Quiz # 2 (Full marks: 20) **Time: 20 minutes** **Nov 02, 2020**

1. Fill in the blanks with appropriate word(s). (6)

   Fluid in motion comes to a complete (i)_____ at the surface (**no-slip condition**). The motionless layer adjacent to the surface (ii)_____ _____the neighboring fluid layer as a result of friction and causes the development of the (iii)_____ _____. The flow region adjacent to the surface where the viscous effects (and thus the velocity gradients) are (iv)_____ is called the **velocity boundary layer.** The fluid layer in contact with the surface tries to (v)_____ the plate exerting a ***friction force*** on it. Friction force per unit area is the **shear stress (τ).** Experiments indicate that the shear stress for most fluids is proportional to the (vi)_____ _____.

2. What is a Newtonian fluid? Give at least two examples. (3)

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr
			Engine Oil (unused)				
0	899.0	1797	0.1469	9.097×10^{-8}	3.814	4.242×10^{-3}	46,636
20	888.1	1881	0.1450	8.680×10^{-8}	0.8374	9.429×10^{-4}	10,863
40	876.0	1964	0.1444	8.391×10^{-8}	0.2177	2.485×10^{-4}	2,962
60	863.9	2048	0.1404	7.934×10^{-8}	0.07399	8.565×10^{-5}	1,080
80	852.0	2132	0.1380	7.599×10^{-8}	0.03232	3.794×10^{-5}	499.3

Flow over an isothermal flat plate

Parameter	Laminar flow $Re_x < 5 \times 10^5$	Turbulent Flow $5 \times 10^5 \le Re_x \le 10^7$
Local Friction Coefficient, $C_{f,x}$	$C_{f,x} = \frac{0.664}{Re_x^{1/2}}$	$C_{f,x} = \frac{0.059}{Re_x^{1/5}}$
Local Convection Coefficient, Nu_x	$Nu_x = 0.332\, Re_x^{1/2} Pr^{1/3}$ For $Pr > 0.6$	$Nu_x = 0.0296\, Re_x^{0.8} Pr^{1/3}$ For $0.6 \le Pr \le 60$

Parameter	Laminar flow $Re_x < 5 \times 10^5$	Turbulent Flow $5 \times 10^5 \le Re_x \le 10^7$
Average Friction Coefficient, C_f	$C_f = \frac{1.33}{Re_L^{1/2}}$	$C_f = \frac{0.074}{Re_L^{1/5}}$
Avg. Convection Coefficient, Nu	$Nu = 0.664\, Re_L^{1/2} Pr^{1/3}$ For $Pr > 0.6$	$Nu = 0.037\, Re_L^{0.8} Pr^{1/3}$ For $0.6 \le Pr \le 60$

Fluid properties are taken at film temperature: $T_f = (T_s + T_\infty)/2$

3. Consider a flow over a flat plate. Draw an elemental 2D fluid element and show all force components. Also state the assumptions for this. (4)

4. Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate. (7)