Assignment #5: Compressible Aerodynamics   ME 515
due 4/6/2020 before midnight via Learning Suite   50 possible points

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Because of the time lost with COVID-19 logistics you only need to complete **1 of the following 2 problems**.

5.1 *Compressible CFD.* Analyze the RAE 2822 airfoil at the following conditions corresponding to Case 6 in this experimental data:

M_∞	0.725
α	2.92°
Re	6.5×10^6

The experimental setup fixes transition at 3% chord.

(a) Provide calculations and a brief rationale for selecting significant CFD parameters: domain size and type, prism layer height, first cell height in prism layer, number of layers in prism layer, freestream boundary conditions (pressure/temperature), number of cells or other measure of mesh refinement, and anything else you think would be important to help someone understand/reproduce your approach.

(b) Include several pictures of your mesh at different scales to demonstrate a quality mesh (e.g., near wall, transition from prism layers to outer mesh, near-body mesh, far-field domain).

(c) Compare your C_p distribution, which has been tabulated here for the experimental data.

(d) Compare your lift and drag. The experimental values for this case are $c_l = 0.743$, and $c_d = 0.0127$. Don't expect perfect agreement. Unlike a boundary layer, the shock location is generally not known a priori, and so capturing shock waves accurately is tricky without an adaptive mesh (see this paper for example—same airfoil but different freestream conditions).

5.2 *Supersonic Airfoils.* The main objective of this problem is to help you understand the range of validity of supersonic thin airfoil theory and the results provided by it. Consider a diamond-shaped airfoil with a maximum thickness-to-chord ratios of 5% at a freestream Mach number of $M_\infty = 2.0$. Using *both* Supersonic Thin Airfoil theory *and* Shock-Expansion Theory (where you use the actual $\theta - \beta - M$ diagram/formulae for oblique shocks and Prandtl-Meyer expansion fans), answer the following questions and compare the results from both theories.

(a) Compare the lift coefficient, drag coefficient, and moment coefficient about the leading edge versus angle of attack for both methods across a *reasonable* operating range. You should have three plots (lift, drag, moment).

(b) What is the predicted lift curve slope and how does it compare to subsonic thin airfoil theory?

(c) Where is the predicted aerodynamic center, and how does that compare to subsonic thin airfoil theory?

(d) Discuss any differences you find between supersonic thin airfoil theory and shockwave theory.