University of Maryland
Department of Physics

Physics 122 **Dr. E. F. Redish**
Spring 2010 **Final Exam** **19. May 2010**

(200 points)

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 at the top of every page that has a place for it including this one (on the back).**
   (This is essential since exam booklets will be separated for grading.)

   The first problem booklet contains the short-answer problems. Do your work for these problems (1-6) on the pages for those problems. Write your answers for those problems in the appropriate boxes on the back of this page. Your work on these problems will not be inspected unless there is an ambiguity in your answer.
2. The second booklet contains long-answer problems. Do your work for each of these (I-VI) on the page for that problem. (Work on other pages will not be looked at.) If you need more pages, ask a proctor for a blank page, label it with your name and the problem number, and insert it into the exam behind the page to which it refers when you hand it in.
3. On all the problems *except short answers*, your answers will be evaluated at least in part on how you got them. **No credit may be given 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 give you as much partial credit as you deserve. We cannot give credit for what you are thinking – only for what you show.
5. If on a multi-step problem you can't do one 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. If you try one approach and then decide on another, cross out the one you have decided is wrong. If your paper has both correct and incorrect approaches the grader will not choose between them. You will not receive credit when contradictory statements are present, even if one is correct.
7. All calculations should be done to the appropriate number of significant figures.
8. At the end of the exam, write and sign the honor pledge in the space below: "I pledge on my honor that I have not given or received any unauthorized assistance on this examination

*** Good Luck ***

Answer sheet for short answer questions: (5 pts each unless otherwise noted)

1.1		(8 pts)	4.1	
1.2		(12 pts)	4.2	

2.1			5.1	
2.2		(15 pts)	5.2	
			5.3	

3.1			
3.2		6.1	
3.3		6.2	
		6.3	
		6.4	

DO NOT WRITE IN THE SPACES BELOW.

Part I

1.	2.	3.	4.	5.	6.	Total

Part II

I.	II.	III.	IV.	V.	Total

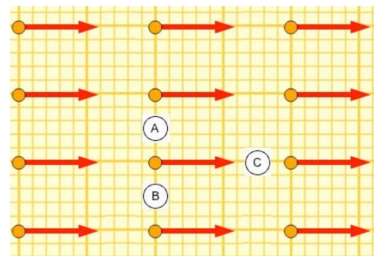
Name____

Physics 122 **Dr. E. F. Redish**
Spring 2009 **Final Exam**

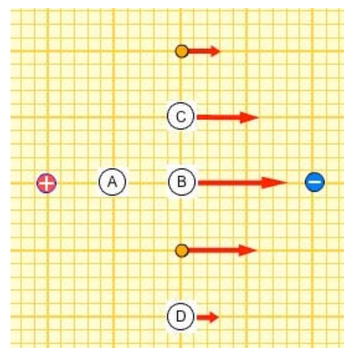
Problems 1-6 are short answer questions. Write the answers in the appropriate box on your answer sheet. No explanations are required for these items. Any scratch work on these pages will only be looked at in case of ambiguity. Give all answers that are correct (but you will lose points for each incorrect answer given). If none are correct, write N. If you are asked to rank a set of situations indicate ">" to mean greater than and "=" to mean equal. Do *<u>not</u>* *use "<" signs. Your answer should be a string of letters that looks something like E = F > G > H meaning E and F are equal and bigger than G and G is bigger than H. You, of course, should use the letters of your situation and the appropriate ranking.*

1. (**20 pts**)

1.1 A positive charge might be placed at one of three spots in a region where there is a uniform electric field as shown by the red arrows. Rank the magnitude of the electrostatic potential, *V*, felt by the charge at positions A, B, and C. (8 pts)



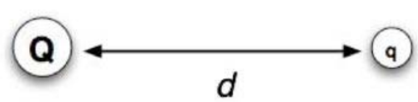
1.2 A positive and negative charge are placed in a region as shown. The resulting E field is shown at 5 places on the perpendicular bisector of the line joining the two charges. Rank the electrostatic potential, *V*, at the four locations marked A, B, C, and D. (12 pts)



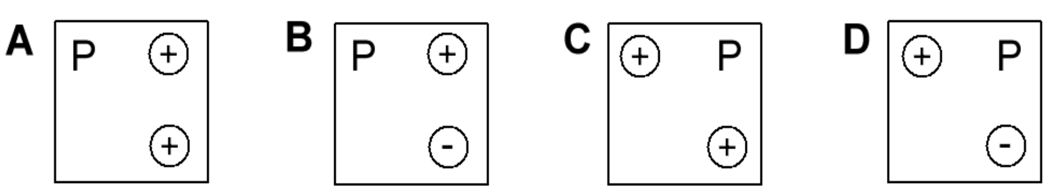
2. (20 pts)

