MAGNETISM 3D

version 2.1

For WINDOWS

User Guide

Physics Curriculum & Instruction

MAGNETISM 3D
version 2.1

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System Requirements
Windows 10 / 11

Technical Support
If problems are encountered installing or using MAGNETISM 3D software, or if you have questions or comments, please contact:
support@PhysicsCurriculum.com

INTRODUCTION

Magnetism 3D is an interactive software program that allows students to study magnetic fields using a variety of stunning visualization methods. *Magnetism 3D* utilizes colorful two-dimensional and three-dimensional graphics to display magnetic field lines for current-carrying straight wires, current-carrying wire loops, solenoids, and permanent magnets.

The three-dimensional graphics can be rotated in space about multiple axes for a true 3D perspective! The user is provided with a wide variety of simple to use tools that permit any desired configuration comprised of any number of objects to be created on-screen. Simply click the desired object from the toolbar, input the chosen parameters, and position the object on-screen.

Software Features:

- View 2D & 3D magnetic field lines.
- Choose from a variety of magnetic field generating objects that may be used in any combination including: current-carrying straight wires, current-carrying wire loops, solenoids (with or without an iron core), and permanent magnets.
- All objects can be customized by inputting values such as current, length, radius, loops per centimeter . . .
- View options include: 3D space, 3D topographic mapping, 2D surface, 2D color-coded mapping & linear integral convolution, and 2D iron filings.
- Option to display on-screen magnetic field vectors indicating individual contributions from various objects and net magnetic field for any location.
- Numeric display indicates strength of magnetic field at any location.
- Option to display the path of a charged particle as it moves under the influence of the magnetic field. Select the particle's charge/mass ratio and velocity.
- Capability to explore Ampere’s law by drawing a closed path with the amount of current passing through the enclosed surface automatically calculated.
- Designed for both high school and college physics courses.

INSTALLING *ELECTROSTATICS 3D* SOFTWARE

INSTALLATION

Double-click on the **Magnetism3D ver21 Install.exe** file. The on-screen instructions will guide you through the complete installation.

RUNNING THE PROGRAM

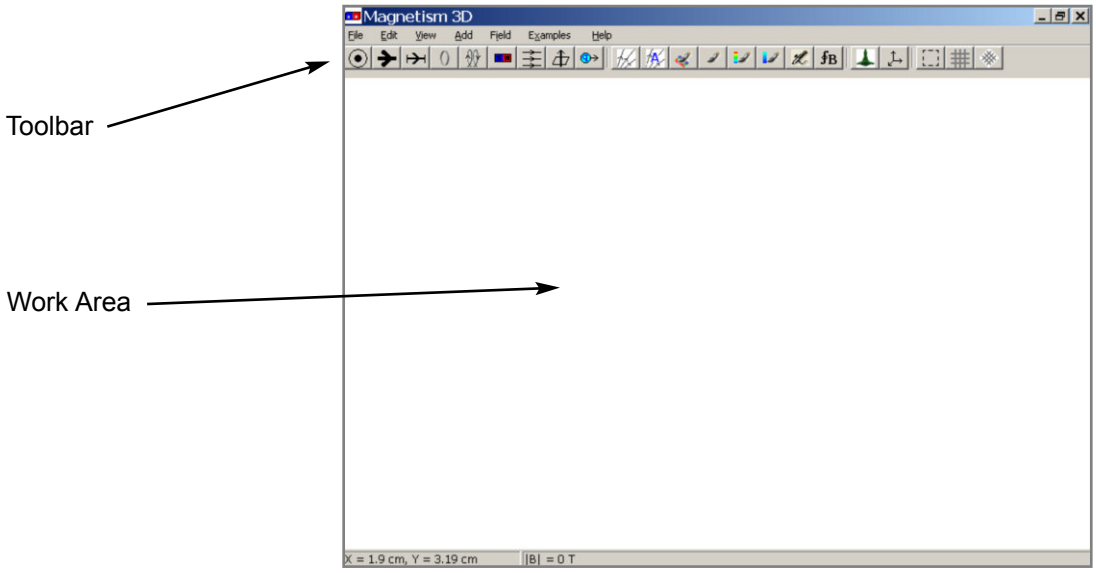
Launch *MAGNETISM 3D* by selecting it from the Windows Start menu.

