Massachusetts Institute of Technology *Spring Term 2005*

8.02X Electricity and Magnetism

Problem Set 2 and Experiment Problem LVPS

Issued: **Fri, Feb 4**
Due: **Fri, Feb 18, 4PM <- note Date + Time!**

Please note that **both students** for each partnership must submit the LVPS experiment write-up, answering the LVPS experiment questions found below and submit the answers together with pset 2. This is **in addition** to the LVPS experiment check-off, which is due Fri, 2/18, 3PM.

Reading suggestions (from Young & Freedman, University Physics, 11th edition)

Mon, 2/14: Electric Flux, Gaus' Law: 22-1 to 22-5
Wed, 2/16: Electric Potential Energy, Electric Potential (1/2): 23-1, 23-2
Fri, 2/18: Electric Potential Energy, Electric Potential, Quiz Review: 23-3

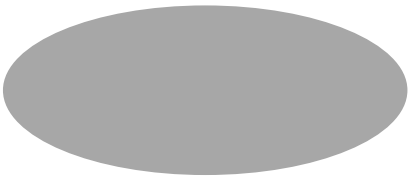
Homework Problems (30 points)

Problem 1 (5 Points) Consider an infinite plane (non-conducting) with a uniform negative surface charge density σ.

(a) Draw a sketch of the electric field (using field lines) close to the plane.
(b) Explain in words why the field has to look the way you have drawn (using symmetry arguments). (Keep your explanation to 2-3 sentences)

Problem 2 (5 Points) Consider an ellipsoidal conducting object carrying a positive charge Q (shown below).

(a) Draw a sketch of the elecric field (using field lines) very close to the surface of the object. Your sketch should show where the magnitude of the electric field will be biggest.
(b) Explain in words how the fact that we are looking at a **conducting** object determines the direction of the field relative to the surface at very small distances to the surface. (Keep your explanation to 2-3 sentences)



Problem 3 (5 points):
Consider an electric dipole consisting of point charges **+q** and **–q**, separated by a fixed distance **d.**

(a) Determine the net force and net torque on the dipole in a uniform electric field **E** as a function of the angle ϕ between the axis of the dipole and the direction of the field.
(b) Now the dipole is brought into the field of a fixed point charge **Q**, which is at distance **r** from **+q** and distance **(r+d)** from **–q**. We observe that the dipole accelerates towards **Q**. Is **Q** positive or negative?
(c) If the dipole has mass **m**, what will be the initial acceleration of the dipole in case (b)?

Problem 4 (5 Points): Young + Freedman, Challenge Problem 22.65

Problem 5 (5 Points): Young + Freedman, Exercise 23.39

Problem 6 (5 Points): Young + Freedman, Problem 23.61

Experiment Low Voltage Power Supply (LVPS)

Due Date: Check-off by Friday, 2/18, 3PM in lab 4-355.
Lab Hours: Monday: 3-5 pm, Tuesday: 7:30-9:30pm, Wednesday: 7:30-9:30 pm, Thursday: 3-5 pm, Fridays: 12-3 pm

There will be 2 bonus points for check-off on Monday, 2/14 and 1 bonus point on Tuesday, 2/15!

Check-off Criteria:

- Every partnership needs to build two LVPS's.
- One working LVPS must be demonstrated, with an output voltage range between 1.2 and 17V
- All connections need to be properly soldered, with no shorts or bad contacts
- You should be prepared to explain the testing procedure out lined below
- **You will NOT be responsible for a detailed explanation of how the LVPS works (yet)!**
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LVPS Measurement:

To test the characteristics of the LVPS, we will see how the output voltage of the LVPS changes when a load (the 8W filament of the 1157 lamp) is connected to the LVPS output.
To perform the measurement, you will need to do the following:

1. Connect the LVPS to the wall transformer. Use a multimeter to determine the output voltage of the LVPS. Verify that by turning the pot you can vary the output voltage between approximately 1.2 and 17V.
2. Determine which filament of the 1157 lamp is the 8W filament and which is the 26W filament.
3. For 8 different settings of the potentiometer between the minimum and maximum, record the LVPS output voltage without the lamp connected (no-load voltage) and with the 8W filament of the lamp connected (load voltage) for the same pot setting.

LVPS Homwework tasks (20 points total):

(Data table, graph and answer need to be handed in by BOTH partners, together with pset 2 on Fri, 2/20)

Task 1 (10 points): Record the no-load and load ($V_{no\ load}$ and V_{load}) voltages in a table. Plot V_{load} in a graph against $V_{no\ load.}$

Task 2 (5 points): Determine over which range of no-load voltages connecting the lamp leaves the LVPS output voltage unchanged.

Task 3 (5 points): Describe how you distinguished the 8W and 27W filament.