國立中央大學108學年度碩士班考試入學試題

所別：機械工程學系 碩士班 熱流組(一般生)

科目：流體力學及熱傳學

本科考試可使用計算器，廠牌、功能不拘

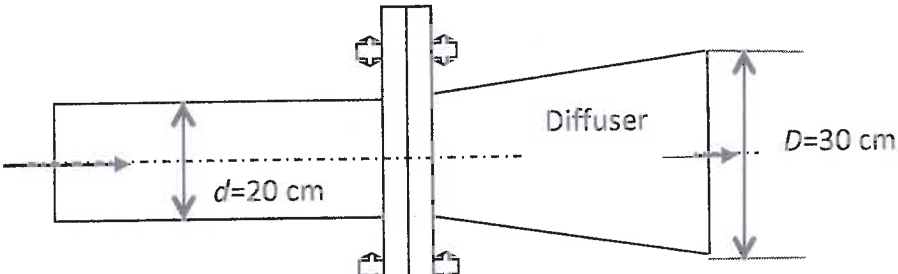
計算題及問答題 *計算題需計算過程

Fluid Mechanics

1. Water (density of 1000 kg/m^3) is flowing through a pipe (diameter 20 cm) to a diffuser with diameter of 30 cm, at a rate of 0.15 m^3/s. The diffuser is bolted to the water pipe. Assume the flow is steady and incompressible with negligible frictional effects, please determine:

(a) Water velocities in the pipe, and the outlet of the diffuser. (10%);

(b) The force exerted on the bolts due to the water flow. (15%)



2. Consider a steady, incompressible, Newtonian fluid flow of the density ρ and the viscosity μ through a long, horizontal section of round pipe diameter D, in which the average speed is V across all the pipe section. Because of the frictional forces between the fluid and the pipe wall, there exist a shear stress τ_w on the wall. Here a constant average roughness height of ε in the inside pipe wall is assumed.

(a) Please use the dimensional analysis to prove the Darcy friction factor $f = 8\tau_w/\rho V^2$ as a function of two dimensionless parameters, i.e. $f = \phi(Re, \varepsilon/D)$. (10%)

(b) Air under standard condition flows through a 4.0 mm diameter drawn tubing with an average velocity of V = 50 m/s. For such conditions the flow would normally be turbulent. Please determine the value of the Reynolds number. (5%) Also, what is the major head loss h_L in a 0.1 m section of the tube (unit: meter). (10%) (Hint: The density and the viscosity of the air are ρ = 1.23 kg/m^3 and μ = 1.79 x 10^{-5} N·s/m^2. The roughness of the pipe ε = 0.0015 mm. The friction factor can be found from the Moody chart below).

