

# Caltech Physics League: Fall 2009 Challenge 1

Available 10/26/09, Due 11/2/09 at 9:00 AM

## Problems

Treat all the information in the practice Mars-elevator problem as given.

After years of successful operation, the Mars elevator hits a rocky stretch. A second, much smaller asteroid strikes the asteroid that is acting as ballast. The impact happens with the small asteroid moving perpendicular to the elevator string and to the motion of the ballast. The diameter of the smaller asteroid is 500m, and it is made pretty much of the same material as the ballast.

1. How long does it take for the signal to propagate to the Earth through the elevator string?

To prevent a whiplash of the bottom of the elevator string in such events, the bottom of the elevator was fastened to a huge rocky cube of side of 40m (again, same material as the ballast) which is essentially hanging on the bottom of the elevator string. This rock was then fastened such that it could not move sideways.

2. The smaller asteroid velocity at impact (in Mars's reference frame) is  $5000\text{m/s}$ . Right after the disturbance of this impact arrives at the bottom rock, how much force needs to be supplied to the rock so that it doesn't move?

Hint: Think about the angle  $\theta$  in the accompanying derivation of waves in ropes. How does it change as the tension in the rope changes?

Your answers this round should be accurate to about 10%.

## CPL rules

1. Many CPL problems can be solved using numerical integration and equation solving, e.g. with Mathematica.
  - Numerical solutions will receive full credit
  - However, using brave approximations it will always be possible to find a closed form simple expression that is correct to the desired accuracy. These solutions will receive **bonus points**.
2. You may only spend **2 hours** on these problems.
3. When you are done, leave your solutions in Gil's mailbox at Sloan Annex, or email a scan of the solution to Gil: [refael@caltech.edu](mailto:refael@caltech.edu) or to John: [joschu@caltech.edu](mailto:joschu@caltech.edu).

