PART I: MULTIPLE CHOICE

Each multiple choice question has one best answer – circle the letter of the best answer and, for full credit, explain your choice by invoking the appropriate concept, principle, and/or mathematical relation. No credit will be given if the explanation is entirely incorrect, even if your choice is correct. (4 points each for full credit)

1. Two Styrofoam packing “peanuts” (or puffs), suspended from threads, exhibit a slight attraction toward each other. From this we can infer that
   a) neither puff can be charged.
   b) at least one of the puffs must be charged.
   c) both puffs must be charged, and with the same sign charge.
   d) both puffs must be charged, and with opposite sign charges.

2. Consider two point-like charges, $q_A$ and $q_B$, separated by a distance $r$. The electrostatic force between them is $F$. If the magnitude of $q_A$ is halved and that of $q_B$ is reduced to 1/3 of its original value, and $r$ is reduced to 1/4 of what it had been, then the force between the two charges becomes
   a) $F/96$
   b) $F/24$
   c) $2F/3$
   d) $8F/3$

3. In the United States, AAA, AA, C, and D cells (batteries) all have a voltage difference of about 1.5 volts between their terminals. This means that they all can deliver about the same
   a) amount of energy.
   b) amount of charge.
   c) energy per unit charge.
   d) product of energy times charge.
4. Consider two equal and opposite spherical charges, each of magnitude Q. If the distance between the two charges is 2r, the potential half way between the two charges will be

a) zero  
b) kQ/r  
c) 2[kQ/r]  
d) 2[kQ^2/r^2]

5. A variable resistor (a resistor whose resistance can be changed) is connected across a constant voltage source. Which of the following graphs best represents the power, P, dissipated by the resistor as a function of its resistance, R.

   ![Graphs](image)

6. If resistors R_1, R_2, and R_3 all have the same value in the circuit shown in the diagram, which of the following is NOT true?

a) The largest current will pass through R_1.  
b) The voltage across R_3 is 5 volts.  
c) The power dissipated in R_1 could be 10 watts.  
d) If R_2 were to burn out, current would still flow through R_1 and R_3.  
e) The net resistance of the circuit is less than R_1.
7. Consider a pair of parallel metal plates with a 5 mm air gap between them, such as the parallel plate capacitor demonstrated in lecture. One plate is connected to the positive terminal of a battery and the other plate to the negative terminal. If a dielectric material, such as a sheet of plastic, is inserted between the plates,

a) no work is done as a result, and the energy stored remains constant.
b) work is done, thereby increasing the amount of stored energy in the capacitor.
c) work is done, decreasing the amount of energy stored in the capacitor.
d) C and V increase, while stored energy and Q both decrease.
e) none of these

8. A 6.0 µF capacitor and a 8.0 µF capacitor are connected in parallel. The combination is then connected in series with a 12.0 V battery and a 14.0 µF capacitor. What is the voltage across the 6.0 µF capacitor?

a) 4.0 V
b) 5.0 V
c) 6.0 V
d) 12.0 V
PART II: FREE RESPONSE — Choose any four of the following five problems.

9. A large electroscope is made from 1-meter long threads with 20-gram ping-pong balls attached to the ends. The two balls are given the same negative charge and consequently repel each other, the threads making an angle of $30^\circ$ with respect to the vertical as shown.

(a) What must be the charge on each of the balls? [12 pts]
(b) Draw a picture how they would hang if you doubled this charge on the left ball only. The drawing need not be to scale, but you should indicate important aspects and/or differences from the original scenario. [5 pts]
10. Near the surface of the Earth there is an electric field of about 150 V/m which points downward. Two identical balls with mass m=0.500 kg are dropped from a height of 2.00 m. One of the balls is positively charged with Q1= 500 µC, and the second is negatively charged with Q2= -500 µC.

(a) Which ball experiences the greater acceleration downward? Why? [4 pts]
(b) Using conservation of energy (mechanical and electrical) considerations, determine the difference in the speeds of the two balls when they hit the ground. (neglect air resistance) [13 pts]
11. If the 25-Ω resistor in the accompanying circuit diagram were shorted out (a wire of zero resistance put across it), what then would be the current through the 10-Ω resistor? [17 pts]

[Hint: redraw the circuit in such a way that it is clear which resistors are in series and/or parallel]
12. Two resistors and two capacitors are arranged as shown in the circuit diagram. All potentials are measured with respect to the negative end of the battery, which we shall define as $V=0$.

(a) What is the potential at point $a$ with the switch open? [3 pts]
(b) What is the potential at point $b$ with the switch open? [3 pts]
(c) What is the potential at point $a$ with the switch closed? [4 pts]
(d) What is the potential at point $b$ with the switch closed? [4 pts]
(e) What is the charge on the 12 $\mu$F capacitor when the switch is closed? [3 pts]
13. Consider the circuit shown.

(a) What is the magnitude and direction of the current through R1? [6 pts]
(b) What is the magnitude and direction of the current through R2? [6 pts]
(c) What is the magnitude and direction of the current through the 6 volt battery? [5 pts]