

Problem set 4

1 Times

You throw a stone straight up. How do the upward and downward times compare (i.e. bigger, smaller, or the same): (a) neglecting air resistance and (b) including air resistance.

2 Messy collision

i) A ball comes in from the left and causes a series of collisions; the initial motion is

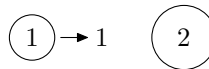


The number in the circle is the object's mass (in arbitrary units) and the arrow shows the object's velocity (in arbitrary units). All motion is one dimensional; all collisions are elastic.

Which choice describes the motion after the all the collisions?

- a) $\frac{1}{2} \leftarrow$ (1) $\frac{1}{2} \leftarrow$ (1) (1) (1) (2) $\rightarrow \frac{1}{2}$
- b) $\frac{1}{3} \leftarrow$ (1) (1) (1) (1) (2) $\rightarrow \frac{2}{3}$
- c) $\frac{1}{2} \leftarrow$ (1) (1) (1) (1) (2) $\rightarrow \frac{3}{4}$
- d) $\frac{1}{2} \leftarrow$ (1) (1) (1) (1) (2) $\rightarrow \frac{1}{2}$

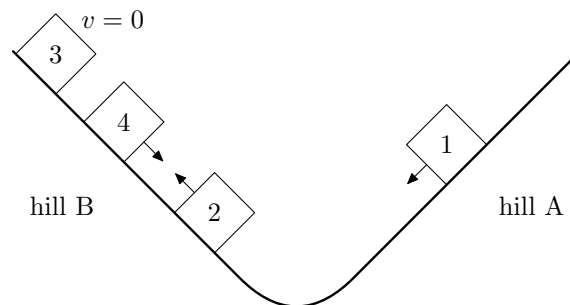
ii) By transforming to the zero-momentum frame, work out the result of this collision (also one-dimensional and elastic):



Comment on similarities or differences with part i.

3 Skiing

You ski down hill A and up hill B, then ski backwards down hill B and backwards up hill A (see figure). There is no friction or air resistance, so the cycle repeats forever. As a skilled skier, you know that ski poles are for wimps; instead, from your hand, you dangle a string with a mass at its end. Draw the direction of the string: (1) as you ski down hill A (square with 1 in it), (2) as you ski up hill B (square with 2 in it), (3) when you are momentarily stopped on hill B (square with 3 in it), and (4) as you ski backwards down hill B (square with 4 in it). There is plenty of friction in the pendulum. How does each string's direction change if there is slight friction on the slopes?



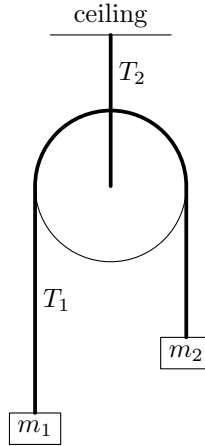
4 Rainfall

The sun spits out 4×10^{26} W. Estimate the average annual rainfall over the earth's surface.

5 Pulley

Problems in previous weeks have taught the methods of extreme cases and of analogy, mostly in mathematics. There was a request to practice these methods again in a physics question (remember the extreme-cases method for the iron ball floating in mercury).

Here it is. The pulley is frictionless and the strings (heavy lines) are massless.



a) Make an educated guess, in Newtons, for the tension T_2 , when $m_1 = m_2 = 3.5 \text{ kg}$ (use $g = 10 \text{ m s}^{-2}$). What if $m_1 = 3 \text{ kg}$ and $m_2 = 4 \text{ kg}$? Explain your guesses.

b) Make an educated guess for a , the acceleration of m_1 . A suggested method: The acceleration is always some fraction of g and will depend on the masses. So plot a/g versus a suitable function of the masses. How to decide that function? It should be dimensionless, just as a/g is – most useful quantities in physics are dimensionless. For example, m_1/m_2 . But it should also be symmetric in m_1 and m_2 , since neither is special; whereas m_1/m_2 (or its reciprocal) treats the masses quite differently. Perhaps $m_2 - m_1$? A reasonable thought, since the bigger the mass difference, the bigger the acceleration. But it's not dimensionless. So try

$$\frac{m_2 - m_1}{m_2 + m_1}.$$

So plot a/g versus $(m_2 - m_1)/(m_2 + m_1)$, for cases that you can easily analyze (extreme cases!). From your plot, make a guess for a/g .

c) Make an educated guess for T_2 , the tension in the string holding the pulley to the ceiling. A suggested method: Make T_2 dimensionless by dividing it by a relevant force, plot that quantity versus $(m_2 - m_1)/(m_2 + m_1)$, and guess the function. Using that function, make new guesses for the questions in part (a).

d) Using Newton's laws, work out T_2 and a . [Hint: $T_2 = 2T_1$. Why?] Compare with your answers for parts (b) and (c).