PH 1120
Electricity and Magnetism **Term B, 2008**

STUDY GUIDE #2

In this part of the course we will study the following topics:

- Electric potential difference and electric potential for a uniform field
- Electric potential difference and electric potential for a point charge
- Calculation of the potential of a system of point charges by the principle of superposition
- Motion of a charge through a region of varying potential
- Equipotential surfaces and their relationship to electric field lines
- Capacitors as circuit elements and as devices for storing electrical energy

The electric potential provides an alternative way of thinking about electric fields that is appealing because the potential is a scalar and not a vector. Nevertheless the potential encodes complete information about the electric field, including its vector character. Understanding how it does this is one of the major goals of this part of the course. The potential is also important because of its connection with the all-important concept of energy.

Definition 1. The potential difference, $V_B - V_A$, between two points B and A is the *negative* of the work done by the electric field on a unit positive charge that is taken from A to B.

Remark: The potential difference between two points is independent of the path along which the charge is moved between the points. The truth of this statement is not obvious. A proof of it will be given in lecture for the case of a uniform electric field. In a more advanced course in electromagnetism you would learn that this is true of all "conservative" electric fields. The notion of potential difference is so useful precisely because it is independent of the path between the points.

Definition 2. The absolute potential at any point is the potential difference between that point and an arbitrarily chosen reference point, where the absolute potential is taken to be zero.

Potential difference and potential energy of a uniform field are treated first in lecture because they are easier to understand than the same concepts for point charges.

Objective 7: Potential, potential difference and equipotentials for a uniform field
Suggested Study Procedure:
Study Ch 23.1, 2. Look particularly at pp.781-2 and Example 23-9
Suggested Problems:
Exercises 23.13, 29, 31, 45; Problems 23.53,60

Objective 8: Potential, potential difference, and energy considerations for point charges
Suggested Study Procedure:
Study Ch.23.1, 2, 3 and Ch.23.4, pp.798-800 for equipotential surfaces. Study Figs.23.24 and 23.25 closely. We won't study equipotential surfaces in much detail in this course, but this is an important concept you are bound to encounter in a more advanced course on electromagnetism..

Suggested Problems:

Exercises 23.5, 21, 28, 30

Objective 9: Capacitance, Series/Parallel Equivalence, and Energy Storage

Suggested Study Procedure:

Study Ch. 24.1, 2, 3

Suggested Problems:

Exercises 24.5,15, 23, 25, 31; Problems 24.53, 57

Optional Reading. The notion of dielectrics will be touched on only lightly in the lectures. However those of you wanting to learn more about this important topic should read Ch.24-4.

Homework Assignment #5 (due Mon 11/10 by Midnight)

Go to www.masteringphysics.com and log in. Click on Assignment list and select Assignment #5. You will get 4 chances to submit the correct answer. If your first answer is incorrect, you should consider making use of the hints.

Homework Assignment #6 (due Wed 11/12 by Midnight)

Go to www.masteringphysics.com and log in. Click on Assignment list and select Assignment #6. You will get 4 chances to submit the correct answer. If your first answer is incorrect, you should consider making use of the hints.

Homework Assignment #7 (due Fri 11/14 by Midnight)

Go to www.masteringphysics.com and log in. Click on Assignment list and select Assignment #7. You will get 4 chances to submit the correct answer. If your first answer is incorrect, you should consider making use of the hints.

Homework Assignment #8 (due Mon 11/17 by Midnight)

Go to www.masteringphysics.com and log in. Click on Assignment list and select Assignment #8. You will get 4 chances to submit the correct answer. If your first answer is incorrect, you should consider making use of the hints.

SUMMARY HOMEWORK 2

Shown on the next page is a copy of what the front page of Exam 2 will look like.
After that are the problems you need to do and submit. These problems are similar (but not identical!) to what you can expect on the exam.
Do all 6 problems. However only 4 of them (selected at random) will be graded.
The exam will not be as long as this homework, it is designed for a 50 minute period.

