General Physics 1–Honors (PHYS 101H): Problem Set 2

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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:

$$\begin{aligned} x(t_0) &= \frac{1}{2}at_0^2 + v_0 t_0 + x_0 \\ &= \frac{1}{2} \cdot 9.8 \cdot 1.0^2 + 1.5 \cdot 1.0 + 0.7 \\ &= \boxed{7.1\,\mathrm{m}}. \end{aligned}$$

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.

This Problem Set, in particular, will provide practice in applying the kinematic equations to projectile motion and free fall problems in one and two dimensions. You will also practice applying a Taylor series. 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.

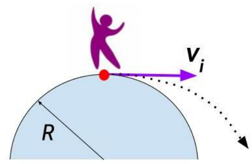

Figure 1: Person kicking a pebble on a boulder for Problem 3. I don't know why they are doing this.

Question 1 **15pts**

A hot-air balloon rises from ground level at a constant velocity of 5.3 m/s. Three minutes after liftoff, a sandbag is dropped accidentally from the balloon. (Assume the upward direction is positive.)

(a) Calculate the time it takes for the sandbag to reach the ground (in s).

(b) Calculate the velocity (in m/s) of the sandbag when it hits the ground. (Indicate the direction with the sign of your answer.)

(c) What assumptions did you make in this calculation? Suppose that we actually recreated this question in an actual experiment and measured the actual time it took to reach the ground. Do you think that your result in part (a) would be greater or smaller than the actual time taken in our real experiment, and why?

Question 2 **10pts**

If a ball is dropped from rest at height h, and if the drag force from the air takes the form $F_d = bv$, then it can be shown that the ball's height as a function of time equals

$$y(t) = h - \frac{mg}{b}\left(t - \frac{m}{b}\left(1 - e^{-bt/m}\right)\right)$$

Expand the exponential as a Taylor Series to find an approximate expression for $y(t)$ in the limit where t is very small.

Question 3 **25pts**

A person standing on top of a hemispherical boulder of radius R kicks a pebble (see Figure 1), initially at rest on top of the boulder, with an initial horizontal velocity $\overline{v}_i$.

(a) What is the minimum value of the initial speed, v_i, that ensures the pebble does not touch the boulder after it is kicked?

(b) With this initial speed (i.e. your answer to part a), where does the pebble hit the ground?