Career Episode 2

Beam Engine Automata

Introduction

CE 2.1.1

This was a project done for the unit of Advance Mechanical Design which I studied in my Bachelor of Engineering Technology degree. This project related to a challenge that was given to the students by the Lecturer to showcase our learning skills. I began working on this project in _____ and it came to an end in _____.

Background

CE 2.2.1

The Lecturer gave a challenge to the students in response to which we performed this project. The aim of this project was to use 3 mechanisms and make moving automata. The emphasis of this project was on to finding a cheap and affordable design for automata which should use 3 mechanisms. For the purpose of this project, I performed a careful examination. I took 3 designs and decided to use beam engine. I knew from research that the beam engine was initially used to pump water from mines and then later on as a steam engine. I understood that the beam engine used 3 mechanisms. I decided to use wood pallets in order to maximize the cost effectiveness of the design.

CE 2.2.2

The purpose of this project was for the students to understand different mechanism that we use on a daily basis. I knew that simple and complex mechanical systems, working on basic mechanics principles, are used in all devices ranging from vehicles to watches. The most common mechanisms I understood were cam, gears, levers and springs. I understood the importance of using mechanical tools to rotate devices, lifting or pushing.

CE 2.2.3

It was a team of 3 students including me. The team was leaderless, so we all were working together without any special distinction.

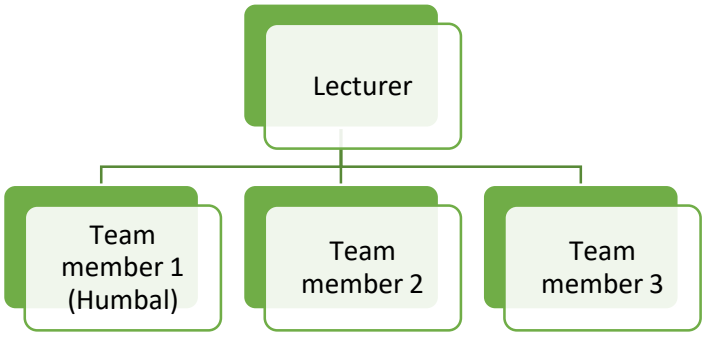


Figure 1: Project Reporting

Personal Engineering Activity

CE 2.3.1

I knew that beam engine automata work on 3 different mechanisms: Cam, Crank and Four bar linkage. I decided to conduct more research on the mechanisms to fully understand them. Through my research and prior knowledge, I got better understanding of the mechanism involved. I knew cams are mechanical devices that convert rotational motion into linear notion. During one of our lab works of the same unit, I along with my fellows had made a cam mechanism with the help of [redacted]. That helped me a lot in designing the project. In this type, I had made a metal connected with a shaft and it pushed rod up and down.

Figure 2: Cam lab work

CE 2.3.2

Similarly, I knew that crank mechanism is used to convert rotational motion into transitional motion. It has three revolutionary joints. In another lab work, I had understood the working of crank and was also able to understand the motion of crank.

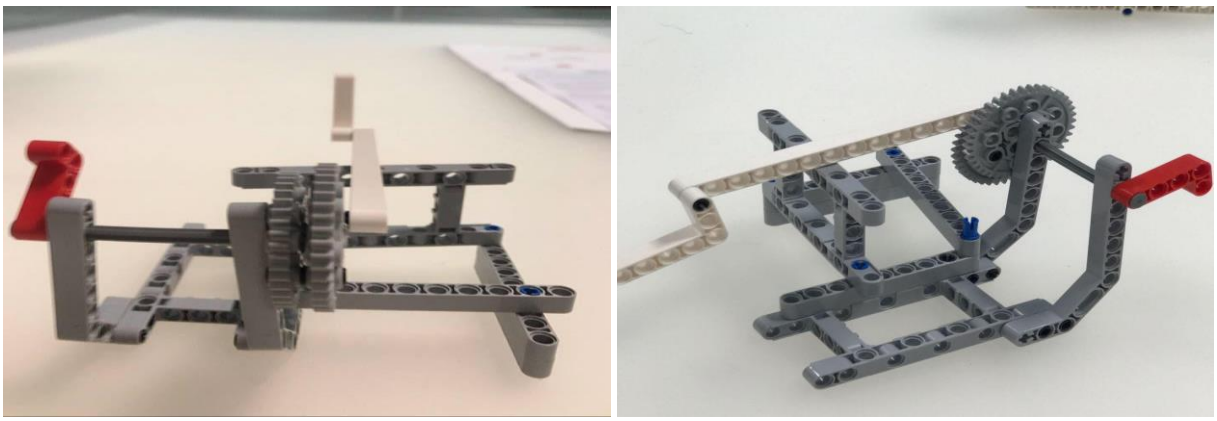


Figure 3: Crank lab work

CE 2.3.3

Similarly, I understood that four bar mechanism has four bar shaped links and 4 turning pairs. Every 4-bar linkage has 1 fixed bar known as frame which may be actually the bar shaped, but mainly it represents the frame of a moving machine, and in this case is normally a huge casting of irregular shape. I also knew that one of the turning members in a 4 bar linkage usually plays its role as a driver and it is

known as crank, while the other one is normally called the rocker or follower. The floating link that joints the crank and the rocker is known as connecting rod. In a lab work, I understood the motion of the 4 bar linkage.

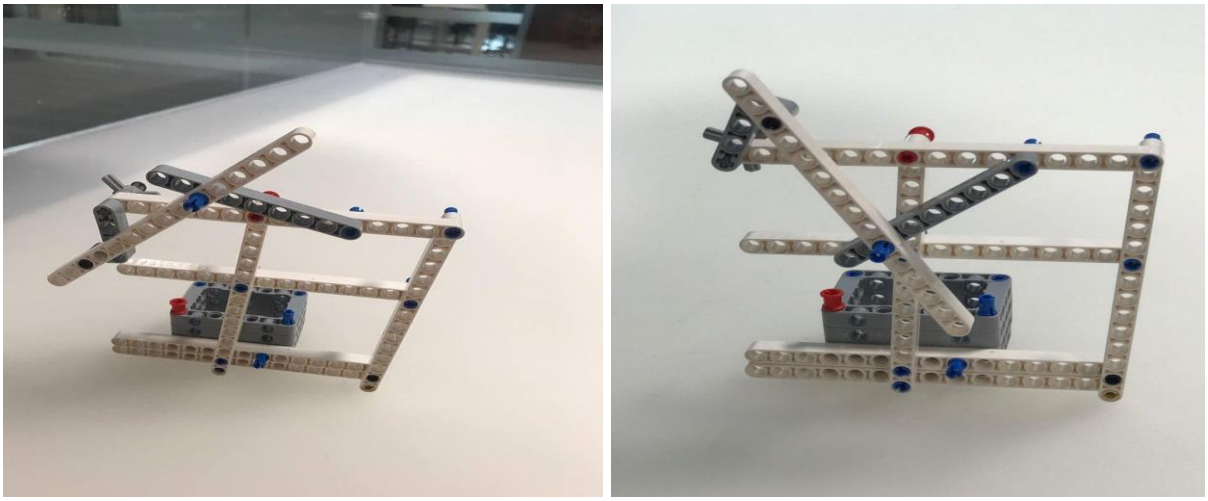


Figure 4: 4-Bar Linkage Lab Work

CE 2.3.4

In the beginning of the construction phase of the project, I made a strong base with strong wood. I attached a strong piece of wood, 90 degrees vertical to the middle of the base. Then I attached a fixed point on the top of it with 4 points to attach the 4-bar linking system, which was designed by my group mate prior to the construction. After that I constructed a fixed point and a wheel in the corner by using glue and wood building the cam mechanism. After that I built the connecting rod and crank mechanism which also connected to the four-bar linkage.

