Name: ____

PHYS 1220-02 Exam 3

Each question counts as one point unless otherwise indicated. (Point values are meaningful only when adding scores within the same standard: each standard counts the same toward your course grade.) You may use an 8.5"×11" note sheet written on both sides and a calculator. Please write your answers in the boxes provided. Show your work outside the boxes. If you need to change the answer you wrote in a box, erase it and write your intended answer. This is easiest if you write in pencil. You have 110 minutes.

Some physical constants you may find useful are

Coulomb constant	k	$8.987 \times 10^{9}\,\frac{\mathrm{N}\cdot m^2}{\mathrm{C}^2}$
Vacuum permittivity	ε_0	$8.854 \times 10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{N}\cdot\mathrm{m}^2}$
Elementary charge	e	1.602×10^{-19} C
Vacuum permeability	μ_0	$4\pi \times 10^{-7}\,\frac{\mathrm{N}}{\mathrm{A}^2}$

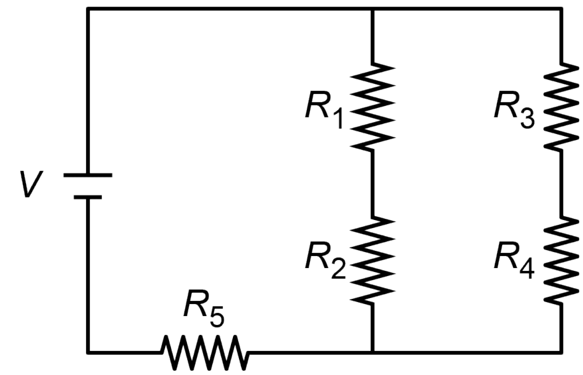
1. A particular resistor with a voltage of 3.60 volts across it dissipates heat at the rate of 72 milliwatts.

   A. What is the current through the resistor?

   B. What is the resistance of the resistor?

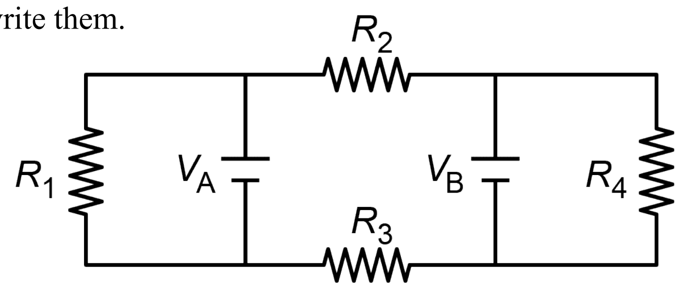
2. The standard wire used in household circuits is 14 gauge copper, which has a diameter of 1.63 millimeters. Aluminum is cheaper and lighter than copper, so one might be interested in using aluminum wire instead of copper. What diameter of aluminum wire would give the same resistance per meter as 14 gauge copper wire? The resistivity of copper is $1.68 \times 10^{-8}\ \Omega\cdot$m, and the resistivity of aluminum is $2.65 \times 10^{-8}\ \Omega\cdot$m.

3. In the circuit at right, $V = 9.00$ volts, $R_1 = 10.0\ \Omega$, $R_2 = 30.0\ \Omega$, $R_3 = 80.0\ \Omega$, $R_4 = 40.0\ \Omega$, and $R_5 = 15.0\ \Omega$. What is the voltage across resistor 5 (the 15-Ω resistor)?



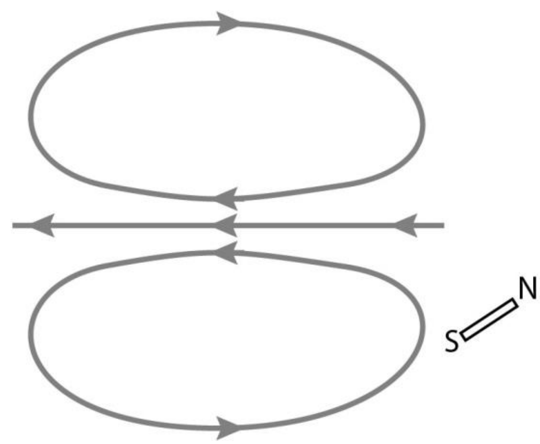
4. (7 points) The circuit below contains two voltage sources, so, as I admitted in class, I don't know a good way to analyze it without making a set of Kirchhoff's circuit rules equations. Draw arrows on the circuit diagram to specify the direction of the current through each of the four resistors and two voltage sources in this circuit. (The directions don't need to be the actual direction of the current through the components, but the arrow direction will specify which direction is positive.) Give each arrow a unique label. Then, write a set of enough independent Kirchhoff's circuit rules equations to find the currents through all the components.

