Name____

University of Maryland
Department of Physics

Physics 122 — **Dr. E. F. Redish**
Spring 2011 — **Exam 1** — **4. March. 2011**

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 <u>not</u> 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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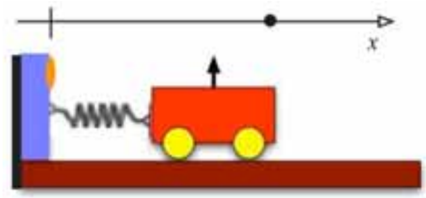
1. (25 points) A sonic ranger is attached to a spring, which is attached to a wheeled cart. The x-coordinate reported by the ranger is shown above the diagram. The small black circle on the axis indicates the point at which the cart's arrow points when the spring is at its rest length.



The cart has been pulled out to a positive x value greater than the rest length and released. After a few oscillations the ranger starts to collect data. At the time at which that happens is taken the cart looks as shown in the picture above and we take it as $t = 0$. For the time interval shown, friction can be ignored.

In the figures below are shown graphs for a number of different variables either taken directly from the ranger's data or calculated from it. All the graphs are shown as functions of time (horizontal axis). Identify which of the graphs could possibly be graphs of the indicated variables if the vertical axis had the right units. Note that the horizontal axis (with arrow) goes through the zero of the vertical axis in each case. Put all the answers that could be right. If none work, put N.

