Midterm Exam No. 03 (2016 Fall)

PHYS 205A: University Physics

Date: 2016 Nov 14

(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.**) A mass undergoes uniform circular motion, that is, it moves along a circle at constant speed.

   (a) What is the work done by the net force on the mass? (Hint: Determine the direction of the acceleration of the mass at a particular instant? Determine the direction of the net force acting on the mass at this instant? Determine the direction of displacement at this particular instant?)

   (b) What is the change in the kinetic energy of the mass, while it goes around the circle three times?

2. (**10 points.**) A 5.00 kg particle moves from the origin O to position Ⓒ, having coordinates $x = 4.50\,\text{m}$ and $y = 4.50\,\text{m}$, as shown in Figure 1. One force on the particle is the gravitational force acting in the negative y direction.

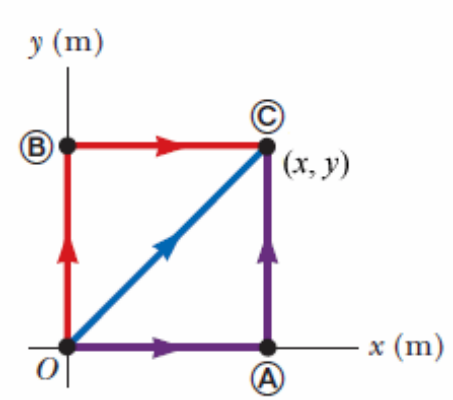

Figure 1: Problem 2.

(a) Calculate the work done by the gravitational force in going from the origin O to position Ⓒ, via the point Ⓐ.

(b) Calculate the work done by the gravitational force in going from the origin O to position Ⓒ, along the straight (diagonal) line connecting the two points.

3. (**10 points.**) Figure 2 shows a pendulum of length $L = 1.0\,\text{m}$ and mass $m = 5.0\,\text{kg}$. It starts from rest at angle $\theta = 30.0°$. Neglect air resistance.

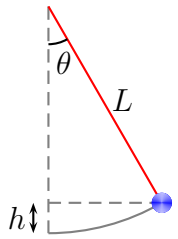

Figure 2: Problem 3.

(a) Determine the work done by the force of tension on the mass.

(b) Determine the velocity of the mass when $\theta = 0$.

4. (**10 points.**) A mass $m = 30.0\,\text{kg}$ slides down a frictionless incline, starting from rest at point A at height $h = 2.0\,\text{m}$. After sliding down the incline it moves horizontally on a frictionless surface before coming to rest by compressing a spring of spring constant $k = 5.0 \times 10^4\,\text{N/m}$ by a length x. See Figure 3.

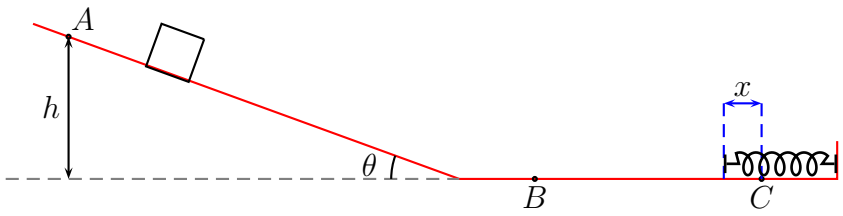

Figure 3: Lecture-Example 4.

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

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

5. (**10 points.**) A car of mass $m_1 = 2000.0\,\text{kg}$ is moving at speed $v_{1i} = 20.0\,\text{m/s}$ towards East. A truck of mass $m_2 = 6000.0\,\text{kg}$ is moving at speed $v_{2i} = 10.0\,\text{m/s}$ towards North. They collide at an intersection and get entangled (complete inelastic collision). What is the magnitude and direction of the final velocity of the entangled automobiles?

6. (**10 points.**) A mass $m_1 = 1.00\,\text{kg}$ moving with a speed $v_{1i} = 10.0\,\text{m/s}$ (elastically) collides with another mass $m_2 = 10.0\,\text{kg}$ initially at rest. Determine the magnitude and direction of the velocities of the two masses after collision.

7. (**10 points.**) The potential energy of a particle moving in three dimensions, described by the rectangular coordinates x, y, and z, is given by the function

$$U(x) = \frac{a}{r}, \qquad r = \sqrt{x^2 + y^2 + z^2}, \qquad a > 0. \tag{1}$$

(a) Determine the expression for the force when the particle is at point (x, y, z).

(b) Is the force attractive (directed towards the origin) or repulsive (directed away from origin)?

8. (**10 points.**) A rod of length $L = 5.00\,\text{m}$ has linear density (mass per length) given by

$$\frac{dm}{dx} = a\,x^2, \tag{2}$$

where x is the distance from one end, and $a = 3.00\ \text{kg/m}^3$.

(a) Determine the mass of the rod.

(b) How far from the $x = 0$ end is its center of mass?