

NAME \_\_\_\_\_

**MIDTERM 2**

Physics 141

Fall Quarter 2008

H.J.Frisch HEP320 (702-7479) Nov. 11, 2008

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(50 min: 3 questions) HINT- READ THE QUESTIONS.

Make a good clear picture before you do anything, and show your work! Much partial credit will be given for setting up the problem correctly, but we gotta be able to figure out what you're doing. Random chicken-scratching will be ignored or worse. Plugging in the numbers before you have the symbolic expression will be treated as it deserves (zero points!!). So, work linearly and clearly, and Good Luck!

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Problem 1 **Momentum Conservation- drive carefully** (30 points)

A car of mass 2 tons going east on Rte 2 at 60 mph collides head-on with a truck weighing 8 tons going west at 50 mph. The car and truck crumple and become entangled, so after the collision they move as one object (assume that no significant amount of mass is lost in the collision).

1. Find the velocity of the wreckage after the collision (make sure you draw a picture with a labelled axis so the sign is unambiguous).

2. What is the kinetic energy of the combined wreckage?

Problem 2 **Conservative Forces** (35 points)

Consider a 2-dimensional vector field that describes a force  $\vec{F}$  acting on a small object of mass  $m$ , where  $\vec{F} = A_0(x\hat{x} + y\hat{y})$ .

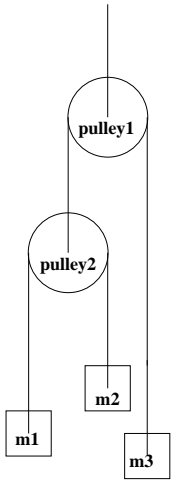
1. (15 points) Explicitly calculate (i.e. do the path integral) how much work is done pushing the mass counter-clockwise around a rectangular path for which the corners are  $(x, y) = (0,0)$ ,  $(w,0)$ ,  $(w,h)$ , and  $(0,h)$ ? (Assume it's done slowly, so ignore the kinetic energy given to the mass).
2. (5 points) Calculate the work done on the first leg if  $w=2$  meters and  $A_0 = 3$  Newtons/meter. (reminder: 1 Joule= 1 Newton-meter) <sup>1</sup>.
3. (15 points) Calculate the curl of  $\vec{F}$ . (I.e. calculate  $\nabla \times \vec{F}$ ).

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<sup>1</sup>In memory of David Foster Wallace- a cross-word puzzle factoid: 1 erg = 1 dyne-cm.

**Problem 3 A Double Atwood's Machine** (35 points)

Two weights of 10 kg each hang from a string that is draped over a pulley, with one weight on each side. The pulley in turn hangs from a second string that is draped over a second pulley, connected on the other side to a third weight (see picture). Ignore the masses of the string and pulleys.



1. (5 points) Set up the equations of motion for the 3 weights.
2. (10 points) Find the equations of constraint on the accelerations by differentiating the equations of constraint on the vertical positions of the weights.
3. (5 points) How many, and which, unknowns do you have? How many equations?
4. (10 points) Solve for the accelerations of the weights, assuming that the system is started with all the weights at rest (use the other side of the page if you need to).
5. (5 points) Explicitly check (i.e. solve) that your solution gives the right answers in the limits  $m_1 = m, m_2 = m, m_3 = 2m$ ; and  $m_i = 0, i = 1, 3$