國立成功大學

112學年度碩士班招生考試試題

編　號：137

系　所：航空太空工程學系

科　目：流體力學

日　期：0206

節　次：第 2 節

備　註：不可使用計算機

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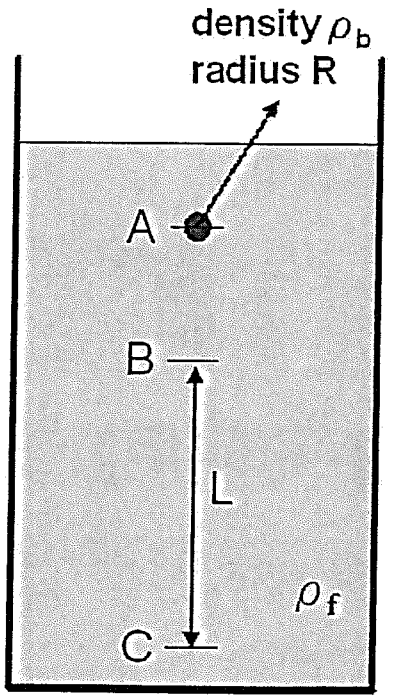
1. As shown in figure below, consider a very small spherical ball with radius R and density ρ_b is allowed to fall freely from a point A in a fluid with a density of ρ_f. The initial velocity of the ball at point A equals zero. The small ball moving in fluids is known to experience buoyant force F_B, gravity force F_G, and drag force F_D. The drag force F_D is proportional to speed V and can be formulated as $F_D=6\pi\mu VR$, where μ is viscosity of fluid, V is the ball speed and R is the ball radius. The ball reaches its terminal speed V_t as it passes through point B and takes time T (second) falling from point B to point C. The distance between point B and point C is L. Please answer the following questions by sketching the free body diagram of the ball, evaluate buoyant force F_B, and gravity force F_G and write down governing equation for the motion of the ball.

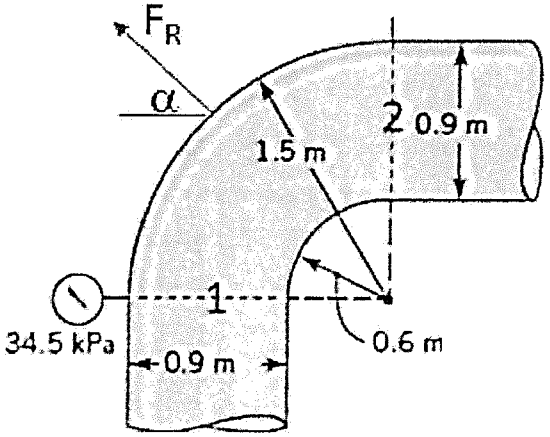
(a) Find out the velocity as function of time V(t). (5 %)

(b) Determine the terminal speed V_t. (5 %)

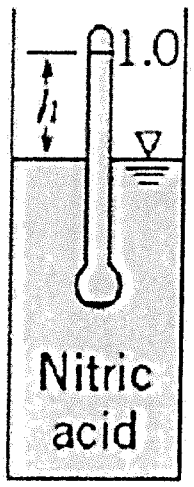
(c) The falling ball experiment can be used to measure viscosity of a fluid. Determine the viscosity μ of fluid in terms of ρ_b, ρ_f, R, μ, L, T and g. (5%)



2. The water flow rate through the vertical bend from bottom inlet shown in the figure is 2.83 m^3/s. The pressure at the location 1 is 34.5 kPa. Find (a) the magnitude (10%) and (b) the direction α (10%) of the resultant force (F_R) of the water acting on the pipe bend.
Hint: Consider the elevation and pressure head changes with no head loss when water flow through the vertical bend and density of water is 999 Kg/m^3.



3. A hydrometer is a specific gravity indicator, the value being indicated by the level at which the free surface intersects the stem when floating in the liquid. The 1,0 mark is the level when in distilled water. For the unit shown, the immersed volume in distilled water is V_w. The diameter of the stem is d. Find the distance, h, from the 1.0 mark to the free surface when the hydrometer is placed in a solution with specific gravity SG_n (15%)



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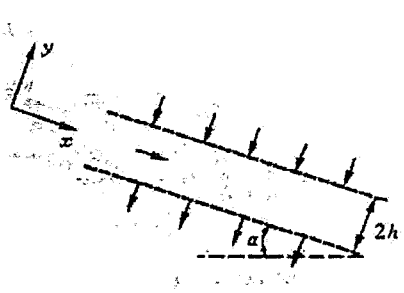
4. (15%) There are two infinite plates filled with water and placed parallel with a gap $2h$ and an incident angle α. The plates are porous so that the fluid is uniformly sprayed into the gap through the upper plate and also uniformly suction through the lower plate. The fluid both drawn off and injected into the plates are both with the constant velocity magnitude v in only y-direction. The velocity of fluid between the plates is depend upon y only. Assume there is the pressure gradient $p_0 = \dfrac{\partial p}{\partial x}$, please find the velocity distribution between the plates.



5. (20%) A model propeller 1 m in diameter is tested in a wind tunnel. Air approaches the propeller at 50 m/s when it rotates at 2000 rpm. The thrust and torque measured under these conditions are 100 N and 10 N·m, respectively. A prototype eight times as large as the model is to be built. At a dynamically similar operating point, the approach air speed is to be 150 m/s. Calculate the speed, thrust, and torque of the prototype propeller under these conditions, neglecting the effect of viscosity but including density.

6. (15%) A liquid flows down an inclined plane surface in a steady, fully developed laminar film of thickness h. Simplify the continuity and Navier-Stokes equations to model this flow field. Obtain expressions for the liquid velocity profile. Relate the liquid film thickness to the volume flow rate per unit depth of surface normal to the flow. Calculate the volume flow rate in a film of water $h = 2$ mm thick, flowing on a surface $b = 1$ m wide, inclined at $\theta = 15^\circ$ to the horizontal.