2.1 A test charge, *q*, is a distance *d* from a charge *Q* as shown. It feels an electric field, E_0. If *q* were replaced by a charge $-3q$, what would happen to the electric field on it? (5 pts)

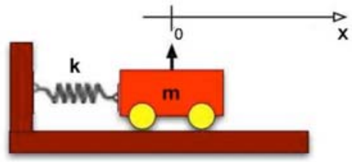
(a) It would change to $-3E_0$
(b) It would change to $3E_0$
(c) It would stay the same
(d) It would change to $-E_0/3$
(e) It would change to $E_0/3$
(f) You can't tell without more information.



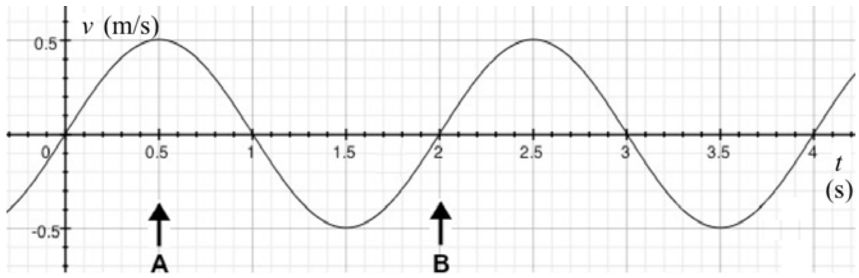
2.2 In the figure below are shown four two-dimensional arrangements of charge. Each of the charges has the same magnitude, but some are positive and some are negative. In each diagram a point is labeled "P". Rank the diagrams by the magnitude of the force felt by a positive test charge placed at P. (15 pts)



3. (15 pts) In the figure at the right is shown a schematic of a small cart attached to a wall with a spring. For the oscillations we will consider, the spring is well described by Hooke's law.



On the graph below is shown the velocity of the cart as a function of time. Use the coordinate system shown.



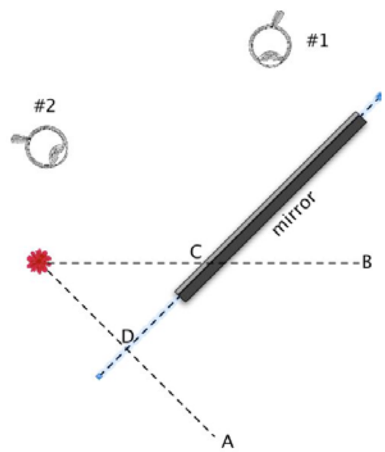
3.1 In the appropriate box on your answer sheet indicate the direction of the force that the spring exerts on the cart at the instant marked by the letter A. Use *L* (for left), *R* (for right), or 0 (if the force is 0). (5 pts)

3.2 In the appropriate box on your answer sheet indicate the direction of the force that the spring exerts on the cart at the instant marked by the letter B. Use *L* (for left), *R* (for right), or 0 (if the force is 0). (5 pts)

3.3 Select the answer or answers that correctly complete the following statement. We can determine the spring constant: (5 pts)

(a) From the information in the velocity graph alone.
(b) From the information in the velocity graph if we also knew the mass.
(c) From the mass alone without using the velocity graph.
(d) We would need additional information. The mass and velocity graph is not enough.

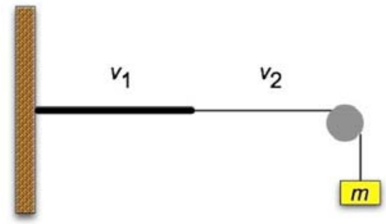
4. (10 pts) A small flower is placed in front of a mirror. Two observers (shown as eyeballs and labeled as #1 and #2) attempt to view the image of the flower in the mirror. Where will each viewer see the image? Some dotted lines are drawn for your convenience.



4.1 To viewer #1 the image will appear to be
(a) Approximately at position A
(b) Approximately at position B
(c) Approximately at position C
(d) Approximately at position D
(e) At some other position.
(f) Viewer #1 will not be able to see the image of the flower in the mirror.

4.2 To viewer #2 the image will appear to be
(a) Approximately at position A
(b) Approximately at position B
(c) Approximately at position C
(d) Approximately at position D
(e) At some other position.
(f) Viewer #2 will not be able to see the image of the flower in the mirror.

