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 $-1.6 \times 10^{-19}$ C and $+1.6 \times 10^{-19}$ C, respectively.
1. An ionized fluorine atom containing 7 protons and 8 electrons has a net charge of
   (A) +1.0 C   (B) −1.0 C   (C) +1.6 × 10^{−19} C   (D) −1.6 × 10^{−19} 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 × 10^{−9} C and a round object has a charge of +1 × 10^{−9} 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?

   ![Diagram of electric forces](image)
   (A) ![Diagram](image)   (B) ![Diagram](image)   (C) ![Diagram](image)   (D) ![Diagram](image)

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) \( \frac{d}{2} \)   (B) \( \frac{d}{\sqrt{2}} \)   (C) \( \sqrt{2}d \)   (D) \( 2d \)

5. In a region of space, the electric potential (i.e., voltage) is constant at 100 V. What is the magnitude of the force on a charge of 5 C in that region of space?
   (A) 500 N   (B) 100 N   (C) 20 N   (D) 0 N
6. An electron is subjected to an electric force of $1.6 \times 10^{-15}$ N in the downward direction. The electric field at the position of the electron is

(A) $1.6 \times 10^{-15}$ V/m, pointing upwards.
(B) $1.0 \times 10^4$ V/m, pointing upwards.
(C) $1.6 \times 10^{-15}$ V/m, pointing downwards.
(D) $1.0 \times 10^4$ V/m, pointing downwards.

7. Bringing together two charges which were initially infinitely far away to a separation of 1.0 m requires 20 J of work. Bringing the same charges from infinitely far away to a separation of 0.5 m requires work of

(A) 5 J  (B) 10 J  (C) 40 J  (D) 80 J

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) ←  (B) →  (C) ↗  (D) No net force

9. A 1 mF ($1 \times 10^{-3}$ F) and a 2 mF ($2 \times 10^{-3}$ 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) $4 \times 10^{-3}$ C  (B) $1.8 \times 10^{-2}$ C  (C) $2 \times 10^{3}$ C  (D) $9 \times 10^{3}$ C

10. 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
11. A **positively charged** solid conducting sphere is surrounded by a thick, spherical conducting shell, as shown in the figure to the right. What is the sign of the net charge on the **inner surface** of the thick conducting spherical shell? **Hint:** Use Gauss’ law, which states that the electric field lines that pierce an imaginary closed surface is proportional to the net charge contained within the surface, and the fact that the electric field within a conductor under static conditions is zero.

(A) Positive  
(B) Negative.  
(C) Zero  
(D) Could be positive, negative or zero.

12. The following pertains to questions 12 and 13. The following diagram shows equipotential surfaces in a region of space. A charge of $-2 \text{ C}$ is moved from position $A$ to $B$ (indicated by the dots).

12. What is the change in the electric potential when moving from $A$ to $B$? (Remember, “change in” means final value minus initial value.)

(A) $-80 \text{ V}$  
(B) $-40 \text{ V}$  
(C) $40 \text{ V}$  
(D) $80 \text{ V}$

13. What is the change in the electric potential energy of the $-2 \text{ C}$ charge when it is moved from $A$ to $B$?

(A) $-80 \text{ J}$  
(B) $-40 \text{ J}$  
(C) $40 \text{ J}$  
(D) $80 \text{ J}$
The following pertains to questions 14 and 15. The following diagram shows equipotential surfaces in a region of space. (Assume the electric field varies smoothly in this region.)

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

15. At which of the marked positions A, B, C or D is the electric field the weakest (i.e., smallest magnitude)?

16. Three resistors that have values of 5Ω, 2Ω and 1Ω are connected in series to a battery. The voltage drop across which resistor is the largest?
   (A) 5Ω  (B) 2Ω  (C) 1Ω  (D) Same in all three.

The following pertains to questions 17 and 18. A battery with EMF of 12 V and an internal resistance of 1Ω is connected to a 5Ω resistor, as shown in the figure below. The negative end of the battery is at zero volts.

17. What is the current through the circuit?
   (A) 2.0 A  (B) 2.4 A  (C) 10 A  (D) 14 A

18. What is the electric potential at point A?
   (A) 6 V  (B) 10 V  (C) 11 V  (D) 12 V
19. To charge up an initially uncharged capacitor, a battery is connected to the capacitor with a resistor in series. The magnitude of the voltage drop across the resistor is maximum
   (A) at the beginning of the charging process.
   (B) in the middle of the charging process.
   (C) at the end of the charging process.
   (D) one \( RC \) time constant after the charging begins.

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 400 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) 100 W  (B) 200 W  (C) 800 W  (D) 1.6 kW

21. **Bonus (more challenging):** 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.)

![Circuit Diagram]

   (A) 1 \( \Omega \)  (B) 2 \( \Omega \)  (C) 6 \( \Omega \)  (D) 10 \( \Omega \)
Question 1: A $+9 \times 10^{-9}$ C point charge is at the origin and a $-3 \times 10^{-9}$ C point charge on the $x$-axis at $x = 2\text{ m}$. What is the electric field on the $x$-axis at $x = 3\text{ m}$ 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.) Use $k = 9 \times 10^9 \text{Nm}^2/\text{C}^2$. 
Questions 2: You have 3 resistors of resistances 1 Ω, $\frac{1}{2} \Omega$ and $\frac{1}{4} \Omega$.

(a) How would you connect the resistors to get the largest equivalent resistance? (Describe in words or sketch a diagram.) What is the value of this largest equivalent resistance? [10 points]

(b) How would you connect the resistors to get the smallest equivalent resistance? What is the value of this smallest equivalent resistance? [10 points]

Remember, $\frac{1}{2} + \frac{1}{4} = \frac{3}{4}$. 