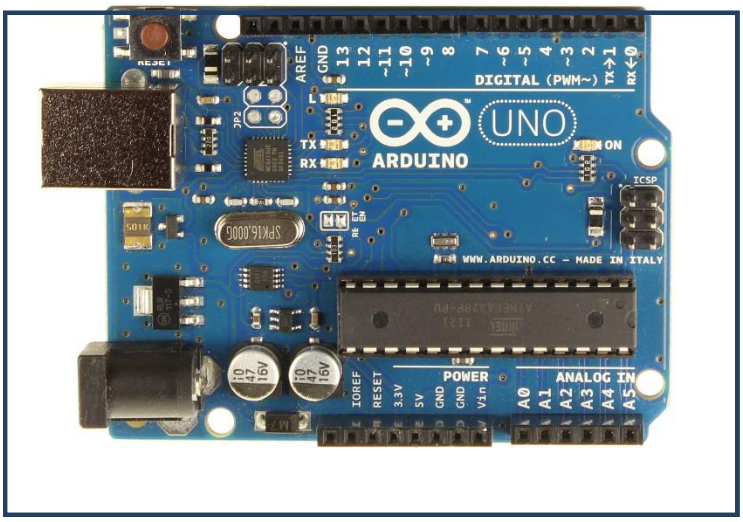


Figure 7: Arduino hardware kit which is a microcontroller

2. Revised Project Statement

A robot is a machine designed to perform specific tasks. It can be controlled by human instructions. Human instructions will be in the form of codes. So, a computer program will be used to write the codes and program the robot. To sum this up, by programming, the robot will be able to understand human instructions easily.

Sensors control the robot by sending information to the controllers in the form of electronic signals. Robots use a variety of different electromechanical sensors to explore and understand their environment and themselves. Thus, using sensors, the robot can detect its surroundings, know its exact position, see in the dark, smell, taste and touch.

The project statement which given by the instructor is to design a robot that can move along a path and push a tuna can outside its path. After knowing the project statement, we have come up with an initial vision of our project which is if we want to be the winning team we need to design a robot that can moves along a black coloured path and then push a tuna can successfully in a short time before the others team.

After thinking and gathering information together about the main components and the principle work of the robot, we came up with some ideas that may help us to make a fast and successful robot, and help us to be the winning team. The first idea we obtained was that the robot must contain sensors such as: light sensor, switch sensor, infrared sensor, sound sensor, laser sensor and rotation sensor to help the robot to move on the path and to explore its surroundings. The second idea is that the shape of the robot must be suitable and not affected by air when going at a higher velocity. Also, the mass of the components of the robot have to be light to increase the robot’s velocity and help it to arrive early. In addition, the number of the wheels of the robot must be four to keep the robot balanced when the velocity is high. The material of the wheels should be able to move in all kinds of surfaces. The robot must be chargeable and contains a spare battery. Also, the robot should contain arms to push and keep the tuna can on the path preventing it from going out the sides and to deliver it to the end of the path successfully. Figure 8 shows various types of Robotics.Finally, the material of the skeleton of the robot should not be affected by environmental factors, and also, it should be strong enough to push multiple tuna cans with each weighing up to 180 grams.

Figure 8: Various types of Robotics.

3. Project Charter:

A team charter is a written document that defines the team's mission, objectives, time frame, and expected outcomes. The benefit of the team charter is to help the team to focus on their performance enabling them to start quickly and engage effectively. In other words, it is a road map that keeps the team focused on their purpose so that they can achieve their objectives successfully. The team charter will include several components that keep the team on track which are: goals, deliverables, key milestones, available resources for the project, and team norms. This will achieve a creative team and reduce the barriers that prevent the team from becoming successful and professional.

Goals:

The main purpose of the project charter is to have clear and specific goals. So, in this step we will document and recognize the sets of goals which are: the team goals, the project goals, and the course goals.

The Goals of the Team:

1. Be the winning team.

2. Get the bonus marks.

3. Finish the project on the time frame (before deadline).

4. Produce the project with high quality.

5. Avoid conflict.

6. Learnnew skills.

7. Be a collaborative team.

8. Be Creative.

The Goals of the Project:

1Keep the team members happy.

2. Meet the requirements.

3. Satisfy the client's needs.

4. Meet the defined budget.

5. Not harmful to the environment.

6. Useful and user-friendly.

7. Can be developed.

8. Easy to use.

The Goals of the Course:

1.Apply knowledge that we have learnt as engineers to produce the project with high quality.

2.Learn how to work with team members cooperatively and exchange the knowledge between the team members.

3. Learn how to solve real life problems.

4. Gain experience through researching, collecting and analyzing the information.

5. Develop our current skills and gain new skills.

Deliverables:

Deliverables are the expected outcomes (the project's tasks) that must be completed and delivered by the end of this course under the terms ofagreement or contract. The following list shows the expected deliverables of the project which will be delivered and completed before the end of this course. The deliverables are:

1. The progress report for the project.

2. The introductory design of the project.

3. Building and constructing the project.

4. Testing and evaluating the project to be sure that it is complies with the concept.

5. Making sure that the project meets our instructor's expectations.

6. The final design of the project.

7. The final Report.

8. Making the poster, oral presentation, and presenting the project.

Key Milestones:

Key millstones have been used in order to organize the work, to monitor measurement of the work performance, and to keep track of progress towards completion[4]. So, by this step we can make a work plan which contains the necessary steps to complete the project and determine whether we reach a point earlier, later or on the time frame. Figure 9 shows the key millstones of the project.

