國立台灣科技大學九十七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

**1. 總分 100 分。 2. 是非題、選擇題務必於答案卷內依序作答，否則不予計分。**

**3. Mathematical and governing equations are listed in page 6.**

**Problem 1. 是非題（共 10 小題，每小題 2 分，共 20 分）**

( ) 1. Compressibility factor, Z, is a measure of deviation from idea–gas behavior. Also, its value is always greater than 1.

( ) 2. In Eulerian description, position vector and time are the independent variables.

( ) 3. The temperature of a liquid will decrease when it undergoes a steady-flow throttling process.

( ) 4. Air is to be heated steadily by an 8-kW electric resistance heater as it flows through an insulated duct. If the air enters at 50℃ at a rate of 1 kg/s, the exit temperature of air is 55.4℃. $C_p$= 1.005 kJ/($kg$ · ℃) for air.

( ) 5. In a shower, cold water at 10℃ flowing at a rate of 5 kg/min is mixed with hot water at 60 ℃ flowing at a rate of 3 kg/min. The exit temperature of the mixture is 44.3 ℃.

( ) 6. A new temperature scale is defined as

Boiling point: 119 degrees and Ice point: -119 degrees.

Then, temperature reading for 50℃ under this new temp. scale is 100 degrees.

( ) 7. A 1,000-kg car is cruising at a constant velocity to climb a 150-m-long uphill road with a slop of 30° (from horizontal) in 7.5 sec. The power required for this car is 196.2 kw. Disregard friction, air drag, and rolling resistance.

( ) 8. For fluid element of an incompressible flow, the velocity can not decrease in all directions.

( ) 9. Whereas viscosity for gas increases with temperature, it also increases for liquid.

( ) 10. If the Bernoulli equation is valid throughout the flow region for a particular flow, then this flow must be an irrotational flow.

國立台灣科技大學九十七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

**Problem 2. 單選題（共 10 小題，每小題 2 分，共 20 分）**

( ) 1. An insulated rigid container is divided into two compartments separated by a partition. One compartment contains air at 30 $^\circ C$ and 1 atm, the other compartment contains air at 80$^\circ C$ and 1 atm. When the dividing partition is removed, the total internal energy of the system (a) increases; (b) decreases; (c) does not change; (d) is converted into entropy; (e) none of the above.

( ) 2. A rigid container contains air (an ideal gas) at 30$^\circ C$. If the air is heated to 120$^\circ C$, its pressure will (a) increase (b) decrease (c) not change (d) cause moving boundary work to occur; (e) none of the above.

( ) 3. In a steady flow irreversible process, the total entropy of a system (a) always increases (b) always decreases (c) always remain constant (d) can increase, decrease, or remain constant; (e) none of the above.

( ) 4. To determine the maximum possible work that a heat engine could produce one must assume (a) entropy does not increase; (b) no heat transfer occurs; (c) no irreversibility occur; (d) no friction occurs; (e) none of the above.

( ) 5. The wake (a) is a region of high pressure;
(b) is the principal cause of skin friction;
(c) always happened when the speed of sound is reached;
(d) always occurs after the separation point;
(e) none of above.

( ) 6. For the absolute viscosity = 0.06 kg/m • s, S.G. = 0.6, and the density of water is 1000 kg/($m^3$). The kinematic viscosity is, in stokes:
(a) 2.78; (b) 1.0; (c) 0.6; (d)0.26; (e) none of the above.

( ) 7. The vertical component of force on a curved surface equals
(a) force on the projection of curved surface onto vertical plane;
(b) weight of the liquid retained by the curved surface;
(c) product of pressure at its centroid and area;
(d) weight of the liquid vertically above this curved surface;
(e) none of the above.

國立台灣科技大學九十七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

( ) 8. The dimples on the surface of a gulf ball are not designed for the purpose to:
(a) generate the turbulence; (b) delay the separation point;
(c) reduce the size of wake; (d) streamlization;
(e) reduce the drag force.

