Speed of Mini HotRod: Long Track Challenge

Teacher Notes

The students may not be aware of the fact that the range of the Rangefinder sensor typically maxes out at about 2 meters. This information appears in this link https://www.thepocketlab.com/specs.html. If they don't know this, they will quickly learn that there must be a limit, for when they place their IR sensor reflecting white cardboard at the far end of the track weird things seem to be happening. Since the track is on the order of 5.5 m long, they then need to come up with a way to deal with this issue.

The author's approach was to place white cardboard reflectors at the right ends of regions A through E. Each reflector had a hole cut in it big enough to allow the Mini HotRod and Voyager to easily slide through, as shown in Figure 1 below. If the hole is too large, students may find that the beam does not reflect properly.

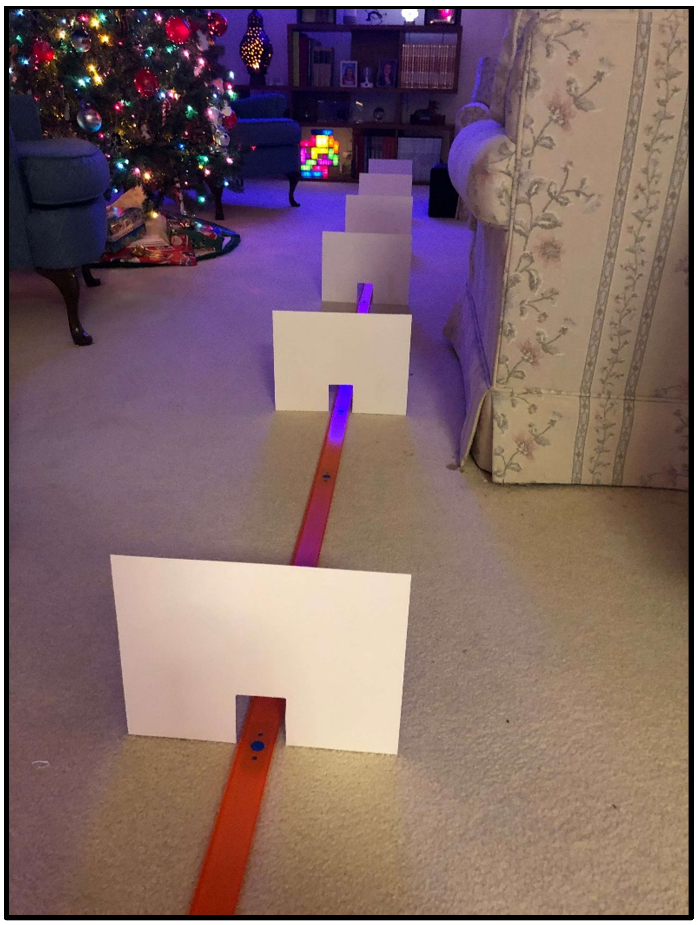

Figure 1

The students may discover that if the cardboard is too small, multiple reflections could come from objects in the room, making analysis virtually impossible. This relates to the 25-degree field of view specification for the rangefinder. The author used 8½" x 11" cardstock with a hole 2" wide by 2.5" high cut for the Mini HotRod and Voyager to slide through.

As the Mini HotRod passes through each white card, the rangefinder has a new card source for its IR reflection. With the spacing of the white cards three track lengths apart, the distance to the card will be quite a bit less than the maximum allowable of 2 m. With the “Absolute Accuracy” specification of the rangefinder listed at 5% of the reading, this provides for very reasonable position measurements. Figure 2 shows a typical Rangefinder position vs. time graph when releasing the Mini HotRod from the top of the ramp and letting it come to an eventual stop at the far end of the track. The data rate was set to 50 points/s.

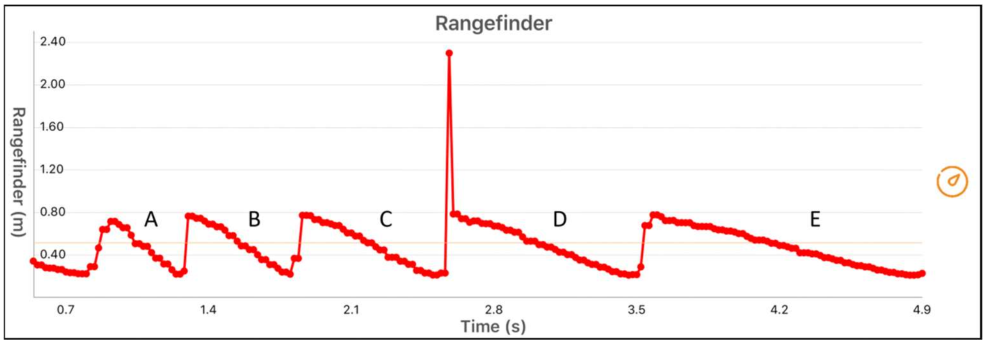

Figure 2

The important data is the position of the Mini HotRod while it is in regions A, B, C, D, and E. These have been labeled in the graph. Since we are interested in finding average speed in each of the five regions, we can approximate this by finding the slope of the data in each of these regions. We could do this doing a linear curve fit for each of these regions. We should note that, in fact, the regions are actually parabolic in shape since the Mini HotRod slows down even within each region. But each region *visually* appears to be an approximate straight line. The student may see an occasional “blip” like that shown between regions C and D in the graph. This is likely due to the rangefinder requiring a small fraction of time to adjust to the “new” white cardboard as it passes through the hole in the “old” cardboard.

It should be noted that when the Mini HotRod is *going down the ramp*, the rangefinder values are meaningless as they are measuring the distance to the floor. This changes some as the Mini HotRod quickly moves down the ramp. This is because the direction of the IR beam is always perpendicular to the orange surface of Voyager, and the Mini HotRod is not always perpendicular to the floor while going down the ramp. After the Mini HotRod reaches the level straight track, Voyager’s IR beam is always perpendicular to the white card boards.

Typical average velocities for regions A through E obtained by the author were 1.68, 1.45, 1.13, 0.85, and 0.65 m/s, respectively. This is in agreement with the decreasing slopes of regions A through E in Figure 2.