Highly suggested: carefully read through the testing policies below on the practice exam. You may only have a few minutes at most to read them at the actual exam (outside of exam time), and will be held to them without exception.

GENERAL INSTRUCTIONS:
· This is a closed book test. You may use a calculator only. (Cell phone calculators not allowed)
· The attached formula sheet has all equations needed to start a problem.
  Your own copy of this (or any other) formula sheet are not allowed.
· You may not leave the exam room without permission.
· Violating any of these procedures is considered academic dishonesty.

FORMATTING YOUR ANSWERS (Long answer section):
· Justify your work sufficiently, with calculation or explanation, in order to receive credit.
· Make your answers clear, legible and organized. If I can’t read it, no credit.
· I cannot grade crossed out or erased work. Be sure before deleting work.
· I cannot give full credit for a correct response if it is accompanied by another contradicting one. However, “hedging your bets” will earn more credit than not having the correct response at all.
· Do not forget to include units and express vectors appropriately for full credit.

Scratch paper policies:
There should be plenty of room on the test to put your answers, but if you feel you need more space, you may choose to turn in work on separate scratch paper. However, you must:
· Put a note on the exam problem/part referring me to “see scratch paper” for further work.
· Number the problem(s) on the scratch.
· Plan ahead for which pages are just for you, and which will be submitted. Don’t turn in unorganized scratch paper “on a whim” at the end of the exam. If any work for the multiple choice questions (cannot be graded) happens to be on the same page, please cross it out or clearly label it as separate from work you need graded.
· All scratch paper will be provided by me. You may not supply your own.
· Though I will make every effort to keep your test together, I am not responsible for lost/mismatched scratch pages. Write your name on every piece of scratch for grading (or bring a pocket stapler).

GOOD LUCK!
SECTION I: MULTIPLE CHOICE. No partial credit. Each question = 5 points

1.) You are walking through a region of space and notice that the equipotentials (of equal ΔV) are increasing in their spacing. This must mean:

a.) the electric field is weakening
b.) the electric field has a component that points in your direction of travel.
c.) Neither a nor b.
d.) Both a & b.
e.) Not enough info.

Questions #2-5 refer to the following:
In the diagram below, charges Q₁ and Q₂ are identical positive charges that are held fixed. Several spatial locations near them are marked. Points 1, 2 & 3 lie along the same line as the two charges. Points 3 & 4 are equidistant from both charges.

Your answer choices are:
a.) if simply released from rest.
b.) but any non-zero initial velocity (directed towards that final point) would be needed.
c.) but a large enough initial velocity (directed towards that final point) would be needed.
d.) N/A – it cannot get to this final point (under any condition specified above.)
e.) N/A – it cannot pass through this final point as requested (it would get stuck there).

2.) A positive charge released at point 1 could pass through point 2:
3.) A negative charge released at point 2 could pass through point 3:
4.) A positive charge released at point 4 could pass through point 3:
5.) A negative charge released at point 4 could pass through point 3:

Questions #6-9 refer to the following:
The circuit shown at right contains a battery and two resistors (R₁=R₂=R; labelled for identification purposes only.) We will take a look at the circuit as shown, as well as with two different possible modifications made to it (in turn, not at the same time.)

Circuit I.) exactly as shown in the figure.
Circuit II.) as shown in the figure, but placed in parallel with R₂:
an extra resistor R₅ (very large; R₅ > R.)
Circuit III.) as shown in the figure, but placed in parallel with R₂:
an extra resistor R₅ (very small; R₅ < R.)

Your answer choices are the following:
a.) Circuit I b.) Circuit II c.) Circuit III
d.) Two of these tie. e.) All three of these tie.

6.) In which circuit does R₁ have the most current?
7.) In which circuit does R₁ have the least current?
8.) In which circuit does R₂ dissipate the least power?
9.) In which circuit does R₂ have the largest voltage drop?
Questions #10-12 refer to the following:
A capacitor (with a dielectric in it) is fully charged by a battery through a large resistor. After charging, you quickly remove the dielectric from between the plates (with the capacitor remaining connected to the battery), and then immediately begin to measure the system from that time forward. During your observation, what happens to the quantities listed below?

