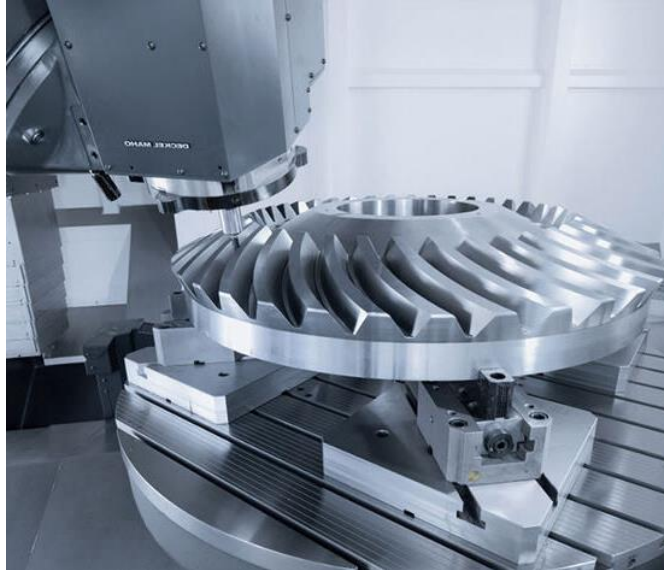


# Overview of Computer-aided Manufacture



## Quick check in... How are we all feeling?



Total Results: 229

# Announcements

- There have not been a lot of practice submissions for the Engineering Standards and Engineering Drawings test.
- This will be particularly important when it comes to submitting your Engineering Drawing file.
- Remember, the following penalties apply for late submission during the test.
  - **Less than 5 minutes late = 50% penalty to maximum available mark.**
  - **Greater than 5 minutes late = 100% penalty to maximum available mark.**

# Announcements

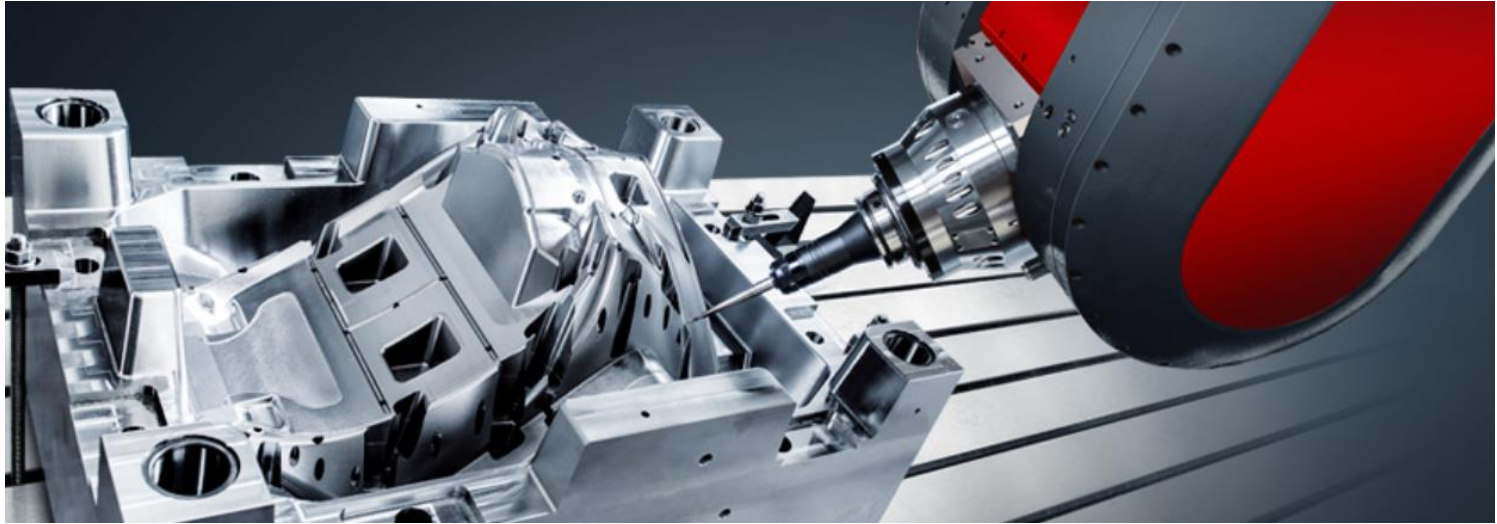
- I know that the panic can be super real sometimes so I will be organizing some additional open consultations
  - **Thursday 11:00 (Additional Consult)**
  - **Thursday 21:00 (Last Minute Consult)**
  - **Friday 12:30 (SOS CONSULT)**

