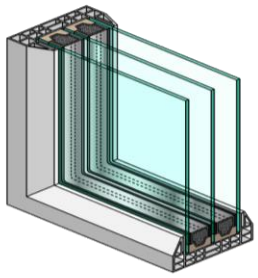
Abd El HafidBoussouf University Center – Mila
Institute of Science and Technology
Process Engineering

January 2023

Heat Transfer Final Exam

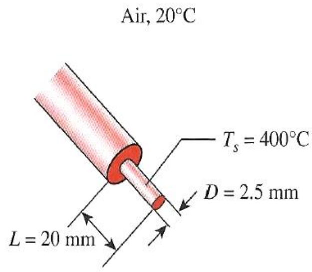
Closed Notes, DO NOT Write on this Sheet, Show All Work

Problem 1 (3 marks):



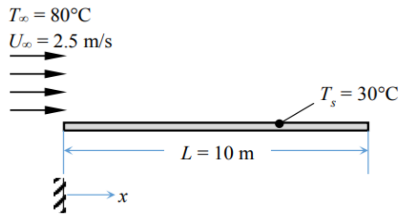
Consider a **1.5-m-high** and **2-m-wide** triple pane window. The thickness of each glass layer (**k_{glass}= 0.80 W/m.K**) is **0.5 cm**, and the thickness of each air space (**k_{air} = 0.025 W/m.K**) is **1 cm**. If the inner and outer surface temperatures of the window are **10 ºC** and **0 ºC**, respectively, find the rate of heat loss through the window.

Problem 2 (3 marks):



A soldering iron has a cylindrical tip of **2.5 mm** in diameter and **20 mm** in length. With age and usage, the tip has oxidized and has an emissivity of **0.80**. Assuming that the average convection heat transfer coefficient over the soldering iron tip is **25 W/m^2.K**, and the surrounding air temperature is **20 ºC**, determine the power required to maintain the tip at **400 ºC**.

Problem 3 (4 points):



A new heat transfer fluid called *ThermoKool* (**k = 0.1414 W/m.°C**, **ρ = 867 kg/m^3**, **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 **T_s = 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
$Nu_x = 0{,}332.Re^{1/2}.Pr^{1/3}$	Flat plate	local, laminar ; $Pr \geq 0.6$
$Nu_L = 0{,}664.{Re_L}^{1/2}.Pr^{1/3}$		average, laminar ; $Pr \geq 0.6$
$Nu_x = 0{,}0296.Re^{0,8}.Pr^{1/3}$		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 ; $100 > Pr > 0.6$, $Re_{x,\,cr} = 500\,000$; $Re_L \leq 10^8$; $0{,}6 \leq Pr \leq 60$

Problem 4 (10 points):

Consider a pipe of length **L = 17 m**, inner radius **r_1 = 15 cm**, outer radius **r_2 = 20 cm**, and thermal conductivity **k = 14 W/m.K**. Heat is generated in the pipe wall material uniformly at a rate of ($\dot{e}_{gen} = 4,28.10^6\ (\frac{W}{m^3})$). The inner and outer surfaces of the pipe are held at **T_1 = 60 ºC** and **T_2 = 200 ºC**, respectively. Obtain a general relation for the temperature distribution inside the pipe under steady conditions, and determine the temperature of the pipe wall at a radius of **r = 17.5 cm**.

CONSERVATION OF ENERGY EQUATION:

Cylindrical Coordinate System:

$$\frac{1}{r}\frac{\partial}{\partial r}\left(kr\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial}{\partial \phi}\left(k\frac{\partial T}{\partial \phi}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right) + \dot{e}_{gen} = \rho C\frac{\partial T}{\partial t}$$