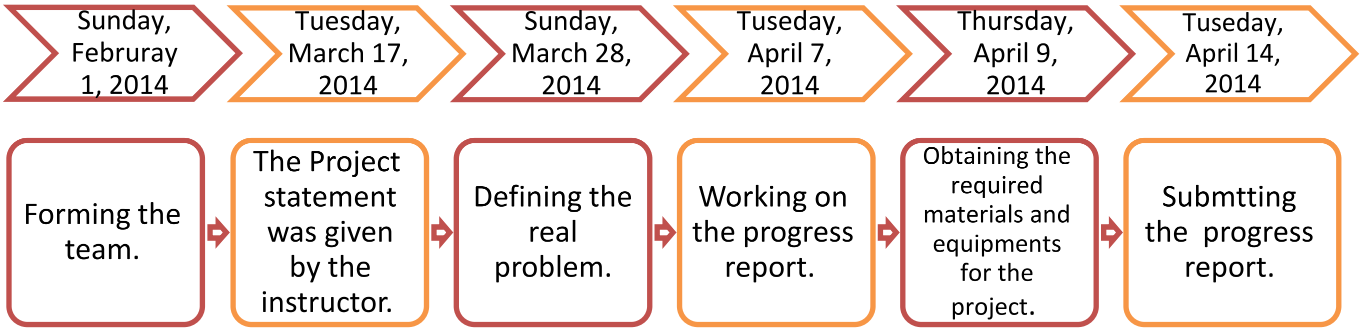


Figure 9: Key Milestones.

Resources:

The resources which are available to be used in the project are:

1. The Engineering Design (A Project-Based Introduction) and the Strategies Creative Problem Solving textbooks.
2. The website such as: educational websites, YouTube, and Wikipedia.
3. The instructor of the course.
4. The experts in the project's subject field.
5. Books that are specialized in the project's subject.

Team Norms:

The team norms are established with all members of the team in order to produce creative work throughout the course and to become an effective and productive team[5]. The following table shows the team norms which will benefit us a lot to become a great team by following them.

Table 1: The list of the team norms.

Promoters	Barriers
Do high quality work.	Do low quality work.
Respect other members.	Do not care about team goals.

Give opinions, share ideas,and help each other.	Carelessness and laziness.
Sharing ideas with the team.	Being selfish.
Managing the team and distributing the tasks.	Do some problems that lead to team lapses.
Take responsibility.	Lack of attention or interest.
Flexible to accept changes.	Impatient.
Motivating other members.	Depending on the others.

4. Work Breakdown Structure (WBS):

The work breakdown structure is one of the most important tools to manage the scope of the project. It organizes all of a project's tasks to be executed by the team members considering that each major task is broken down into a number of subtasks. We used this tool in our project to design a robot as shown in figure 10. This tool helped us to organize the project work and identify what exactly is required from us to complete our project professionally and successfully.

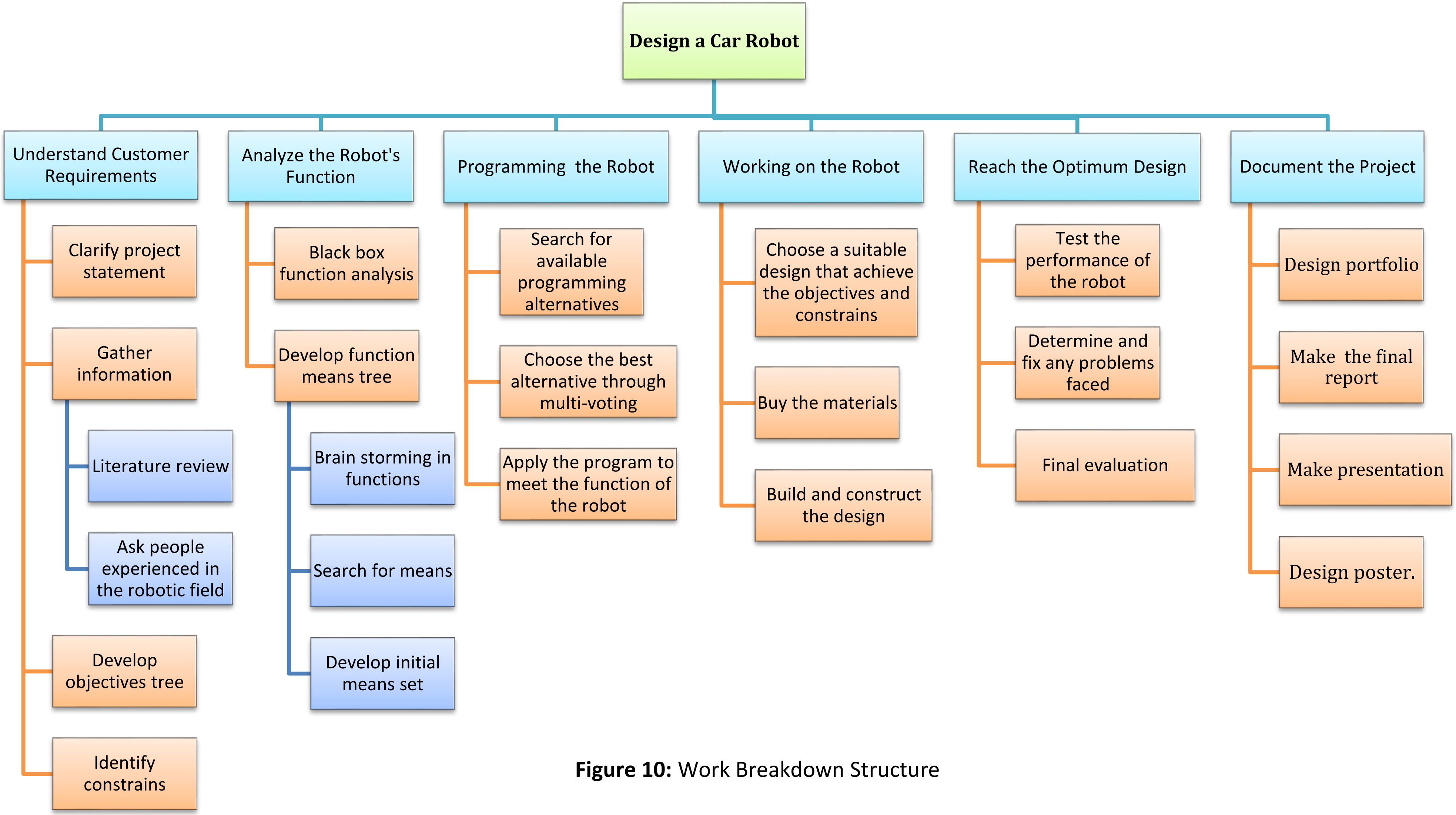


Figure 10: Work Breakdown Structure

5. Linear Responsibility Chart (LRC)

Effective project management requires decisions that depend and focus on both “what” and on “who.” After making “what” decisions about deliverables, now we can create a linear responsibility chart, also called a responsibility matrix, which identifies different levels of responsibility. The linear responsibility chart describes who is responsible for every task, what level of responsibility, sub tasks, and decisions associated to them as shown in table[3]. We have to do it in order to arrange the implementation of the project. Levels of responsibilityare explained in table[2].

