Idaho State University – Department of Physics
PHYS 499 / PHYS 630 Accelerator Physics — Spring 2009

Homework 1 (due Jan 21)

Topics: Review of mechanics, electromagnetism, and relativity.

1. No mention of gravity as a force to be taken into account is usually made in accelerator physics. Confirm that gravity can be neglected using the following order-of-magnitude estimate.

   The Earth's magnetic field is of the order of 1 gauss or 10^{-4} T — small compared with the various bending and focusing fields usually encountered in accelerators. (a) Calculate the speed that a proton would have in order for the magnetic and gravitational forces to be equal in a field of 1 gauss. (b) Calculate the corresponding kinetic energy in eV.

2. Copy and complete the following table:

Particle	Electron e^-	Proton p	Gold ion $^{197}\mathrm{Au}^{79+}$
Charge, q (e)	-1	+1	+79
Rest energy, mc^2	0.511 MeV	0.938 GeV	197 u
Kinetic energy, T	1 MeV	1 GeV	1 GeV/nucleon
Momentum, p			
Velocity parameter, $\beta = v/c$			
Magnetic rigidity, $(B\rho)$			

3. The Universe contains some superb accelerators. Cosmic ray protons can enter the top of the atmosphere with an energy of 1 J or more. They are not easily bent by extragalactic magnetic fields, and therefore their original direction is preserved. The Pierre Auger Observatory (`www.auger.org`) recently observed that the origin of some of these extremely energetic cosmic rays are active galactic nuclei (AGN), where giant black holes are probably located.

   Calculate (with at least two significant digits) the difference $c - v$ between the speed of light in vacuum c and the speed v of a 1-joule proton.