Physics 218: Mechanics. Exam 2, Secs. 813–815 27 Oct. 2005

Instructor: Dr. George R. Welch, 415 Engineering-Physics, 845-7737

Print your name **neatly**:

Last name: | | | | | | | | | | | | | | | | | |

First name: | | | | | | | | | | | | | | | | | |

Sign your name: ______________________________

Please fill in your Student ID number (UIN): _ _ _ – _ _ – _ _ _ _

IMPORTANT

Read these directions carefully:

- There are 6 problems totalling 100 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.

- **Indicate what you are doing!** We cannot give full credit for merely writing down the answer. **Neatness counts!** I will give generous partial credit **if** I can tell that you are on the right track. This means you must be *neat* and organized.

- Each problem with its associated figure is self explanatory. If you *must* ask a question, then come to the front, being as discrete as possible so as not to disturb others.

- Put your name on each page it is asked for. You will lose credit if you fail to print your name on each page it is asked for.

Print your name: ____

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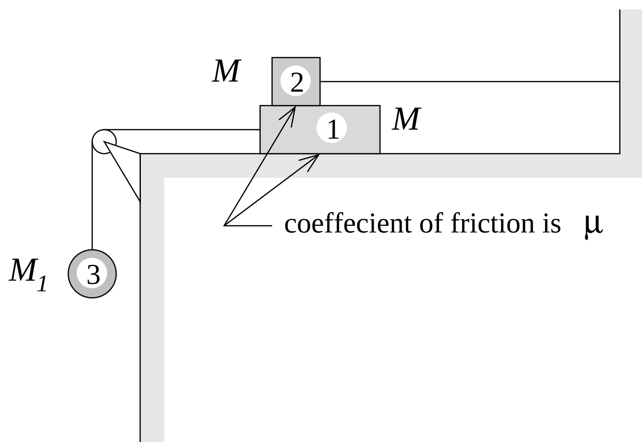
Problem 1a. 10 points.

As shown below, three blocks are connected with two ropes. The three blocks are labelled 1, 2, and 3 in the Figure. Block 1 slides on a rough horizontal surface, and Block 2 sits on block 1. Block 2 is connected by a light, strong, horizontal rope to the wall so it cannot move to the left. Block 1 is connected by a rope over a light, frictionless pulley to Block 3. The coefficient of static friction between block 1 and the surface is μ and the coefficient of static friction between blocks 1 and 2 is also μ.

The mass of blocks 1 and 2 are both M. Do not call the masses anything else, such as M_1 or M_2. Instead use the value I have given you: M.

Calculate the largest value that M_3 can have without block 1 slipping. You may denote the mass of block 3 as M_3 and then find an expression for M_3. The answer will only contain M, μ, and numerical factors.



Be **neat.** Neatness helps. Work *neatly*.

Print your name: ______________________________

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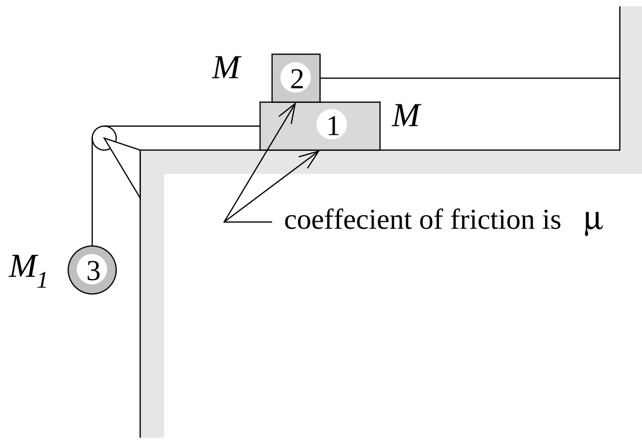
Problem 1b. 10 points.

This is the same contraption as in part 1a, except now it is given that $M_3 = 3M$, and now μ represents the coefficient of *kinetic* friction. Assume that μ is small enough that blocks 1 and 3 accelerate.

Calculate the magnitude of this acceleration. Express your answer only in terms of g, μ, and numerical factors. The mass M does not appear in the answer.



