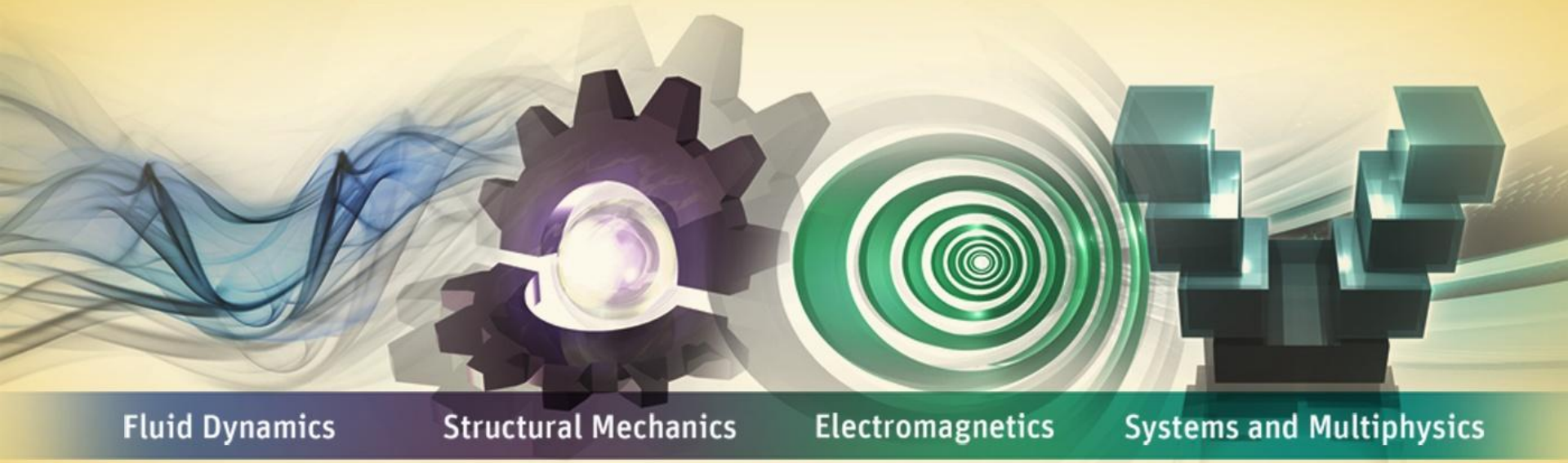
ANSYS

Realize Your Product Promise™

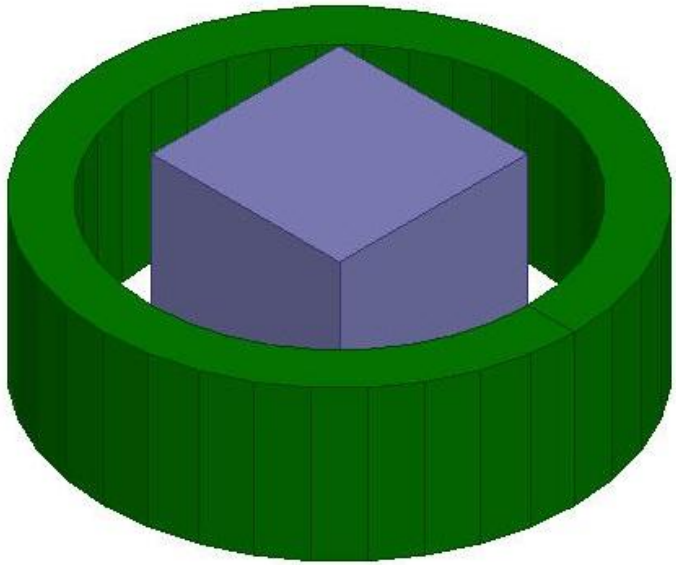
Workshop 10:
Basic Parametric Analysis



ANSYS Maxwell 3D V16

About Workshop

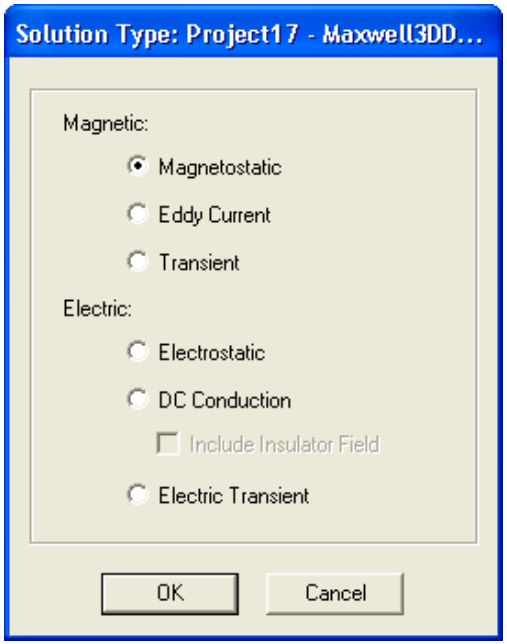
- **Parametric study using a coil and Iron slug**
  - This workshop describes the steps required to setup a parametric analysis offered through Optimetrics.
  - A simple magnetostatic problem will be used to demonstrate the setup. The coil current and the dimensional length of an iron slug will be varied and the impact of changes in above parameters on the force exerted on the slug will be observed.



Problem Setup

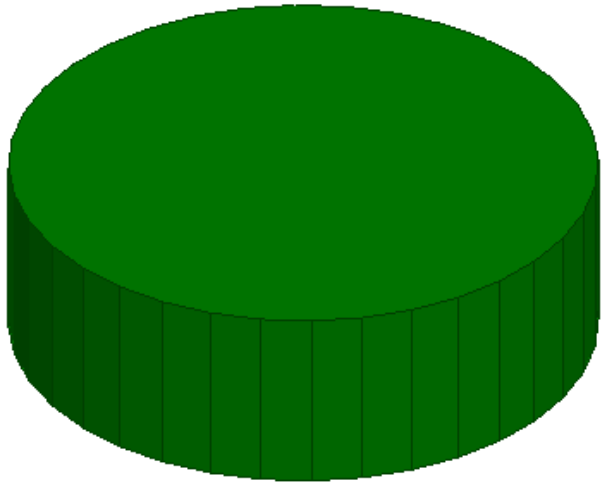
- **Create Design**
