

SPU 26 Assignment 3 Due Monday, Oct. 8th before lecture

Purpose: This is where we combine the biometric data from assignment 2 and dead reckoning to see how well we can estimate a short journey, and evaluate distances based on the small angle approximation.

In this assignment, you will measure the height of the Harvard Chapel's steeple using the techniques we learned. It is important that you *do not* use artificial means to do this (e.g. measuring distances using Google maps etc). We will later compare your results with the actual distance and height. You'll walk from the Chapel to the Center for Astrophysics (CfA), go to the roof and look back at the steeple. The CfA roof is open to the public during normal working hours (9-5) Monday-Friday.

Materials:

- a) Your body
- b) Protractor and string

1.) You start at the base of the steps of the Chapel, facing Widener Library. This is going to be the origin of your coordinate system. We'll take the line from the base of the steps directly to Widener as one axis of the coordinate system. North (behind you) will be positive (for northing). The perpendicular axis will take east as positive (for easting). Technically this axis from the Chapel to Widener is a bearing of 194° , but we'll call this "south" for the purposes of this exercise.

2.) Dead reckoning – starting from the steeple, orient yourself with some reliable direction indicator, like shadows cast by objects or wind. Walk on a path of your choosing to the Center for Astrophysics (CfA). This is at 60 Garden Street and indicated on the Google map below. Keep track of the number of paces, and each time you turn, keep track of the new direction and the angle of the turn, so that when you are done, you can reconstruct a map of your path from the steeple to the CfA. A protractor and string will aid you in estimating the changes in angle, particularly on the odd streets of Cambridge.

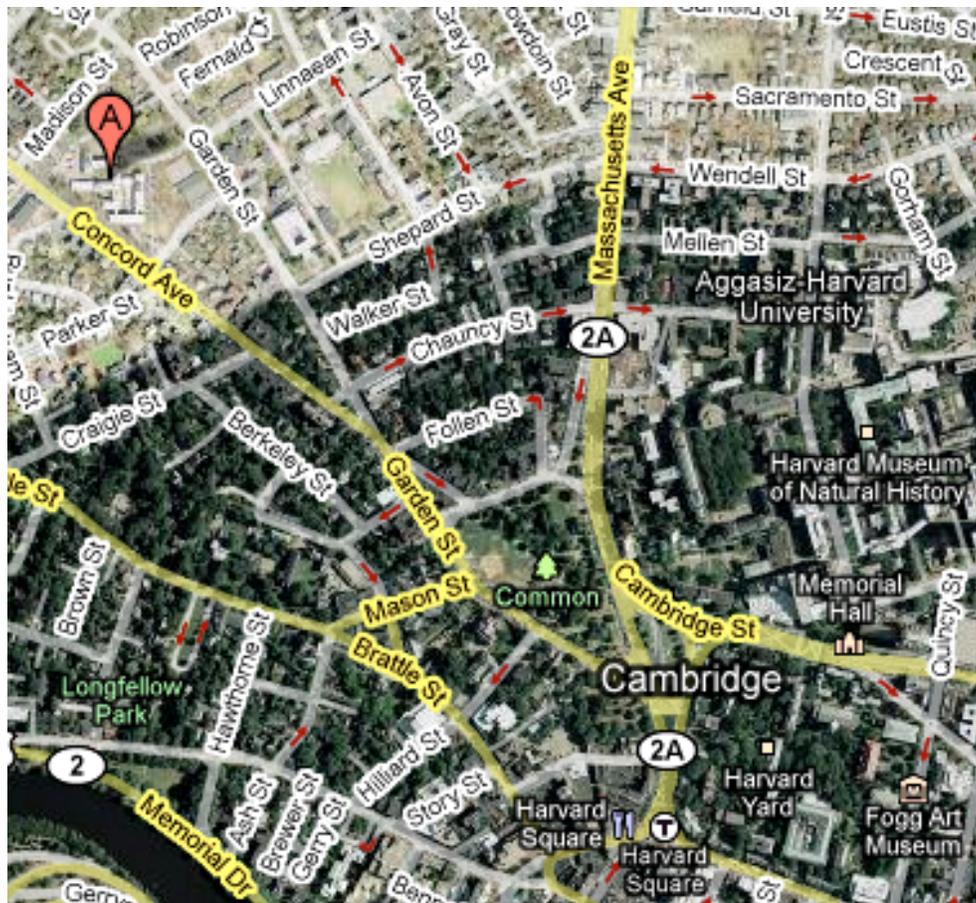
3.) Go to the roof of the CfA. The entrance is indicated by the upside down tear-drop with the letter "A" on it in the figure below. You'll climb several flights of stairs to get to the roof. Remember to do this during normal working hours (9-5). Once you're on the roof, it will take a bit of time to get oriented, but you should be able to see the steeple (in addition to a lot of other things). Use your fingers to get an angular height of the steeple. Measure the angular height of the white upper half of the steeple, which should be fully visible. Include the weather vane on top as part of the height estimate.

