MECH 542: CAD/CAM Principles and Practice

# Project #1 : PART A – Linkage Model Siemens NX

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**Submitted: February 3th, 2023**

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# Section 1 : Introduction

Design intent is commonly understood as the expected behaviour of a CAD model when altered. Feature-based parametric CAD is a popular 3D modelling technology that is widely being used in industry. Adding geometric features via parent/child relationships results in an interconnected structure. Parent/child dependencies can also be the source of numerous regeneration issues, forcing designers to completely rebuild the CAD model, which wastes time and money. The focus was to identify the purpose of the design and the justifications for the specific decisions made when generating a 3D CAD model. Even though, the concepts of design rational and design intent are subjective to understanding the future needs and requirements, I have tried to document the reasons for my design approach and explained the reasons behind that decision made.

The complete design was carried out using Siemens NX software tool. The given design/linkage model was studied and I tried to identify the design intent and if it has any historical connection to the design rational. Finally, I decided to incorporate few tings like defining expressions for the variables, choosing the plane from which the first sketch will be made, capturing and transferring all critical dimensions provided into Siemens NX, ensuring the appropriate representations were followed like sketch constraints, modelling operations and relationship between modelling operations.

# Section 2 : Development

## 2.1 Dimensions Provided

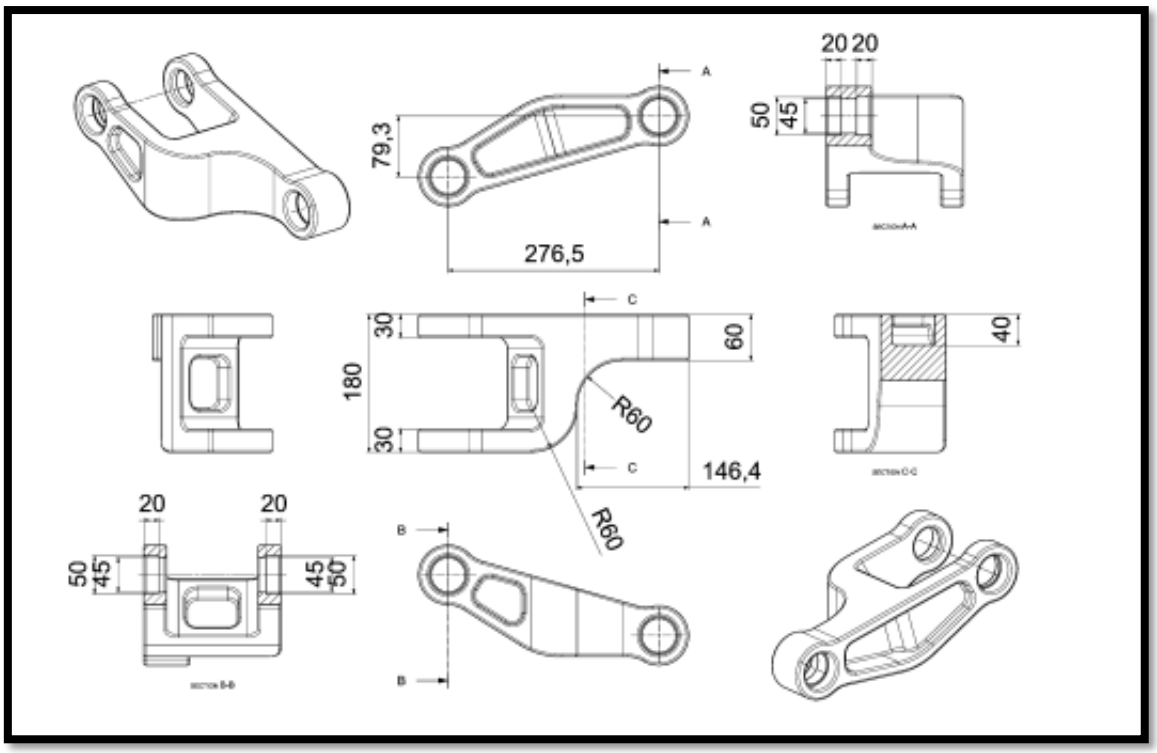


*Figure 1: This shows the dimensions of the linkage model with critical dimensions*