  - Select the menu item ***Project → Insert Maxwell 3D Design***, or click on the icon

- **Set Solution Type**
  - Select the menu item ***Maxwell 3D → Solution Type***
  - Solution Type Window:
    1. Choose **Magnetostatic**
    2. Click the **OK** button



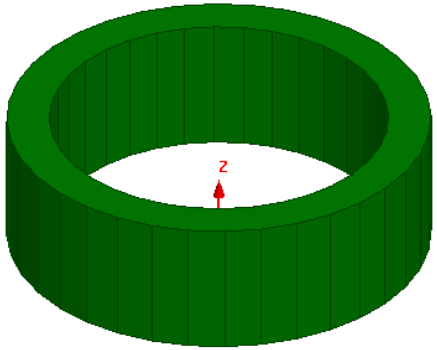
Create Coil

- **Create Regular Polyhedron**
  - Select the menu item ***Draw → Regular Polyhedron***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 1.25, dY: 0, dZ:0.8**, Press the **Enter** key
    3. Number of Segments: **36**
  - Change the name of the Object to **Coil**
  - Change the material of the object to **Copper**
  - Change the color if desired



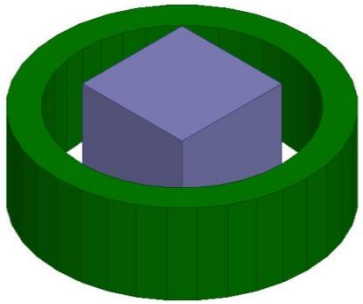
Create Coil (*Contd…*)

