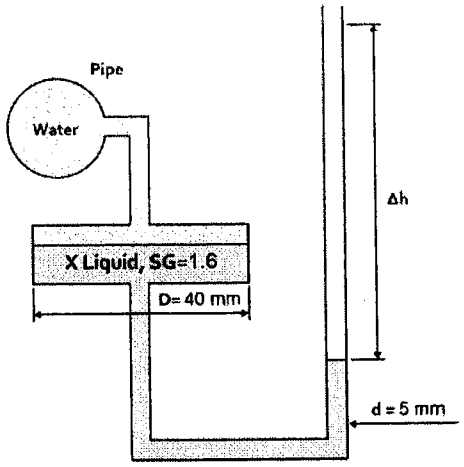
國立中央大學 110 學年度碩士班考試入學試題

所別： 機械工程學系 碩士班 熱流組(一般生)　　共 2 頁　第 1 頁

科目： 流體力學及熱傳學

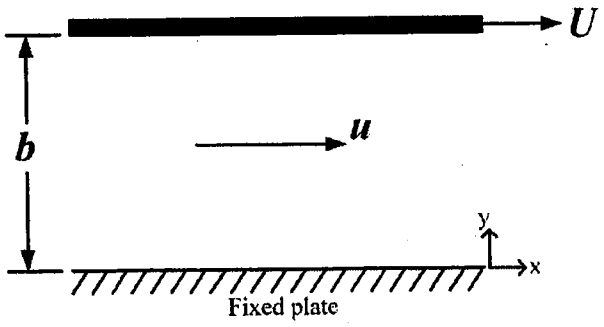
本科考試可使用計算器，廠牌、功能不拘　　＊請在答案卷(卡)內作答

1. 如圖所示系統可用來量測水槽壓力之增加值Δp，試問：當系統其 X Liquid 液面高度上升 80 mm （Δh = 80 mm）時，水槽壓力改變量 Δp 為何？ (25%)



2. Two horizontal, infinite, parallel plates are spaced a distance b apart, please see the following figure. A viscous liquid is contained between the plates. The bottom plate is fixed (y = 0), and the upper plate (y = b) moves parallel to the bottom plate with a velocity U. Because of the no-slip boundary condition, the liquid motion is caused by the liquid being dragged along by the moving boundary. Assuming that there is no pressure gradient in the direction of flow (x-direction) and the flow is steady and incompressible without the y-component velocity. (a) Derive the governing equation of the above 2-D flow from the x-direction Navier–Stokes equation (see below). (b) Determine the velocity distribution between the plates. (c) Determine an expression for the flowrate per unit width passing between the plates. Express your answers of (b) and (c) in terms of b and U. (25%)

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)\ (x \text{ direction})$$



3. A hot solid cube (having sides of equal length) of temperature T_{c0} is put into a pot containing cold water of temperature T_{w0}. Assume that the heat exchange only occurs between the cube and water. (20%)

(a) Write down the equation for determining the final equilibrium temperature.
(b) Assuming both the cube and water keep spatially uniform in temperature, write down the equation for evaluating the temperature evolution for the cube and water, respectively.
(c) Consider the cube is not spatially uniform in temperature but the water is. Write down the equation and boundary conditions for evaluating the temperature distribution in the cube.
(d) Consider neither the cube nor the water keeps uniform in temperature. Write down the equation and boundary conditions for evaluating the temperature distribution in the water.

注意：背面有試題

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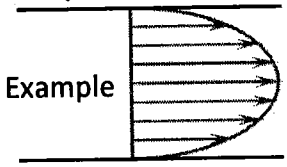
4. The net radiative heat flux at the surface of an opaque medium can be evaluated using the following equation if the absorptivity of the medium is equal to its emissivity

$$q'' = \frac{\varepsilon}{1-\varepsilon}(\sigma T_s^4 - J)$$

where ε is the emissivity, σ the Stefan-Boltzmann constant, T_s the surface temperature and J the radiosity. This equation seems to predict a very large radiative heat flux for a blackbody that has $\varepsilon = 1$. Please explain. (5%)

5. What are the definitions of the following terms? (10%)
(a) Friction coefficient; (b) Biot number; (c) Stanton number; (d) Nusselt number; (e) Prandtl number. [Example]: Reynolds number, $Re_D = \rho uD/\mu$, where r: fluid density, u: flow velocity, D: tube diameter, and μ: fluid viscosity.

6. Please sketch the velocity and temperature profiles of laminar and turbulent flows in a circular tube by following the format of the example. (6%)



Laminar velocity | Turbulent velocity | Laminar Temperature $T_w > T_m$ | Turbulent Temperature $T_w > T_m$

7. Water at temperature of 300 K and velocity of 0.3 m/s flows over a heating surface at temperature of 350 K. The length and width of the plate are 1.0 m and 0.2 m respectively. (total: 9%)

(a) What temperature should you use for evaluating the fluid properties? (2%)

(b) Is it a laminar flow or turbulent flow at the midpoint (x=0.5 m)? (2%)

(c) Please calculate the local heat transfer coefficient at the midpoint (x=0.5 m) of the flow. (5%)

Water properties and useful equations are listed below:

Temperature (K)	ρ (kg/m³)	c_p (kJ/kg·K)	μ (N·s/m²)	k (W/m·K)	Pressure (kPa)
290	999.0	4.184	$1{,}080 \times 10^{-6}$	0.598	1.917
310	993.0	4.178	695×10^{-6}	0.628	6.221
330	984.3	4.184	489×10^{-6}	0.650	17.19
350	937.7	4.195	365×10^{-6}	0.668	41.63
370	960.6	4.214	289×10^{-6}	0.679	90.40
390	945.2	4.239	237×10^{-6}	0.686	179.4

Nu = 4.36 for q" = constant

Nu = 3.66 for T_w = constant

$Nu = 0.332 Re^{0.5} Pr^{1/3}$

$Nu = 0.0296 Re^{0.8} Pr^{1/3}$

$Nu = 0.023 Re^{0.8} Pr^{n}$, where n = 0.3 for cooling, n = 0.4 for heating

$Nu = 0.023 Re^{0.8} Pr^{1/3}$

$$Nu = 0.027 Re^{0.8} Pr^{1/3} \left(\frac{\mu}{\mu_s}\right)^{0.14}$$

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