Midterm Exam No. 02 (Fall 2025)

PHYS 205A-002: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Date: 2025 Oct 8

(Name) (Signature)

Instructions

1. Seating direction: In alternate rows, B, D, F, . . . , on even-numbered seats.
2. Total time = 50 minutes.
3. There are 4 conceptual questions and 3 problems in this exam.
4. Equation sheet is provided separately.
5. For partial credit you need to present your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of smart devices, including smart watches, is strictly prohibited. They should stay out of reach during the exam.
8. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) A weighing scale is designed to measure the normal force acting on the object placed on the scale. A stuntman drives a car, while placing himself on the weighing scale, over the top of a hill, the cross section of which can be approximated by a circle of radius R. See Figure 1. Will the stuntman weigh heavier or lighter when the car is going over the top of the hill.

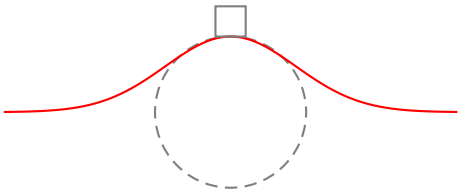

Figure 1: Problem 1

2. (**5 points.**) The Atwood machine, shown as System 1 in Figure 2, consists of two masses m_1 and m_2 connected by a massless (inextensible) string passing over a massless frictionless pulley. A modified version of the Atwood machine, shown as System 2 in Figure 2, consists of the same two masses m_1 and m_2 connected by a massless (inextensible) string passing over two massless frictionless pulleys. Which of the two systems leads to a larger acceleration? Why? [Caution: Intuition from real life experience involves friction.]

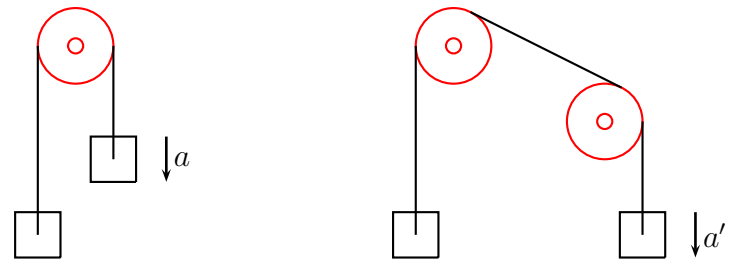

Figure 2: Problem 2

3. (**5 points.**) Figure 3 illustrates an attempt by a student to keep a mass m from falling down. How much should the horizontal force $\vec{\mathbf{F}}$ be if it has to keep the mass m pinned to a frictionless vertical wall by pushing on it horizontally.

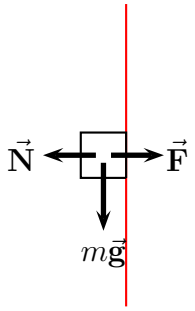

Figure 3: Problem 3

4. (**5 points.**) Consider a balloon filled with air, and another balloon filled with helium. Helium being lighter than air tends to rise up in air. While a car is taking a circular turn will a helium balloon inside the car tend to move radially inward or radially outward?

5. (**10 points.**) A mass is held above ground using two ropes as described in Figure 4. Let $m = 20.0\,\text{kg}$, $\theta_1 = 30.0°$, and $\theta_2 = 60.0°$. Find the tension in each of the strings.

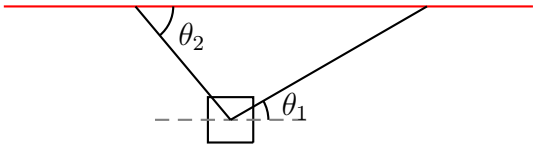

Figure 4: Problem 5.

6. (**10 points.**) A mass $m_2 = 2.0\,\text{kg}$ is connected to another mass $m_1 = 4.0\,\text{kg}$ by a massless (inextensible) string passing over a massless pulley, as described in Figure 5. The coefficient of static friction between mass m_1 and the surface is 0.50 and the coefficient of kinetic friction between the block and plane is 0.25. Will the masses move if they are initially at rest. Determine the tension in the string afterwards.

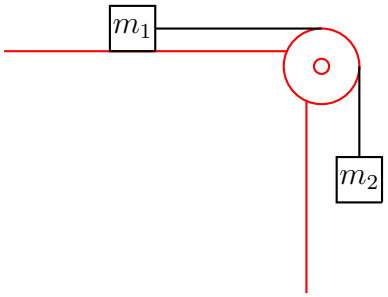

Figure 5: Problem 6

7. (**10 points.**) You have a toy hanging down from the rear-view mirror in your car. At a certain moment of time if the cord makes an angle of $\theta = 30.0^\circ$ with the vertical, what is the acceleration of the car at that moment?