جامعة الأمير محمد بن فهد

PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Fall 2020-2021

Senior Design Project Report

Design and development of mechanism based drive bicycle

In partial fulfillment of the requirements for the

Degree of Bachelor of Science in Mechanical Engineering

Team-09

Team Members

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Advisor Name: Dr. Muhammad Asad

Co-Advisor Name: Mr. Taha Waqar

Abstract

For the last few decades, efforts are being made to propose new and efficient solutions to come up with the design of chainless drive bicycles. Though chained cycles are still commonly used, being lighter in weight and cheaper in maintenance, however, during off-road cycling, and when torque requirements increase, either chain gets disengaged from the sprocket or altogether break. Most of the new proposed mechanical designs to modify or replace chains are bevel and worm gears based. However, the gear manufacturing cost, maintenance, or replacement cost is a major hurdle in this development.

For this project, a four-bar linkage mechanism was developed. The mechanical Bicycle System is a systems project that contains a pedal attached to a triangle-shaped conrod of a parallelogram mechanism of three cranks. The shaft is fixed to the crank, and the shaft rotates on a bearing, so the wheel is connected to the shaft through a wheel placed inside the rim hub. Three crank concepts help the parallelogram mechanism overcome its dead positions.

Results show that it is possible and relatively simple, to build a mechanical bicycle by oneself. Each of these will be built upon and improved further by future students, one category at a time. The hope is that this design can become very efficient, cost-effective, and one day mass-produced.

Acknowledgments

We would like to express our appreciation to our advisor Dr. Muhammad Asad for his continuous support during the execution of our project and his sincere encouragement as well. Also, we wish to express our sincere thanks to our co-advisor, Mr. Taha Waqar, for sharing his expertise and valuable guidance and encouragement extended to us. We take this opportunity to express gratitude to all department faculty members for their help and support.

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Chapter 1: Introduction

1.1 Project Definition

In this project design and installation of a new linkage mechanism attached to a shaft contributes in increase the required torque efforts from the rider on off-road surfaces to accelerate a bicycle. This project mechanism will be applied in two main scenarios while going up on off-road. When going off-road, the driver of the bicycle will have to use our mechanical approach so it could be easier to ride. The first part of the project is by utilizing a linkage mechanism that will be connected to the rear wheel by a shaft initiated by a switch fixed between the paddles. This switch will start/stop the linkages to contribute to switching between our two mechanisms, linkages and chain system. Mainly it is a mechanical project, it will have a shaft, bearing, crank, binary links, and quaternary link. The project is applicable and useful for off-road activities, daily bicycle uses of transportation, and those who cycle/pedal on hills that vary in ground elevation.

1.2 Project Objectives

The main important objectives in this project are:

- To propose a linkage based mechanism to drive bicycles.
- Increase torque requirements during off-road.
- Modify existing bicycle to incorporate a linkage-based drive mechanism along with a chain drive.

1.3 Project Specifications

The project is applicable for any bicycle available in the market. The bicycle that has been selected for this project has the specifications:

Table 1.3.1: The system measurements

Item	Specification
Rear Shaft	L:80mm R:14mm
Frame	L:196mm W: 4 mm H:120mm
Padel Crank	L:274mm W: 4 mm H:12mm
Disk	L:120mm W: 4 mm H:104mm
Crank A	L:161mm W: 4 mm H:5mm
Crank B	L:161mm W: 4 mm H:5mm

Table 1.3.2: Engineering Standard

STANDARD	
Material	AISI 4340
Hex cap screws	ISO 965
Nut	ISO 4032

Chapter 2: Literature Review

2.1 Project background

Machines are instruments that are used to achieve work. A mechanism is the heart of a machine. It is the mechanical portion of a machine that has the function of transferring motion and forces from a power source to an output.

Figure 2.1.1: Binary link

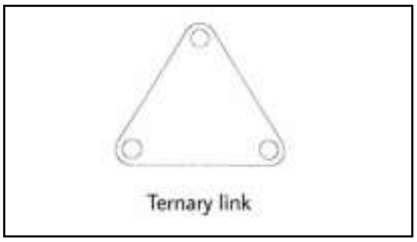


Figure 2.1.2: Ternary link

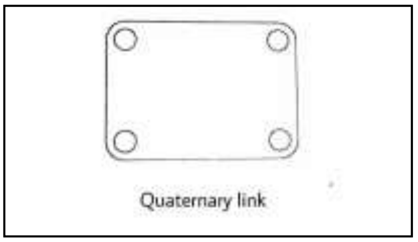


Figure 2.1.3: Quaternary link

Mechanisms are an assemblage of rigid members (**links**) linked together by joints (**also referred to as Mechanical linkage or linkage**). Links are the individual parts of the mechanism. They are considered rigid bodies and are connected with other links to transmit motion and force. Elastic parts, such as springs, are not rigid and, therefore, are not considered links. They do not affect the kinematics of a mechanism and are usually ignored during kinematic analysis. They do supply forces and must be included during the dynamic force portion of the analysis. Change Point Mechanism (**Figure 2.1.4)** the sum of two sides is the same as the sum of the other two. Having this equality, the change point mechanism can be positioned such that all the links become collinear.

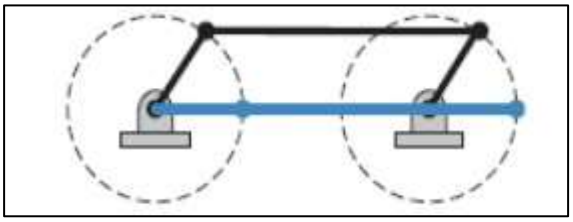


Figure 2.1.4

2.2 Previous Work

Bygen (2014) [1], Korean bike manufacturer Bygen has devised a solution to, the common problem posed by a link mechanism. To get around this problem, Bygen's Hank Direct Bike doesn't have a chain or belt drive but is instead a linkage that transfers power from the pedals to the rear wheels. It's claimed to be more efficient than a chain or belt-drive. According to Brown, because the levers are much longer than traditional cranks, riders are able to deliver more torque (and thus power) to the wheel for a given amount of effort.

Figure 2.1.5

Chapter 3: System Design

3.1 System Introduction

Engineering is based on the fundamental sciences of mathematics, physics in most cases, engineering involves all the way of design analysis enhanced with the energy conversion from source (input) to outputs, using the basic principles of maths and physics.

Integrated solid parts to produce a specific aim is what we called a mechanism in other words a mechanism design is an observation that all mechanical systems contain tasks of motion, path, and function generation. Mechanisms probably are made by connecting a minimum of two linkages to achieve the desired goal. Most mechanisms are named as per the number of linkages they are made from, as four-bar and six-bar mechanisms.

Design and analysis of machinery and mechanisms relies on the designer's ability to visualize the relative motions of machinery components, Kinematics science take the main position for building these machines.

DOF (degrees of freedom) in robotics is a well-known abbreviation that indicates the axis and ranges which robots can move with. From (1) to six (6) DOF is the range of robotics movements. Some robots have more than 6 DOF known as the redundant robots as the have more than enough freedom to do different movements. The most common robot's types are 6-DOF and 7-DOF. For a robot of 6-DOF we can get translational movements in all three perpendicular axes of movements and respective rotational movement taking each axis into account. More DOF will give more flexibility to do your job and intended tasks. These 6-DOF robots can be seen in: pick and place in industries, teaching and learning, writing and some of them are used in surgical operations and lab tests.

3.2 Problem Statement

In this project design and installation of a new linkage mechanism attached to a shaft contributes in increase the required torque efforts from the rider on off-road surfaces to accelerate a bicycle. This project mechanism will be applied in two main scenarios while going up on and off-road. When going off-road, the driver of the bicycle will have to use our mechanical approach so it could be easier to ride. The first part of the project is by utilizing a linkage mechanism that will be connected to the rear hub by a shaft initiated by a switch fixed between the paddles. Mainly it is a mechanical project, it will have a shaft, bearing, crank, binary links, and quaternary link. The project is applicable and useful for off-road activities, daily bicycle uses of transportation, and those who cycle/pedal on hills that vary in ground elevation.

3.3 Design

Integrating the mechanical links to run smoothly was one of our main goals in building this mechanical system. And to full fill this goal we try to simulate what was sketched by hand with mechanical software which used for these functions. In this section, we will explain our assembly parts and dimensions as per drew in the software. Figures (3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5, and 3.3.6) show the parts (Running wheel, Crank A, Crank B, Pedal, Disk, and the frame, respectively.

