515.

Problem 37.30 (RHK)

Using the results the problem **514** (Problem **37.29 (RHK)**), *we have to predict the value of the Earth's magnetic field* (*magnitude and inclination*) *at* (a) *the magnetic equator*; (b) *a point at magnetic latitude* 60^0; *and* (c) *the north magnetic pole*.

Solution:

The magnetic field of the Earth can be approximated as a dipole magnetic field, with horizontal and vertical components, at a point a distance r from the Earth's centre, given by

$$B_h = \frac{\mu_0 \mu}{4\pi r^3} \cos L_m \ , \quad B_v = \frac{\mu_0 \mu}{2\pi r^3} \sin L_m \ ,$$

where L_m is the magnetic latitude (latitude measured from the magnetic equator toward the north or south magnetic pole). The magnetic dipole moment is 8.0×10^{22} A m^2. The radius of the Earth is $R_E = 6.37 \times 10^6$ m.

(a)

The Earth's magnetic field at the magnetic equator will be

$$B_h = \frac{10^{-7} \times 8.0 \times 10^{22}}{\left(6.37 \times 10^6\right)^3} \text{ T} = 0.031 \times 10^{-3} \text{ T} = 31 \ \mu\text{T},$$

and

$$B_v = 0.$$

The inclination of the Earth's magnetic field at the magnetic equator will be zero.

(b)

The horizontal and the vertical components of the Earth's magnetic field at a point on its surface at the magnetic latitude 60^0 will be

$$B_h = \frac{\mu_0 \mu}{4\pi r^3} \cos 60^0 = 15.5 \ \mu\text{T},$$

and

$$B_v = \frac{\mu_0 \mu}{2\pi r^3} \sin 60^0 = 53.6 \ \mu\text{T}.$$

The magnitude of the Earth's magnetic field at the magnetic latitude 60^0 will be

$$B = \left(15.5^2 + 53.6^2\right)^{1/2} \ \mu\text{T} = 55.8 \ \mu\text{T}.$$

The angle of inclination is

$$\phi_i = \tan^{-1}\left(\frac{53.6}{15.5}\right) = 73.9^0.$$

(c)

The Earth's magnetic field at the magnetic north pole will be

$B_v = 61.9\ \mu\text{T},$

and

$B_h = 0.$

The inclination of the Earth's magnetic field at the magnetic north pole will be

$\phi_i = 90^0.$