University of Akron July 15, 2009

Physics 262: Physics for Life Sciences II
Second Exam

- Time allowed: 90 minutes
- Calculators are **not** permitted.
- Section A contains multiple choice questions. There are 20 questions + 3 more challenging bonus questions, worth 3 points each. Points will **not** be deducted for incorrect answers in this section, so you should answer all 23 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.
- Solutions will be posted on the course web site after the exam ends.

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.

Reminder: Adding fractions

To add fractions together, you must write the fractions in terms of a **common denominator** before adding the numerators together. For example,

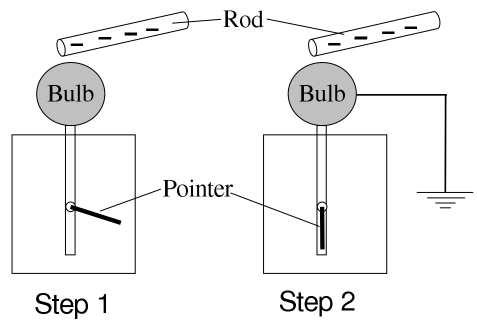
$$\frac{1}{3}+\frac{4}{7} = \underbrace{\frac{1\times 7}{3\times 7}}_{\substack{\text{multiply top}\\ \text{\& bottom by 7}}} + \underbrace{\frac{4\times 3}{7\times 3}}_{\substack{\text{multiply top}\\ \text{\& bottom by 3}}} = \frac{7}{21}+\frac{12}{21} = \frac{7+12}{21} = \frac{19}{21}.$$

SECTION A

1. An ionized flourine atom containing 7 protons and 8 electrons has a net charge of

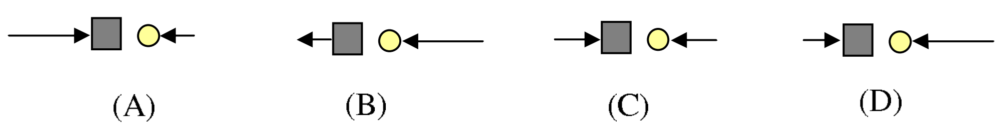
   (A) $+1.0\,\text{C}$ (B) $-1.0\,\text{C}$ (C) $+1.6 \times 10^{-19}\,\text{C}$ (D) $-1.6 \times 10^{-19}\,\text{C}$

2. I bring a negatively charged rod near (but not touching) the bulb of an initially electrically neutral electroscope, so that the pointer of the electroscope rises (Step 1). Keeping the rod near the bulb, I then ground the electroscope by touching the bulb, which results in the pointer falling (Step 2). In step 2, which of the following is true about the net charges on the bulb and the pointer of the electroscope?



   (A) Both the bulb and pointer have net positive charge.
   (B) The bulb has net positive charge and the pointer is electrically neutral.
   (C) The bulb is electrically neutral and the pointer has net positive charge.
   (D) Both the bulb and the pointer are electrically neutral.

3. A square object has a charge of $-2 \times 10^{-9}\,\text{C}$ and a round object has a charge of $+1 \times 10^{-9}\,\text{C}$. They are placed close to each other. Which of the following figures best indicates the directions and magnitudes (indicated by the length of the vectors) of the electric forces of the objects on one another?



4. The magnitude of the Coulomb (*i.e.*, electric) force between two point charges is F when they are separated by a distance d. The separation is changed so that the magnitude of the Coulomb force between them is $2F$. What is the new separation between the charges?

   (A) $\dfrac{d}{2}$ (B) $\dfrac{d}{\sqrt{2}}$ (C) $\sqrt{2}\,d$ (D) $2d$

5. In a region of space, the electric potential is constant at $100\,\text{V}$. What is the magnitude of the force on a charge of $5\,\text{C}$ in that region of space?

   (A) $500\,\text{N}$ (B) $100\,\text{N}$ (C) $20\,\text{N}$ (D) $0\,\text{N}$

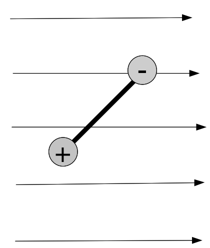
6. If there are more electric field lines going into than coming out of a Guassian (*i.e.*, an imaginary closed) surface, this means that

   (A) there cannot be any positive charges enclosed by the Gaussian surface.
   (B) there more negative than positive charges enclosed by the Gaussian surface.
   (C) there are more positive than negative charges enclosed by the Gaussian surface.
   (D) there cannot be any negative charges enclosed by the Gaussian surface.

7. An electron is subjected to an electric force of 1.6×10^{-15} N in the downward direction. The electric field at the position of the electron is

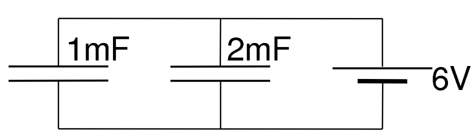
   (A) $(1.6)^2 \times 10^{-34}$ V/m, pointing upwards.
   (B) 1.0×10^4 V/m, pointing upwards.
   (C) $(1.6)^2 \times 10^{-34}$ V/m, pointing downwards.
   (D) 1.0×10^4 V/m, pointing downwards.