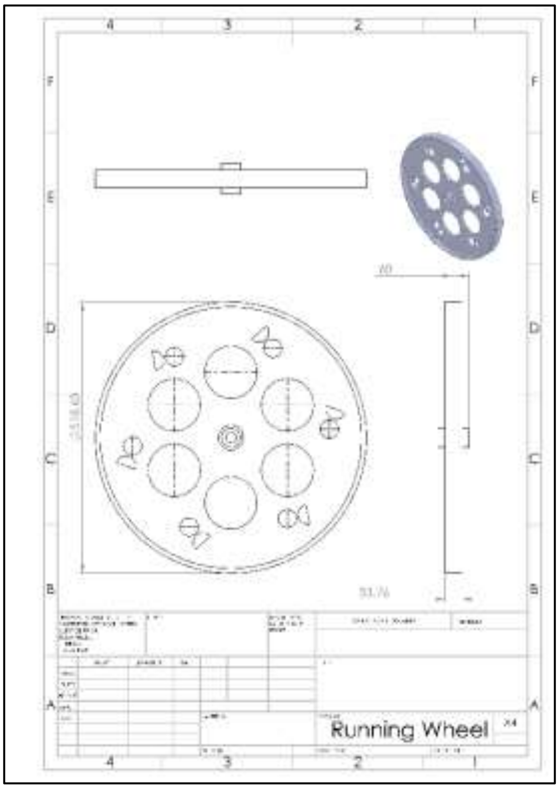


Figure 3.3.1: Running Wheel

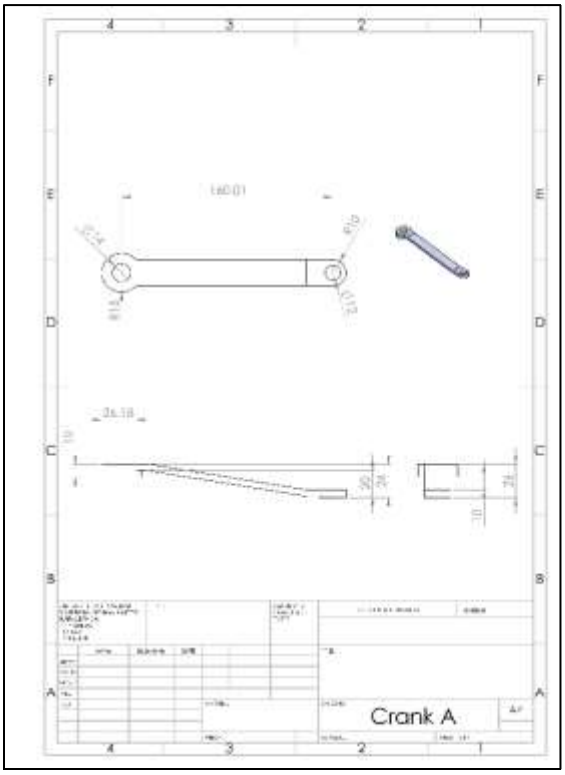


Figure 3.3.2: Crank A

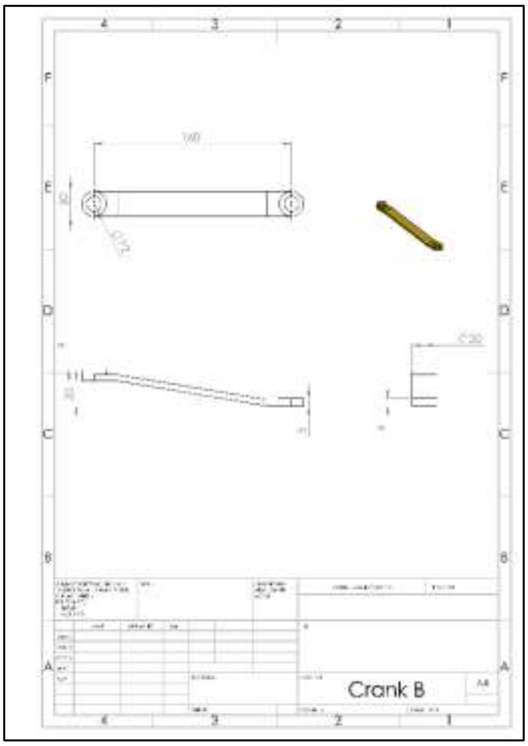


Figure 3.3.3: Crank B

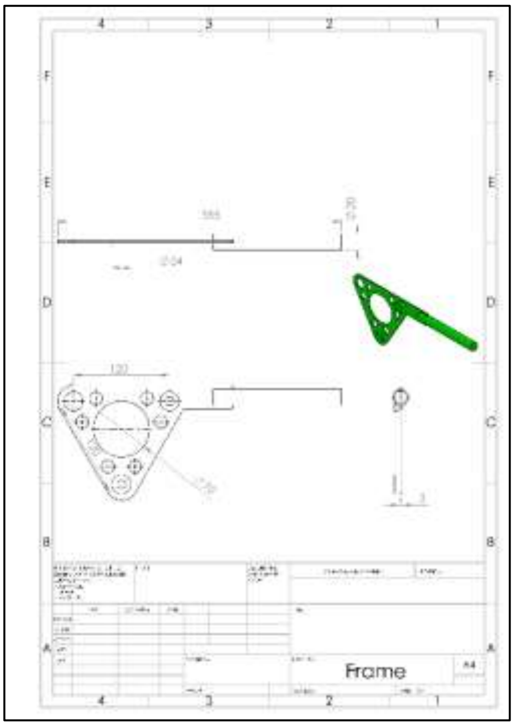


Figure 3.3.4: Frame

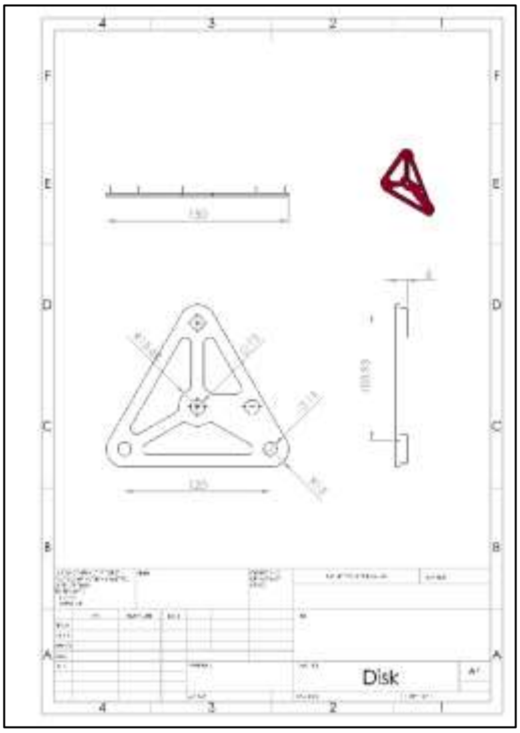


Figure 3.3.5: Disk

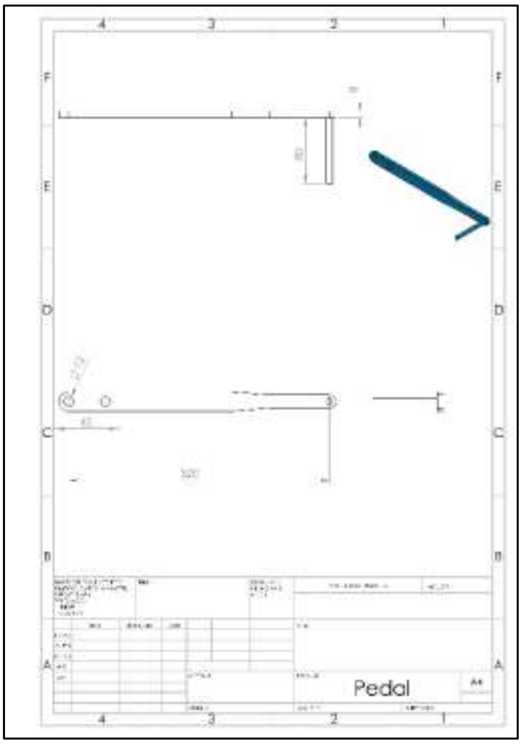


Figure 3.3.6: Pedal Crank

Figure 3.3.7: shows the full mechanism views and how the parts had been connected.

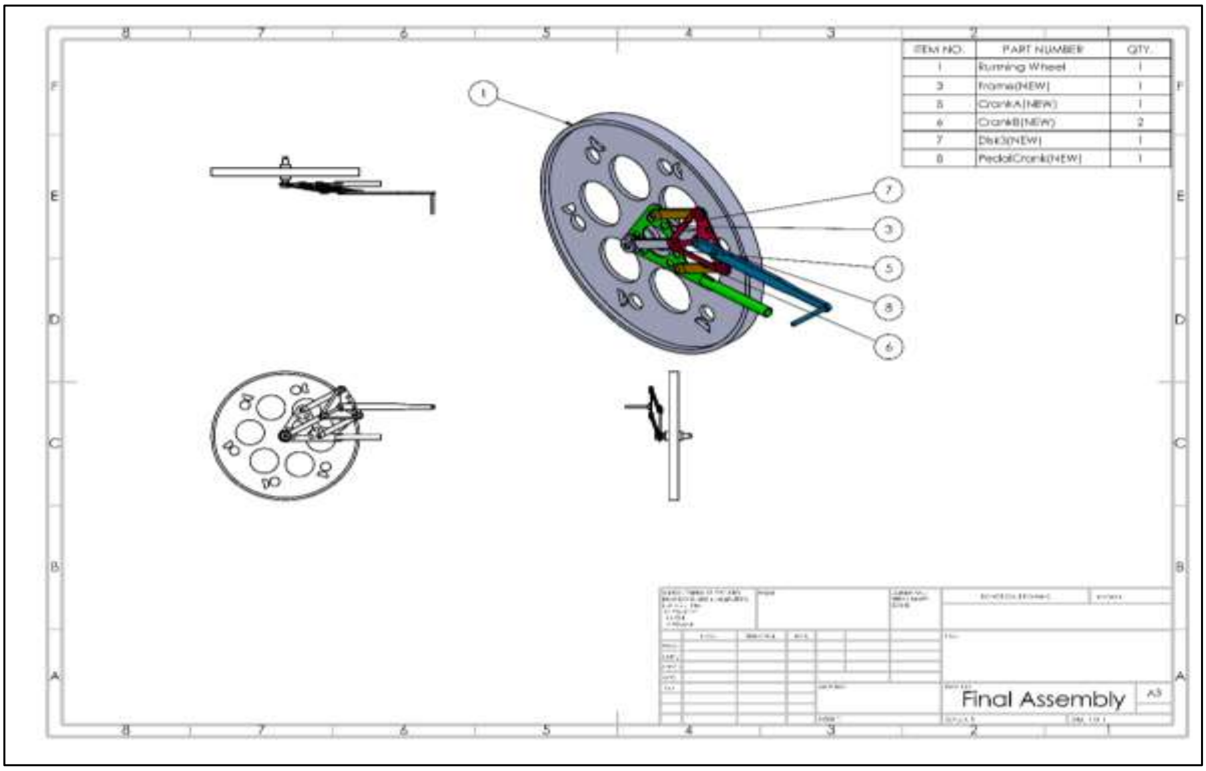


Figure 3.3.7: Full mechanism assembly

Chapter 4: System Testing and Analysis Experimental Setup, Data Acquisition System on SOLIDWORKS software

4.1 Kinematic Modeling

[1] It is a fact that kinematic modelling is one of the essential parts of mechanisms analysis, if not the most important part. Kinematic analysis can be traced back to physics as a component of motion analysis which deals with the motion only without considering the forces causing the motion [Sugiarto & Conradt, 2017]. Tracking a position or even reaching a point with physical links forced you to concern about how joints vary between your links (manipulator).