Table 2: System of measuring the level of responsibility

Number	Key
1	Primary responsibility
2	Support/Work
3	Must be consulted
4	May be consultant
5	Review

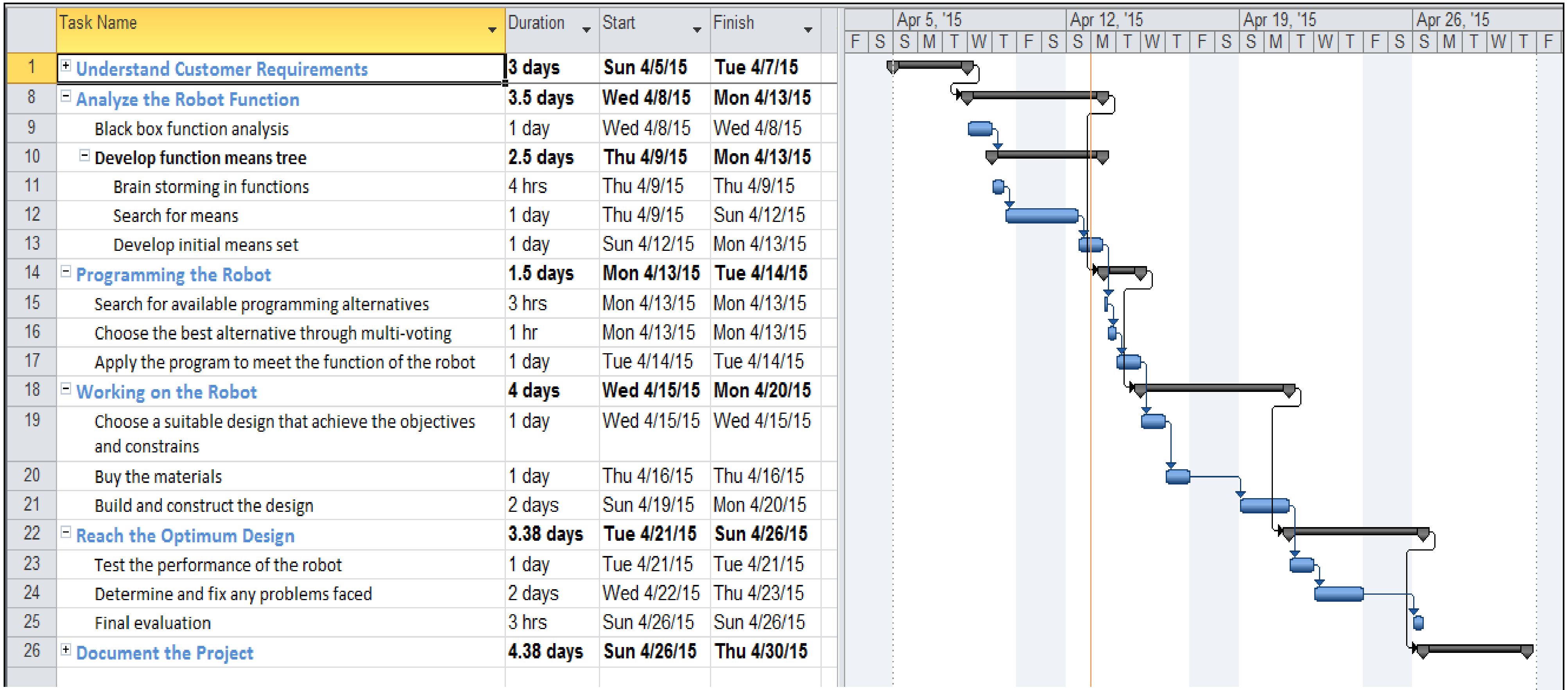
Table 3: Linear Responsibility Chart (LRC)

Task#	Responsibility	Team Member						Client	Outside consultant
		#1	#2	#3	#4	#5	#6		
Task 1	Understand Customer Requirements		1			2			
Task 1.1	Clarify project statement	2	1	2	2	2	2	3	
Task 1.2	Gather information	2	2		2		1		3
Task 1.2.1	Literature review		1	2	2				
Task 1.2.2	Ask people experienced in the robotic field	2		2		1	2	4	3
Task 1.3	Develop objectives tree	2	1			2		4	
Task 1.4	Identify constrains	1		2	2		2	3	4
Task 2	Analyze the Robot Function	2		2		1		4	3
Task 2.1	Black box function analysis		2			1	2		3
Task 2.2	Develop function means tree	1		2		2		4	3
Task 2.2.1	Brain storming in functions	1	2	2	2	2	2	4	3

Task 2.2.2	Search for means		2		1		2		4
Task 2.2.3	Develop initial means set	2			2	2	1	3	4
Task 3	Programming the Robot			1		2	2		3
Task 3.1	Search for available programming alternatives	2	1		2				4
Task 3.2	Choose the best alternative trough multi-voting	1	2	2	2	2	2		
Task 3.3	Apply the program to meet the function of the robot			2	1	2			4
Task 4	Working on the Robot	2		2	2	2	1		
Task 4.1	Choose a suitable design that achieve the objectives and constrains	2		1			2	3	4
Task 4.2	Buy the materials		2	1					
Task 4.3	Build and construct the design	2		2		1			4
Task 5	Reach the Optimum Design	2	1				2		
Task 5.1	Test the performance of the robot	1		2	2			5	
Task 5.2	Determine and fix any problems faced			2		1	2	3	4
Task 5.3	Final evaluation	1		2			2	3	5
Task 6	Document the Project	2	1		2	2	2	6	
Task 6.1	Design portfolio	5	2		2		1		
Task 6.2	Make the final report	1	2	2	2	2	5	4	
Task 6.3	Make presentation		2		1		2		
Task 6.4	Design poster.	2	1		2	2		6	

6. Gantt Chart or MS Project

Gantt chart describes the chronology of the project, which represents the start and finish dates of the work break down structure of the project. Consequently, the Gantt chart includes the required time duration for each task. The benefit of the Gantt chart is to organize the entire work. In our project we used MS Project to build the Gantt chart. The following pagein figure 11 contains a screenshot of the MS project with the Gantt chart for our project. A pdf file of the expanded MS project is also attached.



