國立中正大學 114 學年度碩士班招生考試試題

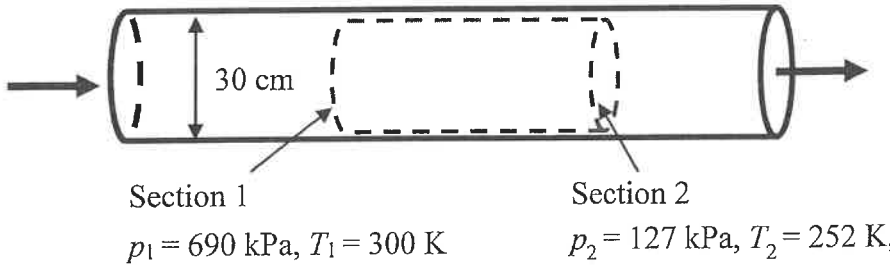
科目名稱：流體力學　　本科目共 2 頁　第 1 頁

系所組別：機械工程學系-丙組

1. (15%)Air flows steadily between two cross sections in a straight pipe with 30 cm of inside diameter. The static temperature and pressure at each section are indicated in the figure. If the average air velocity at section 2 is 320 m/s. Assume uniform velocity distributions at each section. Gas constant is 286.9 J/kg・K.

   (1) Determine the average air velocity at section 1. (5 %)

   (2) Determine the friction force exerted by the pipe on the air flowing between sections 1 and 2. (10 %)



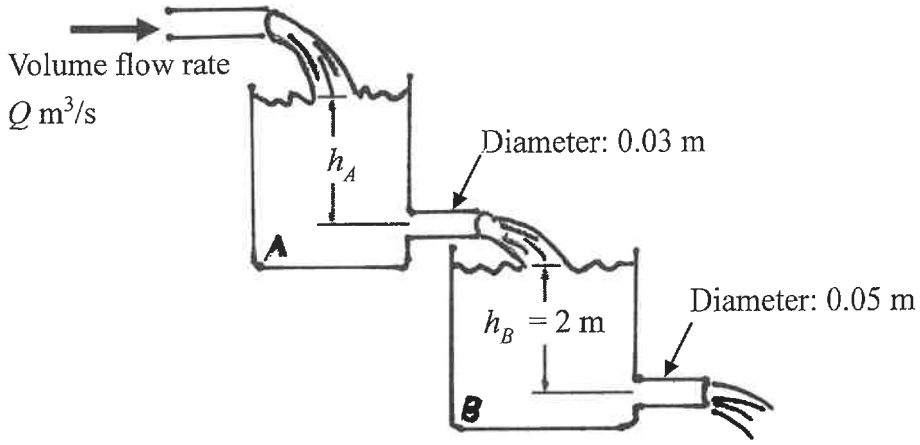
2. (15%)Consider a three-dimensional flow with velocity components $u = -x$, $v = 4x^2y^2$, and $w = x\text{-}y$.

   (1) Determine the acceleration field. (5 %)

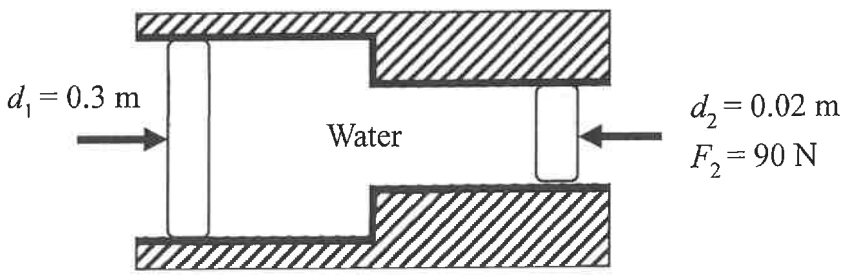
   (2) Is the flow incompressible? (5 %)

   (3) Is the flow irrotational? (5 %)

3. (10%)Water flows steadily through the tanks shown in the figure. Determine the water depth, h_A.

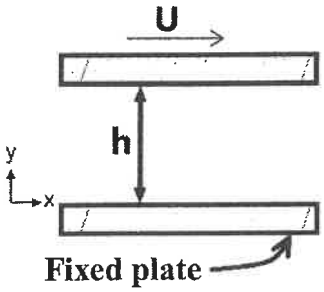


4. (10%)A 0.3 m diameter pipe is connected to a 0.02 m diameter pipe. Both pipes are horizontal with pistons at each end. If the space between the pistons is filled with water and neglect friction. What force will have to be applied to the larger piston to balance a force of 90 N applied to the smaller piston?



5. (15%)With the physical quantities: density: ρ; velocity: V; length scale: L; dynamic viscosity: μ; surface tension: σ; sound speed: C; gravity: g; state the mathematical definition and explain the physical meaning of the following dimensionless parameters:
   (1) Reynolds number, Re (5%)
   (2) Weber number, We (5%)
   (3) Mach number, Ma (5%)

6. (20%)The viscous, incompressible flow between the parallel plates shown in the figure is caused by both the motion of the top plate and a pressure gradient, $\frac{\partial p}{\partial x}$. The top plate moves with a constant velocity U in the x direction. Assume the flow is two-dimensional and fully-developed, derive the general solution for u(y). (10%) Determine the relationship between U and $\frac{\partial p}{\partial x}$ so that the shearing stress acting on the fixed plate is zero. (10%)
   Hint:
   The continuity equation is: $\nabla \cdot \vec{V} = 0$
   The momentum equation is: $\rho \frac{D\vec{V}}{Dt} = -\nabla P + \rho\vec{g} + \mu\nabla^2\vec{V}$



7. (15%)A small metal sphere of 2 mm diameter is released in a tank of special liquid. The density and dynamic viscosity of this liquid is $2000/\pi$ [kg/m^3] and $10^{-3}/\pi$ [N · sec/m^2], respectively. At very low Reynolds number, drag coefficient of a sphere can be estimated to be $C_D = \frac{24}{Re_D}$, where Re_D is based on the diameter of the sphere. The density of the metal sphere is $6000/\pi$ [kg/m^3].
   (1) Draw a free-body diagram of the metal sphere and determine all the forces exerted on the metal sphere. (8%)
   (2) Find the terminal velocity of the metal sphere. (Hint: Terminal velocity is the velocity when the metal sphere has no acceleration.) (5%)
   (3) What is the value of Re_D? (2%)