For #10-11, your answer choices are:
a.) increases
b.) decreases
c.) stays the same value (as before the dielectric was removed)
d.) Not enough info.

10.) The charge stored on the capacitor plates.
11.) The voltage difference across the capacitor plates.

12.) Which of these statements best describes what is happening in the system (during your measurement)?
a.) The battery is putting charge onto the capacitor plates.
b.) The battery and capacitor are at equal voltage, so no charge flows.
c.) The resistance prevents charge from flowing, so no charge flows.
d.) The capacitor is putting charge back onto the battery.
e.) The capacitance increases since the dielectric was removed.

Questions #13-14 refer to the following:
Object A is negatively charged, and is brought nearby (but not touched) to object B, an uncharged conductor connected to ground.

13.) If A is taken away after B is disconnected from ground, then B overall will end up with
a.) positive charge   b.) negative charge   c.) zero charge.   d.) Not enough info.

14.) In this process, in order for object B to end up with a net charge, the nearby object A:
a.) must be a conductor
b.) must be an insulator
c.) It can be either a conductor or an insulator.
d.) It depends on if object B itself is conducting or insulating.
e.) It depends on if you want object B to get a net negative or positive charge.

END OF MULTIPLE CHOICE SECTION.
SECTION II: LONG ANSWER. Partial credit will be assigned. An answer with insufficient or no explanation and/or calculation to make it clear that the problem was done correctly will receive NO CREDIT. The questions are worth 25 points each.

1.) The figure below shows four identical charges \( Q_1 = Q_2 = Q_3 = Q_4 = +2 \text{ nC} \) fixed on the corners of a square of side \( L = 4 \text{ m} \) whose center is at the origin.

a.) Electric Field:
In the figure, draw in the direction of the field at five points: the center of the square, and at the midpoint of each side of the square. Show/explain below. (If any are zero, indicate this instead.)

b.) Voltage: Find the voltage at
i.) the center of the square.
ii.) the midpoint of each side of the square.

c.) Suppose a proton were released from rest at the following locations. After a long time has passed, find where it is located and how fast it is travelling.
   i.) the center of the square.
   ii.) the midpoint of the bottom of the square (halfway between \( Q_3 \) & \( Q_4 \).)
2. The circuit shown consists of a battery ($\varepsilon=9\, \text{V}$), two resistors ($R_1=2\, \Omega$, $R_2=4\, \Omega$), and an initially empty capacitor ($C=3\, \text{F}$). At $t=0$, the circuit is connected.

a.) Just after the circuit is connected:
Find the voltage drops and currents flowing to/through each circuit element. Show work and fill in the table.

![Circuit Diagram]

<table>
<thead>
<tr>
<th>a.) When circuit first connected:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1 =$</td>
</tr>
<tr>
<td>$V_2 =$</td>
</tr>
<tr>
<td>$V_C =$</td>
</tr>
</tbody>
</table>

b.) Repeat when the circuit has been connected for a very long time.

<table>
<thead>
<tr>
<th>b.) After a very long time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1 =$</td>
</tr>
<tr>
<td>$V_2 =$</td>
</tr>
<tr>
<td>$V_C =$</td>
</tr>
</tbody>
</table>

c.) Sketch the voltage vs. time. Include $V_1$, $V_2$, and $V_C$ on the same graph. On the right, conceptually explain the general shape of your graphs.

\[ V \]

\[ t \]

d.) At some point during the above process, $V_2 = 4\, \text{V}$. Again find the quantities requested in part a. Also, on the graph above mark off all three voltages at this time.

<table>
<thead>
<tr>
<th>c.) When $V_2 = 4, \text{V}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_1 =$</td>
</tr>
<tr>
<td>$V_2 = 4, \text{V}$</td>
</tr>
<tr>
<td>$V_C =$</td>
</tr>
</tbody>
</table>