Name:

Physics 122 – Spring 2012 – Test 2

Instructions:

There are some useful tables at the end of this exam paper.
You may use a calculator and your 3x5 index card. Please ATTACH your index card to the test afterwards. Problems 1-5 require *only* an answer, but you *may* provide an explanation for the possibility of partial credit. Problems 6-12 require work to be shown in an orderly fashion. *IDEA* method is recommended but not required. If I cannot easily follow your work, you will receive reduced credit.

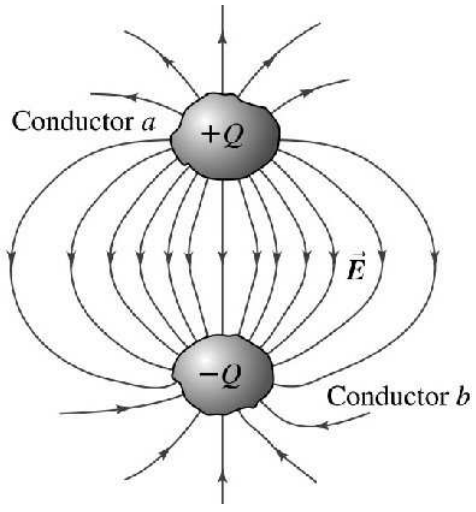
1. *(5 pts.)* The value of the constant ϵ_0 is 8.86×10^{-12} in SI units. What are appropriate units for ϵ_0? (There is more than one correct answer, but you only need to give one answer. Show work for part credit.)

2. *(5 pts.)* Electric potential is usually expressed in Volts, but it can be expressed in other SI units. Which of the units below are also appropriate for potential?

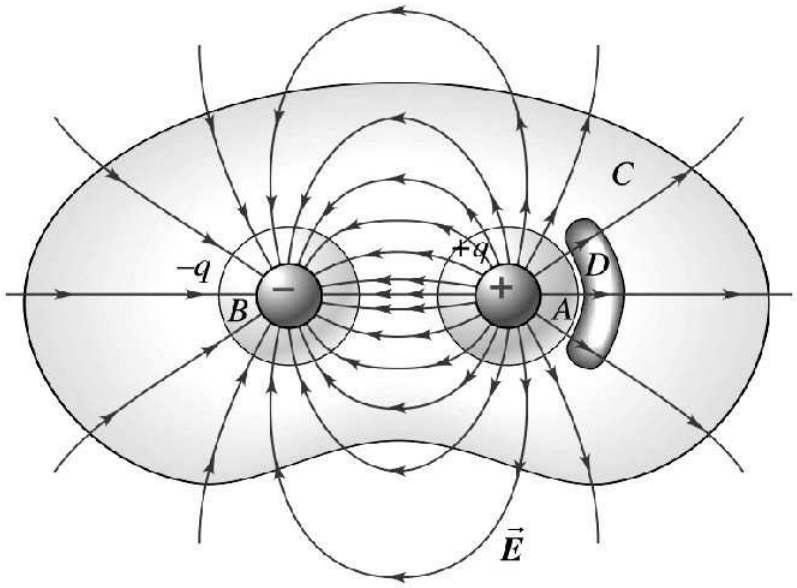
(a) N/C
(b) V/m
(c) N · m
(d) J/s
(e) C/s
(f) J/C

3. *(5 pts.)* The two conductors a and b are insulated from each other, forming a capacitor. You increase the charge on a to +2Q and increase the charge on b to -2Q, while keeping the conductors in the same positions. What effect does this have on the capacitance C?

(a) C is multiplied by a factor of 4.
(b) C is multiplied by a factor of 2.
(c) C is unchanged.
(d) C is multiplied by a factor of 1/2.
(e) C is multiplied by a factor of 1/4.



Problem 3: Two conductors form a capacitor.



Problem 4: Arbitrary surfaces in electric fields created by charges shown. The positive and negative charges are equal in magnitude.

4. *(5 pts.)* For the surfaces labeled A–D in the figure, indicate whether the net electric flux through that surface is positive, negative, or zero.

5. *(5 pts.)* Protons and neutrons are made of quarks, and quarks have charges that are in thirds of a proton charge. A "strange quark" has a charge of 1/3 the charge of proton. A "top quark" has 2/3 the charge of an proton. The mass of a top quark is 1800 times the mass of a strange quark. A top quark and a strange quark go into a bar. No other particles are around. What can you say about the magnitude of the electric force that the quarks exert on each other?

(a) Both particles feel the same force.
(b) The force on the top quark is larger than the force on the strange quark because it has a larger charge.
(c) The force on the strange quark is larger than the force on the top quark because it has a much smaller mass.
(d) Neither particle feels a force because their charges are less than a proton charge.
(e) Answer depends how much they have had to drink.
(f) Answer depends how much *you* have had to drink.

