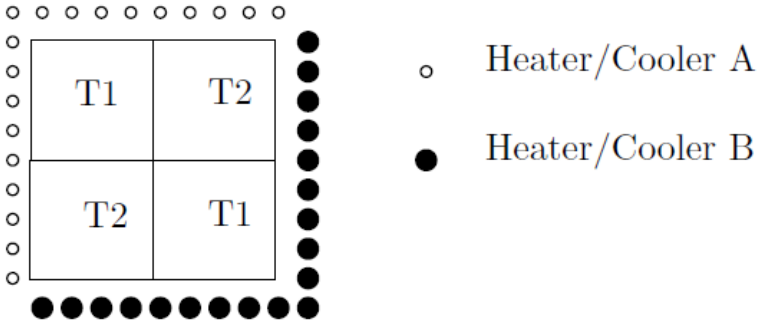
Purpose

The purpose of this assignment is to have you work with two-dimensional arrays in the context of a simulation.

Scenario

The scenario is a heat-flow simulation of the transfer of heat from two sides of a metal plate across the entire plate. A metal plate, as shown below, begins at a pair of fixed temperature. Heater/cooler A is placed up against the top and left (north and west) sides of the plate. Heater/cooler B is placed up against the bottom and right (south and east) sides of the plate. The plate itself starts at two initial temperatures: T1 and T2, as shown below.



For example, the plate might start at T1=10 degrees and at T2=35 degrees, the first heater/cooler might be at 80 degrees and the second heater/cooler might be at 60 degrees. As the simulation starts the sides of the plate will begin to heat up and thus take on temperatures closer to the heaters. This transfer of heat will continue across the plate until it reaches a "stable" temperature, where stable is defined, roughly, as "not changing significantly".

Method

To implement this simulation, we will use a finite state element approximation, that is, we will model the plate with a 2-D array. Only the plate is represented by the 2-D array; thus the heater/coolers are outside (but exactly adjacent to) the array. The plate will be represented by an (8x6) array: 8 rows and 6 columns, thus 48 elements. The temperature of all the plate elements will be initially set to the two initial plate temperatures.

To simulate the transfer of heat, you will traverse the entire array over and over. On each traversal, you will visit each element in your array and compute the new temperature in the following fashion: To determine the new temperature of a specific element, take the average of its four neighbors (north, east, south,west) from the previous cycle. Be careful, if you are updating an element on an edge of the plate, then you will have only THREE plate values and ONE "outside" value, where an "outside" value is the temperature of one of the heater/coolers. And a corner has two "outside" values. After you complete each traversal you should print out the two 2-D array of updated temperatures. Then replace the values of the old temperature by the new one for the next cycle. The simulation of traversals continues until no element in the array changes by a significant relative amount, where the significant amount is determined by the value of the last input item (see below). A relative amount means a percent change. Thus a value of .01 signifies a 1% change; it does not mean a change of .01 degree.

Data Structure

To store the simulated transfer of heat, you will store the heat temperatures in a pair of 2-D (8x6) array of doubles, one for the previous temperature values and the other for the new ones being computed.

Input

All input values will come from an input file. User supplies the name of the file when prompted.

The input includes 5 real (double) values:
The first heater/cooler temperature (A)
The second heater/cooler temperature (B)
The first initial plate temperature (T1)
The second initial temperature (T2)
The stabilizing criterion value

The stabilizing criterion value is a value to indicate WHEN to stop the simulation. The halting condition is defined as: "If NO element in the array changes by a relative amount MORE THAN the stabilizing criterion then the simulation can stop". (This means that the temperature in the plate is settling down to its final temperature and continued traversals will only slightly change the temperature distribution). See the posted files for examples of input.

Output

The output will first echo the input data then display the heat-plate temperatures. You should display each plate as the temperatures change until the halt criterion is satisfied. Be sure to look at the posted output examples and follow them closely. Make sure that you have the correct number of iterations.

You can send output to the screen – no need to print the output to a file.

Details

- Remember that the stabilization criterion is a relative change, not a degree change. Relative change is defined as:

  $$|t_o - t_n|/t_o$$

  where t_o is the old temperature and t_n is the new temperature

- You must use at least the following functions (all of them must be commented):
  - A function named display_plate that will display the temperatures as in the examples. You can assume that the temperature values will be in the range 0 – 99.99 and your display should look good for all temperatures in this range. Your display should look almost exactly like the sample output. Display temperatures with 2 decimal places.
  - A function to initialize the plate
  - A function that does one update of the plate temperatures
  - You may have as many other functions as you wish

- The program must be split into multiple files:
  - The main must be the only function in one code file (.c)
  - All the other functions should be in a second code file (.c)
  - The other functions should be forward declared (prototype declarations) in a header file (.h) and included in both code files
  - The definition for constants should all be done in the header file
  - **Be sure to submit all three files!**

- As always test your program carefully and follow good programming style.

Other Details

- You must follow all the coding style rules as specified in our "coding guidelines". In particular:
  - You must put your name enclosed in a comment box at the top, and keep any other comments that are already there.
  - Keep lines to a reasonable sizer to the point of making your code easily readable.
  - You must use good names for any variables you create (a full word that describes what it is there for).
- Details that you do not follow are penalized after other scored items are added up, so even if you got a 100 for the functionality of your program, you can still get a lower score because you did not follow all the other requirements for the assignment.

Submission

Submit this assignment with the code 9P followed by the names of all 3 files:
For example: `submit 9P 9P.c 9P-functions.c 9P.h`