Midterm Exam No. 03 (2023 Fall)

PHYS 205A-002: UNIVERSITY PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Date: 2023 Nov 6

(Name) (Signature)

Instructions

1. Seating direction: Please be seated on seats with seat-numbers divisible by 4.
2. Total time = 50 minutes.
3. There are 4 conceptual questions and 3 problems in this exam.
4. Equation sheet is provided separately.
5. To be considered 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. Restroom breaks are allowed. Under questionable circumstances this might lead up to a Makeup Exam.
9. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) The velocity of a 25 kg object changes from $\vec{\mathbf{v}}_i = (4.0\,\hat{\mathbf{i}} + 3.0\,\hat{\mathbf{j}})\,\mathrm{m/s}$ to $\vec{\mathbf{v}}_f = (6.0\,\hat{\mathbf{i}} + 8.0\,\hat{\mathbf{j}})\,\mathrm{m/s}$ while it traverses along a path. What is the total work done by all the forces acting on the object during this change in velocity.

2. (**5 points.**) A 25 kg mass slides down a surface, see Figure 1. Determine the work done by the force of friction while it falls a vertical height of $h = 3.0\,\text{m}$ and gains a speed of $4.0\,\text{m/s}$ starting from rest.

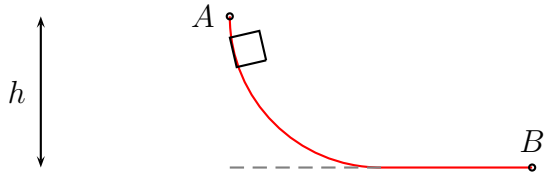

Figure 1: Problem 2.

3. (**5 points.**) What are conservative forces? Give two examples of forces that are conservative.

4. (**5 points.**) A mass m_1 moving with a speed 5.0 m/s (elastically) collides with another identical mass $m_2 = m_1$ initially at rest. Determine the magnitude and direction of the final velocities of the masses after collision.

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.

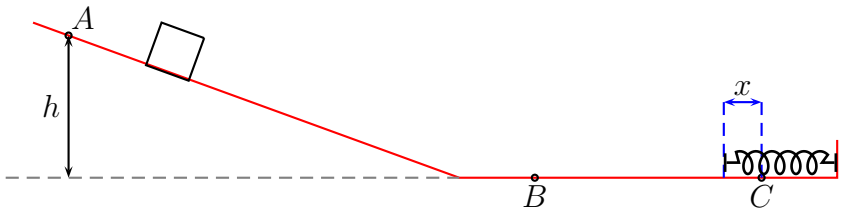

Figure 2: Problem 5.

6. (**10 points.**) A bullet of mass $m_1 = 30.00\,\mathrm{g}$ is fired into a wooden block of mass $m_2 = 3.000\,\mathrm{kg}$ that is hanging like a pendulum. The bullet is embedded in the block (complete inelastic collision). The block (with the bullet embedded in it) goes $h = 30.0\,\mathrm{cm}$ high after collision. Calculate the speed of the bullet before it hit the block.

7. (**10 points.**) Consider a thin rod of length $L = 1.0\,\mathrm{m}$ placed on the positive x-axis with one end at the origin. It has mass per unit length, dm/dx, described by

$$\rho(x) = b\,x, \qquad b = 1.0\,\frac{\mathrm{kg}}{\mathrm{m}^2}, \tag{1}$$

where x is the distance from end placed at the origin. At what distance from the end placed at the origin is the center of of mass of the rod?