

8.02X Electricity and Magnetism

Problem Set 3

Issued: Wed, Feb 16

Due: Fri, Feb 25,, 4PM <- note Date + Time!

Reading suggestions (from Young & Freedman)

Fri, 2/18 : Quiz 1 Review

Tue, 2/22: Quiz

Wed, 2/23: Electric Potential cntd 23-3, 23-4

Fri, 2/25: Capacitance 24-1

Homework Problems (30 points total)

Problem 1 (10 points) Two pointlike test charges $+q$ and $-q$ are brought separately into the vicinity of a pointlike charge $+Q$. First charge $+q$ is brought to a distance r from $+Q$ and then $+q$ is removed and $-q$ is brought to the same distance r .

- (a) At distance r from $+Q$, which of the two charges $+q$ or $-q$ has the greater potential energy U , relative to $U(\text{infinity}) = 0$?
- (b) How big is the difference in potential energy for $+q$ and $-q$?
- (c) What can you say about the electric potential in the two cases?

Problem 2 (10 points) A proton is shot towards a lead nucleus from very far away. The proton reaches a closest distance to the nucleus of 10 fermi before being pushed back. What is the initial speed of the proton?

Problem 3(10 points) Consider two spherical conductors with radii A and B ($A \gg B$), that are connected by a conducting rod. The spheres carry a combined net charge $+Q$.

- (a) Explain why the electric potential of the surface of both spheres will be the same
- (b) Determine the ratio of the electric field strengths near the surfaces of the two spheres.

EXPERIMENT HVPS Questions

Lab Hours: Mondays: 3-5 pm, Tuesday: 7:30-9:30 pm, Wednesday: 7:30-9:30 pm, Thursday: 3-5 pm, Fridays: 12-3 pm

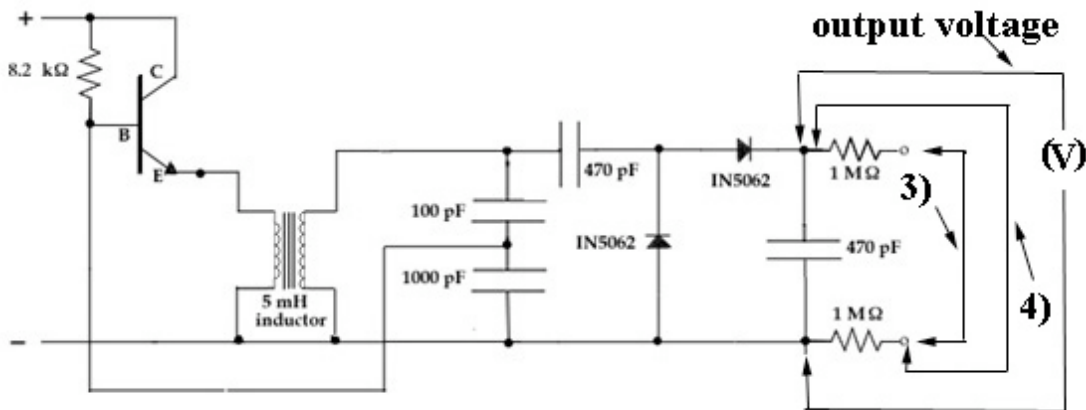
Due Date: Check-off by March 4. To satisfy the check-off for the Building the HVPS you must do the following tasks.

You will be graded according to the following criteria:

1. ☐ Your HVPS works properly.
2. ☐ The HVPS is wired according to the wiring diagrams that are shown in the lab write-up.
3. ☐ All connections are properly soldered without shorts.
4. ☐ You should be prepared to briefly explain the questions below.
5. ☐ **You will not be responsible yet for a detailed explanation of how the HVPS works.**

Bonus Points Policy: Check-offs that are finished during the week of Feb 22-Feb 25 will receive 3 extra points. Check-offs on Mon 2/28 will receive 2 extra points, and check-offs on Tue Mar 1 will receive 1 extra point.

Question 1: *Testing The HVPS.*



Measurements:

We will measure the voltage output of the HVPS with no-load and with the $1\text{ M}\Omega$ resistors as loads. Adjust the pot on your LVPS so that the output voltage of the LVPS is between 1.5 V and 12 V . Use one of your multimeters to monitor the output voltage of the LVPS throughout the following measurements. Set the other multimeter to the 1 K range and connect the leads not at the output of the HVPS but just before the $1\text{ M}\Omega$ resistors position (in the above diagram this connection is labeled output voltage). **(Place your**

positive red input into the appropriate input to the meter, labeled +DC 1000 V. The black ground input goes in the usual place.)

- 1) Determine the range of output voltages for the HVPS.

Now make five measurements of your HVPS between 100V to 1000V with three loads, MMM only, the MMM and the two $1\text{ M}\Omega$ resistors, and the MMM and one $1\text{ M}\Omega$ resistor. For each setting of the pot:

- 2) For each setting of the pot, measure the output voltage of the HVPS with your MMM (note that the MMM is the only load).
- 3) Use a clip lead to connect the ends of the two $1\text{ M}\Omega$ resistors together so as to put them in series across the output of the HVPS (in the above diagram this connection is labeled (3)). For each setting of the pot, measure the new output load voltage of the HVPS.
- 4) Use a clip lead to put only one of the $1\text{ M}\Omega$ resistors as a load across the output of the HVPS (in the above diagram this connection is labeled (4)). For each setting of the pot, measure the new output voltage of the HVPS.

Record your results in the accompanying data table at the end of this problem (which you should hand in with your answers).

Question 2:

- 1) The multi-meter, on the 1K scale, acts like a resistor with resistance of $20,000\Omega/VDC$. This means that to find the resistance you multiple $20,000\Omega/VDC$ by the full scale voltage reading which is 1000V. What is the resistance R_{MMM} of your multi-meter on the 1K scale?
- 2) Draw circuit diagrams of your HVPS, the multi-meter and the loads. Is your multi-meter in parallel or in series with the load?
- 3) When the multi-meter is in parallel with the load the equivalent resistance R_{eq} is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_{MMM}} + \frac{1}{R_{load}}.$$

When the multi-meter is in series with the load the equivalent resistance R_{eq} is given by

$$R_{eq} = R_{MMM} + R_{load}.$$

What is the equivalent resistance for loads of $2\text{ M}\Omega$ and $1\text{ M}\Omega$ loads?

- 4) Calculate the current output of your HVPS given by

$$I = \frac{V_{output}}{R_{eq}}.$$

Calculate the current output of your HVPS for each setting of the pot for both the $2M\Omega$ load and $1M\Omega$ load. Record your results in the last two columns of the data table.