LAB PACK / NETWORK INSTALLATION

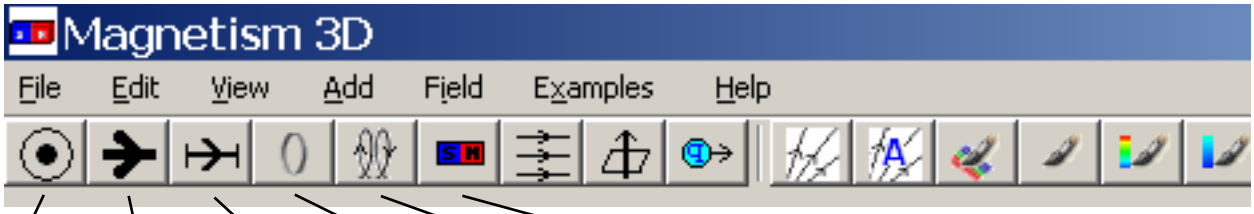
For those schools purchasing a Lab-Pack License, *MAGNETISM 3D* may be run on multiple computers at one building or one campus as specified by the license agreement. The software may be installed on a network, provided that the number of computers running the software at any given time does not exceed that specified in the license agreement. The software may also be installed on stand-alone computers, provided that the number of computers with installed software does not exceed that specified in the license agreement.

Magnetism 3D Tutorial

When *Magnetism 3D* is started up, you are presented with the 2D environment. Magnetic field producing objects are selected and edited in this environment. The toolbar at the top of the screen allows you to work with a variety of magnetic field producing objects that can be freely arranged into any desired configuration in the work area.



2D Environment



Toolbar

Adds **Unlimited Vertical Wire** perpendicular to work area plane.
User Inputs:
Current

Adds **Unlimited Horizontal Wire** in the same plane as work area.
User Inputs:
Current

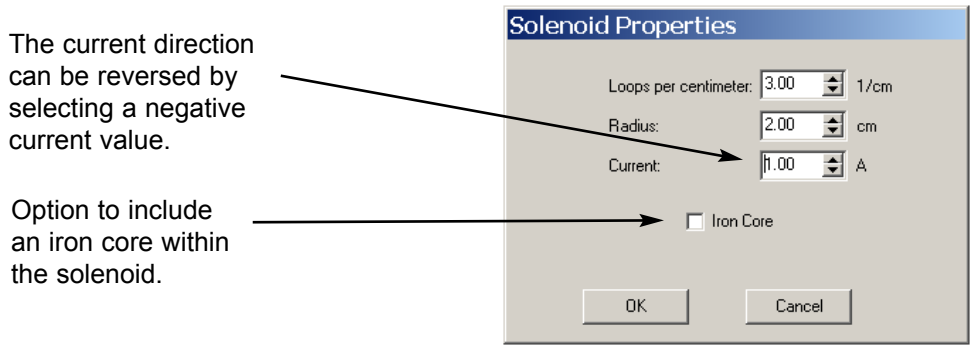
Adds **Limited Horizontal Wire** in the same plane as work area.
User Inputs:
Current
Wire Length

Adds **Vertical Wire Loop** perpendicular to work area plane.
User Inputs:
Current
Radius

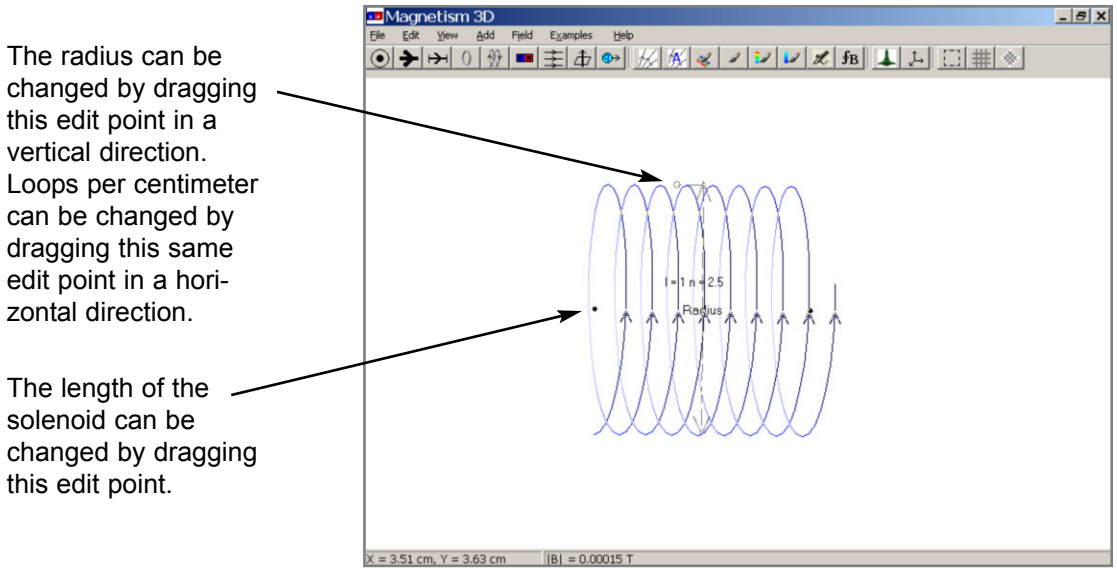
Adds **Solenoid** to work area.
User Inputs:
Current
Radius
Loops/cm
Iron Core option