We analyze the mechanisms forces and parts reactions to the input force we are going to assume three conditions, the first one is the connection between the running wheel and the crank A is a point without any mechanical locks. Secondly, we apply the 500 N force to the running wheel as a person weighs to see how the system reacts. The third assumption we are doing our analysis I one position of the running system that is shown in Figure 4.1.1.

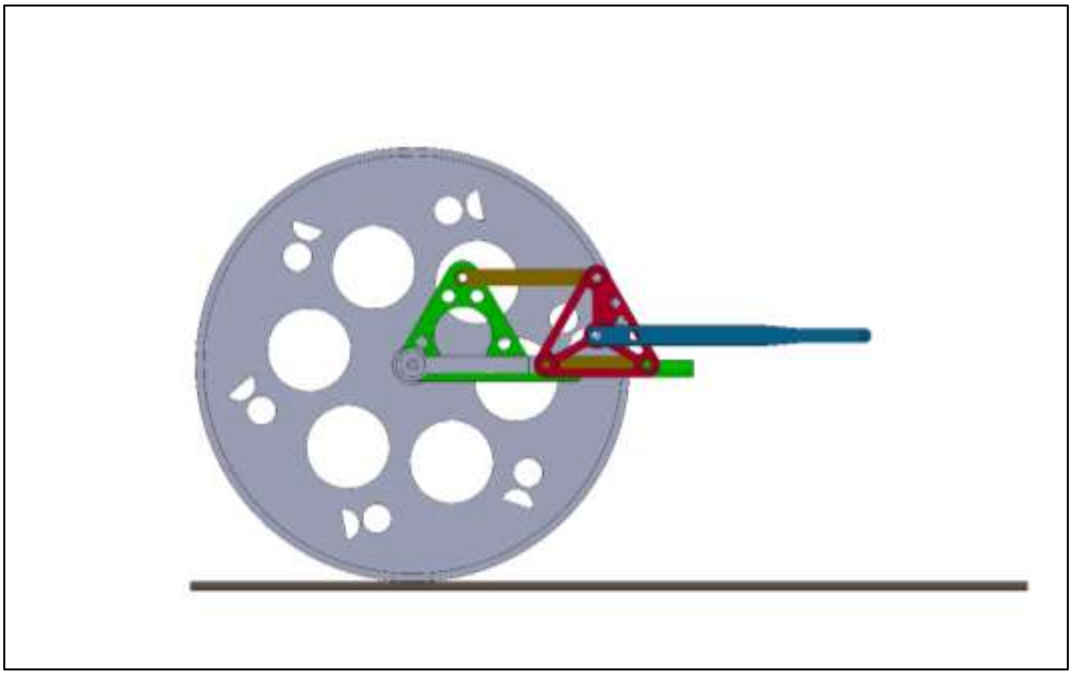


Figure 4.1.1: Position to analyze

We are representing the dimensions of the acting forces on the wheel to overcome the friction force at the outside surface of the wheel contacting the ground.

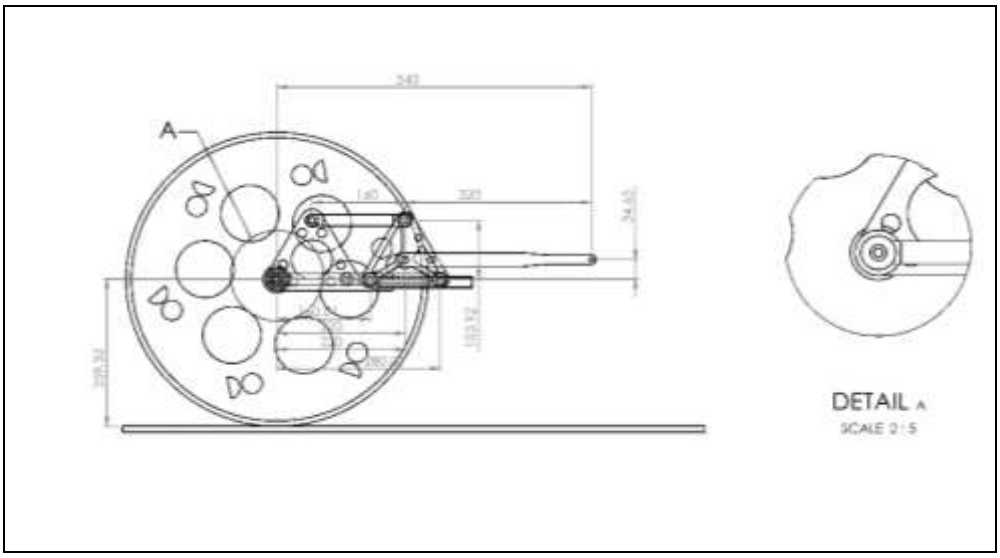


Figure 4.1.2: Mechanism dimensions

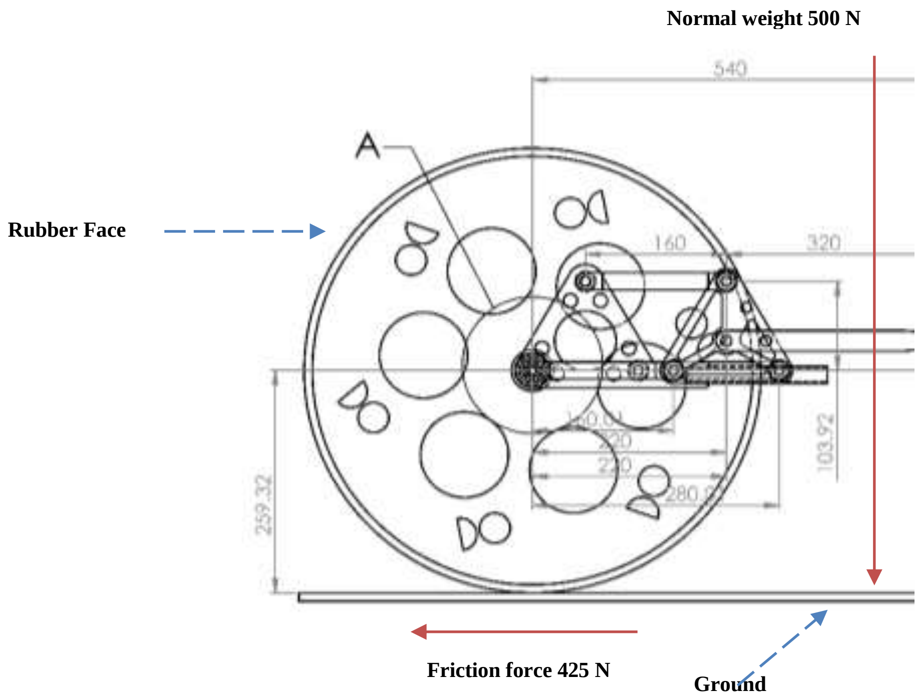


Figure 4.1.3: Friction Force analysis

$$\boldsymbol{Fr} = \mu * \boldsymbol{N}$$

Where Fr is the friction force and the μ is the dimensionless friction coefficient between rubber and concrete that equals 0.85, N is the Normal weight force = 500 N as per assumption.

By substituting the values of N and μ, in the Friction equation, it results in 425 opposing force.

Now we can transfer this force to the inner wheel part that is shown **in detailed A in Figure 4.1.2** as a counter moment to the pedal force.

$$\boldsymbol{M} = \boldsymbol{F} * \boldsymbol{R} \quad \textit{where } f \textit{ is the force and } R \textit{ is the distance or raduis}$$

F = to the friction force 425 and **R** is equal to the distance shown in Figure 4.1.3 = 260 mm.

By finalizing this equation, we got **M = 110.5 N.M.**

M1 counter moment around origin O

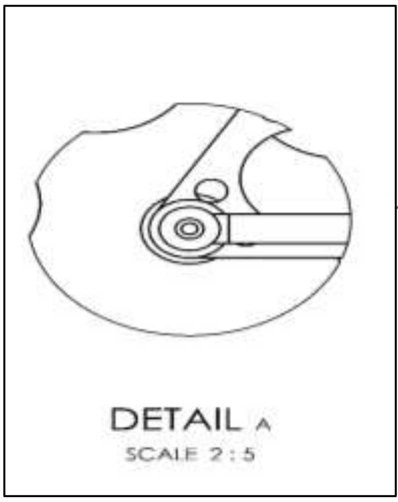


Figure 4.1.4: Detailed inner shaft

By having a deep look at the detailed A we find that its only the Crank B that is responsible for applying the force against the friction force and momentum, so if take in mind the shaft radius with force from the Crank B we can rotate the wheel and keep it moving. To do this by equations we assume the counter moment is acting on the face of the shaft with a diameter of 24 mm. with a radius of 12 mm.

M1 = F1 * R

For **R = 12 mm** and **M1 = 110.5 N.m**. The force **F will result a 9.2 KN.**

To transfer the moment to Point A at the Crank B link we will continue use the same equation of equilibrium.