## 2.2 Design Intent

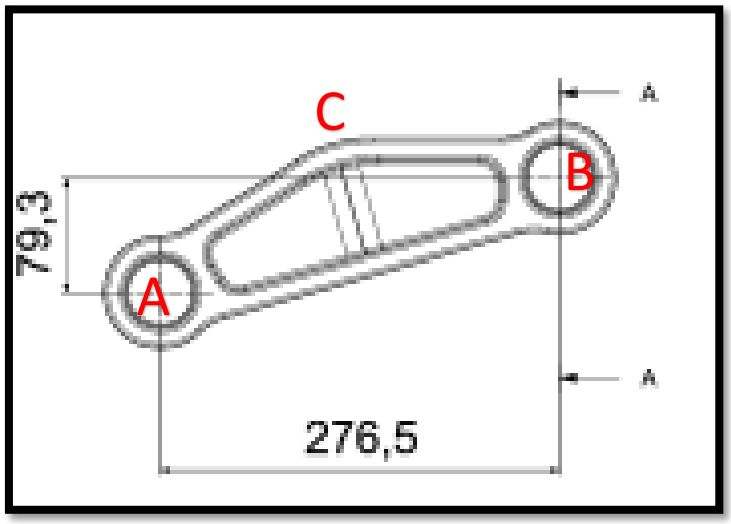


*Figure 2: The first sketch was based on the shown figure and design intent was defined.*

The following decisions were made before beginning with part sketching and modelling.

- The origin is at the centre of point A
- The part will be developed by making and extruding the sketch as shown in Figure 2, this will be the base block.

- The inclination between two points A and B will be maintained as seen in the above figure. This will ensure the top-down extrude cut (top surface of point C) which needs to be performed will become easier as we don't have to create a angled plane.
- The holes at A and B are through holes and symmetrical.
- There is another set of holes on the opposite side of point A, which will be symmetric and concentric to ensure the holes are through holes.

## 2.3 Possible Future Changes

A model's response to future design changes is very important and if we cannot anticipate the changes during the design stage, the finalised model becomes unusable. CAD models must be easy to change so that design alterations in the product development cycle are accomplished quickly. By general convention I found that that using simpler features increases the time required to model the original artifact, but increases the reuse of the model in future modifications. Also, usage of reference datum, features in a correct sequence increases model understanding when a secondary user needs to make any alterations. I have listed below few of the things which I consider to be possible for next iterative design.

- Change in the diameter of the through holes
- Change in the overall width of the linkage part to accommodate for larger components to be inserted between the holes.
- Changes in the length of the linkage between holes at point A and B (Fig2) .
- Change in the diameter of inner hole, where the linkages will be mounted.
- Change in outer dimensions of linkage part corresponding to fillets and chamfers that may be changed to reduce weight and overall outlook.
- Change in the inclination of the linkage after simulating it for stress, tensile, fatigue.

## 2.4 Overview of Steps Followed

After analysing the template provided several of the parameters were missing and were to be assumed to look like the end part. Considering this in mind, these were the steps followed:

- Several dimensions were estimated for their values and sketches to be constrained.
- Since certain parameters were missing, I felt it is important to unconstraint the sketches so that they can be modified in the later steps if any changes had to be implemented/ forgotten to be implemented.
- Basic feature commands like extrude, extrude cut, cylinder holes and edge blend features were extensively used.
- My intention was to minimise the operations required to obtain the end model as much as possible as outlined before.

# Section 3 : Modelling

## 3.1 Representation of Operations

The goal was to minimise the number of operations and sketches required to reach the final model without compromising on the design intent and ensuring all future edits were possible based on the selection made for the extrude and cut operations.