3.) When you are done, having recorded this information, draw a map of the path you took, to scale, and find the straight line distance from the CfA to the Steeple. Then, using your angular measurement, estimate the height of the steeple using the small angle approximation. You also should be able to find a heading of each leg of your journey, estimate the azimuth of your heading relative to the northing/easting coordinate system I defined above, and find the northing and easting of each leg of your journey and add

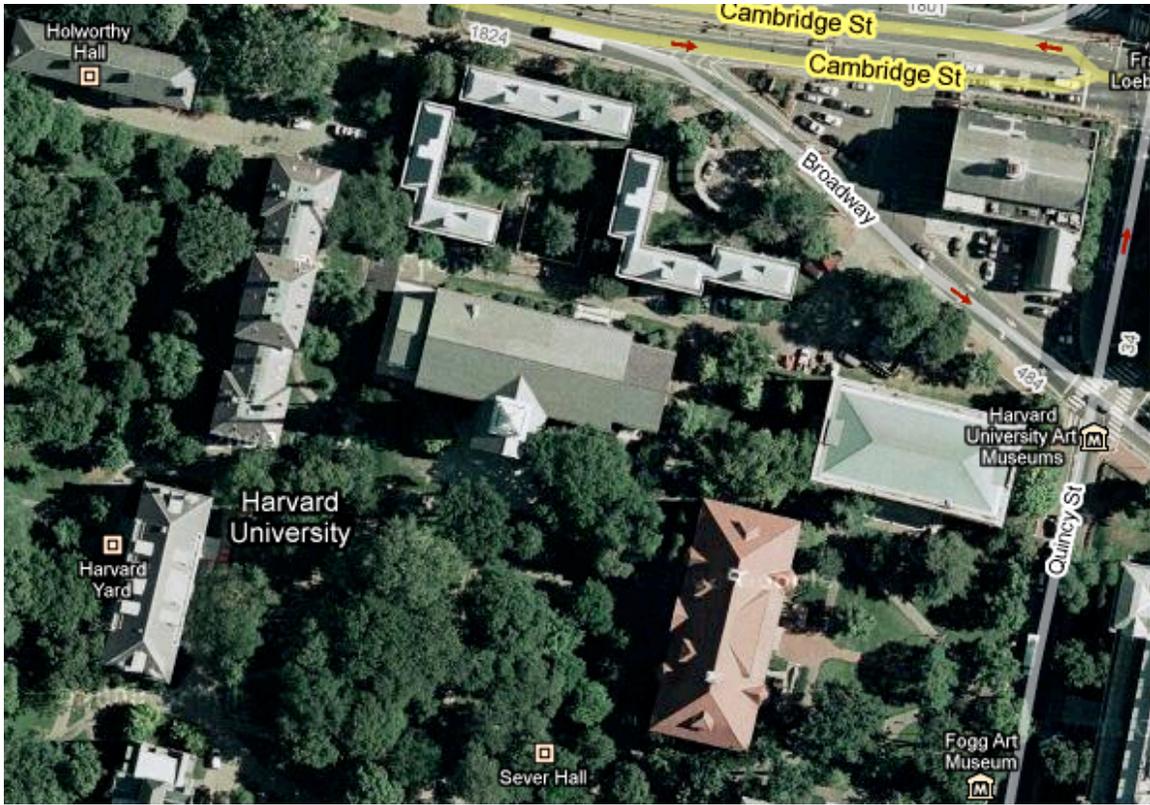
them separately and find the northing and easting of the CfA relative to your start and use this to find the straight line distance to the CfA.