	Task Name	Duration	Start	Finish
1	**Understand Customer Requirements**	**3 days**	**Sun 4/5/15**	**Tue 4/7/15**
8	**Analyze the Robot Function**	**3.5 days**	**Wed 4/8/15**	**Mon 4/13/15**
9	Black box function analysis	1 day	Wed 4/8/15	Wed 4/8/15
10	**Develop function means tree**	**2.5 days**	**Thu 4/9/15**	**Mon 4/13/15**
11	Brain storming in functions	4 hrs	Thu 4/9/15	Thu 4/9/15
12	Search for means	1 day	Thu 4/9/15	Sun 4/12/15
13	Develop initial means set	1 day	Sun 4/12/15	Mon 4/13/15
14	**Programming the Robot**	**1.5 days**	**Mon 4/13/15**	**Tue 4/14/15**
15	Search for available programming alternatives	3 hrs	Mon 4/13/15	Mon 4/13/15
16	Choose the best alternative through multi-voting	1 hr	Mon 4/13/15	Mon 4/13/15
17	Apply the program to meet the function of the robot	1 day	Tue 4/14/15	Tue 4/14/15
18	**Working on the Robot**	**4 days**	**Wed 4/15/15**	**Mon 4/20/15**
19	Choose a suitable design that achieve the objectives and constrains	1 day	Wed 4/15/15	Wed 4/15/15
20	Buy the materials	1 day	Thu 4/16/15	Thu 4/16/15
21	Build and construct the design	2 days	Sun 4/19/15	Mon 4/20/15
22	**Reach the Optimum Design**	**3.38 days**	**Tue 4/21/15**	**Sun 4/26/15**
23	Test the performance of the robot	1 day	Tue 4/21/15	Tue 4/21/15
24	Determine and fix any problems faced	2 days	Wed 4/22/15	Thu 4/23/15
25	Final evaluation	3 hrs	Sun 4/26/15	Sun 4/26/15
26	**Document the Project**	**4.38 days**	**Sun 4/26/15**	**Thu 4/30/15**

Figure 11: Gantt chart

7. Percent Complete Matrix (PCM)

The Percent Complete Matrix "PCM" is used for monitoring and controlling processes of the project. Rows are associated with required tasks. Columns indicate expected durations, percentages completed, and statuses. We apply this method in our project as shown in table [4].

Table 4: Percent Complete Matrix (PCM)

Task		Planned Duration (days)	Percent of Total	Status (see keys)	Credit (days)
Start the project		0	0%	0	0
Task 1	**Understand Customer Requirements**	**3.00**	7.08%	2	3.00
Task 1.1	Clarify project statement	0.17	0.39%	2	0.17
Task 1.2	**Gather information**	**1.00**	2.36%	2	1.00
Task 1.2.1	Literature review	1.00	2.36%	2	1.00
Task 1.2.2	Ask people experienced in the robotic field	1.00	2.36%	2	1.00
Task 1.3	Develop objectives tree	1.00	2.36%	2	1.00
Task 1.4	Identify constrains	1.00	2.36%	2	1.00
Task 2	**Analyze the Robot Function**	**3.50**	8.27%	1	1.17
Task 2.1	Black box function analysis	1.00	2.36%	1	0.33
Task 2.2	**Develop function means tree**	**2.50**	5.90%	1	0.83
Task 2.2.1	Brain storming in functions	0.17	0.39%	1	0.06
Task 2.2.2	Search for means	1.00	2.36%	1	0.33
Task 2.2.3	Develop initial means set	1.00	2.36%	1	0.33
Task 3	**Programming the Robot**	**1.50**	3.54%	1	0.50
Task 3.1	Search for available programming alternatives	0.13	0.30%	2	0.13
Task 3.2	Choose the best alternative through multi-voting	0.04	0.10%	2	0.04
Task 3.3	Apply the program to meet the function of the robot	1.00	2.36%	0	0.00

Task 4	**Working on the Robot**	**4.00**	9.45%	0	0.00
Task 4.1	Choose a suitable design that achieve the objectives and constrains	1.00	2.36%	0	0.00
Task 4.2	Buy the materials	1.00	2.36%	0	0.00
Task 4.3	Build and construct the design	2.00	4.72%	0	0.00
Task 5	**Reach the Optimum Design**	**3.38**	7.98%	0	0.00
Task 5.1	Test the performance of the robot	1.00	2.36%	0	0.00
Task 5.2	Determine and fix any problems faced	2.00	4.72%	0	0.00
Task 5.3	Final evaluation	0.13	0.30%	0	0.00
Task 6	**Document the Project**	**4.38**	10.34%	0	0.00
Task 6.1	Design portfolio	0.21	0.49%	0	0.00
Task 6.2	Make the final report	2.00	4.72%	0	0.00
Task 6.3	Make presentation	0.25	0.59%	0	0.00
Task 6.4	Design poster.	1.00	2.36%	0	0.00
End the project		0	0%	0	0
Total		42.34	100.00%		11.89
Key: 0= Not Started, No Credit. 1=In Process, 1/3 Credit. 2=Completed, Full Credit.					

✓ Defining the Problem

1- Initial Design Attributes

After we have gathered information about robots in general, we now have a total view about our design and what attributes it should has. In this section an initial attributes is going to be introduced that leads to the objectives of the design, which will be further explained in the Objectives Tree by the next section.

