SYMMETRY AND PERIODICITY

You can create two-dimensional or rotationally symmetric (RS) models. Both of these types reduce a three-dimensional design into a two-dimensional model. The program requires only a cross-section of a model in order to calculate the solution. Modeling the cross-section greatly reduces both the modeling and solution time.

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SYMMETRY AND PERIODICITY

Tech Tips:

Symmetry

You can create two-dimensional or rotationally symmetric (RS) models. Both of these types reduce a three-dimensional design into a two-dimensional model. The program requires only a cross-section of a model in order to calculate the solution. Modeling the cross-section greatly reduces both the modeling and solution time.

Defining Symmetry

Before you create geometry, study the model for symmetry conditions so that you can avoid entering geometry and parameters that are not required for the solution.

Defining Periodicity

Defining the periodicity specifies how the basic unit repeats to form the entire model. The periodicity can be Rotational or Linear in nature.

Angular Periodicity

In many devices, the geometry and sources occur in a periodic pattern around some point in the geometry.
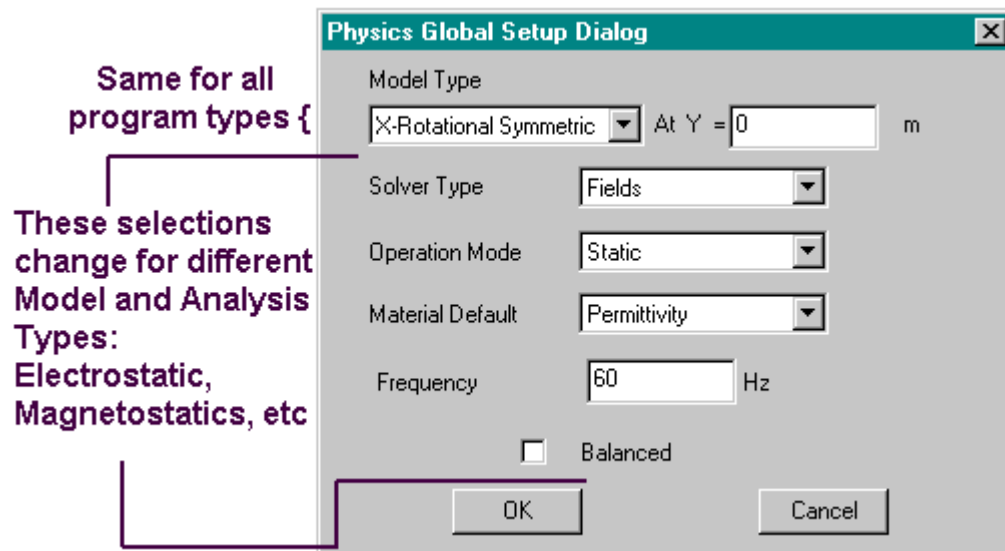
Linear Periodicity

The linear periodicity option allows you to truncate models containing a basic unit that repeats in a linear pattern.

Defining the Type of Model

There are three different settings for the type of model.

- You can define the geometry of a model as two-dimensional or rotationally symmetric (about the X or Y axis)

You can define all of these types using the Physics Global Dialog, shown below.

Same for all program types {

These selections change for different Model and Analysis Types: Electrostatic, Magnetostatics, etc

Physics Global Setup Dialog

Model Type

X-Rotational Symmetric At Y = 0 m

Solver Type Fields

Operation Mode Static

Material Default Permittivity

Frequency 60 Hz

☐ Balanced

OK   Cancel

Setting the Type of Geometry

In the PROGRAM, you can create two-dimensional or rotationally symmetric (RS) models. Both of these types reduce a three-dimensional design into a two-dimensional model. The PROGRAM requires only a cross-section of a model in order to calculate the solution, as the fields only vary slightly in the 'ignored' dimension. Modeling the cross-section greatly reduces both the modeling and solution time.

The following table summarizes the three model types:

Type	Effect on Solution
Two-D (two dimensional)	Assumes that the field quantity changes in the x-y plane but not in the third (z) direction. The solution describes the variation of fields in the x-y directions.
X Rotation (symmetric about a line parallel to the x-axis)	The solution is independent of the angular coordinate. Field quantities vary only in the r-z plane. The solution at one value of the angular coordinate describes the full three-dimensional mode.
	The RS (r=0) axis is parallel to the x-axis. Create all of the geometry above the axis of symmetry. The PROGRAM ignores any geometry below the symmetry axis.
Y Rotation (symmetric about a line parallel to the y-axis)	Same as X Rotation, except that the RS (r=0) axis is parallel to the y-axis and the geometry must be to the right the axis of symmetry. The PROGRAM ignores any geometry to the left of the axis.

