1 Assignment 2 - Panel Methods MCEN90018

This assignment should be done in groups of 2 students. Both students in the group will get the same mark for this assignment. If you choose to do the assignment alone, no concession will be given. Your assignment will be marked the same as an assignment done by two students. Assignment to be handed in by Friday 29th April 2016. There is minimal write-up, just a working code and figures, as requested below, and sufficient explanation such that I can follow your reasoning.

For this assignment, you are going to produce your own simple source panel code, and then modify this to the vortex panel technique. The report should be very short, including only figures and codes where requested.

1. Produce a panel code for solving an eight panel cylinder as shown in the set of notes. The cylinder has radius $a = 1$, and the background flow is horizontal from left to right with $U_\infty = 1$. Plot the colour contours of u fluctuation and streamlines starting from $x = -3$, $y = -2 : 0.25 : 2$. This first part should look very similar to figure 10 from these notes. Use different colours (i.e `colormap(hot)`) to reassure me that you have not cheated. Include your code in your report. **(10 Marks)**

2. Calculate the pressure coefficient C_p from the tangential velocity component at the midpoint of the 8 panels. Compare this to the theoretical solution. Again include your code. **(10 Marks)**

3. Repeat parts 1 and 2 for a 64 panel cylinder (include plots - but do not include code for this part). **(10 Marks)**

4. Modify your source panel code to calculate the flow around a cambered airfoil profile with coordinates produced via the Jowkowski transformation described in the box below. In this case $a = 1$, $c = 0.95$, $x_s = -0.0498$ and $y_s = 0.02$. The airfoil is to be implemented at an angle of attack of $^{+}10°$. Assume $U_\infty = 1$. Plot a similar figure to part 1. A colour contour plot of u with streamlines starting at x = 5, y = -3:0.3:3 and also one additional streamline that starts at the airfoil trailing edge. Set your color axis limits between 0.5 and 1.5. Set your axis limits $-5 < x < 5$ and $-3 < y < 3$. Use `colormap(jet)`

   (20 Marks)

```
axis([-5 5 -3 3])
caxis([0.5 1.5]
colormap(jet)
```

The coordinates of a Jowkowski airfoil can be obtained through three transformations applied to the complex coordinates of a circle with radius a.

Transformation 1 We shift the circle with radius a relative to a Jowkowski circle of radius c by the amounts x_s and y_s, such that the two circles intersect on the x axis (to obtain the sharp trailing edge cusp).

$$z_{cs} = z_c + x_s + iy_s$$

where x_s and y_s are the shifts in x and y respectively, and z_{cs} is the shifted circle z_c

Transformation 2 We apply the Joukowski transformation

$$z_j = z_{cs} + \frac{c^2}{z_{cs}}$$

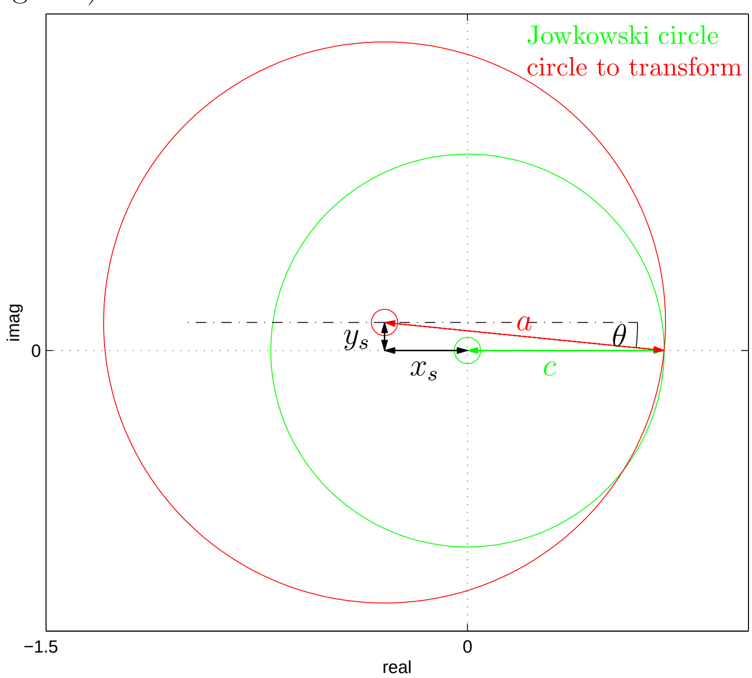
where z_j is the complex cordinates of the Jowkowski airfoil.

Transformation 2 We add the angle of attack α

$$z_j = z_j e^{-i\alpha}$$

where α is the angle of attack (*in radians!!!*)

TIP In order to have panel 1 start at the trailing edge, it is useful to define the first coordinate of the circle with radius a at the point of intersection with the Jowkowski circle (at angle -θ)



5. Modify your code to perform a vortex panel simulation of the same airfoil at the same angle of attack. Show a streamline that starts at the airfoil trailing edge to demonstrate that the Kutta condition has been satisfied. **(15 Marks)**

6. Discuss the limitations of the vortex panel method simulation of the airfoil. (for example when can we rely on such simulations to calculate lift and drag of airfoils? what is missing from this simulation?) **(10 Marks)**

7. **Bonus question - you can obtain an H1 grade without attempting this**. Compare the streamlines from the vortex panel method approach of question 6, to that obtained from the same Jowkowski transformation of the flow around a cylinder with circulation of strength $\Gamma = 4\pi U_\infty a \sin(\arcsin(\frac{y_s}{a}) + \alpha)$ **(15 Marks)**