February 16, 2005   Physics 202

EXAM 1

Print your name and section <u>clearly</u> on all <u>five</u> pages. (If you do not know your section number, write your TA's name.) Show all work in the space immediately below each problem. **Your final answer must be placed in the box provided**. Problems will be graded on reasoning and intermediate steps as well as on the final answer. Be sure to include units wherever necessary, and the direction of vectors. **Each problem is worth 25 points**. In doing the problems, try to be neat. Check your answers to see that they have the correct dimensions (units) and are the right order of magnitudes. You are allowed one 5" x 8" note card and no other references. The exam lasts exactly one hour.

(Do not write below)

SCORE:

Problem 1: _____

Problem 2: _____

Problem 3: _____

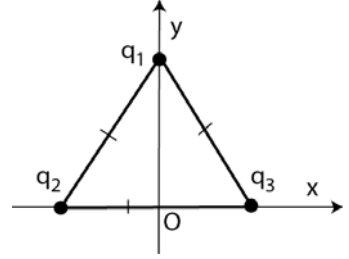Problem 4: _____

TOTAL: _____

Possibly useful information:

$\varepsilon_0 = 8.85 \times 10^{-12} \; C^2 \, N^{-1} \, m^{-2}$
$k = 8.99 \times 10^9 \; N \, m^2 \, C^{-2}$
$e = 1.602 \times 10^{-19} \; C$

PROBLEM 1

Three charges $q_1 = + Q$, $q_2 = -Q$, and $q_3 = -Q$, where $Q = 1.35 \times 10^{-6}$ C
are fixed in positions at the vertices of an equilateral triangle with each
side 1.82 m long as shown.

a. What is the magnitude of the electric field at the origin (x=0, y=0)?
(5 pts.)

b. What is the angle of the electric field at the origin in + or - degrees from the x-axis? *(5 pts.)*

c. What is the electric potential at the origin? *(5 pts.)*

d. How much work in Joules is required to bring a fourth charge $q_4 = 1.20 \times 10^{-6}$ C from infinity
to the origin? *(5 pts.)*

e. What is the magnitude of the net force exerted on q_4 at the origin by the charges q_1, q_2, and q_3
together?*(5 pts.)*

PROBLEM 2

The earth's electric field is measured at one point on its surface to be 89 N/C. If this were true everywhere over the earth's surface (treating it as a solid *conducting* sphere of radius 6400 km):

a. What is the charge inside and on the surface? *(8 pts.)*

Inside:	Surface:

b. What is the magnitude of the electric field inside the Earth? *(4 pts.)*

c. What is the magnitude of the electric potential inside and on the surface of the Earth? *(8 pts.)*

Inside:	Surface:

d. What is the magnitude of the electric field outside the Earth at a distance of 6400 km *from the surface*? *(5 pts.)*

PROBLEM 3

A parallel plate capacitor has plate area of 620 cm^2, plate separation of 4.0 mm and is connected to a power supply that charges it to 130 V. It is then disconnected from the power supply.

a. Find the electric field between the plates *(4 pts.)*

b. Find the surface charge density on one of the plates *(4 pts.)*

c. A sheet of insulating dielectric ($\kappa = 4.2$) is inserted that completely fills the space between the plates. Find the new electric field between the plates *(4 pts.)*

d. Find the capacitance of the capacitor with the dielectric *(4 pts.)*

e. Find the induced surface charge density on each face of the dielectric *(4 pts.)*

f. Find the magnitude and sign of the change in stored energy caused by inserting the dielectric *(5 pts.)*

PROBLEM 4

A 7.0 V battery and five capacitors of capacitance each 5.0 μF form the circuit shown

a. What is the combined capacitance of C_4 and C_5? *(5 pts.)*
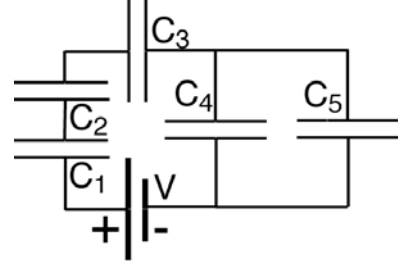
b. What is the total capacitance of the entire circuit? *(5 pts.)*

c. What is the total charge on capacitor C_1? *(5 pts.)*

d. What is the total energy stored in this circuit? *(5 pts.)*

e. After the whole circuit is immersed in oil ($\kappa = 2.5$), what is the total energy? *(5 pts.)*