國立臺灣科技大學 112 學年度碩士班招生試題

系所組別：機械工程系碩士班丙組
科　　目：熱力與流力

（ 總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分 ）

1. (20%) Please answer the following questions:

   (1) (2%) Calculate the gas constant for an ideal gas with the following properties as:
   - specific heat at constant volume $C_V = 0.168$ kcal/kg · K, and
   - ratio of specific heat $\gamma = 1.40$.

   (2) (2%) Write down the definitions for the dew-point temperature. Also, when are dry-bulb and dew-point temperatures identical?

   (3) (2%) For a specified compression ratio, is Diesel cycle or Otto cycle more efficient? Explain your answer in brief.

   (4) (2%) For an ideal gas undergoing an isothermal expansion process at 60℃, please calculate the changes of internal energy and enthalpy when its volume expands from 15 to 50 m^3.

   (5) (2%) Three cycles (Stirling cycle, Ericsson cycle, and Carnot cycle) operate under the same temperature limit. Please evaluate which cycle can deliver the highest efficiency. State the reasons for your answer.

   (6) (2%) A perfect fitting pot and its lid often stick after cooking (heat addition), and it becomes very difficult to open the lid when the pot cools down. Explain why this happens and what you should do to open the lid.

   (7) (2%) What are point and path functions? Give one example for each function.

   (8) (2%) For a cycle, is the net work necessarily zero? For what kind of systems will this be the case?

   (9) (2%) What is the zeroth law of thermodynamics?

   (10) (2%) Show that for polytropic process, what is the boundary work? (2: the final state, 1: the initial state.) For an ideal gas under constant-temperature (isothermal) process, how is the boundary work?
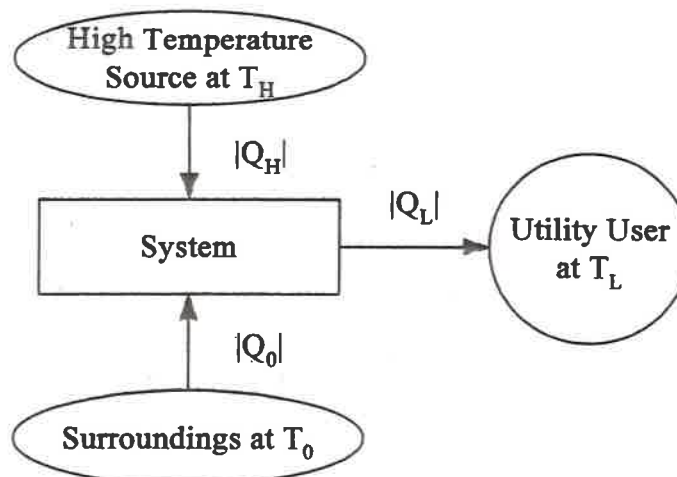
(總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分)

2. (12%) Regarding the first and the second laws of thermodynamics, please answer the followings:

(1) (4%) Write down mathematic expressions of the 1st law of thermodynamics for both closed and SSSF (steady state, steady flow) systems. Also, state the corresponding physical meaning for each term.

(2) (4%) Please derive the Gibbs equation (or Tds relation) via the combination of entropy definition and the 1st laws of thermodynamics. Note that you should list all the assumptions made during the derivation process.

(3) (4%) Please derive the equation of entropy change for an ideal gas with constant specific heat.