You still need to be **neat.** Neatness still helps. Continue to work *neatly.*

Print your name: ____

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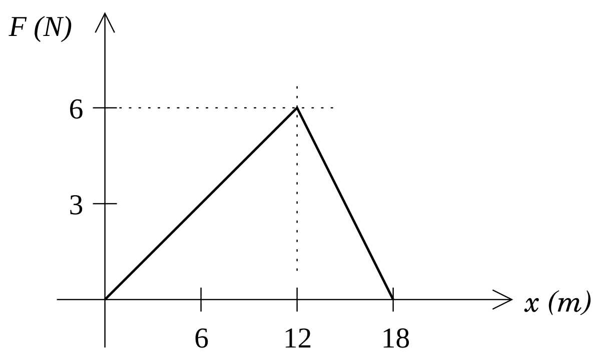
Problem 2. 20 points.

A machine applies a force F parallel to the x-axis to a 3 kg sled moving on the frozen surface of a small pond. As the machine controls the speed of the sled, the x-component of the force that is applied varries with the x-coordinate of the sled as shown in the Figure. Suppose the sled is initially at rest at $x = 0$. Find the speed of the sled after the sled has moved to $x = 18$ m. You can ignore all other horizontal forces on the sled.



Show your steps and **neatly** indicate what you are doing. There will be no credit for just writing down the answer.

Print your name: ______________________________

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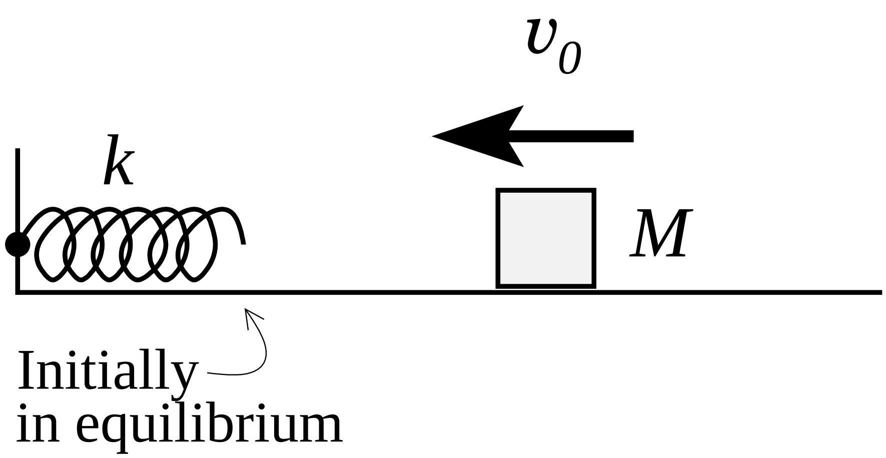
Problem 3. 10 points.

A block of mass M is moving at speed v_0 along a frictionless horizontal surface toward a spring with force constant k that is attached to a wall. The spring has negligible mass.



(a) Find the maximum distance the spring will be compressed.

(b) Find the acceleration of the block at the point calculated in part (a).

Make sure you are being neat. Working neatly will help you get it right.

Print your name: ____

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Problem 4. (20 points)

A certain spring is found *not* to obey Hooke's law; it exerts a restoring force

$$F(x) = -kx - \beta x^2$$

if it is moved a distance x from its equilibrium position, where k and β are given positive constants. The mass of the spring is negligible. Suppose a particle of mass m is connected to the end of this spring.

(a) Calculate a potential energy function $U(x)$ for this particle. Let $U = 0$ when $x = 0$.

(b) For this part, we will assume that the particle has been moved a distance $x = k/\beta$ and released from rest. You are to calculate what will be the speed of the particle when it has returned *half way* back toward $x = 0$.

You may work part (b) either of two ways: Either just do the algebra, and express your answer in terms of m, k, β, and numerical factors (it is a simple result) − **or** − you may assume that $k = 30$ N/m, $\beta = 10$ N/m^2, and that $m = 90$ kg and just calculate a numerical value for the velocity. However, if you plug in the numbers right away, it will be more difficult to look for partial credit.

If you work **neatly** I will find more partial credit for you!

