PS 250 – Sample Exam

Name_____ Score:_____/ 100 Cumulative grade:_____

Relax. Look over all questions before you begin, and attempt the easier ones first. Place your answers in the boxes provided. To receive full credit you must SHOW your work and EXPLAIN your method. Write NEATLY and COHERENTLY.

$m_e = 9.1\times10^{-31}$ kg $\qquad$ $m_p = 1.67\times10^{-27}$ kg

$\mu_0 = 4\pi\times10^{-7}\,\frac{\mathrm{N}}{\mathrm{A}^2}\left[\,or\ \frac{\mathrm{Tm}}{\mathrm{A}}\right]$ $\qquad$ $\varepsilon_0 = 8.85\times10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{N\,m}^2}$ $\qquad$ $e = 1.6\times10^{-19}\,\mathrm{C}$

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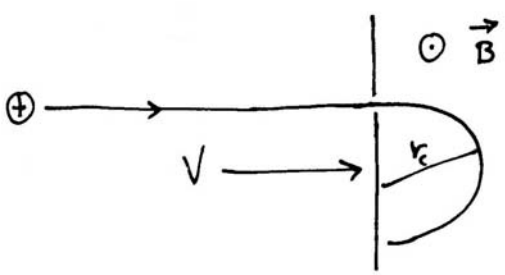
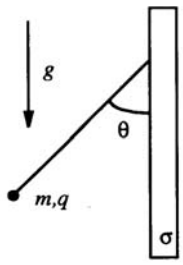
1. [20 points] An alpha particle (a Helium nucleus, which consists of two neutrons and two protons, mass m, and charge $q = 2e$) is accelerated to a velocity V and then enters a region where a magnetic field B exists that is perpendicular to the direction of motion of the alpha particle. What is the radius r_c of the path of the alpha particle? (If you don't recall the formula for the cyclotron radius, derive it by having the magnetic force supply the centripetal acceleration.)



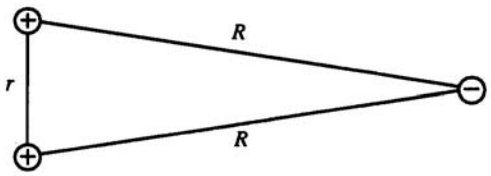
2. [25 points] Use the Biot-Savart Law to calculate the magnitude of the magnetic field at the center of a circular loop of radius *R*, that carries a current *I*.

1. [25 points] A point charge that carries a charge $q = -2\times10^{-3}\,\text{C}$ and has a mass m hangs from a thread in the Earth's gravitational field next to an infinitely large, uniformly charged sheet with charge density (per-unit-area) σ. The thread makes an angle $\theta = \pi/4$ from the vertical. The system is in static equilibrium.



(a) **[10 points]** If the charge density on the sheet is $\sigma = -4.4\times10^{-10}\,\text{C/m}^2$, determine the magnitude of the horizontal force exerted on the point charge by the sheet.

3. [25 points] A helium ion, He^+, consists of two protons a distance $r = 10^{-15}$ m apart, along with an electron a distance $R = 10^{-10}$ m from each of the protons. Of course, neutrons are also present, but since they do not interact electrically, we can ignore them. Calculate the electric potential energy of this system. That is, calculate how much total work must an external force do when assembling these three charges from infinitely far away.



4. [25 points] A ring of radius R is oriented in the y-z plane with the x-axis passing through the center of the ring. The charge density (per-unit-length) is **<u>not constant</u>** but varies as

$$\lambda = \lambda_0 \sin(\theta/2) \ ,$$

where θ is measured in a counterclockwise direction from the positive +y-axis, and λ_0 is a constant. Find an approximate expression for the electric field vector on the x-axis (at point P) when $x >> R$. Your expression must be in terms of the quantities that describe the ring (i.e., R and λ_0).

(HINT: Very little calculation is needed.)