Engineers are problem solvers: Bead Puzzle

As well as many other things !

Problem statement

Starting from Figure 1 (“Initial state”), move one of the beads such that both beads are on the same loop as shown in Figure 2 (“Final state”), without cutting or untying the rope or breaking the beads or the bar. Note that section C to D (shown as a dotted line in figure 2) is in front of the two loops (from your point of view), such that if you pulled on the two loops, it would form a tight knot (see Figure 3) and lock the rope to the bar.

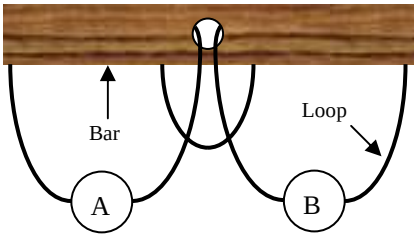

Figure 1: Initial state

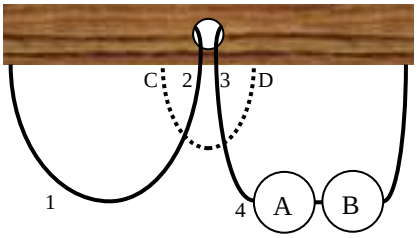

Figure 2: Final state

Figure 3: The “tight knot”
Picture taken from
http://www.cleverwood.com/2_bead_classic_string_puzzle.htm

How do we start?

We start by thinking about the boundaries, constraints, facts, concepts or making observations related to the problem. This is a process where we gather the relevant theory and data:

- Begin by assuming that there is at least one solution to the problem.
- This is a spatial problem, so the solution will need us to think in up to 3 dimensions and to concentrate on “ relative displacement” (or “ relative position”) and “change of relative position” (or “relative motion”). We know this, as something has to move, somewhere, somehow.
- Neither bead can pass through the hole, but the rope can move through the hole. We know this simply because of the relative sizes of the beads, hole and rope diameters.
- In order to go from the initial state to the final state, at least one of the beads must slide along the rope independent of the position of the rope in 3D space. This means that the bead can stay stationary relative to the bar, but the rope can move relative to the bar and therefore also move relative to the bead. We know this because we cannot remove either of the beads from the rope, and at the start, we have a long way to travel along the rope if we want to go from one bead to the other.
- In order to go from the initial state to the final state, **if** the rope and one of the beads did not move relative to the bar, the other bead would have to slide all the way along the rope and go through the hole once in one direction and then once in the other direction. Test this by moving your finger along the rope from one bead to the other. This means the net effect is that the bead that moves will not have passed through the hole (remember that we are comparing the initial state to the final state). This is good news, as neither bead can actually pass through the hole.
- If you imagine the bead move along the rope, you should notice that it only travels on a short part of the rope between going through the hole in one direction, and then coming back through the hole in the other direction. Therefore, for this part of the rope, if we move the rope relative to the bead, the bead never has to go through the hole.

Solution: Application of the theory
To start with, we will identify positions and sections of the rope:

- Positions are defined as positions along the rope as shown in figure 2, regardless of where the rope is relative to the bar. Imagine you paint different coloured dots on the rope at positions 1 to 4 as shown in Figure 2.
- Section C to D of the rope is shown as a dotted line in Figure 2. We use the same idea as for positions 1 to 4. Imagine two positions C and D, and you paint all of the rope that links these two positions.

Now starting from the initial state, follow these steps:

- Move bead A from position 1 to position 2.
- Pull section C to D of the rope through the hole. This can be done by holding the rope firmly at positions 2 and 3 and pulling away from the hole, towards you, from your point of view. Section C to D must come all the way through the hole. This process will pull other parts of the rope through the hole too, but do not worry about that. Just concentrate on these steps.
- Move bead A from position 2 to position 3.
- Pull section C to D of the rope back through the hole.
- Move bead A from position 3 to position 4.

How does this relate to Engineering?

- The overall process is used in many engineering activities. The process started with writing a problem statement, moved to identifying constraints and relevant concepts, and then formed the practical solution.
- Some specific concepts used included spatial awareness, relative position and relative motion (change of relative position with time), comparing initial and end states.
- You could also have included some experimentation, testing of your ideas or hypothesis.

Final comments

- As with most problems, once you have the solution, it always seems easy, but the skill is in finding the solution yourself, developing an analysis as given above. If you can do this on your own, you can solve new problems, problems that you have never seen before.
- This is just one of the skills you would develop whilst studying your degree here at Asian U, Faculty of Engineering and Technology – fundamental problem solving skills.
- Contact us via med@asianust.ac.th

I hope you enjoyed this puzzle,

Paul

(Head of Mechanical Engineering)