M = F*R = 0.16 m, **M= 110.5** NM and F2 will result to 690.6 N

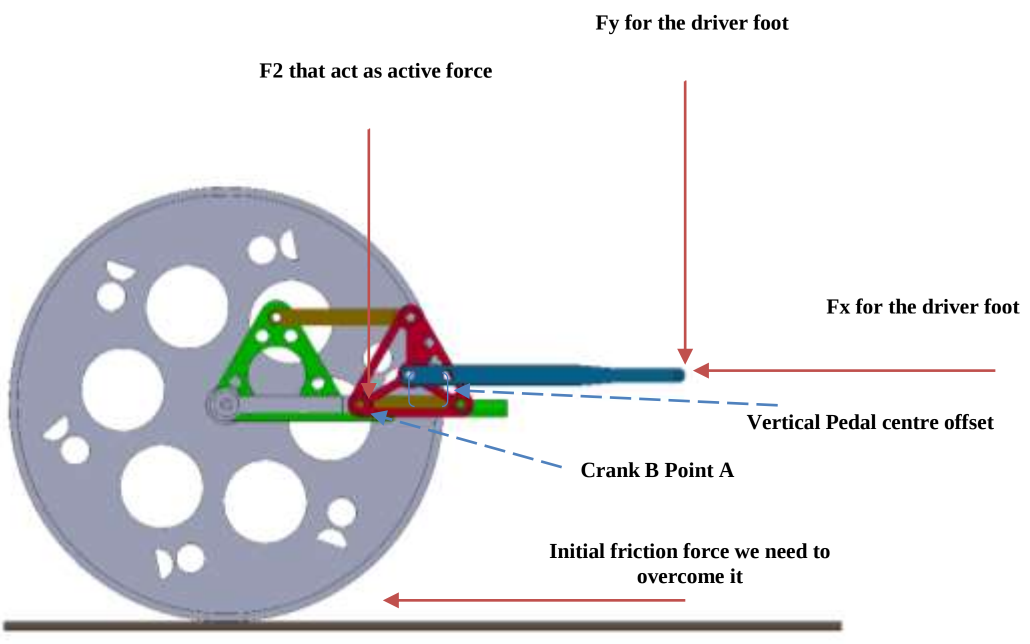


Figure 4.1.5: Pedal force analysis

The Crank B is driven by the pedal, and the pedal centered in the disk with an angle of 30 from the pivot of the Crank B point A, and an offset of 35mm. The force F2 will combine the two combinations of the foot force acting on the pedal surface.

Fx = F2 * Cos ϴ , **Fy = F2 * Sin ϴ**. The two forces will result as:

Fx = 690.6 * Cos30

Fx = 690.6* .866 = **597 N**

Fy = 690.6 * Sin 30

Fy = 690.6* 0.5 = **345.3 N**

4.2 Position analysis

After going with the model and how the static forces react to each other, we will ahead to the position analysis. It's shown in **figure 4.1.5** four points we will track by changing the input value which the crack B angel rotation.

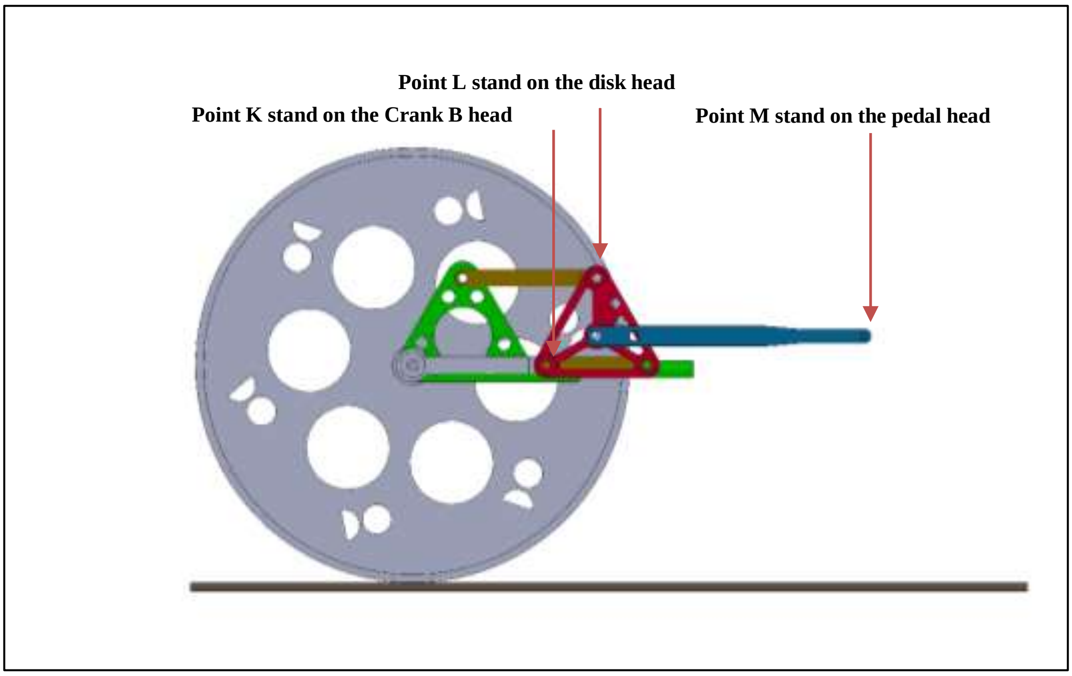


Figure 1: Points K, L, and M on the mechanism to be tracked

Now we will draw the skeleton of the mechanism that helps to find the DOF for it, it has shown clearly that the system has one degree of freedom. But we will use Gruebler's equation as follows:

$$DOF = 3\,(n-1) - 2f1 - 1f2$$

Where:

n: stands for Number of linkages, $\boldsymbol{f1}$: stands for Pivot Joints Type, $\boldsymbol{f2}$: stands for rolling- slide joints.

Figure 4.2.2 shows the skeleton of the mechanisms with the joints type and number of links.

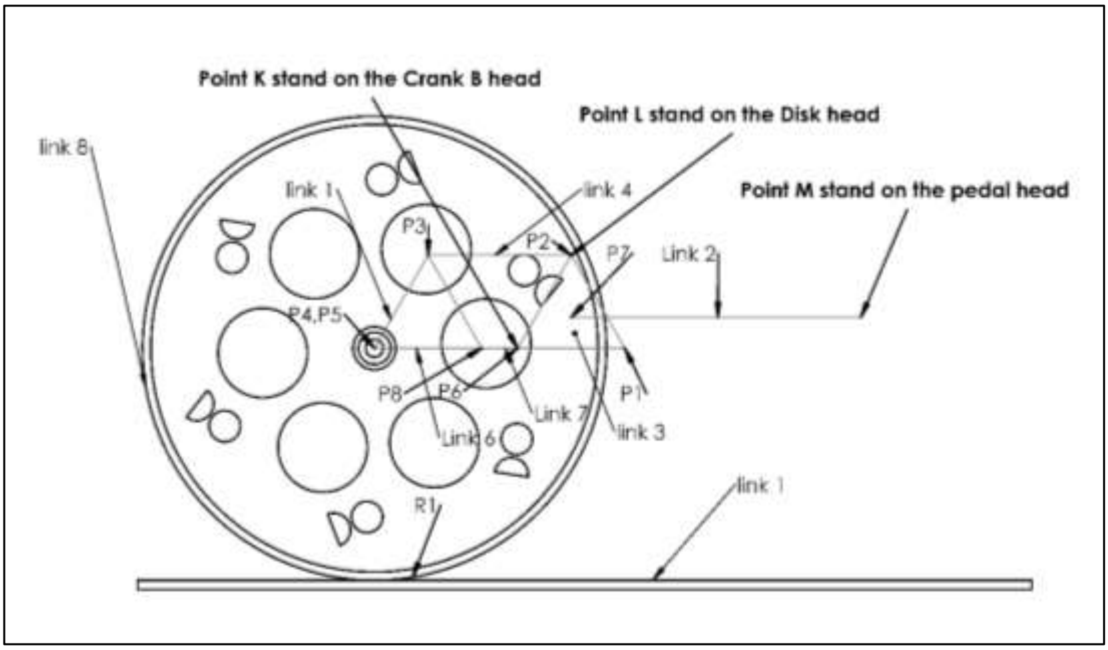


Figure 4.2.2: Mechanisms skeleton, joint types and numbers and links numbers.

We can see the number of links is 7 and the pivot joints are 8 in addition to 1 roller joint, by substitute these numbers in Gruebler's equation we can find:

$$DOF = 3\,(7-1) - 2*8 - 1*1 = 1$$

Here the DOF is one.

Figure 4.2.3 shows the example of calculating points (K, L, and M) positions using the software.

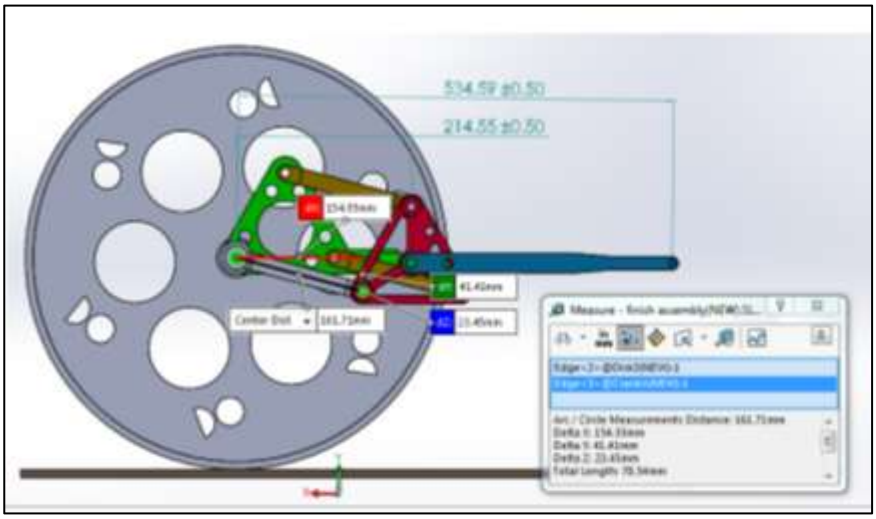


Figure 4.2.3: Points K, L, M values after 15 degree rotation of Crank B "CCW".

Table4.2. 1: Points K, L, M values changed between the angle of Crank B and Ground (Θ).

	Angle Θ (0 – 270) CCW measured	Point K x values mm	Point L x values mm	Point M x values
1	15	154	214	534
2	30	138	198	518
3	45	113	173	493
4	60	80	140	460
5	75	41	101	421
6	90	0	60	379
7	120	-80	-20	300
8	150	-138	-78	241
9	180	-160	-100	220
10	225	-113	-53	266
11	250	-54	-5	325
12	275	18	74	394
13	300	80	140	460
14	330	138	198	518

By implementing the data from table 1 on the scatter chart using the Excel software we result a Figure 4.2.4.

