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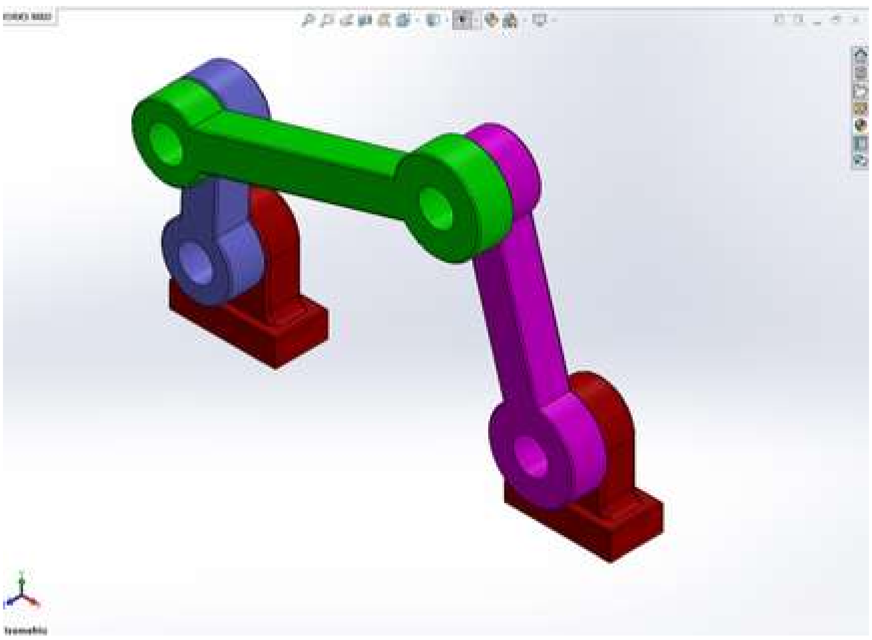
ME360 - Project 4: Four Bar Mechanism

Motion Analysis is a powerful tool that can be used for a variety of purposes. Namely, it can be used to study the mechanisms of an assembly without having to create a physical prototype. Up to this point in my career, I have only used CAD software to model parts and have just recently been introduced to the full utility of what the software has to offer. This included using Motion Analysis to study parts in order to see how they will perform. In a prior project, I was shown how FEA in CAD software can be used to study properties of a part, how parts interact with each other, and how to have CAD software optimize a design. The last utility of CAD is performing motion analyses that can be used to study how parts in motion work and interact with each other. And to do this, I studied a very common mechanism, the Four Bar Mechanism.



A color-coded assembly of the four bar mechanism

Project Goals: The goal of this project is to assembly a Four Bar Mechanism with provided parts and perform a motion study on it in order to observe how the parts interact with each other. This includes obtaining quantitative data on metrics such as torque, power, and reaction forces.

Learning objectives: The skills used to complete this project are related to how to use CAD software to its fullest potential. This includes:

- Using a CAD software (in this case Solidworks) to assemble parts
- Designing a motion study to see how parts interact
- ler to obtain quantitative data

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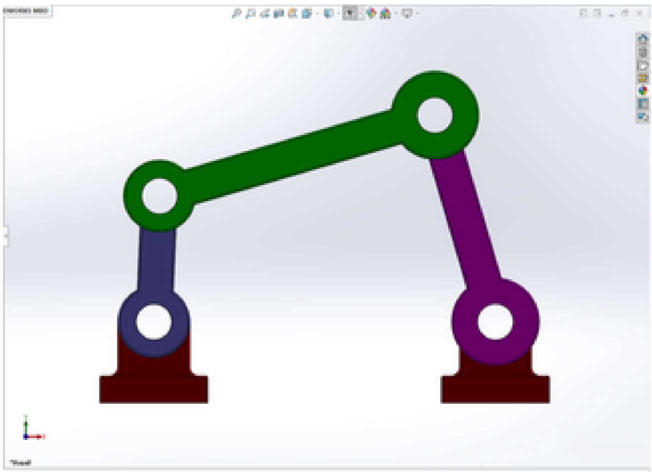
The Assembly

