Abdelhafid Boussouf University – Mila
Institute of Science & Technology
Process Engineering – L3
Heat Transfer – UEF 3.1.1

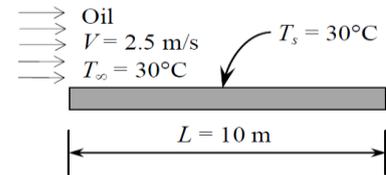Academic year: **2025-2026**   Instructor: **Dr. Mohamed Bouti**

In-Class Exercises n°03

Exercise 3.1

Engine oil at **80°C** flows over a **10-m-long** flat plate whose temperature is **30°C** with a velocity of **2.5 m/s**. Determine the **total drag force** (F_D) and the **rate of heat transfer** (q_v) over the entire plate per unit width.

(Figure 3.1)

Exercise 3.2

Hydrogen at **15 °C** and a pressure of **1 atm** is flowing along a flat plate at a velocity of **3 m/s**. If the plate is **0.3 m** wide and at **71 °C**,

1) Determine the regime flow of hydrogen over the flat plate?
2) Sketch a representative scheme.

   Calculate the following quantities at $x = 0.3\ m$:

3) hydrodynamic boundary layer thickness (δ), in cm,
4) thickness of thermal boundary layer (δ_T), in cm,
5) local friction coefficient ($C_{f,x}$), dimensionless,
6) average friction coefficient ($\overline{C_f}$), dimensionless,
7) drag force (F_D), in N,
8) local convection heat transfer coefficient (h_x), in **W/m²•K**,
9) average convection heat transfer coefficient ($\overline{h}$), in **W/m²•K**, and
10) rate of heat transfer (q), in **W**.

Exercise 3.3

A new heat transfer fluid called *ThermoKool* (**k = 0.1414 W/m.°C, ρ = 867 kg/m³, μ = 0.06108 kg/m.s, Pr = 1551**) flows over a flat plate with a velocity of **U∞ = 2.5 m/s** and temperature **T∞ = 80 °C**. The plate is maintained at **Ts = 30 °C**. Dimensions are shown in the figure.
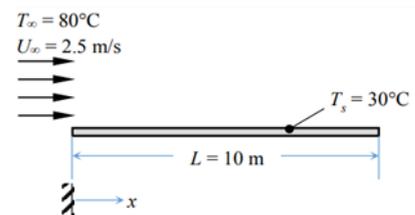
1) Determine if the flow is entirely laminar, entirely turbulent, or whether it transitions somewhere along the plate.

2) Find the total rate of heat transfer per unit width from the *ThermoKool* to the plate.

Correlation	Geometry	Conditions
$Nu_x = 0{,}332.Re^{1/2}.Pr^{1/3}$		local, laminar ; $Pr \geq 0.6$
$Nu_L = 0{,}664.Re_L^{1/2}.Pr^{1/3}$		average, laminar ; $Pr \geq 0.6$
$Nu_x = 0{,}0296.Re^{0,8}.Pr^{1/3}$	Flat plate	local, turbulent ; $100 > Pr > 0.6$, $Re_x > 500\ 000$
$Nu_L = 0{,}037.Re_L^{0,8}.Pr^{1/3}$		average, turbulent ; $100 > Pr > 0.6$; $Re_L > 500\ 000$
$\overline{Nu_L} = (0{,}037.Re_L^{0,8} - 871).Pr^{1/3}$		average, mixed ; $100 > Pr > 0.6$, $Re_{x,\ cr} = 500\ 000$; Re_L $\leq 10^8$; $0{,}6 \leq Pr \leq 60$