**Exercise #1**: designing the instrument setup

You have been hired by the engineering firm managing the Codorus Creek improvement project. They need you to perform a seismic survey to determine 1) how deep the bedrock is and 2) how difficult it will be to excavate the overburden. They have provided the engineering drawing below, with the approximate locations of the seismic surveys indicated as red lines (note: the seismic lines may not cross streets).

During your background research, you find a report on the local bedrock known as the "Conestoga Formation" limestone. Reports of nearby observations suggest that this limestone may have seismic velocities of 2,000 - 3,000 ft/s. Soil generally has a seismic velocity of 1,000 - 1,500 ft/s. The bedrock depth in this region of Pennsylvania is anticipated to be between 10 - 30 ft.

In general, if we want to detect an interface between two layers, we want to observe BOTH direct arrival points AND refraction points - usually the minimum would be four. Remember, the refraction points would need to be earlier in time - i.e., "below" - the direct arrival, otherwise they will not show up in the field data. If you simulate a travel time - offset plot that has fewer than 4 points of either the direct arrival or refraction, it would indicate that the parameters were not acceptable to achieve the goals of your survey: either the geophone spacing is too small or too large for the subsurface velocity structure.

Use this information to change the green boxes in the spreadsheet above and answer the following two specific questions about how you will set up your 24-chanel seismic instrument:

* How long of a seismic line will be needed to be sure we detect the bedrock?
* What is the required geophone spacing we would need to be sure that the soil layer (direct wave) is captured by at least 4 geophones?

**Explore**

At the top left of this worksheet are the cells that control the simulated travel time-offset plot. You can change anything that is green. Orange cells are calculated for you.

1. look at the formulas in the "direct arrival" and "refraction" columns. Explain in your own words how these travel times are being calculated given the "known" (i.e., estimated for the purposes for designing the experiment) input information in the green cells. You will be solving for velocity and depth in the actual field experiment.
2. by changing ONLY the geophone spacing, make a travel time-offset plot that would *not* resolve the refraction arrival from the bedrock. Why? What is happening?
3. by changing ONLY velocity1, make a travel time-offset plot that would *not* resolve the refraction arrival from the bedrock. Why? What is happening?
4. by changing ONLY *h* (depth to bedrock), make a travel time offset plot that would *not* resolve the refraction arrival from the bedrock. Why? What is happening?