AA 543 Winter 2017 HW#5

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1 Definition of problem

Solve numerically the 2D Euler equations for the transonic flow over a NACA 0012 airfoil using the Jameson scheme (Jameson et al., AIAA 1981).
The following conditions are given:

- Angle of attack $\alpha = 0\,\text{deg}$
- Free-stream Mach number $M_\infty = 0.85$

These further free-stream conditions are defined given an altitude of 10 km as per the Standard Atmosphere Table 1976.

- $\gamma \approx 1.4$
- Density $\rho_\infty = 0.414\ \text{kg/m}^3$
- Temperature $T_\infty = 223.3\ \text{K}$
- Pressure $p_\infty = 26.5\ \text{kPa}$
- Sound speed $c_\infty = \sqrt{\gamma \frac{p_\infty}{\rho_\infty}} = 299 \approx 300\ \text{m/2}$
- Velocity $|\vec{u}_\infty| = M_\infty c_\infty = 255\ \text{m/s}$.
  Therefore $u_\infty = |\vec{u}_\infty| \cos\alpha = 255\ \text{m/s}$ and $v_\infty = |\vec{u}_\infty| \sin\alpha = 0\ \text{m/s}$.
- Energy $E_\infty = e + \frac{|\vec{u}_\infty|^2}{2}$ where $e = \frac{p_\infty}{\rho_\infty(\gamma-1)}$. The free-steam energy is then $E_\infty = 193\ \text{J}$

2 Development of the numerical scheme

2.1 Grid

Grid created in Homework #3.
(Copy calcs for cell center point, area and cell wall normals from notes)

2.2 Normalization (??)

(Normalize to free-stream values?)

2.3 Initial conditions

Initial conditions will be the same as the free-stream values everywhere.

$$U_{i,j}^{0} = \begin{bmatrix} \rho_\infty \\ \rho_\infty u_\infty \\ \rho_\infty v_\infty \\ \rho_\infty E_\infty \end{bmatrix} \tag{1}$$

2.4 Boundary conditions

2.5 Spacial discretization of 2D Euler equations with Jameson scheme

(copy from notes)

2.6 Temporal discretization with Runge-Kutta 4 step time integration scheme

(copy from notes)

2.7 Determining convergence to steady state condition

3 Results & Analysis

3.1 Bonus

A Code

A.1 2d_eulerjameson.cc