- **Create Second Polyhedron**
  - Select the menu item ***Draw → Regular Polyhedron***
    1. Using the coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the radius
       - **dX: 1, dY: 0, dZ: 0.8**, Press the **Enter** key
    3. Number of Segments: **36**
  - Change the name of the Object to **Hole**
- **Subtract Objects**
  - Press **Ctrl** and select the objects **Coil** and **Hole** from the history tree
  - Select the menu item, ***Modeler → Boolean → Subtract***
    1. Blank Parts: **Coil**
    2. Tool Parts: **Hole**
    3. Click the **OK** button



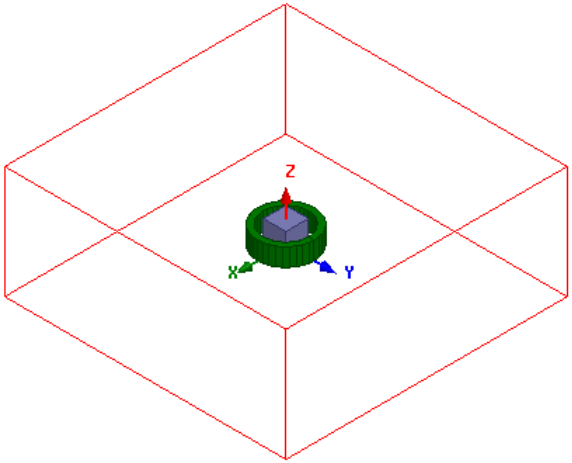
Create Slug

- **Create Iron Slug**
  - Select the menu item ***Draw → Box***
    1. Using the coordinate entry fields, enter the box position
       - **X: -0.5, Y: -0.5, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 1, dY: 1, dZ: 1**, Press the **Enter** key
  - Change the name of the resulting object to **Slug**
  - Change material of the object to **Iron**



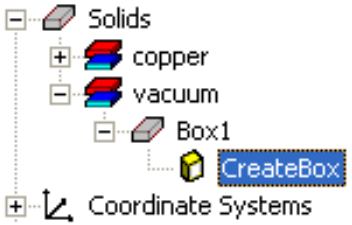
Note: The material properties for iron has a linear permeability. This means that no non-linear BH curve is being used in this example.

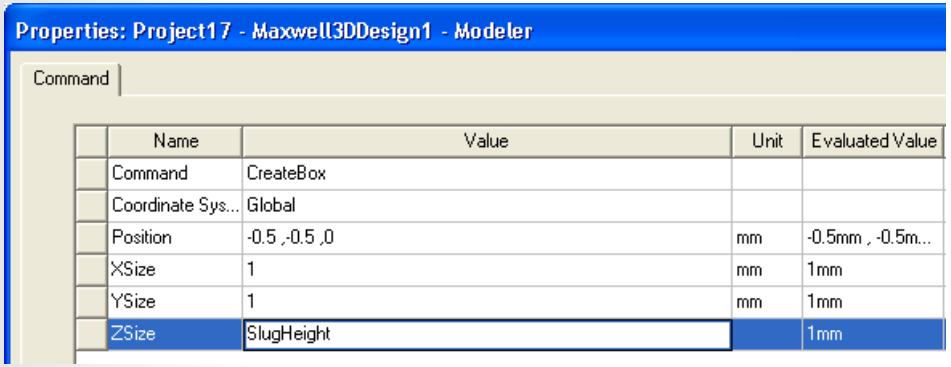
- **Create Simulation Region**
  - Select the menu item ***Draw → Region***
  - In Region window,
    1. Padding all directions similarly: ☑ **Checked**
    2. Percentage Offset:
       - Value: **200**
    3. Press **OK**



Add Parameter SlugHeight

- **Add parameter for Slug Height**
  - Expand the history tree for the object **Slug** and double click on **CreateBox** command
  - In Properties window,
    1. For **ZSize** specify value as **SlugHeight**, press **Tab** to accept
    2. In Add Variable window,
       - Unit Type: **Length**
       - Unit: **mm**
       - Value: **1**
       - Press **OK**





Note: By defining a variable name (SlugHeight) it becomes a design variable. The design variables are accessible by selecting menu item Maxwell 3D → Design Properties.