5. (**15 pts**) An elastic string is composed of two parts, each of the same length and made of the same material but one has twice as large a cross-sectional radius as the other. One end is attached to a wall and the other end is attached to a weight and is hung over a pulley to give the string tension as shown in the figure at the right.



5.1 How does the tension in the thick part of the string compare to the tension in the thin part? (5 pts)

(a) The tension in the thick part is greater.
(b) The tension in the thin part is greater.
(c) The tension in the two parts is the same.
(d) You don't have enough information to tell.

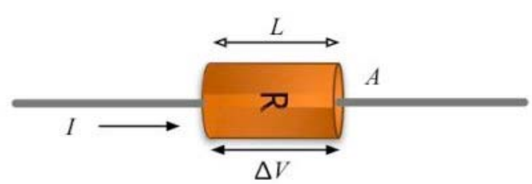
5.2 The string is plucked so that a pulse moves along it, starting in the thick part and moving into the thin part. It moves at speed v_1 in the thick part and at speed v_2 in the thin part. What is the ratio v_1/v_2? (5 pts)

(a) 1	(f) 4
(c) ½	(g) $\sqrt{2}$
(d) 2	(h) $1/\sqrt{2}$
(e) ¼	(n) You can't tell from the information given.

5.3 How will the width of the pulse when it appears on the thin part of the string compare to the width of the pulse on the thick part where it was created?

(a) It will be wider on the thick part.
(b) It will be wider on the thin part.
(c) They will have the same width.
(d) You can't tell from the information given.

6. (**20 pts**) A steady current is flowing through a resistor that is made out of an electrically uniform substance. It is well described by Ohm's law. The resistor has the dimensions and electrical measurements as indicated in the figure.



6.1 Which of the following statements are likely to be at least partially responsible for the validity of Ohm's law for this resistor? (5 pts)

(a) The resistor is made from a material that is a conductor.
(b) The resistor is made from a material that is an insulator.
(c) Moving charges in the resistor feel a resisting frictional force that is independent of their velocity.
(d) Moving charges in the resistor feel a resisting drag force that is linearly proportional to their velocity.
(e) None of the above statements can be relevant to the validity of Ohm's law.

6.2 Suppose that the original resistor is replaced by a resistor of the same length and identical material but twice the cross sectional area. Further suppose that the potential drop across the resistor is the same as for the original. The current through the new resistor will be (5 pts)

(a) The same as for the original resistor.
(b) Twice as big as for the original resistor.
(c) Half as big as for the original resistor.
(d) Some other multiple of the original current.
(e) You can't tell from the information given.

6.3 Suppose that the original resistor is replaced by a resistor of the same cross sectional area and identical material but twice the length. Further suppose that the potential drop across the resistor is the same as for the original. The current through the new resistor will be (5 pts)

(a) The same as for the original resistor.
(b) Twice as big as for the original resistor.
(c) Half as big as for the original resistor.
(d) Some other multiple of the original current.
(e) You can't tell from the information given.

6.4 Suppose that the original resistor is replaced by a resistor of the same physical dimensions but made of a material that has half the density of charges to carry current, but each carrier has double the charge of those in the original resistor. Further suppose that the potential drop across the resistor is the same as for the original. The current through the new resistor will be

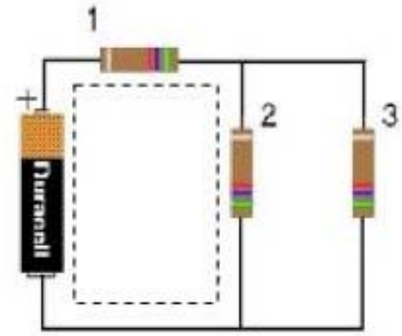
(a) The same as for the original resistor.
(b) Twice as big as for the original resistor.
(c) Half as big as for the original resistor.
(d) Some other multiple of the original current.
(e) You can't tell from the information given.

Go on to the second part
of the exam (in the other booklet).

Name____**Points**_________

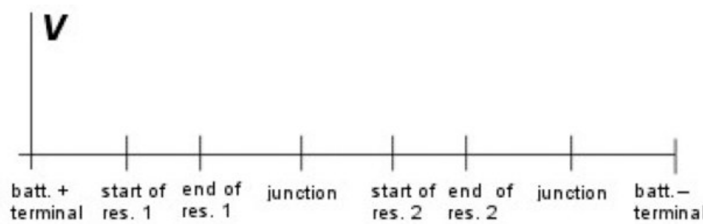
I. (25 points)

