General Physics 1–Honors (PHYS 101H):
Problem Set 6

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Overview

The written Problem Sets will help you gain experience with how to present your solutions to university-level physics problems. This will be necessary for your midterm and final exams, as well as future courses thoughout your undergraduate career. Present your solutions legibly and as logically as you can. What this means in practice is the following:

1. Write down what quantities you know.
2. Write down the relevant equations.
3. When carrying out manipulations or substituting values into equations, try to write each equality on separate lines. For example:

$$\begin{aligned} x(t_0) &= \frac{1}{2}at_0^2 + v_0t_0 + x_0 \\ &= \frac{1}{2}\cdot 9.8 \cdot 1.0^2 + 1.5 \cdot 1.0 + 0.7 \\ &= \boxed{7.1\,\mathrm{m}}. \end{aligned}$$

4. Circle or underline your final answers to identify them clearly (see the equation above)..

I will post solutions that will also provide one possible model for how to present solutions.

Some hints:

1. Only substitute values at the end of your calculation and try to carry out all manipulations symbolically.
2. Double check the order of magnitude of your answer.
3. Double check the units of your answer.
4. Double check the number of significant figures of your answer (do not give more significant figures than the question provides for physical quantities).

This Problem Set, in particular, will provide practice in moments of inertia, torque, and angular momentum in two dimensions.

This Problem Set is worth 50 points; there are three questions in this Problem Set.

Instructions

Read these instructions carefully. You must submit your Problem Set as a **single PDF** file (it is best to use an app like Adobe Scan to make your solutions legible), with the file name `lastname_hwXX.pdf` (replace `lastname` with your last name and `XX` with the problem set number). If you do not submit your Problem Set according to these instructions, you will be deducted five points.

Question 1 **10pts**

A massless stick lies on a table, with a length a hanging over the edge and a length b on the table, as shown in figure 1. A ball with mass m lies on the stick at its right end and a second ball with mass m is dropped above the left end of the stick. This second ball hits the stick with speed v_0. Assuming that all collisions are elastic, what are the velocities of the two balls right after the collision?

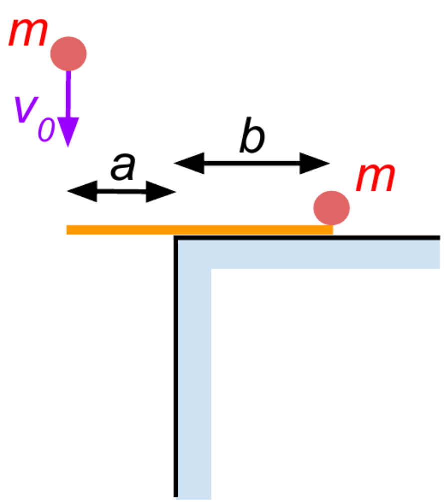

Figure 1: Diagram for Question 1.

Question 2 **20pts**

A uniform disc with mass m and radius R lies in a vertical plane and is pivoted at its center. A stick with length ℓ and uniform mass density, λ, is glued tangentially at its top end to the disc. This setup is shown in figure 2.

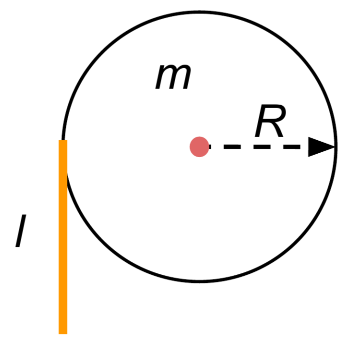

Figure 2: Diagram for Question 2.

(a) Show that the moment of inertia is

$$I = \frac{mR^2}{2} + \frac{\lambda \ell^3}{3} + \lambda \ell R^2.$$

(b) Assuming that the stick is held vertically and then released, what is the initial angular acceleration of the system?

(c) For what value of ℓ (expressed in terms of m, R, and λ) is this angular acceleration a maximum?

Question 3 **20pts**

Two uniform solid cylinders are placed on a plane inclined at an angle θ with respect to the horizontal. Both cylinders have mass m, but one radius is twice the other. A massless string connects the axle of the larger cylinder to the rim of the smaller cylinder, as illustrated in figure 3. The cylinders are released from rest.

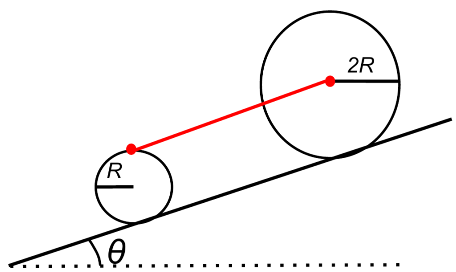

Figure 3: Diagram for Question 3.

(a) Assuming that the cylinders roll without slipping down the plane, what are their accelerations?

(b) If the coefficient of static friction between both cylinders and the plane is $\mu_S = 1.2$, what is the largest angle θ for which no slipping occurs between either cylinder and the plane?