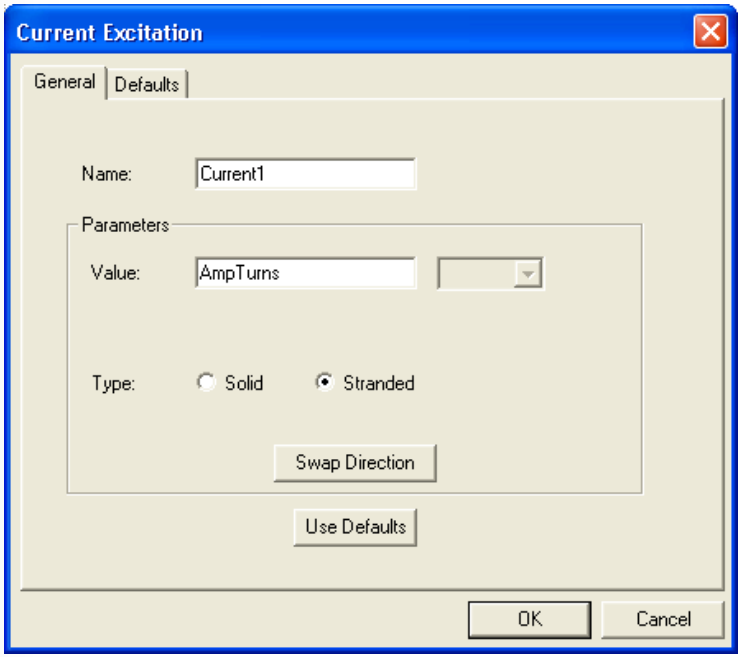
If variable name is appended by symbol $, it will be defined as project variable and can be accessed across the designs

Create Coil Terminal

- **Create Coil terminal**
  - Select the object **Coil** from the history tree
  - Select the menu item ***Modeler → Surface → Section***
    1. Section Plane: **YZ**
    2. Press **OK**
  - Change the name of the resulting sheet to **Terminal**
- **Separate Sheets**
  - Select the sheet Terminal from the history tree
  - Select the menu item ***Modeler → Boolean → Separate Bodies***
- **Delete Extra Sheet**
  - Select the sheet **Terminal_Separate1** from the history tree
  - Select the menu item ***Edit → Delete***

Assign Excitation

- **Assign Excitation**
  - Select the sheet **Terminal** from the history tree
  - Select the menu item ***Maxwell 3D → Excitations → Assign → Current***
  - In Current Excitation window,
    1. Name: **Current1**
    2. Value: **AmpTurns**
    3. Type: **Stranded**
    4. Press **OK**
  - In Add Variable window,
    1. Unit Type: **Current**
    2. Unit: **A**
    3. Value: **100**
    4. Press **OK**

