AQUEDUCT ENGINEERING EXERCISE - OPTION B: SURVEYING A TUNNEL

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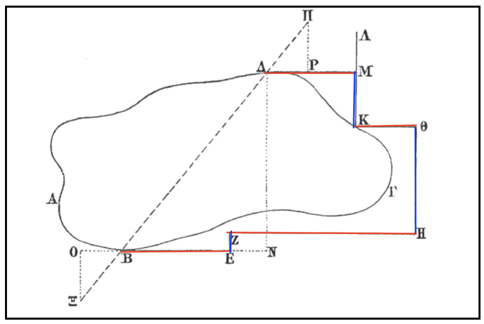
The initial task of identifying the entry and and exit points is simplified if we assume our tunnel will be a perfectly straight line, so that's what I'll assume for this exercise. After we've established our entrypoint, we must find the exit, and this is relatively straightforward as we can take advantage of the relatively flat ground around the hill to perform odometry.

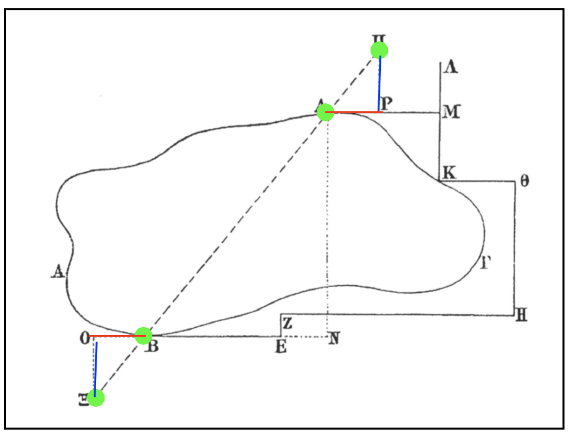


By moving in perfectly orthogonal sections all the way around the hill, we can sum our vertical and horizontal movements to obtain precise relative coordinates of the exit point position. This information is really only useful for obtaining the length of our tunnel using Pythagorean's theorem, and our next step is to establish precise digging orientations and also to figure out a method that both digging teams can use to maintain this orientation.

A useful method for maintaining angle over a large distance is to "sight a line of pegs" as Nonius Datus writes. Similar to sights that one might use on a bow and arrow or other straight-line projectile ranged weapons (below is a screenshot from a popular video game), aligning your sight against a minimum of two points in 3D space allows you to fully constrain a perfectly straight line.

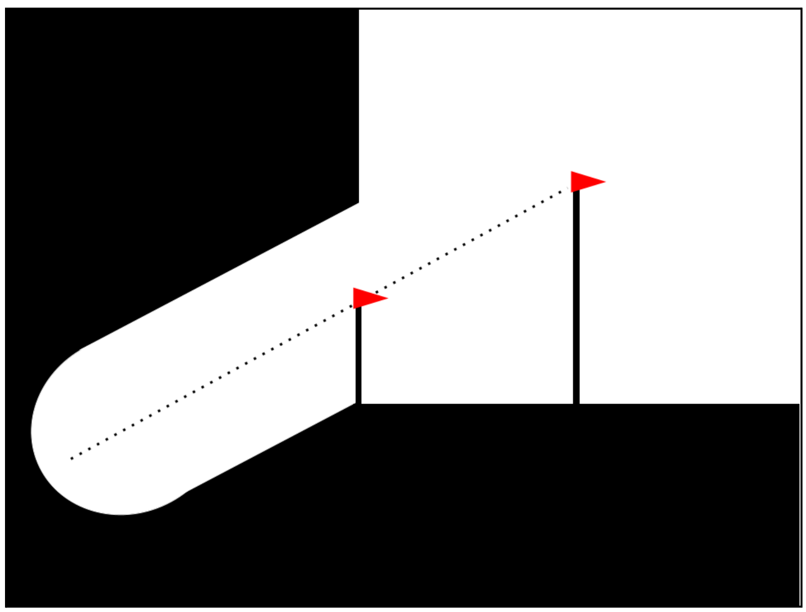
Above: "Iron sights" allows user to ensure projectile will travel in a straight path to target

Additionally, if you attempt to align more than two pegs, you will not be able to align them all in your sight if any given peg does not lie on a straight line path among the others. This allows for a convenient alignment self-test, if one attempts to place several pegs out in the real world in a perfectly straight line.



We can use this method to place pegs at the green dotted locations indicated, and we can do so accurately by walking a horizontal and vertical distance *proportional* to the horizontal and vertical distance we measured when first surveying our entry/exit points, such that the angle of the pegs when aligned in our sights is the angle we intend to dig (at least on a flat plane). For our digging teams, the task is simple: dig as straight as you can, just ensure that when you look back at the entryway, that you can perfectly align both pegs in your vision. If you cannot, you are off course. Additionally, for more desired accuracy, one can place multiple pegs, both on the inside of the tunnel that is actively being dug, and outside, at a distance even further away from Ξ *or* Π.

Lastly, we arrive at the question of vertical orientation and distance. First we can calculate the vertical distance the tunnel will drop by multiplying our descent rate by the length of the tunnel, which we obtain using our odometry instruments when calculating the relative position of the entry/exit points and right angle geometry. Now that we know the relative Z position, we can adjust our exit point Z coordinate to be at the appropriate height, and simply employ the use of our peg strategy but in the vertical dimension.



Admittedly, I am making the potentially incorrect assumption in this diagram that we can achieve sufficiently high alignment accuracy through the use of simple, closely positioned manmade pegs (flags on very high poles in this case, instead of placing some marker on a distant landmark) but I'm not 100% sure how else it could be done. This is doubly true when one considers the problematic case of digging a tunnel upward, at an angle so high that all visibility to distant landmarks is obscured - in that case *I'd really hope* manmade markers are sufficiently accurate if I were the Romans.