淡江大學105學年度碩士班招生考試試題

33-1

系別：航空太空工程學系A組　　　科目：流體力學

考試日期：3月5日(星期六) 第2節　　　本試題共 3 大題， 5 頁

本試題雙面印刷

一、　簡答題(25/100)

1. 在流體力學中以力學的角度要如何去區分流體(fluid)與固體(solid)？
2. 何謂不滑動邊界條件(no-slip condition)？它是什麼原因造成的？
3. 簡述 streamline、pathline 與 streakline 的定義與特徵。
4. 簡述聲速(speed of sound)的定義，它與流體的可壓縮性(compressibility)有何關係？
5. 何謂幾何相似(geometric similarity)、運動相似(kinematics similarity)與動力相似(dynamic similarity ）？以及它們之間的相關性為何？

二、　選擇題(25/100)(均為複選題)

1. Bernoulli 方程式必須滿足下列哪些條件(1)不可壓縮流,(2)無黏度流,(3)穩態流,(4)無旋量流,(5)無散度流,(6)無重力場流,(7)沿常數流函數曲線。
2. 流函數在下列哪些條件下方成立(1)與速度勢垂直條件,(2)流體密度為常數,(3)二維空間,(4) 無旋量流,(5) 穩態流,(6)無黏度流。
3. 雷諾數（Re）係由哪些力的比例關係組成(1)壓力,(2)慣性力,(3)阻力,(4)升力,(5)黏滯力,(6)重力。
4. 穩態不可壓縮流之 Navier-Stokes 方程式係由下列哪些項次組成(1)黏度擴散項,(2)表面張力項,(3)時間微分項,(4)壓力梯度項,(5)重力場項,(6)剪應變項,(7)對流項,(8)熱傳導項。
5. 流體力學中因次分析法中重複變數(repeated variables)的選定時，需要考慮下列哪些特徵(1)幾何特徵,(2)人為特徵,(3)流體特徵,(4)動力特徵,(5)環境特徵,(6)時間特徵。

三、　應用題(50/100)

背面尚有試題

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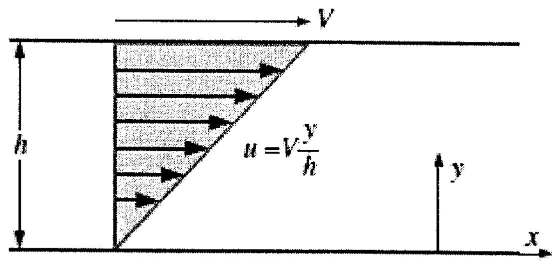
系別：航空太空工程學系 A 組　　　科目：流體力學　　33-2

考試日期：3 月 5 日(星期六) 第 2 節　　　本試題共 3 大題， 5 頁

1. Consider fully developed Couette flow—flow between two infinite parallel plates separated by distance h, with the top plate moving and the bottom plate stationary as illustrated in figure



above. The flow is steady, incompressible, and two-dimensional in the xy-plane. The velocity

$$\vec{V} = (u, v) = V\frac{y}{h}\vec{i} + 0\vec{j}$$

field is given by .

i. Is this flow rotational or irrotational?

ii. If it is rotational, calculate the vorticity component in the z-direction.

iii. Do fluid particles in this flow rotate clockwise or counterclockwise?

iv. Calculate the linear strain rates in the x- and y-directions.

v. Calculate the shear strain rate ε_{xy}.

Hints:

Vorticity vector in Cartesian coordinates:

$$\vec{\zeta} = \left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right)\vec{i} + \left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right)\vec{j} + \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\vec{k}$$

Strain rate tensor in Cartesian coordinates:

$$\varepsilon_{ij} = \begin{pmatrix} \varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz} \\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz} \\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz} \end{pmatrix} = \begin{pmatrix} \frac{\partial u}{\partial x} & \frac{1}{2}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) & \frac{1}{2}\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}\right) \\ \frac{1}{2}\left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right) & \frac{\partial v}{\partial y} & \frac{1}{2}\left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}\right) \\ \frac{1}{2}\left(\frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}\right) & \frac{1}{2}\left(\frac{\partial w}{\partial y} + \frac{\partial v}{\partial z}\right) & \frac{\partial w}{\partial z} \end{pmatrix}$$

