Midterm Exam 03 (2020 Fall)

PHYS 203A-002: College Physics

Department of Physics, Southern Illinois University–Carbondale

Date: 2020 Oct 27

Instructions

- There are 11 questions in this exam.
- To be considered for partial credit present your work in detail and organize it clearly.
- This is a timed exam, from 12:35 PM to 01:50 PM. This time includes the time required for downloading the exam and uploading the solutions.
- Submit a single PDF file on D2L. Note that D2L will not allow submissions few minutes after 01:50 PM.
- In case of technical issues contact me by email at the earliest. Accommodations will be made after fairness to other students is taken into consideration.
- This is an open book and open resource examination, and use of Internet is allowed. However, consultation is prohibited.

1 Conceptual questions

1. (**5 points.**) A pendulum consists of a swinging mass suspended from the ceiling using a massless string. Determine the work done by the force of tension in the string on the hanging mass.
2. (**5 points.**) What is the difference between elastic collisions and inelastic collisions?
3. (**5 points.**) What is the SI unit of impulse? What is the SI unit of momentum? Are they same?
4. (**5 points.**) You climb the stairs to go up three floors in a building, and later use the elevator to return back to where you started. What is the work done by the gravitational force on you during this closed path.

2 Problems

5. (**10 points.**) A mass of 20.0 kg starts with an initial velocity of 5.0 m/s at the bottom of a frictionaless incline that makes an angle of $\theta = 30.0°$ with the horizontal. The mass moves up the frictionless incline, solely due to thrust from the initial velocity, comes to stop, and starts to slide down.

   (a) Identify the forces acting on the mass.

   (b) Determine the work done by the force of gravity during its motion from bottom to top the point when it comes to stop.

6. (**10 points.**) A roller coaster of mass 500.0 kg moves on the curve described in Figure 1. Assume frictionless surface. It starts from rest at point A, with height $h_A = 40.0$ m from the horizontal.

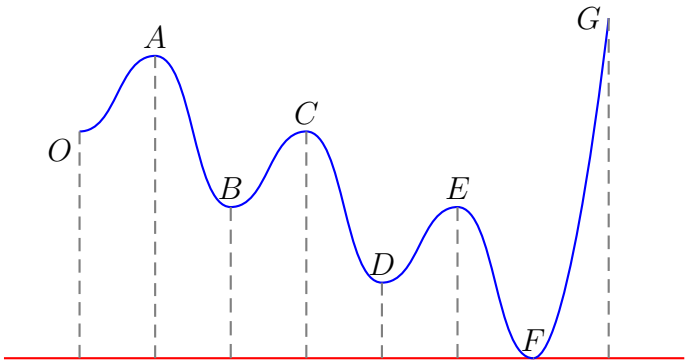

Figure 1: Problem 6.

   (a) What is the work done by the normal force while the mass moves between points A and C?

   (b) Determine the velocity of the mass at point C, given height $h_C = 30.0$ m from the horizontal.

7. (**10 points.**) A mass $m = 20.0$ kg slides down a frictionless incline, starting from rest at point A at height $h = 1.0$ m. After sliding down the incline it moves horizontally on a frictionless surface before coming to rest by compressing a spring of spring constant $k = 2.0 \times 10^4$ N/m by a length x. See Figure 2.

   (a) Determine the change in kinetic energy of the mass between points A and C.

   (b) Determine the change in gravitational potential energy of the mass between points A and C.

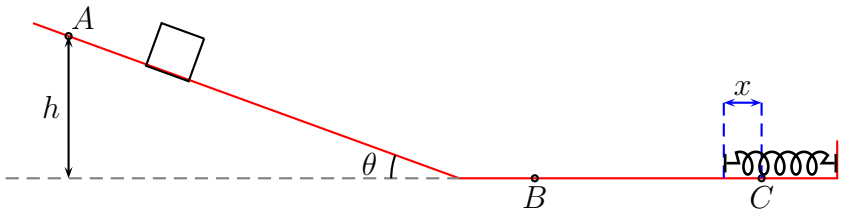

Figure 2: Problem 7.

(c) Determine the change in potential energy stored in the spring while the mass moves between points A and C.

8. (**10 points.**) It takes 440 kJ of work to accelerate a car from 20.0 m/s to 30.0 m/s. What is the car's mass?

9. (**10 points.**) A car of mass $m_1 = 3000.0\,\text{kg}$ is moving at speed $v_{1i} = 25.0\,\text{m/s}$ towards East. A truck of mass $m_2 = 7000.0\,\text{kg}$ is moving at speed $v_{2i} = 25.0\,\text{m/s}$ towards North. They collide at an intersection and get entangled (complete inelastic collision). What is the magnitude and direction of the final velocity of the entangled automobiles?

10. (**10 points.**) A mass of $m_1 = 1.0\,\text{kg}$ moving with a speed $v_{1i} = +10.\,\text{m/s}$ (elastically) collides with another identical mass $m_2 = 1.0\,\text{kg}$ initially at rest. They are moving along the same line before and after the collision. Determine the magnitude and direction of the velocities of the masses after collision.

11. (**10 points.**) John's mass is 90.0 kg, and Barbara's is 60.0 kg. John is standing on the x axis at $x_J = +7.00\,\text{m}$, while Barbara is standing on the x axis at $x_B = +2.00\,\text{m}$. Determine the center of mass of John and Barbara.