Autodesk® Simulation for Designers, not Doctors! (No Phd Required) SM3257-L

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Cartesian coordinates [edit]

With the velocity vector expanded as $\mathbf{v} = (u, v, w)$, we may write the vector equation explicitly,

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right) = -\frac{\partial p}{\partial x} + \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) + \rho g_x,$$

$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z}\right) = -\frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right) + \rho g_y$$

$$\rho\left(\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right) + \rho g_z.$$

Note that gravity has been accounted for as a body force, and the values of g_x, g_y, g_z will depend on the orientation of gravity with respect to the chosen set of coordinates.

The continuity equation reads:

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0.$$

When the flow is incompressible, ρ does not change for any fluid parcel, and its material derivative vanishes: $\frac{D\rho}{Dt} = 0$. The continuity equation is reduced to:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

The velocity components (the dependent variables to be solved for) are typically named *u*, *v*, *w*. This system of four equations comprises the most commonly used and studied form. Though comparatively more compact than other representations, this is still a nonlinear system of partial differential equations for which solutions are difficult to obtain.

Cylindrical coordinates [edit]

A change of variables on the Cartesian equations will yield[15] the following momentum equations for *r*, ϕ, and *z*:

$$r:\quad \rho\left(\frac{\partial u_r}{\partial t} + u_r\frac{\partial u_r}{\partial r} + \frac{u_\phi}{r}\frac{\partial u_r}{\partial \phi} + u_z\frac{\partial u_r}{\partial z} - \frac{u_\phi^2}{r}\right) = -\frac{\partial p}{\partial r} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u_r}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 u_r}{\partial \phi^2} + \frac{\partial^2 u_r}{\partial z^2} - \frac{u_r}{r^2} - \frac{2}{r^2}\frac{\partial u_\phi}{\partial \phi}\right] + \rho g_r$$

$$\phi:\quad \rho\left(\frac{\partial u_\phi}{\partial t} + u_r\frac{\partial u_\phi}{\partial r} + \frac{u_\phi}{r}\frac{\partial u_\phi}{\partial \phi} + u_z\frac{\partial u_\phi}{\partial z} + \frac{u_r u_\phi}{r}\right) = -\frac{1}{r}\frac{\partial p}{\partial \phi} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u_\phi}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 u_\phi}{\partial \phi^2} + \frac{\partial^2 u_\phi}{\partial z^2} + \frac{2}{r^2}\frac{\partial u_r}{\partial \phi} - \frac{u_\phi}{r^2}\right] + \rho g_\phi$$

$$z:\quad \rho\left(\frac{\partial u_z}{\partial t} + u_r\frac{\partial u_z}{\partial r} + \frac{u_\phi}{r}\frac{\partial u_z}{\partial \phi} + u_z\frac{\partial u_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u_z}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 u_z}{\partial \phi^2} + \frac{\partial^2 u_z}{\partial z^2}\right] + \rho g_z.$$

