# Magnetic Dipole Lab

*Equations for magnetic force associated with a dipole*

$$F_r = \frac{\mu m}{2\pi r^3} * \cos(\theta) \quad F_\theta = \frac{\mu m}{4\pi r^3} * \sin(\theta) \quad F_t = \frac{\mu m}{4\pi r^3} * \left(4\cos^2\theta + \sin^2\theta\right)^{\frac{1}{2}}$$

The units of these equations are in Tesla (T).

Please give ALL your answers in nano-Tesla (nT). Remember that 1 Tesla in $10^9$ nano-Tesla.

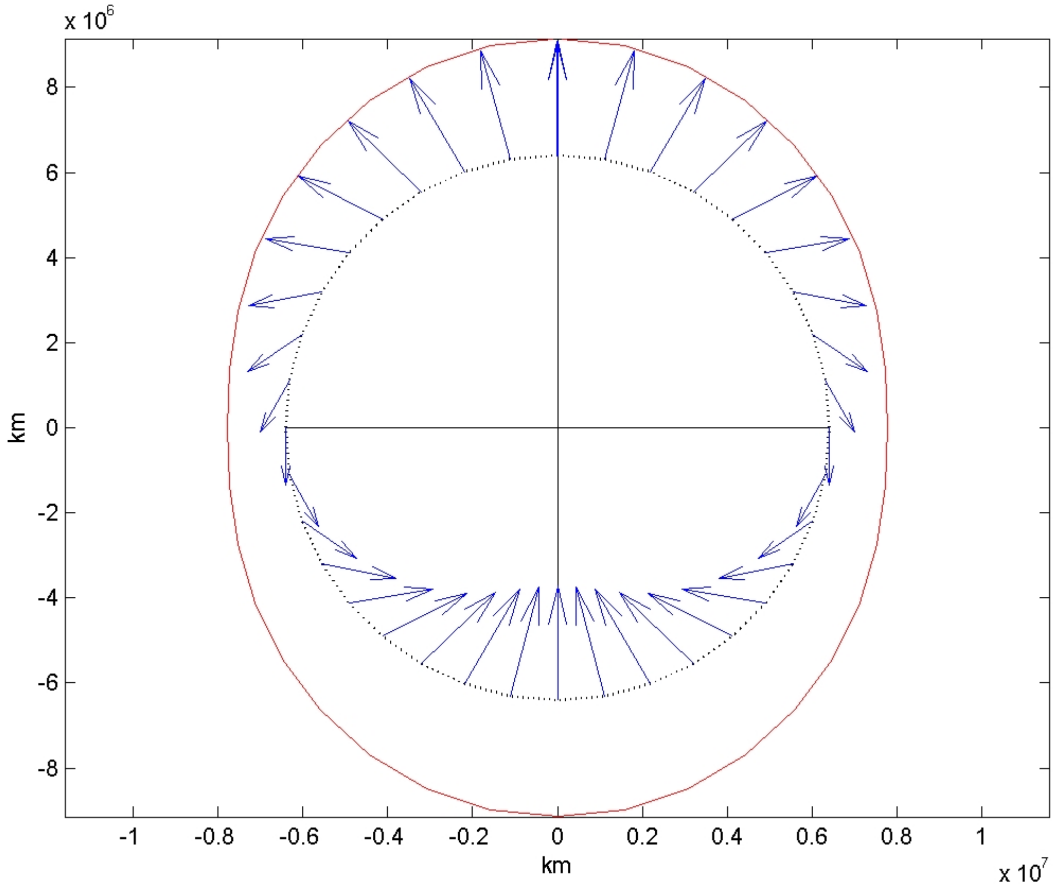
Theta $(\theta)$ is the angle with respect to the north pole $(\theta = 0°)$. Note that the angle theta is reckoned as positive in a clockwise direction starting at the north pole. All angles must be evaluated in trigonometric functions using radian units (1 radian = 180º/3.14).

Assume that the dipole moment m=8*$10^{22}$ A/m^2, r=6.4 * $10^6$ m (surface of earth) and the magnetic permeability is 1.25*$10^{-6}$ Newtons/$A^2$.