Adds **Permanent Magnet** to work area.
User Inputs:
Magnet Strength
Height
Length

1) In this tutorial, we are going to work with the solenoid. Click on the *Solenoid* button on the toolbar. The solenoid appears in the work area at the location of the cursor. Move the cursor to position the solenoid in the middle of the work area and click to anchor it at this location. A dialog box opens up allowing you to input the solenoid properties of *loops per centimeter (wire windings per centimeter)*, *radius*, *current,* and whether or not to include an *iron core*. Accept the default values, except deselect the iron core for now and click *OK*.



2) The solenoid's properties can also be modified by clicking on the solenoid (so that it is selected) and dragging one of the edit points:



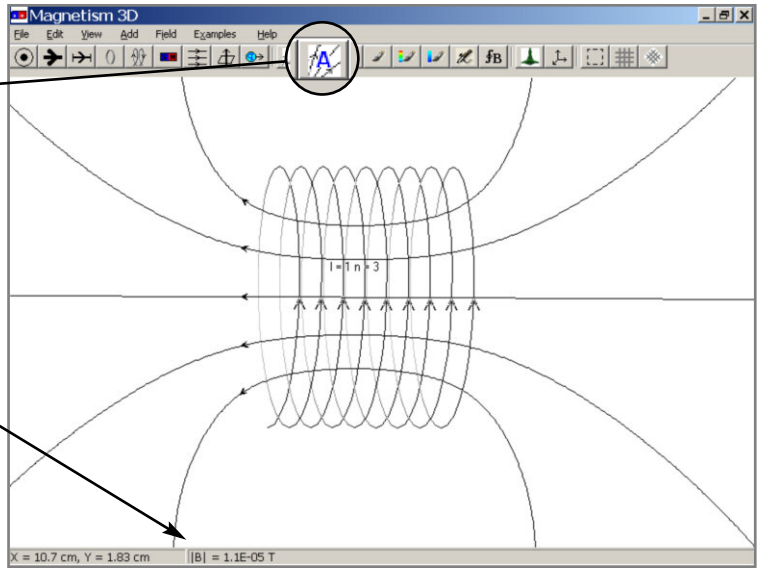
Modifying a solenoid in the 2D environment

3) Once placed in the work area, the solenoid can be moved simply by clicking on it and then holding down the mouse button while dragging. Right-clicking on the solenoid yields a drop-down list allowing you to change its properties or delete it from the work area.

4) Magnetic field lines can be automatically displayed by clicking on the *Draw Automatic Field Lines* button. The density of the automatic field lines can be changed by clicking *Field* on the overhead menu, then selecting *Automatic Field Line Density* from the drop-down list. Also, note that at the bottom of the screen the magnitude of the magnetic field is numerically displayed for the present location of the cursor.

Magnetic field lines can be automatically drawn by clicking on the *Draw Automatic Field Lines* button on the toolbar.