# Topics

- CNC Milling Axis Types
- Workflow for CNC Production
- Stock Definition
- Work Coordinate System
- Operation Simulations
- Post processing
- Live demonstrations

# CNC Milling Axis Types

- Not all CNC Milling machines are created equal.
- The level of degrees of freedom for the cutter and the material dictate the axis type.



# CNC Milling Axis Types

- 2.5D Milling is when the tool is free to move in the x- and y-axis directions.
- Material is removed at various depths.
- Suitable for very simply CAM parts.





# CNC Milling Axis Types

- 3 axis milling is when the tool and material are able to move relative to each other.
- The tool moves along the z-axis whereas the material is capable of being moved along the x and y axes.
- This tends to be suitable for most CAM parts.
- The CNC Milling machine in the Kirby Makerspace is a 3 axis machine.
  - You will produce your CNC machining assessment components with this machine.





# CNC Milling Axis Types

- 4 axis milling introduces the ability to rotate the material.
- This allows you to get more efficient with the tool pathways and can save significant time.
- [https://www.youtube.com/watch?v=7jvl\\_plyw8s](https://www.youtube.com/watch?v=7jvl_plyw8s)



# CNC Milling Axis Types

- 5 axis milling typically allows for the ability to rotate the material along two different axes.
- The parts that benefit the most from this level of tool and material freedom are parts with complex freeform surfaces.
- <https://youtu.be/CqePrbeAQoM>



# Production Workflow



CAD



CAM



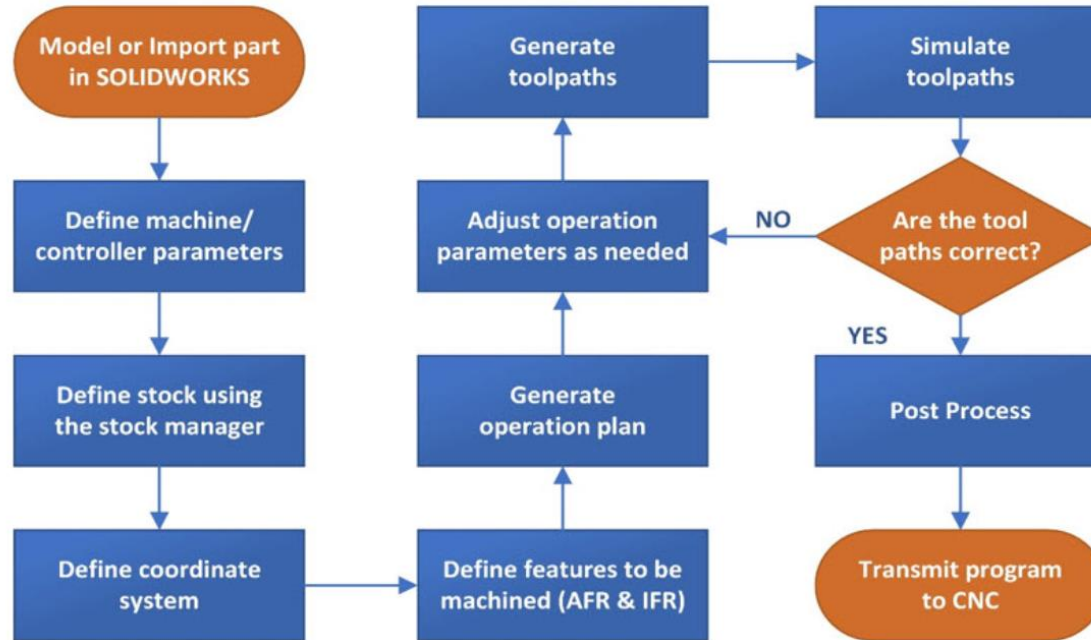
```
G-Code CAM  
N1 (FILE NAME = DETALJ MEKANIK00 ON TUESDAY, MARCH 21, 2016)  
N10 (DEFAULT MILL POST)  
N15 G01  
N20 G0 Z10  
N25 M1  
N30 X24.0000 Y40.0001  
N40 G1 Z0.000 F8000  
N45 T120.0000  
N50 G1 X20.0000 Y12.9999 I-12.0000 J-0.0075  
N55 G1 X20.0000 Y40.0001  
N60 G0 Z10  
N65 X24.0000 Y20.9549  
N70 M1  
N75 G0 Z0.0000  
N80 X170.0000 Y120.0000  
N85 G1 Z10  
N90 Y40.0001  
N100 X160.0000 Y80.0000  
N105 Z0.000  
N110 G1 Z0.000  
N115 G1 I-40.0000 J0.0000  
N120 G0 Z10  
N125 X194.0000 Y120.0151  
N130 G1 Z0.0000  
N135 G1 X170.0000 Y120.0455 I-12.0000 J0.0077  
N140 G0 Z10  
N145 X24.0000 Y40.0001  
N150 G1 Z0.000  
N155 T120.0000  
N160 G0 Z10  
N165 M1  
N170 M12
```

