General Physics - E&M (PHY 1308) Lecture Notes

Homework008

SteveSekula, 18 October 2010 (created 18 October 2010)

no tags

Homework 8

Expectations for the quality of your handed-in homework are available at http://www.physics.smu.edu/sekula/phy1308/HomeworkPolicy.pdf. Failure to meet these guidelines will result in loss of points as detailed in that document. This assignment covers material from Wolfson Chapter 26.

The total assignment is worth 80 points.

This homework is due by 5pm on Monday, October 25 (place in my mailbox in Fondren Science 102)

Reading Assignment:

Chapter 26

Required Problems from Wolfson and Sekula

These are **required problems that are part of the official homework assignment.**

- CH26-18 (20 Points)
- CH26-62 (20 Points)

Problem *SS-14*: The Design of the Large Hadron Collider (20 Points)

The Large Hadron Collider (LHC) is a subatomic particle physics experiment designed to recreate the universe as it existed about 10^{-15} seconds after it was created in the Big Bang. The goal of this project is to try to better understand why we exist at all by recreating a moment after the birth of the universe. SMU has four professors and about 6 students working on projects at the LHC. The experiment is international in scope, consisting of over 5000 physicists (students, scientists, and professors) from across the globe, and cost over $10 billion to build. The LHC recreates the very early universe by smashing together protons at the highest energies ever directly created by humans. The protons, with electric charge $q = +1.6 \times 10^{-19}\mathrm{C}$, are currently accelerated by electric fields up to speeds approaching that of light; this represents a momentum, in "particle physics units", of $p = 3.50\mathrm{TeV/c}$, where c is the speed of light, $c = 2.998 \times 10^{8}\mathrm{m/s}$ and $1\mathrm{TeV} = 10^{12}\mathrm{eV}$. The protons are maintained in a circular orbit using strong magnetic fields that are perpendicular to the direction of proton motion; that orbit has a circumference of $26.0\mathrm{km}$.

- Part (a): convert the momentum of the protons from "particle physics units" of $\mathrm{TeV/c}$ to MKS units ($\mathrm{kg \cdot m/s}$).

- Part (b): Calculate the magnetic field strength required to maintain the protons in their $26.0\mathrm{km}$ circumference orbit in the LHC.

Problem *SS-15*: Magnetic Fields from the Brain (20 Points)

The brain is an incredibly complex electric circuit. As a result of all that moving electric charge, the brain generates very weak magnetic fields which can be detected by sensors places directly on the scalp. These magnetic fields are EXTREMELY weak compared to, say, the earth's magnetic field; the strongest biological magnetic fields have strengths of only $1.0 \times 10^{-12}\mathrm{T}$ (or 1.0 picoTesla). Let us consider a sensor, called a SQUID, placed on the surface of the head which is capable of measuring such a field (this device is real). Treat the magnetic field strength measured by the sensor as arising from a single neuron in the brain

located just inside brain surface, about 10.0mm from the sensor (the thickness of the skull and scalp). Let's treat the neuronal current as flowing *perpendicular* to the radial distance from the neuron to the SQUID, along a long, straight neuron whose axon length is large (2.0cm) compared to the skull and scalp thickness.

- Calculate the current, in nano-Amps (nA), passing through the neuron that gives rise to this magnetic field.

Optional Warm-Up Problems

These problems are not required. They are odd-numbered problems from Wolfson, similar to those below, to help you warm up. You can compare your answers to those in the student solution manual. If you do not have this manual, ask another student in the class for a photocopy of the solutions.

- CH26-19
- CH26-25
- CH26-59