University of Akron July 15, 2008

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 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 14 and 26 points. Where appropriate, show how you obtained your answers, and remember to include the correct units.
- Solutions will be posted on the course web site soon after the exam ends.

Some useful information

- The charges on an electron and a proton are $-1.6 \times 10^{-19}\,\mathrm{C}$ and $+1.6 \times 10^{-19}\,\mathrm{C}$, respectively.

SECTION A

1. Which of the following is/are SI unit(s) of electric field? (Hint: If you are unsure of what the units are, look at your equation sheet.)

   I. N/C

   II. V/m^2

   (A) I only (B) II only (C) both I and II (D) neither

2. If 10^{19} electrons pass a point in a copper wire every second, going from left to right, what is the direction and magnitude of the (conventional) current in that wire?

   (A) 10^{19} A going from left to right.

   (B) 10^{19} A going from right to left.

   (C) 1.6 A going from left to right.

   (D) 1.6 A going from right to left.

3. Object A is positively charged, and it attracts object B. What can we say about object B?

   (A) Object B **must** be positively charged.

   (B) Object B **must** be negatively charged.

   (C) Object B **must** be electrically neutral.

   (D) More than one of the above choices can be true.

4. Inside an electrical conductor in static equilibrium,

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

   (B) the electric field must be zero and the electric potential must be constant (but not necessarily zero).

   (C) the electric field is a constant (but not necessarily zero) and the electric potential must be zero.

   (D) the electric field and electric potential are both constants (both not necessarily zero).

5. Object A has a charge of Q and object B has a charge of $4Q$. If $\vec{\mathbf{F}}_A$ is the the force on A due to B, and $\vec{\mathbf{F}}_B$ is the force on B due to A, then

   (A) $\vec{\mathbf{F}}_B = \vec{\mathbf{F}}_A$ (B) $\vec{\mathbf{F}}_B = 4\vec{\mathbf{F}}_A$ (C) $4\vec{\mathbf{F}}_B = \vec{\mathbf{F}}_A$ (D) $\vec{\mathbf{F}}_B = -\vec{\mathbf{F}}_A$

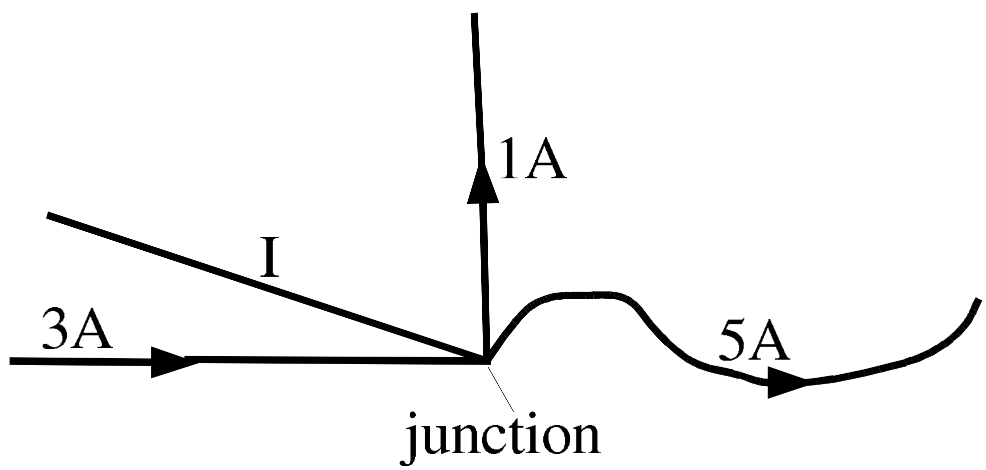
6. If the electric company charges ten cents per kilowatt-hour, what is the electricity cost of leaving a 100 W light bulb on for one hour?

   (A) 1 cent (B) 3.6 cents (C) 10 cents (D) 36 cents

7. The resistivity of iron is six times larger than that of copper at room temperature. If I have a piece of iron and a piece of copper, both of which are 10 cm long, what is the **resistance** of the piece of iron, R_{iron} compared to that of the piece of copper, R_{copper}, at room temperature?

   (A) $R_{\text{iron}} = 6R_{\text{copper}}$
   (B) $R_{\text{iron}} = R_{\text{copper}}$
   (C) $R_{\text{iron}} = \frac{1}{6}R_{\text{copper}}$
   (D) Not enough information given to answer the question.

8. In a circuit, four wires are connected at a junction. If the directions and the magnitudes of the currents are as shown in the figure below, what is the **magnitude** and the **direction** of current I?

