國立成功大學
111學年度碩士班招生考試試題

編　號：65

系　所：機械工程學系

科　目：流體力學

日　期：0219

節　次：第 1 節

備　註：可使用計算機

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1. **(30%)** Consider the laminar, viscous, planar flow of an incompressible fluid contained between two parallel plates distance H apart. The coordinates x and y are respectively measured parallel to and perpendicular to these plates. We shall take $y = 0$ at the static plate and $y = H$ at the moving plate for convenience. The plate at $y = H$ moves with a steady velocity, U, in the x direction. However, unlike simple Couette flow, a pressure gradient, dp/dx, is also applied to the fluid. Find:

(a) The velocity distribution, $u(y)$, in the flow as a function of y, U, H, dp/dx and the viscosity of the fluid, μ.

(b) The magnitude and direction of the particular pressure gradient for which there would be zero net volume flow in the x direction.

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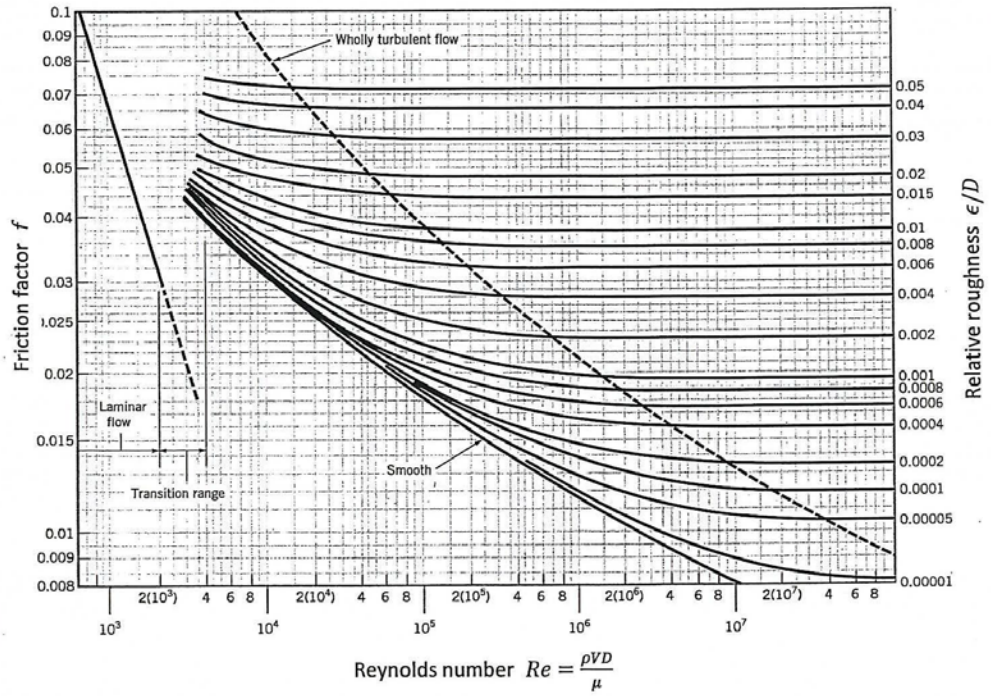
2. **(20%)** A utility company is laying a new water supply pipe with an internal diameter of 5 cm. The flow rate through this pipe will be 0.05 m^3/s. The kinematic viscosity of the water is 10^{-6} m^2/s. When new the interior surface of the pipe has roughnesses which are typically 0.05 mm in size. However, as the pipe ages, the engineer estimates that the roughness could increase to 1.0 mm. Using the chart below find the ratio of the pressure difference needed to generate this flow when the pipe has aged to the pressure difference required when it is new.



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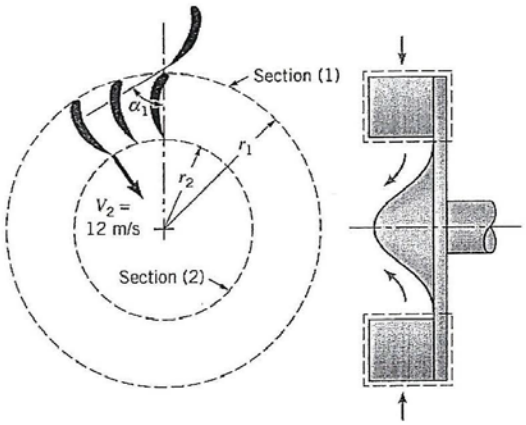
3. **(30%)** (a) An inward flow radial turbine (shown below) involves a nozzle angle $\alpha_1 = 60°$ and an inlet rotor-tip speed $U_1 = 6$ m/s. The ratio of rotor inlet to outlet diameter is 1.8. The absolute velocity leaving the rotor at section (2) is radial with a magnitude of 12 m/s. Determine the energy transfer per unit mass of fluid flowing through this turbine if the fluid is air (with a density of 1.23 kg/m^3). Neglect viscous effects.

(b) Suppose that the energy transfer per unit mass, $\dot{W}/\dot{m}$, of this turbine can be expressed as

$$\dot{W}/\dot{m} = f(D, \omega, Q),$$

where $D = 2r_1$ is the inlet diameter of the turbine, ω the angular speed (so that $U_1 = \omega r_1$), and Q the volumetric flowrate. Determine a suitable subset of dimensionless parameters.

(c) Now, for *dynamically similar* turbines operating at the same angular speed ω, determine how $\dot{W}/\dot{m}$ and Q scale with D.



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4. **(20%)** A 5 cm-diameter sphere weighing 0.6 N is suspended by the jet of air (with a density of 1.23 kg/m^3) as shown below. The drag coefficient for the sphere (based on its frontal area) is 0.5. Determine the reading on the pressure gage if friction and gravity effects can be neglected for the flow between the pressure gage and the nozzle exit.