1- Safe.
2- Moving fast.
3- Attractive appearance.

4- Easy to use and carry.
5- Inexpensive.
6- Environmentally friendly.
7- Easy to fix.

2- Design Objectives , Constraints and Objectives Tree

Objectives are the attributes desired from a design that characterize what artifacts are [5]. Below are the objectives list for our project and the objectives tree as shown in figure 12 which is a hierarchical structure that is used for simplify and make the objectives list neat and clear. This will also help us to discuss them easily.

a- Objectives List

1- Safe

1.1 Safe exterior design.

1.2 Should be stable while moving.

1.3 Made from environmentally friendly materials.

2- Marketable

2.1 Easy to use

2.1.1 Not complicated.

2.1.2 Easy to carry.

2.2 Attractive

2.2.1 Modern and nice appearance.

2.2.2 Shiny colors.

2.3 Relatively inexpensive

3- Useful

3.1 Multi- functional

3.1.1 Fast moving.

3.1.2 It can climb barriers.

3.1.3 It can catch solid objects.

b- Objectives Tree

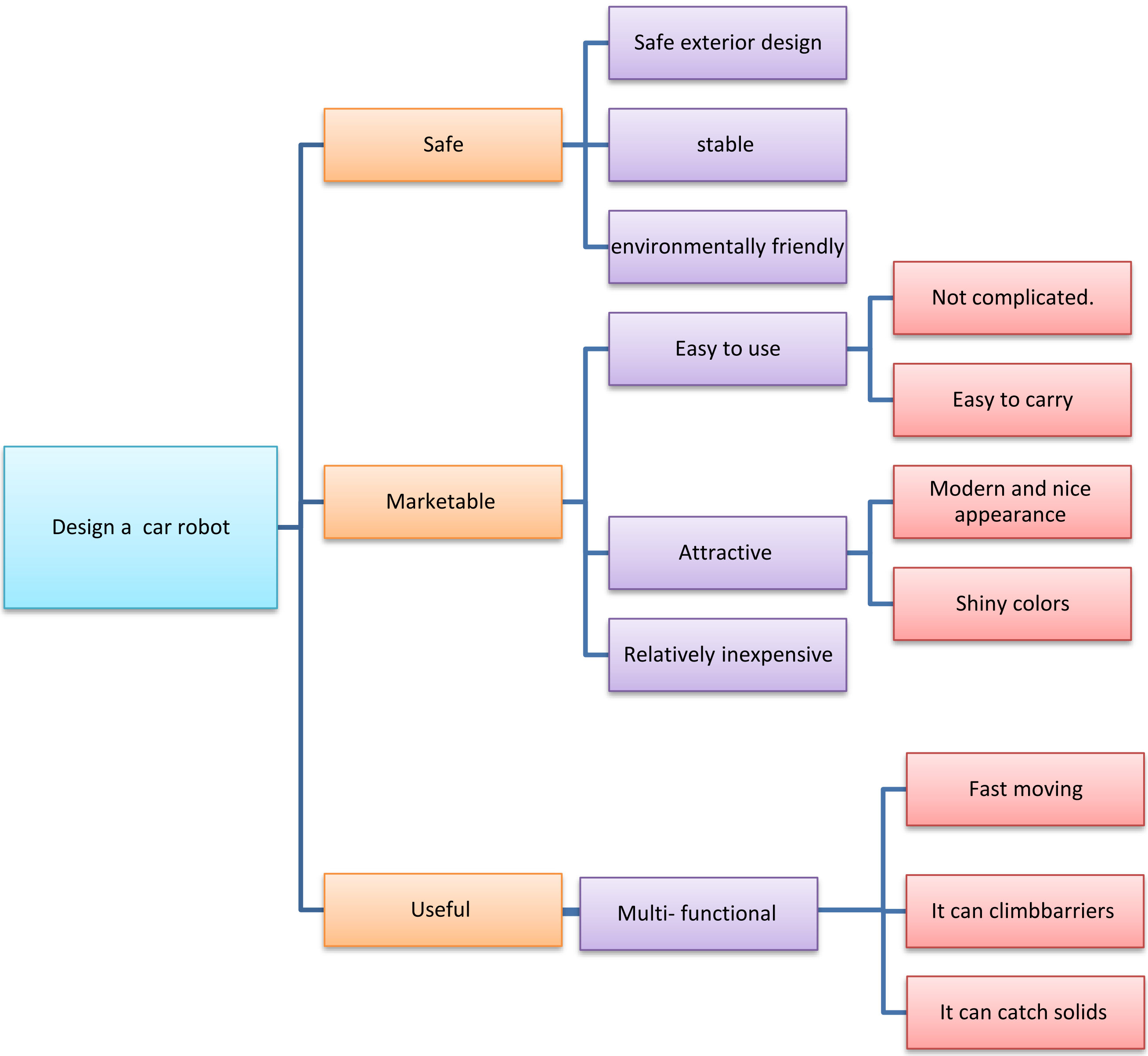


Figure 12: Objectives Tree

C) Realistic Constraints

Constraints identify what the project must have to be accepted. In this section the list of constrains is going to be introduced case of reducing the number of alternatives.

1- The marketing price must not exceed 1000 SR.
2- The weight must be not more than 5 Kg.

3- The height range of the car robot from (15-30)cm, width range from (15-25)cm and the length range from (30-40) cm.
4- Speed of the car robot not exceed 70 mph.
5- Doesn't contain sharp edges.
6- Contain two pairs of wheels with width range from (26 -31) mm and diameter. range from (60-65)mm (not less than or close to the motor diameter).
7- It has a DC motor which already has a gear box attached.
8- The microcontroller of the car robot has holes for screws.
9- It has to be manufactured by the team.
10- It causes no harm to the health be any way.

Metrics to Measure the Achievement of Objectives.

After writing the objectives list and objectives tree, we are going to put our metrics to measure the achievement of objective. This is process is very useful to choose the best alternatives. The metrics that measure the robot objectives is shown in table 5.