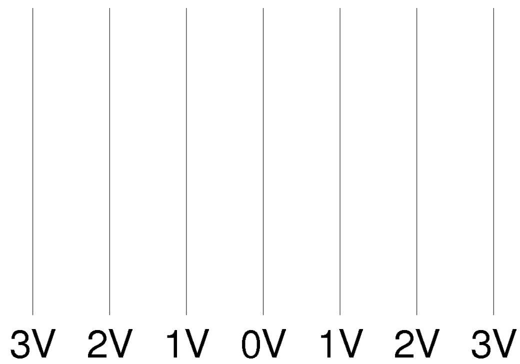


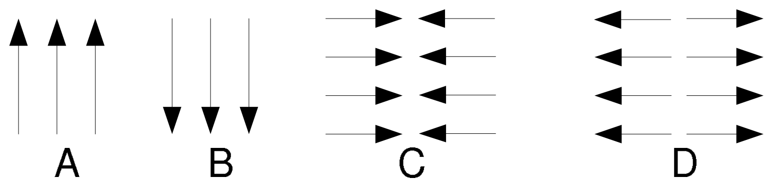
   (A) 3 A, directed away from the junction.
   (B) 3 A, directed towards the junction.
   (C) 9 A, directed away from the junction.
   (D) 9 A, directed towards the junction.

9. If it takes work W to completely separate two points charges that are initially at rest a distance d apart, how much work is required to completely separate these same charges if they are initially $d/2$ apart?

   (A) $W/2$ (B) $W/4$ (C) $2W$ (D) $4W$

10. Which electric field line diagram corresponds to the electric equipotential diagram below?





The following pertains to Questions 11, 12 and 13. Two conducting plates have equal magnitudes of opposite charges. An electron is placed in between these plates (and away from the edges of the plates so that effect of the edges on the electric field can be neglected).

11. Where is the magnitude of the force on the electron the largest?

 (A) Near the positively charged plate.
 (B) Near the negatively charged plate.
 (C) Mid-way between the positively and negatively charged plates.
 (D) Same for all three of the above positions.

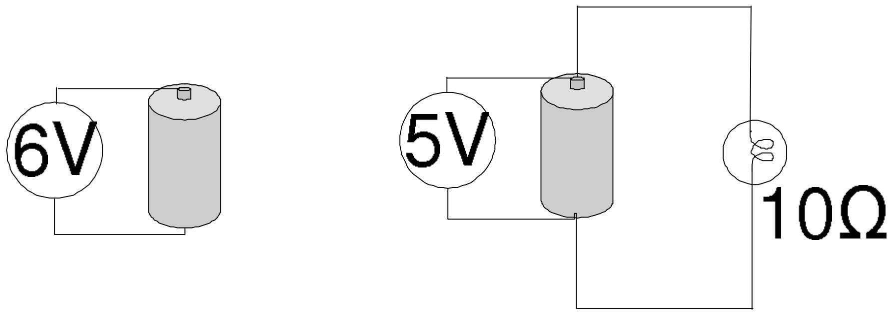
12. Where does the electron experiences the largest electric potential?

 (A) Near the positively charged plate.
 (B) Near the negatively charged plate.
 (C) Mid-way between the positively and negatively charged plates.
 (D) Same for all three of the above positions.

13. Where is the electric potential <u>energy</u> of the electron the greatest?

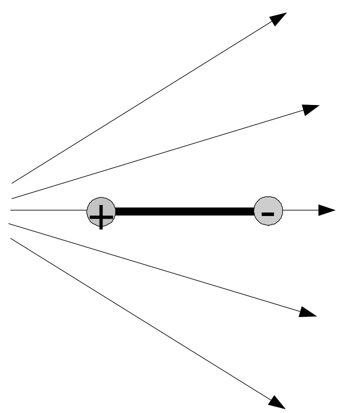
 (A) Near the positively charged plate.
 (B) Near the negatively charged plate.
 (C) Mid-way between the positively and negatively charged plates.
 (D) Same for all three of the above positions.

14. When there is no current flowing through a battery, the potential difference across its terminals is 6 V. When a 10 Ω light bulb is connected to the battery, the voltage across the battery falls to 5 V. What is the internal resistance of the battery?



(A) 0 Ω (B) 2 Ω (C) 10 Ω (D) 20 Ω

15. 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) net force is zero (D) cannot be determined

16. Three capacitors of different capacitances in series are connected to a battery. Which of the following is the same in all three capacitors?