( ) 9. A plate of wood 2 by 2 by 0.5 m, S.G. = 0.5, floats in water with a 200kg load on it. The volume of wooden plate submerged, in cubic meter, is
(a) 0.6; (b) 1.2; (c) 1.8; (d) 2.4; (e) 3.
Note: The density of water is assumed to be 1000 kg / ($m^3$).

( ) 10. The bulk modulus of elasticity
(a) is independent of temperature; (b) increases with the pressure;
(c) has the dimensions of 1/p; (d) is larger when fluid is more compressible;
(e) is independent of pressure and viscosity.

**Problem 3. 是非題 ( 共 10 小題，每小題 1 分，共 10 分)**

The following devices are operated between the same high- (800 K) and low-temperature (200 K) reservoirs.

( ) 1. For a Carnot heat engine, the Carnot efficiency is equal to 0.75.

( ) 2. The COP is larger than 1 for a Carnot refrigerator.

( ) 3. The COP of a Carnot heat pump is equivalent to the COP of a Carnot refrigerator.

( ) 4. During the heat absorption, the process can be internally reversible if the boundary of the system is kept at 650 K.

( ) 5. If the heat ejection is 50 kW, the required work input of a Carnot heat pump is 200 kW.

( ) 6. It is impossible to have a refrigerator absorbing 100 kW from the high temperature reservoir (800 K) and ejecting 30 kW to the low temperature reservoir (200 K).

( ) 7. For a Carnot heat engine, $\oint \frac{\delta Q}{T} = 0$

( ) 8. During the heat ejection process, the entropy of a Carnot heat pump remains the same.

( ) 9. The working fluid is initially kept at saturated vapor state. After an isentropic compression process (P2 > P1), it becomes superheated vapor.

( ) 10. The working fluid is initially kept at saturated vapor state. After an isothermal compression process, it becomes superheated vapor.

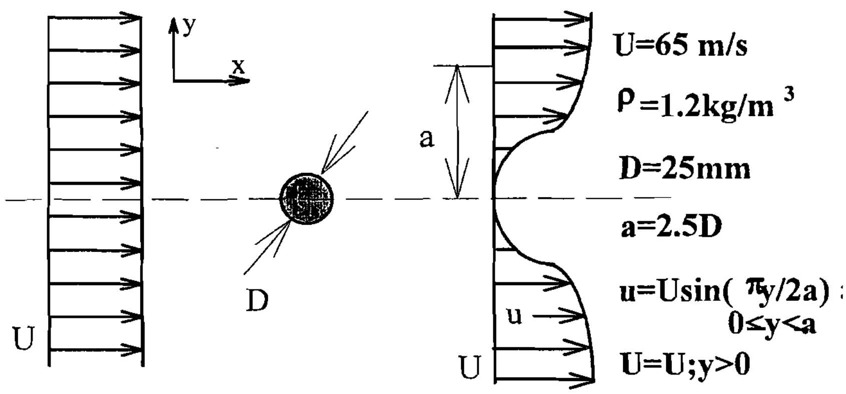
國立台灣科技大學九十七學年度碩士班招生試題

系所組別： 機械工程系碩士班丙組

科 目： 熱力與流力

**Problem 4. (本題 16 分)**

Experimental measurements are made in a low-speed air jet to determine the drag force on a body shown on the figure. Velocity measurements at two sections, where the pressure is uniform and equal, give the results as shown in below. Please evaluate the drag force on this body, per unit width.




**Problem 5. (本題 10 分)**

A frictionless piston-cylinder device contains a saturated mixture of water at 87°C. During a constant-pressure process, 720 kJ of heat is transferred to the surrounding air which is at 27°C. As a result, part of the water vapor contained in the piston-cylinder device condenses. Determine

(a) the entropy change of the water, (3 分)

(b) the entropy change of the surrounding air, and (3 分)

(c) whether this process is reversible, irreversible, or impossible. (4 分)

**Problem 6. (本題 12 分，每小題 4 分)**

Regards the Reynolds transport theory

a) What is the purpose and benefit brought by this theory?

b) By setting the value of $\eta$, show the momentum eq.,

c) By setting the values of $\eta=1/\rho$ ,please show the definition of $div\vec{v}$ .

