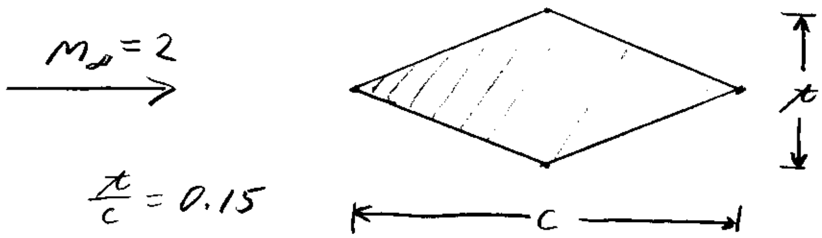
AE 6042 Computational Fluid Dynamics

Assignment # 1

Note: Please show your work.

1) Consider $M_\infty = 2.0$ flow of air around the 15% thick diamond airfoil shown. Is the Full Potential Equation valid at any location in the surrounding flow? Fully explain your answer.



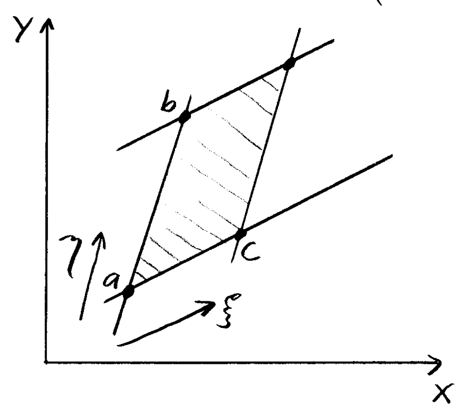
2) The Thompson scheme for generating grids is based on equations 10.21 and 10.22 in the textbook. Starting from the following equations used to define the grid:

$$\nabla^2 x = 0$$

$$\nabla^2 y = 0$$

derive equations 10.22. In your derivation of equations 10.22, you will need to use equations 10.21 which define the control terms P and Q.

3) Show that for the parallelogram-shaped grid cell enclosed by $\overline{ac}$ and $\overline{ab}$ the cell area is equal to $1/J$ for the 2-D generalized transformation (assume $\Delta\xi = \Delta\eta = 1$).



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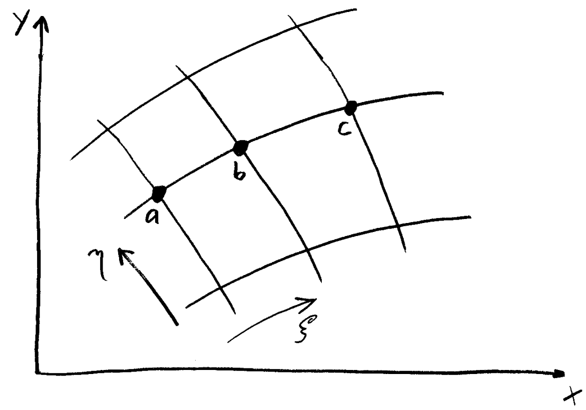
4) In class it was mentioned that the inverse metrics (e.g. $x_\xi, x_\eta, y_\xi, y_\eta$) could be obtained from finite difference approximations for these derivatives. For example, if we want to find x_ξ at point b in the grid we can use

$$(x_\xi)_b = \left(\frac{\partial x}{\partial \xi}\right)_b \approx \frac{x_c - x_a}{\xi_c - \xi_a}$$



However, we do not use finite difference approximations to find the grid metrics (e.g. $\xi_x, \xi_y, \eta_x, \eta_y$) we do not use finite difference approximations for these derivatives. Explain why we do not use approximations like

$$(\xi_x)_b = \left(\frac{\partial \xi}{\partial x}\right)_b \approx \frac{\xi_c - \xi_a}{x_c - x_a}$$

to obtain the grid metrics.

5) Complete Problem 5.37 in the textbook.