Physics 271, Sections H1 & H2 — Thursday, Sep 18, 2014
Problems #2 — Vectors, 2D & 3D Kinematics

1) Affine Combination
Your friends are in New York City and decide to go to a coffeehouse to talk about physics. You want to join them so you call your friend and ask about the place. She tells you that they will be in "three half Empire State Building, minus Chrysler building, plus half Grand Central Station" and she hangs up the phone.

a) To understand what she meant, you decide to put yourself at points A shown in the fig. 1, draw the vectors to E, C, and G, and add them with the given numbers as weights.
b) To explore more, this time you put the origin at the point B and again you find the wighted sum.
c) What do you think?

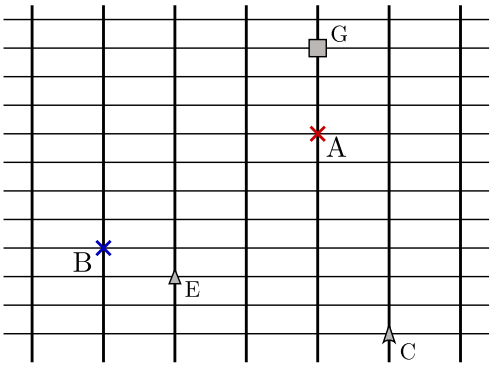

Figure 1: Trying to find a cafè.

2) You are shotting a football on a hill with a slope of angle α. Which angle θ_0 you must choose to have the maximum range on the hill.

3) You want to catch your friend, John Conway, running behind a fence. He runs with a constant velocity $v = 3$ m/s. You have a distance $d = 32$ m from the fence. See fig. 2. There is an opening, so you start running ($u_0 = 0$) with acceleration a toward that opening and plan to catch your friend when you two get there.

a) What should be the a so you catch your friend?
b) Say we attach the coordinate system on John. What is the path you take in his frame of reference?
c) Say we attach the coordinate on you. What is the path John takes on your frame of reference?
d) After you caught John Conway, he asks you to solve similar problem, with different notation:"Consider you were running with constant velocity vector $\mathbf{v}_1$ and I was running with constant velocity $\mathbf{v}_2$. Our position vectors were, with the same order, $\mathbf{r}_1$ and $\mathbf{r}_2$, at some time, call it $t = 0$. What is the condition we get together at some future time? What is the condition we were together at some past time? Can you solve this problem is we had constant accelerations $\mathbf{a}_1$ and $\mathbf{a}_2$?"

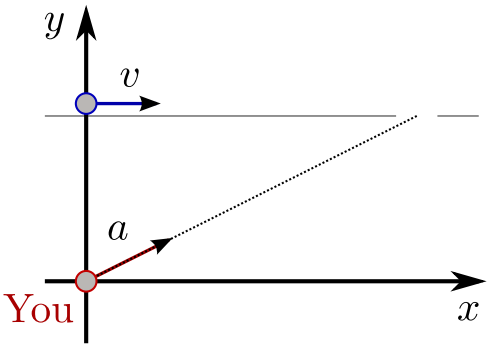

Figure 2: Catching your friend.

4) Sprinklers
You have this lawn sprinkler on your yard which has so many holes. Water comes out of each hole with the same velocity v_0, but so many different angles.
a) Find the max height that water gets. Also find the max distance water gets from the sprinkler on the ground.
b) [for fun] When the sprinkler is sprinkling in all directions, you can see an envelope surface, like a dome, which all water stays just inside of it. In other words all the projectile water paths are inside this dome, and by touching the surface of this dome your hands get wet. Find this surface.

5) You are whirling a stone in a horizontal circle with constant angular velocity. The radius of this circle is $r = 1.0$ m and this circle is at height $h = 2$ m above the ground. All of a sudden, rope breaks. Stone jumps off and travels $X = 10$ m horizontally before falling at the ground.
a) What was the velocity of the circular motion?
b) What was the angular velocity of the circular motion?
c) What was the centripetal acceleration of the stone while on the circular motion?
d) [dynamics] If the mass of the stone is $m = 1.0$ kg, what was the tension of the rope before breaking?