ANSYS

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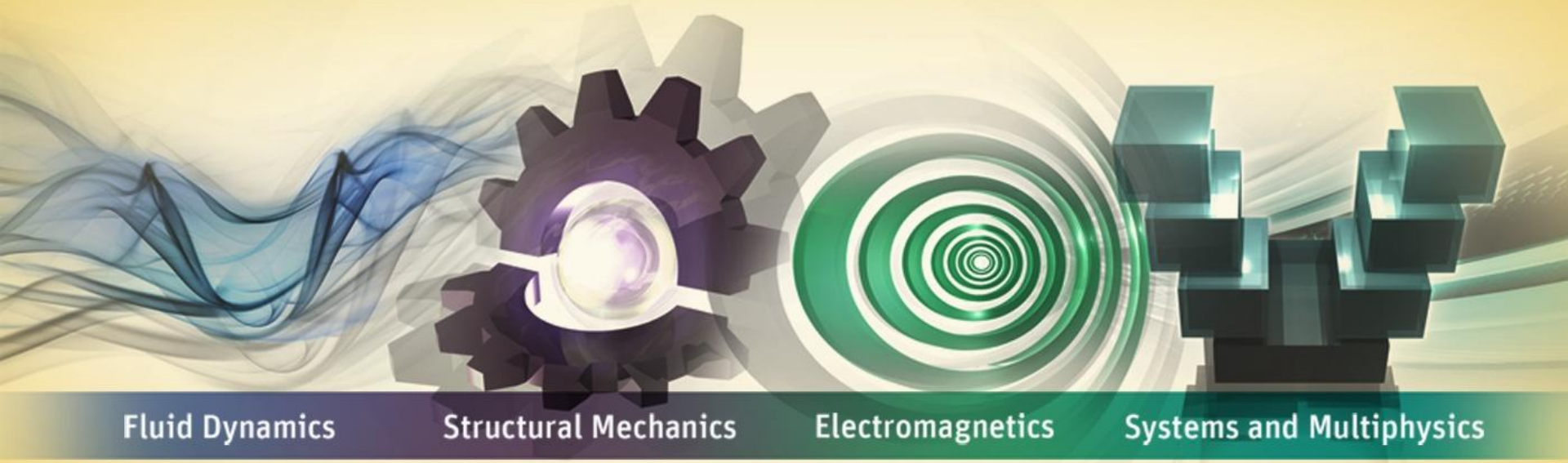
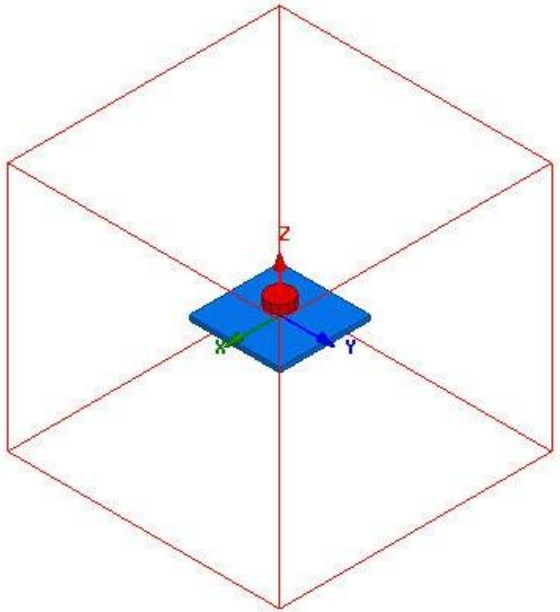
Workshop 11:
Basic Optimetrics Analysis