3. (8%) A system undergoes a cycle while receiving $|Q_0|$ from the surroundings at temperature T_0, $|Q_H|$ from a high temperature source at temperature T_H as shown schematically below. The system delivers energy $|Q_L|$ to a utility user at temperature T_L. Determine the maximum theoretical value of $|Q_L|$ when $T_H = 1200$ K, $T_0 = 300$ K, $T_L = 600$ K, and $|Q_H| = 30$ kJ.
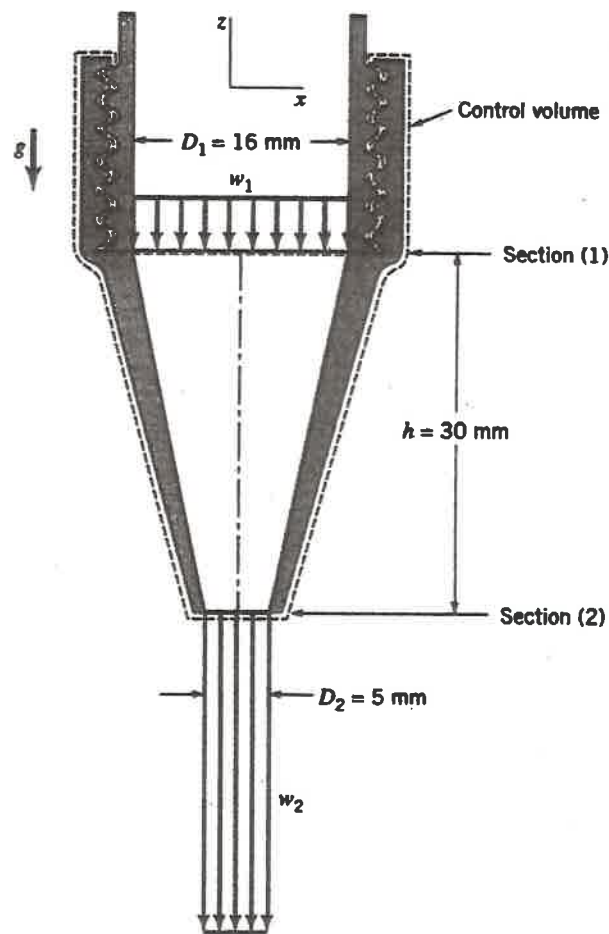
（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分 ）

4. (15%) As shown in the below figure, water (ρ = 999 kg/m³) flows through a nozzle attached to the end of a sink faucet with a flowrate of 6×10^{-4} m³/s. The nozzle inlet and exit diameters are 16 mm and 5 mm, respectively, and the nozzle axis is vertical. The mass of the nozzle is 0.1 kg, and the mass of the water in the nozzle is 3×10^{-3} kg. The pressure at section (1) is 464 kPa. Determine the anchoring force required to hold the nozzle in place.

$$\frac{\partial}{\partial t}\int_{cv} \mathbf{V}\rho \, d\Psi + \int_{cs} \mathbf{V}\rho\mathbf{V}\cdot\hat{\mathbf{n}} \, dA = \sum \mathbf{F}_{\substack{\text{contents of the}\\\text{control volume}}}$$
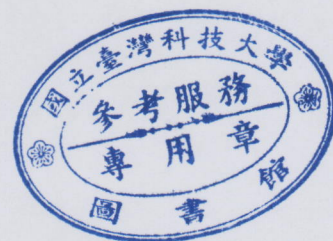
（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分）

5. (15%) Consider flow between the two horizontal, infinite parallel plates as shown in the figure below. Assume steady, incompressible, fully developed flow, no-slip condition, and treat the pressure gradient, dp/dx, as constant. Please derive the velocity profile, $u(y)$ and show your steps in detail.
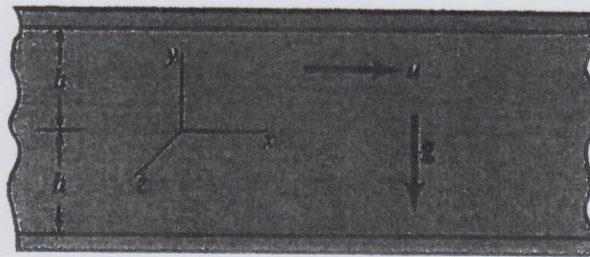
Navier − Stokes equations :

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

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

$$\rho\left(\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}\right) = -\frac{\partial p}{\partial z} + \rho g_z + \mu\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right)$$
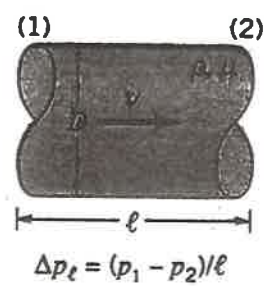
（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分 ）

6. (15%) Consider a steady flow of an incompressible, Newtonian fluid through a long, smooth-walled horizontal, circular pipe. Assume the pressure drop per unit length, ΔP_ℓ, along the pipe is a function of the pipe diameter, D, fluid density, ρ, viscosity, μ, and the mean velocity, V. Determine a suitable set of pi terms to study this problem experimentally. (Hint: the SI unit of viscosity is Pa · s)

$$\Delta p_\ell = (p_1 - p_2)/\ell$$

（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分 ）

7. (15%) Air under standard conditions (ρ = 1.23 kg/m^3, μ = 1.79 × 10^{-5} N·s/m^2) flows through a 4-mm-diameter drawn tubing with an average velocity of 50 m/s. Determine the pressure drop in a 0.1-m section of the tube.