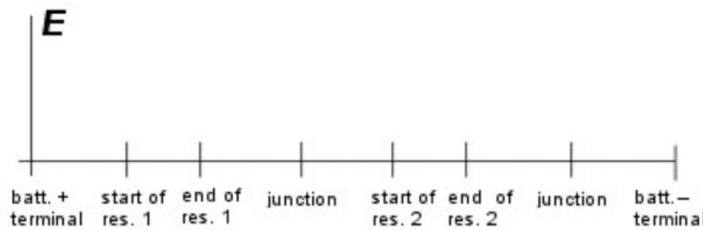
A. The circuit diagram shown at the right contains a 1.5 Volt battery and three identical 50 Ω resistors. Find the current in and voltage drop across each of the resistors and put your answers in the boxes under the figure. Explain your reasoning in the space below. (10 points)

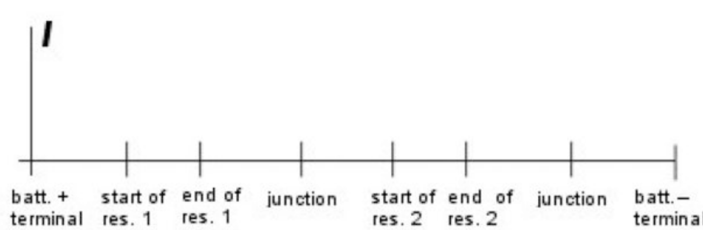


$I_1 =$	$\Delta V_1 =$
$I_2 =$	$\Delta V_2 =$
$I_3 =$	$\Delta V_3 =$

B. In the first two graphs as the right, track the voltage and magnitude of the electric field a test charge would measure as it followed the indicated loop through the circuit (the dotted line). In the third graph, show the current one would measure as one went around that loop. (15 pts)

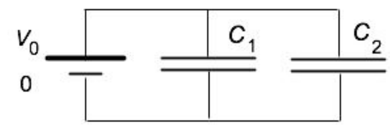






(Continued on back)

II. (15 points)
In the figure at the right are shown two (non-identical) capacitors connected in parallel having capacitances C_1 and C_2. Assume that the capacitors are first connected to each *other* and then to the battery.



A. If the voltage rise in the battery is $\Delta V = V_0$, what is the voltage drop across each of the individual capacitors? Express your answer in terms of the symbols given and put it in the box at the right. In the space below explain how you know. (5 pts)

ΔV_1 =

ΔV_2 =

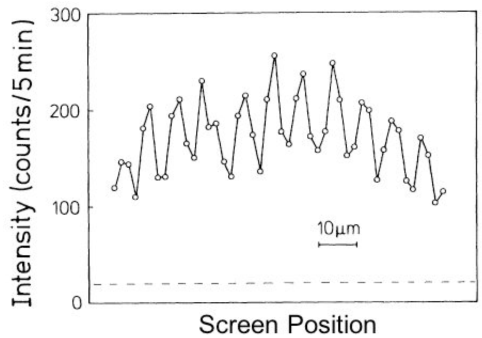
B. If the charge on the positive plate of C_1 is Q, what is the charge on the positive plate of C_2? Express your answer in terms of the symbols given and put it in the box at the right. In the space below explain how you know. (5 pts)

Q_2 =

C. Using your results above, find the effective capacitance of the combined pair of capacitors. (That is, what you would measure their capacitance as if they were contained in a box and you didn't know they were two separate capacitors.) Express your answer in terms of the symbols given and put it in the box at the right. In the space below explain how you know. (5 pts)

C_{eff} =

III. (15 points) Modern theories of atoms describe them not just as little particles but also say they should have wave properties. If this is so, then passing a beam of atoms through a double slit should produce an interference pattern. The figure at the right, taken from an article in *Physical Review Letters*[i], shows the result of passing a beam of Helium atoms through a double slit.

