PHYS 3033/3053 Assignment 6

Due: 11 Nov 2015 at begin of lecture at 3:00 pm

Problem 1.

(a) Find the force on a square loop placed as shown in Fig. 1(a), near an infinite straight wire. Both the loop and the wire carry a steady current *I*.

(b) Find the force on the triangular loop in Fig. 1(b).

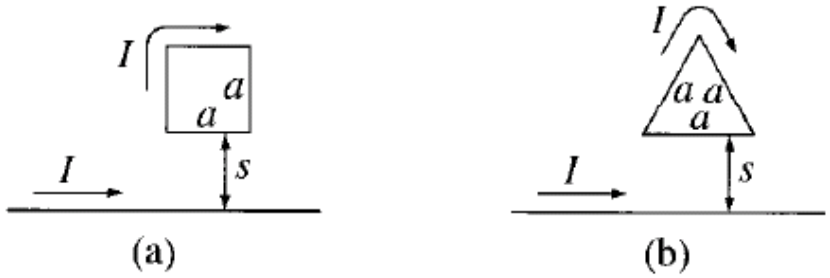


Fig. 1

Problem 2.

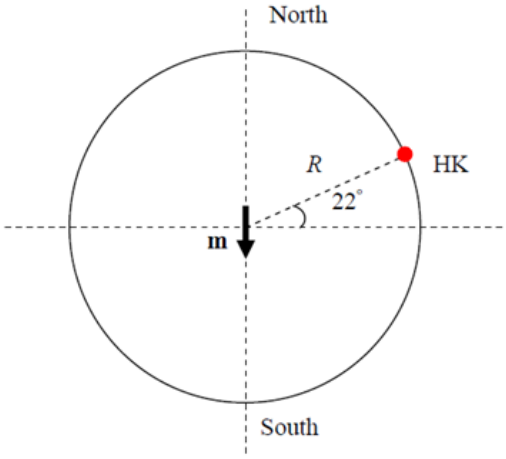
A long cylindrical conductor of radius *R* has a cylindrical cavity of radius *R*' cut out of its volume; the axis of the cavity is parallel to the central axis but displaced a distance *h* to one side. The conductor carries a current *I*, uniformly distributed over its remaining volume. Find the magnetic field in the cavity by Ampere's law.

Problem 3.

Consider a very large flat slab of thickness *D*. Use Cartesian coordinates so that the slab is parallel to the *xy* plane, with its thickness extending from $z = -D/2$ to $z = D/2$. The slab carries a uniform volume current density **J** flowing in the *x* direction. Find the **B** field at a distance *z* from the *xy* plane by Ampere's law.

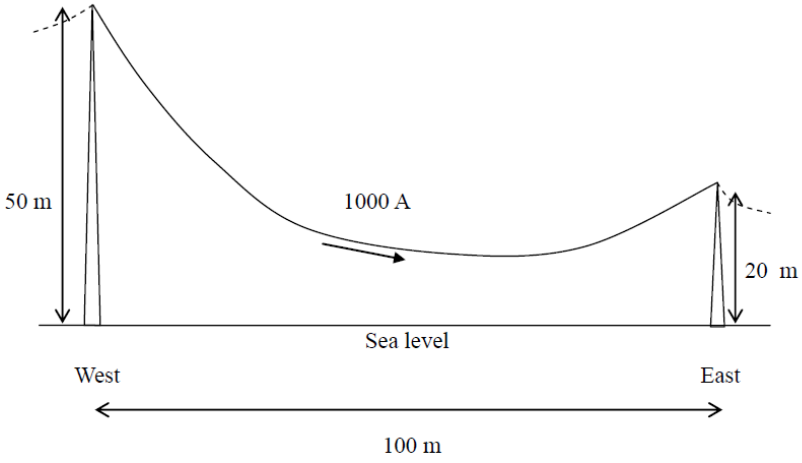
Problem 4.

The Earth's magnetic field is approximately a dipole field. One can imagine there is a pure magnetic dipole **m** at the center of the Earth. For simplicity, we ignore the fact that the magnetic poles do not coincide with the geographic poles, and assume that **m** lies on the rotation axis of the Earth, pointing from north to south, as shown in the figure below.



(a) Assume that $m = 8\times10^{22}$ Am^2, find the Earth's magnetic field at Hong Kong, of which the latitude is assumed to be 22° N exactly. We shall also assume that the Earth is a perfect sphere with a radius of R = 6400 km exactly. Use spherical coordinates with **m** at the origin and pointing at the negative z direction. Express your answer in terms of $\hat{\mathbf{r}}$, $\hat{\boldsymbol{\theta}}$, and $\hat{\boldsymbol{\phi}}$, and use the unit of gauss, where 1 gauss = 10^{-4} tesla.

(b) A wire between two towers in Hong Kong carries a constant current of 1000 A. The length of the wire is 120 m. The horizontal distance of the two towers is 100 m, and the heights of the two towers are 50 m and 20 m. The higher tower is at the west of the lower one, as shown in the figure below.



Find the magnitude of the total magnetic force acting on the wire due to the Earth's magnetic field.