$$h_{L\,major} = f \frac{\ell}{D} \frac{V^2}{2g}$$
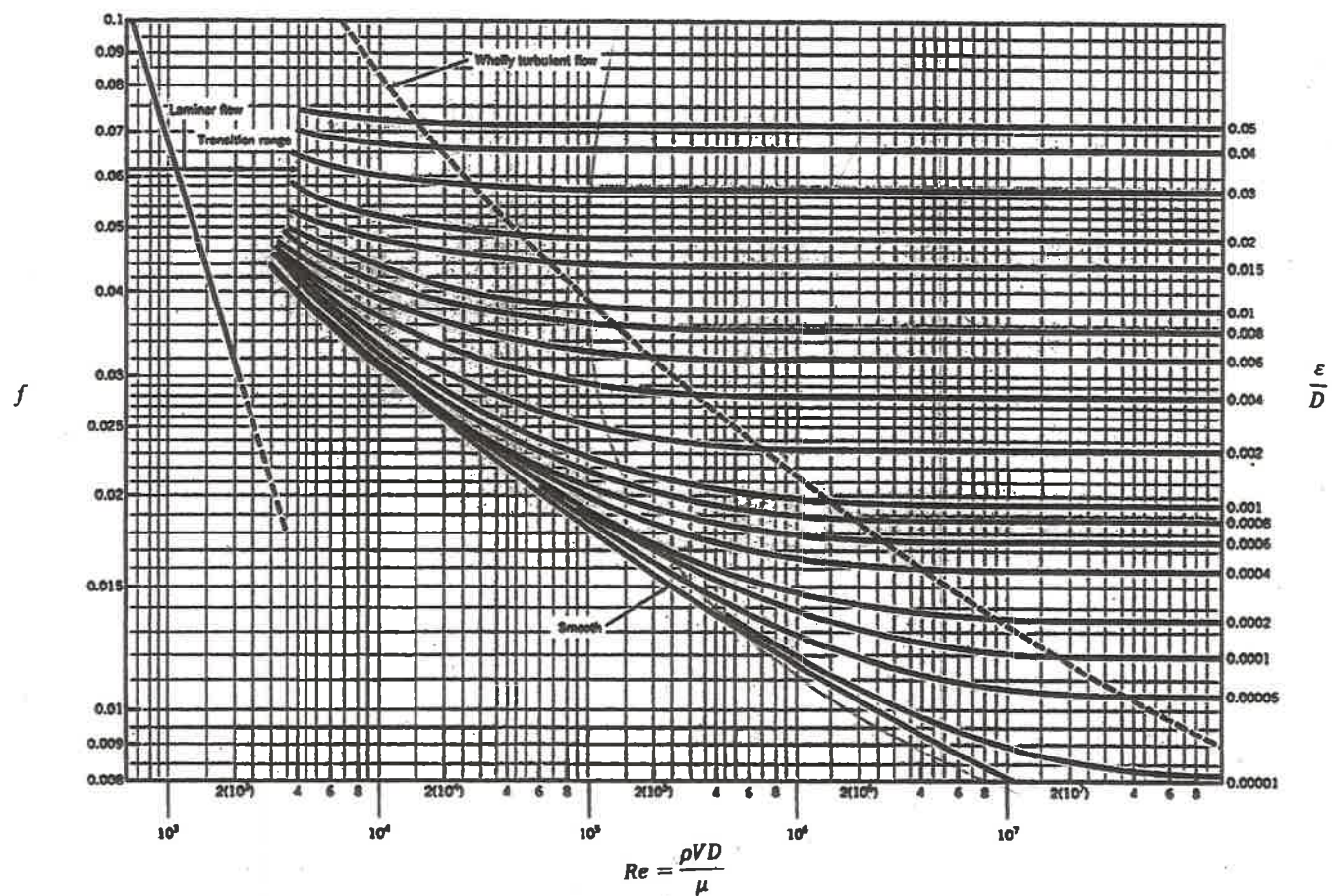
Pipe	Equivalent Roughness, ε	
	Millimeters	Feet
Riveted steel	0.9–9.0	0.003–0.03
Concrete	0.3–3.0	0.001–0.01
Wood stave	0.18–0.9	0.0006–0.003
Cast iron	0.26	0.00085
Galvanized iron	0.15	0.0005
Commercial steel or wrought iron	0.045	0.00015
Drawn tubing	0.0015	0.000005
Plastic, glass	0.0 (smooth)	0.0 (smooth)