Please observe the following guidelines in submitting this homework:

(1) Submit your work on standard 8 ½" x 11" paper (lined or unlined). STAPLE the sheets together (no dog ears please!). Loose sheets that are lost are your responsibility.
(2) PRINT your name and conf sec # on the top page.
(3) Show all your work clearly in order to be eligible for full or partial credit.
(4) Box or circle your answers so that they are easy to pick out.
(5) Keep 3 significant figures except when told otherwise. Don't forget units. A vector should be specified in terms of unit vectors or by its magnitude and direction.

PH 1120

Name: ____________________
Section: ____________________

EXAMINATION 2

Show ALL work (with logically complete statements!) on these pages. If you require more room, write the extra work on the <u>preceding</u> page ... the page <u>facing</u> the problem statement.

Numerical answers should be expressed to 3 significant digits. Answers should carry units, wherever necessary. Express vectors in **i**, **j, k** notation or else indicate their magnitude and direction unambiguously. Place your answer in the BOX, where provided.

This exam is CLOSED BOOK, CLOSED NOTES.

Electron charge = -1.6×10^{-19}C
Electron mass = 9.1×10^{-31}kg
Proton mass = 1.672×10^{-27}kg, Proton charge = 1.6×10^{-19}C
Coulomb constant $k = 1/4\pi\varepsilon_0 = 9 \times 10^9\ Nm^2/C^2$
$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$
$F_{12} = kq_1q_2/r_{12}^2$ in magnitude
$E = kq/r^2$ in magnitude (point charge)
$V = kq/r$ (point charge)
$V_f - V_i = -\mathbf{E}\cdot(\mathbf{r}_f - \mathbf{r}_i)$ – uniform field
$\frac{1}{2} mv_i^2 + qV_i = \frac{1}{2} mv_f^2 + qV_f$
$C = Q/V \quad C = \varepsilon_0 A/d$
$C_{eq} = C_1 + C_2 \quad 1/C_{eq} = 1/C_1 + 1/C_2$
$U = Q^2/2C = \frac{1}{2} CV^2$
$u = \frac{1}{2} \varepsilon_0 E^2$
1p = 1 pico = 10^{-12}, 1n = 1 nano = 10^{-9}, 1μ = 1 micro = 10^{-6}, 1m = 1 milli = 10^{-3}
1 eV (electron volt) = 1.6×10^{-19} J

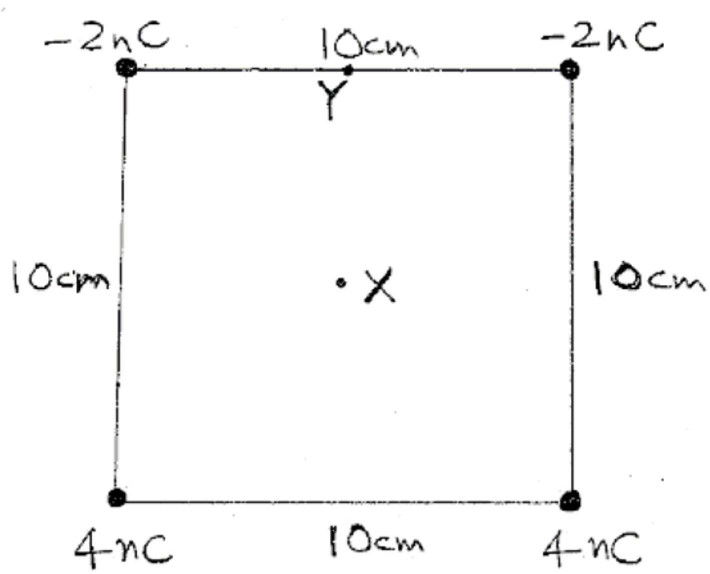
1	
2	
3	
4	

Problems carry the following points:
1 = xx, 2 = xx, 3 = xx, 4 = xx.

1. A charge of +10nC is at (0,0) and an unknown charge q is at (1,0), with all coordinates being in meters. The potential at point A, with coordinates (0.2,0) is +405V.

