Midterm Exam No. 03 (2024 Spring)

PHYS 205A-001: UNIVERSITY PHYSICS

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

Date: 2024 Apr 10

(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 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.**) Identify the physical quantity associated with the integral of the product of mass times acceleration, along the path of the particle,

$$\int_i^f m\mathbf{a} \cdot d\mathbf{r}? \tag{1}$$

2. (**5 points.**) A 25 kg mass slides down a surface, see Figure 1. Determine the work done by the normal force 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.

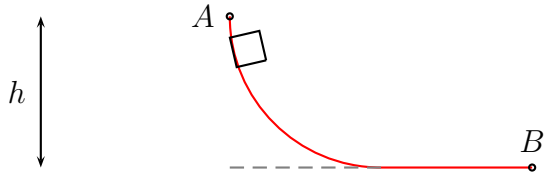

Figure 1: Problem 2.

3. (**5 points.**) You climb up a stair at the North entrance of a building, walk around in the corridors, climb down a stair at the South entrance of the building, and return back to where you started. What is the work done by the gravitational force acting on you during the round trip?

4. (**5 points.**) A mass m_1 moving with a speed 10. m/s (elastically) collides with another identical mass $m_2 = m_1$ moving with a speed 5.0 m/s in the same direction. Determine the magnitude and direction of the final velocities of the masses after collision.

5. (**10 points.**) A roller coaster of mass 500.0 kg moves on the curve described in Figure 2. Assume frictionless surface. It starts from rest at point A where height is $h_A = 40.0\,\text{m}$. Determine the velocity of the mass at point C, given $h_C = 30.0\,\text{m}$.

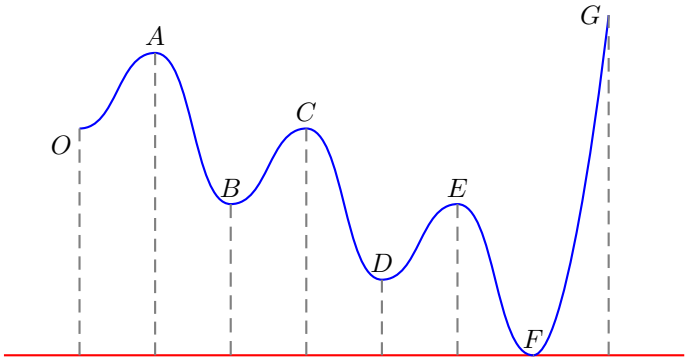

Figure 2: Problem 5.

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

$$U(x) = -ax^2 - bx^4, \qquad a = 4.0\,\frac{\text{J}}{\text{m}^2}, \quad b = 1.0\,\frac{\text{J}}{\text{m}^4}. \tag{2}$$

(a) Determine the points on the x axis where the potential energy is zero.

(b) Determine the points on the x axis where the force on the particle is zero.

(c) What can you conclude about the stability of the particle at the points where the force is zero? That is, is it a stable point or an unstable point?

7. (**10 points.**) A student of mass 90.0 kg, initially at rest, throws a 3.0 kg object in a direction 60.0° with respect to the horizontal while standing on a frictionless surface. If the velocity of the object is 6.0 m/s, what is the recoil speed of the student?