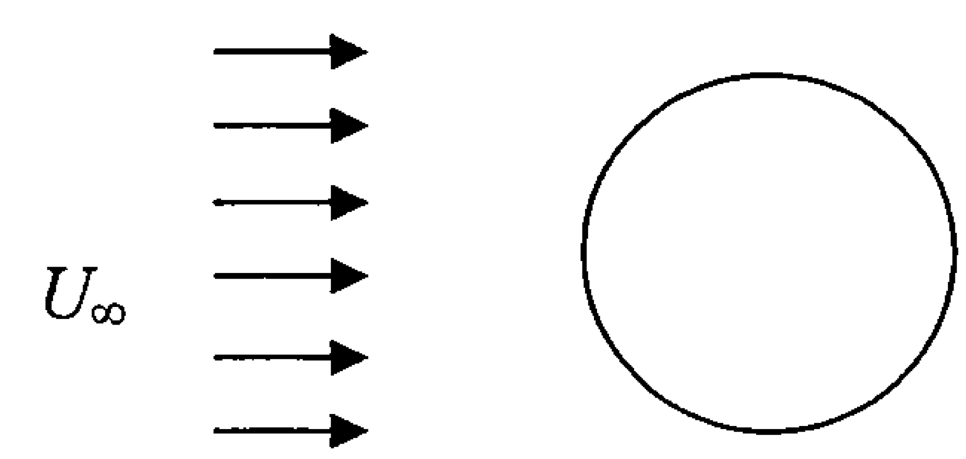
國立清華大學 103 學年度碩士班考試入學試題

系所班組別：動力機械工程學系碩士班 甲組(熱流組)

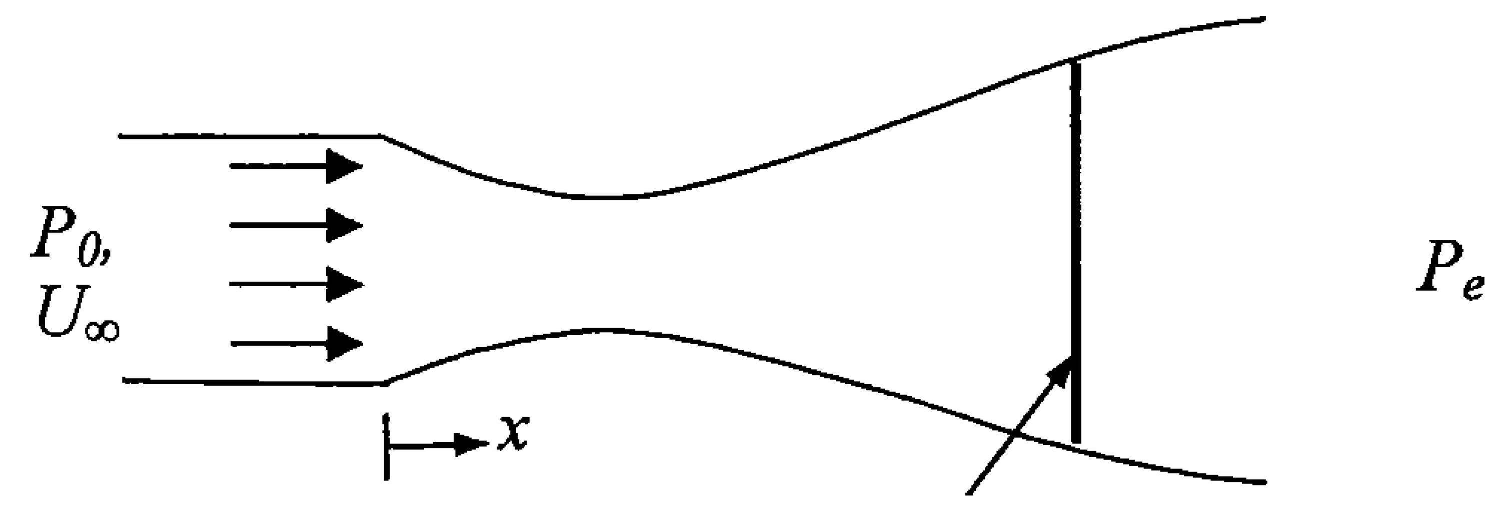
考試科目（代碼）：熱流學二(1101)

