C Programming Coursework

2018

Work in pairs. Program in C.

This assessment will test your ability to understand a problem and logically split it down into a programmable solution using standard programming constructs.

1 Submission

Please adhere to the following guidelines when submitting your work. Failure to do so may result in your work being awarded zero.

- Work must be submitted via SAFE by **5 p.m. on Friday 16th February 2018**
- Each student in the pair must submit that pair's single `.c` code to SAFE
- The name of the file must be the usernames of the students e.g. `ab1234_de5678.c`
- The first line of the file must be a comment with both students' names
- The `.c` file should be the only file submitted; there is no need to submit Tecplot layout files or images

2 Marking and Feedback

The assignment is worth a total of 15 marks. Marks are awarded for the following categories:

- *Correctness* (5 marks): main program works correctly for various trial inputs; error conditions (*e.g.* bad inputs) are handled without crashing
- *Clarity* (7 marks): comments and indenting code; suitable variable names; general structure including appropriate use of functions with suitable names
- *Extension* (3 marks): correctly programming the extension exercise

PENALTIES: You will be penalised 2/15 marks for submitting late. Every subsequent 24 hours will be docked 1/15 marks, so if you submit over one week late you will lose 8/15 marks.

Feedback takes the form of a general feedback sheet that will be put onto blackboard after marks have been released.

3 Task

In this task you will calculate the streamlines through a potential flow solution and display these in Tecplot.

3.1 Theory

At a location, denoted by (x, y), the flow has a velocity vector (u, v) which is given by the following equation:

$$u = 1 + \frac{x}{2\pi(x^2 + y^2)} \quad , \quad v = \frac{y}{2\pi(x^2 + y^2)} \tag{1}$$

A streamline through a flowfield can be calculated using numerical integration. The method used here is a first order Euler method. Given a current location at the current time level (x_{old}, y_{old}), the next location (x_{new}, y_{new}) is given by:

$$x_{new} = x_{old} + u_{old}\Delta t \quad , \quad y_{new} = y_{old} + v_{old}\Delta t \tag{2}$$

where u_{old} and v_{old} are the velocity components at the current location. A basic schematic is shown in figure 1.

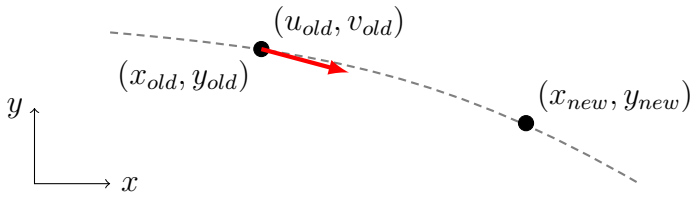


Figure 1: Streamline schematic.

3.2 Exercise

Write a program that adheres to the following specification:

1. Request the number of streamlines to plot.
2. Calculate the streamlines through the flow given by equation 1 that start at $x = -1$, with uniform distribution $-0.75 \leq y \leq 0.75$. Decide a suitable value for Δt, though it will be small. Also set a maximum number of iterations to be performed for each streamline, to avoid getting into an infinite loop.
3. Ensure the streamlines go until they reach the edge of a box defined by $-1 \leq x \leq 1$, $-1 \leq y \leq 1$.
4. Export the x and y locations of the streamlines to a Tecplot formatted file called `stream.plt` such that when loaded will create individual lines for each streamline[1]; an example solution is given in figure 2.

[1]NOTE: you may have to switch on different zones in Tecplot to view the streamlines