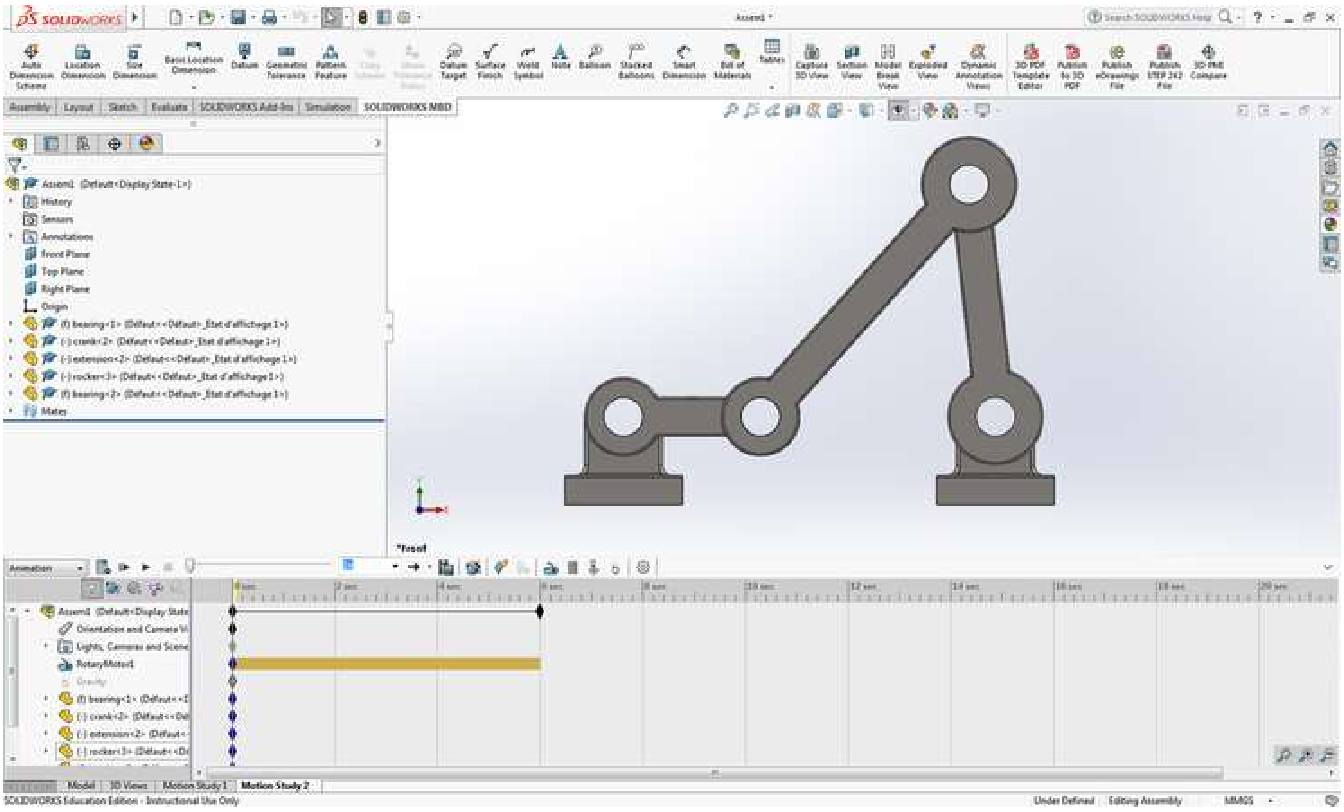
The assembly of the mechanism, contrary to the name, consists of two bearings and three bars. The two bearings. which are fixed, can be replaced with one fixed bar while not affecting the function of the mechanism, thus the name "four bar". The main parts of the assembly are as follows in relation to the image shown to the right:

- Bearing 1: Red part on the left *fixed*
- Bearing 2: Red part on the right *fixed*
- Crank: Blue part
- Extension: Green part
- Rocker: Magenta Part



The Motion Study

Once the parts were fully assembled and all mates (connections) were made, the motion study could be created. First, an analysis was done on the assembly in order to check the degrees of freedom the assembly had. Because this was a mechanism, it should have exactly one degree of freedom. If this was not true, the mates had to be edited in order to get rid of any redundancies, which was the case with me. Once this was done, at it was verified that the degrees of freedom were one, the assembly was set to an initial position. A motor was added to the assembly such that it was situated on the join between the crank and bearing one; this allowed for the crank to turn. The motor was set to 20 rpm and the operation time was set to 6 seconds. The analysis was run and the motion study was performed.