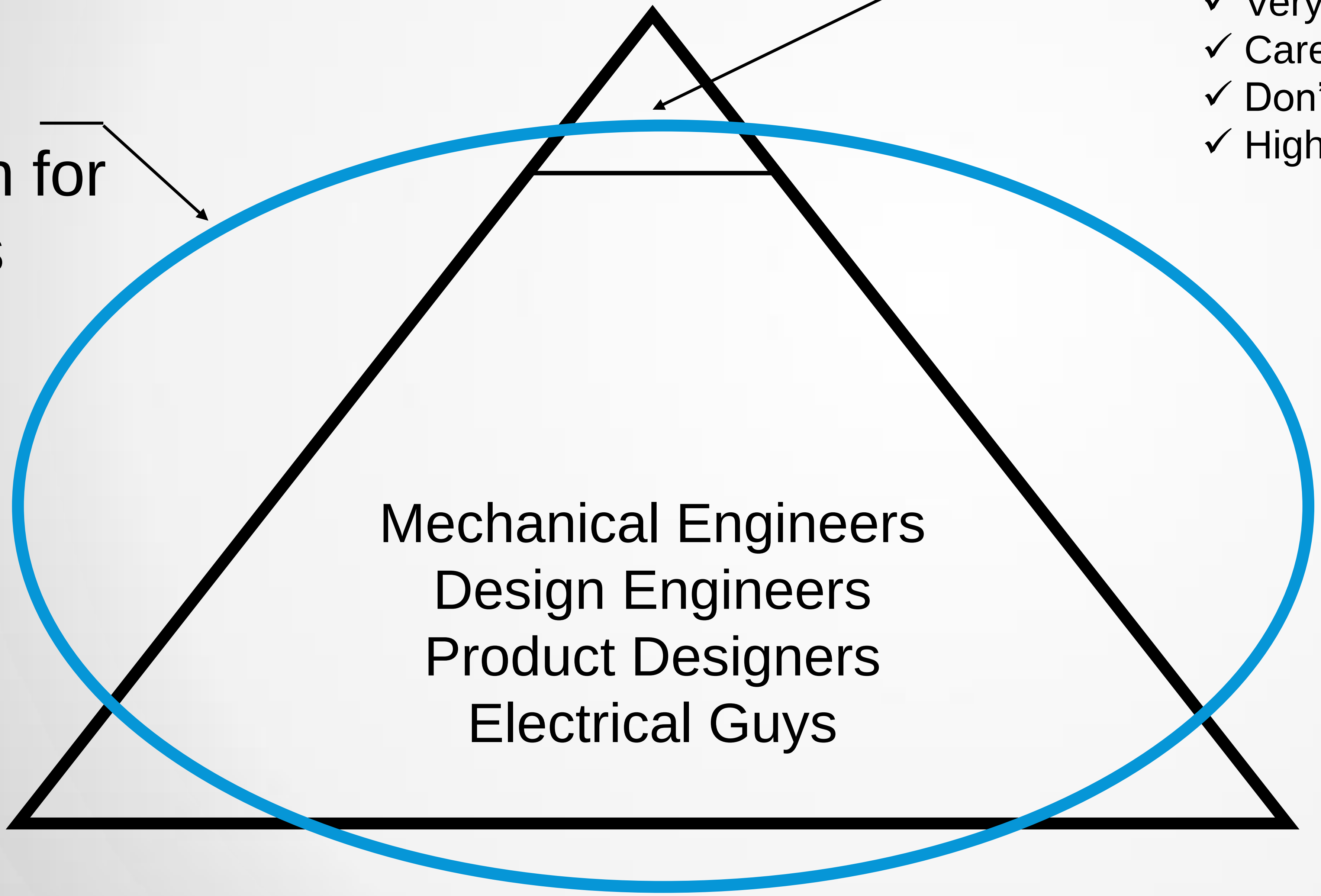
Who -

- Your Instructors
  - Kevin Marchant
    - AE D3 Technologies
  - Dave Graves
    - Sr. Technical Specialist (Autodesk)
- Lab Assistants
  - Wasim Younis
    - Symetri UK
  - James Neville
    - Technical Specialist (Autodesk)
  - Peggy Menzies, Phd
    - CFD Quality Lead (Autodesk)

Upfront Simulation in Engineering

Simulation for the Designers

Upfront Simulation for Designers



Traditional Tools (aka for Doctors)