CE 2.3.5

Having known the concept of degree of freedom as the number of independent parameters which define a systems configuration, I understood that our project has 2 degrees' freedom, the axis rotational link in the Y Direction. First, I hand sketched the mechanism to get the exact shape and to find the accurate measurement.

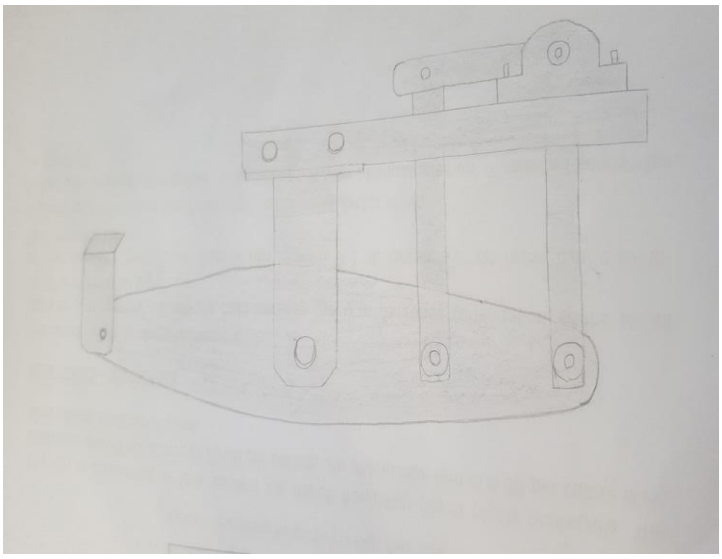


Figure 5: 4 bar Sketch

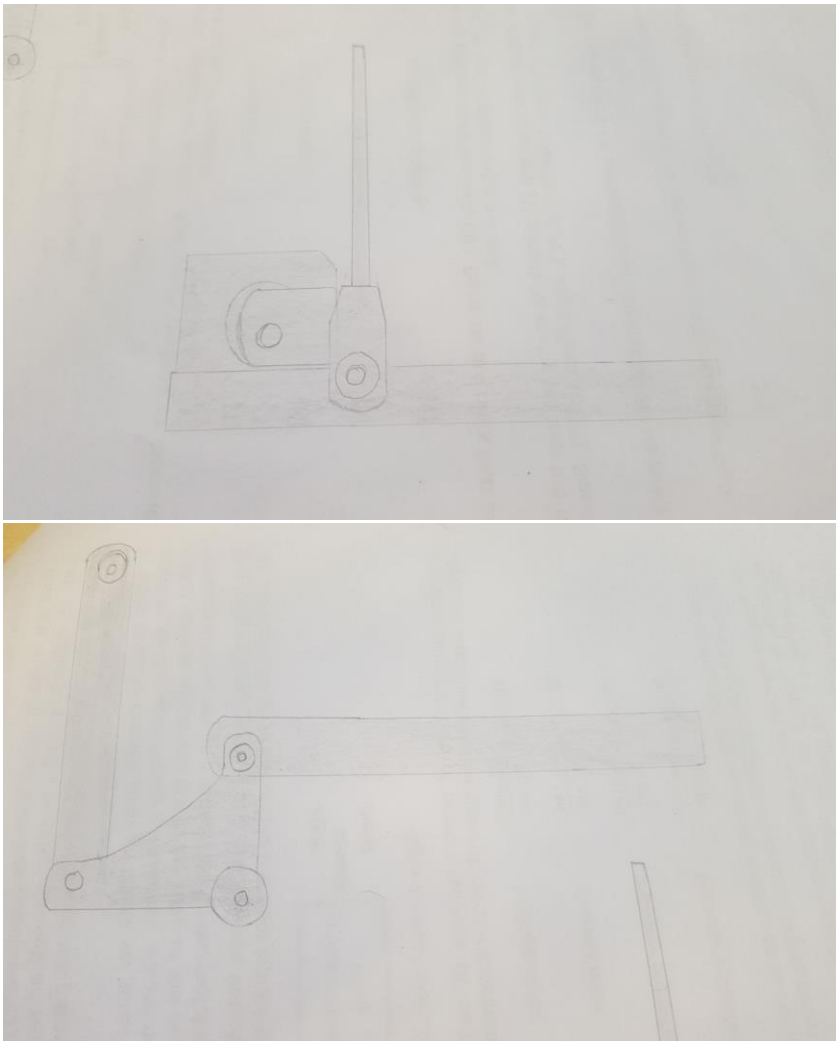


Figure 6: Crank Mechanism Sketch

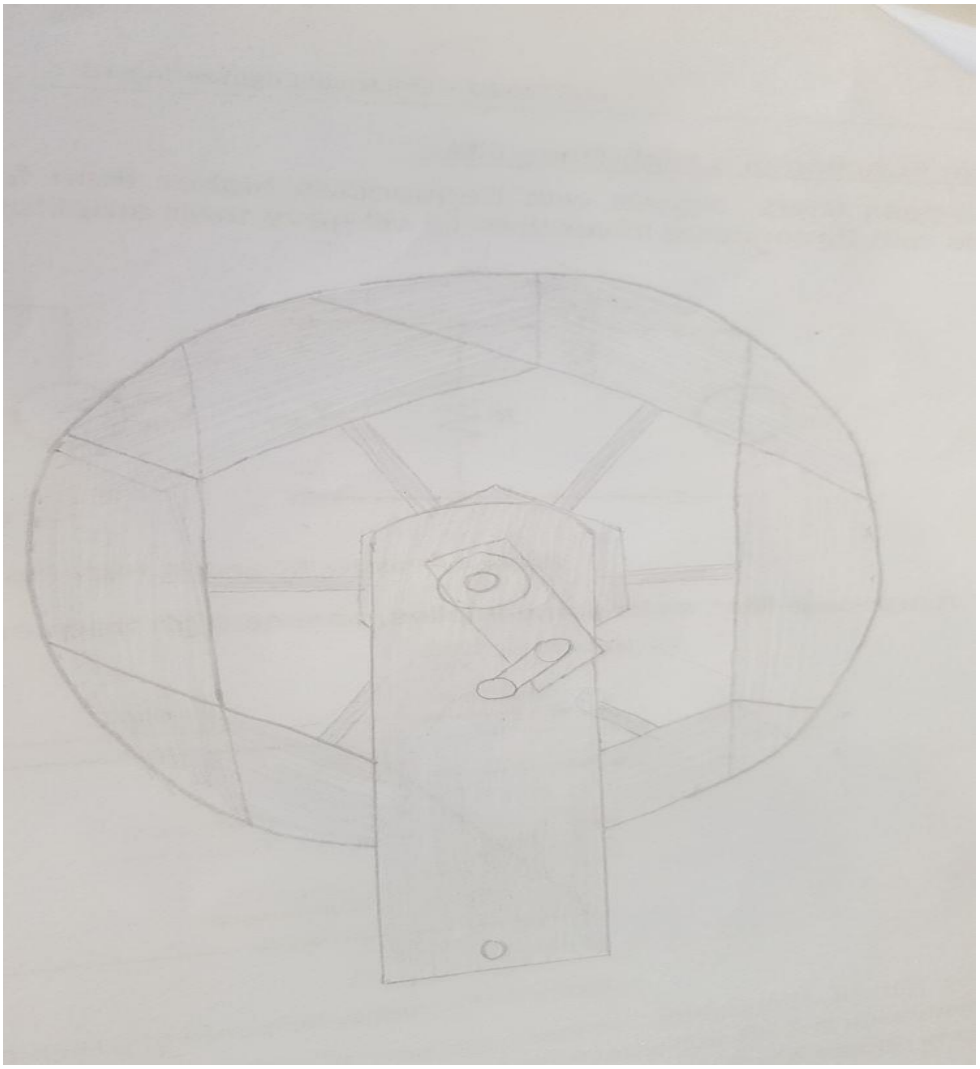


Figure 7: Cam Mechanism Sketch

CE 2.3.6

I performed the simulated the design on CAD after drawing it by hand. I understood that using a computer software would be helpful in not only getting the precise dimensions of the components but also would help us in understanding the loads and forces involved. The below images represent the CAD simulation I performed on SolidWorks software program. I have displayed the simulation done for each component separately.

