Midterm Exam No. 02 (2016 Fall)

PHYS 205A: University Physics

Date: 2016 Oct 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 car is traveling at $30.0\,\text{m/s}$ ($\sim 67\,\text{miles/hour}$) on a horizontal highway. If the coefficient of static friction between road and tires on a rainy day is 0.15, what is the stopping distance?

2. (**10 points.**) A bucket rests on the inclined roof of a house. It starts to rain and the bucket gradually fills with water. Assuming a constant coefficient of static friction between the roof and bucket, no wind, and no tipping, the bucket will start sliding when the:

   (a) weight of water exceeds the maximum force of static friction.

   (b) component of the weight of water + bucket perpendicular to the roof exceeds the maximum force of static friction.

   (c) component of the weight of water + bucket parallel to the roof exceeds the maximum force of static friction.

   (d) But the bucket will never start sliding.

   (e) more information is needed to answer this question.

   Note: To be eligible for partial credit, you have to show clear and organized work.

3. (**10 points.**) As a 40 N block slides down a plane that is inclined at 25° to the horizontal its acceleration is $2.5\,\mathrm{m/s^2}$ directed along the plane. What is the coefficient of kinetic friction between the block and the plane?

4. (**10 points.**) A 20.0 kg block is initially at rest on a horizontal surface. A horizontal force of 80.0 N is required to set the block in motion, after which a horizontal force of 60.0 N is required to keep the block moving with constant speed. Find the coefficient of static friction between the block and the surface.

5. (**10 points.**) A bag of cement weighing $mg = 450\,\mathrm{N}$ hangs in equilibrium from two wires as suggested by the forces shown in Figure 1. Two of the forces make angles $\theta_1 = 30.0°$ and $\theta_2 = 60.0°$ with the horizontal. Assuming the system is in equilibrium, find the magnitude of the tensions T_1 and T_2.

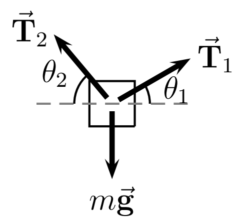

Figure 1: Problem 5.

6. (**10 points.**) A mass $m_2 = 2.0\,\text{kg}$ is connected to another mass $m_1 = 1.0\,\text{kg}$ by a massless (inextensible) string passing over a massless pulley, as described in Figure 2. The surface on which the mass m_2 sits/moves has a coefficient of static firction of 0.60 and a coefficient of kinetic firction of 0.30.

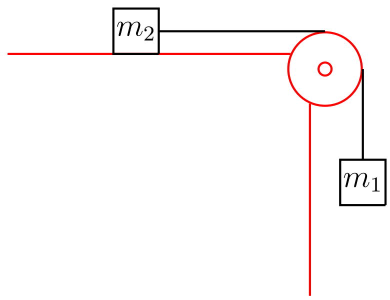

Figure 2: Problem 6.

(a) Write down the Newton's equations of motion for the two masses.

(b) If the masses are initially at rest, will they start moving? If yes, determine the acceleration of the masses. If no, why not?

7. (**10 points.**) A cup of coffee is on a table in an airplane flying at a constant altitude and a constant velocity. The coefficient of static friction between the cup and the table is 0.30 and the coefficient of kinetic friction between the cup and the table is 0.15. Suddenly, the plane accelerates forward, its altitude remaining constant.

   (a) What is the direction of the friction force with respect to the velocity of the airplane?

   (b) What is the maximum acceleration that the plane can have without the cup sliding backward on the table?

8. (**10 points.**) Consider a mass m falling under gravity in the presence of a drag force that is linearly proportional to the speed of the mass. As the mass falls it gains speed. The terminal velocity v_T is defined as the speed at which the the drag force balances the force of gravity, or when the mass m stops accelerating. The solution for this motion, when the mass starts from rest, $v(0) = 0$, is described by

$$v(t) = v_T \left(1 - e^{-\frac{t}{\tau}}\right), \tag{1}$$

where the time constant τ, that sets the scale for time, is given by

$$\tau = \frac{v_T}{g}. \tag{2}$$

At what time, in the scale of τ (or in terms of τ), does the mass attain 75% of the terminal velocity?