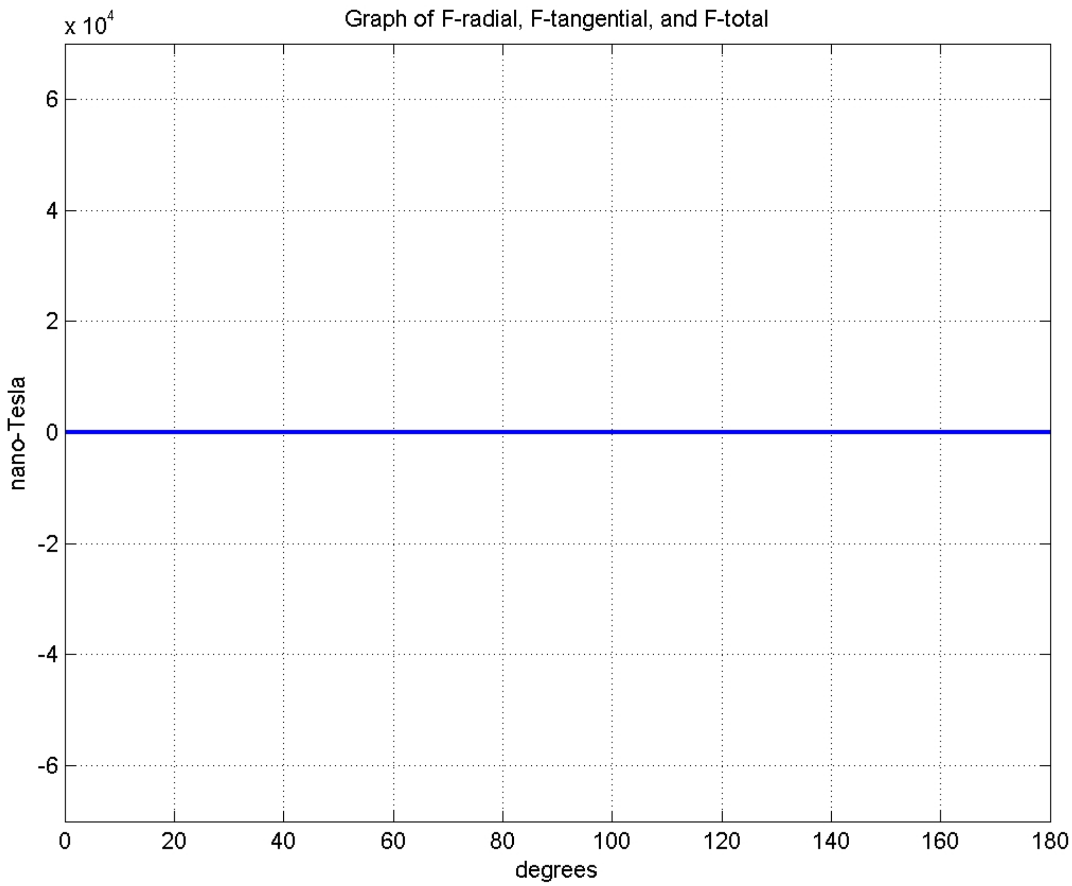
We are assuming that the geographic and magnetic poles are geographically coincident.

1. Calculate the radial, theta, and total field at the north pole and the equator.

2. On the attached dipole magnetic field plot, draw on the $F_r$ and $F_\theta$ vectors as different colored lines or as solid and dashed lines.




3. Make a graph of $F_r$, $F_\theta$, and $F_t$ components of the magnetic field for angles from 0 to 180 degrees. Label your magnetic field amplitudes on your y-axis carefully. Describe in words how the $F_r$, $F_\theta$ and $F_t$ vector magnitudes vary as one goes from the north-pole to the south-pole.




4. Now that you know how to find the $F_r$ and $F_\theta$ magnetic field components for a dipole, calculate the magnetic inclination at the following locations. Please express your answer in degrees. You will need to use the tangent trigonometric relation for a right triangle

$$\tan(angle) = opposite\text{–}side-length / adjacent-side-length\ .$$

The inclination angle you solve for will be with respect to the local vector *normal* to the surface of the sphere. Thus, your inclinations will be 90º different from the definition of inclination in the book which calculates the inclination with respect to the local vector *tangent* to the sphere.

$\theta = 0°$ $I =$

$\theta = 30°$ $I =$

$\theta = 60°$ $I =$

$\theta = 90°$ $I =$