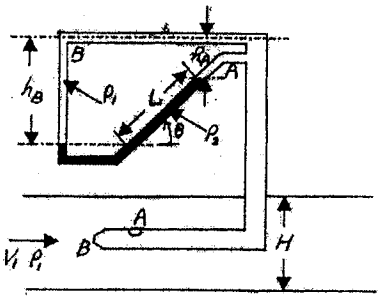
1. Fundamentals (total 10 %)

Define and explain the following terms:
(a) hydrostatic pressure, (b) specific gravity, (c) Newtonian flow, (d) rotational flow, (e) convective acceleration.

2. Bernoulli Equation (total: 20%)

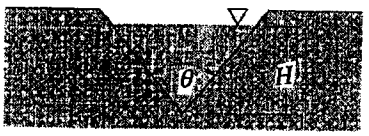
A pitot tube is installed inside a square channel to measure the incompressible flow, and it is attached with an inclined-tube manometer. The corresponding values for the pitot tube and channel are given as: ρ_1=1.2 kg/m^3, ρ_2=1000 kg/m^3, h_A=20 cm, h_B=20 cm, L=50 cm, H=60 cm, g=9.8 m/s^2.

(a) What we call the pressure at point A (p_A) and point B (p_B)? (2%)
(b) Derive the pressure difference (p_A - p_B) in terms of ρ_1, ρ_2, h_A, h_B, L, g. (6%)
(c) Compute the speed of the channel (V_1). (4%)
(d) Compute the volume flow rate of the channel. (3%)
(e) Write out the complete relation between speed and the pressure for this channel flow? Briefly explain this equation and what terms have you neglected in this equation? (5%)



3. Dimensional Analysis **(total: 10%)**

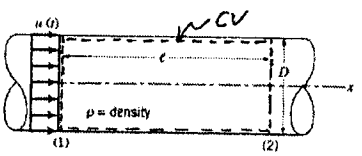
The flowrate, Q, in an open canal or channel can be measured by placing a plate with a V-notch across the channel as shown in the figure below. The height, H, of the liquid above the crest can be used to determine Q. Assume that $Q = f(H, g, \theta)$ where g is the acceleration of gravity. What are the significant dimensionless parameters for this problem?



4. Control Volume/Momentum Equation (total: 25%)

Consider unsteady flow in a constant diameter, horizontal pipe shown in the figure below. The velocity is uniform throughout the entire pipe, but it is a function of time: $\mathbf{V} = u(t)\mathbf{i}$.

(a) Use the x component of the unsteady momentum equation to determine the pressure difference (p_1-p_2). (12%)
(b) Discuss how this result is related to $F_x = ma$. (6%)
(c) Please also determine the pressure difference (p_1-p_2) when the flow is upwards in a vertical pipe. (7%)



注意：背面有試題

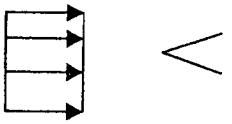
5. Viscous Flow (total 25 %)

Briefly answer and/or define the following questions:

(a) What is the fully developed flow in a circular pipe? (1 %)

(b) What are the boundary layer thickness (δ), the displacement thickness (δ^*), the momentum thickness (Θ), and the wall shear stress (τ_ω)? (6 %)

(c) Draw the typical flow patterns for flow pass a v-gutter at Re = 1, Re = 25, and Re = 10,000, where Re is the Reynolds number based on the width of the v-gutter. (6 %)



(d) A one micron diameter dust particle of density ρ_s = 1 gm/cm^3 is falling through air (ν = 0.15 cm^2/s, ρ = 0.0013) under the force of gravity. Assuming stokes flow, calculate the terminal falling speed of the particle. Please confirm that $Re \ll 1$. How does this speed depend on air density? Explain. (Hint: the stokes drag $D = 3\pi\mu V d_p$) (12 %)

6. Compressible Flow (total 10 %)

Liquids are approximately described by the equation of state (the Tait equation) $\frac{P+B}{B} = \left(\frac{\rho}{\rho_o}\right)^n$, where B and n are constant (B = 3000 atm and n = 7.15 for water), P the pressure, ρ the density and ρ_o the reference density. Please answer the following questions.

(a) What is the speed of sound in terms of P, ρ_o, B, and n? (3 %)

(b) Consider a steady, one-dimensional, frictionless, compressible flow from a reservoir at pressure P_o. What is the differential momentum equation for this flow? (3 %)

(c) What is the Mach number in terms of P, P_o, B, and n? (4 %)