PHYS 230/B01 – FINAL EXAM

Instructor: Dr. K.H. Chow
Date/Time: Monday April 23 2007, 9:00 am – 11:30 am (2.5 hours).
Instructions:
- Answer every part of every problem.
- Use the exam booklets provided to answer the problems.
- Express any final numerical answers to *at least* 3 significant figures.
- One 8.5 x 11 inch formula sheet and calculator are allowed.
- Show your work in a neat and logical manner. This will improve your chances of getting partial marks.

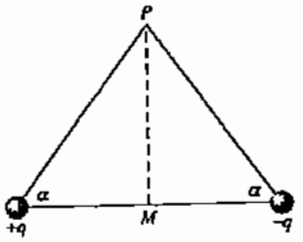
Total points: This exam consists of **7** problems and is out of **100** points.

Constants:

Mass of electron	$= 9.11 \times 10^{-31}$ kg
Mass of proton	$= 1.67 \times 10^{-27}$ kg
Electron charge (magnitude)	$= 1.602 \times 10^{-19}$ C
Acceleration due to earth's gravity g	$= 9.80$ m/s^2
Permittivity of free space ε_0	$= 8.854 \times 10^{-12}$ C^2/(N.m^2)
Permeability of free space μ_0	$= 4\pi \times 10^{-7}$ T.m/A

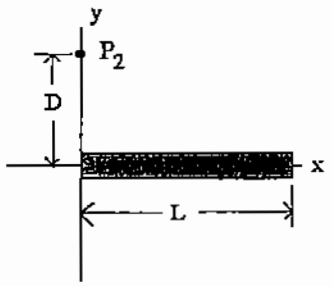
---

1. [15 points]
Two point charges of the same magnitude but opposite signs are fixed to either end of the base of an isosceles triangle (triangle with two sides of equal lengths), as the drawing shows. The electric field at the midpoint M between the charges has a magnitude E_M. The electric field directly above the midpoint at point P has a magnitude E_P. The ratio of these two field magnitudes is $E_M / E_P = 9.0$. Find the numerical value for the angle α in the drawing.

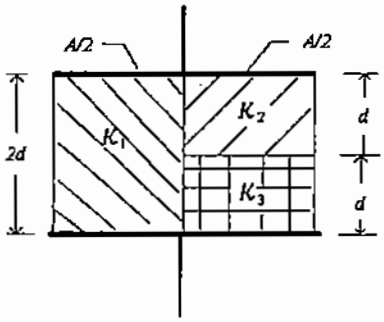


2. [15 points]
An insulating (i.e. non-conducting) solid cylinder, of radius R = 10 cm and length L = 1 m, carries a net charge Q = +6.28 μC. The volume charge density ρ is a function of r (the distance from the axis of the cylinder), and it decreases as $\rho = c/r$, where c is a constant.
(a) Find the numerical value of c.
(b) Find the magnitude of the electric field as a function of r for (a) r < R; (b) r > R. (In part (b), you can neglect the "fringing" effects at the ends of the cylinder.)

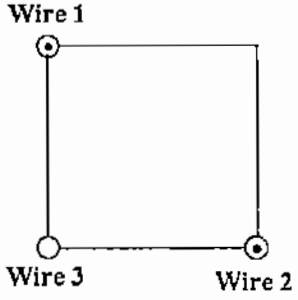
3. [15 points]
The thin plastic rod of length L = 10.0 cm in the figure below has a non-uniform linear charge density $\lambda = cx$, where $c = +49.9 \times 10^{-12}$ C/m^2. (a) With the electric potential V defined to be 0 at infinity, find its value at point P_2 on the y axis at $y = D = 3.56$ cm. (b) Find the direction and magnitude of the y-component of the electric field E_y at P_2.



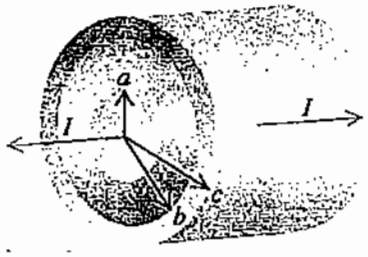
4. [15 points]
The parallel-plate capacitor shown in the figure has plate area $A = 10.5$ cm^2 and plate separation $2d = 7.12$ mm. The left half of the gap is filled with a material of dielectric constant $\kappa_1 = 21.0$; the top of the right half is filled with material of $\kappa_2 = 42.0$; the bottom of the right half is filled with material of dielectric constant $\kappa_3 = 58.0$. If the potential difference between the upper and lower plate is 12.0 Volts, what is the charge stored by the capacitor?



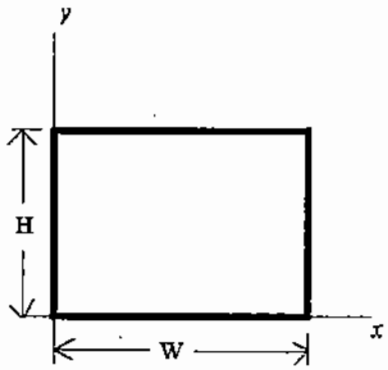
5. [15 points]
The drawing shows an end-on view of three very long straight wires. They are perpendicular to the plane of the paper. The cross sections lie at three corners of a square, as shown. The currents in wires 1 and 2 have magnitude $I_1 = I_2 = I$ and are directed out of the paper. It is found that a proton that is located at the empty corner always experiences zero net force regardless of the magnitude and direction of its velocity vector. [Ignore gravity.]
(a) What is the direction of the current I_3 in wire 3?
(b) What is the ratio I_3/I?



6. [15 points]
A coaxial cable consists of a solid conducting rod with radius a on the axis of a conducting cylinder with inner radius b and outer radius c (see figure below). Assume there is vacuum everywhere else. The inner conducting rod and the outer conducting cylinder carry currents of equal magnitude I but in opposite directions. The currents are distributed uniformly over the cross sections of each conductor. Find the magnitude of the magnetic field for (i) $r < a$, (ii) $a < r < c$ (iii) $r > c$?



7. [10 points]
The figure below shows a rectangular loop of wire. It is immersed in a non-uniform and time-varying magnetic field $\boldsymbol{B}$ that is always perpendicular to and directed into the page. The field's magnitude is given by $B = 4t^2x^2$, with B in Teslas, t in seconds, and x in meters. The loop has width $W = 3.0$ m and height $H = 2.0$ m. (a) What is the magnitude of the induced emf? (b) What is the direction of the induced current (i.e. clockwise or counterclockwise)?



End of Exam – Have a good summer