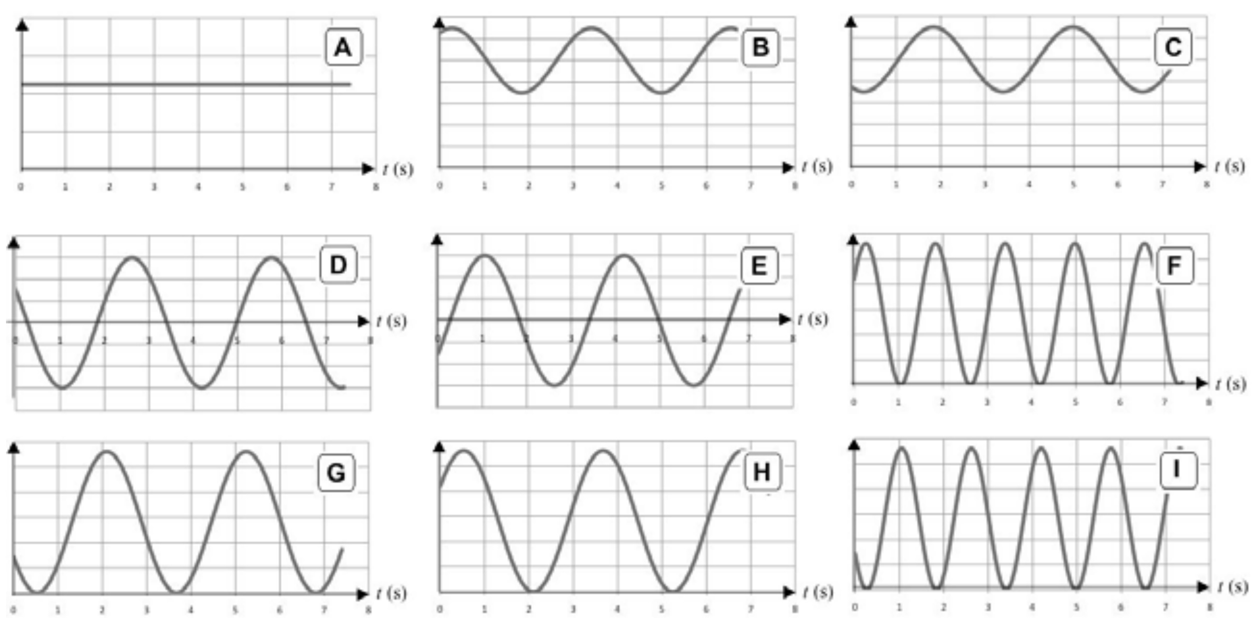
_____ *x* position

_____ *x* velocity

_____ potential energy

_____ kinetic energy

_____ total mechanical energy



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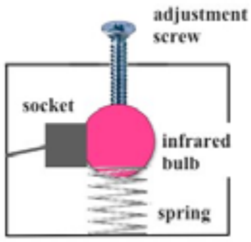
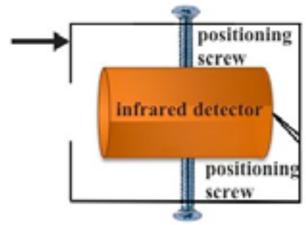
2. (25 points)

A. (10 pts) My garage has an automatic garage door opener that goes up and down at the click of a button. In order to protect against the door smashing closed on someone or something, there is a box containing an infrared bulb on one side of the door near the floor and an infrared detector

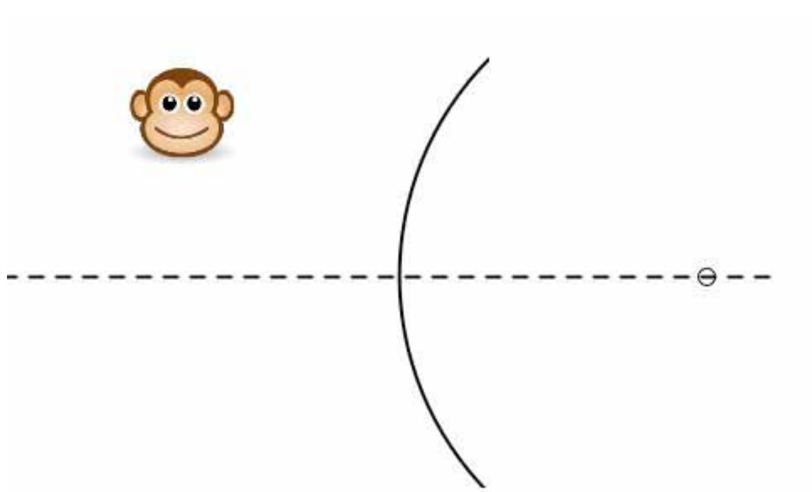


on the other side of the door near the floor. If the beam is unbroken by an object, the detector detects the beam of light and knows the path is clear. If there is something in the way, it blocks the light and the detector sends the door a signal not to go down. Both the bulb and the detector are enclosed in housings (metal boxes with a hole) that lets a beam of infrared light out/in.



The detector is fixed in place, but the bulb can be adjusted up and down slightly by a spring-and-screw arrangement as shown above left. Suppose that the housings (boxes shown as lines) have not been installed at exactly the right heights and the beam from the bulb hits the detector at a point above the entry hole (at the arrow in the figure at the right). I can't move the detector easily because both positioning screws have to be turned at the same time. To get the beam into the detector, should the screw on the bulb be adjusted to raise or lower the bulb? Explain your reasoning. (A diagram helps – but is not sufficient.)

B. (15 points) A small object is viewed in a curved spherical mirror as shown in the figure below. Construct a careful ray diagram to determine where the image of the object will appear to be when viewed in the mirror. The small circle on the right represent the position of the center of the sphere of which the mirror is a part. Is the image real____ or virtual_____? (Check one)



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3. (15 points) A common scam used to separate suckers from their money is the Ponzi scheme. People pay money in and then get their money back from people who put money in at a later time. If the number of people grows, early investors get back more money than they put in – sometimes by a lot. This works until all the people who are willing to put money in are used up. Then those who put money in but haven't yet gotten anything back are shafted.

Analyzing this in detail is too complex for an exam question, but let's get an estimation of an example that at least shows the Ponzi principle: If you get in late, you lose.

