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 16 and 24 points. 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 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. A square object has a charge of $-2 \times 10^{-9}$ C and a round object has a charge of $-1 \times 10^{-9}$ 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?

   ![Figure](image)

   (A)  (B)  (C)  (D)

3. An electroscope is electrically neutral. I bring a negatively charged rod near (but not touching) the bulb of the electroscope, so that the pointer of the electroscope rises. Which of the following is true about the bulb and the pointer of the electroscope?

   (A) Both the bulb and pointer have a net negative charge.
   (B) Both the bulb and pointer have a net positive charge.
   (C) The bulb has a net positive charge and the pointer has a net negative charge.
   (D) The bulb has a net negative charge and the pointer has a net positive charge.

4. The figure below shows electric field lines near a rod (shown in grey in the figure). What can we about the net electric charge on the rod?

   ![Figure](image)

   (A) The rod has a net positive charge.
   (B) The rod has a net negative charge.
   (C) The rod is electrically neutral.
   (D) No information can be inferred regarding the net charge on the rod.
5. Inside an electrical conductor that is in equilibrium (that is, there are no electric currents flowing in the conductor),

(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).

6. It takes work $W$ to bring two point charges from very far apart to a distance $d$ from each other. How much work is required to bring the same two point charges from very far apart to a distance of $d/2$ from each other?

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

7. The figure below shows equipotential surfaces. Each successive equipotential line differs by 10 V. At which point is the magnitude of the electric field the largest? [Assume the potential is “smooth;” that is, there are no sudden variations in the potential as a function of position.]

The following pertains to Questions 8 and 9. You have three resistors, of resistances $1 \Omega$, $2 \Omega$ and $4 \Omega$. You can wire these in any way; that is all in parallel, all in series, or a two of them in parallel and in series with the third.

8. What is the **minimum** equivalent resistance that you can get by wiring together these three resistors?

(A) $\frac{1}{7} \Omega$  (B) $1\frac{3}{4} \Omega$  (C) $2\frac{1}{3} \Omega$  (D) $4\frac{2}{3} \Omega$

9. If you wire these three resistors in series and you send an electric current through them, which resistor dissipates to most power?

(A) The $1 \Omega$ resistor  (B) The $2 \Omega$ resistor
(C) The $4 \Omega$ resistor  (D) Same for all three
10. 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 $\pi r^2$) 
(A) $8R$  (B) $2R$  (C) $R$  (D) $R/2$

11. An initially uncharged capacitor is connected across its terminals of a 6 V battery. If $1.2 \times 10^{-5}$ C of charge flows through the battery as it completely charges the capacitor, what is its capacitance? (Note: $\mu = \text{micro} = 10^{-6}$, $k = \text{kilo} = 10^3$, $M = \text{mega} = 10^6$)
(A) $2 \mu F$  (B) $7.2 \mu F$  (C) $500 kF$  (D) $\frac{1}{72} MF$

12. Capacitors in parallel, regardless of their capacitances, have the same
(A) voltage.  (B) charge.  (C) stored energy.  (D) electric current.

13. At $t = 0$ the switch $S$ is closed in the circuit shown below. If the capacitor is initially uncharged, which of the following graphs best represents the voltage across the capacitor as a function of time?

14. A European hairdryer has a power rating of 800 W (that is, it would consume 800 W of power when plugged into a European electrical outlet). If you plug it into a U.S. electrical outlet, how much power would that hairdryer consume? The RMS (root-mean-square) voltage in the U.S. is 120V and in Europe is 240V.
(A) 200 W  (B) 400 W  (C) 1.6 kW  (D) 3.2 kW

15. When the ends of two bar magnets are near each other, they repel one another. The ends must be
(A) one north, the other south.
(B) both north.
(C) both south.
(D) either both north, or both south.
16. A particle moves anti-parallel (i.e. in exactly the opposite direction) to a uniform magnetic field, and it experiences no magnetic force. What can we say about the net electric charge on the particle?

(A) It must have net positive charge.
(B) It must have net negative charge.
(C) It must have net zero charge.
(D) Cannot conclude anything about the net charge.

17. An *electron* moves from right to left (←) in the presence of a magnetic field that points out of the paper (☉). In what direction is the magnetic force on the electron?

(A) up ↑
(B) down ↓
(C) out of paper ⊙
(D) into the paper ⊗

18. A proton moving at a speed of $1 \times 10^8 \text{ m/s}$ in a uniform magnetic field of 4 T experiences a force of magnitude $1.6 \times 10^{-11} \text{ N}$. What angle does the velocity vector of the proton make with the magnetic field?

(A) $\sin^{-1}(0) \left[= 0^\circ \text{ or } 180^\circ \right]$
(B) $\sin^{-1}(0.25) \left[= 14^\circ \text{ or } 166^\circ \right]$
(C) $\sin^{-1}(0.5) \left[= 30^\circ \text{ or } 150^\circ \right]$
(D) $\sin^{-1}(0.75) \left[= 49^\circ \text{ or } 131^\circ \right]$

19. A long straight wire carries an electric current to the right. At a point $P$ directly below the wire (as shown in the figure below), in which direction is the magnetic field caused by the current in the wire?

(A) up ↑
(B) down ↓
(C) out of paper ⊙
(D) into the paper ⊗
20. Consider two long straight parallel wires, one directly on top of the other, each carrying the same magnitude of electric current. In the top wire the current flows to the left, and in the bottom the current flows to the right, as shown in the figure below. At a point \( P \) that is in the plane of and exactly half way between the two wires, in which direction is the net magnetic field caused by the currents in the wires?

(A) down ↓
(B) out of paper ⊙
(C) into the paper ⊗
(D) None – the magnetic field is zero.

21. **Bonus:** (More challenging) The figure below shows electric currents in a rectangular wire loop and, next to it, a long straight wire. The straight wire is in the plane of the rectangular loop. In what direction is the magnetic force on the rectangular wire loop, due to the magnetic field caused by the current in the long straight wire?

(A) down ↓
(B) up ↑
(C) left ←
(D) right →
(E) None – the magnetic force is zero.
Question 1 (16 points)

(a) An electron is acted upon by an electric force of magnitude $3.2 \times 10^{-14}$ N in the downward direction. What is the magnitude and direction (up, down, East, West ...) of the electric field at the electron’s location? [8 points]

(b) If it takes $+2.4$ J of work to move a charged object from 0 V to $-6$ V (without changing the object’s kinetic energy) what is the electrical charge on the object? (Include the correct sign of the charge in your answer. There are no other forces acting on the object aside from the electric force.) [8 points]
Question 2 (24 points)

Consider the circuit on the right. Assume the battery is ideal (no internal resistance) and its electromotive force (voltage difference between the negative and positive electrodes) is 10 V. The negative terminal of the battery is at an electric potential of 0 V.

(a) What is the electric potential (i.e., voltage) at point A? [4 points]

(b) What is the electric current through the 20 Ω resistor? [4 points]

(c) What is the electric current through the 2 Ω and 3 Ω resistors? [6 points]

(d) What is the electric potential (i.e., voltage) at point B? [5 points]

(e) What is the electric current through the battery? [5 points]