大葉大學 九十二 學年度 研究所碩士班 招生考試試題紙					
系 所 別	組 別	考 試 科 目（中 文 名 稱）	考 試 日 期	節 次	備 註
機械所	丙 組	流體力學或熱力學	4月13日	第 二 節	可攜帶計算機

★ 請考生特別注意：請由以下題目中任選 5 題作答（答題數不可超過 5 題，第 6 題（含）以上不予計分）。

1. (20%)

Air undergoes two processes in series:

Process 1-2: polytropic compression, $pv^{1.3}$ = constant, from p_1 = 100 kPa, $v_1 = 0.04$ m³/kg to $v_2 = 0.02$ m³/kg

Process 2-3: constant-pressure process to $v_3 = v_1$

Sketch the processes on a $p - v$ diagram and determine the work per unit mass of air, in kJ/kg.

2. (20%)

Air is compressed adiabatically from $p_1 = 1\,\text{bar}$, $T_1 = 300\,\text{K}$ to $p_2 = 15\,\text{bar}$, $v_2 = 0.1227\,\text{m}^3/\text{kg}$. The air is then cooled at constant volume to $T_3 = 300\,\text{K}$. Assuming ideal gas behavior, and ignoring kinetic and potential energy effects, calculate the work for the first process and the heat transfer for the second process, each in kJ per kg of air. Solve the problem each of the two ways:

(a) using data from the following Table 1.

Table 1 Ideal gas properties of air.

T (K)	*h* (kJ/kg)	*u* (kJ/kg)	T (K)	*h* (kJ/kg)	*u* (kJ/kg)
290	290.16	206.91	620	628.07	450.09
300	300.19	214.07	630	638.63	457.78
310	310.24	221.25	640	649.22	465.50
320	320.29	228.42	650	659.84	473.25

(b) using a constant specific heat, assuming $c_v = 0.718\,\text{kJ/kg}\cdot\text{K}$.

3. (20%)

Steam enters a turbine operating at steady state with a mass flow rate of 4600 kg/h. The turbine develops a power output of 1000 kW. At the inlet, the pressure is 60 bar, the temperature is 400℃, and the velocity is 10 m/s. At the exit, the pressure is 0.1 bar, the quality is 0.9 (90%), and the velocity is 50 m/s. Calculate the rate of heat transfer between the turbine and surroundings, in kW.

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<tr><td colspan="7">大葉大學 九十二 學年度 **研究所碩士班** 招生考試試題紙</td></tr>
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The following properties are given.

At p = 60 bar (T_{sat} = 275.64℃) and T = 400℃: v = 0.04739 m^3/kg, u = 2892.9 kJ/kg, h = 3177.2 kJ/kg.

Table 2 Properties of Saturated Water: Pressure Table

Press. bar	Temp. ℃	Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg		
		Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7

4. (20%)

A 0.8-lb metal bar initially at 1900°R is removed from an oven and quenched by immersing it in a closed tank containing 20 lb of water initially at 530°R. Each substance can be modeled as incompressible. An appropriate constant specific heat value for the water is c_w = 1.0 Btu/lb·°R, and an appropriate value for the metal is $c_m = 0.1$ Btu/lb·°R. Heat transfer from the tank contents can be neglected. Determine

(a) the final equilibrium temperature of the metal bar and the water, in °R, and

(b) the amount of entropy produced, in Btu/°R.

5. (20%)

Draw the $T-s$ diagram for an ideal Brayton cycle. Determine the pressure ratio, p_2/p_1, across the compressor of an ideal Brayton cycle for the maximum net work output per unit of mass flow if the state at the compressor inlet (state 1) and the temperature at the turbine inlet (state 3) are fixed. Use a cold air-standard analysis and ignore kinetic and potential energy effects. Express final result of p_2/p_1 in terms of T_1, T_3, and the specific heat ratio k (= c_p/c_v). (Must show your work.)

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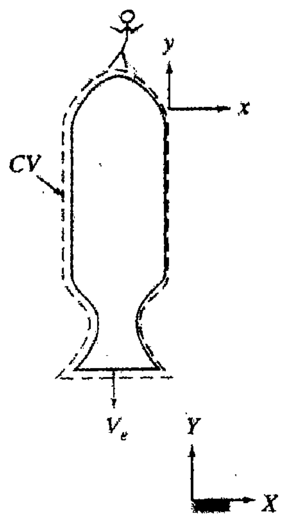
註：考生可否攜帶計算機或其他資料作答，請在備註欄註明（如未註明，一律不准攜帶）

6. (20%)

A small rocket, with an initial mass of 400kg, is to be launched vertically. Upon ignition the rocket consumes fuel at the rate of 5 kg/s and ejects gas at atmospheric pressure with a speed of 3500 m/s relative to the rocket. Determine the initial acceleration of the rocket and the rocket speed after 10 s, if air resistance is neglected.

