國立中正大學
112 學年度碩士班招生考試
試 題
[第 2 節]

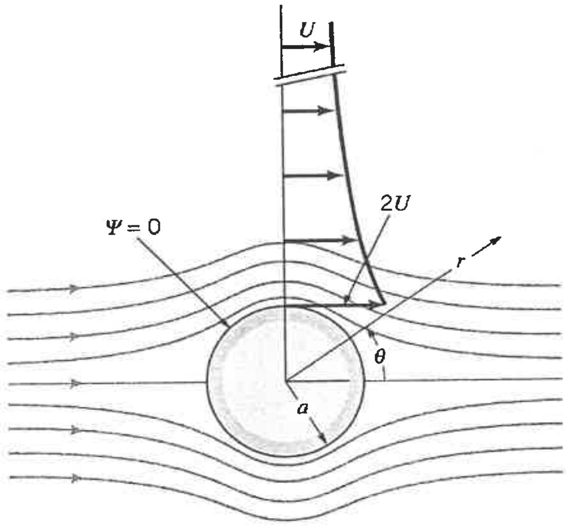
科目名稱	流體力學
系所組別	機械工程學系-丙組

—作答注意事項—

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
3. 入場後於考試開始 40 分鐘內不得離場。
4. 全部答題均須在試卷（答案卷）作答區內完成。
5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

1. (20%) Please use the information given in the "Supplementary Information" to determine the stream function (5%), coordinates of the stagnation point (5%) and velocity distributions (10%) for the potential flow over a cylinder as shown below.

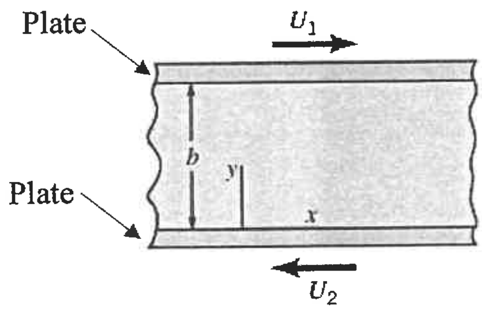


2. (4%) Please explain what the application of Reynolds transport theorem is.

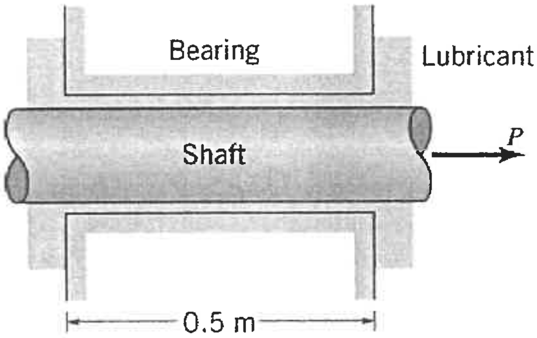
3. (6%) Please explain, in terms of fluid kinetics, the physical meanings of the following two vectors （where $\vec{V}$ is the velocity vector）：

$$\nabla \cdot \vec{V} \text{ and } \nabla \times \vec{V}$$

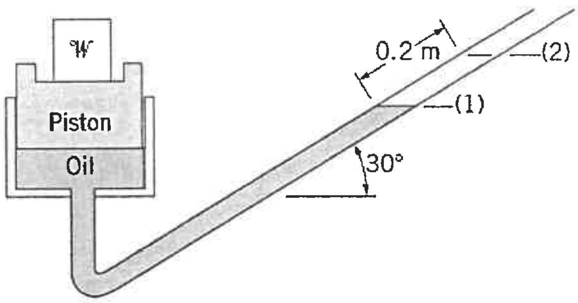
4. (20%) An incompressible, viscous fluid is placed between horizontal, infinite, parallel plates as shown below. The two plates move in opposite directions with constant velocities, U_1 and U_2, as shown. The pressure gradient in the x direction is zero, the flow is laminar flow and the only body force is due to the fluid weight. Please use the Navier-Stokes equations to derive an expression for the velocity distribution between the plates.



5. (15%) A 30-mm-diameter shaft is pulled through a cylindrical bearing as shown in the following figure. The lubricant that fills the 0.35-mm gap between the shaft and bearing is an oil having a kinematic viscosity of $7.0 \times 10^{-4}\ \mathrm{m^2/s}$ and a specific gravity of 0.8. Determine the force P required to pull the shaft at a velocity of $4\ \mathrm{m/s}$. Assume the velocity distribution in the gap is linear.



6. (15%) A 0.2 m diameter piston is located within a cylinder that is connected to a 0.01 m diameter inclined tube manometer as shown in the following figure. The fluid in the cylinder and the manometer is oil (density = $800\ \mathrm{kg/m^3}$). When a weight, W, is placed on the top of the cylinder, the fluid level in the manometer tube rises from point (1) to (2). How heavy is the weight? Assume that the change in position of the piston is negligible.



7. (20%) A nozzle is designed to accelerate the fluid from V_1 to V_2 in a linear fashion. That is, $V = ax + b$, where a and b are constants. If the flow is constant with $V_1 = 5\ \mathrm{m/s}$ at $x_1 = 0\ \mathrm{m}$ and $V_2 = 20\ \mathrm{m/s}$ at $x_2 = 1\ \mathrm{m}$, determine the local acceleration, the convective acceleration, and the acceleration of the fluid at points (1) and (2).

Supplementary Information:

Navior-Stokes equation

$$\rho\left(\frac{\partial \vec{V}}{\partial t}+(\vec{V}\cdot\nabla)\vec{V}\right)=\rho\vec{g}-\nabla P+\mu\nabla^2\vec{V}$$

Summary of Basic, Plane Potential Flows.

Description of Flow Field	Velocity Potential	Stream Function	Velocity Components[a]
Uniform flow at angle α with the x axis (see Fig. 6.16*b*)	$\phi = U(x\cos\alpha + y\sin\alpha)$	$\psi = U(y\cos\alpha - x\sin\alpha)$	$u = U\cos\alpha$ $v = U\sin\alpha$
Source or sink (see Fig. 6.17) $m > 0$ source $m < 0$ sink	$\phi = \frac{m}{2\pi}\ln r$	$\psi = \frac{m}{2\pi}\theta$	$v_r = \frac{m}{2\pi r}$ $v_\theta = 0$
Free vortex (see Fig. 6.18) $\Gamma > 0$ counterclockwise motion $\Gamma < 0$ clockwise motion	$\phi = \frac{\Gamma}{2\pi}\theta$	$\psi = -\frac{\Gamma}{2\pi}\ln r$	$v_r = 0$ $v_\theta = \frac{\Gamma}{2\pi r}$
Doublet (see Fig. 6.23)	$\phi = \frac{K\cos\theta}{r}$	$\psi = -\frac{K\sin\theta}{r}$	$v_r = -\frac{K\cos\theta}{r^2}$ $v_\theta = -\frac{K\sin\theta}{r^2}$

[a]Velocity components are related to the velocity potential and stream function through the relationships:

$$u = \frac{\partial\phi}{\partial x} = \frac{\partial\psi}{\partial y} \qquad v = \frac{\partial\phi}{\partial y} = -\frac{\partial\psi}{\partial x} \qquad v_r = \frac{\partial\phi}{\partial r} = \frac{1}{r}\frac{\partial\psi}{\partial\theta} \qquad v_\theta = \frac{1}{r}\frac{\partial\phi}{\partial\theta} = -\frac{\partial\psi}{\partial r}$$