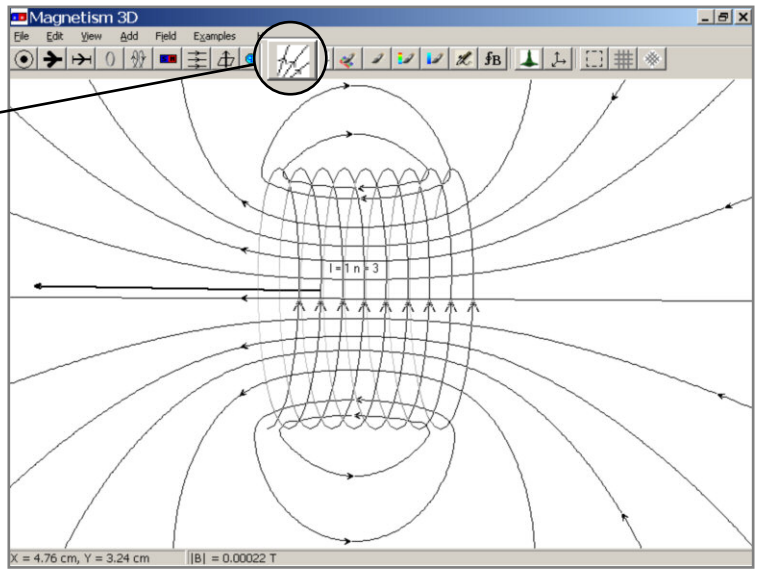
The strength of the magnetic field at the location of the cursor is displayed at the bottom of the screen along with the cursor's x-y coordinates.



Automatic magnetic field lines in 2D Environment

5) Additional field lines may be added at any selected location. Click on the *Draw Magnetic Field Lines* button on the toolbar, and then click a desired location in the work area to add a field line at that point. Whenever the *Draw Magnetic Field Lines* button is selected, vectors are displayed at the cursor location showing the net magnetic field and also individual field contributions if multiple objects are involved. By moving the cursor, the magnetic field vector can be displayed for any point in the work area.

By clicking on the *Draw Magnetic Field Lines* button, additional field lines may be added at any selected location. Magnetic field vector(s) are also displayed at the present cursor position.



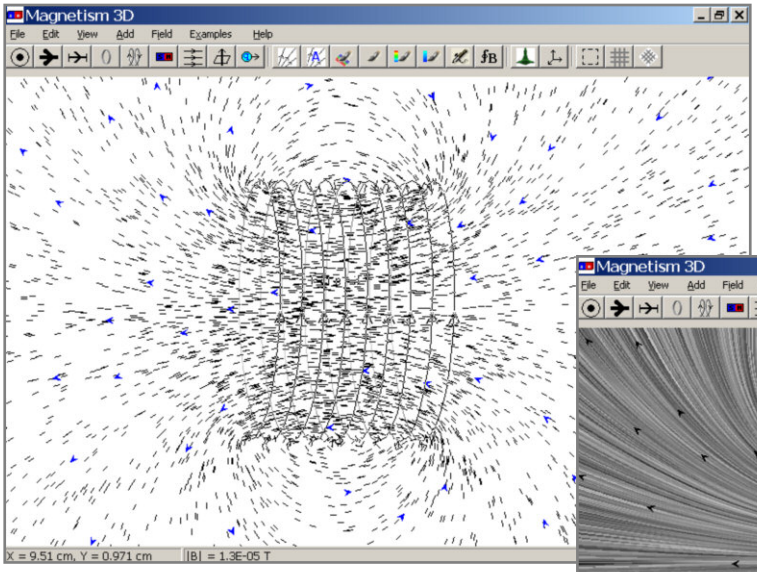
Adding additional field lines in 2D environment

6) By default, the magnetic field lines have white pulses moving through them indicating the direction of the magnetic field. This feature can be turned off by clicking *View* on the overhead menu, and then selecting *Sparkles* from the drop-down list. The speed of the pulses can be changed by selecting *View >> Sparkles Speed*. Magnetic field lines may be cleared from the work area by selecting *Edit >> Clear B Lines*.

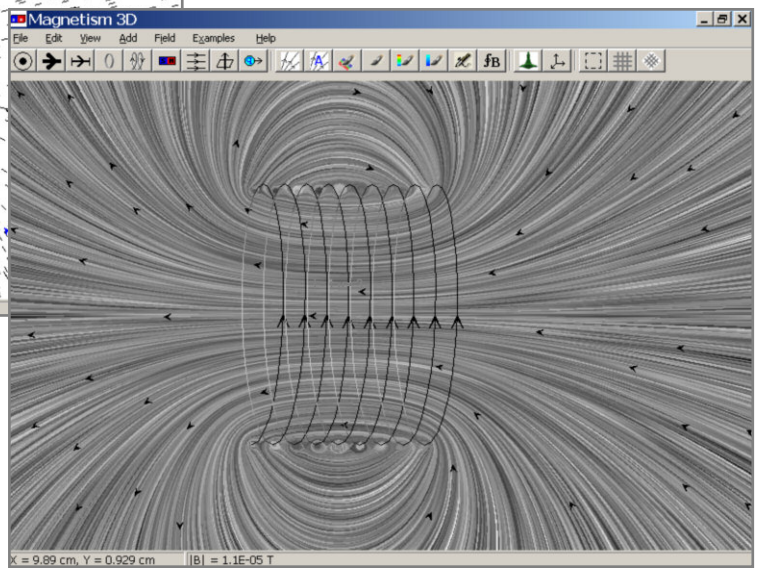
7) In addition to field lines, several other magnetic field visualization methods may be viewed in the 2D environment. These visualization methods may be selected from the toolbar and include:
i. Colored Continuous Field Lines (Linear Integral Convolution)
ii. Non-Colored Continuous Field Lines (Linear Integral Convolution)
iii. Magnetic Field Intensity Shown by Different Colors
iv. Magnetic Field Intensity Shown by Shades of Blue
v. Iron Filings