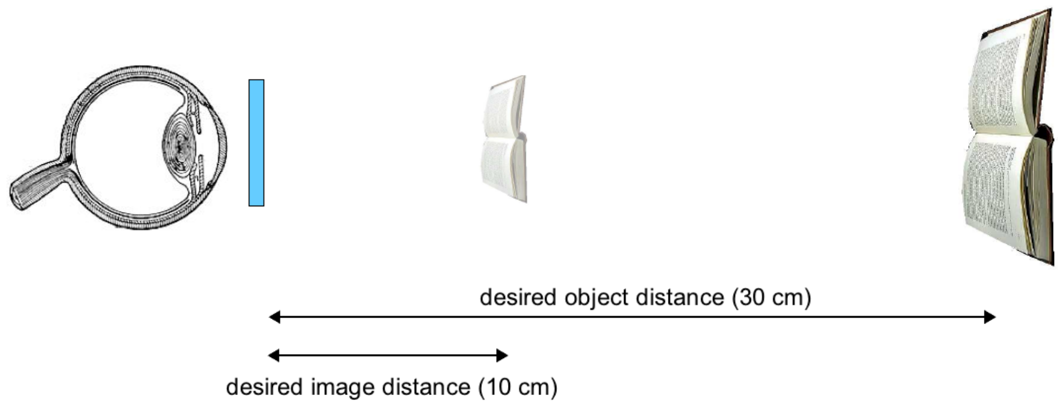


The slits are 8 μm apart and the screen collecting the atoms is 64 cm away from the slits. If the peaks that are seen in the figure are two-slit interference peaks, what would be the wavelength of the atoms? Explain your reasoning. (*Note*: This was the first experiment demonstrating interference with whole atoms. The data is a bit ragged since it was difficult to get a sharp wavelength – which is determined by the velocity of the atoms in the beam. The agreement of this measured value with the predicted theoretical wavelength was a convincing argument that the experimenters had actually seen the phenomenon.)

(Continued on back)

[i] O. Carnal and J. Mlynek, "Young's double slit experiment with atoms," *Phys. Rev. Lett.* **66** 2689 (1991)

IV. (20 pts) An optician's nearsighted patient would like to be able to read a book without having to hold the book close to his face. If a natural distance to hold the book away from your eye is 30 cm, and the patient has to hold the book at 10 cm to read it comfortably, the optician wants to design a lens that will make an object that is 30 cm away appear to be only 10 cm away to the patient as shown in the figure below.

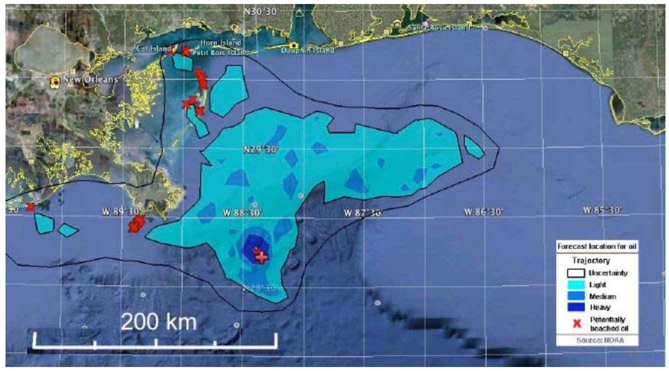


A. The optician wants the image to be right-side up and on the same side of the lens as the object. Should he use a converging lens or a diverging lens? Explain your reasoning. (5 pts)

B. The picture shows the image as smaller than the object. Is this correct? If the distances are as shown, what will be the magnification factor (ratio of the image size to object size)? (5 pts)

C. What is the focal length of the lens the optician needs to use to get the desired result? (10 pts)

V. (15 points) The Deepwater Horizon drilling rig in the Gulf of Mexico exploded on April 14, 2010 and has been leaking oil into the Gulf ever since. As of this writing, one estimate is that 5000 barrels of oil are leaking each day. (One barrel of oil is a measure of volume that is about 1/6 of a cubic meter.) In the figure at the right is shown a prediction of the distribution of the oil about 2 months after the spill assuming the spill continues until then before it is sealed. Assume that the spill is of uniform thickness (ignoring the legend that says "Light" or "Heavy") estimate how thick the oil will be on top of the water. (FYI: The diameter of an oil molecule is about 10^{-7} m.)



Be sure to clearly state your assumptions, how you came to the numbers you estimated, and your logic since grading on this problem will be mostly based on your reasoning, not on your answer.

VI. (10 points) In the first semester of this class, as we analyzed the mechanics of motion we emphasized thinking about the intuitions you had developed from everyday experiences and reconciling them with the physics you were learning. In this term, we studied more complex issues: oscillation, optics, and electricity. Were you able to continue thinking about everyday intuitions this term, or did you not find it useful to do that? If you found it useful, give a specific example of an issue where your intuition helped make sense of something or where you were able to modify your intuition to reconcile it. If you did not find it useful, pick a topic and show how your intuition failed and why you were unable to reconcile it with the physics we were learning. *Note: This is an essay question. Your answer will be judged not solely on its correctness, but for its depth, coherence, and clarity.*

☐ Grader: There is work on the back of this page.

VII. (5 points – extra credit) Have you learned anything in this class that you think will be of any use to you in five years? If so, what? If not, why not? Any thoughtful answer will receive full extra credit points. (Don't do this until you have completely finished the rest of the exam.)