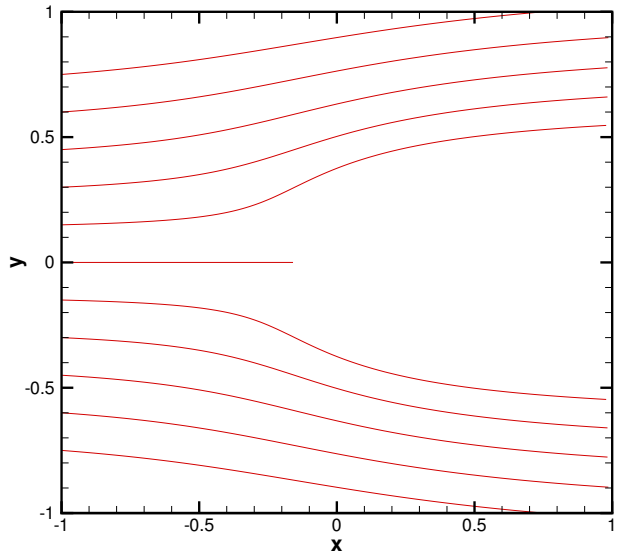


Figure 2: Example solution for 11 streamlines

3.3 Extension Exercise

Create a structured grid of data in x and y using 101 points in each direction (you should therefore have 10201 points in total). Ensure the points in each direction are uniformly spaced apart in $-1 \leq x, y \leq 1$. Extend your code to also evaluate the flowfield (equation 1) on all points in the structured grid; ensure you evaluate u, v and the velocity magnitude. Export u, v and the velocity magnitude to a Tecplot structured data file called `field.plt` such that when loaded into Tecplot will create a Cartesian plot of the data that allows the user to select which velocity component to plot. An example contour plot for the velocity magnitude is given in figure 3.

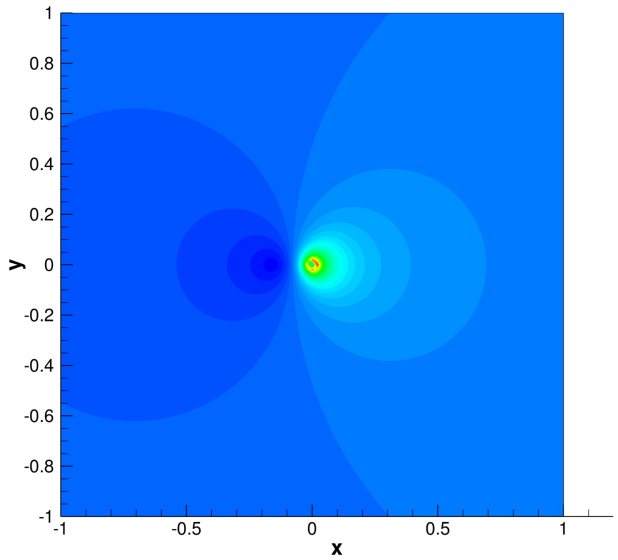
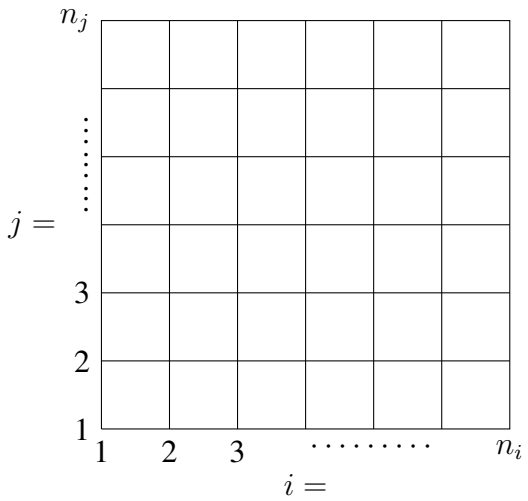


Figure 3: Example extension solution for field plotted with velocity magnitude

Appendix: Tecplot 2-D Structured Data Format

The format for a Tecplot formatted 2-D structured data set is as follows. The structured grid of data contains n_i points in the i direction (which in Cartesian format is the x direction), and n_j points in the j direction (which in Cartesian format is the y direction). An example structured grid with the suitable indexing is shown below.



If each point is defined by an x and y location, and if each point has some variable values associated with it (where these variable names are `v1` and `v2`) then the correct Tecplot format is (see lecture 5 for an example):

```
VARIABLES = "x" "y" "<v1>" "<v2>"
ZONE I=<ni> J=<nj> F=POINT
<x(1,1)>        <y(1,1)>        <v1(1,1)>       <v2(1,1)>
...
<x(ni,1)>       <y(ni,1)>       <v1(ni,1)>      <v2(ni,1)>
<x(1,2)>        <y(1,2)>        <v1(1,2)>       <v2(1,2)>
...
<x(ni,2)>       <y(ni,2)>       <v1(ni,2)>      <v2(ni,2)>
...
...
<x(1,nj)>       <y(1,nj)>       <v1(1,nj)>      <v2(1,nj)>
...
<x(ni,nj)>      <y(ni,nj)>      <v1(ni,nj)>     <v2(ni,nj)>
```