i. *ii.* *iii.* *iv.* *v.*

8) Visualization methods may be cleared from the work area by selecting *Edit >> Clear B Lines*. On slower computers, some visualization methods may take a considerable amount of time to render. In these instances, the process can be sped up by limiting the rendering to a smaller selected area. Click on the *Region of Interest* button on the right side of the toolbar, then drag out a rectangular region in the work area that you wish to have rendered.



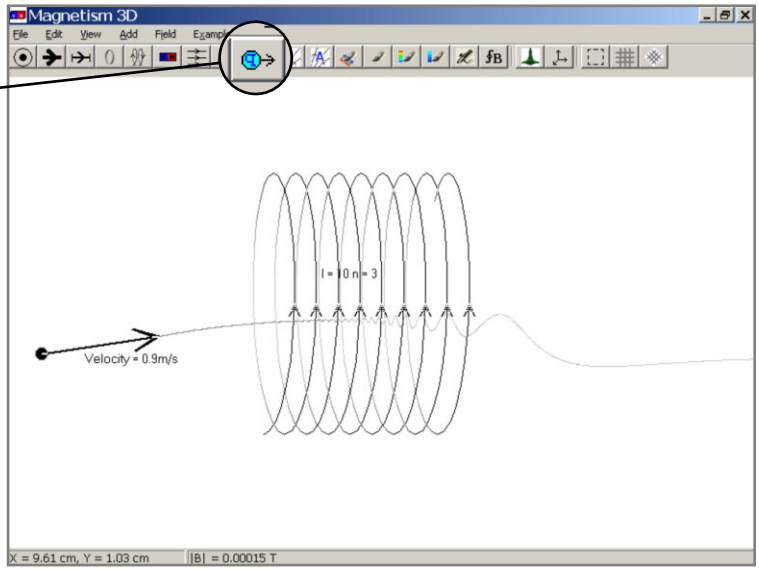
Iron Filings visualization method



Non-colored Continuous Field Lines visualization method

9) To observe how the magnetic field influences the motion of a charged particle, select the *Add Charged Projectile* button from the toolbar. After inputting the charge/mass ratio and clicking *OK,* position the cursor anywhere in the work area and then hold down the mouse button while dragging out the initial velocity vector of the charged particle. Both the direction and magnitude of the velocity vector can be established. The motion path of the particle will be drawn upon release of the mouse button. To clear the path, select *Edit >> Clear Charged Projectiles*. In some cases, the charged particle traces out a helical motion path. This path is best observed in the 3D environment which will be discussed in the next section.

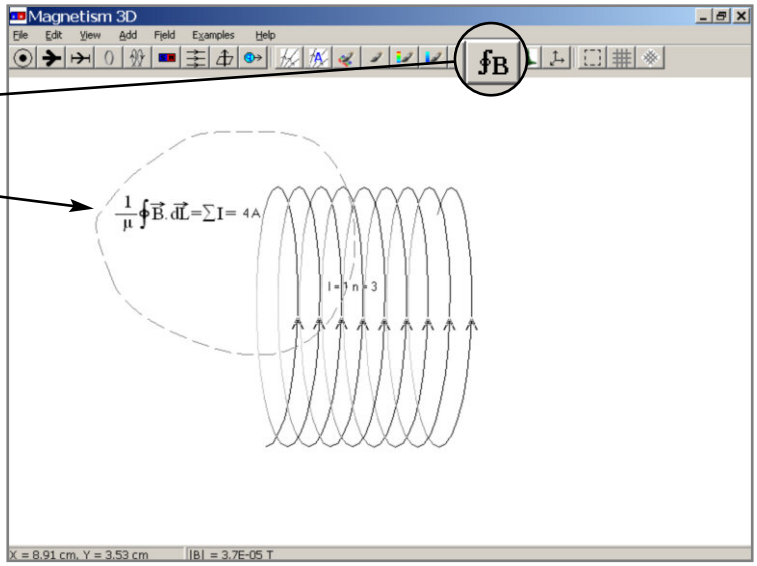
By clicking on the *Add Charged Projectile* button, the path of a charged particle moving through the magnetic field can be observed. (In this screen image, the solenoid's current has been increased to 10 A.)