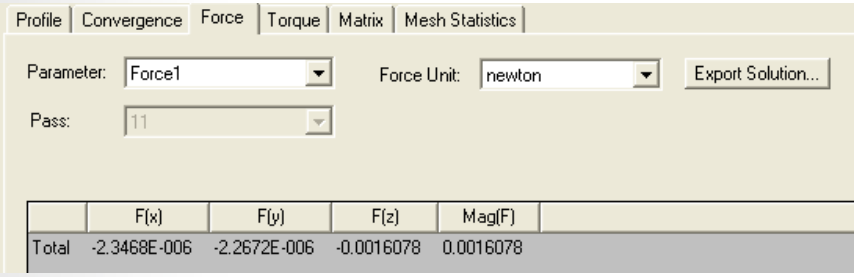


Analyze

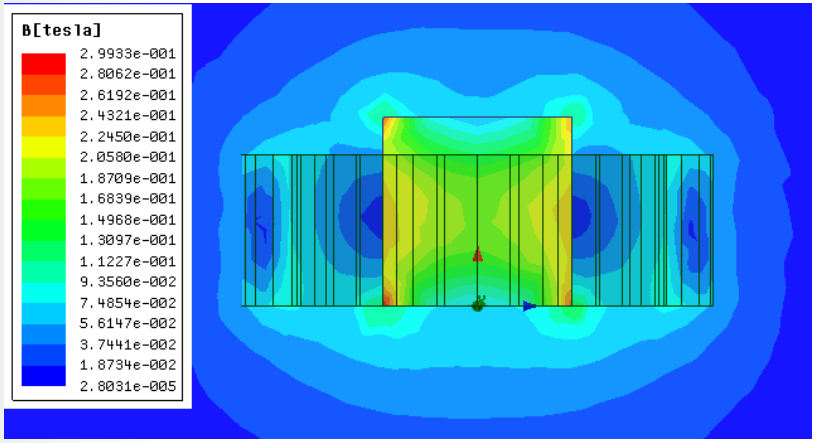
- **Assign Force Calculation**
  - Select the object **Slug** from the history tree
  - Select the menu item ***Maxwell 3D → Parameters → Assign → Force***
  - In Torque window,
    1. Name: **Force1**
    2. Type: **Virtual**
    3. Press **OK**
- **Create an analysis setup:**
  - Select the menu item ***Maxwell 3D → Analysis Setup → Add Solution Setup***
  - Solution Setup Window:
    1. **General** tab
       - Maximum Number of Passes: **15**
    2. Click the **OK** button
- **Run Nominal Solution**
  - Select the menu item ***Maxwell 3D → Analyze All***

Results

- **View the Solution Data:**
  - Select the menu item ***Maxwell 3D → Results → Solution Data***
    1. To view Force values
       - Select the **Force** tab



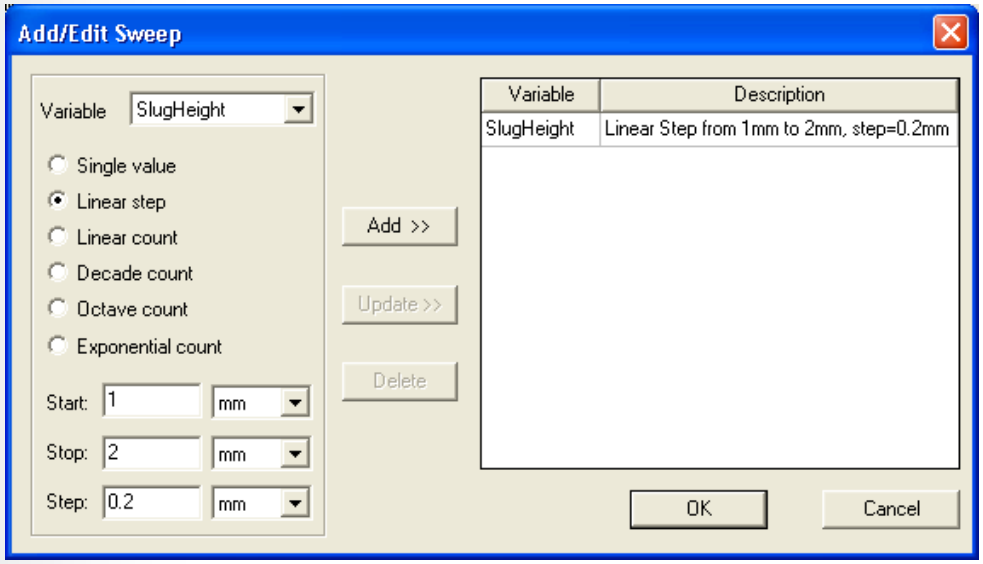
- **Plot Mag_B**
  - Expand the history tree for Planes and select the plane **Global:YZ**
  - Select the menu item ***Maxwell 3D → Fields → Fields → B → Mag_B***
  - In Create Field Plot window,
    1. Press **Done**



  - The results show about 0.2 Tesla field in the Center of the Slug which is well within the linear region of the BH curve for most steels

