Name____

University of Maryland
Department of Physics

Physics 122 — **Dr. E. F. Redish**
Spring 2009 — **Exam 2** — **17. April. 2009**

Instructions:

Do not open this examination until the proctor tells you to begin.

1. When the proctor tells you to begin, <u>**write your full name at the top of every page.**</u> 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. 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. <u>**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!**</u>
3. On all the problems *except the multiple choice questions in problem 1 or where it says* <u>*not*</u> *to explain*, your answers will be evaluated at least in part on how you got them. More than half the credit of the problem may be given for the explanation. YOU MAY EARN LITTLE OR NO CREDIT FOR YOUR ANSWERS IF YOU DO NOT SHOW HOW YOU GOT THEM. Partial credit will be granted for correct steps shown, even if the final answer is wrong. Explanations don't need to be long, but they need to show what physics you are using and assumptions you are making.
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 you try one approach and then decide on another, cross out the one you have decided is wrong. If your paper contains both correct and incorrect approaches the grader will not choose between the two. You will not receive any credit when contradictory statements are present, even if one is correct.
6. All calculations should be done to the appropriate number of significant figures.
7. 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 exam."):

#1:	#2:	#3:	#4:	#5:	Total

****** Good Luck ******

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1. (24 points) For the four items below, choose all the answers that are correct and put the letters corresponding to them in the boxes at the right. If none of the answers are correct put N and put a brief explanation on the back of the page.

1.1. (6 pts) Three pithballs are suspended from thin threads. Various objects are then rubbed against other objects (nylon against silk, glass against polyester, etc.) and some (possibly all) of the pithballs have been charged by touching them with one of these objects. It is found that pithballs 1 and 2 repel each other and that pithballs 2 and 3 repel each other. From this we can conclude that

(a) 1 and 3 carry charges of opposite sign.
(b) 1 and 3 carry equal charges of the same sign.
(c) all three carry charges of the same sign.
(d) one of the objects carries no charge.
(e) we need to do more experiments to determine the sign of the charges

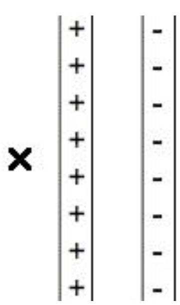
1.2. (6 pts) Three pithballs are suspended from thin threads. Various objects are then rubbed against other objects (nylon against silk, glass against polyester, etc.) and some (possibly all) of the pithballs have been charged by touching them with one of these objects. It is found that pithballs 1 and 2 attract each other and that pithballs 2 and 3 repel each other. From this we can conclude that

(a) 1 and 3 carry charges of opposite sign.
(b) 1 and 3 carry equal charges of the same sign.
(c) all three carry the charges of the same sign.
(d) one of the objects carries no charge.
(e) we need to do more experiments to determine the sign of the charges.

1.3 (6 pts) In the 17^{th} century, Isaac Newton and Christian Huygens had two different models to describe the mechanism by which light got its various observable behaviors. Which of the following statements are true?

(a) Newton's model is more accepted today because it correctly describes the refraction and reflection of light and Huygens' doesn't.
(b) Huygens' model is more accepted today because it correctly describes the interference of light and Newton's doesn't.
(c) Newton's model is favored because it correctly predicted that light travels faster in a dense medium than in air or vacuum.
(d) Huygens' model is favored because it correctly predicted that light travels slower in a dense medium than in air or vacuum.

1.4 (6 pts) Two large insulating sheets have equal and opposite charges spread uniformly over them. If the sheets are placed close together a small distance apart (compared to their sizes), it is found that the electric field near to the plates but outside of them (at the "x" in figure) is very small – almost 0. The reason for this is



(a) The field from the nearer sheet blocks the field from the farther sheet.
(b) The field from the farther sheet falls off because it is farther away.
(c) The fields from the two sheets are opposite and almost cancel.
(d) It's not true. The field at the "x" is actually large.
(e) The field is not close to 0, but it is constant as you move away from the sheet.

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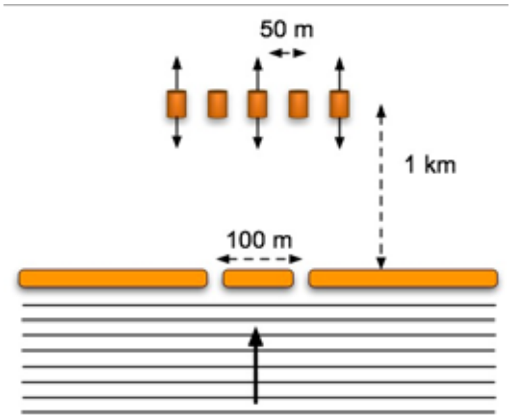
2. (26 points) You are out in a rowboat on a lovely calm sunny day. You are in a small lagoon (a few kilometers on a side) that is protected from the open ocean by a series of barriers. One of the barriers has two fairly narrow openings set 100 m apart. One km from these openings is a set of floating buoys, held in position on the water's surface by a set of ropes that define the allowed swimming area. The buoys are set 50 m apart.