Path of a charged projectile in 2D Environment

10) Ampere's Law can be explored by selecting the *Path Tool for Ampere's Law* button from the toolbar. Position the cursor in the work area and then hold down the mouse button while dragging out a closed path. Upon releasing the mouse button, the amount of current passing through the enclosed surface is calculated using Ampere's Law. After the path is drawn it can be altered by clicking on the dashed line — this produces a series of points along the line that can be repositioned. To clear the path, click on the dashed line and select *Edit >> Delete.*

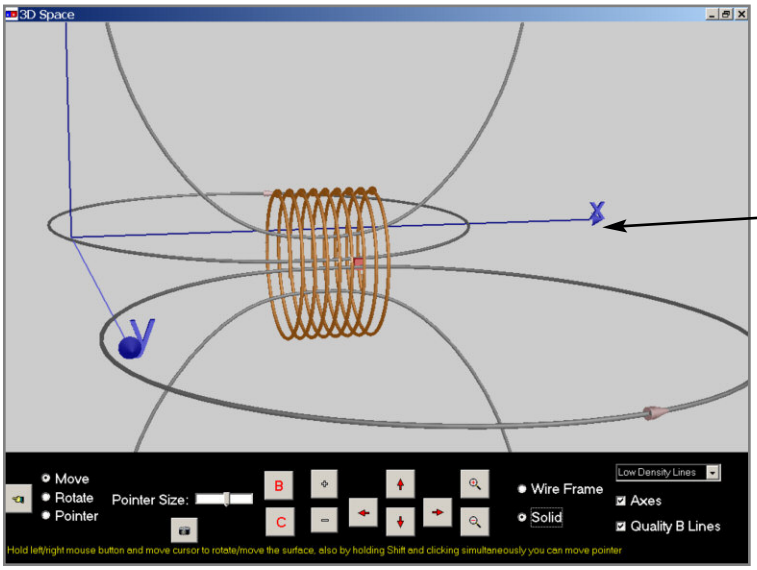
By clicking on the *Path Tool for Ampere's Law* button, any desired path can be drawn with the amount of current passing through the enclosed surface calculated using Ampere's Law.



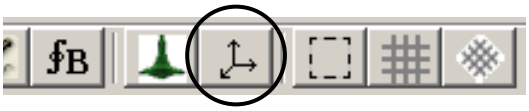
Ampere's Law in 2D Environment

3D Environment

11) The 3D environment provides an extraordinary perspective on Magnetic fields and the motion path of a charged particle. It is truly three-dimensional in that objects can be rotated about multiple axes so that depth can be clearly perceived. The zoom feature even allows you to view from within the field looking out! Magnetic field producing objects and their configurations are first created in the 2D environment before moving into the 3D environment. We will continue to work with the solenoid used from the start of this tutorial. To enter the 3D Space environment, select the *3D Space* button on the toolbar.



3D Space environment



3D Space button on toolbar

To rotate the solenoid and field lines, place the cursor anywhere in the 3D environment and hold down the mouse button - move the mouse up/down to rotate about a horizontal axis, or left/right to rotate about a vertical axis.

Make sure the following options are all selected: **Low Density Lines**, **Axes**, and **Quality B Lines**.

12) The solenoid and field lines can be rotated using two different methods: (i) Place the cursor anywhere in the 3D environment and hold down the mouse button — move the mouse up/down or left/right to rotate about two different axes. (ii) Select *Rotate* from the options presented in the lower-left corner of the screen, then use the red arrow buttons at the bottom of the screen to rotate in different directions.