Post  
Processing



Manufacturing

# Typical CAM Process Plan



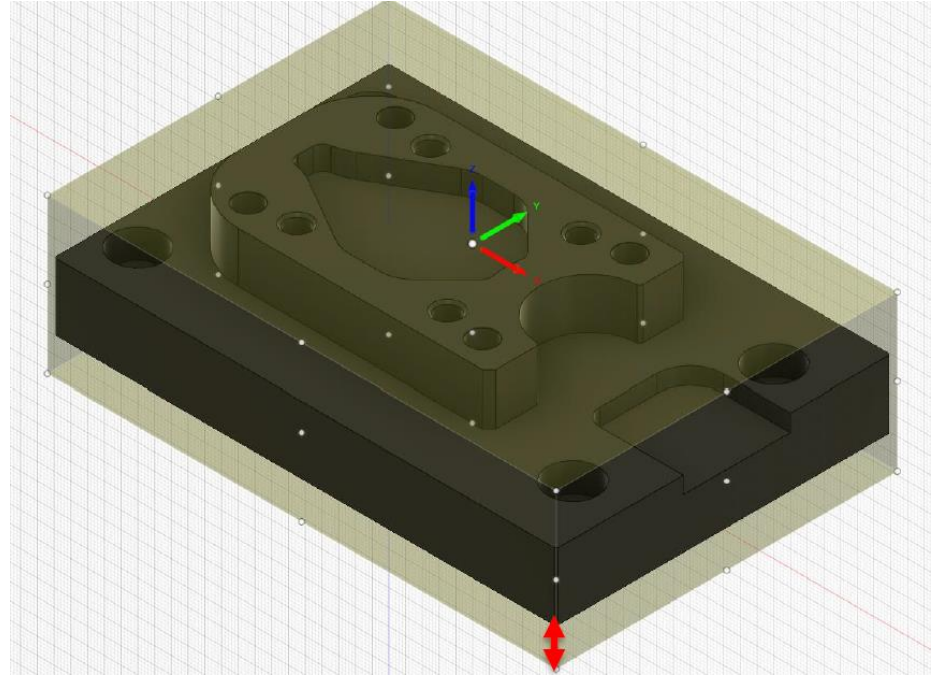
Source: <https://www.javelin-tech.com/blog/2019/03/solidworks-cam-getting-started-guide/>

# Important CAM Concepts to Know

- Before we get to our live demonstration, it is important that we cover off the following concepts
  - Stock
  - Coordinate systems
  - Cutting rule for endmills
  - Simulations
  - Post Processing

# Stock Set Up

- When we are creating 3D models, it is easy to forget the realities of manufacture.
- We need to define the stock that the component/part will be manufactured from.
- Typically, we set it up two ways
  - Specify the exact dimensions
  - SolidworksCAM can create an envelope that exceeds the model dimensions by a given offset