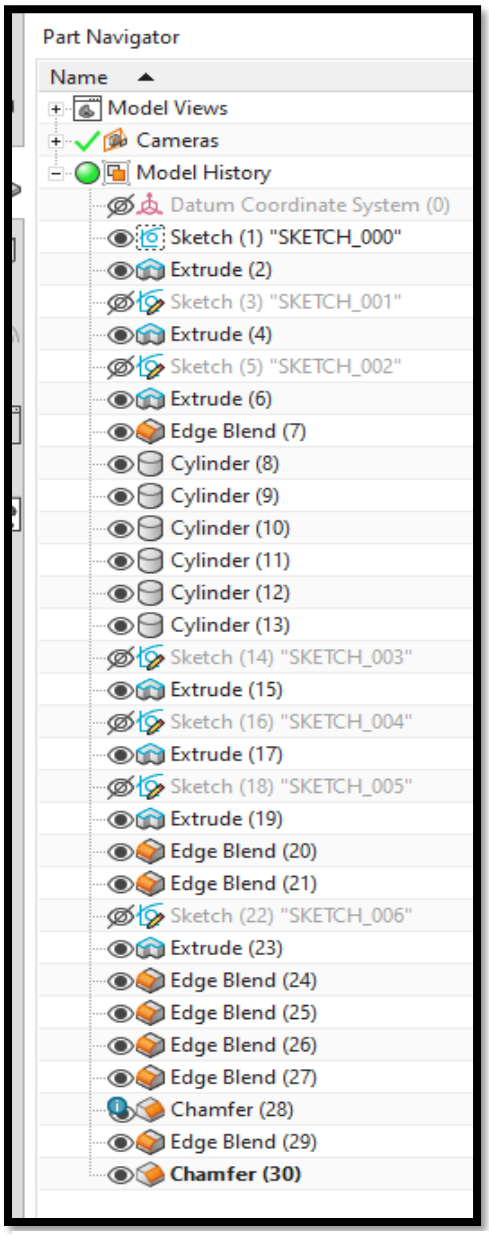


*Figure 3: Feature tree showing operations performed*

## 3.2 Sketch Constraints

All sketched made were **fully constrained** to ensure there wont be any unwanted relations between lines, circles and other segments. **Comments** were added wherever necessary for the dimensions to be easily able to edit them in the later stage.

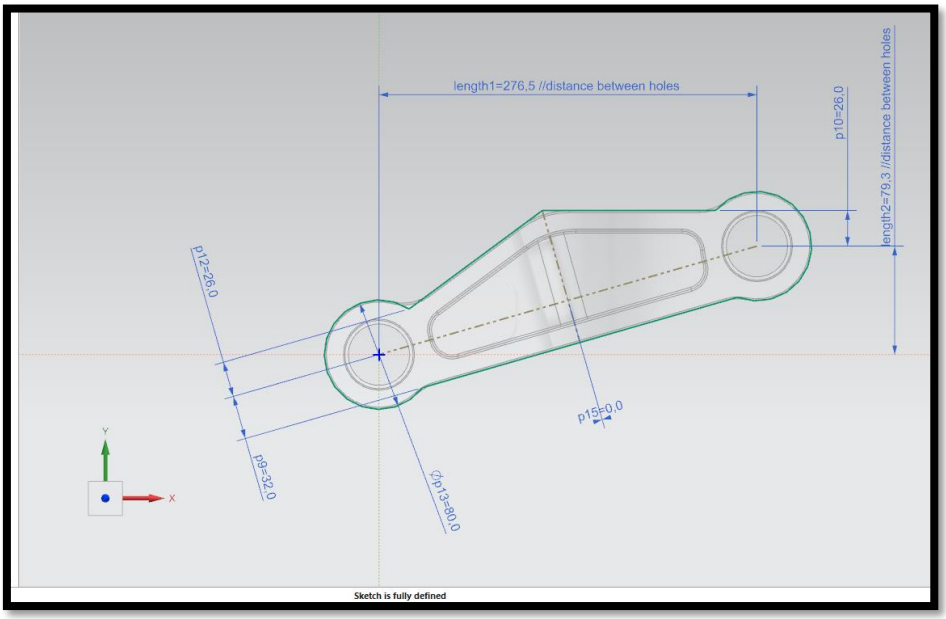


*Figure 4: Sketch 1 showing that it's fully constrained along with comments for certain dimensions*

## 3.3 Expressions Used

Expressions feature in Siemens NX was used to annotate the dimensions with comments whichever were deemed important to be edited in a later stage. By changing the formula or by further understanding the future requirements of the model development, specific formulas may be created to dynamically change values when specific diameter/length are varied.