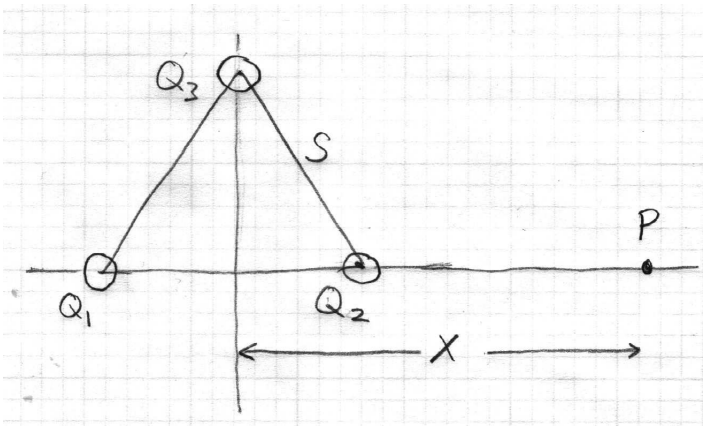
6. *(10 pts.)* A proton is placed in an electric potential given by the function V(x) = $2x^2 + 4x - 6$ (V is in Volts and x is in meters). What force does the proton feel at the point x=1 meter?

7. *(20 pts.)* Charges Q_1, Q_2, Q_3 are arranged in an equilateral triangle with side "s" as shown in the figure below. Another charge Q_4 is placed at point "P" a distance "X" from the origin.

(a) If s=1 meter, X=2 m, $Q_1 = Q_2 = 20\ \mu$C, $Q_3 = 0$ and $Q_4 = 40\ \mu$C what is the magnitude of the force exerted on Q_4?

(b) Now assume that all four charges have the same (positive, non-zero) value called simply Q. X and s are arbitrary (but $X > s$ as shown in the figure). Write an expression for the force felt at P in terms of Q, X, and s. Make sure to express your force in terms of vector components.

(c) Plug into your answer from part (b) and give a numerical answer given s=1, X=2, Q=30 μC.



Problem 7: Three charges arranged in an equilateral triangle of side s.

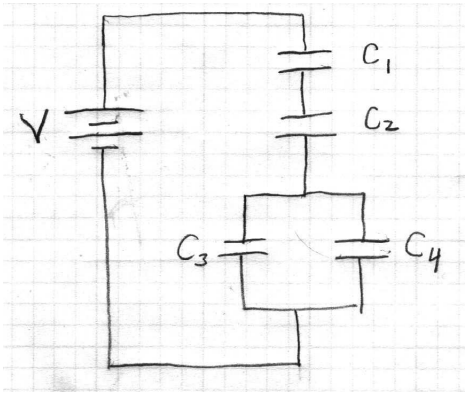
8. *(15 pts.)* A square, flat, charged plate lays on the ground. The side of the plate is 10 cm. The total charge on the plate is 40 nC. Use Gauss's law to calculate the magnitude of the electric field (a number) at point P. Draw the plate, the point P, representative field lines and your Gaussian surface. State your assumptions. [HINT: Do not over-complicate this. Make (appropriate) approximations.]

(a) Answer the questions posed above assuming the point P is 1 mm above the center of the plate.
(b) Answer the questions posed above assuming the point P is 1 km above the center of the plate.
(c) Draw two more sketches showing the plate, P and representative equipotential lines for case (a) and (b) above. Approximate sketches are fine.

9. *(10 pts.)* A 3-cm-diameter metal sphere carries a positive charge Q. The electric field at the sphere's surface exceeds (barely) the breakdown field in air (see table at end of exam).

(a) Find Q.
(b) What is the electric potential at the sphere's surface? (relative to ∞).
(c) If a proton were released from rest at the surface of the sphere, what would be its speed far from the sphere?

10. *(10 pts.)* In the circuit below, all four individual capacitors have the value two microFarads. As you know, the four capacitors can be replaced by a single equivalent capacitor. What is the value of that capacitor? Show your work.



Problem 10: Four equal capacitors in a circuit.

11. *(10 pts.)* A parallel plate capacitor (with air or vacuum in the gap) is charged to 80 Volts. The capacitance is 100 pF and the plates are separated by 0.5 mm. Find:

(a) The area of the plates.
(b) The charge on the capacitor.
(c) The electric field magnitude in the gap.
(d) The energy stored in the capacitor.

12. *(5 pts.)* A capacitor with the same area and gap as in the previous problem has the gap filled with glass. Again, 80 V is applied. Find:

(a) The new capacitance.
(b) The charge on the capacitor.
(c) The electric field magnitude in the gap.
(d) The energy stored in the capacitor.

Constant	Value
Elementary charge	1.6×10^{-19} C
ϵ_0	8.86×10^{-12} (SI units)
Proton mass	1.67×10^{-27} kg
Electron mass	9.91×10^{-31} kg

Substance	Dielectric Constant	Breakdown Field (MegaVolt/m)
Air	1.0006	3
Polyethylene	2.3	50
Glass	5.6	14