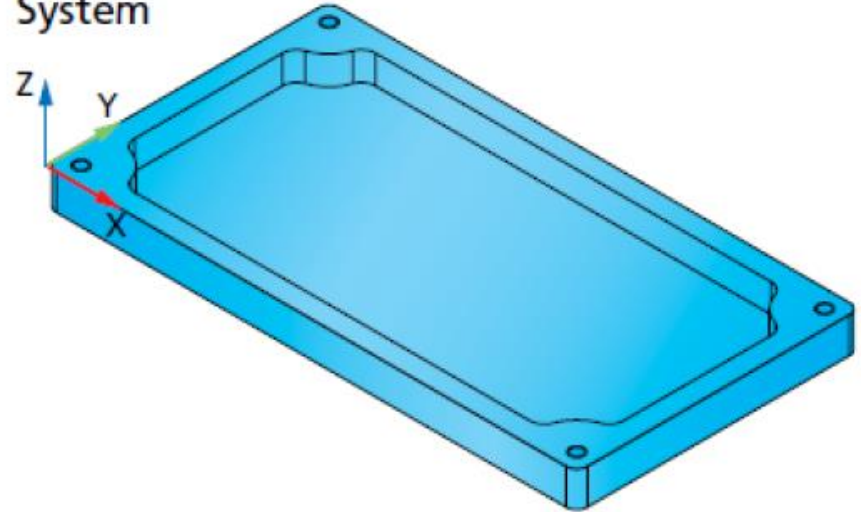




# Coordinate Systems

- In order for our tool to know where to cut, we need to define a work coordinate system (WCS).
- This acts as the origin for all machining operations that we define during the CAM process.
- We typically pick a corner of the stock but any sensible location will do.
- Before running the CNC machine, we need to match the machine origin to the coordinate system we defined.

Coordinate System



# Cutting Rule for Endmills

- Throughout this course we will use face mills, end mills, drills, chamfer mills and spot drills
- However, the majority of our operations will be carried out by end mills.
  - Initial roughing
  - Horizontal and vertical finishing
  - Boring
- Therefore, it is important that we consider an appropriate machining strategy to prolong the life of the end mill.

# Cutting Rule for Endmills

- A good rule that is used for endmills is as follows

$$1.1DOC\% \times WOC\% = 0.2$$

- where  $DOC\%$  is the depth of cut and  $WOC\%$  is the width of cut, both as a percentage of the tool diameter.
- What this means is the deeper your depth of cut, the shallower your width of cut needs to be and vice versa.
- For example, let's consider our 6mm endmill. If our DOC is two times the tool diameter (12 mm), then we can only have a WOC that is 9% the tool diameter (0.55 mm).
- **This is extremely important for when you do the CAM for your CNC Machining Assessment.**

# CAM Operation Simulation

- Perhaps the most important and powerful tool available to us is the ability to simulate the operations we have defined.
- This is very important and allows us to find tool collisions and other problems before they occur.
  - What other problems might happen?

# What other issues might CAM simulations identify?

“ Issues such as the drill bit being the wrong size ”

“ time ”

“ Safety issues ”

Total Results: 170

# CAM Operation Simulation

- Perhaps the most important and powerful tool available to us is the ability to simulate the operations we have defined.
- This is very important and allows us to find tool collisions and other problems before they occur.
  - What other problems might happen?
- This also allows us to get a prediction for the time required to manufacture our part.



# Post Processing

- Once we are satisfied with the machining operations and tool pathways, we need to be able to program the machine to do what we want.
- This is achieved by outputting the required operations in a programming language known as G-Code.
- G-Code looks like gibberish, but the computer loves it.
- Different machines will use different G-Code formats so it is important to pick the right one.