The set up motion study with the initial position on display.

Four Bar Motion Isometric

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Four Bar Motion Front

Analysis
A motion study can be used to gather data on a variety of metrics. By hand, performing a motion analysis can be difficult and tedious as a complex set of algebraic equations paired with classical physics equations is not easy to handle. However, a computer can do these calculations almost instantly in order to compute data on targeted metrics. One such metrics is the movement of a singular point on the assembly. Data was gathered on the motion of the midpoint of the extension as it moved during the simulation. This data was plotted:

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This was not the only data that was gathered. Data could be gathered from the performance of the motor. This included the torque provided by the motor. In order to do this, gravity was added to the motion study and the materials of all the individual parts were defined. When compared to the time and angle of the crank, the instances of max torque could be determined.

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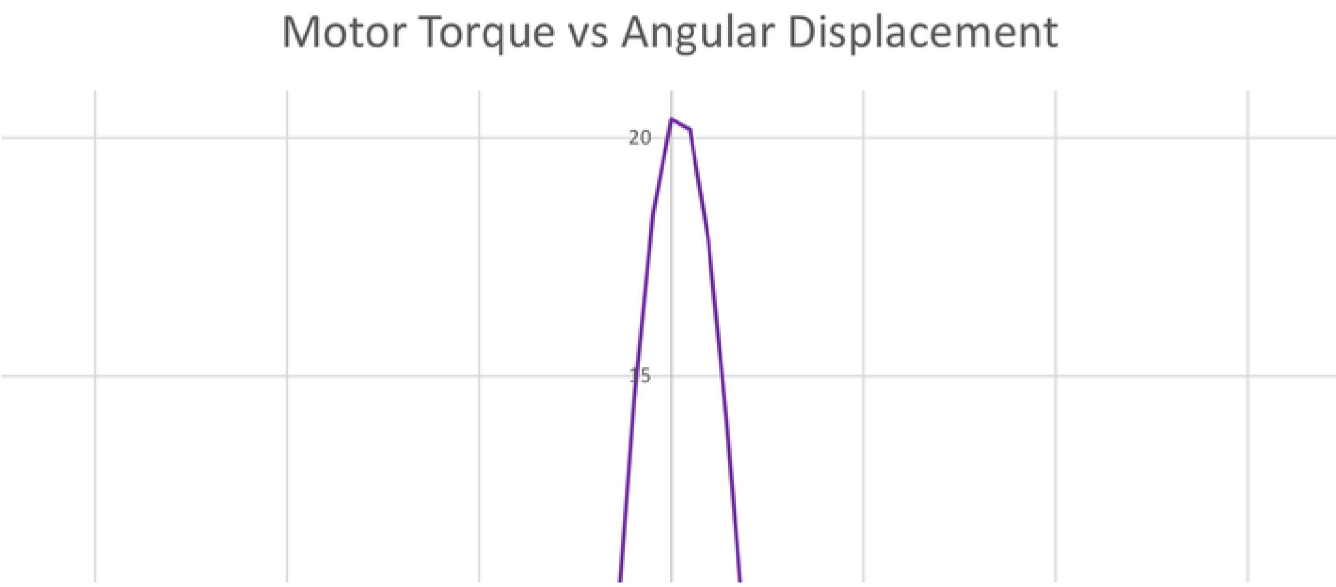

From this data, it is easy to see that the maximum torque is about 20.4 N which occurs periodically when the crank is at its initial position, 0 degrees. While this dataset does not show this, negative motor torques are possible. This would occur if the motor turned in the opposite direction, and thus the crank would spin in the opposite direction. With the motor providing a torque, the fixed points of the assembly undergo reaction forces. Again, a motion study analysis can be used to determine what those forces are at each instance of time.

