

Electrodynamics, Physics 322
Winter 2005

First midterm
Instructor: David Cobden

8.20 am, January 31, 2005

You have 60 minutes. End on the buzzer at 9.20. Answer all **12** questions.

Write your name on every page and your ID on the first page.

Write all your working on these question sheets. Use this cover page for extra working (you might get credit for it.)

It is important to show your calculation or derivation. You won't get full marks just for stating the correct answer if you don't show how you get it.

Watch the blackboard for corrections or clarifications during the exam.

This is a **closed book** exam. **No notes allowed. No calculators!**

Do not turn this page until the buzzer goes!

$$\mathbf{A}_{dipole}(\mathbf{x}) = \frac{\mu_0}{4\pi} \frac{\mathbf{m} \times \hat{\mathbf{r}}}{r^2}$$



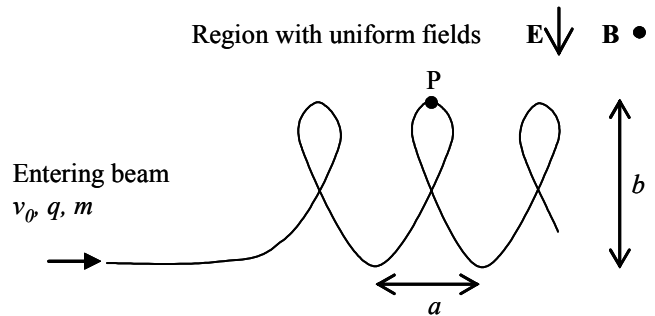
from Nearingzero.com

I. You're given a beam of monoenergetic charged particles of velocity v_0 , whose path you can visualize by passing it through a low density gas which fluoresces.

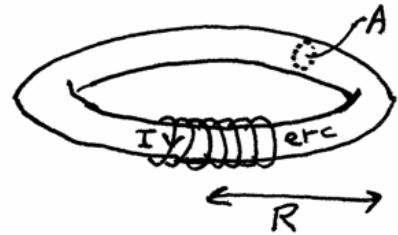
1. [10] Show how you could find the charge/mass ratio q/m of the particles by observing the shape of the beam when it passes through a uniform magnetic field $\mathbf{B} = B \hat{\mathbf{z}}$.

2. [10] Show how you could find v_0 by applying a uniform electric field \mathbf{E} in addition to this magnetic field such that the beam becomes straight.

3. [10] When the beam enters a particular combination of crossed electric and magnetic fields \mathbf{E} and \mathbf{B} the trajectory of the beam lies in a plane and is as sketched below. What is the velocity of the particles at point P? (Consider kinetic energy.)



II. A toroidal solenoid is a wire coil which is curved into a circle of radius R and a cross-sectional area A , as indicated. It has N turns uniformly spaced around its perimeter and carries current I .



4. [8] Derive Ampere's law in integral form starting from Ampere's law in differential form.

5. [12] Use it in a single step to find the approximate magnetic field inside the coil. Do the same for the field outside. Make clear your reasoning and approximation(s) made.

6. [3] Does the answer to the previous question depend on the cross-sectional shape of the coil?

7. [4] How much magnetic flux is enclosed by one loop of the coil?

8. [6] Sketch below the form of the lines of the vector potential \mathbf{A} outside the solenoid, in the Coulomb gauge.

III. A cube of side a with one corner at the origin has a magnetization $\mathbf{M}(\mathbf{r}) = K_0(x/a)\hat{\mathbf{z}}$ which is perpendicular to the upper and lower faces ($z = 0$ and $z = a$) and increases linearly from zero at one side ($x = 0$) to a magnitude K_0 at the other ($x = a$).

9. [11] Find all the bound currents in the system.

10. [10] Find the vector potential $\mathbf{A}(\mathbf{r})$ *far away* from the cube ($r \gg a$) in the Coulomb gauge.
11. [8] A current I is passed along a long straight horizontal wire a distance $D \gg a$ above the cube (parameterized by $y = D, x = 0$). Find the approximate torque on the cube.
12. [8] Find the approximate net force exerted on the cube by this current.