

Introduction to CAD

NX Workshop 1

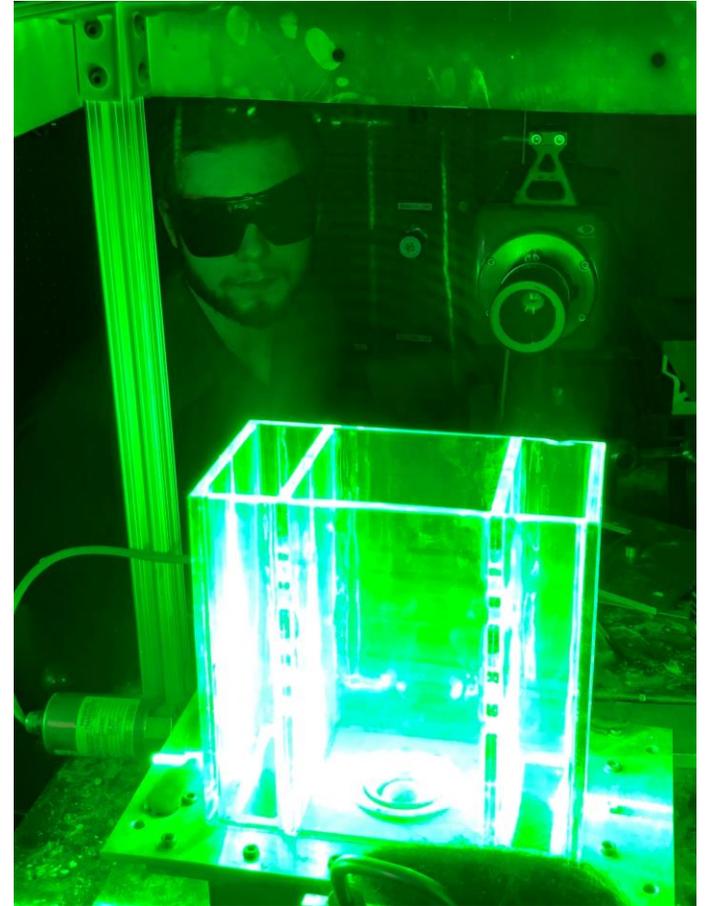
Instructor: Kyle Twarog

First Some Housekeeping

- This seminar series will focus on the use of NX in the mechanical design process
 - It will not touch on all aspects of NX. Additional exploration will be needed to be truly proficient in this (or any other) CAD software package
- Materials for this course will be hosted on my personal website:
<http://theshadylibrary.com/>
 - In-class discussions and demonstrations cannot be recorded, and therefore cannot be posted for review
- This seminar series will be setup so as to allow for a lecture followed by guided practice of various concepts.

A Little About the Instructor

- I am a PhD student in the Combustion Diagnostics Laboratory under Dr. Jackie Sung
 - <https://combdialab.engr.uconn.edu/>
- I received my BSME at UConn in 2017
- I have been formally instructed in both traditional drafting and 2/3D modeling
- If you have any questions regarding this seminar or general engineering topics, please email me at: kyle.twarog@uconn.edu



Where did we come from?

- Until the early 1960s, all mechanical design was done in 2D space using traditional drafting methods
 - In this workflow, a design engineer would work in concert with a draftsman, or a team of draftsmen, to produce and revise drafts of their parts
 - Something to consider, at this time the term 'calculator' still referred to a person, usually a woman with a high-school education, who would be tasked with doing calculations and plotting figures for an engineering department
- 2D CAD systems were adopted in the aeronautics, automotive, and architectural industries, with different packages being oriented for each of their use
 - This focus on a single industry for a given package still holds with some packages today

Where did we come from?

- 3D CAD systems were also invented in the 1960s, however functionality was limited
 - These systems were not widely adopted
- NURBS (Non-uniform rational B-spline), a mathematical model used to create complex curves, first appeared in commercial software in 1989, however 3D modeling did not become widespread until the mid-90s
 - This rise in adoption was due to the dramatic increase in personal workstation power as well as the advancement of computer graphics capabilities
 - If you want to see examples of these older systems, look at some of the B-roll of History Channel's Modern Marvels
- By the early 2000s 3D CAD had become widespread in most industries, and had begun to interface with both simulation and manufacturing suites

CAD/CAE/CAM

- Computer Aided Design (CAD)
 - Software tools that allow for the creation of 2/3D models of a specified geometry and scale
- Computer Aided Engineering (CAE)
 - Software tools that allow for the evaluation and/or optimization of a pre-constructed CAD model based using a specified set of computational models and boundary conditions
- Computer Aided Manufacturing (CAM)
 - Software tools that allow for the creation of machine code so as to manufacture a pre-constructed CAD model utilizing a specified piece of equipment and tooling

What is a 'Solver'

- The engine of any CAD package, this is the part of the software that solves a given set of mathematical inputs and commands so as to render an image

CAD Packages

- Various CAD packages are preferred for use by different industries and divisions of companies based on their feature sets
 - Most companies only utilize a single CAD solution so as to allow for effective communication
- Current trend is toward increased CAE/CAM integration within CAD packages

The logo for PTC's NX CAD software, consisting of the letters 'NX' in a bold, blue, sans-serif font.The logo for Autodesk Inventor, featuring a stylized orange 'I' icon to the left of the text 'AUTODESK®' and 'INVENTOR®' stacked vertically in a black, sans-serif font.The logo for SolidWorks, featuring a stylized red '3D' icon to the left of the text 'SOLIDWORKS' in a red, italicized, sans-serif font.

