University of Maryland
Department of Physics

Spring 2009 | **David Hammer**
Physics 161 | **April 30, 2009**

Third exam

Answer all questions on these sheets. Please write clearly and neatly; we can only give you credit for we can read. **We need your name and section number on every page, because we will separate the pages for grading.**

The first set of questions are multiple choice. There's no partial credit for these – just choose the best answer and indicate it clearly.

The second set are "short answer," and they all require explanations, whether the word "explain" appears in the question or not! <u>You'll get no credit, even if your answer is correct, if we can't follow your reasoning.</u> Your explanation may be in words, mathematics, and/or diagrams. Full credit is for a correct answer with a clear explanation. You'll get partial credit for sensible reasoning, even if the answer is incorrect.

Please: Think about the physics, not about the psychology of how I write exams!

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Name (printed) Section #

At the end of the exam, rewrite and sign the pledge: I pledge on my honor that I have not given or received any unauthorized assistance on this examination.

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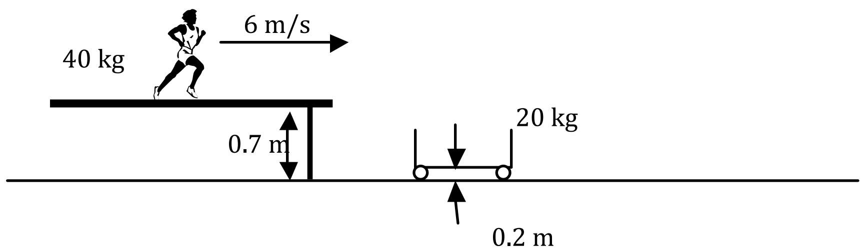
Signature and date

Multiple choice questions (8 points each)

Just the answer counts for these; no partial credit.

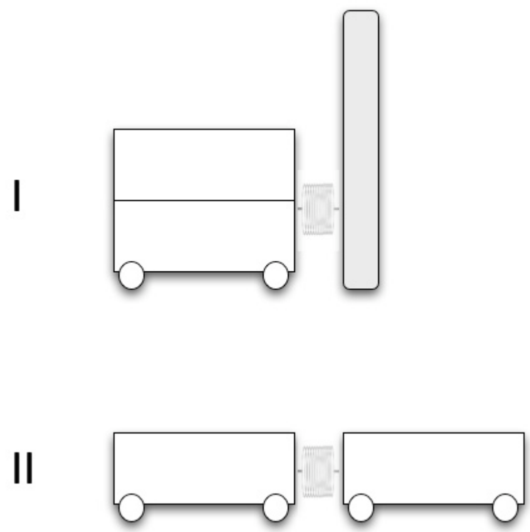
1) A boy (Abner, 8.5 years old, 40 kg, height 1.2 m) runs at 6 m/s off of a short deck (height 0.7 m), jumping into a cart (mass 20 kg, height 0.2 m, low friction wheels, color red). (Yes, I've given more information than you really need!)



About how fast will the cart and he move just after he lands?

a) 6 m/s b) 4 m/s c) 3 m/s d) 2 m/s e) 1 m/s f) 0 m/s

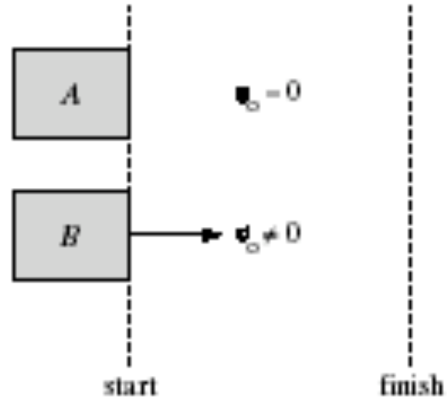
2) For this problem, consider these situations involving a spring and two blocks of equal mass *m*. In I, the blocks are connected; and the spring is compressed between them and a wall. When the spring is released, it pushes the blocks away from the wall. In II, the spring is compressed the same amount between the two blocks, each now on its own set of wheels. When the spring is released, it pushes the blocks apart.



Assume the masses of the wheels and spring are negligible compared to the mass of a block, and that they roll with negligible friction compared to the force by the spring. How does the speed of a block in II compare to the speed of the blocks in I?

a) Each block in (II) moves with a speed greater than half the speed of the blocks in (I), but less than the same speed.
b) Each block in (II) moves with the same speed as the blocks in (I).
c) Each block in (II) moves with half the speed of the blocks in (I).
d) Each block in (II) moves at a speed greater than the speed of the blocks in (I).
e) One block in (II) moves with a speed greater than the block in (I), and the other does not move at all.

3) Two identical masses A and B have identical forces acting on them to the right, continuously from a starting line to a finish line. If A is initially at rest and B is initially moving to the right, which mass has the larger increase in momentum, and which has a larger increase in energy?



Pick one:

a) Mass A has a larger increase in momentum, and a larger increase in energy.

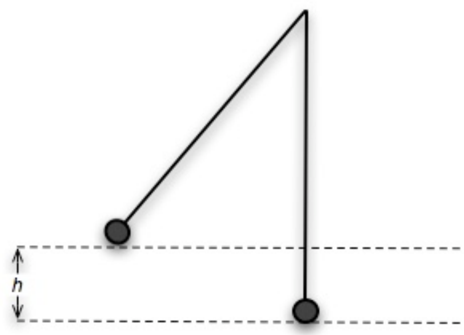
b) Mass B has a larger increase in momentum, and a larger increase in energy.

c) Mass A has a larger increase in momentum but the same increase in energy.

d) Mass B has a larger increase in momentum but the same increase in energy.

e) They have the same increase in momentum and the same increase in energy.