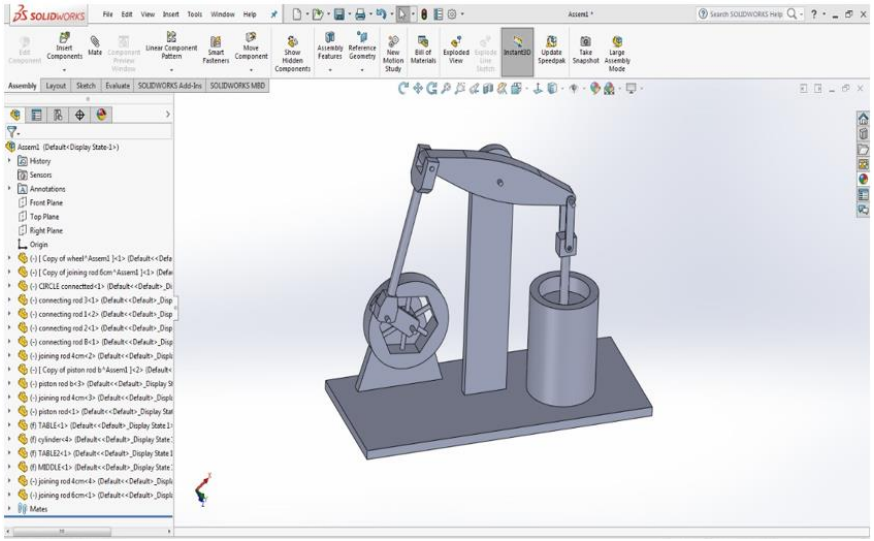


Figure 8: CAD Design (1)

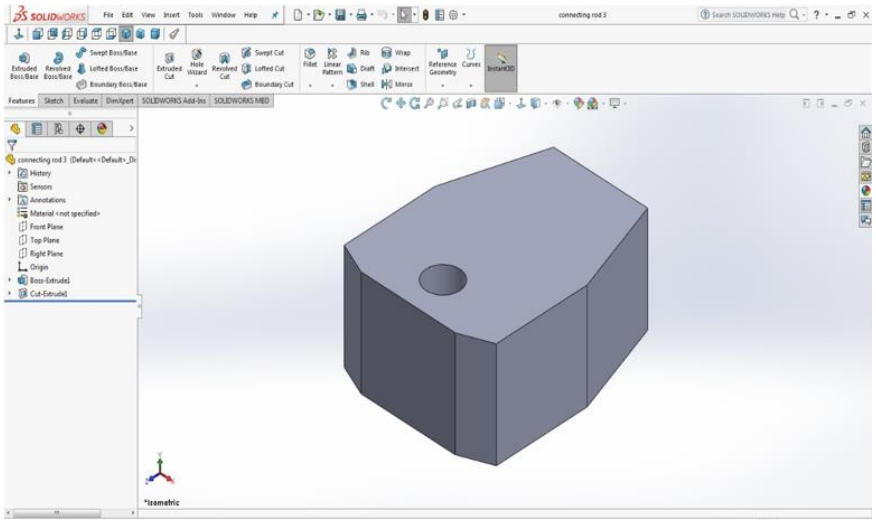


Figure 9: CAD Design (2)

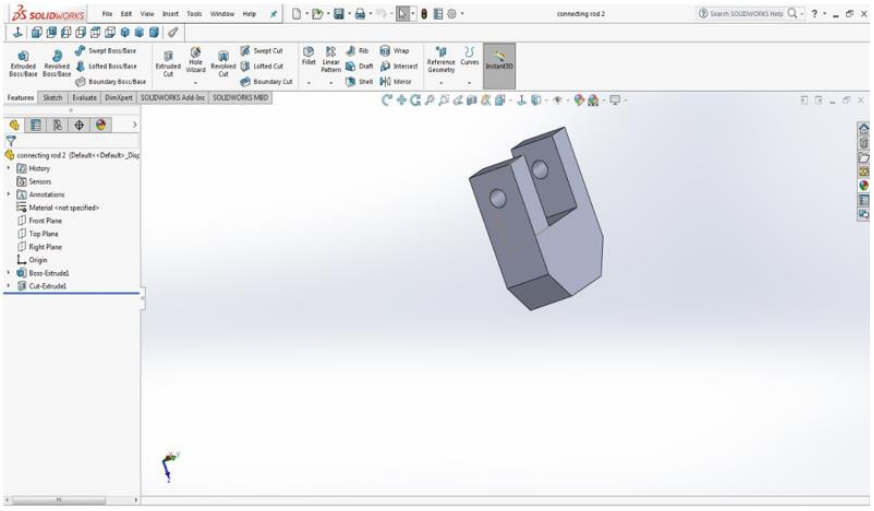


Figure 10: CAD Design (3)

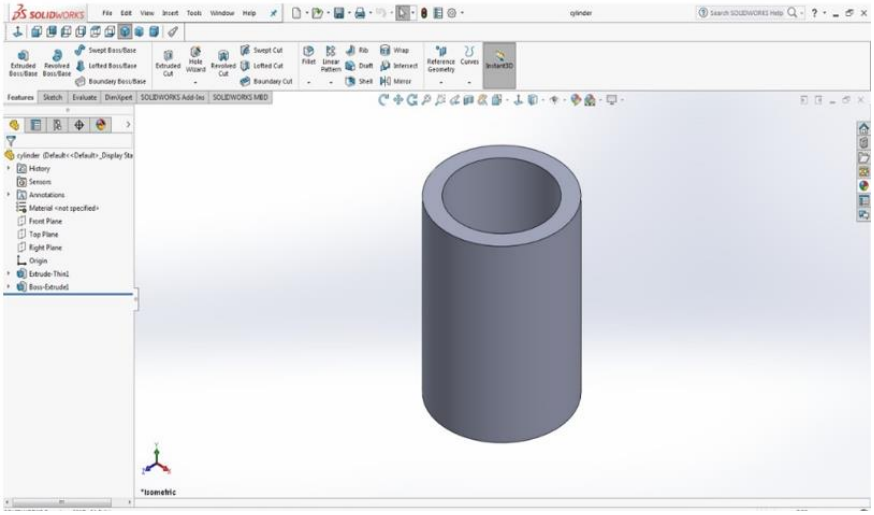


Figure 11: CAD Design (4)

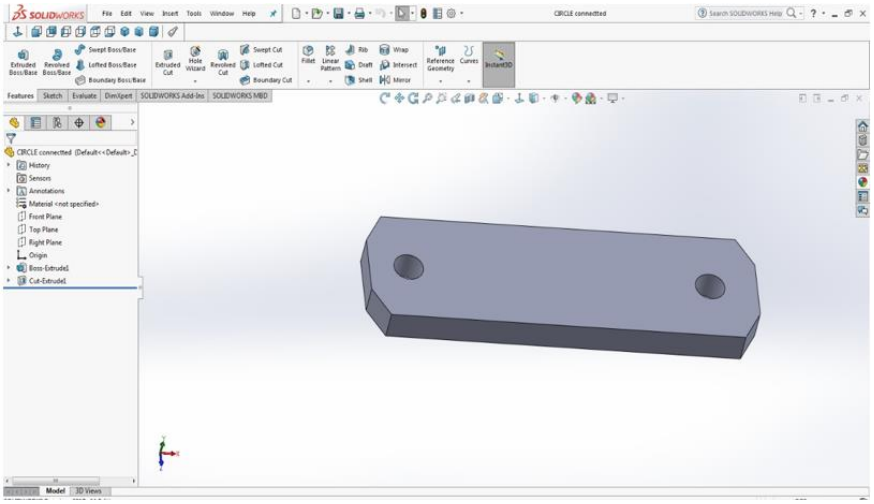


Figure 12: CAD Design (5)