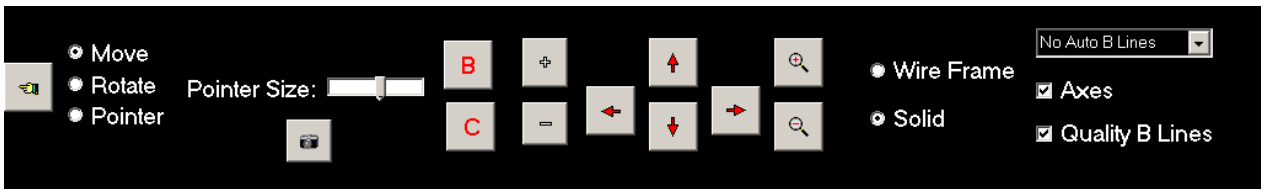
NOTE: Rendering magnetic field lines in three-dimensional space requires numerous calculations be performed by your computer's CPU and may require some time on older computers. The progress indicator will give a sense as to the time required for a particular calculation.

Exit: exits the *3D Space* environment and returns to 2D environment.

Pointer Size: changes the size of the 3D pointer.

Arrow buttons: change function depending on selection of *Move*, *Rotate*, or *Pointer* at far left. ⊞ ⊟ buttons move 3D Pointer up/down in the z-direction.

Zoom buttons: zoom-in or zoom-out to frame desired view.



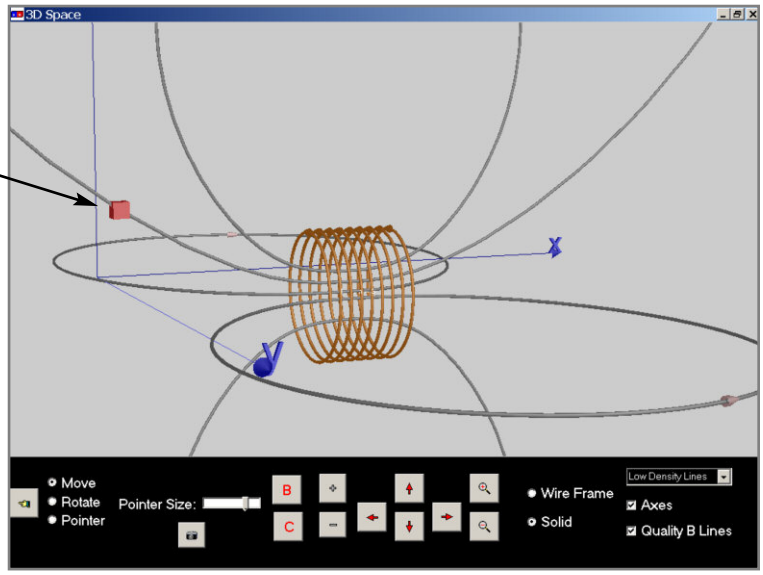
Move: when selected, arrow buttons function to move object(s) up/down and left/right.
Rotate: when selected, arrow buttons function to rotate object(s).
Pointer: when selected, arrow buttons and ⊞ ⊟ buttons function to reposition the 3D pointer.

B button: draws a 3D magnetic field line at the current position of the 3D pointer.
C button: Clears all 3D magnetic field lines.

Wire Frame: draws object surfaces using a wire frame so that the interior is visible.
Solid: draws object surfaces using a solid surface.
Automatic B Lines: automatically generates 3D magnetic field lines. With single objects, only *Low Density Lines* are available. Other density options become available when multiple objects are present.
Axes: displays the x, y, z axes.
Quality B Lines: displays magnetic field lines using tubular surfaces to aid 3D perspective.

13) Additional magnetic field lines can be drawn by positioning the 3D pointer at a desired location and clicking on the *B* button. The 3D pointer can be positioned by selecting *Pointer* from the options presented in the lower-left corner of the screen, then using the red arrow buttons and +/- buttons.

3D pointer moved to a desired location where a new magnetic field line is drawn by clicking on the *B* button.



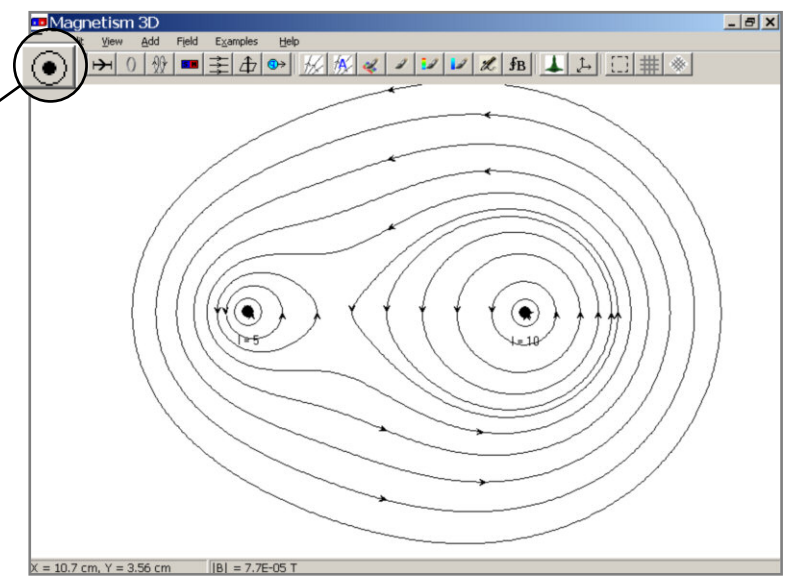
Magnetic field line added in 3D Space environment

