EAE 127 Applied and Computational Aerodynamics

Project 4
Source Panel Method

Submit iPython Notebook as .ipynb file in 'Assignments' section on Smartsite. 'Run All' before uploading, and also include all data so that the code may be run if needed.
DUE: Monday 10/26/15 2:10pm

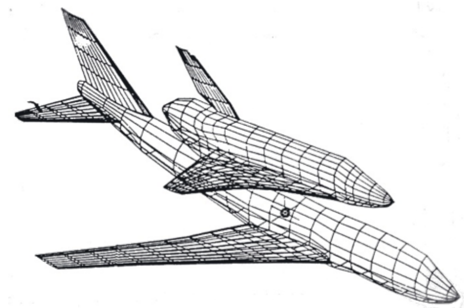

Fig. 1: 3D panel representation of the Shuttle Carrier Aircraft

1 Flow Over A Non-Rotating Cylinder

Solve flow over a non-rotating cylinder using source panel method (See AeroPython Lesson09). Discretize the cylinder into 8, 32, and 100 panels for three independent solutions to observe the effect of panel size distribution. Use the panel centers as the control points.

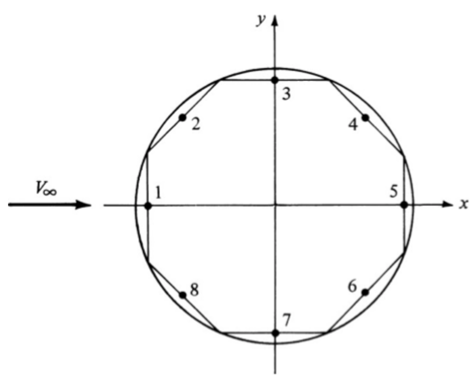

Fig. 2: Panel representation of cylinder

For each case, solve the flowfield around the cylinder in uniform flow and check that the resulting panel source distributions create a closed body according to Eqn 3.157 in Anderson. **On a single figure, plot surface pressure distribution as a function of** θ (Anderson Fig 3.43) for:

- Cylinders discretized with 8, 32 and 100 panels
- Non-rotating cylinder potential flow theory results (Anderson Eqn. 3.101)

Comment of the sensitivity of the solution to the number of panels used.

Plot the error in the cylinder surface pressure distribution compared to the analytic solution as a function of number of panels to quantify the effect of number of panels on accuracy. **Calculate the error** as the difference of the integrated areas of the surface pressure curves of the analytical and panel method solutions (Eqn 1).

$$Error = \int_0^{2\pi} C_{P,Analytic} \cdot d\theta_{Analytic} - \int_0^{2\pi} C_{P,Panel} \cdot d\theta_{Panel} \tag{1}$$

For the case with 32 panels, **additionally plot**:

- **Pressure contours** surrounding cylinder (plot coefficient of pressure)
- **Streamlines** surrounding cylinder

2 Symmetric Airfoil

Solve flow over a NACA 0017 airfoil using source panel method. Using 100 panels with control points at the centers of the panels, observe the effects of panel size distribution by plotting **(on the same plot) surface pressure distribution for**:

- Even panel spacing in the x-direction
- Panel size distributed according to x-spacing on a circle
- Inviscid XFOIL panel code results (provided)

For the uniform panel spacing model, **additionally plot**:

- **Pressure contours** surrounding airfoil
- **Streamlines** surrounding airfoil

Using the uniform panel spacing model, **integrate the surface pressure for solutions with increasing numbers of panels** to calculate the aerodynamic force coefficients C_l and C_d. **Plot the force coefficients against number of panels used** to determine the number of panels where the solution converges and **report this number**. **What should you expect the values of the force coefficients to be for truly invicid, symmetric flow**?

NOTE: For problems 1 and 2, use a freestream velocity $V_\infty = 1$

3 Quonset Hut

Calculate the lift force induced on a quanset hut (see Fig. 3) of radius $r = 20ft$ during a hurricane with wind velocities of $V_\infty = 100mph$ using potential flow panel methods. Assume that the wind is flowing parallel to the ground and that the cross-section of the structure is a half-circle. Even though we cannot simulate lifting flow with *source* panel method, we can calculate the pressure distribution over a non-rotating cylinder and then assume that the dividing streamline itself is a solid body (the ground). **Integrate the pressure distribution** over the top of the cylinder in the direction normal to the ground to calculate the lift force induced by the hurricane.

Fig. 3: Quonset hut: Half-cylindrical, sheet metal structure