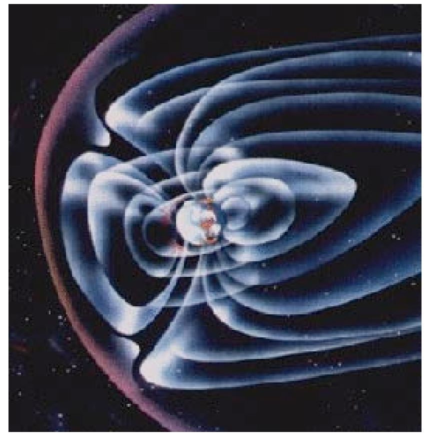
Thinking in three dimensions

In the Cartesian 'X-Y' coordinate system, a pair of 2 numbers (x, y) define the address of a point on the plane. Because we live in a 3-dimensional world, a third number needs to be added to define a point (x, y, z). Many physical quantities are represented in this way.

This activity will let you use data from NASA's ACE satellite to calculate the strength of the solar wind's magnetic field using the Pythagorean Theorem.



A perspective drawing of Earth's 3-dimensional magnetic field.

Scientists represent many physical quantities by triplets of numbers which form the sides of a 3-dimensional triangle in space.

- A simple extension of the Pythagorean Theorem lets you calculate 3-dimensional quantities. Here's what it looks like:

$$W^2 = X^2 + Y^2 + Z^2$$

Here's how to do it!

A scientists measures the three components to the velocity (in kilometers per second) of a satellite (x, y, z) and finds:

(145.0, 103.0, 523.7)

The total speed, V, of the satellite is given by

$$V^2 = (145.0)^2 + (103.0)^2 + (523.7)^2$$
$$V^2 = 21{,}025.0 + 10{,}609.0 + 274{,}261.7$$
$$V^2 = 305{,}895.7$$
$$V = 533.1 \text{ kilometers per second}$$

Now you try!

Solar Wind Velocity

Date	X	Y	Z	B^2	B
1-7	10.9	-5.7	-1.0		
1-10	-10.2	+11.4	-4.0		
4-17	+9.6	-18.6	+14.5		
5-23	-4.8	+22.2	+16.6		
5-28	-0.88	+0.94	+0.18		
7-11	-2.8	-3.6	+1.2		

In 2002, the ACE satellite measured the three components to the solar wind magnetic field at a location 1.5 million kilometers from Earth. The table above gives the data for a series of these observations. Use the 3-dimensional Pythagorean Theorem, together with the three magnetic field measurements (X, Y, Z), to calculate the total strength of the solar wind field.

Enter the answer in the last column.