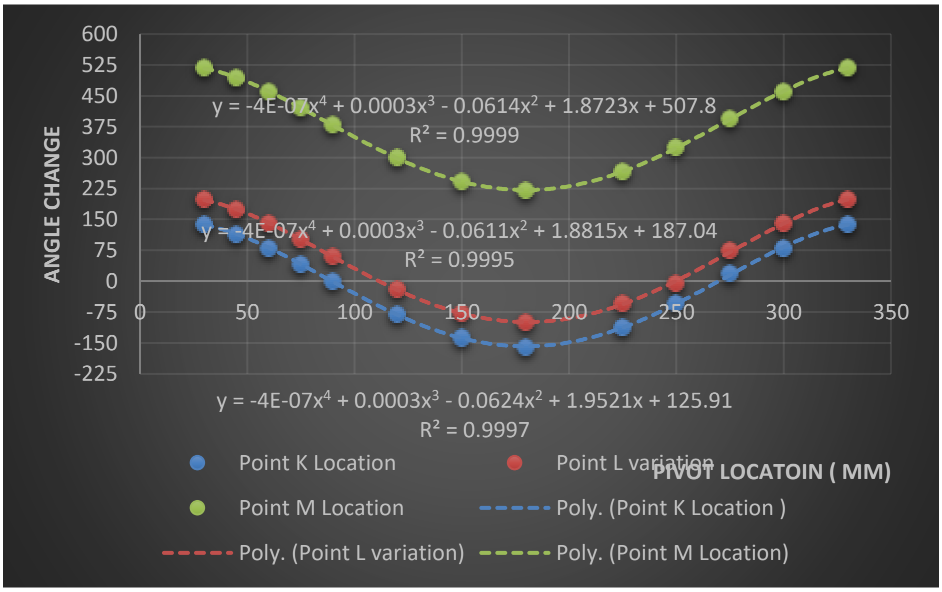


Figure 4.2.4: Point K, L, M implemented at scatter chart using Excel.

Chapter 5: Project Management

5.1 Project Plan

In our project, there are many tasks included. Each task is assigned to one or more members. Here is the all information about the tasks, team members, and the duration of each task to be completed. See table 5.1.1 for tasks & durations and table 5.1.2 for the assigned members.

Table 5.1.1: Tasks and their durations

WBS	TASK	START	END	DAYS	% DONE
1	**[Task 1]**		-		
1.1	Identifying Project	Sat 9/05/20	Sat 9/12/20	8	100%
1.2	Determine objectives	Sat 9/05/20	Sat 9/12/20	8	100%
1.3	Contribution of Team Members	Sat 9/05/20	Sat 9/12/20	8	100%
1.4	Challenges and Decision Making	Sat 9/05/20	Sat 9/12/20	8	100%
1.4.1	Challenges and Decision Making	Sat 9/05/20	Sat 9/12/20	8	100%
1.4.2	Project Bill of Materials and Budget	Sat 9/05/20	Sat 9/12/20	8	100%
2	**[Task 2]**		-		
2.1	Taking the Calculations of the mechanism	Sun 9/13/20	Tue 9/15/20	3	100%
2.2	Measure dimension of parts	Sun 9/13/20	Tue 9/15/20	3	100%
2.3	Part 1: Rear Shaft/ Crank/ Rear Hub	Wed 9/16/20	Wed 9/16/20	1	100%
2.4	Part 2: Disk/ Screws.	Thu 9/17/20	Fri 9/18/20	2	100%
2.5	Part 3: Frame/ Bearing/ Pedal Crank	Sat 9/19/20	Sun 9/20/20	2	100%
2.6	Part 4: Bolts/ Pedal	Mon 9/21/20	Mon 9/21/20	1	100%
3	**[Task 3]**		-		
3.1	The workout in the software shows the collected data	Tue 9/22/20	Tue 9/22/20	1	100%

3.2	Creating the parts in SOLIDWORKS	Wed 9/23/20	Fri 9/25/20	3	100%
3.3	Part 1: Rear Hub/ Rear Shaft	Wed 9/23/20	Fri 9/25/20	3	100%
3.4	Part 2: Disk/ Cranks/ Screws and Bolts	Wed 9/23/20	Fri 9/25/20	3	100%
3.5	Part 3: Frame/ Pedal Crank	Sat 9/26/20	Mon 9/28/20	3	100%
3.6	Part 4: Bearing/ Pedal	Sat 9/26/20	Mon 9/28/20	3	100%
4	**[Task 4]**		-		
4.1	Prototype manufacturing (For testing)	Sat 10/10/20	Sat 10/24/20	15	100%
4.2	Prototype assemble	Sun 10/25/20	Tue 10/27/20	3	100%
4.3	Testing and analyses of the system	Wed 10/28/20	Thu 10/29/20	2	100%
4.4	Results, Analysis and Discussion	Thu 10/29/20	Sun 11/01/20	4	100%
4.5	Final discussion	Tue 11/03/20	Wed 11/04/20	2	100%
5	**[Task 5]**		-		
5.1	Final manufacturing (Prototype)	Sat 11/07/20	Fri 11/20/20	14	100%
5.2	Final assemble	Sat 11/21/20	Mon 11/30/20	10	100%
5.3	Testing and analyses of the system	Tue 12/01/20	Sat 12/05/20	5	100%
6	**[Task 6]**		-		
6.1	Presentation preparation and practice	Fri 12/11/20	Tue 12/15/20	5	60%
6.2	Final Report	Sat 12/05/20	Fri 12/18/20	14	100%
6.3	Peer Review	Fri 12/18/20	Sun 12/20/20	3	100%
6.4	Banner	Sat 12/12/20	Sun 12/20/20	9	100%
6.5	Brochure	Sat 12/12/20	Sun 12/20/20	9	100%

Table 5.1.2: Tasks and assigned members

#	Tasks	Assigned Members
1	Chapter 1: Introduction	All
2	Chapter 2: Literature Review	Mohammed Aldossary
		Abdullah Alghamdi
		Ibrahim Alrumaihi
3	Chapter 3: System Design	All
4	Chapter 4: System Testing & Analysis	All
		Mohammed Aldossary

5	Chapter 5: Project Management	Abdullah Alghamdi
		Ibrahim Alrumaihi
		AbdulellahAlmulaifi
6	Chapter 6: Project Analysis	Mohammed Aldossary
		Abdullah Alghamdi
		AbdulellahAlmulaifi

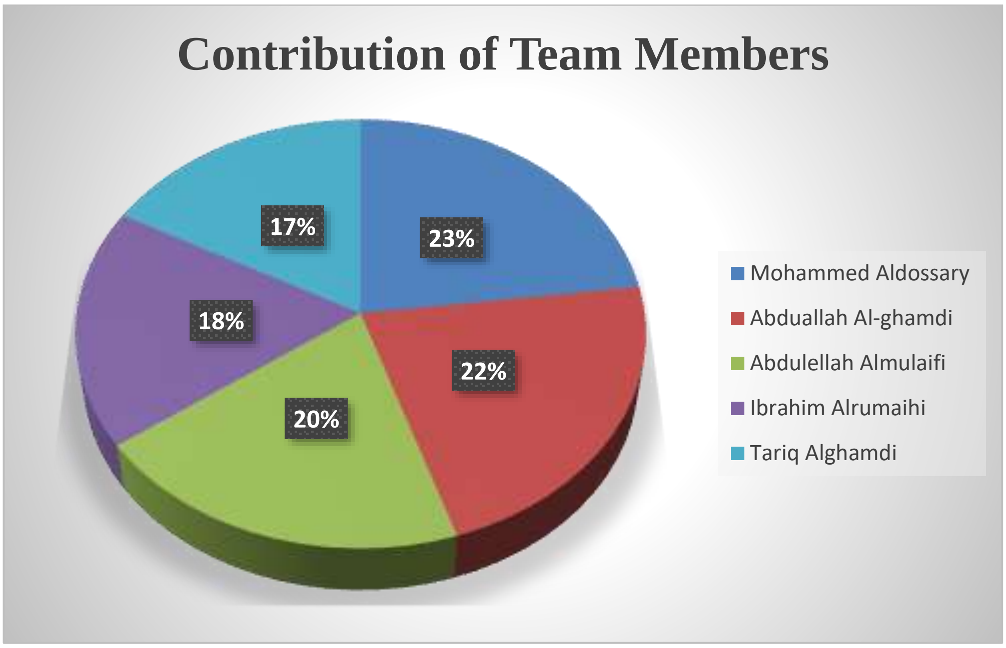
5.2 Contribution of Team Members

Team member's contribution and their willingness to work were discussed in our first meeting as a team, and the tasks were divided and agreed upon by each member.

Table 5.2.1: Tasks the contribution of the members

#	Tasks		Assigned	Cont. %
1	Chapter 1: Introduction		All	100%
2	Chapter 2: Literature Review	Project Background	Abdullah	33.33%
		Previous Work	Ibrahim	33.33%
		Comparative Study	Mohammed	33.33%
3	Chapter 3: System Design	Design Constraints and Design Methodology	Mohammed	20%
			Abdullah	20%
			Ibrahim	20%
			Abdulellah	20%
			Tariq	20%
		Engineering Design standards	Ibrahim	50%
			Abdulellah	50%
		Theory and Theoretical Calculations	Mohammed	35%
			Abdullah	35%
			Ibrahim	30%
		Product Subsystems and	Mohammed	40%

		selection of Components	Abdullah	40%
			Tariq	20%
		Manufacturing and assembly	Mohammed	35%
			Abdullah	30%
			Abdulellah	35%
4	Chapter 4: System Testing & Analysis	Experimental Setup, Sensors and data	All	100%
		Results, Analysis and Discussion	All	100%
5	Chapter 5: Project Management	Project Plan	Mohammed Abduallah Ibrahim Abdulellah	100%
		Contribution of Team members		
		Project Execution Monitoring		
		Challenges & Decision Making		
		Project Bill of Material & Budget		
6	Chapter 6: Project Analysis	Life Long Learning	Mohammed Abduallah Abdulellah	100%
		Impact of Engineering Solution		
		Contemporary Issues Addressed		



5.3 Project Execution Monitoring

During our project, we had many activities that relate to improve our project. These activities including important meetings and events related to our senior project. In table 5.3.1 shows the list of meeting and other events for our project during fall semester 2020.