Table (5): Metrics to Measure the Achievement of Objectives

Item		The objectives and its metrics
Objective 1	Objective	Safe exterior design.
	Metric	From 0 to 10: ❖ If the design has sharp edges and also it contains exposedwires it receives 0. ❖ If it has one or two sharp edges or it contains some wires uncovered it receives 5. ❖ If it doesn't have any sharp edges and all the system is isolatedit receives 10.
Objective 2	Objective	should be stable while moving.
	Metric	From 0 to 100%: ❖ If the robot is not stable it receives 0% ❖ If the robot is stable for a while but then it loses balance it receives 50% ❖ If the robot is completely balanced it receives 100%

Objective 3	Objective	Made from environmentallyfriendly materials.
	Metric	From 0 to 100%: ❖ If the project made of materials that hurt the environment it receives 0. ❖ If some materials of the project hurt the environment it receives 50%. ❖ If all materials of the project is environmentally friendly materials and don't hurt the environment it receives 100%.
Objective 4	Objective	Not complicated.
	Metric	From 0 to 100%: ❖ If it is not easy to use and it's complicated to deal with so no one can use it receives0. ❖ If it can be used by only experts it receives50% ❖ If everyone can deal with the robot easily it receives 100%.
Objective 6	Objective	Easy to carry.
	Metric	From 0 to 100%: ❖ If the robot is very heavy and we can't carry it from one place to another we will give it 0%. ❖ If the robot is difficult to carry and it take from us effort it receives50%. ❖ If we can carry the robot easily without any problem it receives100%.
Objective 7	Objective	Modern and nice appearance.
	Metric	From 0 to 100%: ❖ If it has aunattractive appearance and undesirable for customers we will give it 0. ❖ If it has a look that attracts some people it receives60%. ❖ If the project has a nice appearance and it desirable for customers it receives100%.
Objective 8	Objective	Shiny colors.

	Metric	From 0 to 10 ❖ If the robot hasa nice and shiny colors to attract the customers it receives 10. ❖ If robot has dim and dark colors it receives 0.
Objective 9	Objective	Relatively inexpensive
	Metric	From 0 to 10. ❖ If all components of the project don't exceed 1000 S.R we will give it 10. ❖ If the price is more than 1000 SR we will give it 0.
Objective 10	Objective	Fast moving
	Metric	From 0 to 10. ❖ If speed of the robot in the maximum range (70 mph) to win in the race we will give it 100%. ❖ If the robot's speed is very slowly we will give it 0.
Objective 11	Objective	It can climb barriers
	Metric	From 0 to 100%: ❖ If the robot can climb barriers easily without any problem we will give it 100%. ❖ If the robot can climbbarriers with difficulty we will give it 50%. ❖ If it can't climb barriers for any reason for example its tires small or the speed isn't enough we will give it 0.
Objective 12	Objective	It can catch solid objects
	Metric	From 0 to 100% ❖ If there is no arm to hold objects ,it receives 0% ❖ If it has an arm that cannot firmly hold objects, it receives 50% ❖ If it has an arm that can firmly hold objects, it receives 100%

✓ **Design The Requirement**

1. Black Box (Inputs and outputs).

A black box is a graphic representation of the system or object being designed, with inputs shown, entering the box from one side and outputs leaving on the other side, without knowing what the system is as it is shown in figure[13].

