

## Mathematics 1101Y – Calculus I: functions and calculus of one variable

TRENT UNIVERSITY, 2010–2011

### Solutions to Assignment #1

Please refer to Assignment #1 for the story *Excelsior* and the two problems asked about it.

SOLUTIONS. *Excelsior* is the first “Knot” of Lewis Carroll’s book *A Tangled Tale* [1], which was originally a magazine serial. Lewis Carroll was the pen name of Charles Lutwidge Dodgson, who was a lecturer in mathematics at Oxford, among other things. He is best remembered nowadays for having written *Alice in Wonderland* and *Through the Looking Glass*, as well as various nonsense verse, especially *Jabberwocky* and *The Hunting of the Snark*. Here are the solutions Carroll gives in *A Tangled Tale*:

*Problem.*—“Two travelers spend from 3 o’clock till 9 in walking along a level road, up a hill, and home again: their pace on the level being 4 miles an hour, up hill 3, and down hill 6. Find distance walked: also (within half an hour) time of reaching top of hill.”

*Answer.*—“24 miles: half past 6.”

*Solution.*—A level mile takes  $\frac{1}{4}$  of an hour, up hill  $\frac{1}{3}$ , down hill  $\frac{1}{6}$ . Hence to go and return over the same mile, whether on the level or on the hill-side, takes  $\frac{1}{2}$  an hour. Hence in 6 hours they went 12 miles out and 12 back. If the 12 miles had been nearly all level, they would have taken a little over 3 hours; if nearly all up hill, a little under 4. Hence  $3\frac{1}{2}$  hours must be within  $\frac{1}{2}$  an hour of the time taken in reaching the peak; thus, as they started at 3, they got there within  $\frac{1}{2}$  an hour of  $\frac{1}{2}$  past 6.

The statement of the *Problem* above and the given *Solution* are not as complete, or as general and correct, as they might be. First, notice that Carroll does not make the – necessary! – assumption that the travelers return by the same route explicit, though he does implicitly use it in his solution. Second, he also assumes that the path the travelers took consists of a stretch of level road followed by a hill, so his solution is not quite as general as it might be. There is nothing in the story posing the problems to really eliminate the possibility that the path from the hostel to the peak is partly (or even almost all) downhill. With that in mind, the best one can do is pin the time at which our travelers reached the peak to within *one* hour: the earliest they could have reached it is 5 o’clock (if the path was all downhill) and the latest is at 7 o’clock (if the path was all uphill).

Here is a sketch of another way to answer problem 2 for distance:

Suppose we let  $u$ ,  $d$ , and  $\ell$  denote the time (in hours) spent going uphill, downhill, and on level ground over the round trip. Then the total distance covered is  $D = 3u + 6d + 4\ell$  miles. Since the travelers return after six hours, we know that  $6 = u + d + \ell$ . As they also retrace their path, we also know that the overall uphill distance is the same as the overall downhill distance, so  $3u = 6d$  (or  $u = 2d$ ). So we have three equations in four unknowns we want to solve for  $D$ .

A solution to the distance problem can now be obtained as follows:

Using  $u = 2d$ , rewrite the previous two equations in terms of  $d$  and  $\ell$  alone, giving  $6 = 3d + \ell$  and  $D = 12d + 4\ell$ . There are still more unknowns than equations, but this particular problem can now be solved with a cheap trick:  $D = 12d + 4\ell = 4(3d + \ell) = 4 \cdot 6 = 24$  miles.

The problem of determining the range of possibilities for the time the travelers were at the peak is left to the reader.\* ■

#### REFERENCE

1. *Pillow Problems and A Tangled Tale*, by Lewis Carroll (*Charles Lutwidge Dodgson*). Macmillan and Co., 1895 and 1885, respectively. Reprinted together by Dover Publications, New York. (ISBN 0-486-20493-6) A link to the full text of *A Tangled Tale* can be found at:

<http://www.trentu.ca/mathematics/sb/carroll/>

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\* If you encounter something “left to the reader” in a math article or book, it often means that the author is being to lazy to write something out ... :-)