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 that are parallel and equally spaced from each other. The positive and negative charges are indicated by "+" and "-", respectively. In which direction is the net force of the electric field on the dipole?



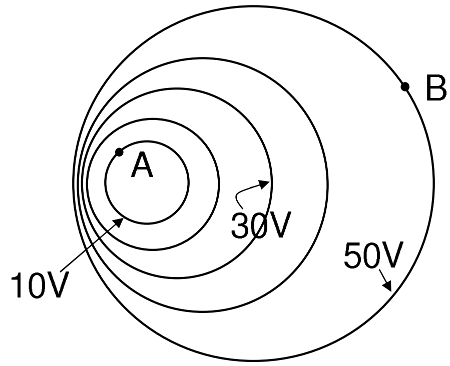
   (A) $\leftarrow$ (B) $\rightarrow$ (C) $\nearrow$ (D) No net force

9. A 1 mF (1×10^{-3} F) and a 2 mF (2×10^{-3} F) capacitor are connected in parallel to a 6 V battery, as shown below. What is the total charge stored in the two capacitors?



   (A) 4×10^{-3} C (B) 1.8×10^{-2} C (C) 2×10^3 C (D) 9×10^3 C

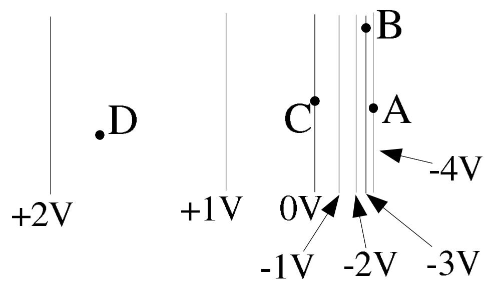
The following pertains to questions 10 and 11. The following diagram shows equipotential surfaces in a region of space. A charge of $-2\,\mathrm{C}$ is moved from position A to B (indicated by the dots).



10. What is the change in the electric potential when moving from A to B? (Remember, "change in" means final value minus initial value.)
    (A) $-80\,\mathrm{V}$ (B) $-40\,\mathrm{V}$ (C) $40\,\mathrm{V}$ (D) $80\,\mathrm{V}$

11. What is the change in the electric potential *energy* of the $-2\,\mathrm{C}$ charge when it is moved from A to B?
    (A) $-80\,\mathrm{J}$ (B) $-40\,\mathrm{J}$ (C) $40\,\mathrm{J}$ (D) $80\,\mathrm{J}$

The following pertains to questions 12 and 13. The following diagram shows equipotential surfaces in a region of space. (Assume the electric field varies smoothly in this region.)



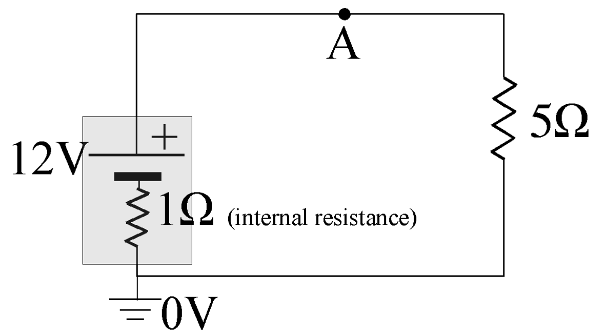
12. In what direction is the electric field pointing in this region of space?
    (A) ← (B) → (C) ↑ (D) ↓

13. At which of the marked positions A – D is the magnitude of the electric field the *smallest*?

14. Three resistors that have values of $5\,\Omega$, $2\,\Omega$ and $1\,\Omega$ are connected in series to a battery. Which resistor gets the most power?
    (A) $5\,\Omega$ (B) $2\,\Omega$ (C) $1\,\Omega$ (D) Same in all three.

15. Three resistors that have values of $5\,\Omega$, $2\,\Omega$ and $1\,\Omega$ are connected in parallel to a battery. Which resistor gets the most power?
    (A) $5\,\Omega$ (B) $2\,\Omega$ (C) $1\,\Omega$ (D) Same in all three.

The following pertains to questions 16 and 17. A battery with EMF of 12 V and an internal resistance of 1 Ω is connected to a 5 Ω resistor, as shown on the right. The negative end of the battery is at zero volts.