| | Name | Formula | Type | Source | Status | Comment |
|---|---|---|---|---|---|---|
| 1 | | | Number | | | |
| 2 | depth1 | 40 | Number | (Extrude(17) End... | | pocket depthlength7 |
| 3 | diameter1 | 45 | Number | (Cylinder(8) Diam... | | hole diameter 45 |
| 4 | diameter2 | 50 | Number | (Cylinder(9) Diam... | | hole diameter 50 |
| 5 | diameter3 | 50 | Number | (Cylinder(10) Dia... | | hole diameter 50 |
| 6 | diameter4 | 45 | Number | (Cylinder(11) Dia... | | hole diameter 45 |
| 7 | diameter5 | 50 | Number | (Cylinder(12) Dia... | | hole diameter 50 |
| 8 | diameter6 | 50 | Number | (Cylinder(13) Dia... | | hole diameter 50 |
| 9 | ledge1 | 146.4 | Number | (SKETCH_001:Sk... | | ledge dimension |
| 10 | ledge2 | 60 | Number | (SKETCH_001:Sk... | | ledge dimension |
| 11 | length1 | 276.5 | Number | (SKETCH_000:Sk... | | distance between holes |
| 12 | length2 | 79.3 | Number | (SKETCH_000:Sk... | | distance between holes |
| 13 | length3 | 20 | Number | (Cylinder(9) Heig... | | hole length 50 |
| 14 | length4 | 20 | Number | (Cylinder(10) Hei... | | hole length 50 |
| 15 | length5 | 20 | Number | (Cylinder(12) Hei... | | hole length 50 |
| 16 | length6 | 20 | Number | (Cylinder(13) Hei... | | hole length 50 |
| 17 | p3 | 0 | Number | (SKETCH_000:Sk... | | |
| 18 | p4 | 0 | Number | (SKETCH_000:Sk... | | |
| 19 | p5 | 0 | Number | (SKETCH_000:Sk... | | |
| 20 | p9 | 32 | Number | (SKETCH_000:Sk... | | |
| 21 | p10 | 26 | Number | (SKETCH_000:Sk... | | |

*Figure 5: Expressions block defined in Siemens NX*

## 3.4 Operations Performed

The sketch was defined in the YX-Plane and the sketch was made at an angle, this step ensured that when I had to do a top-down extrude cut, I did not have to create a separate angled plane. Since, the sketch was already at an angle, the cut was easily performed. By changing the horizontal inclination of the sketch shown below, the top extrude cut angle can be modified.

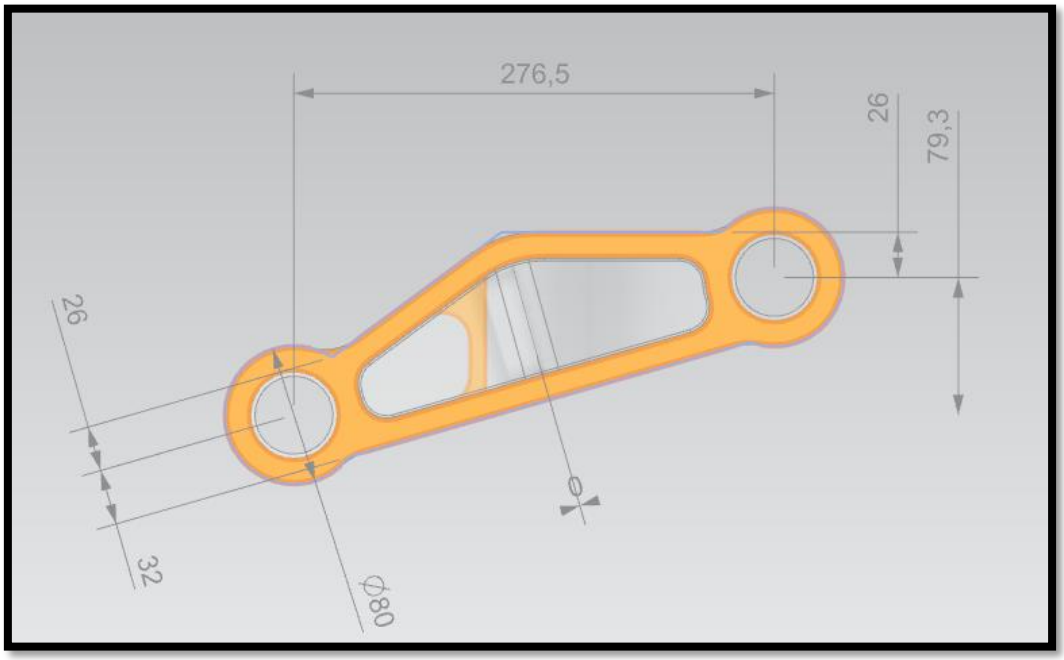


*Figure 6: Sketch before part was extruded, this was the first step of the linkage modelling*