To set the type of model:

1) From the Physics menu, select Physics Global Settings. This displays the Physics Global Dialog.

2) In the first field of the Model Type section, select Two-D, X Rotation or Y Rotation as the type.

3) For X or Y Rotation, enter the location of the rotation axis in the Y= or X= fields.

4) Click OK to set the type and close the Physics Global Dialog.

Defining Symmetry conditions

If a model is symmetric about one or more planes, you can define symmetry conditions to reduce the size of the model and the time and hard disk space required to obtain a solution. Before you create geometry, study the model for symmetry conditions so that you can avoid entering geometry and parameters that are not required for the solution. The following sections describe how to determine if your model has symmetry, what kind of symmetry condition you should assign and how to assign the condition.

Determining if your model has symmetry

The primary requirement for using a symmetry condition in a design is that the geometry and the materials should have mirror symmetry about one or more of the principal planes.

If you want to use a symmetry or anti-symmetry condition, you must confine the model definition to a specific region, decided by the principal planes of symmetry. Suppose $X = 0$ is the plane of symmetry. You cannot define the model in the region $X < 0$, only in the region $X \, ³ \, 0$.

### Deciding between Symmetry and Anti-symmetry conditions

There are two types of symmetry conditions: symmetric and anti-symmetric. Once you determine that the geometry and materials have one or more symmetric planes, examine the direction of current sources and permanent magnets to decide if you should classify the design as symmetric or anti-symmetric. The symmetry or anti-symmetry condition specifies how the program calculates the interaction of fields at the symmetry planes. Depending on the direction of sources, you may not be able to assign a symmetry or anti-symmetry condition even if mirror symmetry exists in the geometry and materials.

Symmetry in Sources

To decide if symmetry or anti-symmetry exists due to sources, simply examine the sources on both sides of the symmetry plane. To use either type, the sources must have the same magnitude on both sides of the symmetry plane. The direction of the sources dictates what type of condition you should use.

If the sources run…	use this type of condition
in the same direction on either side of the symmetry plane	symmetry condition
in opposite directions on either side of the symmetry plane	anti-symmetry condition

The following figures illustrate symmetry and anti-symmetry in sources:

Symmetry

Anti-symmetry
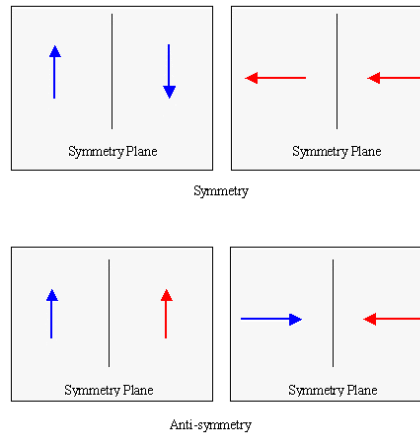
Defining a Symmetry Condition

Once you create the basic geometry unit and assign any required physical properties, you can define the model as symmetric and then solve the model.

> Do not assign elements to surfaces that fall on the planes of symmetry. Consider these surfaces 'artificial' and assume that they do not represent a true material interface.

The Physics Global Dialog, shown below, allows you to set symmetry and anti-symmetry conditions about one or more principal planes.
To define a symmetric model:

1) Open the Symmetry and Periodicity box from the Physics menu.

2) From the list of Symmetric and Periodic Conditions, select Symmetric

3) Select one plane of symmetry or anti-symmetry from the box under the word About.
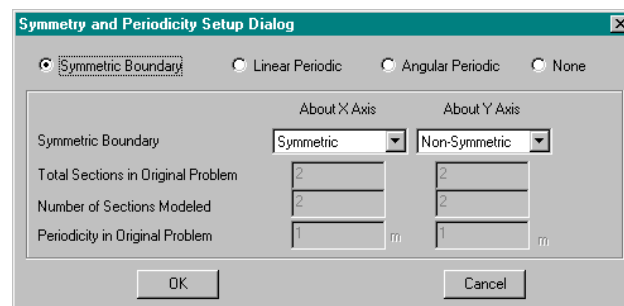
4) Select Symmetric or Anti-Symmetric from the list of available symmetry conditions, depending on the type of symmetry that exists about the plane specified in step 3.

5) Repeat steps 3 and 4 for any additional planes of symmetry.

Perform the analysis for a symmetric model just as you would for a non-symmetric model. You can do post processing in any part of the window space regardless of where truncations occur, although keeping field plots close to the defined geometry regions makes it easier to reference the plots to the model.