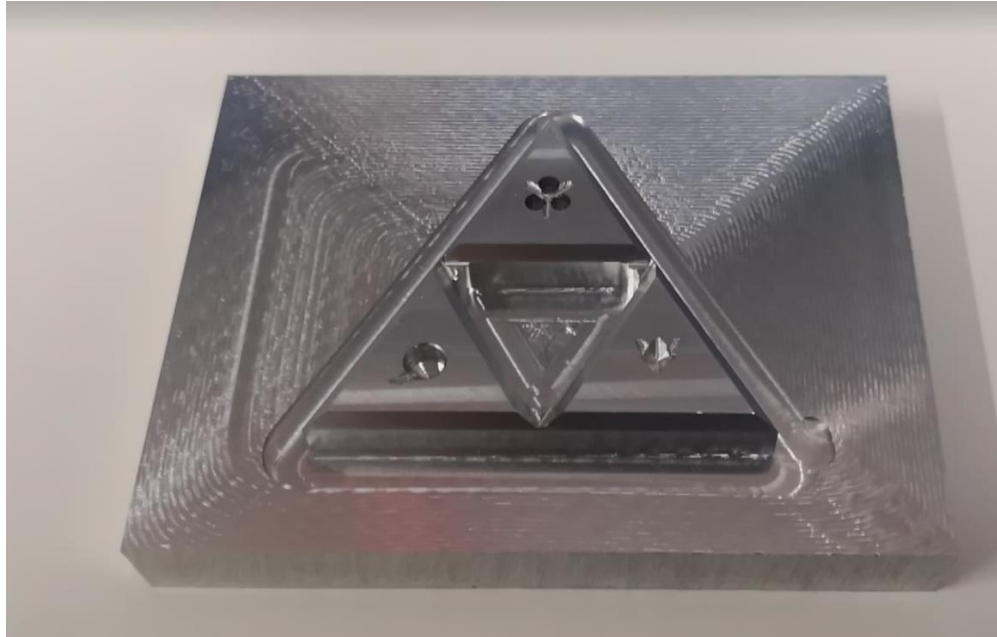
```
27 N220 G1 X-0.5673 A42.843 F9999.9999
28 N230 G1 X-0.5612 A44.338 F1690.6754
29 N240 G1 X-0.5573 A44.754 F2638.8776
30 N250 G1 X-0.5504 A44.717 F1498.2938
31 N260 G1 X-0.5394 A44.175 F943.4968
32 N270 G1 X-0.5314 A44.133 F1300.4534
33 N280 G1 X-0.5269 A44.615 F2309.7131
34 N290 G1 X-0.5384 A45.138 F2981.1274
35 N300 G1 X-0.6033 A48.748 F142.216
36 N310 G1 X-0.6762 A52.357 F142.216
37 N320 G1 X-0.7491 A55.967 F142.216
38 N330 G1 X-0.822 A59.576 F142.216
39 N340 G1 X-0.8371 A60.322 F689.427
40 N350 G1 X-0.8411 A60.877 F2575.8738
41 N360 G1 X-0.8386 A61.37 F4054.3052
42 N370 G1 X-0.8319 A61.577 F1555.9257
43 N380 G94 G1 X-0.8017
44 N390 G93 G1 X-0.7955 A61.325 F1699.2463
45 N400 G1 X-0.7954 A60.815 F9999.9999
46 N410 G1 X-0.8011 A59.458 F1805.5297
47 N420 G1 X-0.8052 A59.044 F2534.4616
48 N430 G1 X-0.8122 A59.087 F1484.6346
49 N440 G1 X-0.822 A59.576 F1051.6124
50 N450 G1 X-0.8311 A59.784 F1140.7757
51 N460 G1 X-0.8403 A59.59 F1133.4538
52 N470 G1 X-0.8494 A59.396 F1133.491
53 N480 G1 X-0.8585 A59.604 F1140.7569
54 N490 G1 X-0.8614 A59.744 F3671.4453
55 N500 G1 A63.049 F9999.9999
56 N510 G94 G1 X-0.4944
57 N520 G93 G1 A61.328 F9999.9999
58 N530 G94 G1 X-0.7499
59 N540 G93 G1 X-0.7652 A61.039 F680.3515
60 N550 G1 X-0.7765 A60.246 F912.042
61 N560 G1 X-0.7811 A59.15 F2249.6619
```

Line 43, Column 1 — Selected 20 columns — 2115 Lines

# **Solidworks CAM Demonstration Time**

# Machining of Triforce + Spiritual Stones

- <https://www.youtube.com/watch?v=K6InHvcaddI&feature=youtu.be>



# Machining of Fixture Plate

- Here is a recording of the CNC machining of the fixture plate that will hold your CNC Machining Assessment workpieces.
- <https://youtu.be/rm66W2vQRLI>