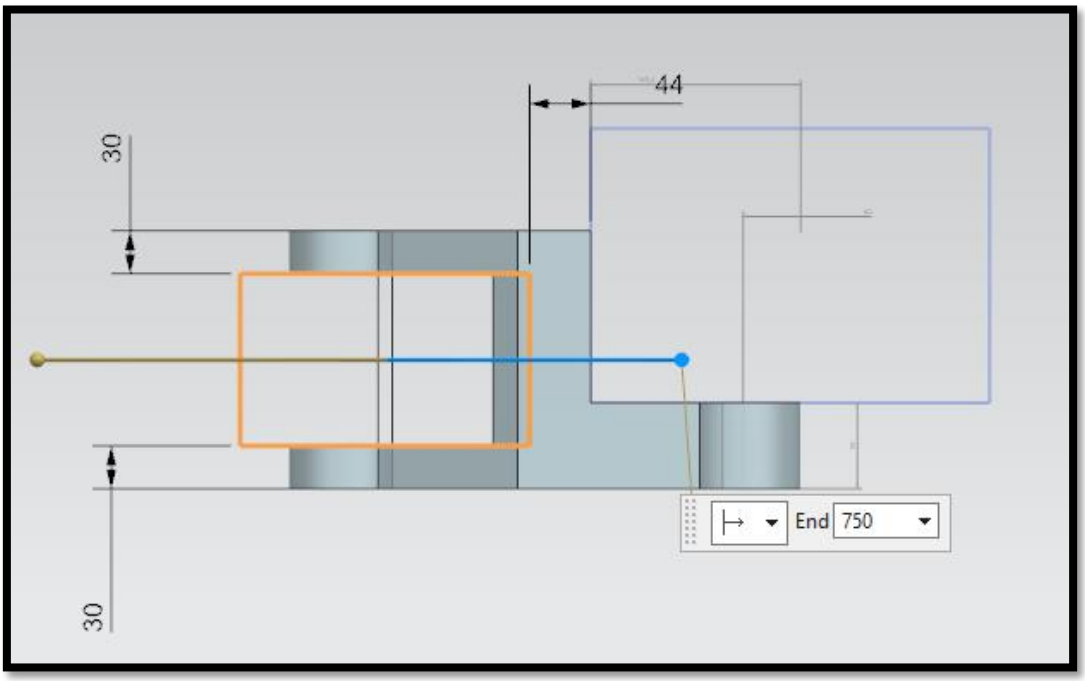


*Figure 7: Sketches from the top view are highlighted and after which extrude cut was performed separately for the sketches shown*

The pocket along the left and right side of the linkage were created by sketching on the side plane of the model. The highlighted part below shows the dimensions of the pocket. The pocket was split into two operations as they were of varying depth, this ensured any future changes are easily implemented.