Table 5.3.1: Project Execution Monitoring Chart

Date	Meeting with group	Meeting with Advisor / Co. Advisor
09/01/2020		
09/08/2020		
09/10/2020		
09/11/2020		
09/14/2020		
09/23/2020		
09/26/2020		
09/30/2020		
10/15/2020		
10/25/2020		
11/2/2020		
11/8/2020		
11/11/2020		
11/26/2020		
11/28/2020		
12/4/2020		

12/8/2020		
12/10/2020		
12/14/2020		
12/16/2020		
12/17/2020		

5.4 Challenges and Decision Making

During the project phases, we faced some challenges that affect the progress of the project. The first challenged that we have faced that a lot of workshops did not have access to our files that we were made by SOLIDWORK. The second challenged is during the COVID-19 pandemic that we faced difficulties to went to the campus to work on our project using SOLIDWORK, and also meet our advisors. As a result, for the first challenge, we decided to save all files of our work in all format to avoid any impact will be in our progress. The second decision of our second challenged that we divided the team into two groups and scheduled our time to go to the campus to finish the works of the project using SOLIDWORK and also meet our advisors on scheduled dates a week before it.

5.5 Project Bill of Materials and Budget

Table 5.5.1: Bill of materials

Component #	Description	Cost per Unit	No. of Units used	Total Cost
1	Bicycle	250 SR	1	250 SR
2	First Prototype 3D Print (Polylactic acid, Acrylic fiber)	175 SR	8	1400 SR
3	Bearings	10 SR	1	10 SR
4	Bolts and screws	2.50 SR	25	56.25 SR
5	Shaft	150 SR	1	150 SR
6	Manufacturing for second Prototype	65 SR	7	455 SR
7	Welding	5 SR	3	15 SR
8	Tools	13 SR	3	39 SR
Grand Total Price				2,375.25 SR

Chapter 6: Project Analysis

6.1 Software Skills

As mechanical engineers, designing on computer-based software is most. The primary software used in this project is SOLIDWORK to design our system part, drawing, proper dimensions, and manufacturing. However, they were involved in all the designs where it helps them a lot in their current Course. Besides, Microsoft Word and Excel are used to make the project report and to manage the tasks in Gantt chart form, all technical skills used in this project gave us an incredible experience.

6.2 Impact of Engineering Solutions

In brief words, our project is inspired by BYGEN company, where there established a new speed change hub. Our project aims to replace the old chain system on bicycles with a new linkage based mechanism where it will give the rider a new experience. In that respect, it has excellent inertia. Besides, our components contain a pedal crank called "Joint Crank", the more leveraged which is more power when pushing the pedal with a small power it's very light and smooth, which means this bicycle can go very fast and further distance with small power; save the cyclist's energy and over 30% high-performance than the original bicycle.

6.3 Contemporary Issues Addressed

Our project was heavily focused on SOLIDWORKS and manufacturing design. We have to address there are some major and minor problems our prototype contains at the moment. Firstly, the crankshaft and the crank A and B were supposed to be manufactured on a 3D CNC machine, but no workshop could do that for our design. They only have a 2D CNC machine, so some angles on the cranks are off, where does not feel as smooth running as should be.

6.4 Hardware Skills

During this project, we have utilized certain tools and machines to assemble and complete our design. As one of the requirements is to modify the shaft the team was exposed to some machine such as lathe machine, milling machine, etc. on the other hand, we got to see the drawing sheets for our design comes to life by watching the CNC machine and 3D Printer make's our design parts.

Chapter 7: Future Recommendations

7.1 Future Recommendations

To sum up, we have tested the idea with the chainless system how can a mechanism work and It worked without any issues. We have seen this mechanism work well to withstand high torque requirements but with a lower speed. We examine that both systems chain and linkages can't work together at the same time because of the difference in the speed ratio between them, for the time being; our objective is to minimize modifications in the existing bicycle. Moreover, we feel interested in this project so, our plan in the near future we will do a modification in the existing system with the sprocket by increases the diameter to be the same height as the Paddel of the linkage mechanism or find other alternative solutions. We used steel parts for manufacturing but this initially selected because of the availability in the market, and its high strength to prevent manufacturing issues. Also, we recommend in the future that aluminum or any other composite material would be better for this system.

8. References

1- *https://www.astmsteel.com/product/4340-steel-aisi/*

2- *https://amesweb.info/Fasteners/Screws/Metric-Hexagon-Socket-Head-Cap-Screw-Dimensions.aspx*

3- https://www.engineersedge.com/hardware/bs_en_iso_4032_hexagon_nuts__14571.htm

4- http://bygen.co.kr/

5- https://en.wikipedia.org/wiki/Chainless_bicycle

Appendix A: Progress Reports

	SDP – WEEKLY MEETING REPORT
	Department of Mechanical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**Fall**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design and development of mechanism-based drive bicycle**		
ADVISOR	**Dr. Muhammad Asad**		
CO-ADVISOR	**Mr. Taha Waqar**		

Month 1: September

ID Number	Member Name
201000763	**Mohammed Aldossary***
201400957	**Abdullah Alghamdi**
201502750	**Tariq Alghamdi**
201301219	**AbdulelahAlmulaifi**
201602139	**Ibrahim Alrumaihi**

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Project Management (Project Plan)	Allteam members	100%	Submitted on BB
2	Challenges and Decision Making / ProjectBill of Materials and Budget	Allteam members	100%	Submitted on BB
3	Measure dimension of parts	All team members	100%	Submitted on BB

- **To be Filled by Project Supervisor and teamleader:**
- **Please have your supervisor fill according to the criteria shownbelow**

<u>Outcome MEEN4:</u> an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

<u>Outcome MEEN5:</u> an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks

MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Mohammed Aldossary***	3	4	4	4
2	**Abdullah Alghamdi**	3	4	4	4
3	**Tariq Alghamdi**	3	4	4	4
4	**AbdulelahAlmulaifi**	3	4	4	4
5	**Ibrahim Alrumaihi**	3	4	4	4

Comments on individual members

Name	Comments
Mohammed Aldossary*	Very good
Abdullah Alghamdi	Very good
Tariq Alghamdi	Very good
AbdulelahAlmulaifi	Very good
Ibrahim Alrumaihi	Very good

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	SDP – WEEKLY MEETING REPORT
	Department of Mechanical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**Fall**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design and development of mechanism-based drive bicycle**		
ADVISOR	**Dr. Muhammad Asad**		
CO-ADVISOR	**Mr. Taha Waqar**		

Month 2: October

ID Number	Member Name
201000763	**Mohammed Aldossary***
201400957	**Abdullah Alghamdi**
201502750	**Tariq Alghamdi**
201301219	**AbdulelahAlmulaifi**
201602139	**Ibrahim Alrumaihi**

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Creating the parts in SolidWorks	Mohammed Abdullah	100%	Submitted on BB
2	Solidworks: Rear Shaft/ Crank/ Rear Hub.	Mohammed Abdullah Ibrahim	100%	Submitted on BB
3	Solidworks: Disk/ Cranks/ Screws and Bolts	Mohammed Abdullah Abdulellah	100%	Submitted on BB
4	Solidworks: Frame/ Pedal Crank/ Bearing	Mohammed Abdullah Tariq	100%	Submitted on BB

- **To be Filled by Project Supervisor and teamleader:**
- **Please have your supervisor fill according to the criteria shownbelow**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks

MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Mohammed Aldossary***	3	4	4	4
2	**Abdullah Alghamdi**	3	4	4	4
3	**Tariq Alghamdi**	3	4	4	4
4	**AbdulelahAlmulaifi**	3	4	4	4
5	**Ibrahim Alrumaihi**	3	4	4	4

Comments on individual members

Name	Comments
Mohammed Aldossary*	Very good
Abdullah Alghamdi	Very good
Tariq Alghamdi	Very good
AbdulelahAlmulaifi	Very good
Ibrahim Alrumaihi	Very good

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	SDP – WEEKLY MEETING REPORT
	Department of Mechanical Engineering **Prince Mohammad bin Fahd University**

SEMESTER:	**Fall**	**ACADEMIC YEAR:**	**2020/2021**
PROJECT TITLE	**Design and development of mechanism-based drive bicycle**		
ADVISOR	**Dr. Muhammad Asad**		
CO-ADVISOR	**Mr. Taha Waqar**		

ID Number	Member Name
201000763	**Mohammed Aldossary***
201400957	**Abdullah Alghamdi**
201502750	**Tariq Alghamdi**
201301219	**AbdulelahAlmulaifi**
201602139	**Ibrahim Alrumaihi**

List the tasks conducted this month and the team member assigned to conduct these tasks

Month 3: November

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Prototype manufacturing	Allteam members	70%	Submitted on BB

List the tasks planned for the month of November and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Waiting for the prototype manufacturing to be completed	All team members
2	Prototype assemble after the prototype is completed	All team members
3	Testing and analyses of the system	Allteam members
4	Results, Analysis and Discussion.	Allteam members
5	Final discussion.	All team members

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks

MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=none; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Mohammed Aldossary***	3	4	4	4
2	**Abdullah Alghamdi**	3	4	4	4
3	**Tariq Alghamdi**	3	4	4	4
4	**AbdulelahAlmulaifi**	3	4	4	4
5	**Ibrahim Alrumaihi**	3	4	4	4

Comments on individual members

Name	Comments
Mohammed Aldossary*	Very good
Abdullah Alghamdi	Very good
Tariq Alghamdi	Very good
AbdulelahAlmulaifi	Very good
Ibrahim Alrumaihi	Very good

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	SDP – WEEKLY MEETING REPORT
	Department of Mechanical Engineering Prince Mohammad bin Fahd University

SEMESTER:	Fall	ACADEMIC YEAR:	2020/2021
PROJECT TITLE	Design and development of mechanism-based drive bicycle		
ADVISOR	Dr. Muhammad Asad		
CO-ADVISOR	Mr. Taha Waqar		

ID Number	Member Name
201000763	Mohammed Aldossary*
201400957	Abdullah Alghamdi
201502750	Tariq Alghamdi
201301219	AbdulelahAlmulaifi
201602139	Ibrahim Alrumaihi

Month 4: December

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Meeting with the adviser to finalized our work	All team members	10%	Submitted on BB

