編號： 71

國立成功大學 109 學年度碩士班招生考試試題

系　　所：機械工程學系

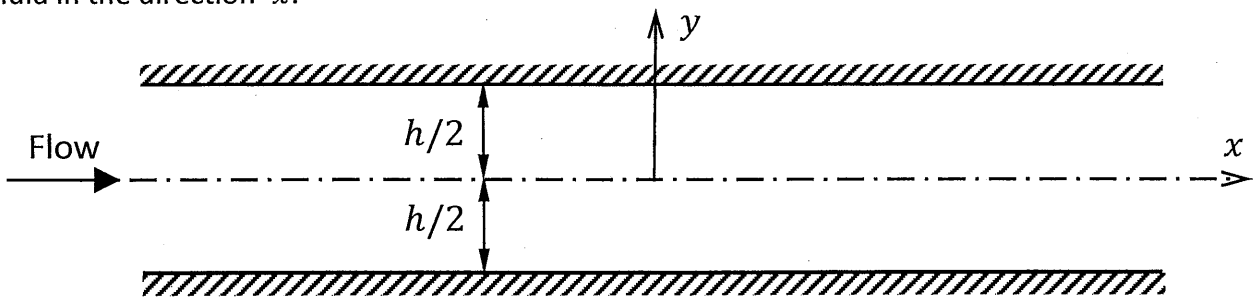
考試科目：流體力學

考試日期：0210，節次：1

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (15%) A capillary tube with an internal diameter of 1 mm is placed vertically in a bucket of water. How high will the level in the capillary tube rise above the level in the bucket if the contact angle at the inner wall of the tube is 10° and the surface tension is 0.07 kg/sec^2?
   Consider a smaller capillary with the same contact angle and surface tension. If the water will vaporize below a pressure of 0.017 bar, what is the maximum capillary height that can be reached, and what size of capillary is needed?

2. (15%) Consider the steady, fully-developed, planar Poiseuille flow of an incompressible, non-Newtonian fluid in the direction x:



The constitutive laws of this particular, non-Newtonian fluid are:

$$\sigma_{xx} = \sigma_{yy} = -p$$

$$\sigma_{xy} = -c\left[\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right]^2 \quad \text{for} \quad y > 0$$

$$\sigma_{xy} = +c\left[\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right]^2 \quad \text{for} \quad y < 0$$

where u and v are the velocity components in x and y directions, respectively, p is the conventional fluid pressure. Determine the mean velocity of the flow, $\bar{u}$, in terms of the spacing, h, the imposed pressure gradient, $-dp/dx$, and the constant c.