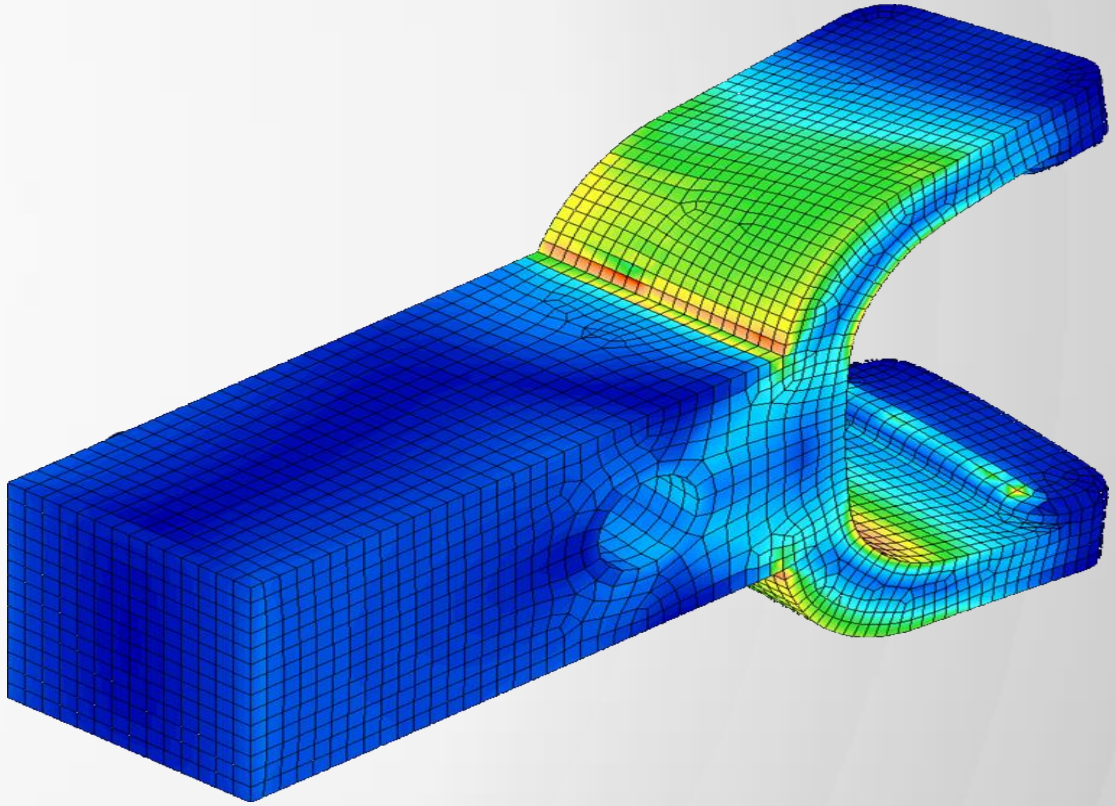
- ✓ Very Specialized
- ✓ Career in Simulation
- ✓ Don’t make design decisions
- ✓ High level problems
  - Combustion
  - Chemical reactions
  - Large Deformation

Autodesk Simulation

- ✓ Easy to Use
- ✓ Tool for Product Development
- ✓ Fast Design Decisions
- ✓ Don’t want to make a career of driving simulation software

What is **FEA** Analysis?

- A method to evaluate the physical performance of a design before it is built
- FEA = Finite Element Analysis
- Finite = Limited, discrete
- **Elements = Small block which results can be solved for**



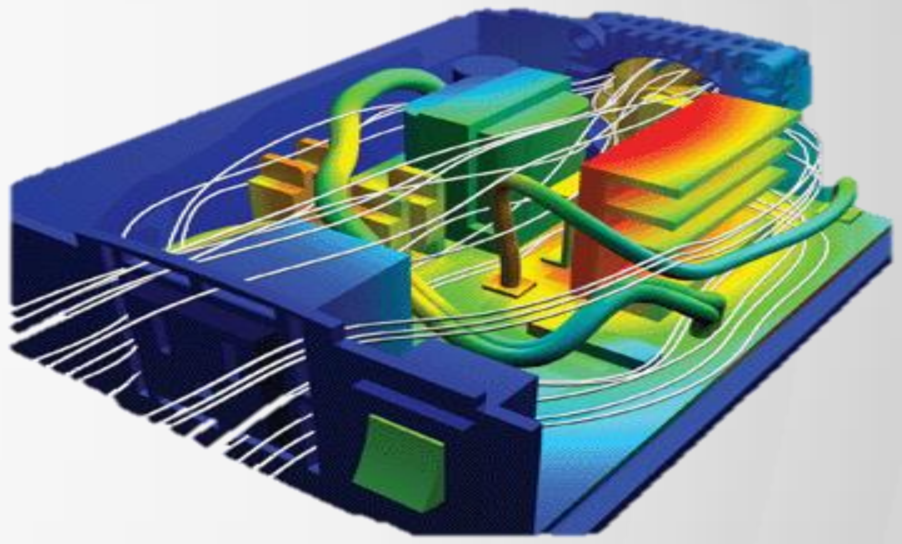
What is CFD Analysis?

