THE UNIVERSITY OF BRITISH COLUMBIA

Science 1 Physics Assignment # 7:

Lorentz Force, Cyclotrons and Ampère's Law

23 Feb. 2000 — finish by 1 Mar.

Tipler Ch. 24, problems **16, 29, 30, 37** & **52**;

1. **FRICTION** *vs.* **THE LORENTZ FORCE:** A 2.0-kg copper rod rests on two horizontal rails 2.0 m apart and carries a current of 100 A from one rail to the other. The coefficient of static friction between the rod and the rails is $\mu_s = 0.50$. What is the smallest magnetic field (not necessarily vertical) that would cause the bar to slide?

2. **CYCLOTRONS:** (Neglect any relativistic effects.) Suppose that we want to build a small cyclotron for protons using a magnet with a uniform field over a region 1.0 m in radius such that the protons reach a maximum kinetic energy of 20 MeV at the outer radius of the magnet. *(a)* What magnetic field must the magnet produce? *(b)* At what frequency must the "dee" voltage oscillate?

   Now suppose we want to build a cyclotron to accelerate electrons *without a magnet*, using the Earth's magnetic field (assume $B = 5 \times 10^{-5}$ T) to keep the electrons moving in circles. *(c)* What is the radius of the electron orbit at 100 eV? *(d)* What is the frequency (in Hz) of the RF electric field we must supply to the cyclotron "dees?"

3. **HOLLOW CYLINDRICAL CONDUCTOR:** A thick-walled hollow conducting cylinder carries a uniformly disrtibuted current I. The (centred) hole in the middle has a radius of R and the outer radius of the conductor is $2R$. Derive an expression for the strength of the magnetic field B as a function of radial distance r from the cylinder axis, in the range from $r = R$ to $r = 2R$; then *plot* (*i.e.* sketch, showing axis labels, scales and values at key points) $B(r)$ in the range from $r = 0$ to $r = 4R$.

. . . *and* Tipler Ch. 25, problems **28, 34, 51, 53** & **55**.