Parametric Sweep Setup

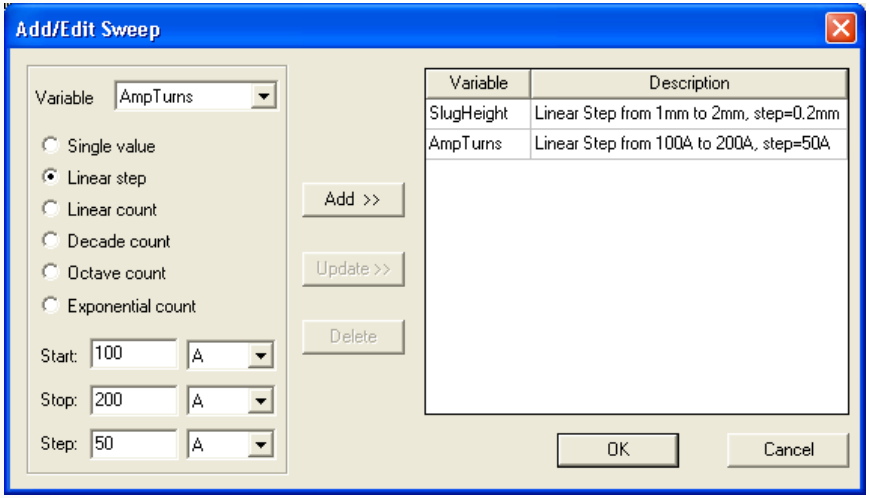
- **Launch Setup Sweep Analysis window,**
  - Select the menu item ***Maxwell 3D → Optimetrics Analysis → Add Parametric***
- **Add Parameter Sweep for SlugHeight**
  - In Setup Sweep Analysis window, select **Add**
  - In Add/Edit Sweep window,
    - Variable: **SlugHeight**
    - Linear Step: ☑ **Checked**
    - Start: **1mm**
    - Stop: **2mm**
    - Step: **0.2mm**
    - Select **Add**



Note: Do not close the Add/Edit Sweep window

Parametric Sweep Setup (*Contd…*)

- **Add Parameter Sweep for AmpTurns**
  - In Add/Edit Sweep window,
    - Change Variable to **AmpTurns**
    - Linear Step: ☑ **Checked**
    - Start: **100 A**
    - Stop: **200 A**
    - Step: **50 A**
    - Select **Add**
    - Press **OK** to close Add/Edit Sweep window

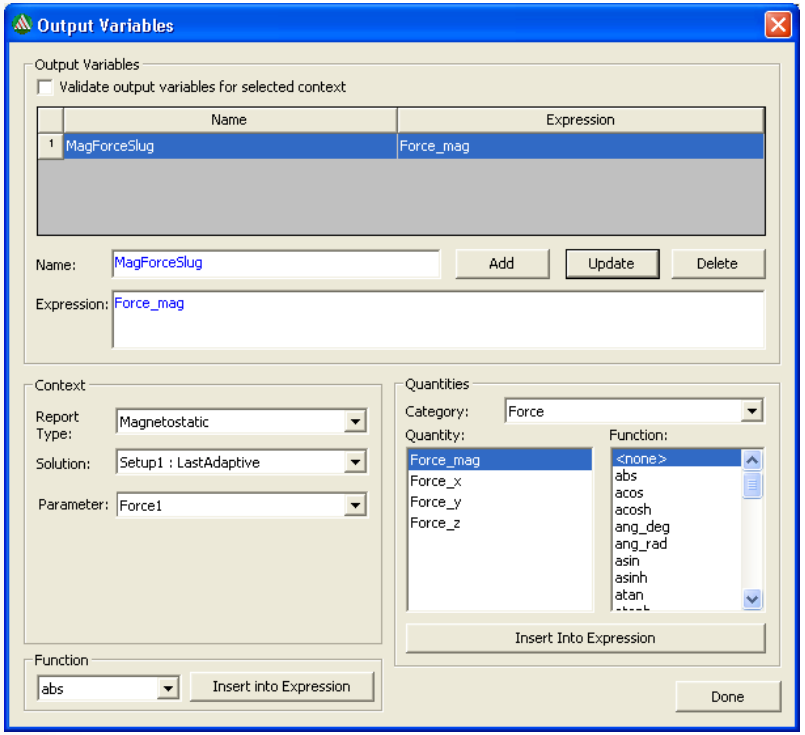


- **View Added Parametric Variations**
  - In Setup Sweep Analysis window,
    - Change tab to **Table** to inspect the combination of solutions that have been created. There should be 18 solutions since we defined 6 variations of SlugHeight and 3 variations of AmpTurns.