Print your name: ____

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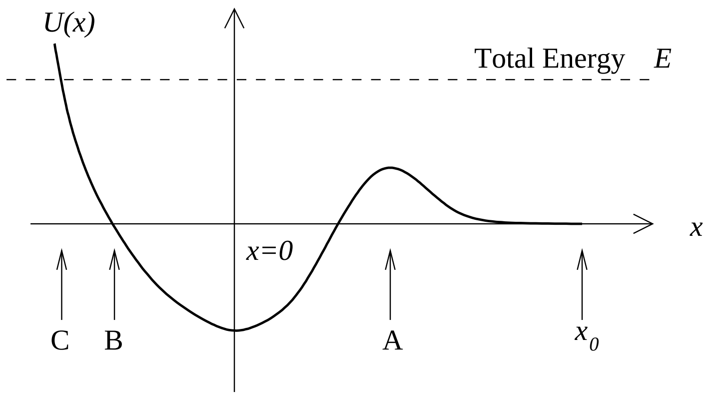
Problem 5. (10 points)

A particle is moving in 1 dimension, under the influence of only conservative forces. The potential energy function $U(x)$ is shown below.

The particle starts at position x_0 moving to the left, and has total energy E which is shown in the figure.



In the space provided before each problem, indicate whether or not the statement is true or false.

_____ (a) The particle is initially nearly at rest in a neutral equilibrium.

_____ (b) The particle slows down until it reaches point A, then stops, and goes back to the right.

_____ (c) The particle slows down until it reaches point A, then speeds up until it reaches $x = 0$, then slows down until it comes to a halt at point B, then reverses direction.

_____ (d) The particle can never reach point C.

_____ (e) The particle moves up and down, until it reaches point C with maximum velocity.

_____ (f) The particle slows down until it reaches point A, then speeds up until it reaches $x = 0$, then slows down until it comes to a halt at point C, then reverses direction.

_____ (g) The particle slows down until it reaches point A, then comes to rest at $x = 0$.

_____ (h) The particle speeds up until it reaches point A, then comes to rest at $x = 0$ then speeds up until it reaches point C.

_____ (i) The particle can never reach point A.

_____ (j) The particle has maximum velocity at point A, then comes to rest at $x = 0$.

Print your name: ____

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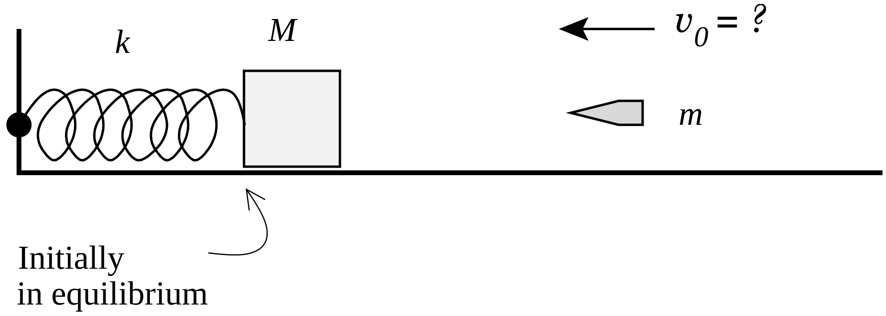
Problem 6. (20 points)

A rifle bullet with mass m is fired toward a block with mass M that rests on a frictionless, horizontal surface and is attached to a coil spring of force constant k as shown in the Figure.



(a) Suppose the bullet strikes and embeds itself in the block, and that the impact compresses the spring a distance S_1. Calculate the initial velocity of the block. Express your answer in terms of k, M, m, and S_1.

(b) Suppose that instead the bullet hits the block, deforms, and falls with zero velocity to the surface. This time, the impact causes the block to compress the spring a distance S_2. Calculate the initial velocity of the block. Express your answer in terms of k, M, m, and S_2.

You need to work neatly! Don't forget to be neat.

You may remove this sheet.

If you do remove this sheet,

DO NOT TURN IT IN!

Potentially useful equations

Calculus:

Derivatives:

$$\text{If } x(t) = C\, t^n \quad \text{then} \quad \frac{dx}{dt} = C\, n\, t^{n-1}$$

Integrals:

$$\int_{t_1}^{t_2} C\, t^n\, dt = C \left[\frac{t_2^{n+1}}{n+1} - \frac{t_1^{n+1}}{n+1} \right]$$

If you do remove this sheet,

DO NOT TURN IT IN!
