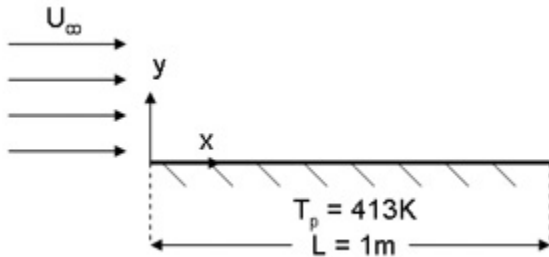# FLUENT - Forced Convection over a Flat Plate- Problem Specification

Author: Rajesh Bhaskaran, Cornell University

Problem Specification
1. Create Geometry in GAMBIT
2. Mesh Geometry in GAMBIT
3. Specify Boundary Types in GAMBIT
4. Set Up Problem in FLUENT
5. Solve
6. Analyze Results
7. Refine Mesh

Problem Specification

In our problem, we have a flat plate at a constant temperature of 413K. The plate is infinitely wide. The velocity profile of the fluid is uniform at the point x = 0. The free stream temperature of the fluid is 353K. The assumption of incompressible flow becomes invalid increasingly less valid for larger temperature differences between the plate and freestream. Because of this, we will treat this as a compressible flow. We will analyze a fluid flow with the following non-dimensional conditions:

$$Re_L = 1.5e6 \qquad Pr = 0.71$$

In order to achieve these flow conditions, we will use these free stream flow conditions:

$$U_\infty = 1 \text{ m/s}$$
$$\mu = 6.667e\text{-}7 \text{ kg/(m·s)}$$
$$k = 9.4505e\text{-}4 \text{ W/(m·K)}$$
$$C_p = 1006.43 \text{ J/(kg·K)}$$
$$T_\infty = 353K$$
$$P_\infty = 101325 \text{ Pa}$$

According to the ideal gas law, this temperature and pressure result in the following freestream density:

$$\rho_\infty = \frac{P_\infty}{RT_\infty} = \frac{101325Pa}{\left(287\dfrac{J}{kg\ K}\right)(353K)} = 1.00 kg/m^3$$

These flow conditions do not necessarily represent a realistic fluid. Rather, they are chosen to provide the Prandtl and Reynolds numbers specified above. This will make calculations simpler throughout this tutorial.

Solve this problem in FLUENT. Validate the solution by plotting the y+ values at the plate. Also plot the velocity profile at x = 1m. Then plot Reynolds Number vs. Nusselt Number. Compare the accuracy of your results from FLUENT with empirical correlations.

Preliminary Analysis

We expect the turbulent boundary layer to grow along the plate. As the boundary layer grows in thickness, the rate of heat transfer (q'') and thus the heat transfer coefficient (h) will decrease.

$$q_x'' = h_x(T_{plate} - T_\infty)$$
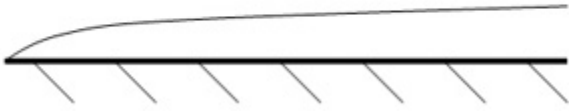
We will compare the numerical results with experimentally-derived heat transfer correlations. We will create the geometry and mesh in GAMBIT, read the mesh into FLUENT, and solve the flow problem.

Go to Step 1: Create Geometry in GAMBIT

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