# Homework 9: Earth's Magnetic Field

*Read Lowrie pp. 281-287; 305-320*
*Due Wed. 4/8*

**1.** Meausurements of the magnetic field at a geomagnetic observatory gave the following results: northward component: 27,000 nT; east component -1800 nT; downward component -40,000 nT.
**(a)** Is the observatory in the northern or southern hemisphere?
**(b)** What are the local values of inclination *I* and declination *D*?

**2.** Lets examine how the Earth's magnetic field varies with latitude. Use Matlab to calculate and plot the following on the surface of the Earth as a function of latitude λ from the south to the north pole:

**(a)** The downward component ***B*** (*Z* in Fig. 5.27 or $B_Z$ right).

**(b)**The northward component of ***B*** (*X* in Fig. 5.27 or $B_X$ right).

**(c)** The magnitude of ***B*** (|***F***| in Fig. 5.27 or |***B***| below). Remember λ = 90°- $\theta$ (see right).

158 *The Geomagnetic Field*

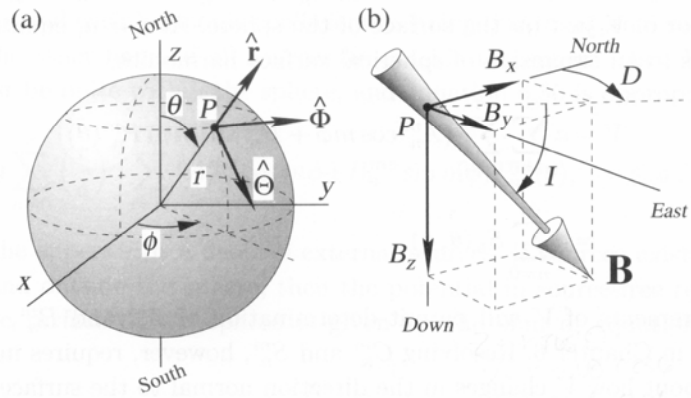
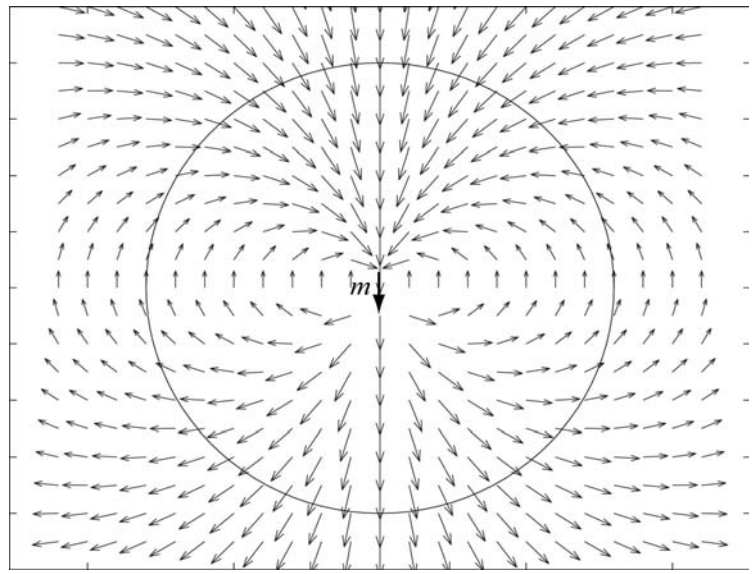



Fig. 8.1. (a) The spherical coordinate system. Point $P$ is defined by coordinates $r$, $\theta$, and $\phi$, and a vector at point $P$ is described in terms of three orthogonal unit vectors: $\hat{\mathbf{r}}$, $\hat{\mathbf{\Theta}}$, and $\hat{\mathbf{\Phi}}$. (b) The cartesian coordinate system at point $P$. The three components of vector $\mathbf{B}$ are shown: $B_x$ is directed north ($B_x = -B_\theta$), $B_y$ is east ($B_y = B_\phi$), and $B_z$ is down ($B_z = -B_r$). Inclination $I$ is the angle of $\mathbf{B}$ below horizontal, positive down; declination $D$ is the azimuth of the horizontal projection of $\mathbf{B}$, positive east.

**3.** The plot to the right shows magnetic field vectors around a dipole. Briefly explain why each of your curves produced in problem 2 make sense.




**4.** Have a look at Fig. 5.33. Order $n$ tells how many wavelengths of fluctuations occur in 360° around the Earth. Thus, $n = 1$ corresponds to a wavelength equal to the circumference of the Earth and $n = 20$ corresponds to a wavelength of fluctuation of about $2\pi R/20 = 2000$ km. Fig. 5.33 shows the strength of different wavelengths as measured by the MAGSAT satellite.

**(a)** The book claims that the source for $15 < n \leq 45$ is dominate by the Earth's crust and that larger wavelength variations ($n \leq 14$) are caused primarily by the core. Like gravity, the shape of a magnetic anomaly changes with distance due to "upward continuation". Given what you understand about "upward continuation" explain why (or why not) the book's claim makes sense.

**(b)** We know that seafloor magnetic lineations have much shorter wavelengths than those corresponding to $n = 45$. Do you expect the use of satellites is a good way to measure these shorter wavelength undulations? What would be a better way?