Defining Periodicity in a Model

Angular Periodicity

In many devices, the geometry and sources occur in a periodic pattern around some point in the geometry. Consider the structure below. One quarter of the geometry repeats itself in a periodic pattern about the center and the sources also repeat in a similar manner.
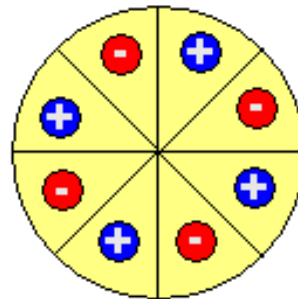

Angular Periodic Structure

The polarity of the sources alternate between **+** and **-**. This is an "anti-periodic" condition. If all of the sources were the same, the structure would illustrate a periodic condition. You can dramatically reduce the design and solution time for a periodic or anti-periodic device if you create only the basic repeating unit, rather than the entire model. The PROGRAM can solve the entire model using only this basic unit.
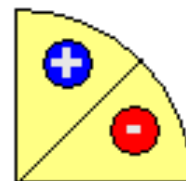
Creating a periodic model

To create a periodic model, examine the device to determine the periodic sections. The only geometry that you require is the basic repeating unit. The required geometry for the structure is:

Basic Repeating
Unit
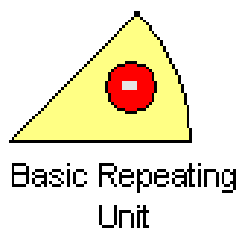
Basic Repeating
Unit

*The basic unit required to solve an Anti-Periodic model*

The basic unit required to solve a Periodic model.

The different periodic sections can take any rotation with respect to each other and still create valid geometry for the solution. This is an important feature if you want to study effects of shifts in position using the PROGRAM Parametrics feature.

Once you have the required geometry, assign physical properties to this geometry. Do not assign boundary elements until you define the periodicity.

Defining the Periodicity

Defining the periodicity specifies how the basic unit repeats to form the entire model. You define periodicity using the Symmetry and Periodicity Setup, shown:
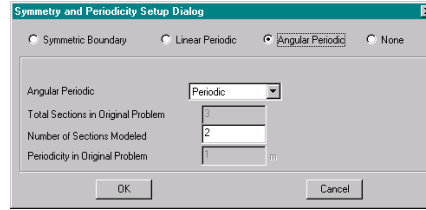
To define the periodicity for a model:

1) From the Physics menu, select Symmetry and Periodicity Setup.

2) Select the Symmetry and Periodicity type by selecting one of the "Radio" buttons.

3) Change the Periodicity setting to Non-Periodic, Periodic or Anti-Periodic, depending on the type of periodicity in the model.

4) In the Sections field, enter the total number of sections in the model. The number of sections multiplied by the angular span of each section should equal exactly 360 degrees.

5) Click OK to apply these settings and close the Symmetry and Periodicity Setup dialog.

The example in the previous pages is anti-periodic about the z-axis (the axis perpendicular to the plane of the screen) and contains four sections.

Defining the Periodic Segments

Once you define the periodicity, you must define the segments that you added in order to truncate the model. These segments do not represent true interfaces.

To define the periodic segments:

1) From the Boundary Conditions menu, select Periodic.

2) Select all of the segments that you added in order to truncate the geometry.

3) Press the right mouse button to assign a periodic condition to the selected segments.
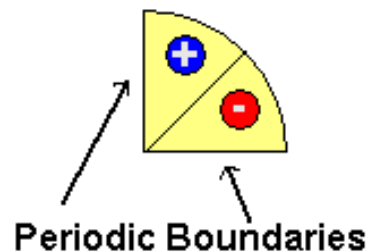
Periodic Boundaries

Linear Periodicity

The linear periodicity option allows you to truncate models containing a basic unit that repeats in a linear pattern. In the figure below, a basic unit repeats linearly along the x-axis. The solution for a given unit does not deviate significantly from the solution for any other unit, so you can use a small section to find the solution for the complete model. Rather than modeling the entire design, create the basic unit and then define a linear periodicity condition.
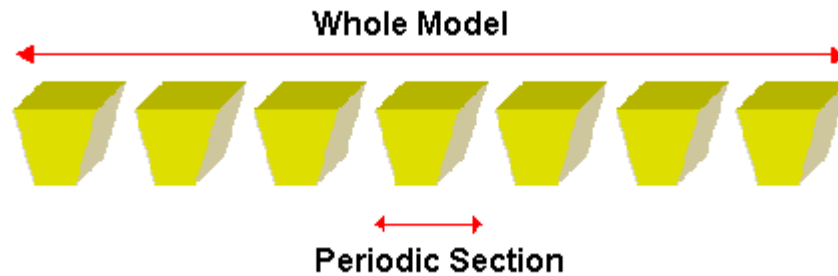
The total number of periodic sections must be fairly large in order to generate an accurate solution from the basic unit. The examples in this section do not represent a sufficiently large number of periodic sections.

