Spring 2006

Physics 262: Physics for Life Sciences II
Section 801: Second Midterm Test

- Time allowed: 75 minutes
- Calculators are not permitted.
- Section A contains multiple choice questions. There are 20 questions + 1 bonus question, worth 3 points each. Points will not be deducted for incorrect answers in this section, so you should answer all 21 questions, even if they are complete guesses.
- Section B has 2 homework-type problems worth 20 points each. Where appropriate, show how you obtained your answers, and remember to include the correct units.

Some useful information

- The charges on an electron and a proton are -1.6×10^{-19} C and $+1.6 \times 10^{-19}$ C, respectively.
- The prefix μ for micro stands for 10^{-6}.

SECTION A

1. An object is initially electrically neutral. If 10^{13} electrons are removed from it, what is its net charge?
   (A) $+10^{13}$ C (B) -10^{13} C (C) $+1.6\,\mu$C (D) $-1.6\,\mu$C

2. Small pieces of paper are attracted to both positively and negatively charged rods. Why?

   (A) The pieces of paper acquire an opposite charge to the charge on the rod.
   (B) The pieces of paper become electrically polarized.
   (C) The pieces of paper become magnetized.
   (D) Bernoulli's effect.

3. I bring a negatively charged rod near an (initially neutral) electroscope (close enough so that the leaf of the electroscope rises). I then ground the electroscope by touching the bulb. I remove my finger, and then I take the charged rod away. Which of the following is true?

   (A) The electroscope has no net charge.
   (B) The electroscope has a positive net charge.
   (C) The electroscope has a negative net charge.
   (D) The bulb on the electroscope has a net positive charge, but the leaf on the electroscope has a net negative charge.

4. An imaginary closed surface (*i.e.,* a Gaussian surface) encloses a volume containing a $+1$ C charge and a -2 C charge (and no other charges). What can we say about the electric field lines that pierce the imaginary surface?

   (A) The same number of electric field lines enter the enclosed volume as leave it.
   (B) No electric field lines either enter or leave the enclosed volume.
   (C) More electric field lines enter the enclosed volume than leave it.
   (D) More electric field lines leave the enclosed volume than enter it.

5. A $+1$ C and a -2 C point charge are 1 m apart. What are the magnitudes of the mutual Coulomb forces on the charges?

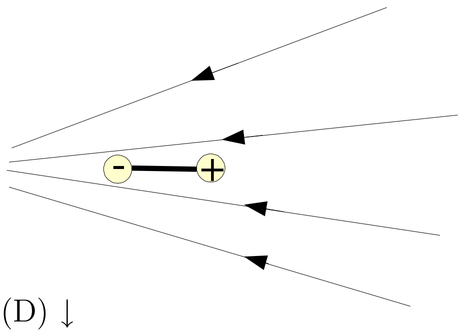
   (A) 9×10^9 N on the $+1$ C charge, and 1.8×10^{10} N on the -2 C charge.
   (B) 9×10^9 N on the -2 C charge, and 1.8×10^{10} N on the $+1$ C charge.
   (C) 9×10^9 N on both charges.
   (D) 1.8×10^{10} N on both charges.

6. An electron is placed in an electric field of magnitude 100 V/m that is pointing to the right. What is the magnitude and direction of the force of the electric field on the electron?

    (A) 100 N to the right.
    (B) 100 N to the left.
    (C) 1.6×10^{-17} N to the right.
    (D) 1.6×10^{-17} N to the left.

7. At a distance d from a point charge, the magnitude of the electric field is E. At a distance $d/2$ from the point charge, the magnitude of the electric field is (assume no other charges are present)
    (A) $E/2$ (B) $E/4$ (C) $2E$ (D) $4E$

8. The figure below shows a charge dipole (an object with a positive charge at one end and an equal magnitude of negative charge at the other) in a region with electric field lines. The positive and negative charges are indicated by "+" and "-", respectively. In which direction is the net force of the electric field on the dipole?



    (A) ← (B) → (C) ↑ (D) ↓

9. A mobile $+0.5\,\mu$C point charge is placed exactly midway between a fixed point $+1$ C and a fixed point -1 C charge. The mobile charge is then projected with an initial speed of 10 m/s. When the mobile charge is very far away from the two fixed charges, what will its speed be? (Assume there are no other charges and no other forces acting on the mobile charge.)

    (A) 20 m/s.
    (B) 10 m/s.
    (C) 5 m/s.
    (D) Cannot be answered from the information given.

10. If we had the same situation as in the previous question, except that both fixed charges are $+1$ C. If the mobile charge is projected with an initial speed of 10 m/s, what will its speed be when it is far away from the two fixed charges?
    (A) 20 m/s (B) 10 m/s. (C) 5 m/s.
    (D) Cannot be answered from the information given.