   You don't need to solve the equations, and you don't need to put them in matrix form. You only need to write them.



5. A 250-μF capacitor is charged to 400 volts and then bridged by an 800 Ω resistor, so that the capacitor discharges through the resistor. At what time after the resistor is connected is the current through the resistor 50 milliamperes?

6. The diagram to the right depicts a bar magnet (north and south poles marked "N" and "S") in a dipole magnetic field (gray curves with arrowheads) that is fixed in place. Describe what happens to the magnet if it is free to move after it is released from the depicted position.



7. A solenoid consists of a conducting wire wound in a helical pattern around a cylindrical form. The wire carries a current *I* when the solenoid is energized.

   A. When the solenoid is energized, do adjacent coils attract each other or repel each other?

   ○ a. Attract ○ b. Repel ○ c. No interaction

   B. When the solenoid is energized, do segments of wire at (diametrically) opposite ends of a coil attract each other or repel each other?

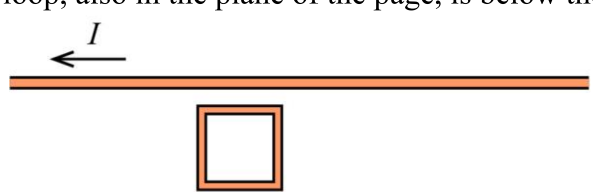
   ○ a. Attract ○ b. Repel ○ c. No interaction

8. A proton (mass 1.673×10^{-27} kg, charge $+1.602 \times 10^{-19}$ C) in the Solar wind approaches Earth. When it passes over Earth's equator, where the Earth's magnetic field is directed due north[1] parallel to Earth's axis, with a magnitude of 4.80×10^{-5} T, the proton is traveling at a speed of 4.0×10^{5} m/s in a plane parallel to the Earth's surface at a direction 6 degrees north of east.

   A. What is the direction and magnitude of the force that Earth's magnetic field exerts on the proton?

   B. Describe the path that the proton subsequently follows. Neglect the force of Earth's gravity on the proton.

9. A long, straight wire in the plane of the page carries a steady current *I* directed to the left. A square conducting loop, also in the plane of the page, is below the wire.



   A. If the square loop is held motionless, what is the direction of the emf induced in it?

   ○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

   B. If the square loop moves to the left (←), what is the direction of the emf induced in it?

   ○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

[1] The Earth's magnetic field is not perfectly aligned along Earth's rotation axis, but bear with me. I'm trying to make this simple.

C. If the square loop moves to the right (→), what is the direction of the emf induced in it?

○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

D. If the square loop moves away from the wire (↓), what is the direction of the emf induced in it?

○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

E. If the square loop moves out of the page toward you, what is the direction of the emf induced in it?

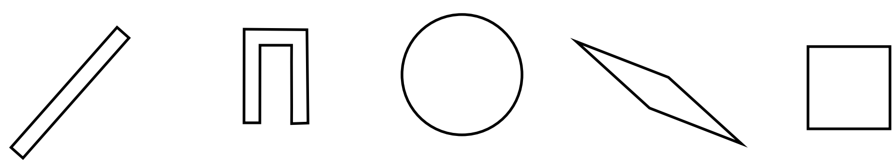
○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

F. If the square loop is held motionless while the current *I* increases, what is the direction of the emf induced in the loop?

○ a. Clockwise ○ b. Counterclockwise ○ c. Zero

10. The conducting loops depicted below have the same perimeter. All lie completely in the plane of the paper.

A. If the loops all carry the same current around them, which one has the greatest magnetic moment? Mark the circle under your selection.



○ a. ○ b. ○ c. ○ d. ○ e.

B. If the square loop (**e**) carries a current in the counterclockwise direction, what is the direction of its magnetic moment?

○ a. Up ↑ ○ b. Down ↓

○ c. Right → ○ d. Left ←

○ e. Into the page, away from you ○ f. Out from the page, toward you

○ g. No direction, because magnetic moment is not a vector

○ h. No direction, because magnetic moment is zero

11. A toroid electromagnet containing 50 windings carries a current of 40 amperes. The toroid has a square cross section 2.0 centimeters on a side, and an inner radius of 4.0 centimeters. (Please forgive the diagram; ask me about the geometry if the diagram is unclear.) Use Ampère's law to find a formula for the magnetic field inside the windings.