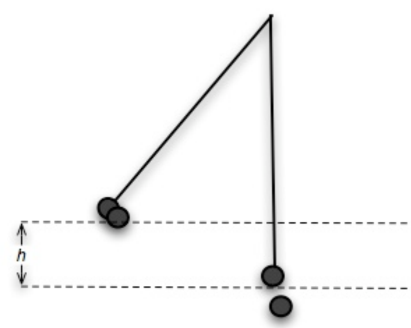
4) Two balls of clay, each of the same mass *m*, are suspended by two strings. We pull one of them back to the left as shown, so that it is a height *h* above where it would hang at rest, and we let it go to swing from there. When it hits the other ball the two stick together, and the now larger lump of clay of mass 2*m* swings back and forth.



When the lump swings to the right, about how high will it go, above the bottom?

a) $h/4$ b) $h/2$ c) $h/\sqrt{2}$ d) h e) $h\sqrt{2}$ f) $2h$ g) $4h$

5) Same two balls of clay, but this time we put them as a pair on the same string. We start them out at height *h* again, and this time at the very bottom of the swing the second ball comes loose and falls off — it just "lets go."



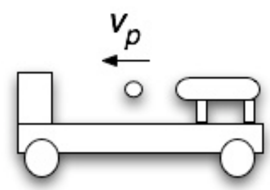
When the remaining ball of clay swings to the right, about how high will it go?

a) $h/4$ b) $h/2$ c) $h/\sqrt{2}$ d) h e) $h\sqrt{2}$ f) $2h$ g) $4h$

Short answer questions, 20 points each

For these you **must** explain; no credit without explanation! Clarity counts!

6) We have a cart rigged with a pellet launcher and a pellet catcher. The mass of the cart (including the launcher and catcher) is M; the mass of the pellet is m, and d is the distance from the launcher to the catcher on the cart. I'll set the cart on the lecture table, and flip a switch to fire the pellet.



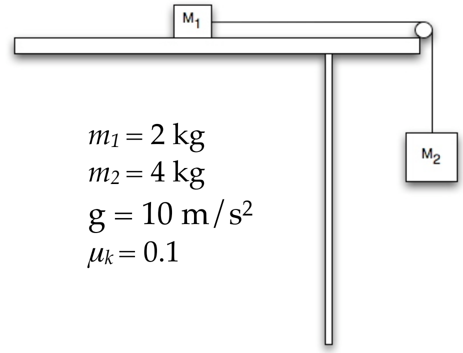
We see the pellet move at a speed v_p (horizontal component of velocity) to the left, when it is launched by the cart.

a) (6 points) If the cart starts at rest, and supposing friction is negligible, write an expression for the speed of the cart v_c, while the pellet is in the air (as shown), in terms of any of the variables defined (M, m, d, and/or v_p).

b) (6 points) Write an expression for v_c after the pellet is caught, in terms of the same variables.

c) (8 points) Write an expression for the distance the cart moves, from the time the pellet is launched to the time it is caught, again in terms of M, m, d, and/or v_p. Explain why the expression you write makes sense.

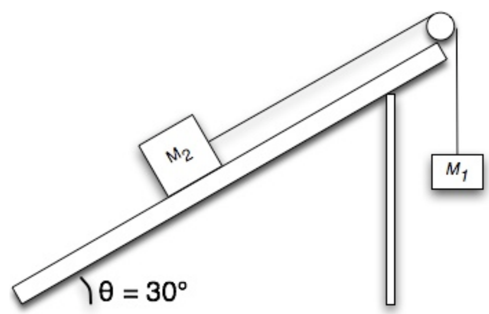
7) Two ways to modify a homework problem. Here, a block of mass m_1 is tied to a cord that runs over a pulley and is attached to a block of mass m_2, which hangs from the cord. As on the homework, assume that the rope and pulley have negligible masses compared to m_1 and m_2, and that the pulley turns with negligible friction. But this time suppose there's a non-negligible coefficient of kinetic friction μ_k between the table surface and m_1.



a) (7 points) We release the masses from rest. Find the kinetic energy of m_1 when it has moved a distance $\Delta h = 0.5$ meters.

b) (3 points) How much of a difference did it make, to the answer in part a, that there was friction between the table surface and m_1?

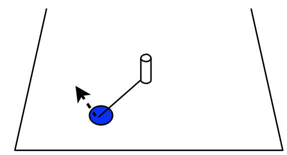
c) (7 points) This time we'll put things on a slope of 30°, and I'm switching the placement of m_1 and m_2, so it's m_1 hanging this time. Find the change in the *potential energy* of the system if m_1 moves a distance $\Delta h = 0.5$ meters. (Same values as above.)



d) (3 points) Use your answer in part c to find the *acceleration* of the masses when we release them.

8) This is the famous "tetherball" question: A ball is tied to a cord and moving around a pole. As it moves, the cord wraps around the pole, so ball is spiraling inward. The question is whether the ball speeds up as the cord shortens due to the wrapping around the pole.

The real situation is complex, so we'll simplify it, in particular to keep the motion in two dimensions: Picture a puck sliding on a frictionless surface, tied to a peg. The puck moves around a peg stuck in the middle of the surface, and as the string wraps around the peg, the puck spirals inward.



Does the puck's speed increase as it spirals inward?

a) Explain why someone might think the puck's speed increases.

b) Explain why someone might think the puck's speed would not increase.

c) Decide which you believe, and explain what you see as flawed in the reasoning for a or b.