ANSYS Maxwell 3D V16

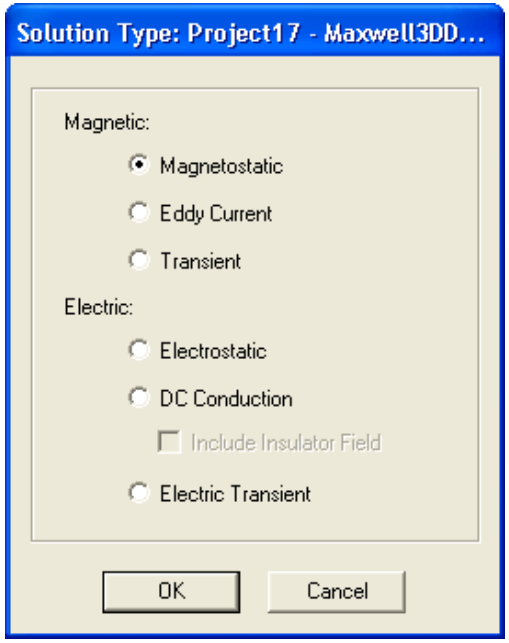
About Workshop

- **Puck Magnet Attractor**
  - Optmietrics is a powerful tool for obtaining optimized values of input parameters for minimum/maximum/required value of Output parameters
  - This example describes how to create and optimize a puck magnet producing an optimal force on a steel plate using the 3D Magnetostatic solver and Optimetrics in the ANSYS Maxwell 3D Design Environment.
  - The optimization obtains the desired force by varying the air gap between the plate and the puck using a local variable.



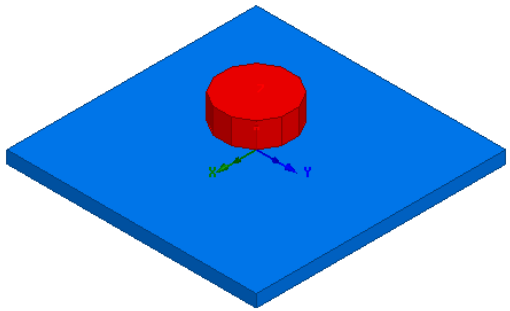
Problem Setup

- **Create Design**
  - Select the menu item ***Project → Insert Maxwell 3D Design***, or click on the icon
  - Change the name of the Design to **Puck_Attractor**
- **Set Solution Type**
  - Select the menu item ***Maxwell 3D → Solution Type***
  - Solution Type Window:
    1. Choose **Magnetic > Magnetostatic**
    2. Click the **OK** button



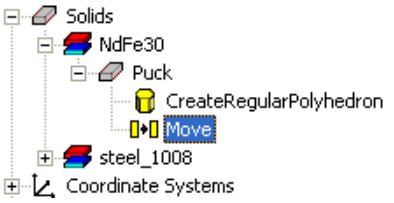
Create Geometry

- **Create Steel Plate**
  - Select the menu item ***Draw → Box***
    1. Using the coordinate entry fields, enter the position of box
       - **X: -10, Y: -10, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the opposite corner
       - **dX: 20, dY: 20, dZ: -1**, Press the **Enter** key
  - Change the name of the Object to **Plate**
  - Change the material of the Object to **steel_1008**
- **Create Puck**
  - Select the menu item ***Draw → Regular Polyhedron***
    1. Using coordinate entry fields, enter the center of the base
       - **X: 0, Y: 0, Z: 2**, Press the **Enter** key
    2. Using coordinate entry fields, enter radius and height
       - **dX: 2, dY: 2, dZ: 2**, Press the **Enter** key
    3. Number of Segments: **12**
  - Change the name of the Object to **Puck**
  - Change the material of the Object to **NdFe30**

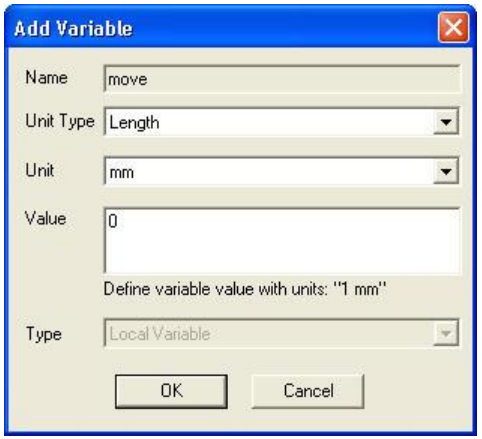


Create Parameter for Puck Motion

- **Create Puck Motion**
  - Select the Object **Puck** from the history tree
  - Select the menu item ***Edit → Arrange → Move***
    1. Using the coordinate entry fields, enter the reference point of move vector
       - **X: 0, Y: 0, Z: 0**, Press the **Enter** key
    2. Using the coordinate entry fields, enter the target point of move vector
       - **dX: 0, dY: 0, dZ: 0**, Press the **Enter** key
  - Expand the history tree for the Object **Puck**
  - Double click on the command **Move** from the tree
  - In Properties window,
    1. Move Vector: Specify as **0, 0, move**
    2. In Add variable window,
       - Unit Type: **Length**
       - Unit: **mm**
       - Value: **0**
       - Press **OK**
    3. Press **OK** to close Properties window