As it begins to get later in the afternoon, the wind begins to pick up and you begin to notice that beyond the barrier, small waves are beginning to hit the barrier. The situation is illustrated in the figure at the right (NOT to scale).

(a) Waves start to pass through the gaps in the barrier. After a while, you notice that three of the buoys are bobbing up and down, but two of them are staying almost stationary. From this information, make a plausible calculation of what the wavelength is of the waves that are approaching the barrier. (15 pts)

(b) The openings in the barrier are to let small boats through and can be closed by gates. What would happen to the bobbing buoys if one of the gates were closed? Why? (6 pts)

(c) In order to do your calculation for part (a) you had to make some assumptions and/or approximations. Name two that you think might actually be important to consider if you wanted to make a more accurate calculation. (5 pts)

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3. (15 points) In the tutorial on lenses, in a darkened room you looked through a converging lens at a lit computer monitor some distance away and saw an inverted (real) image. When you held up a sheet of paper some distance from the lens, you were able to get the image to show up clearly (in focus) on that paper screen. From your experience with that experiment, estimate the focal length of the lens you were using. *Be sure to clearly state your assumptions and how you came to the numbers you estimated, since grading on this problem will be mostly based on your reasoning, not on your answer.*

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4. (10 points) In discussing the concept of a *vector field* we have presented a number of different ways of representing such a field visually. For an electric field, describe which visual representation of the field you prefer, what you feel it represents well, and sketch an example in the box provided. Discuss why we might want to have a visual representation of an electric field in the first place. *Note: This is an essay question. Your answer will be judged not solely on its correctness, but for its depth, coherence, and clarity.*

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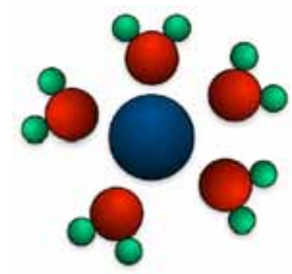
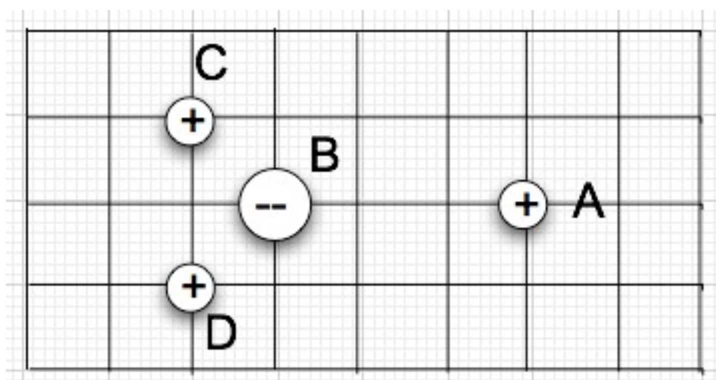
5. (25 points) An important part of the functioning of a biological membrane is its ability to selectively pass either sodium ions (Na^+) or potassium ions (K^+) through channels in the membrane. Because these ions have the same charge and are about the same size, the electric force exerted on them by the membrane will be similar. One mechanism that has been proposed to account for the difference in how membrane channels treat these two ions is the suggestion that the ions attract water molecules providing a sphere of water that magnifies the small size difference between the ions. This "coating of water" is illustrated in the figure at the right.



To actually calculate the size of the ion's "water coat" is difficult. (And we would have to use quantum mechanics, which provides the repulsion that keeps the atoms from getting too close to each other.) But we can get a first idea of what is happening by exploring the electric force between the ion and one water molecule as shown in the figure at the right.

We label the ion A, the oxygen in the water B, and the hydrogen atoms in the water C and D.

(a) To simplify the calculation, we'll make a "simple physics model" – take the ion and the two hydrogens as each having a charge +e, while the oxygen has a charge -2e. Treat each of these as point charges. On the diagram below, draw arrows indicating the direction and relative magnitude of the force the ion exerts on each of the three atoms in water, B, C, and D. (10 pts)



(b) Assuming that atoms of the water are held together somehow (quantum again!), is the net force that A exerts on the molecule (B+C+D) attractive or repulsive? Why do you say so? (8 pts)

(c) How does the force that the water molecule exerts on the ion compare to the force that the ion exerts on the parts of the water molecule? How do you know? (7 pts)

If you need more space, continue on the back and check here. ☐