Homework No. 13 (Spring 2024)

PHYS 205A-001: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale
Due date: Wednesday, 2024 Apr 24, 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.**) The center of mass of an elongated block of mass M, with non-uniform mass distribution inside it, may be determined by an arrangement shown in Figure 1 below. The block is placed on a plank of mass $m = 0$ that rests on two scales separated by a distance equal to the length $L = 2.00\,\text{m}$ of the block. The scales that measure the normal forces read $N_2 = 450.0\,\text{N}$ and $N_1 = 350.0\,\text{N}$. Determine the distance x of the center of mass of the block from one end.
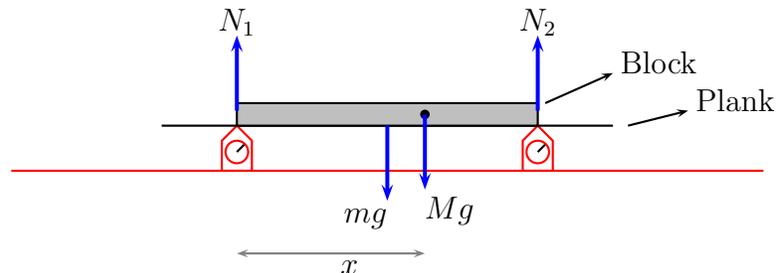

Figure 1: Problem 1.

[**Solution**]

2. (**10 points.**) Workers have loaded a delivery truck in such a way that its center of mass is only slightly forward of the rear axle. The mass of the truck and its contents is $7500\,\mathrm{kg}$. Find the magnitude of the normal force exerted by the ground on the front wheels of the truck.

[**Solution**]

3. (**10 points.**) Five balls of masses $m_1 = 1.0\,\mathrm{kg}$, $m_2 = 2.0\,\mathrm{kg}$, $m_3 = 3.0\,\mathrm{kg}$, $m_4 = 4.0\,\mathrm{kg}$, and $m_0 = 5.0\,\mathrm{kg}$, are connected by massless rods of length $a = 10.0\,\mathrm{cm}$ and $b = 15.0\,\mathrm{cm}$, as shown in Figure 2. This configuration is rotated about an axis coming out of the plane containing the five masses and passing through the mass m_3. The inertia associated with this rotational motion is quantified by the moment of inertia. Compute the moment of inertia.
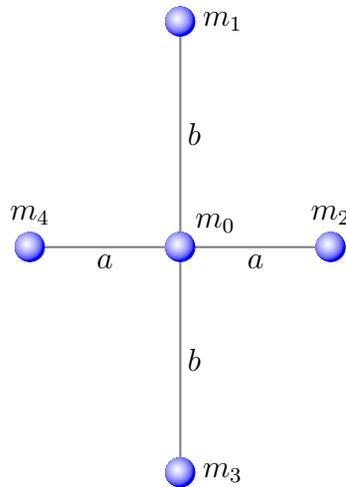

Figure 2: Problem 3.

[**Solution**, 2023F FE P06, 2022F FE P05, 2022S FE P06, 2021S FE P09]

4. (**10 points.**) An object in the shape of a spherical shell, (with $I = \frac{2}{3}MR^2$ when the axis of rotation passes through the center of sphere,) rolls perfectly (without sliding or slipping) on the surface of an incline that makes an angle $30°$ with the horizontal. What is the acceleration of the shell?

[**Solution**]

5. (**10 points.**) A uniform solid sylinder ($I = \frac{1}{2}MR^2$) of radius $10.0\,\mathrm{cm}$ and mass $1.00\,\mathrm{kg}$ is free to rotate about its symmetry axis. The cylinder acts like a pulley. A string wound around the cylinder is connected to a block of mass $m = 0.50\,\mathrm{kg}$, which falls under gravity. See Figure 3. What is the acceleration of the mass m?
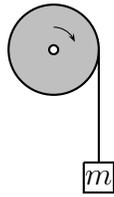
[2018S FE P08, 2016F FE P07, 2015F FE P10]

Figure 3: Problem 5.