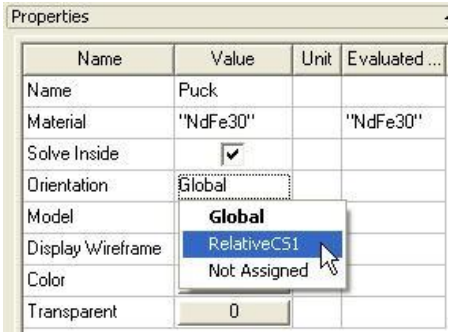


	Name	Value
	Command	Move
	Coordinate System	Global
	Move Vector	0mm ,0mm ,move



Create Relative Coordinate System

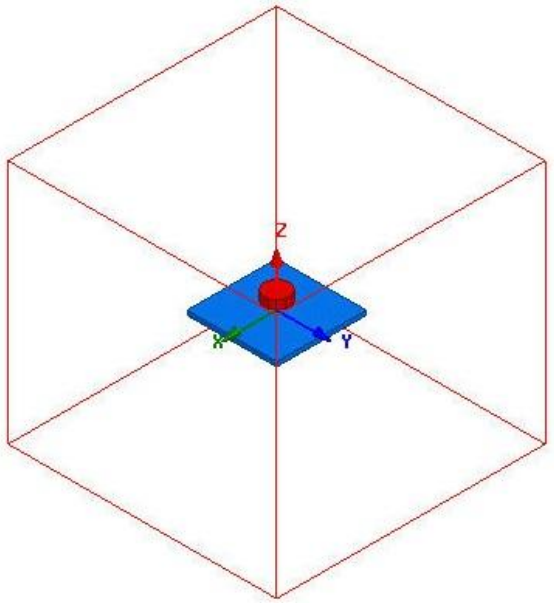
- **Create Relative Coordinate System**
  - Select the menu item ***Modeler → Coordinate System → Create > Relative CS → Rotated***
    1. Using the coordinate entry fields, enter the X axis
       - **X: 0, Y: 0, Z: 1**, Press the **Enter** key
    2. Using the coordinate entry fields, enter a point on XY Plane
       - **dX: 0, dY: 1, dZ: 0**, Press the **Enter** key
- **Assign Coordinate System to Puck**
  - Select the object **Puck** from the history tree and goto the properties window
  - Change the Orientation of the object to **RelativeCS1**



Note: In Maxwell, all magnetic materials are magnetized in X direction. In this step, we will change the direction of magnetization for puck by creating relative coordinate system.

Create Region

- **Change Work Coordinate System**
  - Select the menu item ***Modeler → Coordinate System → Set Work CS***
    1. Select the coordinate System **Global** from the list
    2. Press **Select**
- **Create Simulation Region**
  - Select the menu item ***Draw → Region***
  - In Region window,
    1. Padding individual directions: ☑ **Checked**
    2. Value:
       - +/- X = **100**
       - +/- Y = **100**
       - +/- Z = **500**
    3. Press **OK**