(Hint: Basic equation)

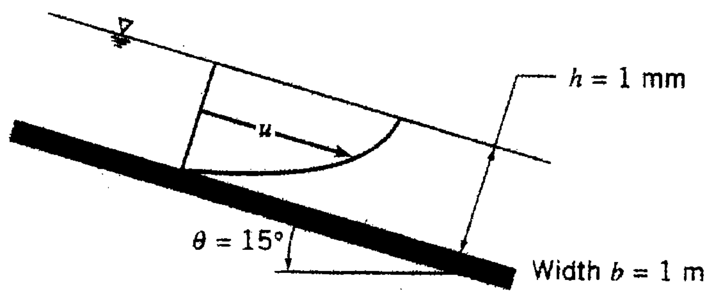


$$F_{B_y} - \int_{CV} a_{rf_y} \rho \, d\forall = \frac{\partial}{\partial t} \int_{CV} v_{xyz} \rho \, d\forall + \int_{CS} v_{xyz} \rho \vec{V}_{xyz} \cdot d\vec{A}$$

7. (20%)

A liquid flows down an inclined plane surface in a steady, fully developed laminar film of thickness h. Simplify the continuity and Navier-Stokes equations to model this flow field. Obtain expressions for the liquid velocity profile, the shear stress distribution, the volume flow rate, and the average velocity. Relate the liquid film thickness to the volume flow rate per unit depth of surface normal to the flow. Calculate the volume flow rate in a film of water 1 mm thick flowing on a surface 1 m wide, inclined at 15° to the horizontal.

Basic equations:



$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

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

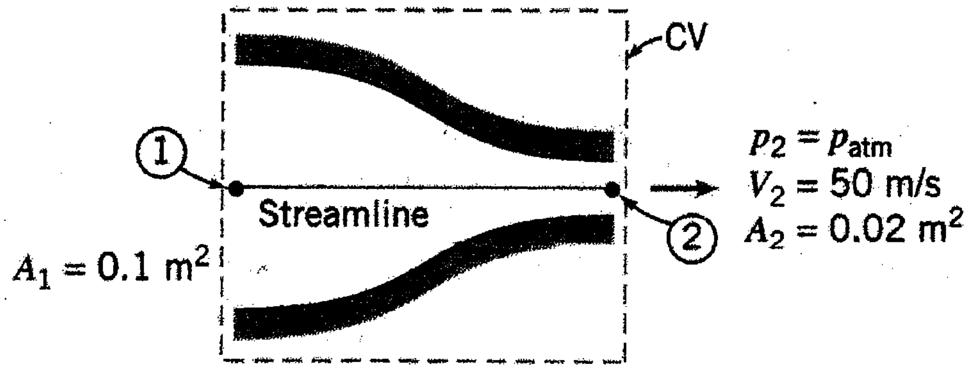
$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z}\right) = \rho g_y - \frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial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

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

8. (20%)

Air flows steadily at low speed through a horizontal nozzle, discharging to atmosphere. The area at the nozzle inlet is 0.1m^2. At the nozzle exit, the area is $0.02\ \text{m}^2$. Determine the gage pressure required at the nozzle inlet to produce an outlet speed of 50 m/s.

Given: Flow through a nozzle, as shown.



Basic equation:

$$\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2} + gz_2$$

$$= 0(1)$$

$$0 = \frac{\partial}{\partial t}\int_{CV} \rho d\forall + \int_{CS} \rho\vec{V}\cdot d\vec{A}$$

$\rho = 1.23\ \text{kg/m}^3$

9. (20%)

The drag force, F, on a smooth sphere depends on the relative velocity, V, the sphere diameter, D, the fluid density, ρ, and the fluid viscosity, μ. Obtain a set of dimensionless groups that can be used to correlate experimental data.

Given : $F = f(\rho, V, D, \mu)$ for a smooth sphere.

10. (20%)

The drag of a sonar transducer is to be predicted, based on wind tunnel test data. The prototype, a 1 ft diameter sphere, is to be towed at 5 knots (nautical miles per hour, 1 nautical mile=6080 ft) in sea water. The model is 6 in. in diameter. Determine the required test speed in air. If the drag of the model at test condition is 5.58 lbf, estimate the drag of the prototype.

Sea water : $\rho = 1.99 slug/ft^3, \nu = 1.69x10^{-5} ft^2/s$

Air : $\rho = 0.00238 slug/ft^3, \nu = 1.57x10^{-4} ft^2/s$