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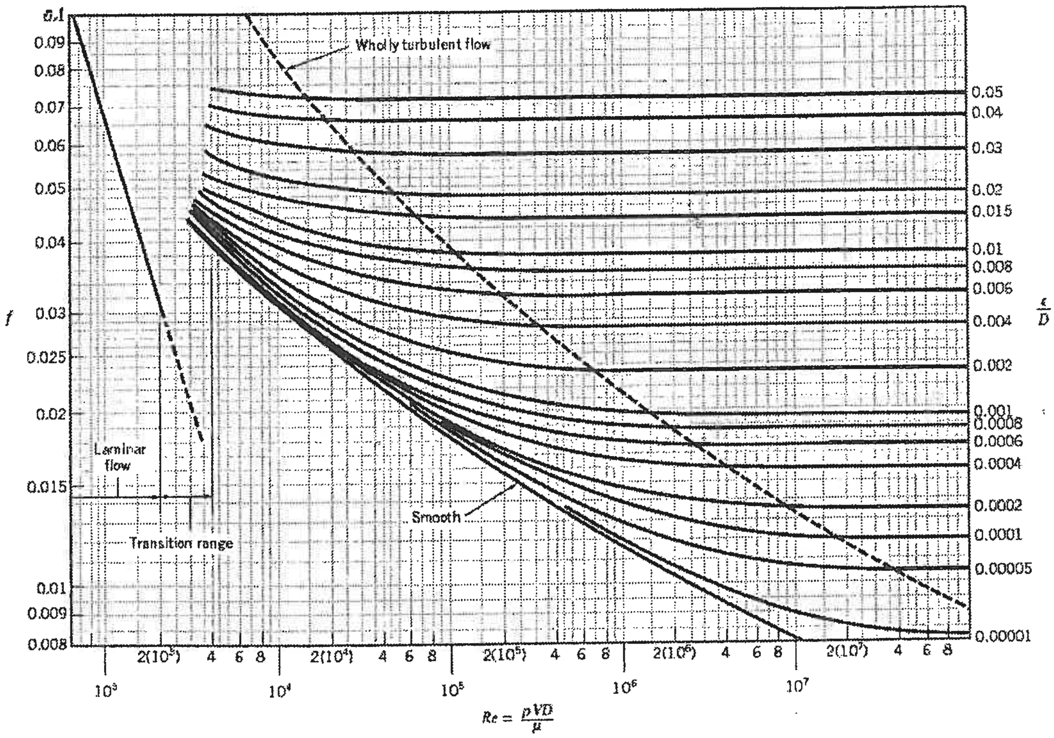
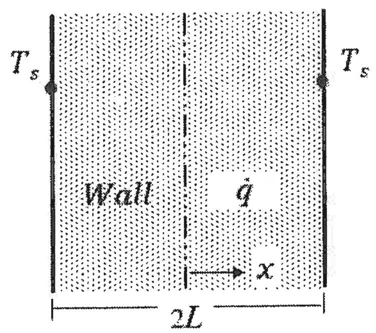


3. Heat conduction.

(a) For a distribution of heat sink $\dot{q} = -\cos\,(\pi x/2L)$ with a common surface temperature T_s, solve the steady-state temperature and the heat flux across the plane wall. Clearly define your variables and parameters, and write down your assumptions. (10%)

(b) Draw the temperature and heat flux profiles across the plane wall. (5%)



4. Heat radiation.

Because there is no atmosphere and therefore no convection in outer space, radiation dominates the heat transfer. Write down the equation and solve it for the body temperature evolution of a space man in the outer space using the lump capacitance method. Clearly define your variables and parameters, and write down your assumptions. (10%)

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5. Heat Convection

(1) For flow through a circular tube with diameter d, if flow rate is constant, what are the values of n1 to n5? (10%)

Laminar	$c_f \sim d^{n1}$	$Nu \sim d^{n1}$	$h_x \sim d^{n2}$
Turbulent	$c_f \sim d^{n3}$	$Nu \sim d^{n4}$	$h_x \sim d^{n5}$

(2) Air at temperature of 300 K and velocity of 4.0 m/s flows over a heating surface at temperature of 350 K. The length and width of the plate are 2.0 m and 1.0 m respectively.

(a) Please calculate the local heat transfer coefficient at the midpoint (x=1.0 m) of the flow path on the plate. (5%)

(b) Please calculate the total heat transfer rate over the entire plate. (10%)

Air properties and useful equations are listed below.

Temperature (K)	ρ (kg/m³)	c_p (kJ/kg K)	μ (Ns/m²)	k (W/mK)	Pr
250	1.3947	1.006	15.96×10^{-6}	0.0223	.720
300	1.1614	1.007	18.46×10^{-6}	0.0263	.707
350	.9950	1.009	20.82×10^{-6}	0.0300	.700
400	.8711	1.014	23.01×10^{-6}	0.0338	.690

$Nu = 4.36$ for $q'' = $ constant

$Nu = 3.66$ for $T_w = $ constant

$Nu = 0.332\, Re^{1/2} Pr^{1/3}$

$Nu = 0.0296\, Re^{4/5} Pr^{1/3}$

$Nu = 0.023\, Re^{4/5} Pr^{n}$, where n = 0.3 for cooling, n = 0.4 for heating

$Nu = 0.023\, Re^{4/5} Pr^{1/3}$,