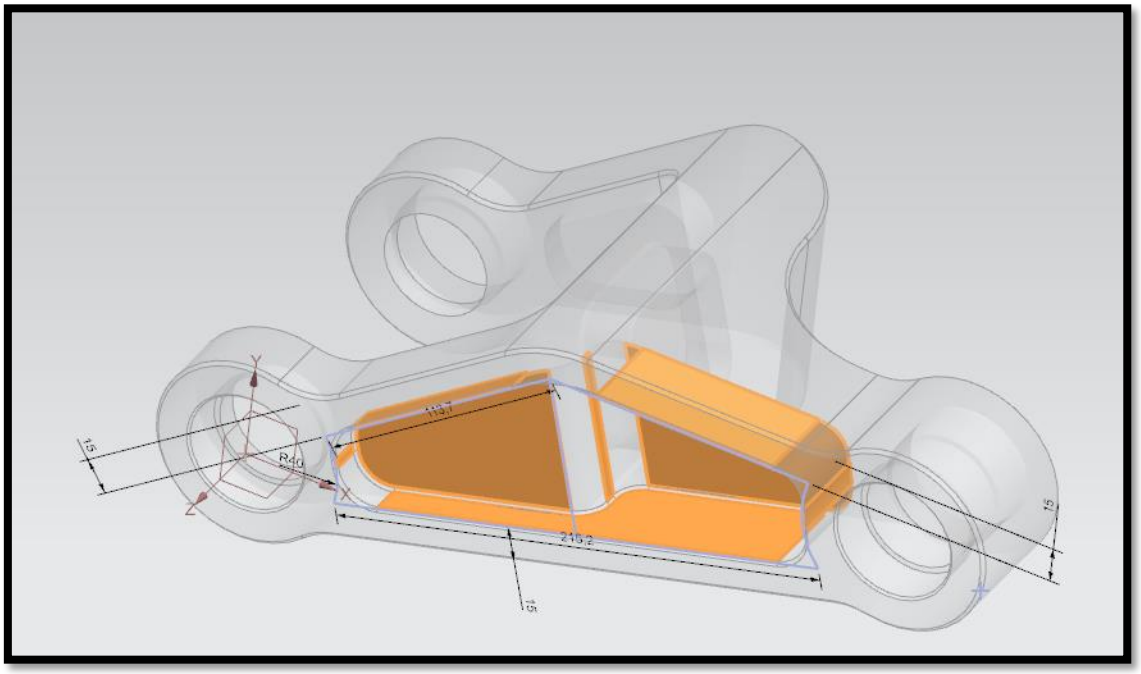


*Figure 8: Side pocket creation using two sketches and two extrude cut operation performed*

The pocket on the inner part of linkage between the two arms is generated below.

