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

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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 applying the equations for kinematics to problems in one dimension. You will also practice applying a Taylor series and deriving a new relation from the kinematic equations.

This Problem Set is worth 50 points; there are five 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).

Figure 1: My dog. Very floofy.

If you do not submit your Problem Set according to these instructions, you will be deducted five points.

Question 1 **10pts**

My dog (see Figure 1!) is very floofy, but can be a little stubborn. When he encounters an interesting scent at some spot on one of our walks, he usually wants to explore it in detail, but sadly sometimes we don't have time. If I pull him with a force $\mathbf{F} = (90.0\hat{\imath} + 137.0\hat{\jmath} + 23.0\hat{k})$ N along the leash:

(a) What is the magnitude of the pulling force (in N)?

(b) What angle does the leash make with the vertical?

Question 2 **10pts**

Suppose that a person takes 0.51 s to react and move their hand to catch an object they have dropped.

(a) How far (in m) does the object fall near Earth's surface, where $g = 9.8$ m/s^2?

(b) How far (in m) does the object fall near the Moon's surface, where the acceleration due to gravity is one sixth (1/6) of that on Earth?

Question 3 **10pts**

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 4 **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 5 **10pts**

Use the equations describing the motion of an object experiencing constant acceleration to show that the relation between the initial (v_i) and final velocities (v_f), the acceleration (a), and the distance an object travels (Δx) is $v_f^2 - v_i^2 = 2a\Delta x$.