Instructions:

Do not open this examination until the proctor tells you to begin. Read these instructions while waiting.

1. When the proctor tells you to begin, write your name and section number at the top of every page. (This is essential since this exam booklet will be separated for grading.)

2. Do your work for each problem on the page for that problem. (This is essential since this exam booklet will be separated for grading.) You might find it convenient to either do your scratch work on the back of the page before starting to write out your answer or to continue your answer on the back. If part of your answer is on the back, be sure to check the box on the bottom of the page so the grader knows to look on the back!

3. On all the problems except short answer problem 1, your answers will be evaluated at least in part on how you got them. If explanations are requested, more than half the credit of the problem will be given for the explanation. LITTLE OR NO CREDIT MAY BE EARNED FOR ANSWERS THAT DO NOT SHOW HOW YOU GOT THEM. Partial credit will be granted for correct steps shown, even if the final answer is wrong.

4. Write clearly and logically so we can understand what you are doing and can give you as much partial credit as you deserve. We cannot give credit for what you are thinking — only for what you show on your paper.

5. If on a multi-step problem you can't do a particular part, don't give up. Go on to the next part anyway. If necessary, define a name for the quantity you couldn't find and express your answer in terms of it.

6. All estimations should be done to the appropriate number of significant figures.

7. You are not permitted to have any outside information during this exam. This includes any written information and any relevant information programmed into a calculator. If you are caught using such information, you will be prosecuted and may receive a grade of XF for this course.
1. (25 points) The figure at the left below shows a cross section of two long parallel wires (labeled A and B) taken in a plane perpendicular to the wires. One or more of the wires may be carrying a current. If a wire carries a current it is in the direction indicated and has magnitude $I_0$. The point in space halfway between the wires is marked E.

For each of the five vector quantities (a) through (e) give the direction of the quantity. To indicate the direction, use one of the letters associated with a directional arrow on the figure at the right below.

If the magnitude of the quantity is zero, write "0".

If the result is in none of the indicated directions, write "N".

_____ (a) the magnetic field at E if only wire B is carrying a current.

_____ (b) the magnetic field at E if both wires A and B carry currents.

_____ (c) the magnetic force on wire A if both wires A and B carry currents.

_____ (d) the magnetic force on a proton at E traveling to the right (i.e., in direction C) if both wires A and B carry currents.

_____ (e) the magnetic force on an electron at E traveling up (i.e., in direction A) if only wire A carries current.

If you need more space, continue on the back and check here.
2. (25 points) In the figure at the right is shown a circuit containing two batteries, two resistors, and a switch. The two resistors do not have the same resistance and the batteries do not have the same voltage.

Answer the following questions. Be sure to indicate for each one how you got your answer.

a. With the switch open, what is the current flowing through resistor $R_1$?

b. With the switch open, what is the current flowing through resistor $R_2$?

c. With the switch open, what is the voltage drop across resistor $R_1$?

d. With the switch open, what is the rate of power dissipation in resistor $R_2$?

e. When the switch is closed, does the current through either resistor change?

If you need more space, continue on the back and check here.
3. (10 points) In this class we have introduced the concept of field. Define what this means, explain why we introduce it, and give an example. Space has been left for you to sketch a figure if you wish.
4. (15 points) Estimate the cost of electricity to light all the lights in your house or dormitory for one year. The current cost of power in the Washington area is $0.03 per kilowatt-hour. Be sure to clearly state your assumptions, since grading on this problem will be mostly based on your reasoning, not on your answer.
5. (25 points) A charged particle of mass $m$ and charge $q$ is accelerated by a pair of metal plates that are charged so that they are at different electrostatic potentials. The situation is shown in the figure at the right. (Assume $q$ is positive.)

a. Assume the left plate has an electrostatic potential $V = 0$ and the right plate has an electrostatic potential $V = V_0$. If the separation between the plates is $d$, what is the magnitude and direction of the electric field between the plates? (Assume $V_0$ is positive.) (5 pts)

b. Will the particle speed up or slow down? Explain. (5 pts)

c. If the ion crosses the right plate with a kinetic energy $KE = K_0$, with what kinetic energy will it cross the left plate? (5 pts)

d. After passing through plate 2, the particle enters a region of uniform magnetic field of strength, $B$ pointing in the direction shown where it will begin to move in a circular path. Explain why, tell in which direction it will curve, and find the radius of the circle. Express your answer in terms of the givens in the problem ($m$, $q$, $d$, $V_0$, $K_0$), and any universal constants you might need ($k_C$, $\mu_0$, $\pi$, $\varepsilon_0$, $G$…). (10 pts)