There are two types of linear periodicity. You can define a periodic or anti-periodic condition. The type of condition depends on the nature of the source. If the sources repeat with the geometry, as shown, define a linear periodic condition.
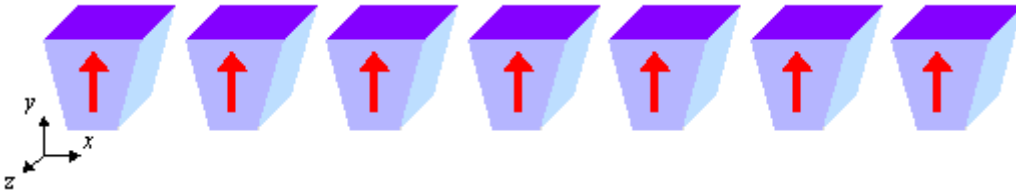

If the sources or boundary conditions alternate in each unit of the model, as shown, you can use an anti-periodic condition. This condition reverses the source or boundary conditions direction, with every new unit.


For any linear periodic condition, you must model an odd number of units. The accuracy of the solution improves with the number of units that you model. For linear periodicity, you do not need to model more than one unit. For an anti-periodic condition, model a minimum of three units for an accurate solution.

Some models exhibit linear periodicity in the geometry, but you cannot define a periodic condition due to the nature of the sources or boundary conditions. In the figure below, the geometry repeats along the x-axis, but there is no pattern in the source. For this type of model, you must create the entire model.
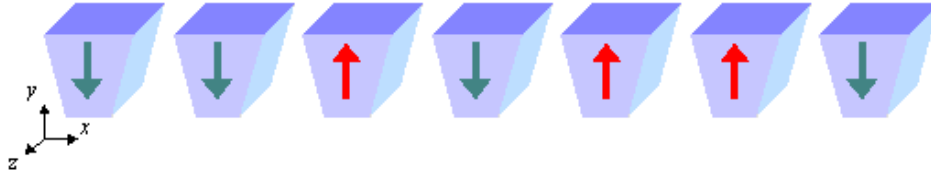
Model exhibiting periodicity in the geometry but not in the sources.

These examples all exhibit periodicity along only the x-axis. You can define a periodic condition about either the x-axis or y-axis. The condition on each axis can be periodic or anti-periodic, depending on the nature of the sources and boundary conditions along that axis. You can also use a linear periodicity condition to break a very long structure into a shorter, more manageable unit, as shown.
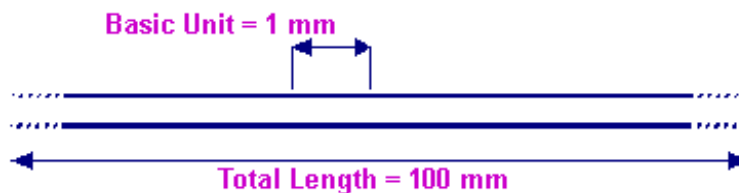
Using a linear periodic condition to model a small section of a large object

Once you determine the type of periodicity displayed by the model, truncate the model to the basic repeating unit and assign the required physical properties.

Defining Linear Periodicity

Defining the periodicity specifies how the basic unit repeats to form the entire model. You define Linear periodicity using the Symmetry and Periodicity Setup dialog, shown below:

To define a linear periodic model:

1) Select Symmetry and Periodicity Setup from the Physics menu to display the dialog.

2) Select the Linear Periodic Radio Button.

3) Select Periodic or Anti-Periodic from the list of periodic conditions.

4) In the Number of Sections Modeled box, enter the number of units that you created. This number must be odd.

5) In the Total Sections in Original Problem box, enter the total number of repeating units in the complete model.

6) In the Periodicity in Original Problem box, enter the length of the repeating unit along the selected axis.

Analyzing a Periodic Model

Symmetric, Angular Periodic, and Linear Periodic conditions cannot be mixed together. In a given model, you can define only one of the three conditions. For example, If you have symmetric conditions set, and you need to change to an Angular Periodic condition, you must reset the symmetric condition.

Once you define the symmetry or periodicity, you must define the segments that you added in order to truncate the model. These segments do not represent true interfaces.

To define the symmetric or periodic segments:

1) From the Boundary Conditions menu, select Symmetric or Periodic.

2) Select all of the segments that you added in order to truncate the geometry.

Press the right mouse button to assign conditions to the selected segments.

Do not assign boundary elements to the segments that contain a symmetric or periodic boundary condition.

Perform the analysis for a periodic model just as you would for a non-periodic model. You can do post processing in any part of the window space regardless of where truncations occur, although keeping field plots close to the defined geometry regions makes it easier to reference the plots to the model

You can perform post processing in any part of the window space, regardless of where you truncated the model. Plots are more easily referenced to the device if you keep them close to the defined geometry.