Final Exam (2015 Fall)

PHYS 205A: University Physics

Date: 2015 Dec 18

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 3.
2. Total time = 2 hours.
3. There are 12 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.**) Starting at time $t = 0$, an object moves along a straight line. Its coordinate in meters is given by

$$x(t) = 54\,t^2 - 3.0\,t^4, \tag{1}$$

where t is in seconds. Determine the acceleration when it momentarily stops?

2. (**10 points.**) A car is traveling at 25.0 m/s on a horizontal highway. What is the stopping distance when the surface is dry and the coefficient of kinetic friction μ_k between road and tires is 0.50?

3. (**10 points.**) Your mass is 85 kg. How much will you weigh on a scale (that measures the normal force) inside an elevator when the elevator, originally moving downward at 15 m/s, is brought to rest with constant acceleration in 3.0 s.
(Hint: Determine acceleration using kinematic equations.)

4. (**10 points.**) A stuntman drives a car over the top of a hill, the cross section of which can be approximated by a circle of radius $R = 250\,\text{m}$. See Figure 1. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill?

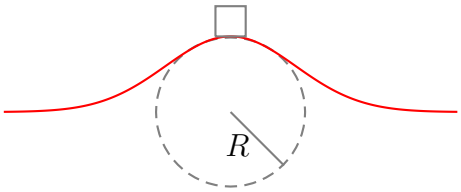

Figure 1: Problem 4

5. (**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 2. Determine the maximum compression x in the spring.

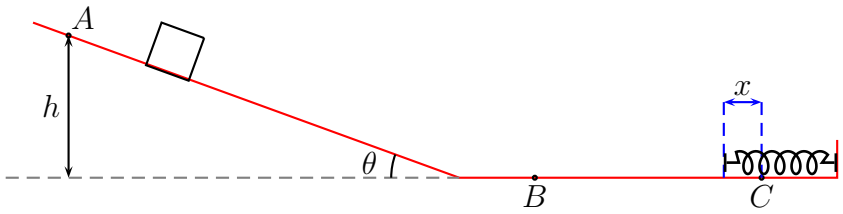

Figure 2: Lecture-Example 5.

6. (**10 points.**) The potential energy of a particle moving along the x axis is given by

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

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 particle is in stable equilibrium.

7. (**10 points.**) A 10.0 grams bullet traveling at a speed of 2500 km/hour is fired into a stationary block of wood having mass 5.00 kg. The bullet imbeds into the block. Determine the speed of the bullet-plus-wood combination immediately after the collision.

8. (**10 points.**) A billiard ball of mass M and radius R is a solid sphere with a moment of inertia of $I = 2MR^2/5$ about its diameter. It is set rolling without slipping at 4.00 m/s on a horizontal section of a track as shown in the figure below. It rolls around the inside of a vertical circular loop of radius $r = 50.0\,\text{cm}$. As the ball nears the bottom of the loop, the shape of the track deviates from a perfect circle so that the ball leaves the track at a point $h = 25.0\,\text{cm}$ below the horizontal section. Find its speed as it leaves the track at the bottom.

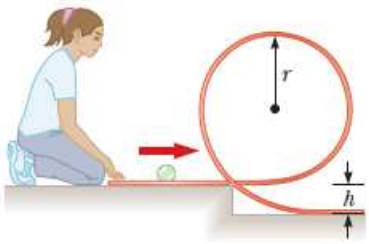

Figure 3: Problem 8.

9. (**10 points.**) An electric motor rotating a workshop grinding wheel at 1.00×10^2 rev/min is switched off. Assume the wheel has a constant negative angular acceleration of magnitude $2.00\,\mathrm{rad/s^2}$.

   (a) How long does it take the grinding wheel to stop?

   (b) Through how many radians has the wheel turned during the time interval it took to stop?

10. (**10 points.**) An object with a mass of $m = 5.0\,\text{kg}$ is attached to the free end of a light string wrapped around a reel of radius $R = 0.250\,\text{m}$ and mass of $M = 3.00\,\text{kg}$. The reel is a solid disk ($I = MR^2/2$), free to rotate in a vertical plane about the horizontal axis passing through its center as shown in the figure below. Determine the magnitude of the acceleration of the object.

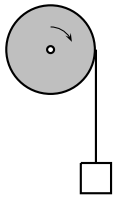

Figure 4: Problem 10

11. (**10 points.**) A student sits on a freely rotating stool holding two dumbbells, each of mass 3.00 kg (see figure below). When his arms are extended horizontally, the dumbbells are 1.00 m from the axis of rotation and the student rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 2.60 kg·m^2 and is assumed to be constant. The student pulls the dumbbells inward horizontally to a position 0.300 m from the rotation axis. Find the new angular speed of the student.

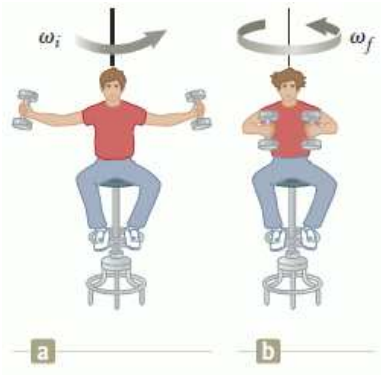

Figure 5: Problem 11.

12. (**10 points.**) Four objects of equal mass m are located at the corners of a square of edge length l. Find the magnitude and direction of the gravitational field at the center of the square.