Physics 222 – Test 2 – Spring 2011

One-page reminder sheet allowed. Constants: $\epsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}, $\mu_0 = 4\pi \times 10^{-7}$ N s^2 C^{-2}, $g = 9.8$ m s^{-2}. *Show all work – no credit given if work not shown!*

1. Given a four-potential $\underline{a} = (\epsilon Cy, 0, 0, Cy)$, where C and ϵ are constants with $0 < \epsilon < 1$:

   (a) Compute the electric field.

   (b) Compute the magnetic field.

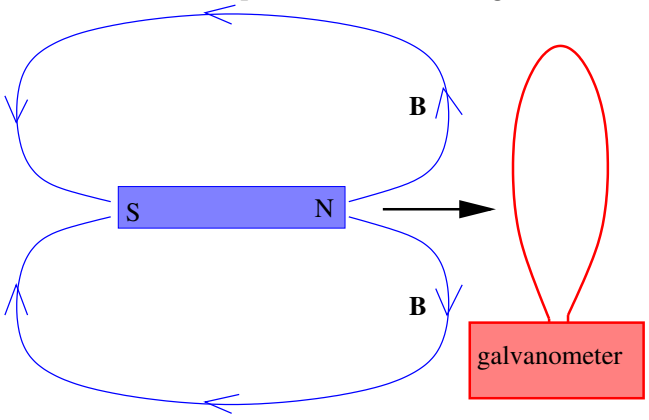
   (c) Determine the velocity of a moving reference frame in which the vector potential, and hence the magnetic field are zero.

   (d) In this moving frame, determine the components of the four-potential and compute the electric field.

2. Near the equator at the surface of the earth, the earth's magnetic field points to the north with a strength of about 3×10^{-5} T. Determine the speed and direction of motion a proton needs (charge: 1.6×10^{-19} C; mass: 1.67×10^{-27} kg) to have the magnetic force to just balance the gravitational force.

3. In the atmosphere of the earth there is a downward-pointing "fair weather" electric field of about 150 V m^{-1}. Determine the sign and magnitude of the net charge on the earth and state what physical law you are using. (The earth's radius is 6.37×10^6 m.)

4. A bar magnet moves at a constant speed through a loop of wire connected to a galvanometer (device for measuring voltage differences) as shown below. Make sketches of the magnetic flux through the loop and the EMF measured by the galvanometer as a function of the position of the magnet and state what physical law you are using.

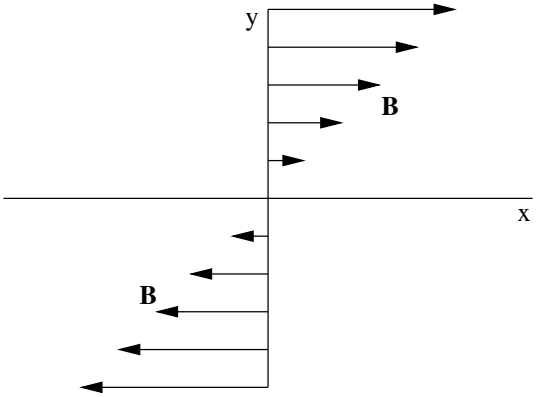


5. A magnetic field has the form $\mathbf{B} = (Cy, 0, 0)$ where C is a constant, as shown below.

   (a) If there is no electric field, what can you infer about the direction and spatial distribution of the electric current?

   (b) If there is no current, what can you infer about the direction, spatial distribution, and time dependence of the electric field?

   (c) State what physical law you are using.



6. A kilogram of the explosive TNT releases 4.7×10^6 J of energy when it explodes. TNT has a mass density of 1.65×10^3 kg m^{-3}.

   (a) Determine the amount of energy released in the explosion of a one-cubic-meter block of TNT.

   (b) Determine the magnetic field for which the same amount of energy is stored in a cubic meter.

   (c) Do the same calculation for the electric field.