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:

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

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 two dimensions and allow you to practice analysing circular motion.

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.

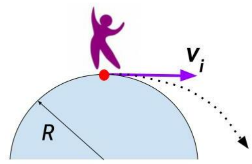

Figure 1: Person kicking a pebble on a boulder for Problem 1. I don't know why they are doing this.

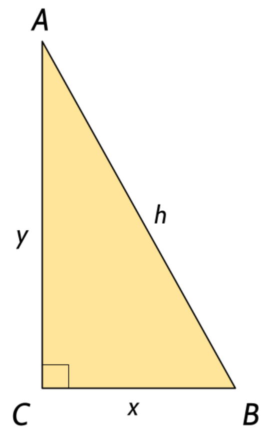

Figure 2: Triangle for Question 3.

Question 1 **15pts**

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?

Question 2 **15pts**

In the vertical right-angled triangle illustrated in Figure 2, a particle falls from A to B either along the hypotenuse, or along the two legs (of lengths y and x) via the third point, C. Assume that there is no friction.

(a) What is the time (call it t_H) if the particle travels along the hypotenuse?

(b) What is the time (call it t_L) if the particle travels along the legs, AC then CB? Assume that at C there is an infinitesimal curved arc that allows the change of the particle's motion to change from vertical to horizontal without any change in its speed. Neglect the time it takes to travel this infinitesimal arc.

(c) Show that $t_H = t_L$ when $x = 0$.

(d) How do t_H and t_L compare in the limit $y \ll x$?

(e) Excluding the $x = 0$ case, what triangle shape yields $t_H = t_L$?

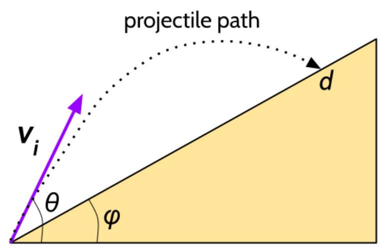

Figure 3: Triangle for Question 3.

Question 3 **20pts**

A projectile is fired up an incline of angle ϕ, with an initial velocity $\mathbf{v}_i$ at an angle θ to the horizontal. Note that $\theta > \phi$.

(a) Show that the projectile travels a distance d up the incline, where d is given by

$$d = \frac{2v_i^2 \cos\theta \sin(\theta - \phi)}{g \cos^2 \phi}.$$

(b) For what value of θ is d a maximum, and what is that maximum value?