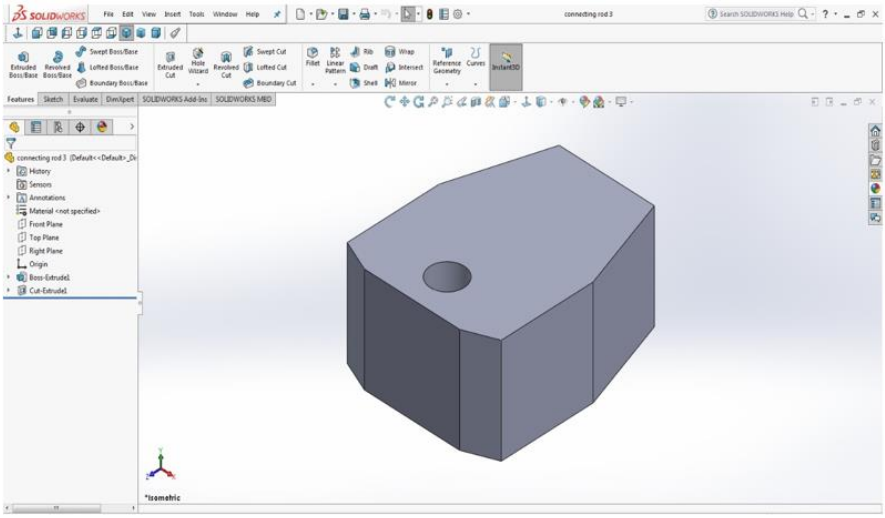


Figure 13: CAD Design (6)

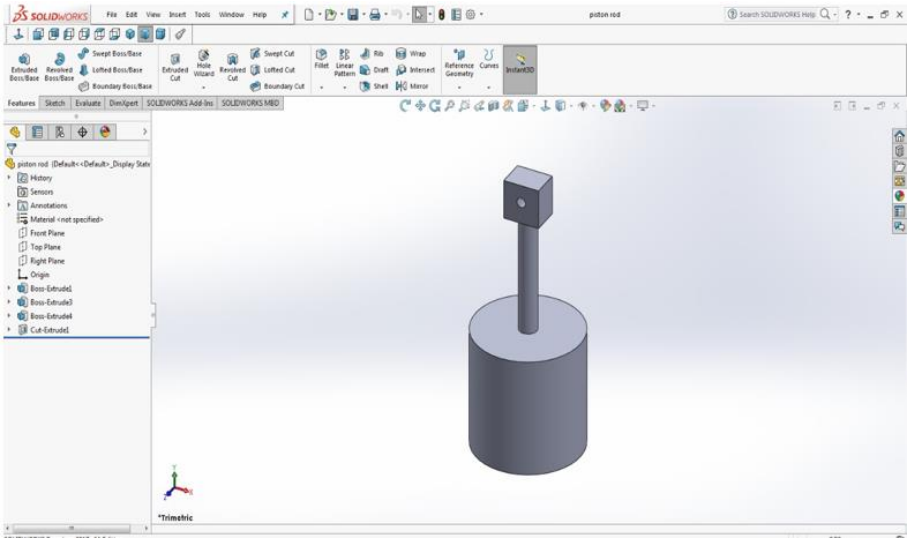


Figure 14: CAD Design (7)

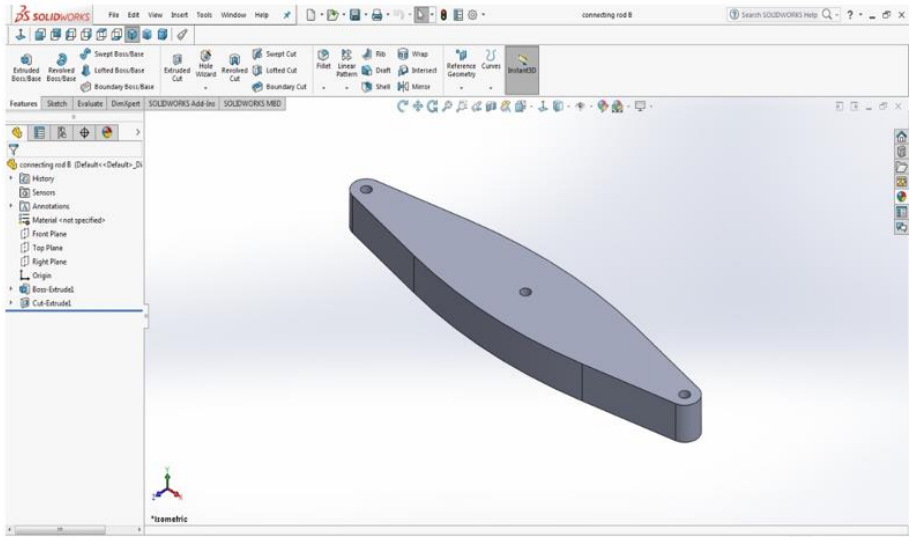


Figure 15: CAD Design (8)

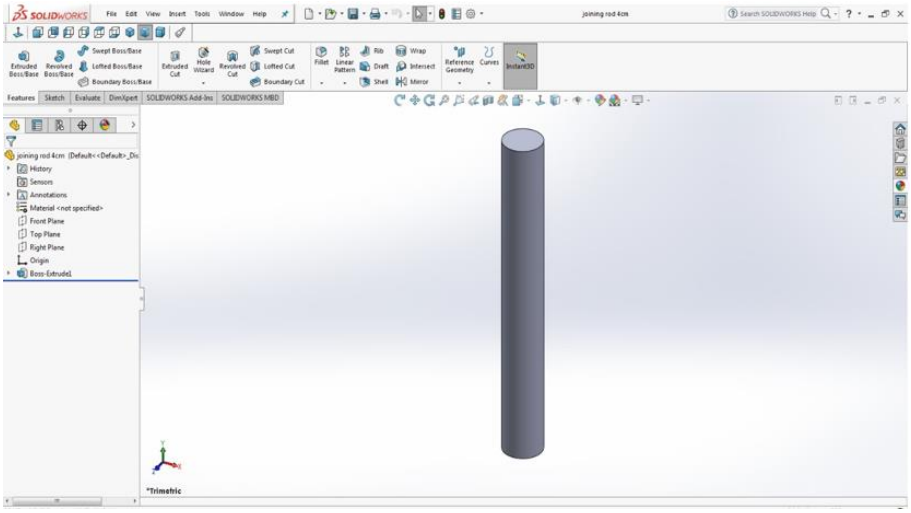


Figure 16: CAD Design (9)

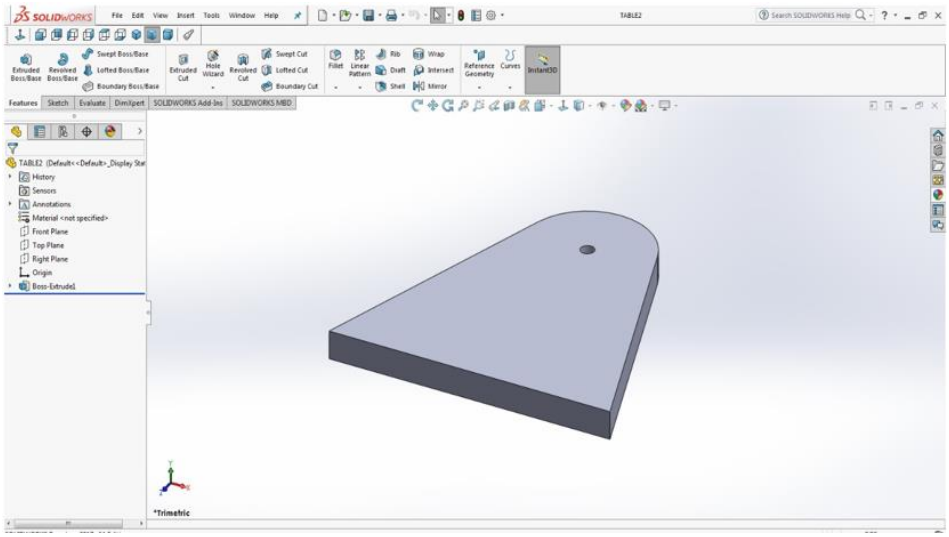


Figure 17: CAD Design (10)

I have displayed the design of the full model in the below images.