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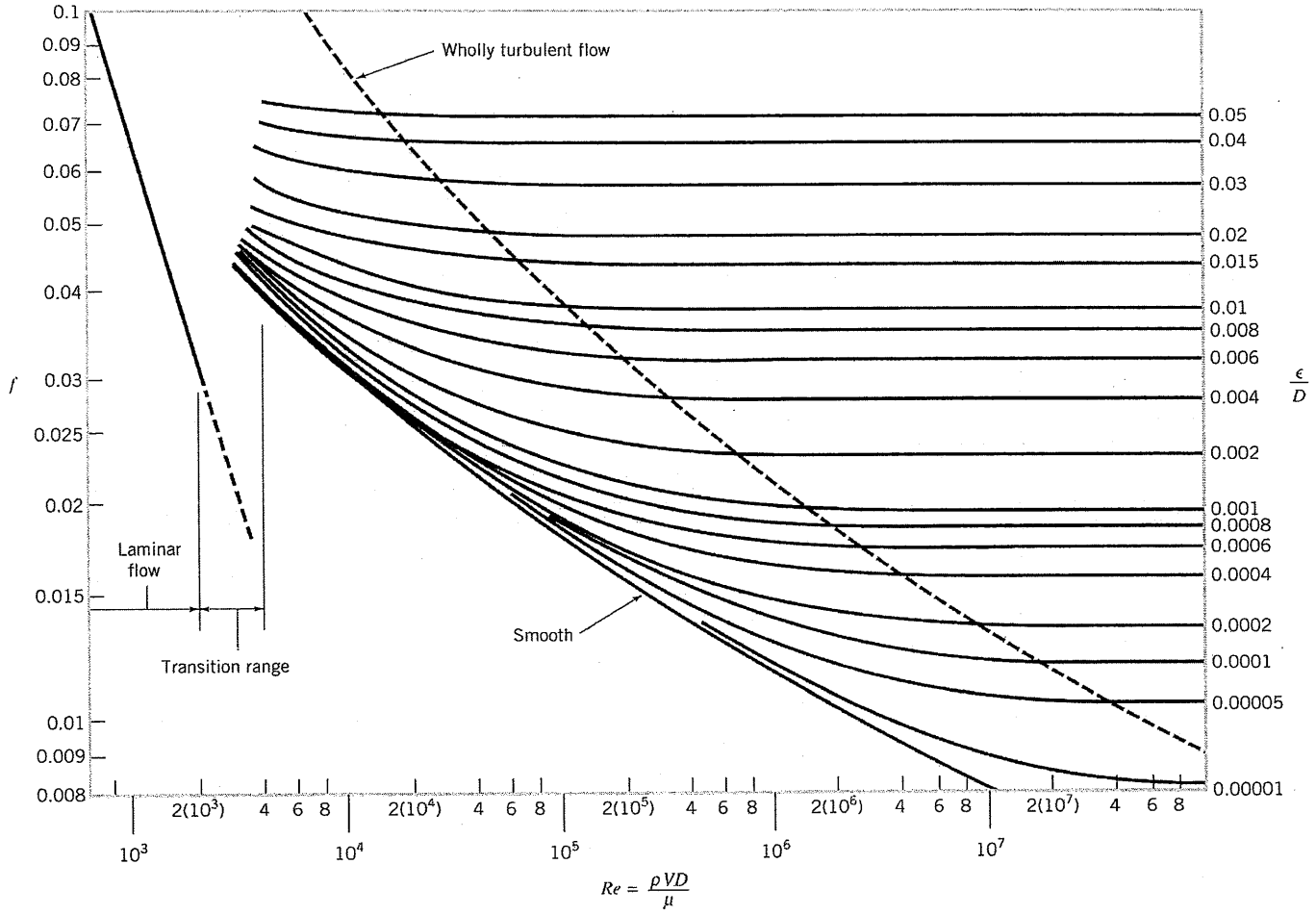
3. (20%) A long ventilation duct is used to transport air at normal temperature (density, ρ = 1.2 kg/m^3, dynamic viscosity, μ = 2.76×10^{-6} m^2/sec). The duct has a smooth interior surface, a circular cross-section with a diameter of 0.5 m and is 50 m long. A pressure difference of 1 kg/m sec^2 is applied between the two ends of the duct. Using the Moody chart find the average velocity of flow through the duct.

(Note: In the chart, $f = D(-\frac{dp}{dx})/\frac{1}{2}\rho V^2$, $Re = \frac{\rho DV}{\mu}$ where D is the duct diameter and V the average velocity of the flow.)



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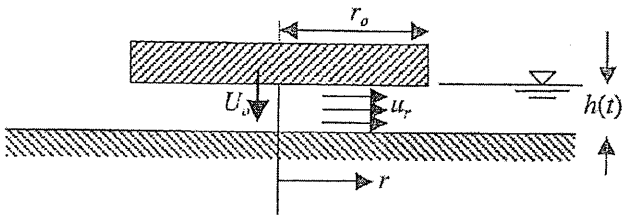
4. A circular plate is forced down at a steady velocity U_0 against a flat surface. Assume that $h<<r_0$ the plate radius, and that the radial velocity $u_r(r,t)$ is a constant across the gap. Please also assume the fluid is inviscid.



(a).(7%) Obtain $u_r(r,t)$ in terms of r, U_0, and h.

