

## Final Exam – Honors Physics

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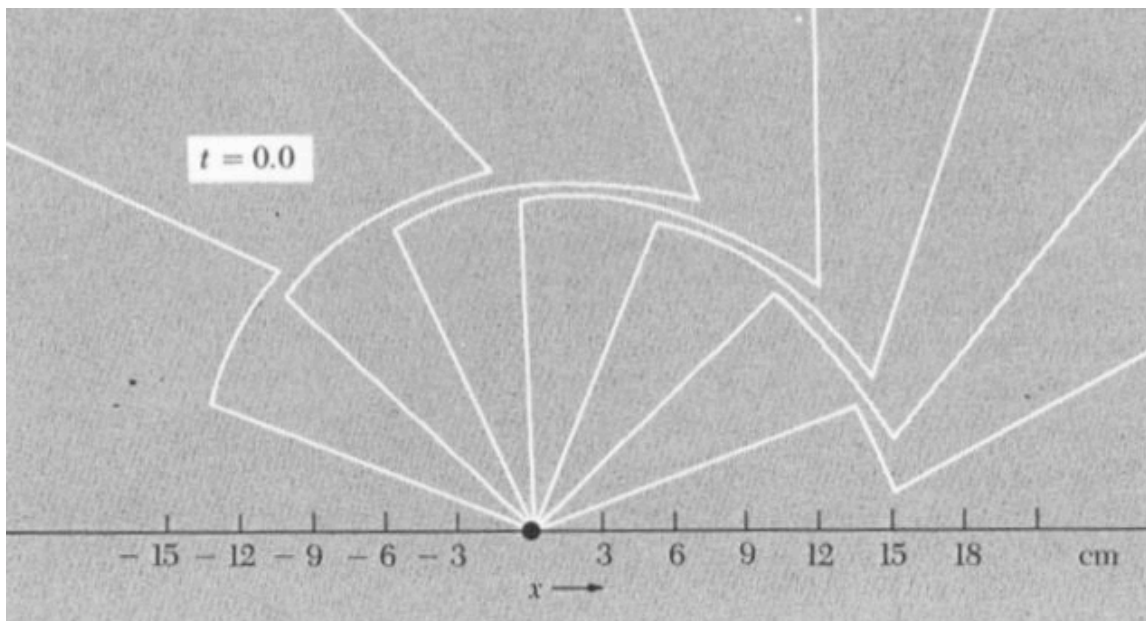
Due Monday May 3, 2004

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### Rules:

1. This is an open-book, open-notes take-home exam.
2. Please show all your work in the blue books – please write your solutions neatly and clearly.
3. You may not consult with anyone about this exam. If you have questions please send me an e-mail.
4. You must return your key to SW135 in the envelope along with exam solution. You will not be given a grade if you do not return your key.

### Problem 1 (25 points)



The figure above shows the electric field lines due to an electron at time  $t = 0$ . Here is what I can tell you – the electron may have been at rest and then suddenly moved with constant velocity  $u$  along the x-axis or it was moving with constant velocity  $u$  and then suddenly stopped. So what did happen, at what time did the transition occur and what is  $u$ ?

Where was the electron at  $t = -7.5 \times 10^{-10}$  s and at that instant what was the magnitude (specify the numerical value) of the electric field at  $x = 0$ ?

**Problem 2 (25 points)**

A solid sphere of charge  $Q$  and radius  $R$  has a spherically symmetric volume charge density  $\rho(r)$  that varies linearly with distance  $r$  from the center of the sphere and  $\rho(0) = 0$ . In terms of  $Q$  and  $R$  how much work was required to assemble this sphere of charge?

**Problem 3 (25 points)**

For a circular coil of wire with  $N$  turns and radius  $R$  the magnetic field along the axis of the coil at a distance  $z$  from the center of the coil is given by:

$$B(z) = \frac{\mu_o N I R^2}{2(R^2 + z^2)^{3/2}}$$

An arrangement of two identical coaxial parallel coils separated by distance  $R$  carrying the same current in the same direction is referred to as a Helmholtz coil producing a very uniform magnetic field along the axis. Suppose you design such an arrangement to produce a 50 gauss magnetic field midway between the two coils with  $R = 1$  m. You have wire that will carry 5 A with a resistance per length of  $5 \Omega / \text{km}$ . You will use a single length of wire to wind both coils. How much power will be dissipated by these coils?

If the coils are separated by 2 m with the current kept at 5 A, what will be the value of the field midway between the coils?

**Problem 4 (25 points)**

Suppose that a particle of mass  $m$  and charge  $+q$  is subject to a uniform gravitational field such that  $\vec{F} = -mg\hat{k}$ . A horizontal uniform magnetic field is given by  $\vec{B} = B_o\hat{i}$ . Write down an expression for the velocity of the particle that will result in the particle moving in a straight line with speed  $u$ .

Now assume that the particle is held at rest at the origin of coordinates and released at time  $t = 0$ . Describe the motion of the particle and be as quantitative as possible. What is the maximum vertical excursion of the particle?