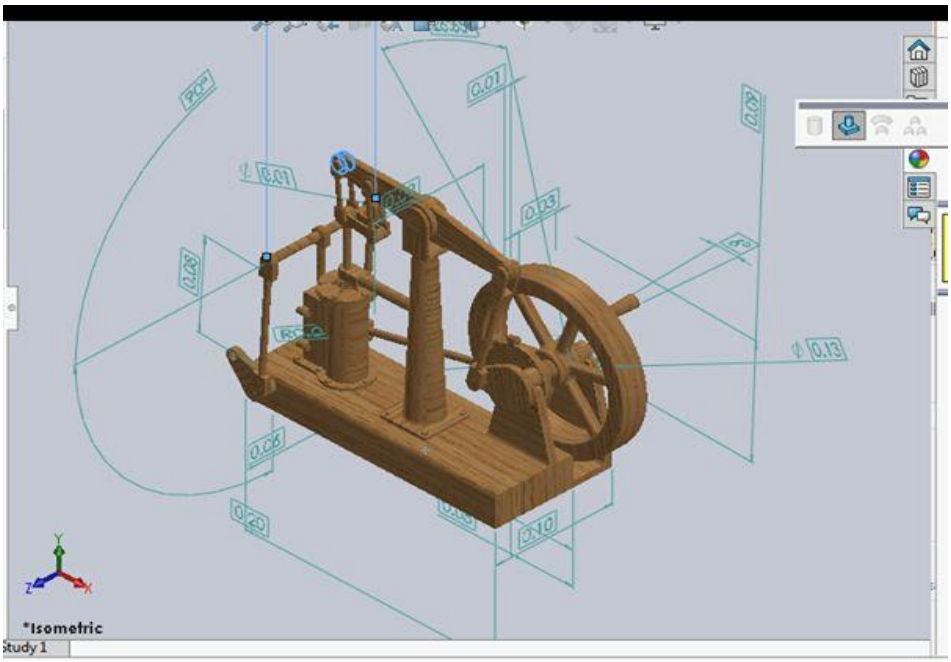


Figure 18: Full Model Rough Design (1)

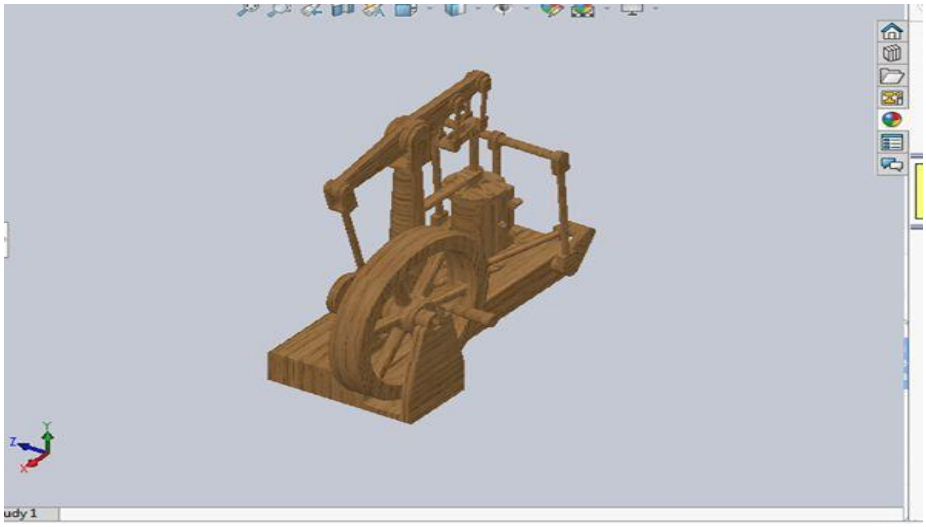


Figure 19: Full Model Rough Design (2)

CE 2.3.7

The machine that I designed was a combination of 3 mechanisms explained above in such a way that if the handle is rotated either by hand or a motor, as the wheel moved the cam mechanism came into play rotating the follower. As the follower rotated, since I had connected it with the 4-bar linkage from the top, and from the bottom I had connected it to the crank mechanism, which rotated the wheel which also helped in moving the 4-bar linkage system.

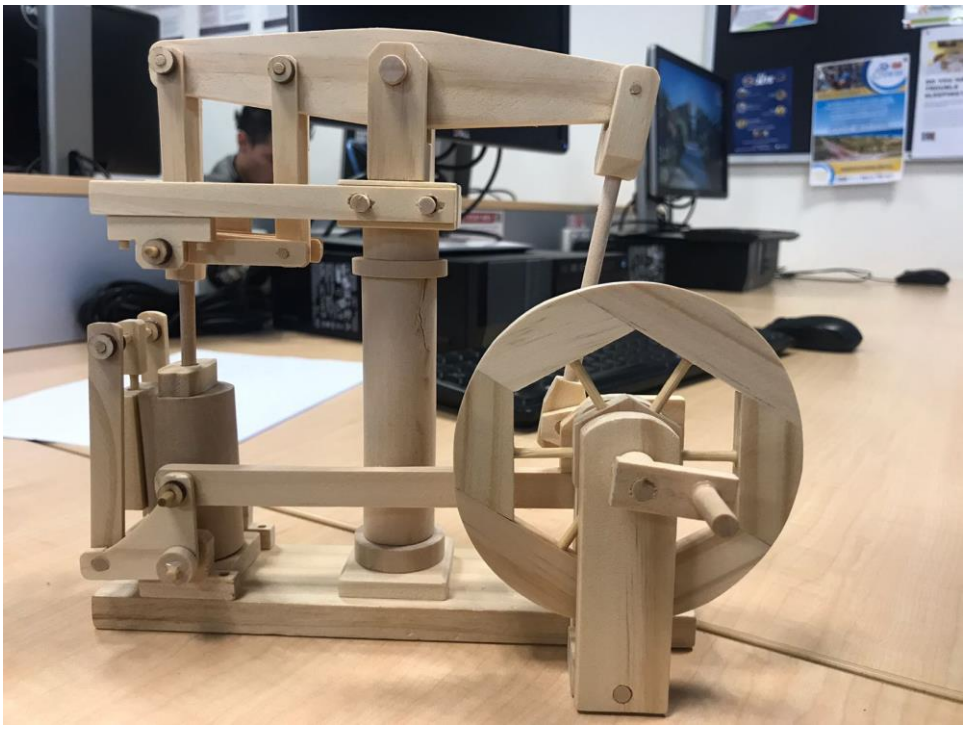


Figure 20: Full Model Design (1)

