Instructions:

Do not open this examination until the proctor tells you to begin.

1. When the proctor tells you to begin, **write your name and section number at the top of every page.** This is essential since this exam booklet will be separated for grading.

2. Do your work for each problem on the page for that problem. You might find it convenient to either do your scratch work on the back of the page before starting to write out your answer or to continue your answer on the back. **If part of your answer is on the back, be sure to check the box on the bottom of the page so the grader knows to look on the back!**

3. On all the problems **except the multiple choices questions in problems 1 and 2**, your answers will be evaluated at least in part on how you got them. If explanations are requested, more than half the credit of the problem will be given for the explanation. **LITTLE OR NO CREDIT MAY BE EARNED FOR ANSWERS THAT DO NOT SHOW HOW YOU GOT THEM.** Partial credit will be granted for correct steps shown, even if the final answer is wrong.

4. Write clearly and logically so we can understand what you are doing and can give you as much partial credit as you deserve. We cannot give credit for what you are thinking — only for what you show on your paper.

5. All estimations should be done to the appropriate number of significant figures.

6. At the end of the exam, write and sign the honor pledge in the space below: “I pledge on my honor that I have not given or received any unauthorized assistance on this examination.”

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**#1: #2: #3: #4: #5: Total**

***Good Luck***
2. (24 points) Two large parallel sheets of charge are separated by a distance $d$, small compared to the size of the sheets. The distance $d$ is small enough that the sheets can be treated as if they were infinite in extent. The amount of charge per unit area in the sheets are $+\sigma$ and $-\sigma$ respectively. A conducting plate of width $d/2$ is slid in between the two plates as shown in the figure at the right.

Select which of the graphs below could be appropriate to give a graph of each of the following quantities. If more than one answer works, give them all. If none works, write N.

a. the electric field between the plates before the metal plate was inserted

b. the electrostatic potential between the plates before the metal plate was inserted

c. the electric field between the plates after the metal plate was inserted

d. the electrostatic potential between the plates after the metal plate was inserted.

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If you need more space, continue on the back and check here.
1. (21 points) For each of the four problems below, put your choice of answer in the open box to the right. If more than one answer is possible, give them all. If none are possible, write N.

i) Which circuit(s) will light the bulb? (The other object represents a battery.)

- Circuit 1
- Circuit 2
- Circuit 3
- Circuit 4

ii) The circuit at the right contains a battery, a capacitor, a bulb and a switch. The switch is initially open as shown in the diagram, and the capacitor is uncharged. Which correctly describes what happens to the bulb when the switch is closed?

- (A) The bulb is dim and remains dim.
- (B) At first the bulb is dim and it gets brighter and brighter until its brightness levels off.
- (C) The bulb is bright and remains bright.
- (D) At first the bulb is bright and it gets dimmer and dimmer until it goes off.

iii) A bulb and a battery are connected as shown. Which is true about the current in this circuit?

- (A) The current is largest at A.
- (B) The current is largest at B.
- (C) The current is largest at C.
- (D) The current is largest at D.
- (E) The current is the same everywhere.
- (F) The current is the same between A and B and smaller than between C and D.
- (G) The current is the same between A and B and larger than between C and D.
- (H) The current is the same everywhere except in the bulb.
- (I) The current is the same everywhere except in the battery.

If you need more space, continue on the back and check here.
3. (15 points) As a part of our initial investigations of charge, we pulled two pieces of Scotch Magic Tape™ apart and observed that they had a force between them. Holding two top tapes not too far apart we saw a repulsive force of about 0.01 N. Estimate how much charge had to be moved to each of the top tapes to produce this force. **Be sure to clearly state your assumptions, since grading on this problem will be mostly based on your reasoning, not on your answer.**

One or more of the following numbers might be useful in solving this problem:

<table>
<thead>
<tr>
<th>Number</th>
<th>Unit Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.718</td>
<td>9 x 10⁹ N-m²/C²</td>
</tr>
<tr>
<td>3.1415</td>
<td>0.667 x 10⁻¹⁰ N-m²/kg²</td>
</tr>
<tr>
<td>9.81</td>
<td>N/kg</td>
</tr>
<tr>
<td>9.1 x 10⁻³¹</td>
<td>kg</td>
</tr>
<tr>
<td>3 x 10⁸</td>
<td>m/s</td>
</tr>
</tbody>
</table>
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Spring 2003  Exam 1  

4. **(10 points)** In discussing electric currents, we developed a model of how currents in electric circuits work. In this model, matter was made up of two kinds of opposite charges, one light and moveable and one heavy and stationary. We also created a number of analogies to help us think about what happens. Pick one of these.

- Give an example of how the analogy you chose helps us think about electric currents.
- Give an example of a place where your chosen analogy leads us astray in thinking about electric currents.
5. (30 points)
(A) All of the bulbs in the figure at the right have the same resistance $R = 1 \, \Omega$ and the battery has an EMF of 1.5 V. Find the current through each bulb and through the battery. Explain your reasoning. (15 pts)

(B) A wire is added to the circuit as in the figure at the right. What happens to the current through (brightness of) each of the bulbs and the battery? Indicate whether it increases, decreases, or remains the same. Explain your reasoning. (15 pts)