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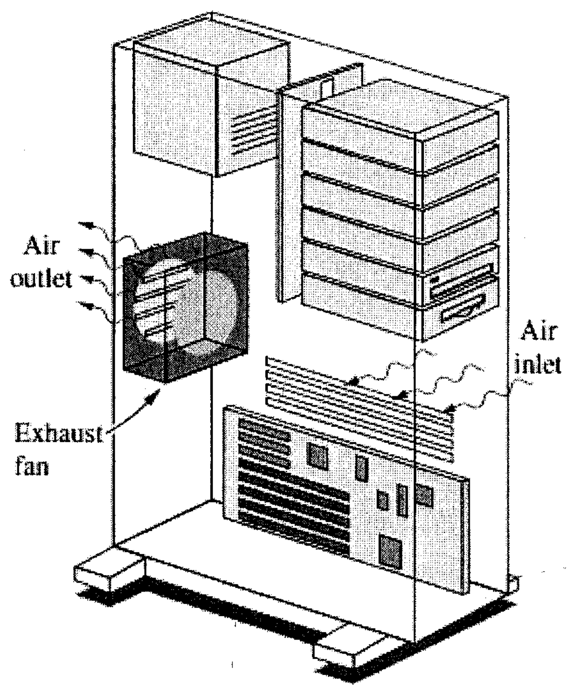
2. A desktop computer is to be cooled by a fan whose flow rate is 0.34 m^3/min. (a) Determine the mass flow rate of air through the fan at an elevation of 3400 m where the air density is 0.7 kg/m^3. Also, if the average velocity of air is not to exceed 110 m/min, (b) determine the

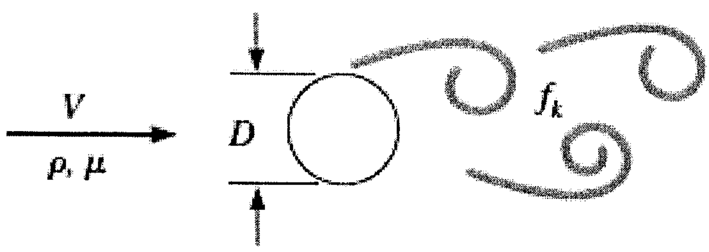


diameter (D) of the casing of the fan.

Hints:

Mass flow rate: $\dot{m}_{air} = \rho \dot{V}_{air}$, Volume flow rate: $\dot{V} = AV = \frac{\pi D^2}{4} V$

3. A periodic Kármán vortex street is formed when a uniform stream flows over a circular



cylinder (Figure above).

Use the method of repeating variables to generate a dimensionless relationship for Kármán vortex shedding frequency f_k as a function of free-stream speed V, fluid density ρ, fluid viscosity μ, cylinder diameter D, and speed of sound c.

Hints:

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Dimensions Associated with Common Physical Quantities

	FLT System	MLT System
Acceleration	LT^{-2}	LT^{-2}
Angle	$F^0L^0T^0$	$M^0L^0T^0$
Angular acceleration	T^{-2}	T^{-2}
Angular velocity	T^{-1}	T^{-1}
Area	L^2	L^2
Density	$FL^{-4}T^2$	ML^{-3}
Energy	FL	ML^2T^{-2}
Force	F	MLT^{-2}
Frequency	T^{-1}	T^{-1}
Heat	FL	ML^2T^{-2}
Length	L	L
Mass	$FL^{-1}T^2$	M
Modulus of elasticity	FL^{-2}	$ML^{-1}T^{-2}$
Moment of a force	FL	ML^2T^{-2}
Moment of inertia (area)	L^4	L^4
Moment of inertia (mass)	FLT^2	ML^2
Momentum	FT	MLT^{-1}
Power	FLT^{-1}	ML^2T^{-3}
Pressure	FL^{-2}	$ML^{-1}T^{-2}$
Specific heat	$L^2T^{-2}\Theta^{-1}$	$L^2T^{-2}\Theta^{-1}$
Specific weight	FL^{-3}	$ML^{-2}T^{-2}$
Strain	$F^0L^0T^0$	$M^0L^0T^0$
Stress	FL^{-2}	$ML^{-1}T^{-2}$
Surface tension	FL^{-1}	MT^{-2}
Temperature	Θ	Θ
Time	T	T
Torque	FL	ML^2T^{-2}
Velocity	LT^{-1}	LT^{-1}
Viscosity (dynamic)	$FL^{-2}T$	$ML^{-1}T^{-1}$
Viscosity (kinematic)	L^2T^{-1}	L^2T^{-1}
Volume	L^3	L^3
Work	FL	ML^2T^{-2}