**Problem 7. (本題 12 分，每小題 4 分)**

For a velocity field as

$$\vec{V}=-\frac{U}{r^2}\cos\theta\,\hat{e}_r-\frac{U}{r^2}\sin\theta\,\hat{e}_\theta$$

where $U$ is a constant.

(a) Is it an incompressible flow?

(b) Is it an irrotational flow?

(c) Determine the expression for stream function,

國立台灣科技大學九十七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

## Summary of Equations

(1) Continuity Equation:

$$0=\frac{\partial}{\partial t}\int_{cv}\rho d\forall+\int_{cs}\rho\vec{V}\cdot d\vec{A};\quad \nabla\cdot\rho\vec{V}+\frac{\partial\rho}{\partial t}=0 \quad \text{or} \quad \frac{D\rho}{Dt}+\rho div\vec{V}=0$$

(2) Momentum Equation:

$$\vec{F}_S+\vec{F}_B-\int_{CV}\left[\vec{a}_{rf}+2\vec{\omega}\times\vec{V}_{xyz}+\vec{\omega}\times(\vec{\omega}\times\vec{r})+\dot{\vec{\omega}}\times\vec{r}\right]\rho d\forall$$

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

$$\rho\frac{D\vec{V}}{Dt}=-\nabla p+div\,\bar{\tau}+\rho\vec{g}$$

(3) The First Law of Thermodynamics:

$$\dot{Q}-\dot{W}_s-\dot{W}_{\text{shear}}-\dot{W}_{\text{other}}=\frac{\partial}{\partial t}\int_{CV}e\rho d\forall+\int_{CS}\left(u+pv+\frac{V^2}{2}+gz\right)\rho\vec{V}\cdot d\vec{A}$$

(4) Mathematics relations:

(a) Gradient Theorem

$$\iiint_V\nabla\phi d\tau=\oiint_S\phi\hat{n}\,dS$$

(b) Divergence Theorem

$$\iiint_V \text{div}\vec{A}d\tau=\oiint_S\vec{A}\cdot\hat{n}dS$$

(c) Curl Theorem

$$\iiint_V\text{curl}\vec{A}d\tau=\oiint_S\hat{n}\times\vec{A}dS$$

(d) Gradient

$$\nabla\phi=\frac{\hat{e}_1}{h_1}\frac{\partial\phi}{\partial q^1}+\frac{\hat{e}_2}{h_2}\frac{\partial\phi}{\partial q^2}+\frac{\hat{e}_3}{h_3}\frac{\partial\phi}{\partial q^3}$$

(e) $$\text{div}\vec{A}=\frac{1}{h_1h_2h_3}\left[\frac{\partial}{\partial q^1}(h_2h_3\hat{A}_1)+\frac{\partial}{\partial q^2}(h_1h_3\hat{A}_2)+\frac{\partial}{\partial q^3}(h_1h_2\hat{A}_3)\right]$$

(f) $$\text{curl}\vec{A}=\frac{1}{h_1h_2h_3}\begin{vmatrix}h_1\hat{e}_1 & h_2\hat{e}_2 & h_3\hat{e}_3\\ \frac{\partial}{\partial q^1} & \frac{\partial}{\partial q^2} & \frac{\partial}{\partial q^3}\\ h_1\hat{A}_1 & h_2\hat{A}_2 & h_3\hat{A}_3\end{vmatrix}$$

(g) $$\vec{V}\cdot\nabla\vec{V}=\nabla\left(\frac{\vec{V}^2}{2}\right)-\vec{V}\times\text{curl}\vec{V}$$

(5) Scalar factors for orthogonal coordinates

| Coordinates | Cartesians | Cylindrical | Spherical |
|---|---|---|---|
| $h_1$ | $h_x=1$ | $h_r=1$ | $h_r=1$ |
| $h_2$ | $h_y=1$ | $h_\theta=r$ | $h_\theta=r$ |
| $h_3$ | $h_z=1$ | $h_z=1$ | $h_\phi=r\sin\theta$ |