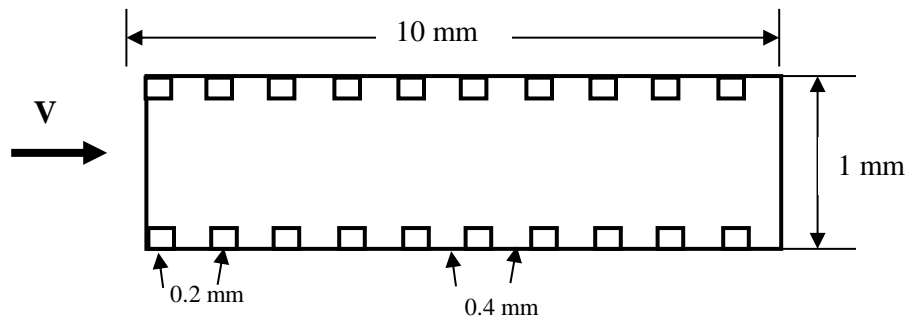


### Electronic Cooling

a) For a duct, assume that there are rectangular roughness elements with a width of 0.2 mm and a height of 0.1 mm mounted on the duct walls with a spacing of 0.4 mm. Evaluate the flow fields for the inlet velocities of 0.01 and 0.1 m/s.



b) Assume that the elements are at a temperature of 50 °C, and the air at the inlet is at 20 °C. Evaluate the temperature field for different flow rates. Also, evaluate the net heat flux and the effective Nusselt number.

c) For the duct with and without roughness elements, assume that the airflow starts at time zero and find the unsteady airflow velocity and the temperature field. Assume that initially, there is no flow and the air temperature is at 50 °C. For the duct without roughness, compare your solution with the exact solution.

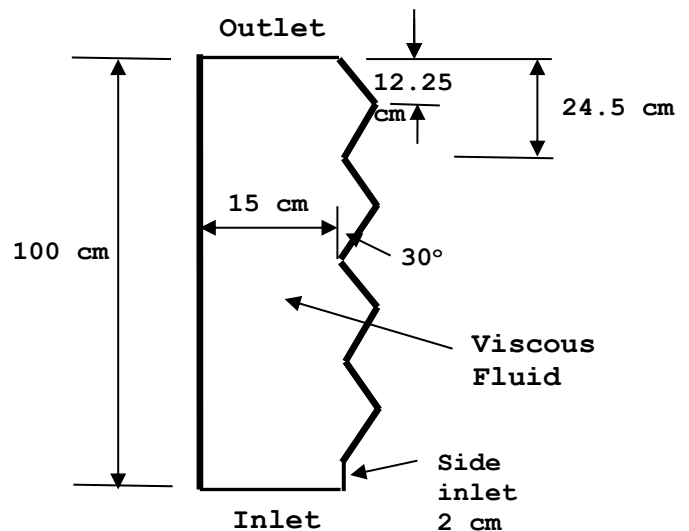
### Flow and Bubbly Flow in a Rough Duct

a) For an asymmetric duct, as shown in the figure, study flows of Newtonian and non-Newtonian (power-law) fluids. Assume that the velocity at the bottom inlet is  $V=0.01$  m/s, and the side inlet has zero velocity. Evaluate the velocity profile and pressure drop across the duct.

b) Repeat part a) when air is injected from the side inlet at a speed of 0.01 m/s. Use the VOF method and consider the cases where

b) The liquid flow velocity is zero.

a) The liquid flow velocity is 0.01 m/s.



### Applications of Computational Modeling to Your Thesis

If you are already familiar with using the Ansys-Fluent code, you can propose a project to apply CFD to your thesis instead of the Part 1 Project.

### Similarity Solution (MATLAB)

Boundary layer flow over a wedge in similarity form reduces to the Falkner-Skan equation given as

$$f''' + ff'' + \beta(1-f'^2) = 0.$$

Here,  $\beta$  is the angle of the wedge and is given as

$$\beta = 2m/(m+1)$$

(The velocity of the outer potential flow is given as  $U \propto x^m$ .)

The boundary conditions are

$$\begin{array}{lll} \text{At} & \eta = 0, & f = 0, \quad f' = 0. \\ \text{At} & \eta = \infty, & f' = 1. \end{array}$$

Use the values of  $m = 0$ ,  $m = 1$ , and  $m = 4$ , and plot  $f$ ,  $f'$ , and  $f''$  versus  $\eta$ .

For  $m=0$ , compare the results with those obtained from ANSYS-fluent code and the exact solution.

### Boundary Layer Flow (ANSYS-Fluent)

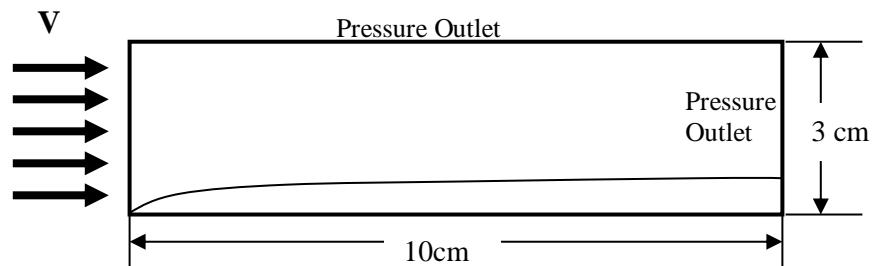
Evaluate the boundary layer flow over a flat plate. The boundary conditions for the top surface and the outlet are pressure outlets.

Determine the features of the boundary layer velocity profile for the case of laminar flow and evaluate the velocity contours,

velocity profiles, boundary layer thickness as a function of distance, and  $C_f$  and  $C_D$ .

Use an inlet velocity of 0.02 m/s and assume the flow is laminar.

Compare your findings with the theoretical predictions.



**Report and Due Dates:** The hard copies of the project reports should be submitted.

Also, the electronic copies of the report and the programs, including FLUENT CAS and DAT files, figures, and the discussion of the results, should be submitted to Moodle. The due date for **Parts 1 and 2** is **December 2, 2025**.

## **Guideline for Technical Report Writing**

### ***First page:***

**Title of the project**

**Names of the authors and their affiliations**

### **Abstract**

Describe what is in the report, the key points, and the significant findings.

### ***Second Page***

#### **Introduction**

Introduce the topic and give the background. Review the related works. Describe the gaps in the literature and set the stage for this work. Also, give a summary of the main findings.

#### **Technical Report**

Formulation or Experimental setup

Experimental procedure

Results and Discussion

Note that all equations should be numbered consecutively. In addition, all assumptions should be stated clearly.

Note that all figures need to be numbered consecutively, and each figure should be discussed.

#### **Conclusions**

State the conclusions of the study.

#### **References**

All references should be listed. All listed references should be referred to in the text.

Make sure to keep the same style in the references. References are given either by year or are numbered. For example,

Smith, J.D. (2000). Title of the paper. Journal of Probabilistic Mechanics, Vol. 4, pp. 345-356.

1. Smith, J.D., Title of the paper. Journal of Probabilistic Mechanics, Vol. 4, pp. 345-356 (2000).