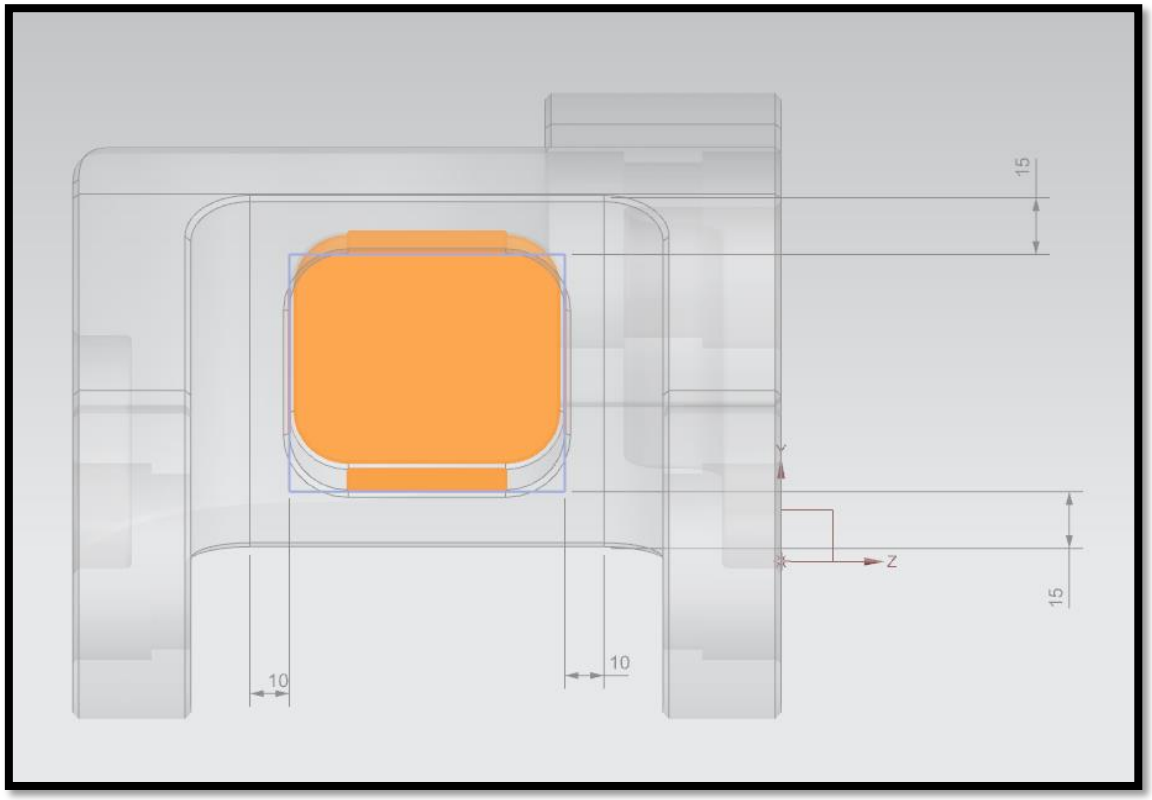


*Figure 9: Pocket creation between the two arms of the linkage*

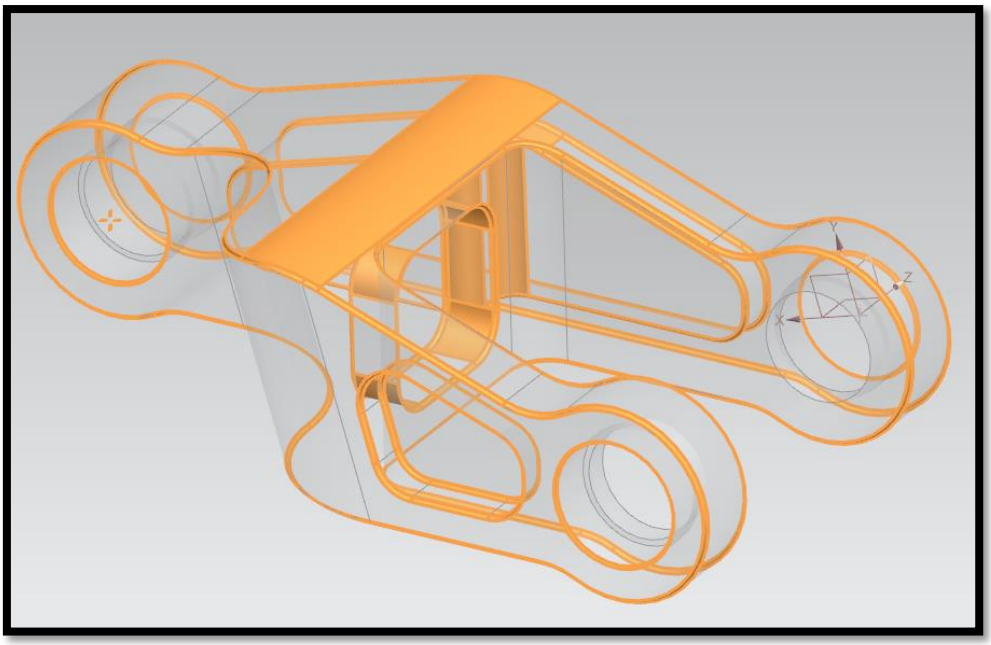

*Figure 10: Final edge blend and chamfer operations performed as per design*

## 3.5 Final Model View

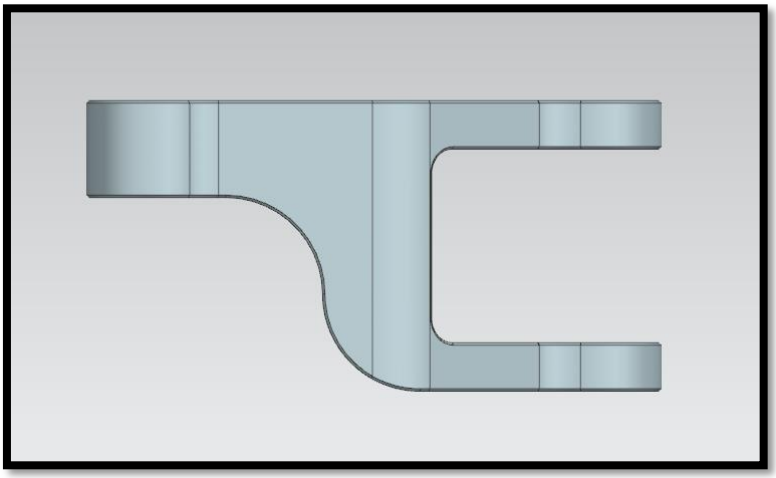

*Figure 11: Top View of Final Model*

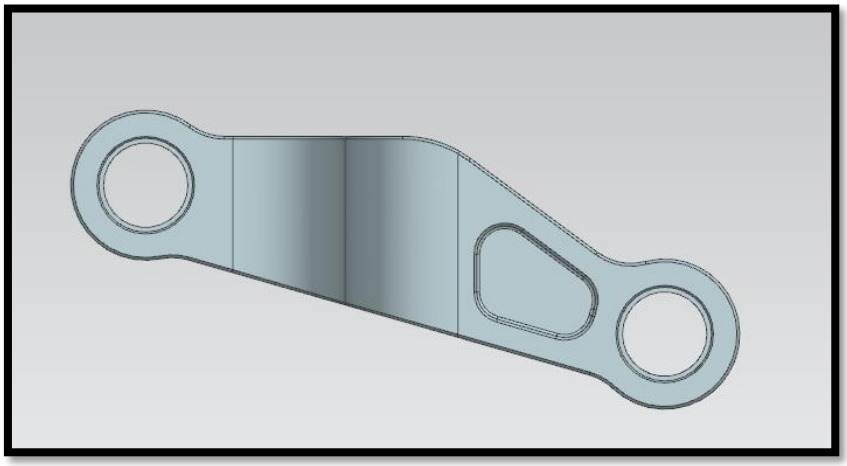

*Figure 12: Front View of Final Model*

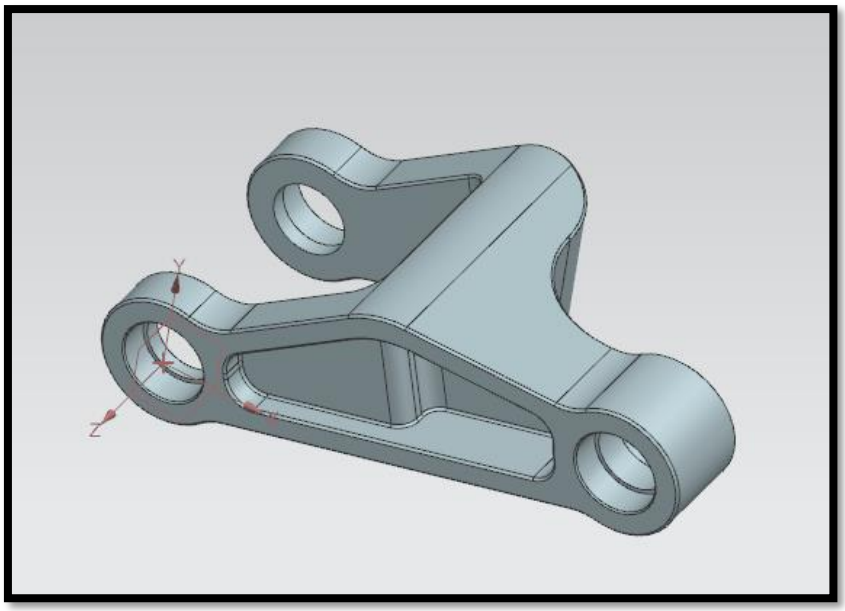

*Figure 13: Isometric View of Final Model*

# Section 4 : Conclusion & Future Work

Based on the design rational established in the beginning of the part creation, it's not always possible to describe a models anticipated behaviour based on the template provided o us. However, I believe the modelling tools and strategies used can influence design behaviour when any secondary user wants to modify the design. This is successfully implemented for the linkage model.

Measures were taken to ensure sketches were constrained, simple operations were used for easy edits in future, comments were added to dimensions wherever necessary, expression table was generated to be further used in future. The model was completed and the initial design intent was satisfied completely.

# Section 5 : References

[1] Otey, J., Company, P., Contero, M., & Camba, J. D. (2017). Revisiting the design intent concept in the context of mechanical CAD education. *Computer-Aided Design and Applications*, *15*(1), 47–60. https://doi.org/10.1080/16864360.2017.1353733

[2] https://blogs.solidworks.com/teacher/wp-content/uploads/sites/3/di_workbook-barnes.pdf

[3] MECH 542 Class Lecture Slides.