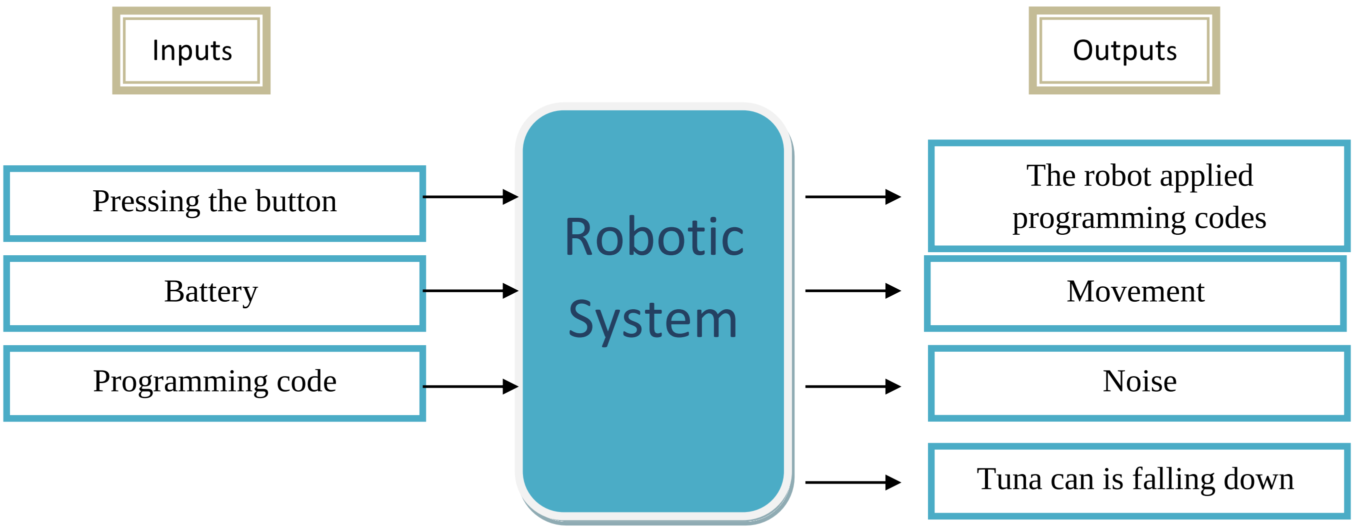
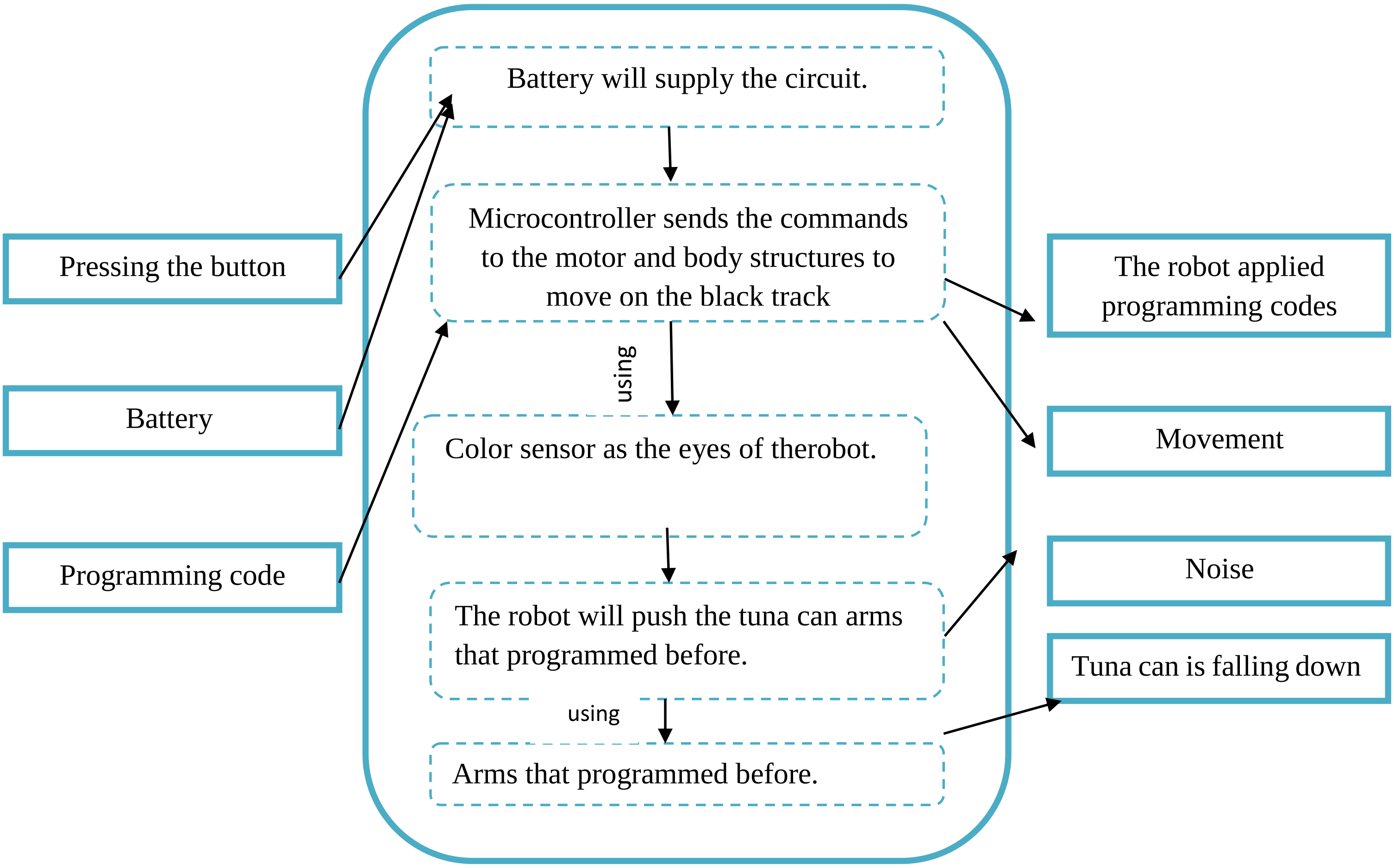


Figure 13: The Black Box.

2.Function to be Realized(Transparent Box).

Transparent box is similar to the black box. It has inputs and outputs, but there is a fundamental difference which is the transparent box detailed process to convert the inputs to outputs as shown in figure[14].



Figure[14]. Transparent Box.

3. Performance Specifications/Design Requirements.

Performance specifications focus on the results of the design rather than process. They are used to measure functions, but without stating the methods for achieving the required results as shown in table[6].

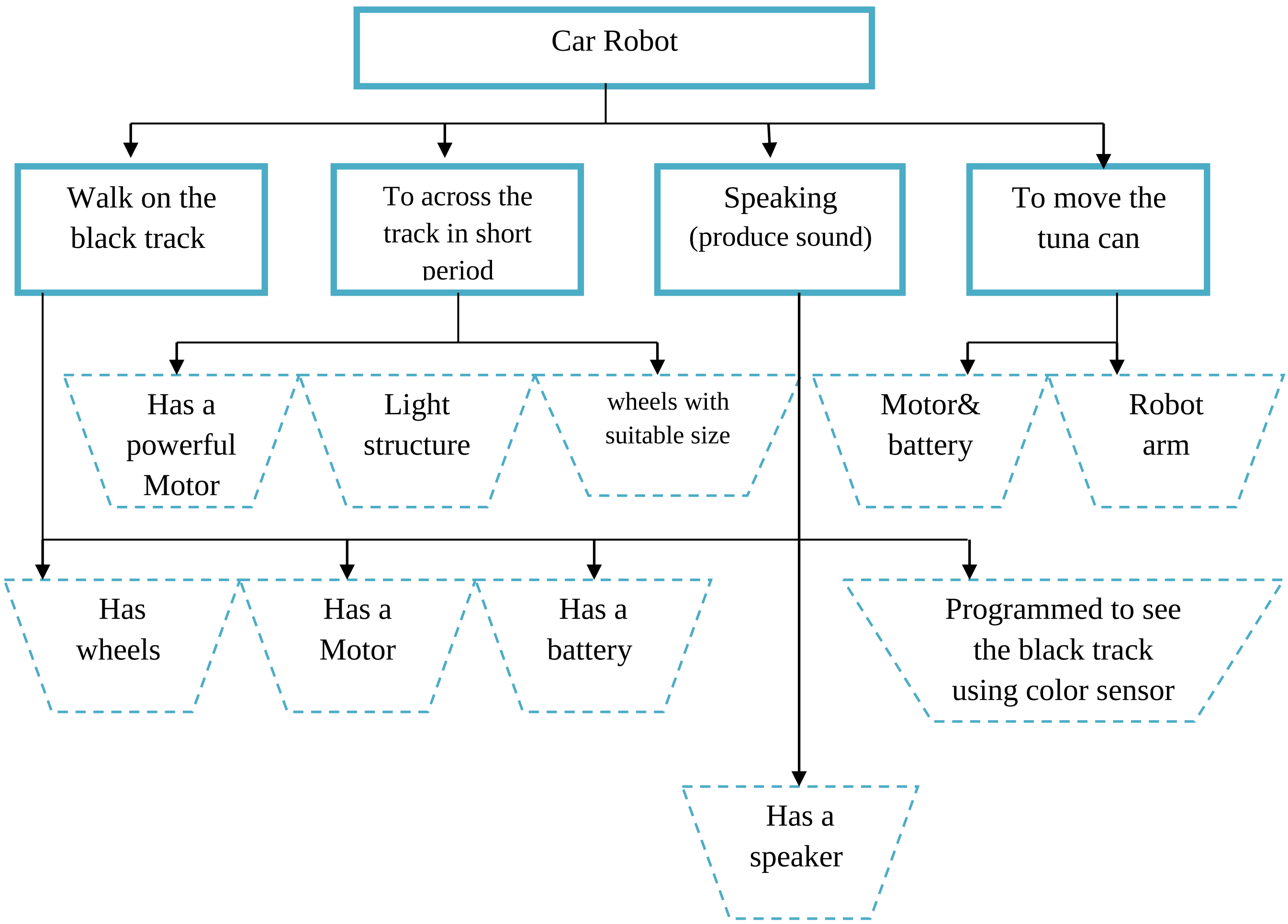
Table[6]. Performance Specifications.