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um vertical forces on the bearings 1 and 2 are 0.35 N and 0.17 N

ing if the assembly can withstand such forces caused by its motion. And

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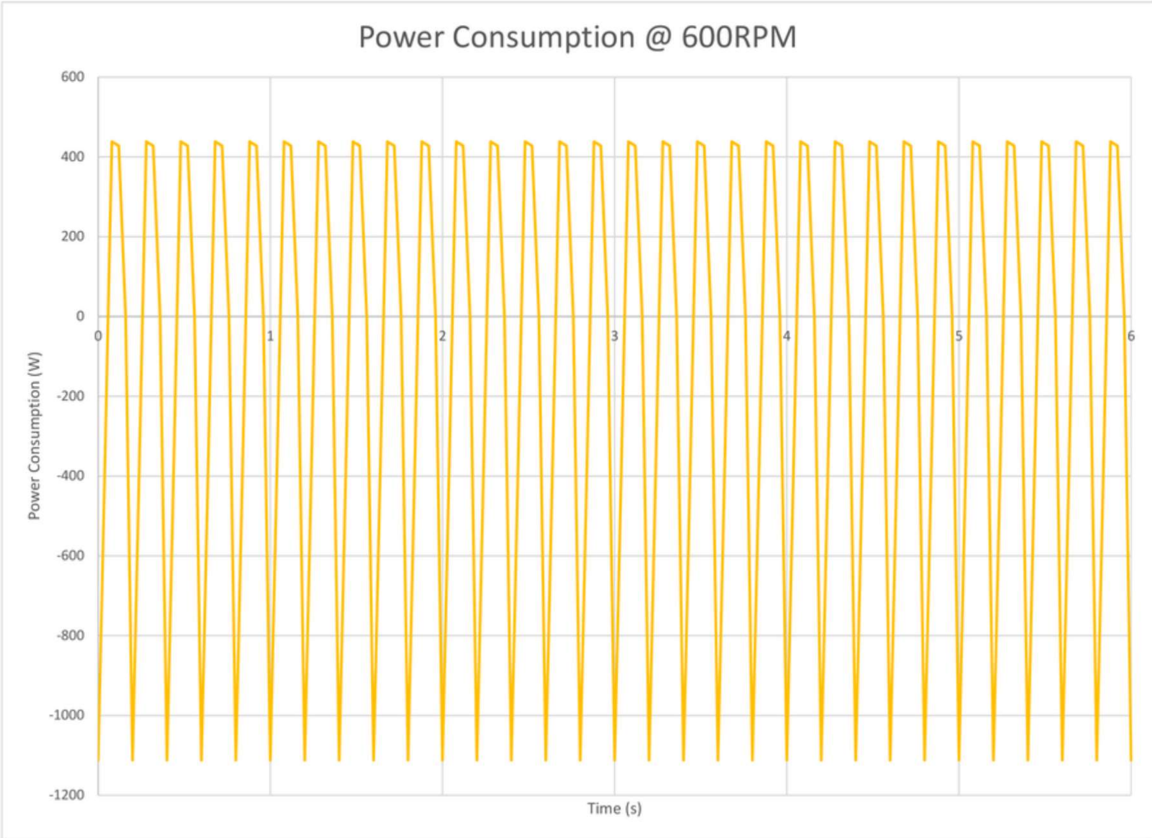

According to this data, the minimum power required to move the crank at a constant speed given the 600 RPM motor speed is about 438 W.

Take-Aways

Motion studies are powerful tools. The greatest utility of these studies allow a designer the ability to create and assembly and test it without having to spend the time and resources on creating a prototype. Meaningful data can be derived and used to determine the performance of a mechanism. This is very useful because it allows for changes to be made easily to a design since different aspects of that design can be tested and troubleshooted before moving onto building a physical object. This is something I plan on implementing when it comes to designing mechanisms in the future.

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