11. Inside a conductor (in static situations),

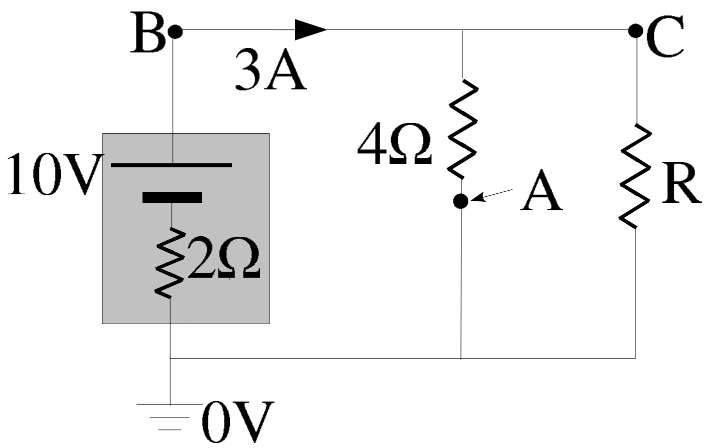
(A) both the electric field and the electric potential must be zero.

(B) the electric field must be a constant (not necessarily equal to zero), and the electric potential must be zero.

(C) the electric field must be zero, and the electric potential must be a constant (not necessarily equal to zero).

(D) both the electric field and the electric potential must be constants (not necessarily equal to zero).

The following pertains to the questions 12 – 16. Consider the following circuit. The negative end of the battery is at zero volts. Assume that the battery has an EMF of 10 V and internal resistance of 2 Ω. Three amps of current flow through the battery.



12. What is the electric potential at point A?
(A) 0 V (B) 4 V (C) 6V (D) 10 V

13. What is the electric potential at point B?
(A) 0 V (B) 4 V (C) 6 V (D) 10 V

14. What is the electric current through point A?
(A) 1 A (B) $2\frac{1}{2}$ A (C) 6 A (D) 10 A

15. What is electric current through point C?
(A) 1 A (B) 2 A (C) 3 A (D) 4 A

16. What is the resistance of resistor R?
(A) 2 Ω (B) 3 Ω (C) 4 Ω (D) 6 Ω.

17. A piece of (circular cross-section) wire of length L and radius r has resistance R. Another piece of wire, made of the same material, of length $2L$ and radius $2r$ will have a resistance of (remember, area of a circle is πr^2)

(A) $8R$ (B) $2R$ (C) R (D) $R/2$

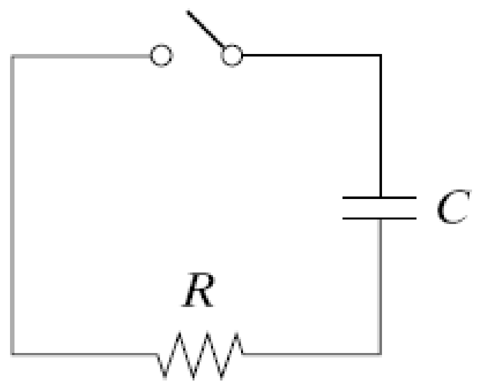
18. When the voltage across a capacitor is 100 V, the magnitude of the charge stored in each plate of the capacitor is 10^{-4} C. What is its capacitance?

(A) 10^6 F (B) 100 F (C) 10 mF (D) 1 μF

19. The root-mean-square voltage of household alternating current is 120 V. This means that relative to grounded wire, the voltage of the "hot" wire ranges from

(A) 0 V to 120 V
(B) −120 V to 120 V
(C) 0 V to $120\sqrt{2}$ V
(D) $-120\sqrt{2}$ V to $120\sqrt{2}$ V

20. The potential difference across the capacitor with the switch open is V_0. A time interval $\Delta t = RC$ after the switch is closed, the current through the resistor is ($e = 2.718....$)



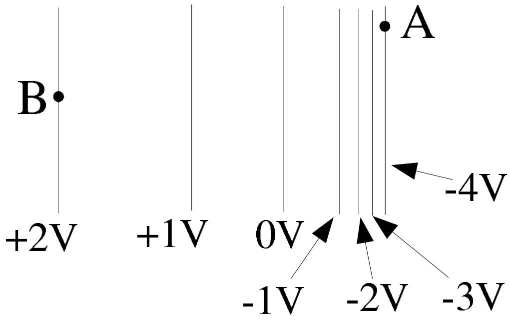
(A) 0 (B) V_0/R (C) V_0e/R (D) $V_0/(eR)$

21. **Bonus:** A number of capacitors are connected in series. As more capacitors are added in series, the effective capacitance

(A) increases.
(B) decreases.
(C) remains unchanged.
(D) increases, decreases or remains the same, depending on the capacitances of the capacitors that are added.

Physics 262, Spr. 06, test 2, section B **Name:** ____________________

1. The lines on the diagram below correspond to equipotential surfaces.



(a) In which direction is the electric field pointing (left, right, up or down)? [3 points]

(b) In which region of the diagram is the electric field the strongest (left, right, up or down)? [3 points]

(c) If the object has charge $+3\,\mathrm{C}$ and starts with $30\,\mathrm{J}$ of kinetic energy at point A (on the $-4\,\mathrm{V}$ line), how much kinetic energy does it have when it reaches point B (on the $+2\,\mathrm{V}$ line)? (Assume there are no other forces acting on the object.) [14 points]

2. A $1\,\Omega$ and a $2\,\Omega$ resistor are connected to a $6\,\mathrm{V}$ battery (with zero internal resistance).

(a) If the resistors are connected to the battery in parallel, what is the power dissipated in the (i) $1\,\Omega$ and (ii) $2\,\Omega$ resistor? [10 points]

(b) If the resistors are connected to the battery in series, what is the power dissipated in the (i) $1\,\Omega$ and (ii) $2\,\Omega$ resistor? [10 points]