- The modeling of fluid flow as it interacts with surrounding surfaces

- CFD = **C**omputational **F**luid **D**ynamics
- Fluid = Liquids and gases
- Dynamics = Movement

- CFD tools today also have the capability to model the effects of temperature

- Flow and Thermal Analysis



- Many Industries across MFG, AEC, ENI

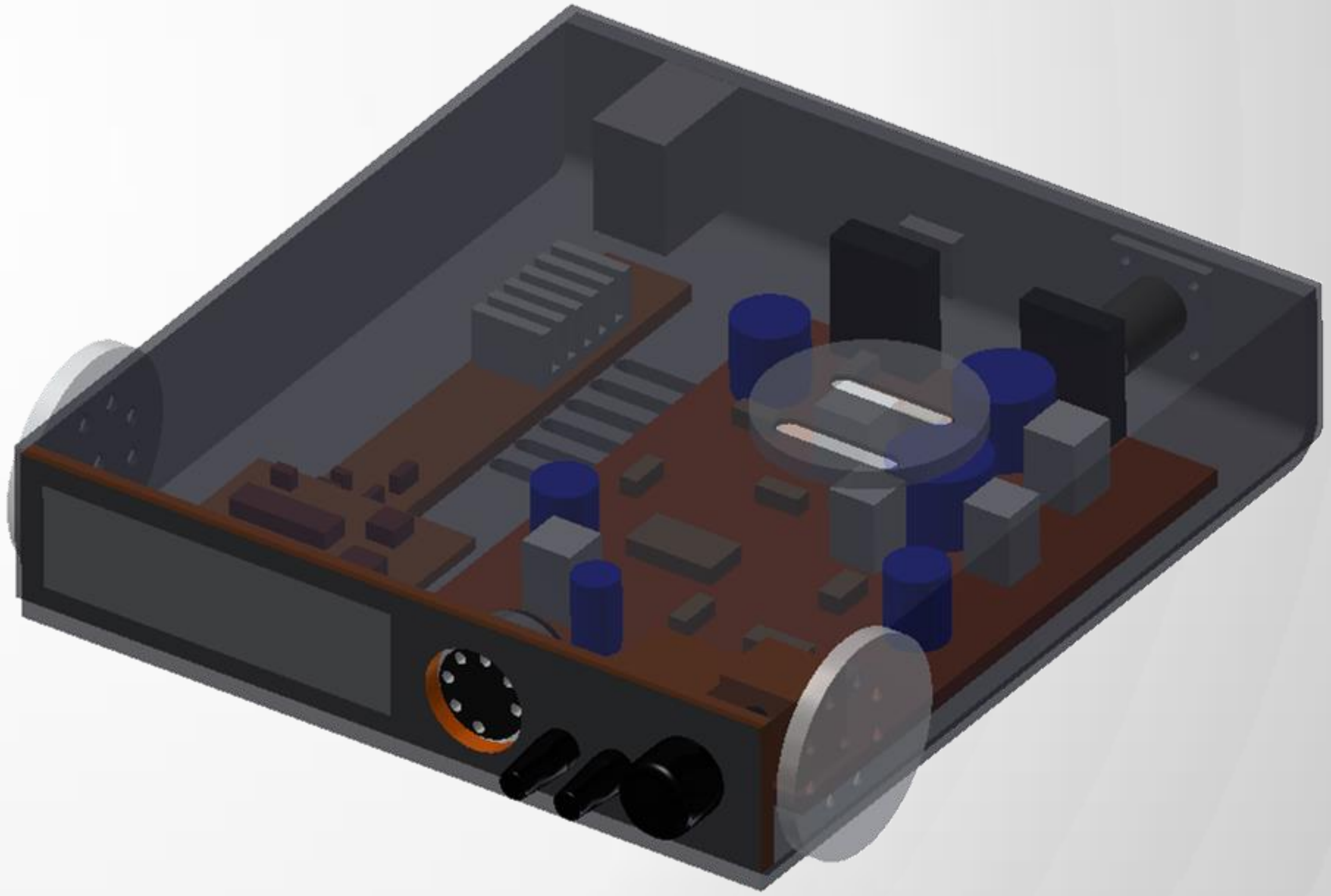
Let’s get started:
(Key learning objectives)

At the end of this class, you will be able to:

- Create an analysis model from Inventor
- Set up and simulate in CFD
- Process thermal results in CFD
- Evaluate and compare a design change