Some Common Variables and Dimensionless Groups in Fluid Mechanics

Variables: Acceleration of gravity, g; Bulk modulus, E_v; Characteristic length, ℓ; Density, ρ; Frequency of oscillating flow, ω; Pressure, p (or Δp); Speed of sound, c; Surface tension, σ; Velocity, V; Viscosity, μ

Dimensionless Groups	Name	Interpretation (Index of Force Ratio Indicated)	Types of Applications
$\frac{\rho V \ell}{\mu}$	Reynolds number, Re	$\frac{\text{inertia force}}{\text{viscous force}}$	Generally of importance in all types of fluid dynamics problems
$\frac{V}{\sqrt{g\ell}}$	Froude number, Fr	$\frac{\text{inertia force}}{\text{gravitational force}}$	Flow with a free surface
$\frac{p}{\rho V^2}$	Euler number, Eu	$\frac{\text{pressure force}}{\text{inertia force}}$	Problems in which pressure or pressure differences are of interest
$\frac{\rho V^2}{E_v}$	Cauchy number,[a] Ca	$\frac{\text{inertia force}}{\text{compressibility force}}$	Flows in which the compressibility of the fluid is important
$\frac{V}{c}$	Mach number,[a] Ma	$\frac{\text{inertia force}}{\text{compressibility force}}$	Flows in which the compressibility of the fluid is important
$\frac{\omega \ell}{V}$	Strouhal number, St	$\frac{\text{inertia (local) force}}{\text{inertia (convective) force}}$	Unsteady flow with a characteristic frequency of oscillation
$\frac{\rho V^2 \ell}{\sigma}$	Weber number, We	$\frac{\text{inertia force}}{\text{surface tension force}}$	Problems in which surface tension is important

Step 1. List all the variables that are involved in the problem.

Step 2. Express each of the variables in terms of basic dimensions.

Step 3. Determine the required number of pi terms.

Step 4. Select a number of repeating variables. The number required is equal to the number of reference dimensions.

Step 5. Form a pi term by multiplying one of the nonrepeating variables by the product of the repeating variables, each raised to an exponent that will make the combination dimensionless.

Step 6. Repeat Step 5 for each of the remaining nonrepeating variables.

Step 7. Express the final form as a relationship among the pi terms and think about what it means.

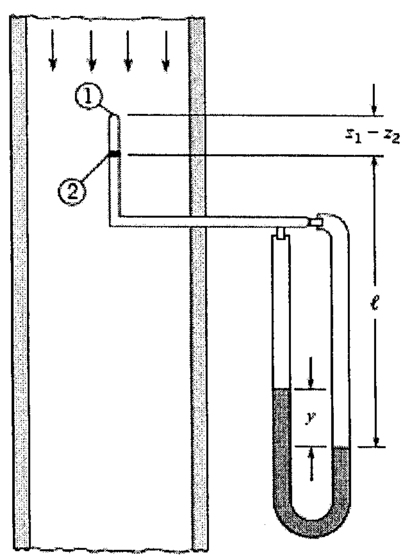
4. Consider the common situation in which a researcher is trying to match the Reynolds number of a large prototype vehicle with that of a small-scale model in a wind tunnel. Is it better for the air in the wind tunnel to be cold or hot? Why? Support your argument by comparing wind tunnel air at 10°C and at 50°C, all else being equal.

   Hints:

   (1) For air at atmospheric pressure and at T = 10°C, $\rho = 1.246$ kg/m^3 and $\mu = 1.778\times10^{-5}$ kg/m×s. At T = 50°C, $\rho = 1.092$ kg/m^3 and $\mu = 1.963*10^{-5}$ kg/m×s.

   (2) Consider $\dfrac{Re_{cold}}{Re_{hot}}$.

5. A mercury(SG=13.55) manometer is connected to the Pitot-static tube in a pipe transporting kerosene(煤油) as shown. If the deflection on the manometer is y=17.5 cm, what is the kerosene velocity in the pipe? Assume that the specific gravity of the kerosene is 0.81.



Hints : $$\frac{p_1}{\gamma}+z_1+\frac{V_1^2}{2g}=\frac{p_2}{\gamma}+z_2+\frac{V_2^2}{2g}$$