Name____

University of Maryland
Department of Physics

Physics 121 **Dr. E. F. Redish**

Fall 2010 **Exam 2 (Makeup)** **18. November. 2010**

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."):

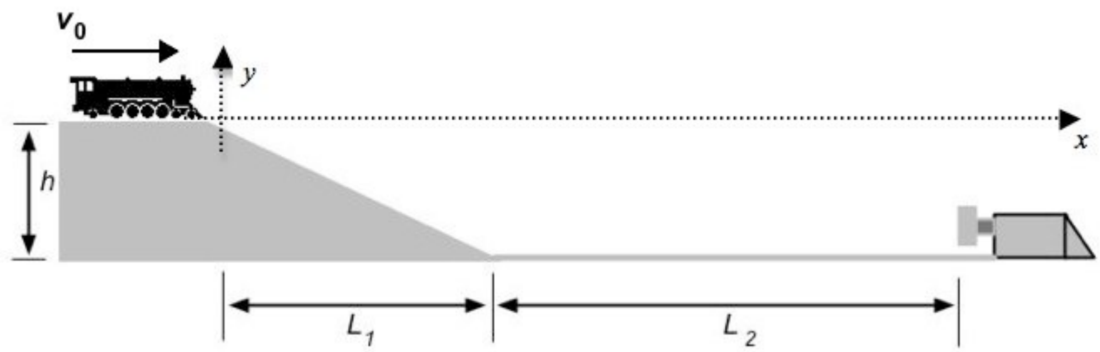
#1:	#2:	#3:	#4:	#5:	Total

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

NAME____ **POINTS**________

Physics 121 **Dr. E. F. Redish**
Fall 2010 **Exam 2 (M.U.)**

1. (25 points) A toy train comes off a hill traveling at a velocity v_0, rolls down an incline of height h, rolls a short distance on a straight track, and strikes a bumper containing a spring, which is strong enough to stop the train. The distances are as indicated on the figure below. The train is just rolling, not powered.



Which of the graphs below could represent the following variables of the system expressed *as a function of the* *position* *of the front end of the engine* using the coordinate system shown? For this problem, ignore friction. Put the letter of all graphs that would work for a given variable in the space provided. If none works, put N and sketch what it would look like.

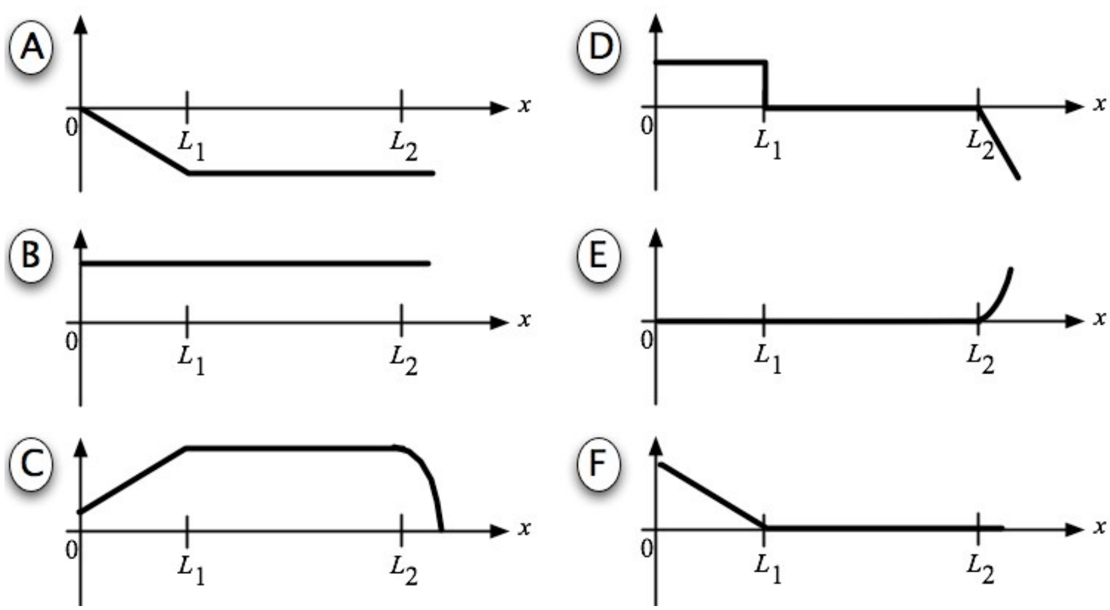
_____ 1. The total mechanical energy of the system.