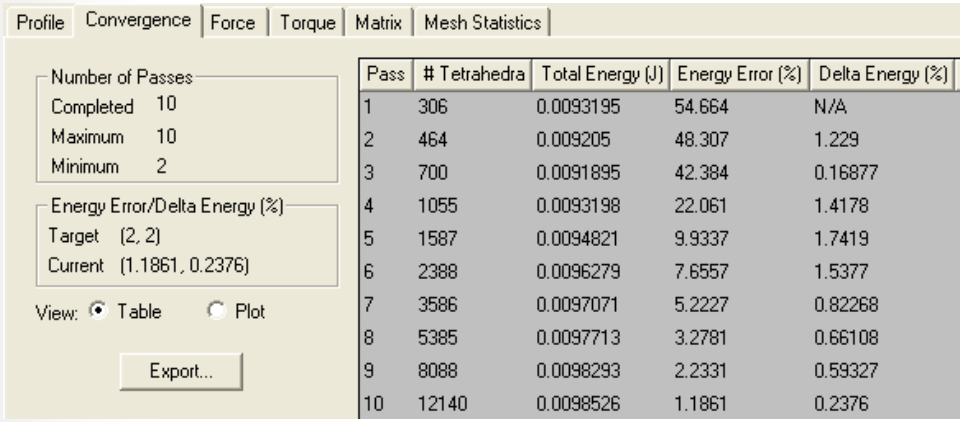


Assign Parameters Force

- **Assign Force Parameter**
  - Select the object **Plate** from the history tree
  - Select the menu item ***Maxwell 3D → Parameters → Assign → Force***
  - In Force Setup window,
    1. Name: **Force**
    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
       - Percentage Error: **2**
    2. Convergence tab
       - Refinement Per Pass: **50%**
- **Run Solution**
  - Select the menu item ***Maxwell 3D → Analyze All***

Solution Data

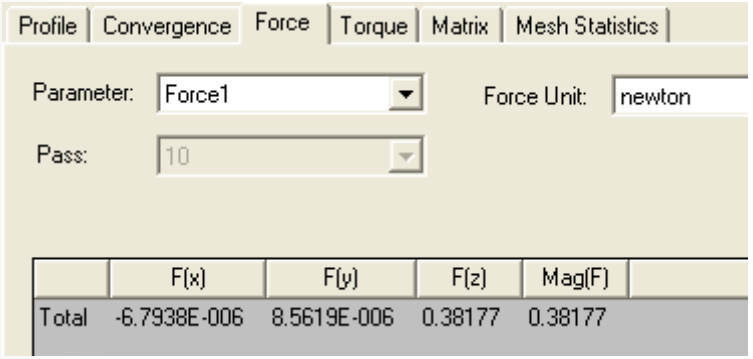
- **View the Solution Data:**
  - Select the menu item ***Maxwell 3D → Results → Solution Data***
    - To view the Profile:
      1. Click the **Profile** Tab.
    - To view the Convergence:
      1. Click the **Convergence** Tab



Pass	# Tetrahedra	Total Energy (J)	Energy Error (%)	Delta Energy (%)
1	306	0.0093195	54.664	N/A
2	464	0.009205	48.307	1.229
3	700	0.0091895	42.384	0.16877
4	1055	0.0093198	22.061	1.4178
5	1587	0.0094821	9.9337	1.7419
6	2388	0.0096279	7.6557	1.5377
7	3586	0.0097071	5.2227	0.82268
8	5385	0.0097713	3.2781	0.66108
9	8088	0.0098293	2.2331	0.59327
10	12140	0.0098526	1.1861	0.2376

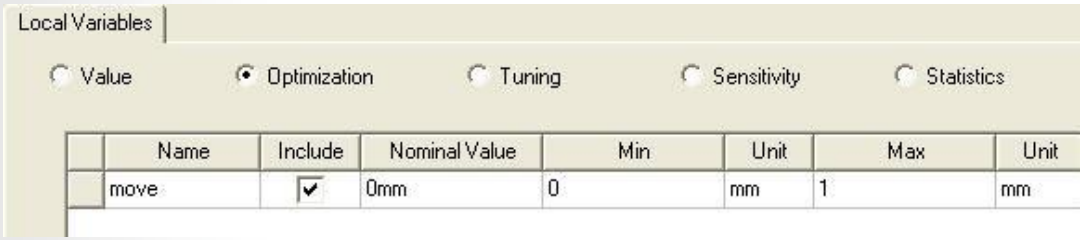
Note: The default view is for convergence is Table. Select the Plot radio button to view a graphical representations of the convergence data.