List the tasks planned for the month of December and the team member/s assigned to conduct thesetasks

#	Task description	Team member/s assigned
1	Final modifications on the prototype	All team members
2	Creating Brochure for the project	Ibrahim Abulellah
3	Creating Banner for the project	Mohammed Abdullah Tariq
4	Presenting the demo of our project	All team members
5	Working the final presentation	All team members

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome MEEN4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN4A. Demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental and societal context	Fails to demonstrate an understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Shows limited and less than adequate understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Demonstrates satisfactory understanding of engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts	Understands appropriately and accurately the engineering professional and ethical standards and their impact on engineering solutions in global, economic, environmental, and societal contexts

Outcome MEEN5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
Criteria	**None (1)**	**Low (2)**	**Moderate (3)**	**High (4)**
MEEN5A: Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Properly and efficently makes team work plans and allocate resources and tasks

MEEN5B: Ability to participate and function effectively in team work projects to meet objectives	Fails to participate and function effectively in team work projects to meet objectives	Shows limited and less than adequate ability to participate and function effectively in team work projects to meet objectives	Demonstrates satisfactory ability to participate and function effectively in team work projects to meet objectives	Function effectively in team work projects to meet objectives
MEEN5C: Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	Communicates properly and effectively with team members

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#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	**Mohammed Aldossary***	3	4	4	4
2	**Abdullah Alghamdi**	3	4	4	4
3	**Tariq Alghamdi**	3	4	4	4
4	**AbdulelahAlmulaifi**	3	4	4	4
5	**Ibrahim Alrumaihi**	3	4	4	4

Comments on individual members

Name	Comments
Mohammed Aldossary*	Very good
Abdullah Alghamdi	Very good
Tariq Alghamdi	Very good
AbdulelahAlmulaifi	Very good
Ibrahim Alrumaihi	Very good

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Appendix B: Engineering standards (Local and International)

Components	Engineering Standard	Details
Material	AISI	4340 Steel Plate: thickness 10mm – 1500mm x width 200mm – 3000mm
Hex cap screws	ISO 965	Hexagon socket head cap screw (M12 thread with 35 mm length)
Nut	ISO 4032	Thread sized M12

