Electrodynamics Exam

Prof. T.E. Coan (x8-2497)
Prof J. Cooley
Prof R. Vega
Fall 2014

Printed Name ______________________________

DIRECTIONS:

0. If we cannot read it, we cannot grade it.

1. **BOX YOUR FINAL ANSWERS**

2. **BOX YOUR FINAL ANSWERS**

3. Do **ANY** 6 of the 7 problems. More is ok.
4. Paginate all pages. Label the problem number clearly.
5. Staple your pages together, in order.
6. Good luck!

Q1 10 pts. A pair of coaxial conductors are made out of thin long metal tubes. The inner tube has a radius a and the outer tube has a radius b. Suppose a steady current I flows down one tube and flows back in the opposite direction in the other tube.

a) 3 pts Find the magnetic field **B**, including direction, inside the inner tube ($r < a$). Draw a diagram if necessary.

b) 4 pts Find the magnetic field **B**, including direction, between the tubes ($a < r < b$). Draw a diagram if necessary.

b) 3 pts Find the magnetic field **B**, including direction, outside the outer tube. Draw a diagram if necessary.

Q2 10 pts. A conducting spherical shell of radius **a** contains a total net charge Q. How much work W is required to uniformly compress the shell to a radius $a/2$? Assume no charge leaks off the shell during the compression.

Q3 10 pts. Consider a cylindrical conducting rod of diameter d and length l ($l \gg d$) that is uniformly charged and placed in vacuum. The electric field near the rod's surface but far from its ends is $\mathbf{E}_0$. What is the electric field $\mathbf{E}$ at $r \gg l$ on the axis of the cylinder? Be sure to specify the field's direction. See the figure below.

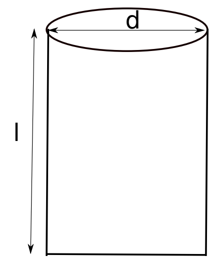

Figure 1: A uniformly charged rod of length l and diameter d sits in a vacuum.

Q4 15 pts. A conducting sphere of radius, **a**, rotates with constant angular velocity ω about the z-axis. A constant, uniform, external magnetic field $\vec{B}$ is applied parallel to the axis of rotation. The total charge on the sphere is zero. Assuming that you can ignore any magnetic field due to the rotating sphere compute the induced potential difference ΔV between the equator and one of the poles of the sphere.

Q5 15 pts. A spherical shell with radius R and uniform surface charge density σ spins with angular speed ω around a diameter. Find the magnetic field $\mathbf{B}$ at the center. You may find the integral $\int \sin^3\theta \, d\theta = -\cos\theta + \frac{1}{3}\cos^3\theta$ useful.

Q6 15 pts. We know that atoms obey quantum mechanics and are very poorly described by classical physics. Here is a demonstration of that. Consider a quasi-circular orbit of a non-relativistic electron around a stationary proton. Including the effects of classical radiation, derive an expression for the time dependence of the electron's radius $r(t)$. You can assume the electron starts out at radius r_0. Introduce any other relevant parameters you may need but clearly indicate what they are. No mystery symbols!

Q7 15 pts. A charged particle enters a uniform static magnetic field $\mathbf{B}$ moving with a non-relativistic velocity $\mathbf{v}_0$ that is inclined at an angle α to the direction of $\mathbf{B}$.

a) 5 pts Compute the power P radiated by the particle.

b) 10 pts If a uniform static electric field $\mathbf{E}$ is added parallel to $\mathbf{B}$, how large must it be to double the previous rate of radiation?