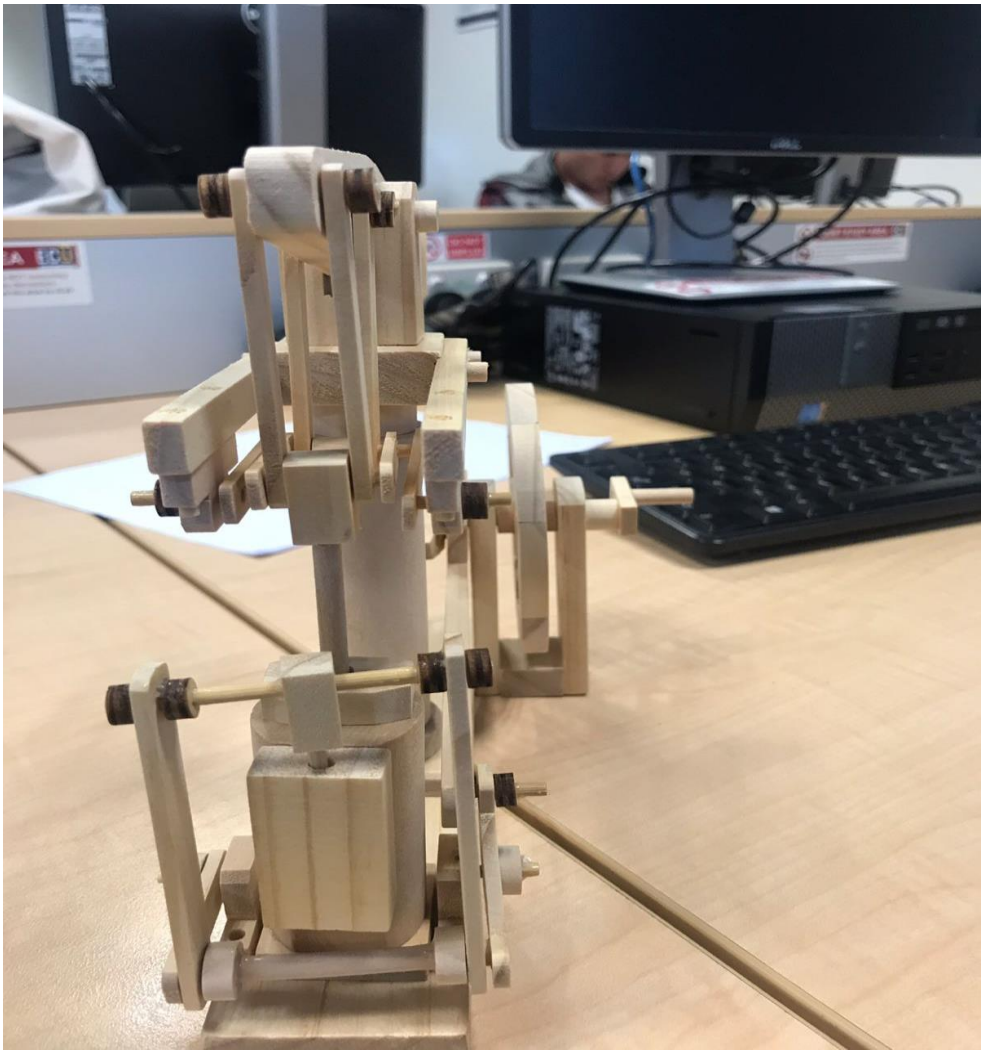
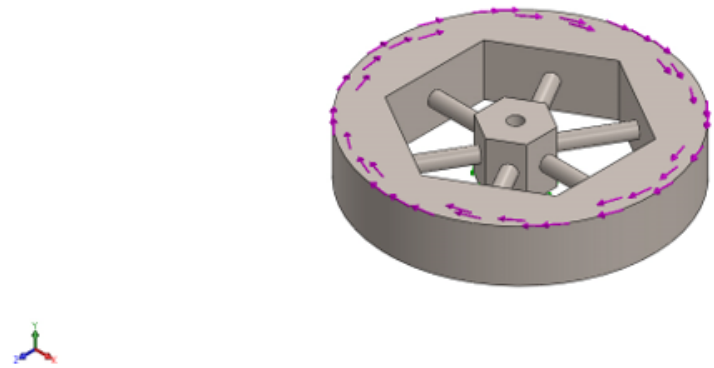


Figure 21: Full Model Design (2)

CE 2.3.8

I performed simulation of cam mechanism.



Model name: wheel
Current Configuration: Default

Solid Bodies

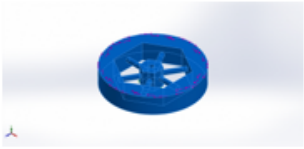
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude1 	Solid Body	Mass:0.661709 kg Volume:8.59362e-005 m^3 Density:7700 kg/m^3 Weight:6.48475 N	-

Figure 22: Cam Wheel Simulation

Following were the study properties.

Table 1: Study Properties Cam Simulation

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\Usman\Desktop\wheel)

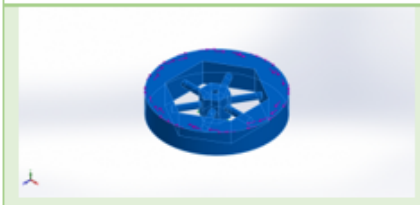
I also made a table to demonstrate the units.

Table 2: Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

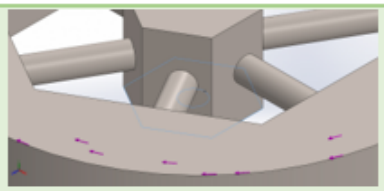
The following table demonstrated the material properties.

Table 3: Material Properties

Model Reference	Properties		Components
	Name:	**Alloy Steel**	SolidBody 1 (Cut-Extrude1) (wheel)
	Model type:	**Linear Elastic Isotropic**	
	Default failure criterion:	**Max von Mises Stress**	
	Yield strength:	**6.20422e+008 N/m^2**	
	Tensile strength:	**7.23826e+008 N/m^2**	
	Elastic modulus:	**2.1e+011 N/m^2**	
	Poisson's ratio:	**0.28**	
	Mass density:	**7700 kg/m^3**	
	Shear modulus:	**7.9e+010 N/m^2**	
	Thermal expansion coefficient:	**1.3e-005 /Kelvin**	
Curve Data: N/A			

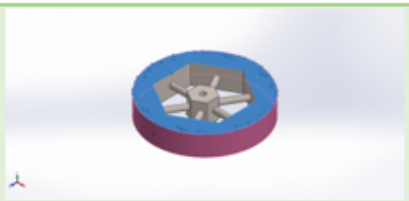
I performed detailed calculations of loads and forces involved using SolidWorks. In the following table I have displayed the important information regarding the loads and fixtures of this component.

Table 4: Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 1 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**0.00599289**	**0.0991808**	**0.035545**	**0.105528**
Reaction Moment (N.m)	**0**	**0**	**0**	**0**

Load name	Load Image	Load Details
Torque-1		**Entities:** 1 face(s) **Reference:** Face< 1 > **Type:** Apply torque **Value:** 60 N.m

I have demonstrated the mesh information in the following tables.