Function	Performance Specifications	Specifications met
To win the race	Has a powerful motor and good wheel.	Yes
Consumes little energy	Contains batteries with LV	Yes
Ability to catch the tona can	Strong arm that can firmly catch objects	Yes

Be safe	Don't have any sharp edge.	Yes

4. Function-Means Tree.

Function-Means Tree is a graphical representation used to illustrate functions and means. For each function several means of accomplishing the function are listed, and then the subsidiary functions that result from that are listed below the means. Functions are represented as rectangles and possible means as trapezoids. Also, Means are methods that will achieve the functions, and they imply solutions as shown in figure[15].



Figure[15]. Function-means tree.

Conclusion

In conclusion, our project should provide us with a well-designed robotic vehicle that follows a specified track and knocks down one or more tuna cans. This progress report serves as a rudimentary step towards applying our project and tracking our achievements. The project was managed, the problem was defined, and the design requirements were specified using the techniques that have been learned throughout the course of IE202.

The following step will be to proceed with the work breakdown structure (WBS) we have developed following the Gantt chart and filling in the percent complete matrix (PCM). The most difficult part in our project is designing the car and learning how to program it. We expect to also face some obstacles with connecting the robot since it is our first time to do so. The final report, poster presentation, and race will all be challenges we have to overcome. We intend to conquer all these challenges with a positive spirit because nothing is impossible for an engineer.

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The Appendices

In the appendices, we have put all the meetings agendas that we made it to do our progress report.

AGENDA FOR MEETING (1)

Member No.	Member Name	Role
1		Leader
2		Notes taker
3		Time keeper
4		Notes taker
5		Technician
6		Work assigner

Meeting time: 2-4 Pm

Meeting place: The lab of engineering faculty

Meeting Date: Thursday 9April

S/ No.	Task Description	Responsible Member	Comments	Estimated time
1	Contact before work and briefing	Leader	**Before** meeting the leader contacted with all team members through WhatsApp to read about progress report from the files was sent by the instructor, specially the rubric to be ready for discussion. And **during** this 10 mins she illustrated what exactly we have to do in this meeting	10mins
2	Discussion	Everyone	We discussed each part of the progress report briefly. We had a problem with only the revised project statement thus, the leader had a call with the instructor to understand.	20mins
3	Working	Everyone	We start working on the project charter, Work Breakdown Structure(WBS) and we initially done with all (Managing the project) section.	80mins
4	Distribution of next work	work assigner, Leader	The work assigner (Fatimah) has assigned tasks to each member which satisfy her ability with the assist by leader(Yousra) and, gave a deadline to finish it by the weekend.	15mins

Total time: 2 hours

The results

We discussed the whole report and how each step will be done briefly. Work distributed fairly to be done individually and then we will have next meeting on Sunday 12April to discuss everything.

AGENDA FOR MEETING (2)

Member No.	Member Name	Role
1		Leader
2		Notes taker
3		Time keeper
4		Notes taker
5		Technician
6		Work assigner

Meeting time: 12-2 Pm

Meeting place: The lab of engineering faculty

Meeting Date: Sunday 12 April

S/ No.	Task Description	Responsible Member	Comments	Estimated time
1	Contact before work and briefing	Leader	The leader has reviewed what we have done and what we are going to do during this meeting.	10mins
2	Discussion	Everyone	We discussed what everyone has done during weekend, and what problems they faced to deal with it together.	20mins
3	Working	Everyone	We have worked on both defining the problem and designing requirements sections. Each member has a chance to generate ideas specially when we have construct black box and function means tree. And for the objectives and constraints each member has already searched about robots so it was easy for us to generate ideas.	90mins
4	Next meeting	Leader	Next meeting will be held on Tuesday 13 April.	5mins

Total time: 2 hours

The results

We almost done with the report, each member has to complete her part by the end of Monday as a deadline and to have our final meeting on Tuesday 13 April.

AGENDA FOR MEETING (3)

Member No.	Member Name	Role
1		Leader
2		Notes taker
3		Time keeper
4		Notes taker
5		Technician
6		Work assigner

Meeting time: 2-4 Pm

Meeting place: Reading room ofengineering faculty

Meeting Date: Tuesday 13 April

S/ No.	Task Description	Responsible Member	Comments	Estimated time
2	Working	Everyone	We all have worked together and reviewed the whole report to figure out mistakes and improve the work.	20mins

Total time: 2 hours

The results

We completed the work and satisfied with our hard work.