

Most science courses discuss the various familiar forms of energy such as kinetic, potential, chemical, thermal and electrical. Most science courses also discuss magnetism, and electromagnetism. Combining these two ideas, we can imagine that magnetic fields also store and release energy – **magnetic energy**. This energy plays an important role in creating many of the most dramatic events scientists study, from solar flares to the Northern lights.

Most objects that astronomers study have shapes that can be approximated as spheres, or cylinders. Here are the formulas for the volumes, **V**, of these shapes. In these formulae, the variables are as follows:

R = radius of sphere or cylinder

h = height of cylinder

The amount of magnetic energy, **Em**, for a field strength, **B**, given in Gauss units and a volume, **V**, given in cubic centimeters can be calculated from this formula:

$$E_m = \frac{B^2}{8\pi} V$$

Sphere $\frac{4}{3}\pi R^3$

Cylinder $h \pi R^2$

Using the formulas above, calculate the total magnetic energy, **Em**, of each system in the table below. You will need to use scientific notation and a calculator!

Object	Shape	B (Gauss)	R (cm)	H (cm)	Em (ergs)
Earth	Sphere	0.5	6.4×10^8		
Geotail	Cylinder	0.002	5×10^9	1.5×10^{10}	
Sun	Sphere	5.0	6.9×10^{10}		
Solar Prominence	Cylinder	100	5×10^9	2.0×10^9	

Answer - Extra Credit Problem

Worked Answers:

Earth: Volume of sphere = $1.333 \times 3.141 \times (6.4 \times 10^8 \text{ cm})^3 = 1094.8 \times 10^{24} \text{ cm}^3 = 1.1 \times 10^{24} \text{ cm}^3$

$$E_m = 0.0398 \times (.5)^2 \times 1.1 \times 10^{24} = 1.1 \times 10^{22} \text{ ergs.}$$

Geotail: Volume of cylinder = $3.141 \times (5 \times 10^9 \text{ cm})^2 \times 1.5 \times 10^{10} \text{ cm} = 117.8 \times 10^{28} \text{ cm}^3 = 1.2 \times 10^{30} \text{ cm}^3$

$$E_m = 0.0398 \times (0.002)^2 \times 1.2 \times 10^{30} = 1.9 \times 10^{23} \text{ ergs}$$

Sun: Volume of sun = $1.38 \times 10^{33} \text{ cm}^3$

$$E_m = 1.4 \times 10^{33} \text{ ergs}$$

Solar Prominence: Volume of cylinder = $1.6 \times 10^{29} \text{ cm}^3$

$$E_m = 6.4 \times 10^{31} \text{ ergs}$$

Definitions:

The **Geotail** is the extension of Earth's magnetosphere into a comet-like tail in the opposite direction of the Sun. The magnetic energy released in the geotail causes charged particles to flow along the magnetic lines of force into Earth's Polar Regions, causing the Aurora Borealis and Aurora Australis.

Solar prominences are loops of magnetic force above large sunspots. The magnetic energy released by prominences can lead to solar flares and expulsions of gas called Coronal Mass Ejections.

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