Open the Demo Assembly in Inventor

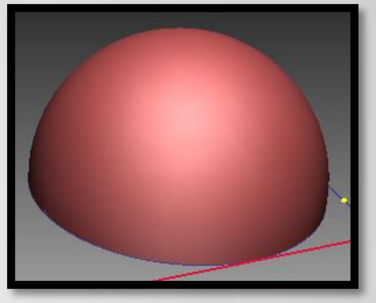
- Navigate to *\SM3257-L\Demonstration\Inventor Geometry
- Open “CB.iam”



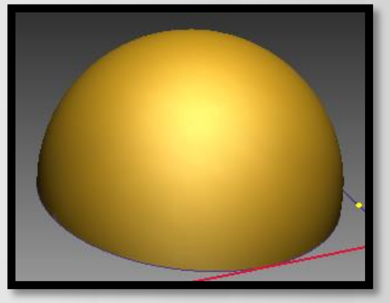
Basics in CFD

- Complete launch → click OK
- Adjust Geometry → Select Merge
- Practice Navigation and Selection:

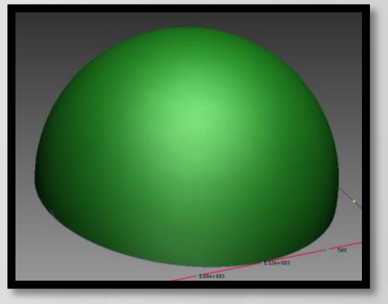
Display Action	ADSK CFD Mouse Command
Wheel Zoom	Scroll
Rotate	Shift + MMB
Pan	MMB
Select/deselect	LMB
Rubberband select	LMB drag
Blank/hide	Ctrl + MMB
Show all	Ctrl + MMB off model



Selected



About to Deselect



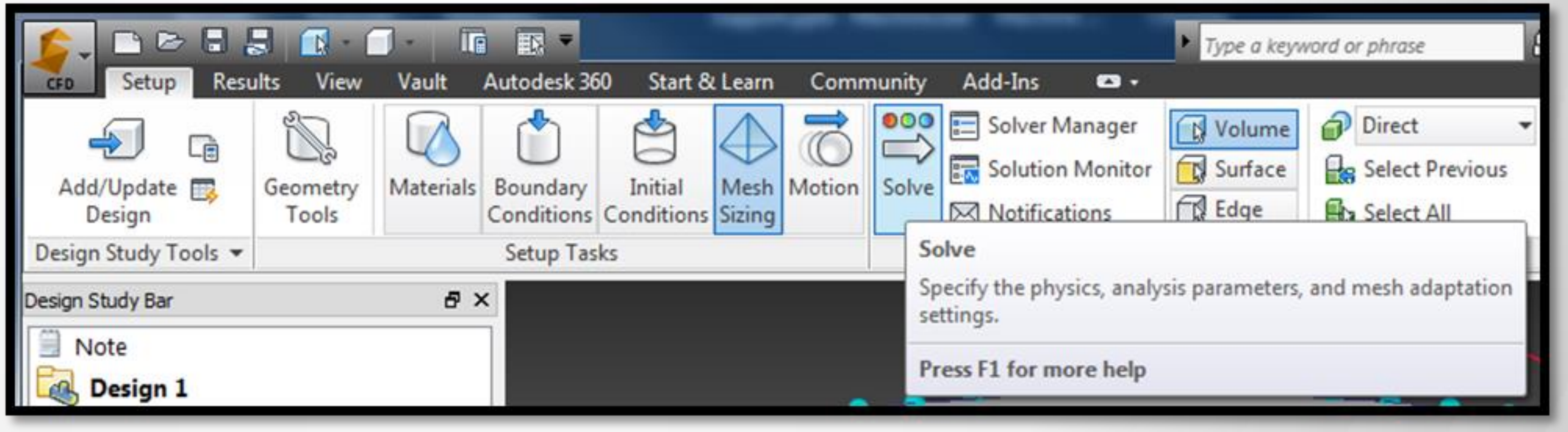
Ready to Select

Steps

- Materials
- Conditions
- Mesh
- Solve
- Review

  Results

Work left to right ->



Thank you!

Questions?