Note: Do not close the Setup Sweep Analysis window

Parametric Sweep Setup (*Contd…*)

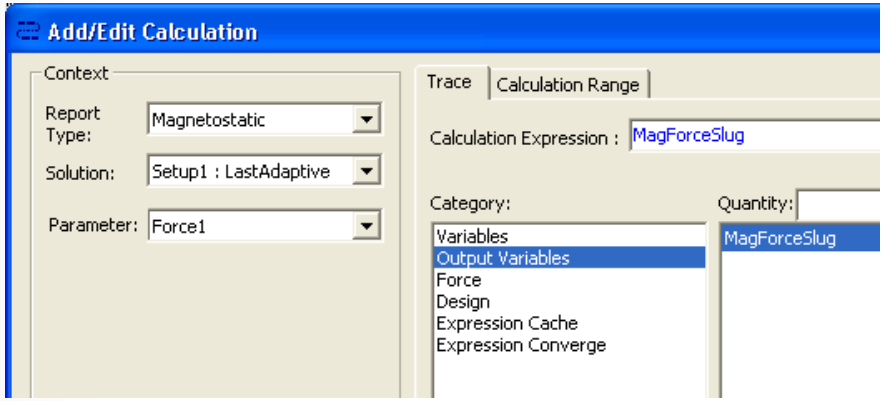
- **Setup Output Parameters: Create Output Variable**
  - In Setup Sweep Analysis window,
    - On **Calculations** tab, select **Setup Calculations**
    - In Add/Edit Calculation window, Select **Output Variables**
    - In Output Variables window,
      - Parameter: **Force1**
      - Category: **Force**
      - Quantity: **Force_mag**
      - Select **Insert Into Expression**
      - Name: **MagForceSlug**
      - Select **Add**
      - Select **Done**



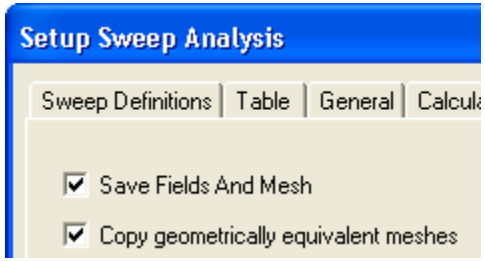
Note: You will now return to Add/Edit Calculations window. Do not close this window

Parametric Sweep Setup (*Contd…*)

- **Setup Output Parameters: Add Output Variable**
  - In Add/Edit Calculation window,
    - Parameter: **Force1**
    - Category: **Output Variables**
    - Quantity: **MagForceSlug**
    - Select **Add Calculation**
    - Select **Done** to close window

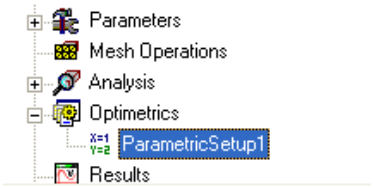


- **Setup Options**
  - In Setup Sweep Analysis window,
    - Select **Options** tab on Setup Sweep Analysis window
      - Save Fields and Mesh: ☑ **Checked**
      - Copy geometrically equivalent meshes: ☑ **Checked**
    - Click **OK** to close



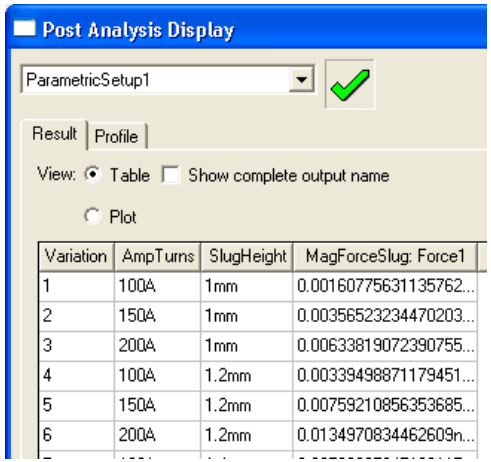
Solve the Parametric Setup

- **Solve Parametric Setup**
  - In Project manager window, expand the tree for **Optimetrics**
  - Right click on the tab **Parametric Setup1** and select **Analyze**