Table 5: Mesh Information Summary

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.220715 cm
Tolerance	0.0110357 cm
Mesh Quality Plot	High

Table 6: Mesh Information Details

Total Nodes	82911
Total Elements	55069
Maximum Aspect Ratio	3.9364
% of elements with Aspect Ratio < 3	99.9
% of elements with Aspect Ratio > 10	0
% of distorted elements (Jacobian)	0
Time to complete mesh (hh;mm;ss):	00:00:09
Computer name:	PC

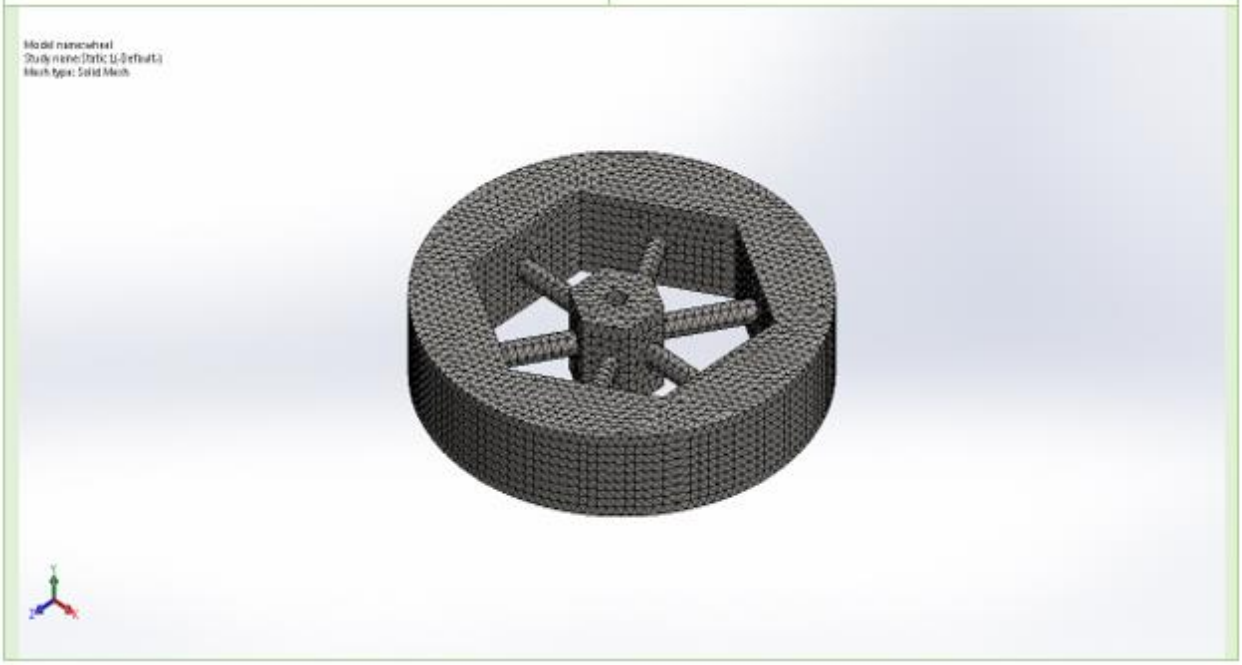


Table 7: Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	0.00599289	0.0991808	0.035545	0.105528

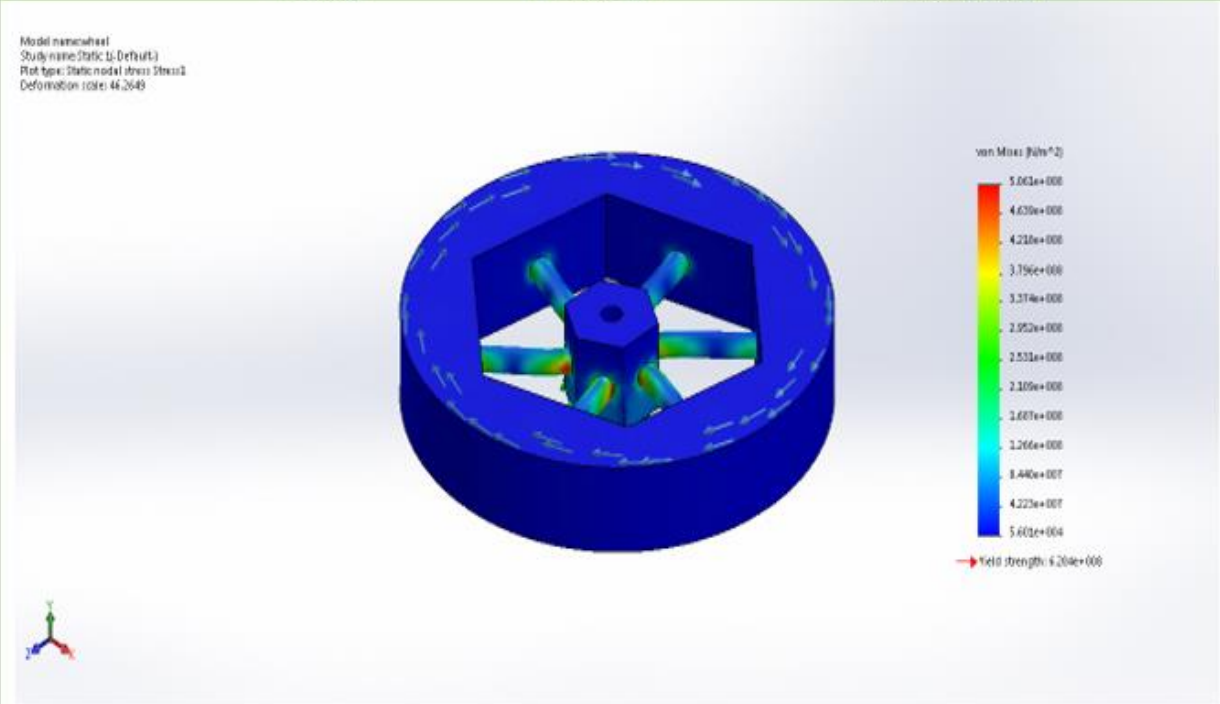
Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

I have demonstrated the study results in the below table.

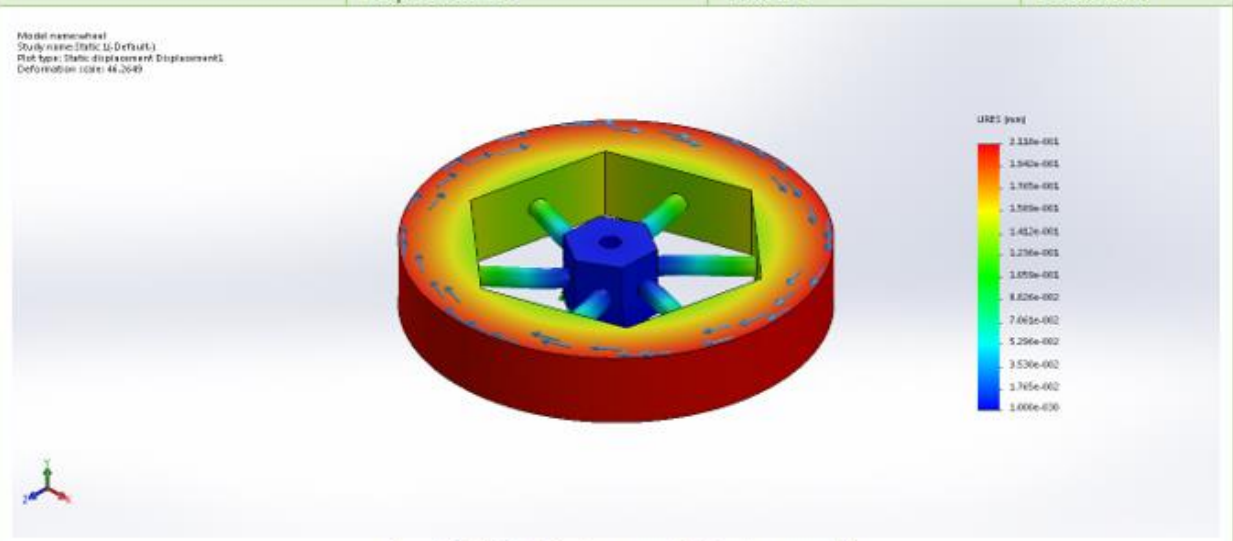
Table 8: Resultant Forces

Name	Type	Min	Max
Stress1	VON: von Mises Stress	5.601e+004N/m^2 Node: 984	5.061e+008N/m^2 Node: 81818



