Homework No. 11 (Spring 2024)

PHYS 205A-001: UNIVERSITY PHYSICS

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

Due date: Wednesday, 2024 Apr 10, 12:00 PM, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Links to solutions are provided. Further, links to few variations of the problem are provided that serve as practice problems.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file, only the last file is graded.

Problems

1. (**10 points.**) A ball having a mass of 150 g strikes a wall with a speed of 5.0 m/s and rebounds with only 50 % of its initial kinetic energy.

   (a) What is the speed of the ball immediately after rebounding?

   (b) If the ball was in contact with the wall for 8.0 ms, what was the magnitude of the average force on the ball from the wall during this time interval?

   [**Solution**]

2. (**10 points.**) A shooter of mass 90.0 kg shoots a bullet of mass 3.00 g in a direction 60.0° with respect to the horizontal, standing on a frictionless surface at rest. If the muzzle velocity of the bullet is 600.0 m/s, what is the recoil speed of the shooter?

   [**Solution**, 2018S MT-03 P05, 2014F MT-03 P04]

3. (**10 points.**) A car of mass $m_1 = 2000.0\,\text{kg}$ is moving at speed $v_{1i} = 35.0\,\text{m/s}$ towards East. A truck of mass $m_2 = 5000.0\,\text{kg}$ is moving at speed $v_{2i} = 25.0\,\text{m/s}$ towards South. 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?

   [**Solution**, 2023S MT-03 P06, 2022F MT-03 P07, 2021S MT-03 P07, 2016F MT-03 P05]

4. (**10 points.**) Two masses, $m_1 = 1.0\,\mathrm{kg}$ and $m_2 = 2.0\,\mathrm{kg}$ are hanging off separate strings. Forst mass m_1 is pulled to a height $h_1 = 1.0\,\mathrm{m}$ and dropped. It swings down and collides with the other hanging mass (m_2 at rest) and they stick to each other (complete inelastic collision). See Figure 1. The collision happens in a plane. How high do the masses rise together after the collision.

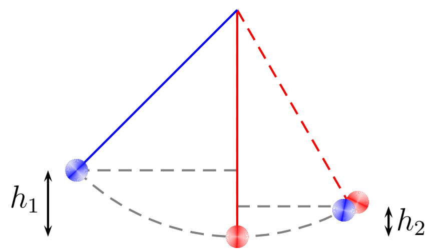

Figure 1: Problem 4.

[**Solution**]

5. (**10 points.**) What is the ratio of the final kinetic energy to initial kinetic energy in a perfectly inelastic collision involving two particles of masses m and M when the mass M is initially at rest? Express your answer in terms of m and M.

[**Solution**]

6. (**10 points.**) A mass $m_1 = 100.\,\mathrm{kg}$ moving with a speed $v_{1i} = +10.\,\mathrm{m/s}$ (elastically) collides with another mass $m_2 = 1.0\,\mathrm{kg}$ initially at rest. Determine the magnitude and direction of the final velocities of the masses after collision.

[**Solution**, 2022S MT-03 P06, 2021S MT-03 P08, 2016F MT-03 P06, 2015F MT-03 P07]

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

$$\rho(x) = a + b\,x + c\,x^2, \qquad a = 0 \qquad b = 1.0\,\frac{\mathrm{kg}}{\mathrm{m}^2}, \qquad c = -0.80\,\frac{\mathrm{kg}}{\mathrm{m}^3}, \tag{1}$$

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?

[**Solution**, 2023F MT-03 P07, 2022S MT-03 P07, 2017F MT-03 P06, 2016F MT-03 P08, 2015F MT-03 P08, 2014F MT-03 P08]