I. The potential difference.

II. The magnitude of charge on each capacitor plate

(A) I only (B) II only (C) Both I and II (D) Neither

17. Two resistors have values of 2 Ω and 1 Ω. What is the effective resistance when they are connected in parallel?

(A) 3 Ω (B) $\frac{3}{2}$ Ω (C) $\frac{2}{3}$ Ω (D) $\frac{1}{3}$ Ω

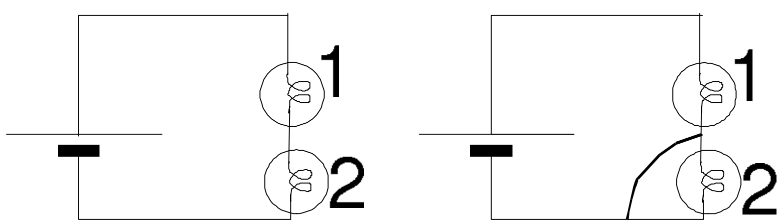
18. When there is a voltage V across a capacitor, the energy stored in it is U. In order to store $2U$ of energy in the same capacitor, the voltage across it must be

(A) $\sqrt{2}\,\text{V}$ (B) 2 V (C) $4\,V$ (D) 8 V

19. In the Kingdom of Benhustan, household AC electricity has an RMS voltage of 100 V. In this glorious kingdom, what is the average power dissipated by a household appliance with a resistance of $100\,\Omega$?

(A) 10 W (B) $\sqrt{2} \times 10$ W (C) 100 W (D) $\sqrt{2} \times 100$ W

20. Two identical bulbs are initially connected in series to a battery with zero internal resistance, as shown below in the figure on the left, and they light up equally brightly. If a wire is used to short-circuit light bulb 2, as shown below in the figure on the right, which of the following will occur? (Assume that the brightness of a light bulb is proportional to the power dissipated by the bulb.)



(A) Bulb 1 becomes twice as bright as before and bulb 2 remains at the same brightness as before.

(B) Bulb 1 becomes twice as bright as before and bulb 2 goes dark.

(C) Bulb 1 remains at the same brightness as before and bulb 2 goes dark.

(D) Bulb 1 becomes 4 times as bright as before and bulb 2 goes dark.

21. **Bonus:** An imaginary closed surface encloses a volume that contains a single point +1 C charge, and no other charges. What can we say in general about the electric field lines that pierce the imaginary surface?

I. There **must** be electric field lines that leave (*i.e.*, pass from the inside to the outside of the volume) the surface.

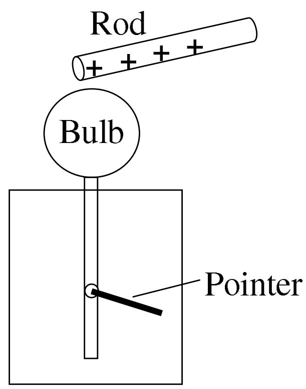
II. There **cannot** be any electric field lines that enter (*i.e.*, pass from the outside to the inside of the volume) the surface.

(A) I only (B) II only (C) Both I and II (D) Neither

22. **Bonus:** A capacitor of capacitance C is made up of parallel conducting plates separated by a distance d. If I insert a dielectric with dielectric constant 10 and of width $d/2$ in between the parallel conducting plates, what is its new capacitance?

(A) $\frac{C}{2}$ (B) $\frac{10C}{11}$ (C) $\frac{11C}{20}$ (D) $\frac{20C}{11}$

23. **Bonus:** An electroscope is initially electrically neutral. I bring a positively charged rod near the bulb of the electroscope, so that the pointer of the electroscope rises, as shown in the figure below. I then ground the electroscope by touching the bulb with my finger, and the pointer falls. I remove my finger, and then I remove the positively charged rod. What happens and why?



(A) The pointer remains down because the electroscope has zero net charge.

(B) The pointer rises because both the bulb and pointer have net positive charge.

(C) The pointer rises because both the bulb and pointer have net negative charge.

(D) The pointer rises because the bulb and the pointer have opposite charges.

Question 1 Two electric charges are brought together until they are 1.0 m apart, causing the electric force to increase by a factor of 4. What was their initial separation? [14]

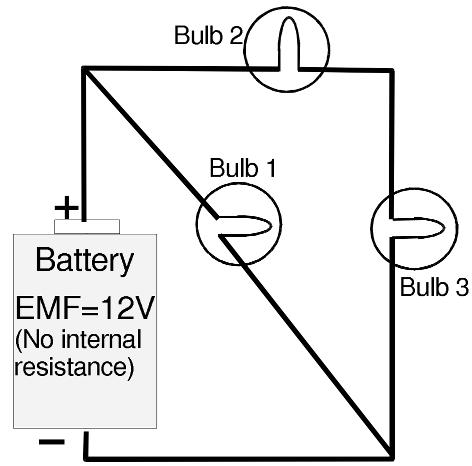
Question 2.

Consider the circuit on the right. Each of the three bulbs has a resistance of $3\,\Omega$. Assume the battery has an electromotive force of $12\,\text{V}$ and no internal resistance.

(a) What is the current through each bulb? [10]

(b) What is the voltage across each bulb? [10]

(c) What is the total power (energy per unit time) supplied by the battery? [6]



All three bulbs each have resistance of 3 Ω.