Midterm Exam No. 03 (2015 Fall)

PHYS 205A: University Physics

Date: 2015 Nov 18

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 3.
2. Total time = 50 minutes.
3. There are 8 questions in this exam.
4. Equation sheet is provided separately.
5. To be considered for partial credit you need to show your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**10 points.**) An object of mass m is suspended from the ceiling of a truck moving with acceleration a, as in the figure below. (Express your answers in terms of the variables m, a, and g.)

   (a) Find the angle θ that the string makes with the vertical.

   (b) Find the tension T in the string.

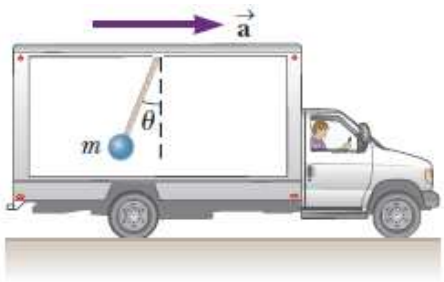

Figure 1: Problem 1.

2. (**10 points.**) Starting from rest, a 20.0 kg mass slides down an inclined plane that makes angle 30.0° with the horizontal. Assume coefficient of kinetic friction of 0.30. The mass is acted on by the force of gravity, the normal force, and the force of friction. The mass slides down a distance $d = 10.0\,\text{m}$ along the incline.

   (a) Determine the work done by the normal force.

   (b) Determine the work done by the force of gravity.

   (c) Determine the work done by the force of friction.

   (d) Determine the change in kinetic energy of the mass.

3. (**10 points.**) A block of mass $m = 3.00\,\text{kg}$ is released from rest from point Ⓐ and slides on the frictionless track shown in Figure 2. (Let $h_a = 7.00\,\text{m}$.) Determine the block's speed at point Ⓑ.

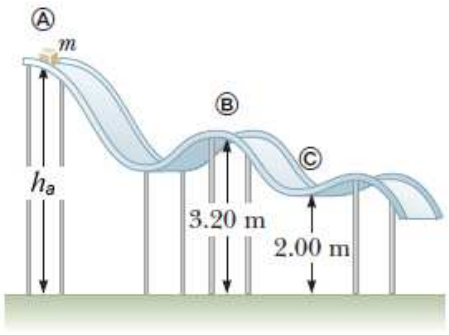

Figure 2: Problem 3.

4. (**10 points.**) A mass $m = 20.0\,\text{kg}$ slides down a frictionless incline, starting from rest at point A at height $h = 1.0\,\text{m}$. After sliding down the incline it moves horizontally on a frictionless surface before coming to rest by compressing a spring of spring constant $k = 2.0 \times 10^4\,\text{N/m}$ by a length x. See Figure 3.

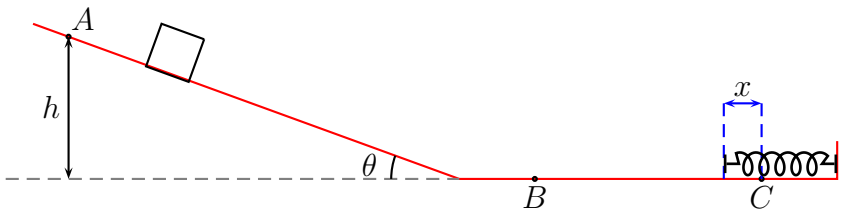

Figure 3: Lecture-Example 4.

(a) Determine the velocity of the mass at point B.

(b) Determine the maximum compression x in the spring.

5. (**10 points.**) The potential energy of a particle moving along the x axis is given by

$$U(x) = ax^2 - bx^4, \qquad a > 0, \quad b > 0. \tag{1}$$

Given $a = \frac{1}{2}\,\frac{\mathrm{J}}{\mathrm{m}^2}$ and $b = \frac{1}{4}\,\frac{\mathrm{J}}{\mathrm{m}^4}$.

(a) Plot $U(x)$ with respect to x.

(b) Determine the points on the x axis when the force on the particle is zero, that is, the particle is in equilibrium.

6. (**10 points.**) A 10.0 grams bullet is fired into a stationary block of wood having mass 5.00 kg. The bullet imbeds into the block. The speed of the bullet-plus-wood combination immediately after the collision is 0.600 m/s. What was the original speed of the bullet?

7. (**10 points.**) An electron collides elastically with a stationary hydrogen atom. The mass of the hydrogen atom is 1837 times that of the electron. Assume that all motion, before and after the collision, occurs along a straight line. What is the ratio of the kinetic energy of the hydrogen atom after the collision to that of the electron before the collision?

8. (**10 points.**) A rod of length $L = 1.00\,\mathrm{m}$ has linear density (mass per length) given by

$$\lambda = a\,x, \tag{2}$$

where x is the distance from one end, and λ is measured in kilograms/meter. How far from the $x = 0$ end is its center of mass?