A chain letter is a kind of Ponzi scheme. Each person who gets one is supposed to send a copy of the letter to 4 people and asks each of them to send it to 4 more, etc. (For this problem, never mind how the money works.) So the first person sends it to 4 people, in stage two, the letter is sent to 16, in the stage three, 64 more get a letter, etc. Assume that every person asked has not been asked before and everyone getting the letter proceeds to send it on to four new people. Estimate how many stages this process can go through before all of the adults in the US have received a letter. (Assuming the total number grows maximally at every step is unrealistic, so this will produce a significant overestimate of how many stages can happen.) *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) When we were trying to model the motion of a simple oscillator (a mass on a spring) we started with the equation "$x = \cos(t)$" but decided it didn't work. Discuss how you would correct this equation and <u>why</u> you would make the changes you do. Your "why" should include not just a specific discussion of why you would make individual changes in this equation, but a sentence or two about the use of equations to describe physical phenomena in general that motivates your specific changes. *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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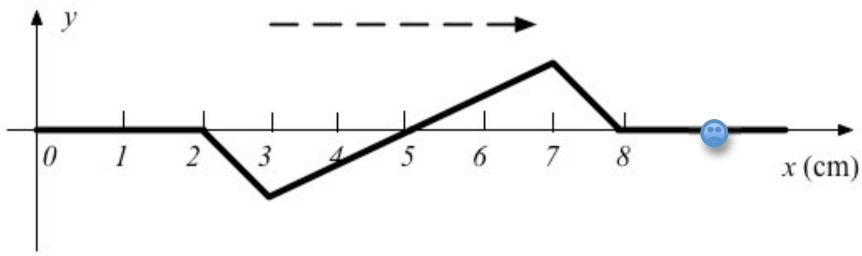
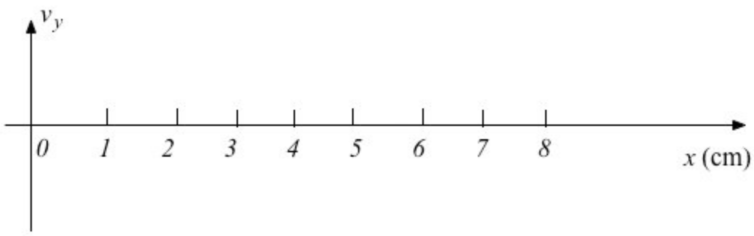
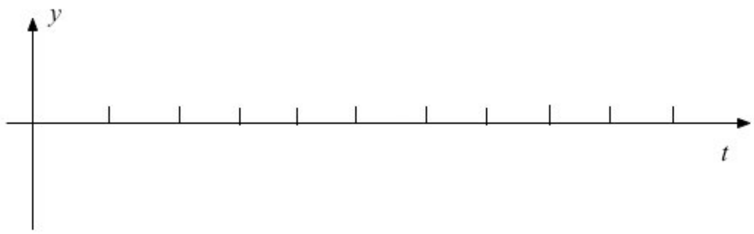
5. (25 points) An instructor holding a long taut spring flicks his hand up-down-up to create a pulse moving down the string to the right that we will approximate as looking like this.



A. (10 pts) On the axes below sketch carefully a graph of the y-component of the velocity of the bits of the spring at the instant of time shown. (Since no vertical scale is shown, you can't get the values of the velocities, but "carefully" means make sure it lines up on the x-axis properly and get the relative size of the different velocities correct.)



B. (10 pts) On the axes below, sketch carefully a graph of the y-position of the small circle (bit of tape on the spring) as a function of time as the pulse passes it. (Since no scale is shown, you can't get the values of the times, but "carefully" means make sure the relative times are correct.)



C. (5 pts) Now the instructor starts repeating the exact same pattern one after another so that the pulses on the long spring look like the figure at the right.

If the small circle in the top figure repeats the up-down-up pattern every 20 milliseconds, can you figure out how fast the pulse moves down the string? If you can, calculate it. If you can't, explain why you can't.

$\boxed{v_0 = \quad}$

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