University of Maryland
Department of Physics

Physics 374 **Dr. E. F. Redish**
Fall 2004 **Exam 2** **22. November, 2004**

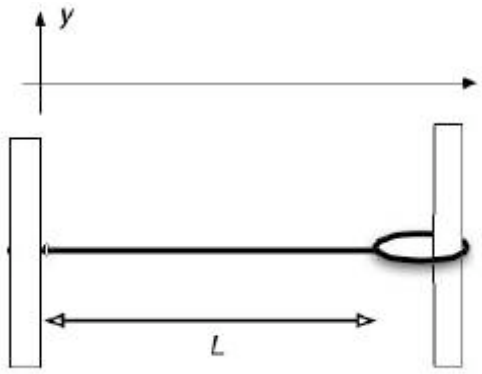
Instructions:

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

1. When the proctor tells you to begin, **write your full name 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. 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 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. All estimations should be done to the appropriate number of significant figures.
6. 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."

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

1. (30 points) An elastic string is stretched and connected to two posts as shown in the picture below. On one end it is fixed, on the other connected to a nearly frictionless ring. Describe the system by the coordinate system shown. The length of the string is *L,* it has a mass *m,* and is pulled taut to a tension *T*. Assume the widths of the rod and ring, the mass of the ring, the friction between the rod and the ring, and gravity can all be ignored for this calculation. Take the 0 of the x-y coordinate system to be at the point where the ring is tied to the left post.



(a) Write the equation of motion for the displacement of the bit of the string at the point x, $y(x,t)$. (5 pts.)

(b) What are the boundary conditions satisfied by the solution of this equation for the case described? (5 pts.)

(c) Find the normal modes for the motion of this string. (10 pts.)

(d) If the string starts at time $t = 0$ displaced into a shape $f(x)$ that satisfies the boundary conditions, how would you find the shape of the string at a later time, t ? Give enough detail that you could actually do the calculation if the function f were given. (10 pts.)

2. (20 points) For each of the objects a.-f. in the Dirac representation, choose which of the descriptions in the list 1-10 fit them. Each of the six expressions may match more than one description or none. Not all of the descriptions must be used.

_____ a. $\sum_{n=1}^{N} |e_n\rangle\langle e_n|$

_____ b. $\langle x|x'\rangle$

_____ c. $\langle f|g\rangle$

_____ d. $|f\rangle = \sum_{n=1}^{\infty} f_n |e_n\rangle$

_____ e. $\int |x\rangle dx \langle x|$

_____ f. $|f\rangle\langle g|$

1. This expression is an inner product.
2. This expression is an outer product.
3. This expression is the Dirac delta function.
4. This expression is the identity operator.
5. This expression is a Fourier expansion.
6. This expression contains elements of a pseudobasis.
7. This expression contains elements of a basis..
8. This expression is a number.
9. This expression is a state in a linear space.
10. This expression is an operator.

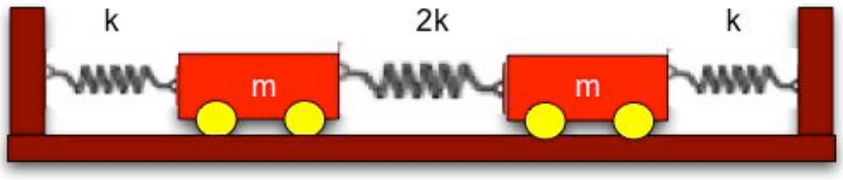
2a. (Extra Credit: 2 points) You are working with a couple of other students on an estimation problem for homework and you note that they have replaced 10^{28} by 1^{29} in their calculation. Do you:

(a) agree and go on
(b) say something. If so, what?

3. (15 points) As part of a Physics Open House a department sets up a bungee jump from the top of their physics building. Assume that one end of an elastic band will be firmly attached to the top of the building and the other to the waist of a courageous participant. The participant will step off the edge of the building to be slowed and brought back up by the elastic band before hitting the ground (we hope). Estimate the length and spring constant of the elastic you would recommend we use. *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.*

4. (10 points) In this class we have introduced the idea of a linear space as a generalization of everyday space. Define a linear space, discuss why it is useful, and give an example.

5. (25 points) Two identical wheeled carts of mass m are connected between two walls as shown in the figure below. The two outer springs have spring constants k and the inner spring has spring constant $2k$. All three springs have a rest length l_0 and the distance between the walls is L.



(a) Choose a convenient coordinate system for describing the positions of the carts and write the equations of motion for the carts. Be sure to specify your coordinate system. (7 pts.)

(b) In writing your equations of motion, you probably ignored some factors or effects that are present in real systems, but that you expected to be small and therefore negligible. Identify 3 such factors. (Choose ones that you might want to include if you were trying to create a really accurate description of this physical system.) (8 pts.)

(c) Find the normal modes and normal frequencies using any approach you want. (10 pts.)