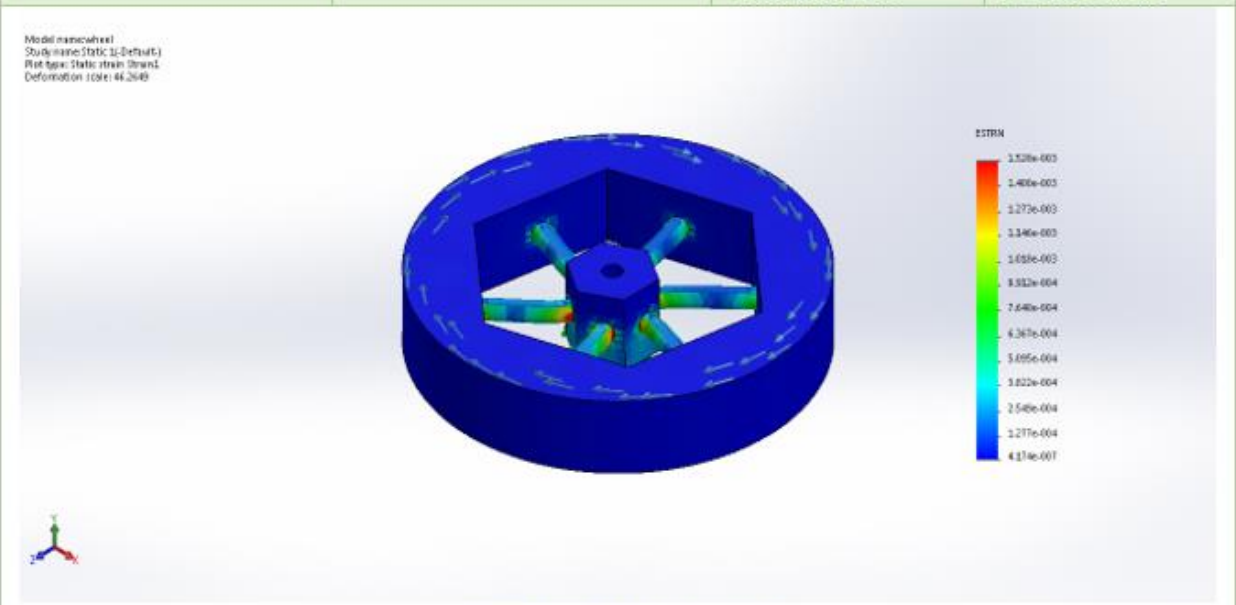
wheel-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+000mm Node: 1	2.118e-001mm Node: 891



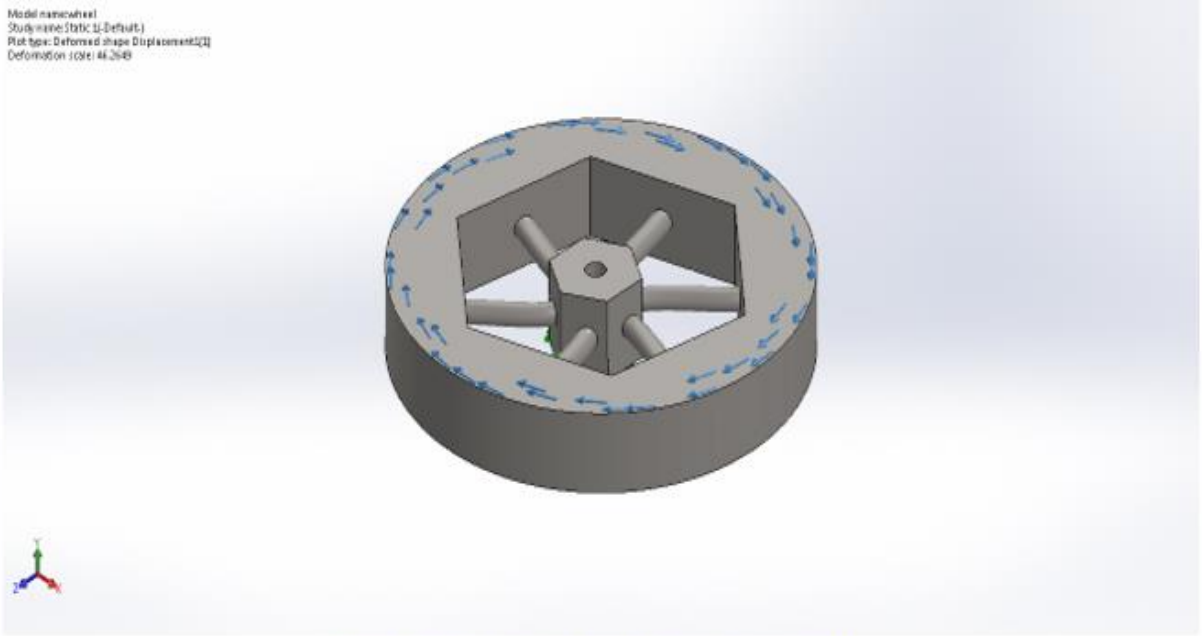
wheel-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	4.174e-007 Element: 14873	1.528e-003 Element: 9990



wheel-Static 1-Strain-Strain1

Name	Type
Displacement1{1}	Deformed shape



wheel-Static 1-Displacement-Displacement1{1}

Similarly, my team mates performed detailed simulation and study for connecting rod and piston rod.

CE 2.3.9

As the project came to an end when the full model design was complete, I then moved on to completing the other important project deliverable which was the project report. I referred to the notes taken during the project work, asked team mates for detail and also relied upon the research performed along with the SolidWorks simulations to complete the project report. I also included detailed drawings that I had initially made before doing CAD simulations in the project report. I ensured to cite all references from where I took information specially during the research phase of the project. I tried to make sure to give credit to anyone whose work I reused for this project.

CE 2.3.10

The project deliverables also involved presenting the project in front of the class. This was a very helpful activity as all class got to learn from all the projects performed. In any leaderless environment, I have noticed that leaders automatically emerge, and same was the case with this project. Each project activity required different skillset and therefore, the individual most comfortable with that activity stood up and took charge. I took lead in presenting the project as I also took lead in generating the project report. We had limited time so the main challenge was to summarize the project along with explaining the technicalities involved, and the steps followed to the audience. The questions at the end of the project were very thought provoking as the fellow students asked why we preferred one mechanism over the other. I took charge in answering the questions of the audience and I explained to them the methodology we followed to reach to the final product design. The lecturer appreciated our project work and told us that he was very much satisfied with our progress and learning.

Summary

CE 2.4.1

The aim of this project was to use 3 mechanisms in automata design. The team paid special attention in order to find a best suitable design for the automata by using 3 mechanisms, to the most affordable way of meeting project objectives. In team meetings, we used to have a detailed discussion on what kind of design should we go for. After careful consideration, research and also discussing it with the Lecturer, we finally reached to the conclusion of making a beam engine. I already knew that a beam engine uses 3 mechanisms so it did fulfil the requirements of the project, and we realized that we could make it in a cost-effective manner. It was a very helpful product designed in the past for pumping water from mines and then also used as a steam engine. The 3 mechanisms involved, I had already worked on during my lab sessions and this became the basis of my comfort with the design.

CE 2.4.2

This project was a challenge given by our unit Lecturer. This project not only enhanced my knowledge buy also provided me with an opportunity to work in a team environment involving a diverse set of individuals. The team comprised of 3 members. At the beginning we did face some problems related to coordination. It felt that we might not be able to work together at all. However, with time the communication became smoother and by the end of the project we were all good friends. Now that I look back, it does not even feel like there was any sort of problem at all. I am glad that we were able to sort out any differences that we had without involving a third party. This project enhanced my ability to work in a team and enhanced my communication skills as well. My overall experienced of working on this project was very good.