- To View Force values
  1. Click **Force** tab



Optimetrics Setup

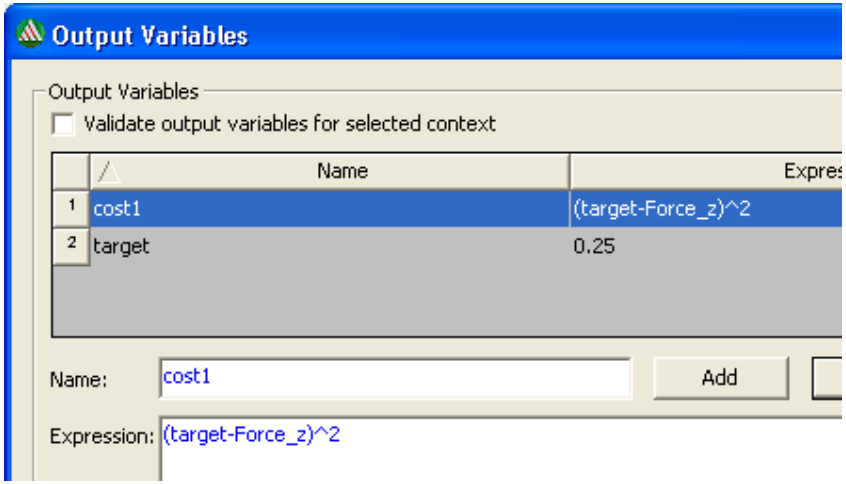
- **Optimetrics Setup**
  - It is possible to optimize position in order to obtain the specified force. For this optimization, the position will be varied to obtain a desired force of 0.25N.
- **Specify Parametric Variables**
  - Select the menu item ***Maxwell 3D → Design properties***
  - In Properties window,
    1. Optimization: ☑ **Checked**
    2. move:
       - Include: ☑ **Checked**
       - Min : **0 mm**
       - Max : **1 mm**
    3. Press **OK**



Note: Unless parameters are included in Optimization, they will not be available for Optimization Setup

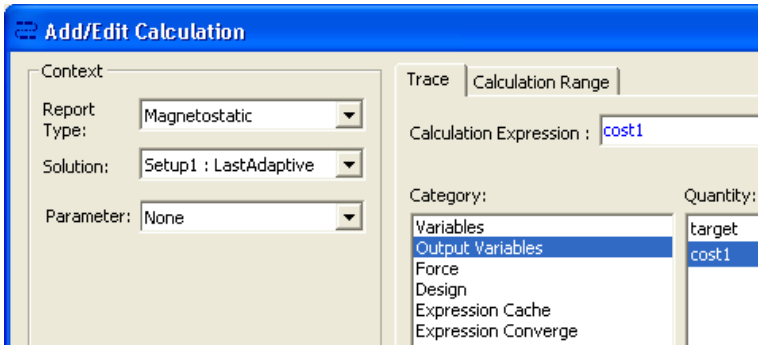
Optimetrics Setup (*Contd…*)

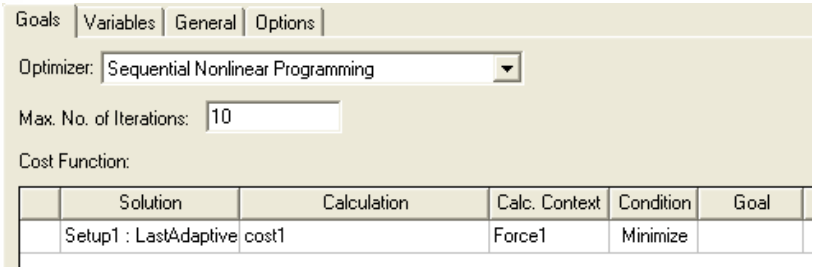
- **Setup Optmization**
  - Select the menu item ***Maxwell 3D → Optimetrics Analysis → Add Optimization***
  - In Setup Optimization window,
    1. Optimizer: **Sequential Nonlinear Programming**
    2. Max. No. of Iterations: **10**
    3. Select **Setup Calculations**
    4. In Add/Edit calculations window, select **Output Variables**
    5. In Output variables window,
       - Name: **target**
       - Expression: **0.25**
       - Select **Add**
       - Set name to **cost1**
       - Set Parameter to **Force1**
       - Expression: **(target – Force_z)^2**
       - Press **Add**
       - Press **Done**

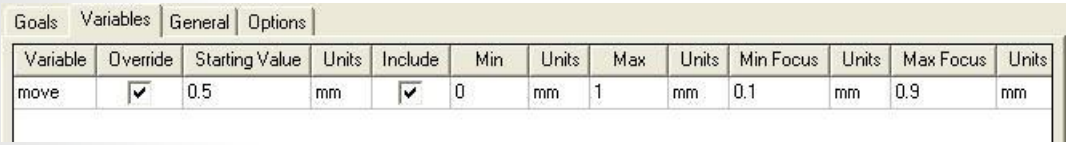


Optimetrics Setup (*Contd…*)

