Midterm Exam No. 02 (Spring 2025)

PHYS 205A-001: UNIVERSITY PHYSICS

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

Date: 2025 Mar 7

(Name) (Signature)

Instructions

1. Seating direction: On even-numbered seats in alternate rows, B, D, F, ...
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.**) On a diagram illustrate the direction of the centripetal acceleration at Carbondale (at a latitude of $\theta = 38^\circ$ N) due to rotation of Earth. Earth rotates about its axis once in 24 hours. Radius of Earth is 6400 km. Earth is spherical to two significant digits.

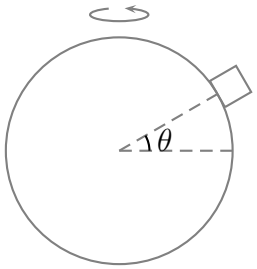

Figure 1: Problem 1

2. (**5 points.**) A weighing scale is designed to measure the normal force acting on the object placed on the scale. A mass m rests on this weighing scale while it is placed on the floor of an elevator. Will the mass weigh heavier when it is speeding while moving upward or when it is slowing down while moving upward?

3. (**5 points.**) A 10.0 kg mass rests on an incline that makes 30° with respect to the horizontal. Determine the magnitude of the force of static friction acting on the mass if the coefficient of static friction between the mass and incline is 0.80.

4. (**5 points.**) Consider the case of drag force that is linearly proportional to velocity. For a mass m falling under gravity and experiencing such a drag force after starting from rest we have the equation of motion

$$m\frac{dv}{dt} = mg - bv, \tag{1}$$

which leads to the solution

$$v(t) = v_T\Big(1 - e^{-\frac{t}{\tau}}\Big), \tag{2}$$

where the terminal velocity v_T is defined by requiring $dv/dt = 0$, that is

$$v_T = \frac{mg}{b} \tag{3}$$

and $\tau = v_T/g$ is the time constant and sets the scale for time. Plot the velocity of mass as a function of time.

5. (**10 points.**) A mass is held above ground using two ropes as described in Figure 2. Let $m = 20.\,\text{kg}$, $\theta_1 = 30.^\circ$, and $\theta_2 = 45^\circ$. Find the tension in each of the strings.

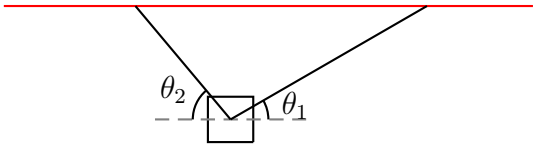

Figure 2: Problem 5.

6. (**10 points.**) A mass $m = 20.0\,\text{kg}$ is on an incline with $\theta = 30°$. The coefficient of static friction is $\mu_s = 1.1$ and coefficient of kinetic friction is $\mu_k = 0.60$. The mass is projected upward with an initial velocity of $15\,\text{m/s}$. How far up the incline does the mass move before it comes to a stop.

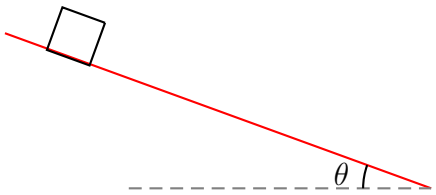

Figure 3: Problem 6.

7. (**10 points.**) A 12 kg mass slides down a frictionless track going around a vertical loop of radius 15 m, as illustrated in Figure 4. Determine the magnitude and direction of normal force acting on the mass, while it is at the highest point on the track and moving at 14 m/s.

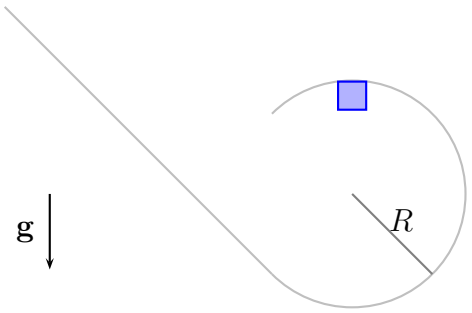

Figure 4: Problem 7.