Basic Building Blocks

- Points
 - (x,y,z)
- Lines
 - Define endpoints
- Arcs
 - Endpoints and radius of curvature are defined
- Circles
 - Central point and radius is defined
- Spline
 - Creates a set of piecewise polynomials of known order

3D Modeling

- 3D shapes can ONLY be created utilizing at least one closed and fully defined 2D shape
 - Other support geometries may be open, but at least one must be closed
- Surfaces
- Solid Bodies
 - Composed of surfaces that form a fully enclosed and defined volume
 - This is important especially when defining custom surfaces mathematically
 - These structures are the final product of any 3D model, and are the only structures that can be used to form a physical part

Coordinate Systems

- **Absolute or Global Coordinate System**
 - This is the coordinate system utilized by the solver across an entire file
 - This cannot be changed or defined by the user, however the user can define structures using this coordinate system
 - 'Default'
- **Work Coordinate System**
 - This is a user defined coordinate system in both axis orientation and origin point
 - This is commonly utilized to define the orientation and position in relative space of an entire part
 - Redefining this coordinate system does not alter the existing geometry
- **Datum Coordinate System**
 - Similar to the Work Coordinate System, however this is defined in relation to an existing datum object
 - Redefining the coordinate system will alter any geometry that is dependent on this coordinate system

Datum Objects

- Points
- Axis
 - Continuous 1D structure
- Plane
 - Continuous 2D structure
- All three are utilized to define the position in virtual space of other structures
- Choosing your datums is important! NEVER arbitrarily choose a datum!
 - This includes the centerpoint of your part's coordinate system(s)
 - Think through your parts and how they will interface with other parts. What datum would make sense if you were working with the whole assembly? How about if you changed the size of your part?

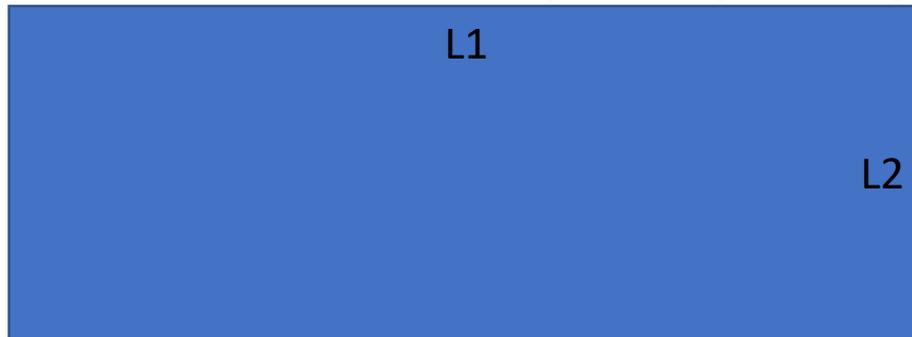
Parametric Modeling

- Parametric Modeling utilizes defined relations (parameters) to construct a given geometry
 - These parameters can be both automatically defined and user defined
 - Changes to parameter values will automatically change the geometry itself

Define 'A' = 8

$$L1 = 2A$$

$$L2 = A$$



This rectangle is now defined by the value of A, and will hold its shape and aspect ratio regardless of the value of A

Degrees of Freedom and Constraints

- 2D structures must be defined utilizing constraints equal to the degrees of freedom of that structure
 - Each point of a 2D structure has three DOF: X, Y, Z
 - Lines have 6 DOF
 - Circles have 4 DOF
- Constraints are defined relations between at least one DOF and the relevant coordinate system
 - Ex. Defining a point at (2,2,0) fully constrains that point
 - Ex. Defining a second point at (2,4,0) would fully define the line between the two points
 - Ex. Defining a line starting from (2,2,0) in the XY plane exactly 30 degrees from the Y axis and exactly 2 units long would fully define the line

Degrees of Freedom and Constraints

- Be careful when defining the constraints of structures!
- The solver will 'assume' a solution to a given structure and render that solution, however the final outcome can change dramatically as you define constraints!
 - Ex. If the line segment is not defined as being in the XY plane originally

Types of Files

- Part files
 - These are the standard files for 3D modeling systems and are utilized to model a single part or object in detail
 - Depending on the file extension, these files can be transferred individually from one CAD package to another
- Assembly files
 - These are composed of many individual Part files, each defined (or assembled) relative to each other
 - These are utilized to model larger structures from bolt faces to entire buildings
 - These files are usually dependent on the existence of their component Part files
 - In other words, they cannot be opened or utilized if the Part files do not exist or are unreadable
- Drawing files
 - These are 2D representations of your model
 - These are the most important of all files, as these are what will actually be utilized to manufacture your part regardless of the manufacturing method used
 - This includes the use of CNC and CAM in conjunction with the other 3D files

Creating a Model

1. Define a plane
2. Create a 2D Sketch on that plane
 - A Sketch is the continuous 2D drawing space on which a 2D structure can be defined
3. Define a closed 2D structure within that Sketch
4. Repeat 1-3 as needed
5. Define a 3D structure based on the existing Sketches
6. Repeat process as needed to create the part

Philosophy of Use of CAD

- CAD is only a tool, it is not a solution to an engineering problem
- Objects created in the virtual world cannot always be created in the real world
 - Try to be aware of the manufacturing techniques and operations required to make a given part as you construct it in CAD
 - Always check your models for impossible structures!
- Remember that the solver cannot read your thoughts, and will not always define structures as desired automatically
- CAD is like programming: the user is usually the problem
- Always check units!

Now lets work with some basic 2D sketches and 3D primitives in NX!