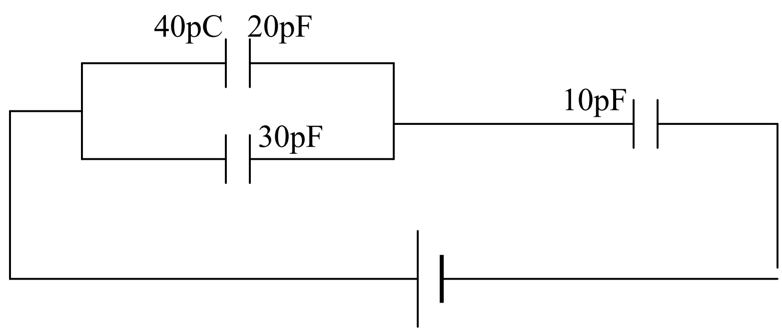
(a) Determine the magnitude and sign of the unknown charge q.
(b) Calculate the potential at point B, with coordinates (0.8,0).
(c) A proton is observed to move in a straight line from A to B. If its kinetic energy at A is 100eV, what is its kinetic energy at B? (give the answer in eV).
(d) Ignoring the points at infinite distance, pick out the best possibility for each of the statements below and write it down on your homework sheet.
The electric field vanishes:
(1) to the left of the 10nC charge (2) between the charges (3) to the right of the charge q
The electric potential vanishes:
(1) to the left of the 10nC charge (2) between the charges (3) to the right of the charge q

2. Four point charges of -2nC, -2nC, 4nC and 4nC are at the corners of a square of side 10cm, as shown in the sketch below. A charged particle released from rest at X, the center of the square, is observed to move in a straight line through the point Y, the midpoint of the top edge.



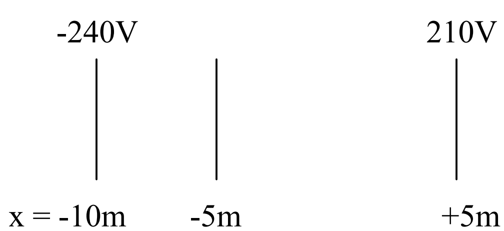
(a) What is the sign of the charge on this particle, positive or negative?
(b) What is the potential difference between points X and Y? State which point is at the higher potential.
(c) If the magnitude of the charge is 5nC, how much work is done on it by the electric field as it moves from X to Y?
(d) What is the kinetic energy of the particle, in ev, at the point Y?

3. Three capacitors are hooked up to a battery of unknown voltage, as shown below. The 20pF capacitor has a charge of 40pC (this is the magnitude of the charge on each of its plates).



(a) Determine the charge on the 30pF capacitor
(b) Determine the charge on the 10pF capacitor
(c) Determine the voltage put out by the battery.
(d) Calculate the equivalent capacitance of the circuit.
(e) Calculate the total energy stored in all the capacitors.

4. Several equipotential surfaces for a uniform electric field are shown below. The position coordinate of each equipotential is indicated below it and its absolute potential above it.



(a) Determine the magnitude and direction of the electric field. Describe the direction clearly in your answer.
(b) What is the value of the -5m equipotential?
(c) What is the x-coordinate of the 0V equipotential?

5. A parallel plate capacitor is connected to a battery and charged. The battery is then disconnected and the plate separation is increased to 3 times the original value.
(a) How does the charge on the plates change?
(b) How does the potential difference between the plates change?
(c) How does the energy stored in the capacitor change?

Answer in the form "the charge on each plate goes up by a factor of 2", " the potential difference goes down by a factor of 10", etc.

6. Three charges of 5nC are at the corners of an equilateral triangle of side 10cm, as shown in the sketch below.
(a) Calculate the electric field at X, the center of the triangle.
(b) Calculate the electric field at Y, the midpoint of the bottom side.
(c) Calculate the energy density in the electric field at X.
(d) Calculate the energy density in the electric field at Y.