TIP: The 3D pointer can be quickly positioned by holding down the SHIFT key and clicking simultaneously. This will place the 3D pointer at the cursor location. You can then follow-up by using the mouse to rotate to an overhead (or side) view and SHIFT-click again to place the 3D pointer at the desired depth. Practice this method a few times, you'll soon find it to be very convenient.

14) By clicking on the button displaying the *hand icon* you can return to the 2D environment to make changes to the solenoid and observe the resulting magnetic field in both environments.

15) To clear the work area and start over with new objects select *File* >> *New* from the overhead menu in the 2D environment. We will work with one final arrangement consisting of two vertical wires. Click on the *Unlimited Vertical Wire* button on the toolbar and position the wire slightly left of center screen. Click the mouse to lock down the vertical wire and enter a current of 5 A in the pop-up dialog box. Repeat this same procedure placing a second vertical wire several centimeters to the right of the first. Enter a current of 10 A for this second wire.

Using the *Unlimited Vertical Wire* button, two vertical wires possessing currents of 5 A and 10 A are placed in the work area. In this screen image, field lines have been drawn using the *Automatic Field Lines* button.

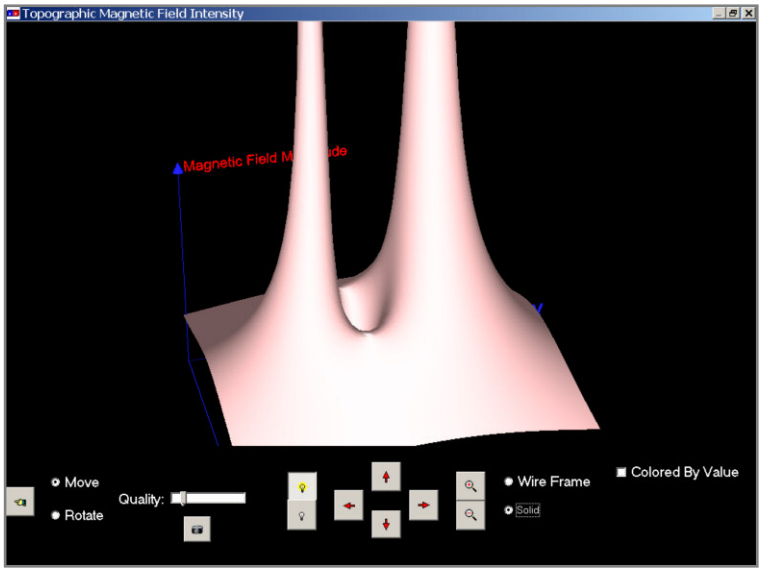


Two vertical wires in 2D environment

16) Another three-dimensional environment can be accessed by clicking on the *Topographic Magnetic Field Intensity* button on the toolbar. This topographic plot shows the magnitude of the magnetic field as a function of height, allowing one to visualize the magnetic field strength on a three-dimensional surface.

Topographic Magnetic Field Intensity button on toolbar

The plot can be rotated using the same methods as in the *3D Space* environment. The x-y plane corresponds to the work area plane, the height (z-axis) shows the magnitude of the magnetic field.



Topographic Magnetic Field 3D environment

17) The controls in the 3D Topographic environment are very similar to those in the 3D Space environment. The *Wire Frame* option in this environment is particularly useful in that it produces a network of lines allowing the contour to be easily perceived. The Quality slider is used to set the image resolution — setting this to higher levels may significantly increase the rendering time of the topographic plot.

18) This concludes the *Magnetism 3D* tutorial. Return to the 2D environment and experiment with other objects and configurations. Elaborate object configurations can be created — an object can be used multiple times in a given configuration, and used in any combination with other objects. Once placed in the work area, objects can be dragged to a new location and edited by right-clicking on the object.