16. What is the current through the circuit?

(A) 2 A (B) 2.4 A (C) 10 A (D) 14.2 A

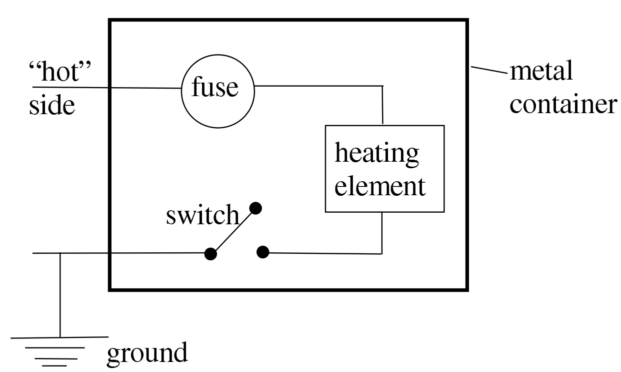
17. What is the electric potential at point A?

(A) 6 V (B) 10 V (C) 11 V (D) 12 V

18. When a capacitor discharges through a resistor, the magnitude of current through the resistor is maximum

(A) at the beginning of the process.
(B) at the middle of the process.
(C) at the end of the process.
(D) after one RC time constant.

19. What, if anything, is wrong (in terms of safety) with the wiring of the elements of a household electric heater shown below?



(A) The fuse is on the wrong side of the heating element.
(B) The switch is on the wrong side of the heating element.
(C) Both fuse and switch are on wrong sides of the heating element.
(D) There is nothing wrong.

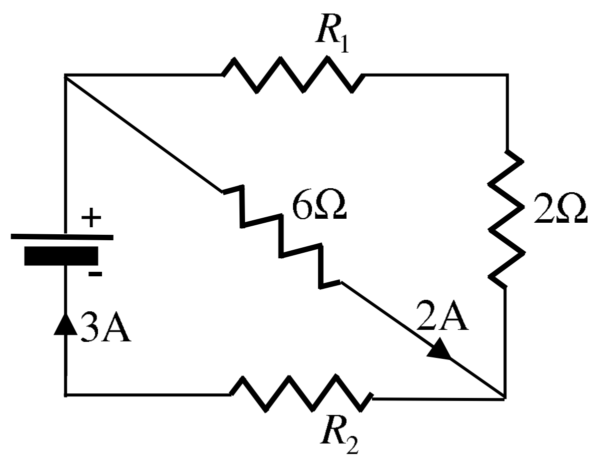
20. In the nation of Lowvoltagestan, household electricity has an RMS voltage of 60 V, compared to 120 V in the U.S. If a U.S. hairdryer that is rated at 500 W is plugged into a Lowvoltagestan outlet, what power is consumed by the hairdryer (assuming it still works and its resistance is the same as in the U.S.)?

(A) 125 W (B) 250 W (C) 1000 W (D) 2000 W

21. **Bonus 1:** Two 2-mF capacitors, consisting of metallic plates with air (which has a dielectric constant of 1) in between the plates, are connected in **series**. If material with dielectric constant 2 is subsequently inserted in (and completely fills the space) between the plates of one of these capacitors, what is the equivalent capacitance these two capacitors in series?

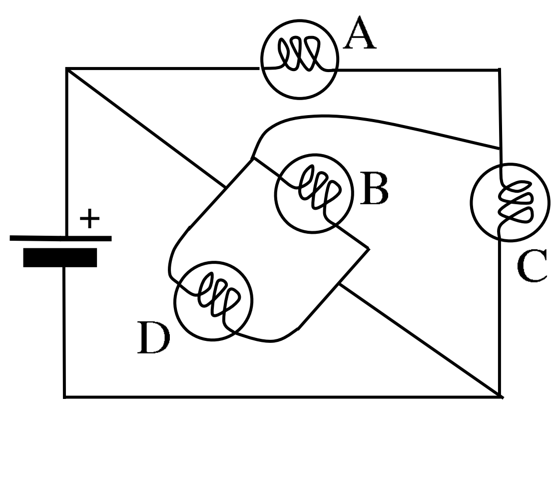
(A) 1 mF (B) $\frac{4}{3}$ mF (C) 4 mF (D) 6 mF

22. **Bonus 2:** In the following circuit, the electromotive force of the battery and R_2 are unknown. What is the resistance R_1? (**Hint:** Use Kirchhoff's current and voltage theorems.)



(A) 1 Ω (B) 2 Ω (C) 6 Ω (D) 10Ω

23. **Bonus 3:** Which of light bulbs A – D will **not** light up?



Question 1: A $+4 \times 10^{-9}$ C point charge is at $x = 2$ m and a -1×10^{-9} C point charge is at $x = -3$ m. What is the electric field at $x = 0$ m due to these two charges? (Include the correct sign in your answer; *i.e.*, "+" and "−" for the electric field pointing in the positive and negative x-directions, respectively.)

Questions 2: You have 3 resistors of resistances $1\,\Omega$, $\frac{1}{2}\,\Omega$ and $\frac{1}{4}\,\Omega$.

(a) What is the equivalent resistance when you connect all three resistors is **series**? [8 points]

(b) What is the equivalent resistance when you connect all three resistors in **parallel**? [12 points]