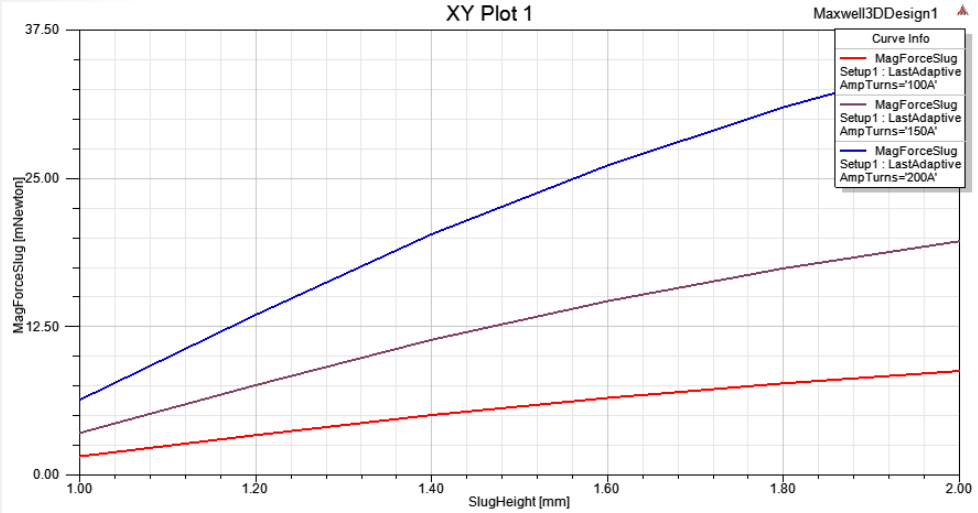
Note: the solving criteria is taken from the nominal problem, Setup1. Each parametric solution will re-mesh if the geometry has changed or the energy error criteria is not met as defined in Setup1.

- **View the Results of Parametric Sweep**
  - In Project manager window, expand the tree for **Optimetrics**
  - Right click on the tab **Parametric Setup1** and select **View Analysis Results**
  - In Post Analysis Display window,
    1. View: Select **Table** to view results in tabular form



Create XY Plot

- **Plot Force vs. AmpTurns vs. SlugHeight**
  - Select the menu item ***Maxwell 3D → Results → Create Magnetostatic Report → Rectangular Plot***
  - In Report window,
    1. Parameter: **Force1**
    2. Primary Sweep: **SlugHeight**
    3. X : **Default**
    4. Category: **Output Variables**
    5. Quantity: **MagForceSlug**
    6. Select the **Families** tab**:**
       - Ensure that that **AmpTurns** is selected as the Sweeps variable.
    7. Select **New Report**
  - The Plot should appear as shown in image
  - Right click on the plot and select export to export the data in text file



Create Data Table

- **Create a Table of SlugHeight, Force, and AmpTurns**
  - Select the menu item ***Maxwell 3D → Results → Create Magnetostatic Report → Data Table***
  - In Report window,
    1. Parameter: **Force1**
    2. Parametric Sweep: **SlugHeight**
    3. X : **Default**
    4. Category: **Output Variables**
    5. Qantity: **MagForceSlug**
    6. Select **New Report**

Data Table 1

	SlugHeight [mm]	MagForceSlug [mNewton] Setup1 : LastAdaptive AmpTurns='100A'	MagForceSlug [mNewton] Setup1 : LastAdaptive AmpTurns='150A'	MagForceSlug [mNewton] Setup1 : LastAdaptive AmpTurns='200A'
1	1.000000	1.607756	3.565232	6.338191
2	1.200000	3.394989	7.592109	13.497083
3	1.400000	5.086352	11.409835	20.284165
4	1.600000	6.527895	14.666419	26.073633
5	1.800000	7.757301	17.425473	30.978625
6	2.000000	8.792534	19.708633	35.037573