- **Setup Optmization *(Contd…)***
  6. In Add/Edit Calculations window,
     - Parameter : **Force1**
     - Category: **Output Variables**
     - Quantity: **cost1**
     - Select **Add Calculation** and **Done**
  7. Set Condition for **cost1** to **Minimize**
  8. Change the tab to **Variables**
  9. For the variable **move**
     - Starting value: **0.5mm**
     - Min: **0 mm**
     - Max: **1 mm**
     - Press **OK**





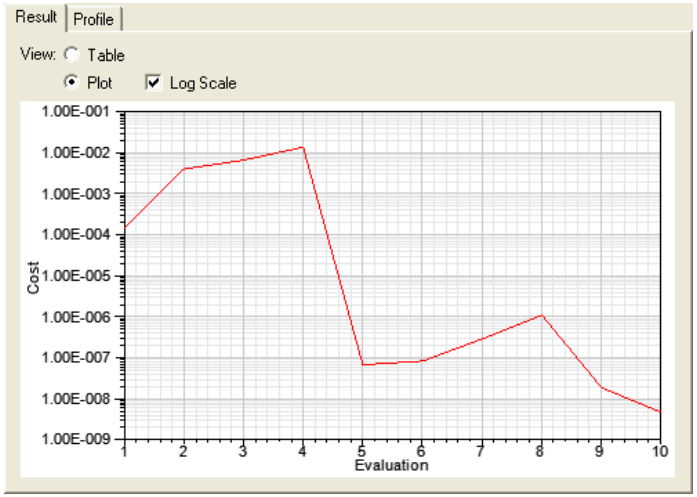


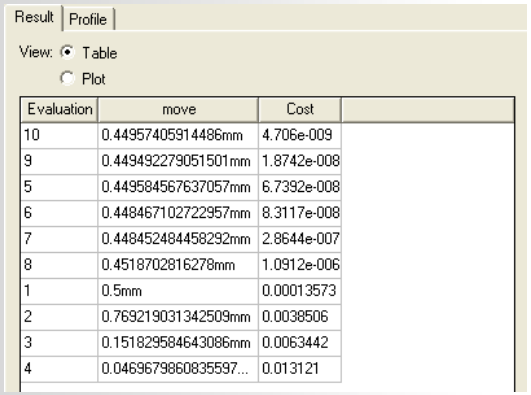
Note: Above Optimization Setup will vary move parameter in the range 0 to 1mm in order to minimize Cost1 which is difference between Target and Calculated value

Users can set min and max focus points on Variables tab if probable location of minima is know.

Run Optimization

- **Solve Optimization Analysis**
  - Expand the Project Manager tree to view **Optimetrics**
  - Right click on the tab **Optimization Setup1** and select **Analyze**
- **View Optimetrics Results**
  - Select the menu item ***Maxwell 3D → Optimetrics Analysis → Optimetrics Results***
  - In Post Analysis Display window,
    1. Log Scale: ☑ **Checked**
  - Change View to **Table** to see actual values
  - Minimum value comes at around **0.45mm**





Evaluation	move	Cost
10	0.44957405914486mm	4.706e-009
9	0.449492279051501mm	1.8742e-008
5	0.449584567637057mm	6.7392e-008
6	0.448467102722957mm	8.3117e-008
7	0.448452484458292mm	2.8644e-007
8	0.4518702816278mm	1.0912e-006
1	0.5mm	0.00013573
2	0.769219031342509mm	0.0038506
3	0.151829584643086mm	0.0063442
4	0.0469679860835597...	0.013121

Create Plot of Cost vs Move

- **Create Report**
  - Select menu item ***Maxwell 3D → Results → Create Magnetostatic Report → Rectangular Plot***
  - In Report window,
    1. Parameter: **Force1**
    2. X : **Default**
    3. Category: **Output Variables**
    4. Quantity: **cost1**
    5. Select **New Report**
- **Modify Plot Attributes**
  - Double click on **Y axis** of plot
  - In Properties window,
    1. **Scaling** tab
       - Axis Scaling: **Log**
       - Pres **OK**