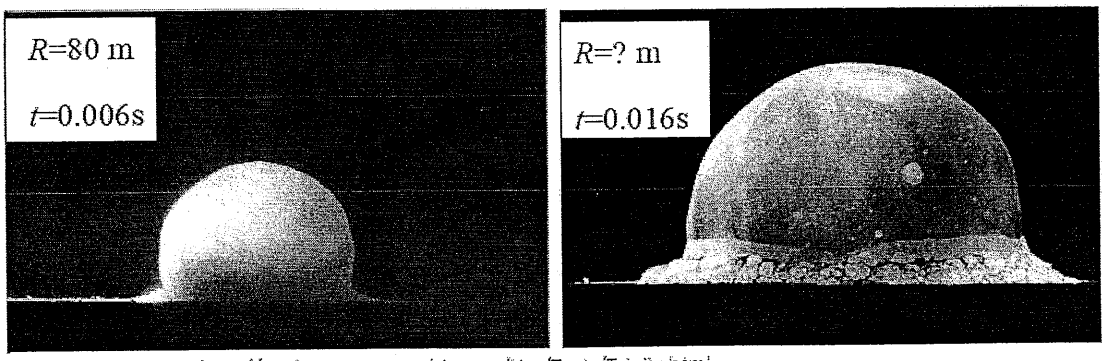
(b).(7%) Calculate the pressure distribution $p(r)$ in terms of r, U_0, and h assuming that $p(r=r_0)$ is atmospheric pressure p_0.

(c).(6%) Determine the magnitude and direction of the force acting on the circular plate.

5. G. I. Taylor is a British fluid dynamicist during World War II. Although he was not directly involved in the Manhattan project that was operated by US government to develop the atomic bomb, he used dimensional analysis to estimate the energy released by the bomb very successfully from the time-series pictures published in a popular magazine. Taylor assumed that the energy of atomic bomb $\boldsymbol{E}$ (joule) was released in a small place, and the shock wave is spherical. The size of the shock wave $\boldsymbol{R}$ can be acquired from different time $\boldsymbol{t}$ based on the given pictures, and the density of the surrounding air is denoted as $\boldsymbol{\rho}$.

(a).(9%) Determine, with the aid of dimensional analysis, how the energy $\boldsymbol{E}$ depends on shock wave radius $\boldsymbol{R}$, time $\boldsymbol{t}$, and density $\boldsymbol{\rho}$.

(b).(6%) If the size of the shock wave is measured as R=80 m at t=0.006 sec, what will it be as t=0.016 sec?



http://nuclearweaponarchive.org/Usa/Tests/Trinity.html

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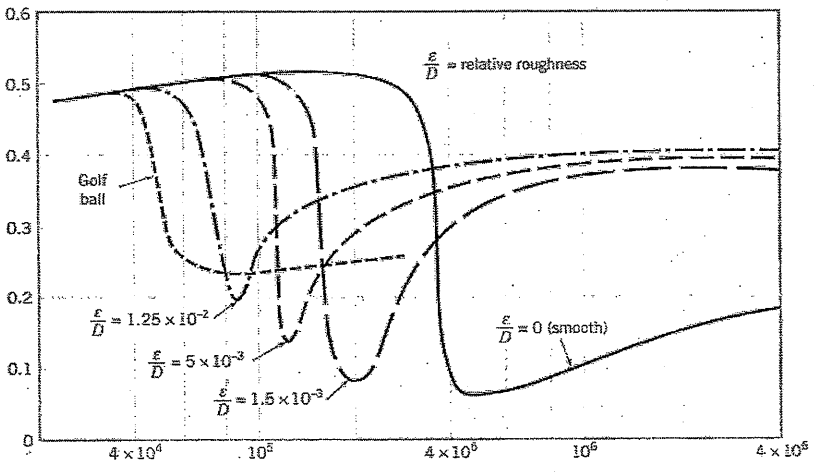
6. The effect of surface roughness ε on the drag coefficient C_D of a sphere in the Reynolds number is highlighted in the figure below where D (0.14 ft) is the diameter, U is the travelling speed, and ν ($1.57 \cdot 10^{-4}$ ft^2/s) is the kinematic viscosity.

(a)(5%) For each curve, the sudden drop of drag is related to laminar-to-turbulence transition, what is the reason that causes this significant change in drag? Why a golf ball is made with roughness on its surface?

(b)(5%) For a top professional golfer, the fastest tee shot of the travelling speed U is 280 ft/s. Determine the drag force ratio between the golf ball and smooth ball (ε=0) if the ball is hit with a travelling speed U as 200 ft/s.

(b)(5%) Now assume you could have hit the ball with a travelling speed faster than 400 ft/s. Which ball you want to use in the game, golf ball or smooth ball?

$$C_D = \frac{F_D}{\frac{1}{2}\rho U^2 \frac{1}{4}\pi D^2}$$



$$\mathrm{Re} = \frac{UD}{\nu}$$