_____ 2. The potential energy of the spring.

_____ 3. The gravitational potential energy of the train.

_____ 4. The kinetic energy of the train.

_____ 5. The x-component of the net force on the train.



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NAME____ POINTS_______

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2. (25 points) Two students are driving a Porsche of mass M <u>at a constant speed</u> v around the traffic circle in front of the Physics building. Assume that the road in the circle is level and has a radius R. The coefficient of friction between the car's wheels and the road is μ.

(a) In terms of the quantities given, what is the magnitude and direction of the car's acceleration? (5 pts)

(b) At the instant when it passes directly in front of the Physics building, is there a net force on the car? If there is, what is responsible for it and how big must it be? Express your answer in terms of the quantities given and explain your reasoning. (10 pts)

(c) The mass of the car and passengers is 1700 kg, the circle has a radius R = 25 m, and the coefficient of static friction between rubber and a dry road is μ = 0.6. What is the fastest speed the car can go without slipping? If you need the gravitational field for this calculation, use g = 10 N/kg. (10 pts)

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3. (15 points) Some people think that it is implausible that humans can be affecting the amount of CO_2 in the atmosphere because the atmosphere is so big and we are so small. The total mass of the atmosphere <u>is</u> very large – about 5 x 10^{18} kg. But CO_2 is a fairly small fraction of this – about 6 x 10^{-4} of its mass. According to the website on carbon footprints,[*] the average amount of CO_2 produced by a person in the US is about 20 metric tons per person per year. (One metric ton is 10^3 kg.) If every person in the world produced this much CO_2 every year, how long would it take to increase the amount of CO_2 in the atmosphere by 20%? (This is oversimplified, but gives us a reasonable idea of whether it is at all plausible that human produced CO_2 can be significant.) *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.*

[*] http://www.carbonfootprint.com/carbonfootprint.html

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4. (10 points) In our discussion of the law of momentum conservation, we were careful to show its connection with the fundamental principles – the relevant Newton's laws. State the principle of momentum conservation and discuss whether you found the connection between it and Newton's laws helpful. Give reasons for your decision. *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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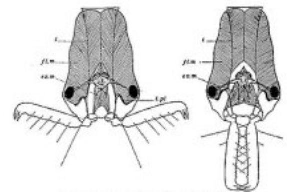
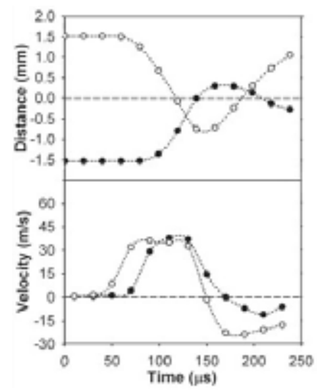
NAME____ POINTS_______

5. (25 points) A remarkable species of ants known as "trap-jaw ants" have a pair of jaws (mandibles) that can open to 180^{o} and quickly snap shut, either to attack prey or in self defense. As a defense mechanism, snapping its jaws shut on the ground sends the ant flying off backwards or up into the air, to a distance many times the ant's length. The head of the ant with the jaws in the open and closed position are shown at the right.[†]



A group at Berkeley[‡] took high-speed videos of the ants jumping. (The frame rate was one frame every 20 <u>micro</u>seconds – 2 x 10^{-5} s – about 1000 times faster than an everyday video!) From these videos, they were able to extract the position and velocity of the snapping mandibles, as shown in the graphs at the right. These are the data for "unobstructed" mandibles – ones that snap closed but don't hit anything. Let's use these data to get an idea of the forces involved.



A. One mandible (the one represented by the open circles in the graphs) changes its speed from about 40 m/s (that is NOT a typo) to -30 m/s in about 40 μs (4 x 10^{-5} s). If the mass of the mandible is 130 μg (1.3 x 10^{-7} kg), find the momentum change of the mandible and the average force acting on it during that time. (10 pts)

$\Delta p =$

$\langle F^{net} \rangle =$

B. If the force from the two mandibles is exerted on an object in front of the ant, the ant will be thrown backward or upwards. If the mass of the ant is 12 mg (1.2 x 10^{-2} kg), with what speed will the ant be thrown backwards? (10 pts)

$v_0 =$

C. If each mandible moves 2.0 mm while exerting its force on the ground about how high will the ant be thrown in the air? (Simplify the calculation by ignoring air resistance and assuming the ant is pushing straight down the entire time.) (5 pts)

$h =$

[†] Wikipedia, *Odontomachus*, accessed 11/16/10.

[‡] S. N. Patek et al., *Proceedings of the National Academy of Sciences* **103**:34 (8/22/2006) 12787-12792

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