In lecture on Monday, October 8th, turn in the following (remember to put your name, your TF's name and your section meeting time on the assignment turned in):

- a) A map of your path, as drawn (could be a computer based drawing – e.g. Adobe Illustrator or a hand drawn). Graph paper will work. Pay attention to scale when you start drawing. If you use graph paper, a protractor and ruler are important for accuracy. Indicate the straight line distance from the Steeple to the entrance to the CfA in miles from your graph.
- b) The angular height of the upper (white) part of the steeple in radians and degrees
- c) The height of the upper (white) part of the steeple in feet
- d) The easting distance in miles. This will be a negative number based on the definition of positive being east, as you'll mostly be moving to the west.
- e) The northing distance in miles. This will be a positive number as you'll mostly be moving north.
- f) The straight line distance to the CfA from your northing and easting measurements
- g) Guess the uncertainty on your northing and easting position based on your intuition. Express your answer in distances.
- h) On the course website, on week 5, please enter the following information: easting, northing, straight line distance to the CfA, angular height of steeple, and estimate of height of steeple, all based on your measurements.



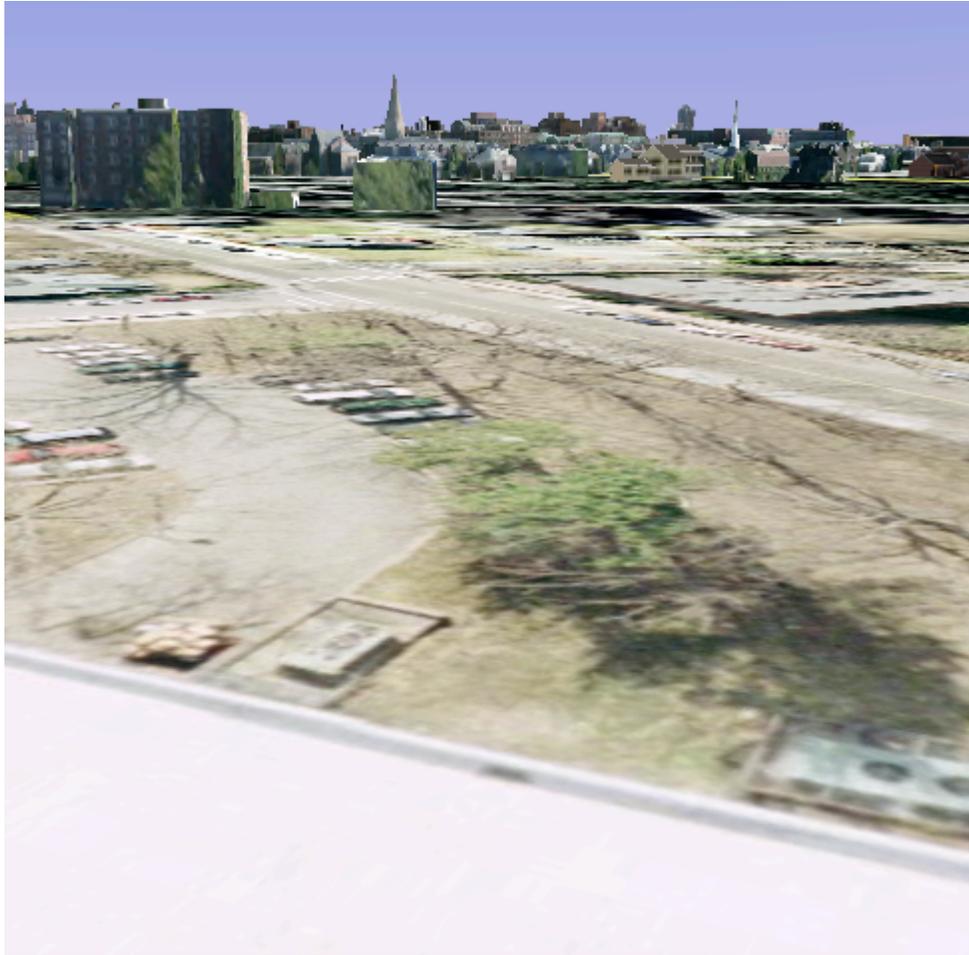
Large scale view that spans the path from the Chapel to the Cfa



Point of departure: The steeple.



The CfA: Entrance is right where the "A" is located in this photo.



What Google Earth “thinks” the view will be from the roof.