Physics 271, Sections H1 & H2 — Thursday, Sep 11, 2014
Problems #1 — Measurements, 1D Kinematics, Vectors

1) You are standing on the edge of the roof of the physics department at the height of $H = 25$ m. At time $t = 0$ you shoot a football right up in the sky. Ball just misses the edge, and hits the ground, at $t = 5$ sec. The height of the ball, with respect to the ground, at different times, is plotted on fig. 1. We name the initial velocity of the football has, right after shooting, v_0. Use $g = 10$ m/s^2.

a) On the graph, show the point that the ball hits the ground and explain what is wrong with the graph. Show the point the ball reaches maximum height. What v_0 stands for on this graph?
b) Find v_0 and try to confirm it on the graph.
c) Find the time the football reaches the maximum height. Check with the graph.
d) Find the maximum height. Again confirm with the graph.

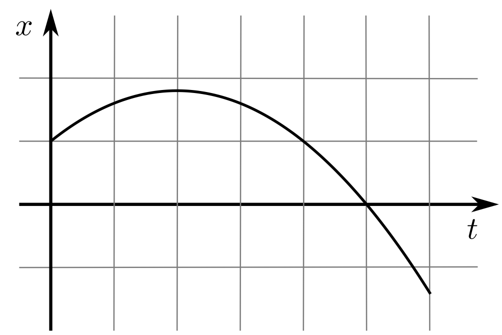

Figure 1: $x(t)$ graph for the football.

2) You are one of the doctors without borders. You were in Guinea fighting with Ebola. Because of complications you had to stay longer and you missed your significant other[s]. Finally, you get back to the US. You are on the airport, finally done with all the airport complications. All of a sudden, you see your significant other[s] at a distance $d = 50$ m.
a) Say you leave your luggage and start running towards them at time $t = 0$, with constant velocity of $v = 5$ m/s. Your significant other[s] run towards you with constant velocity $u = 4$ m/s. Draw two position-time curves on one graph, one for your position-time and one for your significant other[s]. Find how long it takes for you to get together.
b) Assume, instead, you accelerate constantly with $a = 2$ m/s^2. You significant other[s] is coming toward you with constant velocity $u = 5$ m/s. Again draw the two position-time curves on one graph. Also draw the velocity-time curves. Find the time you get together.

3) You are driving fast and a bit tailgating. You have a distance d from the car in front of you, both driving with velocity v_0. Suddenly, at time $t = 0$, the car in front of you brakes with deceleration $\beta > 0$. You step on the brake at $t = \tau < v_0/\beta$, your reaction time. It gives you a deceleration of $\alpha > 0$.
a) Draw the velocity-time graphs for both the cars, on one graph.
b) Write down the condition on the parameters so that you just avoid the collision. Simply start with small α and find possible d and work out the way to $\alpha \to \infty$.

4) Typical ants use bifurcation with angle $\theta = 60°$ so that the roaming ants can distinguish the path that goes to the nest with two paths which goes away from the nest. They create a chemical trail. See fig. 2. Each time an ant group can choose right, r, or left, l. Say you are in A, taking the path lr will take you to the point B. Assume that ants go one unit distance each time before next bifurcation.

a) Consider a path made by the sequence rlr, starting from point A. Find the displacement vector. Another group goes the sequence rll starting from A. What is the displacement vector and distance between these two groups?
b) Find $\mathbf{u} \cdot \mathbf{v}$, where $\mathbf{u}$ made with the path $rllr$ from A and $\mathbf{v}$ is the path $rrrl$.
c) [for fun] Starting from point A, can the ants go back to the point A? How?
d) [for fun] Can you show a path that a group of ants pass through a specific line twice but in opposite directions?

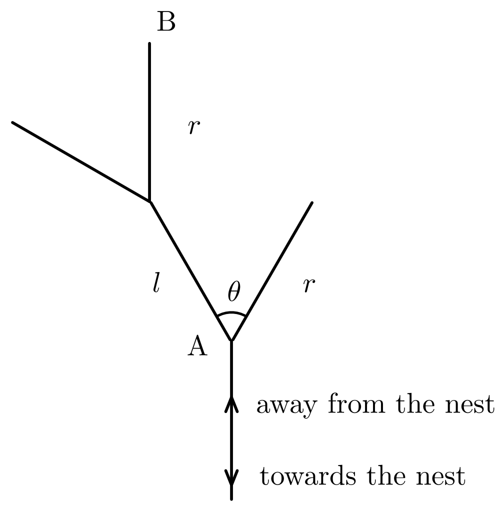

Figure 2: Ants trail.