Appendix C: CAD drawings and Bill of Materials

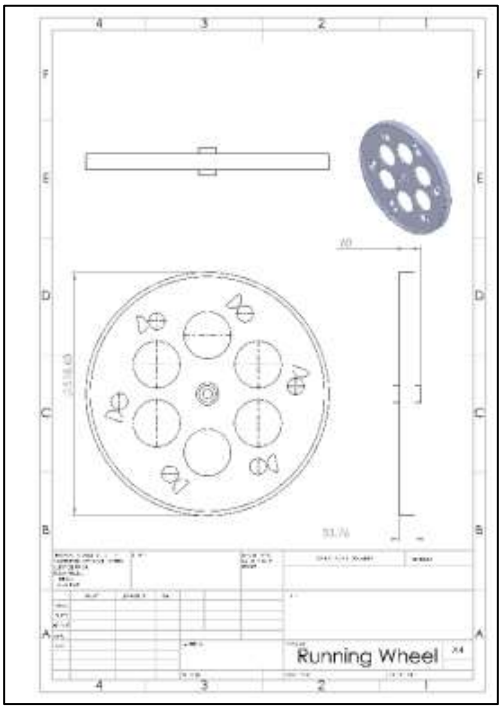

Figure C.2: Running Wheel

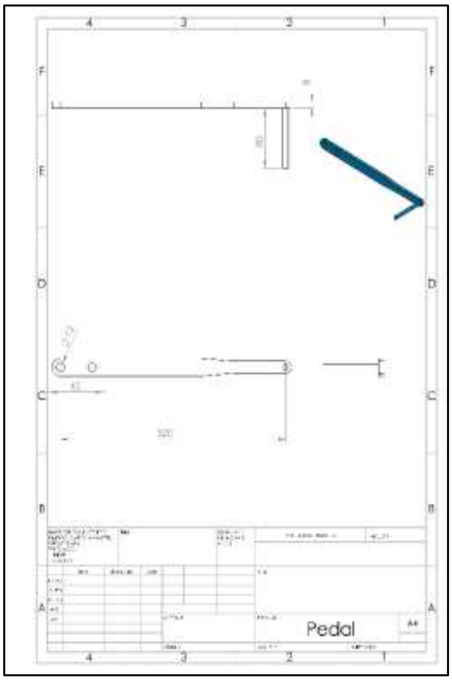

Figure C.3: Pedal Crank

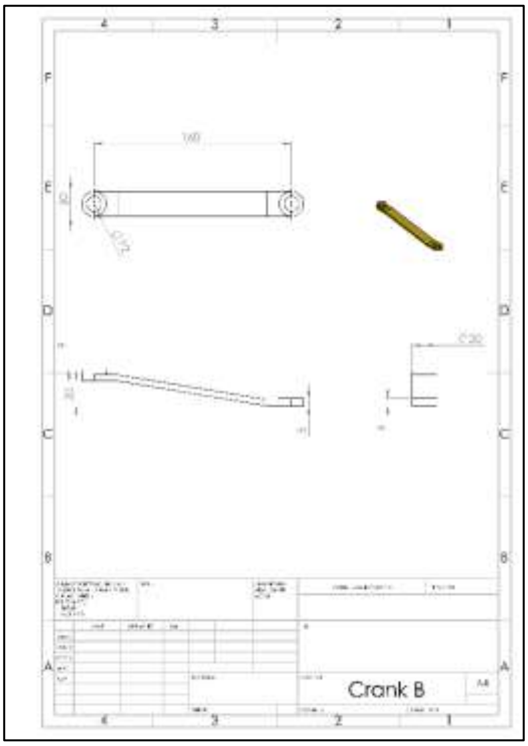

Figure C.3: Crank B

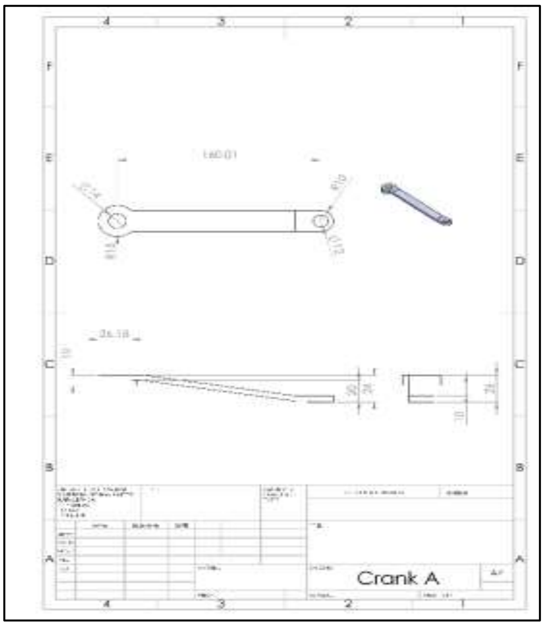

Figure C.4: Crank A

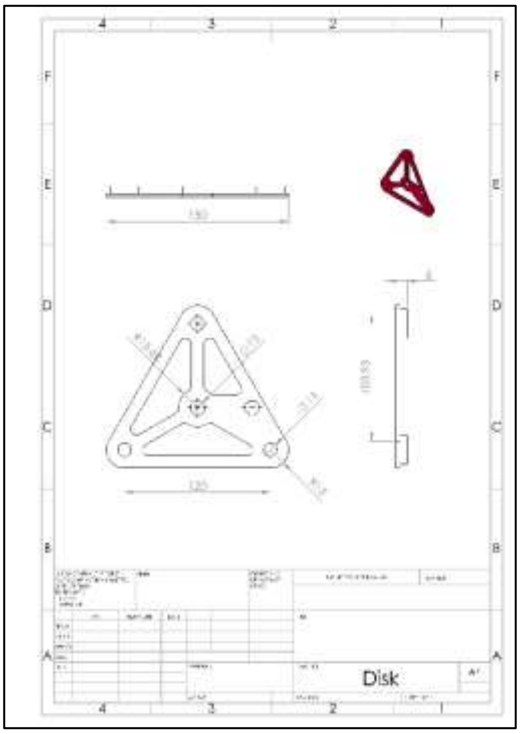

Figure C.5: Disk

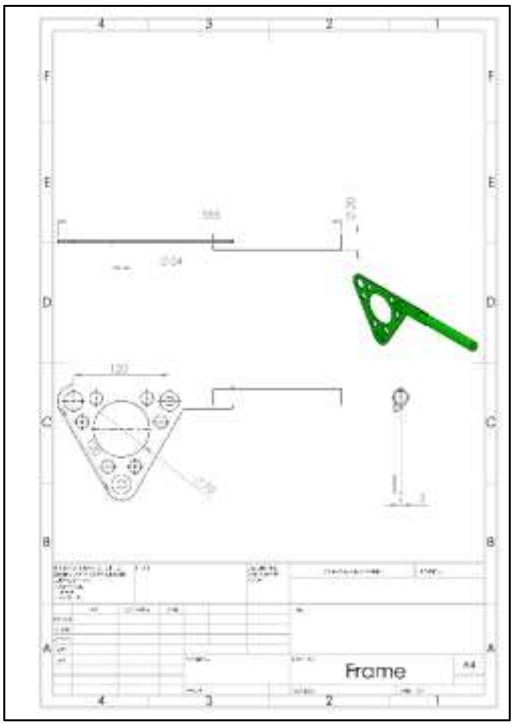

Figure C.6: Frame

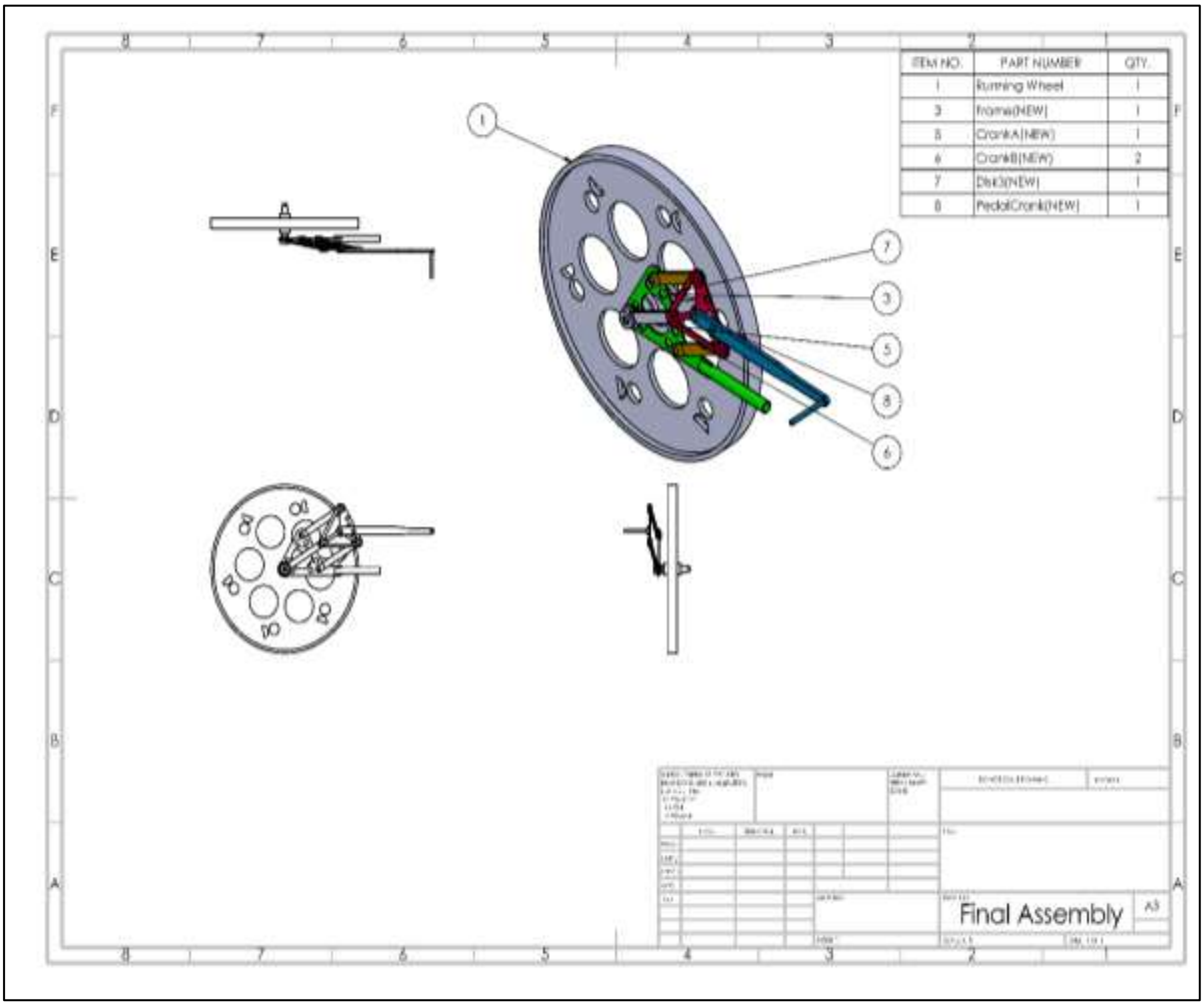

Figure C.7: Full mechanism assembly

Appendix D: Datasheets

	Angle Ɵ (0 – 270) Ccw measured	Point K x values mm	Point L x values mm	Point M x values
1	15	154	214	534
2	30	138	198	518
3	45	113	173	493
4	60	80	140	460
5	75	41	101	421
6	90	0	60	379
7	120	-80	-20	300
8	150	-138	-78	241
9	180	-160	-100	220
10	225	-113	-53	266
11	250	-54	-5	325
12	275	18	74	394
13	300	80	140	460
14	330	138	198	518

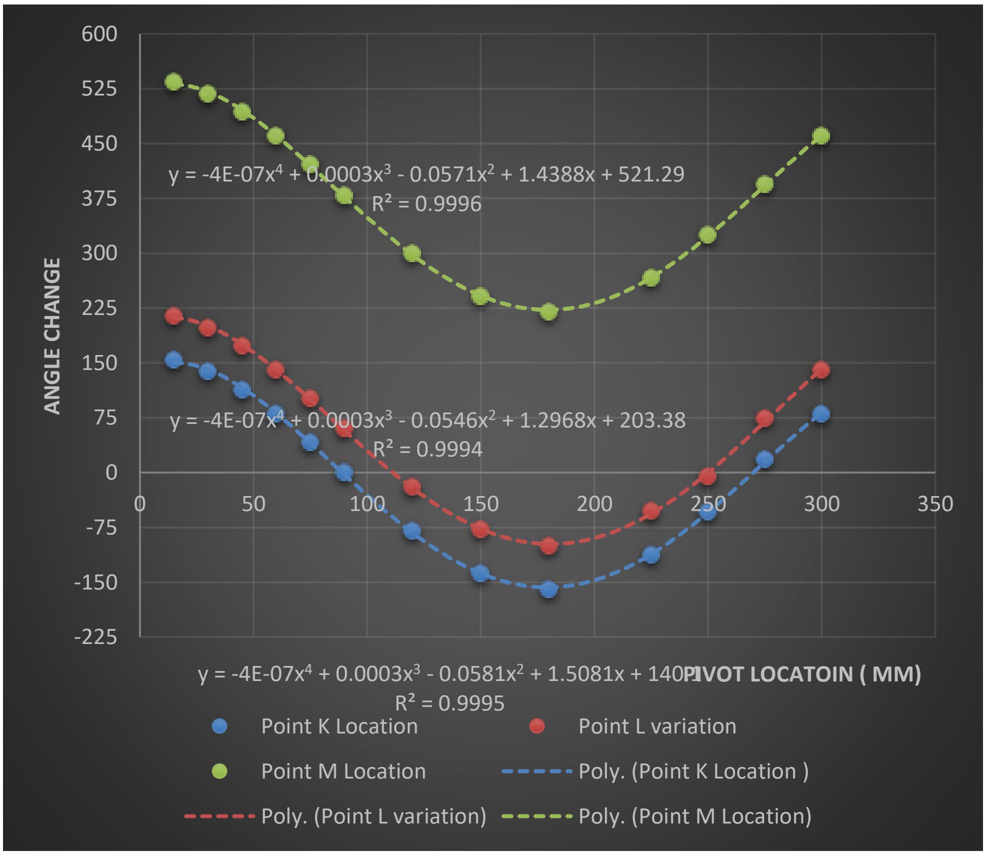

Figure D.1: Point K, L, M implemented at scatter chart using Excel

Appendix E: Gantt chart

WBS	TASK	START	END	DAYS	% DONE
1	**[Task 1]**		-		
1.1	Identifying Project	Sat 9/05/20	Sat 9/12/20	8	100%
1.2	Determine objectives	Sat 9/05/20	Sat 9/12/20	8	100%
1.3	Contribution of Team Members	Sat 9/05/20	Sat 9/12/20	8	100%
1.4	Challenges and Decision Making	Sat 9/05/20	Sat 9/12/20	8	100%
1.4.1	Challenges and Decision Making	Sat 9/05/20	Sat 9/12/20	8	100%
1.4.2	Project Bill of Materials and Budget	Sat 9/05/20	Sat 9/12/20	8	100%
2	**[Task 2]**		-		
2.1	Taking the Calculations of the mechanism	Sun 9/13/20	Tue 9/15/20	3	100%
2.2	Measure dimension of parts	Sun 9/13/20	Tue 9/15/20	3	100%
2.3	Part 1: Rear Shaft/ Crank/ Rear Hub	Wed 9/16/20	Wed 9/16/20	1	100%
2.4	Part 2: Disk/ Screws.	Thu 9/17/20	Fri 9/18/20	2	100%
2.5	Part 3: Frame/ Bearing/ Pedal Crank	Sat 9/19/20	Sun 9/20/20	2	100%
2.6	Part 4: Bolts/ Pedal	Mon 9/21/20	Mon 9/21/20	1	100%
3	**[Task 3]**		-		
3.1	The workout in the software shows the collected data	Tue 9/22/20	Tue 9/22/20	1	100%
3.2	Creating the parts in SOLIDWORKS	Wed 9/23/20	Fri 9/25/20	3	100%
3.3	Part 1: Rear Hub/ Rear Shaft	Wed 9/23/20	Fri 9/25/20	3	100%
3.4	Part 2: Disk/ Cranks/ Screws and Bolts	Wed 9/23/20	Fri 9/25/20	3	100%
3.5	Part 3: Frame/ Pedal Crank	Sat 9/26/20	Mon 9/28/20	3	100%
3.6	Part 4: Bearing/ Pedal	Sat 9/26/20	Mon 9/28/20	3	100%
4	**[Task 4]**		-		
4.1	Prototype manufacturing (For testing)	Sat 10/10/20	Sat 10/24/20	15	100%
4.2	Prototype assemble	Sun 10/25/20	Tue 10/27/20	3	100%
4.3	Testing and analyses of the system	Wed 10/28/20	Thu 10/29/20	2	100%
4.4	Results, Analysis and Discussion	Thu 10/29/20	Sun 11/01/20	4	100%

4.5	Final discussion	Tue 11/03/20	Wed 11/04/20	2	100%
5	**[Task 5]**		-		
5.1	Final manufacturing (Prototype)	Sat 11/07/20	Fri 11/20/20	14	100%
5.2	Final assemble	Sat 11/21/20	Mon 11/30/20	10	100%
5.3	Testing and analyses of the system	Tue 12/01/20	Sat 12/05/20	5	100%
6	**[Task 6]**		-		
6.1	Presentation preparation and practice	Fri 12/11/20	Tue 12/15/20	5	60%
6.2	Final Report	Sat 12/05/20	Fri 12/18/20	14	100%
6.3	Peer Review	Fri 12/18/20	Sun 12/20/20	3	100%
6.4	Banner	Sat 12/12/20	Sun 12/20/20	9	100%
6.5	Brochure	Sat 12/12/20	Sun 12/20/20	9	100%

Appendix F: CAD (Deflection Analysis)