 *請在【答案卷、卡】作答

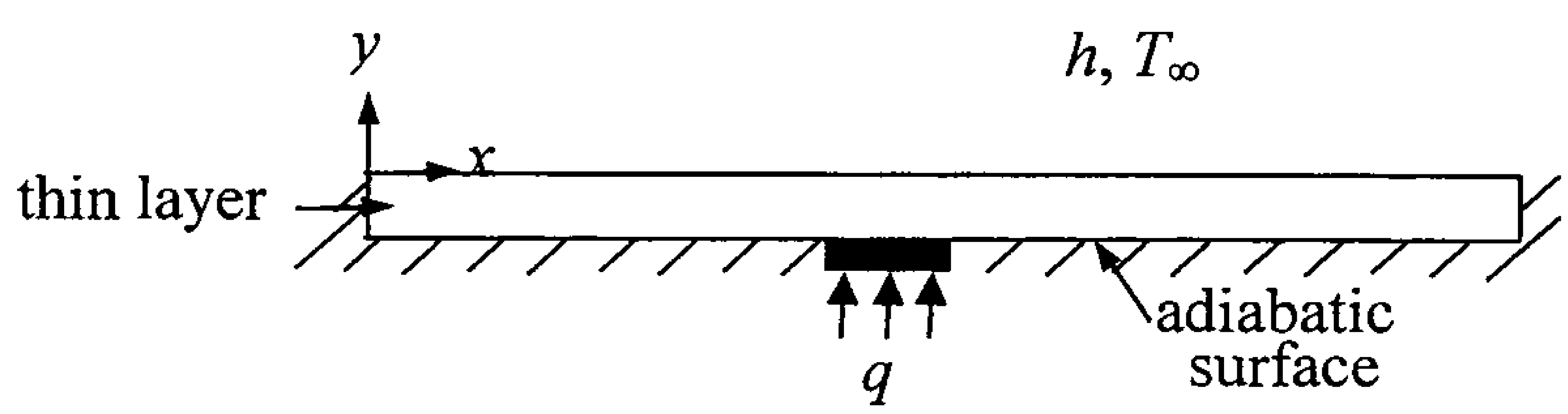
1. (20%) Consider the local stress $\tau(s)$ and total drag force D exerting on the surface of a smooth cylinder in a fluid flow, as in the figure below. The Reynolds number $\rho U_\infty d/\mu = 10^6$, where d is the diameter of the cylinder.
   (a) Draw a curve of $\tau(s)$, where s is the coordinate along the circumference（圓周）of the cylinder from the front stagnation point to the rear stagnation point. Also explain for its variation. (Note: There can be different regions with different mechanisms.)
   (b) Draw the flow pattern around the cylinder, including the development of the boundary layer and the wake flow.
   (c) Discuss how the drag force is formed on the cylinder. In fact, there are different mechanisms. Which mechanism leads to a higher contribution to the drag force in this case? Why?



2. (18%) In the air flow within the converging/diverging nozzle, a normal shock wave occurs as shown below. The upstream total pressure is P_0 and the environment pressure is P_e. Assume the flow is non-viscous and one-dimensional with only longitudinal variation.
   (a) Explain why and how the normal shock wave happens.
   (b) Draw the longitudinal variations of air-flow Ma number, static pressure, and temperature, respectively, from the inlet to the outlet. Also explain for their changes across the shock wave.



3. (12%) Consider the two-dimensional steady-state heat conduction in a thin layer heated on one side and under convection at the other side, as in the figure below. Except the upper surface and the part of the lower surface in contact with the heater, all other surfaces are insulated. For the two cases: (i) the layer is an aluminum alloy having $k = 200$ W/mK; (ii) the layer is an anisotropic graphite having $k_x = 1500$ W/mK and $k_y = 5$ W/mK, answer the following:
   (a) Write the 2-D, steady-state conduction energy equation in the thin layer for each case, respectively.
   (b) Draw five isotherms (等溫線) between the heater and the upper surface along with a few heat flow paths for each case, respectively.
   (c) Discuss on the relation between flow directions and the temperature gradient ∇T in the layer for each case, respectively.



4. (20%) (a) Explain a fully developed temperature profile for the forced convection of laminar flow inside a circular tube. (5%)
   (b) Explain the Nusselt number equal to a constant if fully developed temperature profiles exist. (10%)
   (c) Can you qualitatively compare the relative magnitudes of hydrodynamic entry length and thermal entrance length? (5%)

5. (15%) (a) Explain the physical meaning of the Grashof number? (5%)
   (b) On what dimensionless parameters does the Nusselt number of laminar natural convection primarily depend? (5%)
   (c) What is the laminar range of dimensionless group obtained from the above problem for the natural convection from a vertical plate? (5%)

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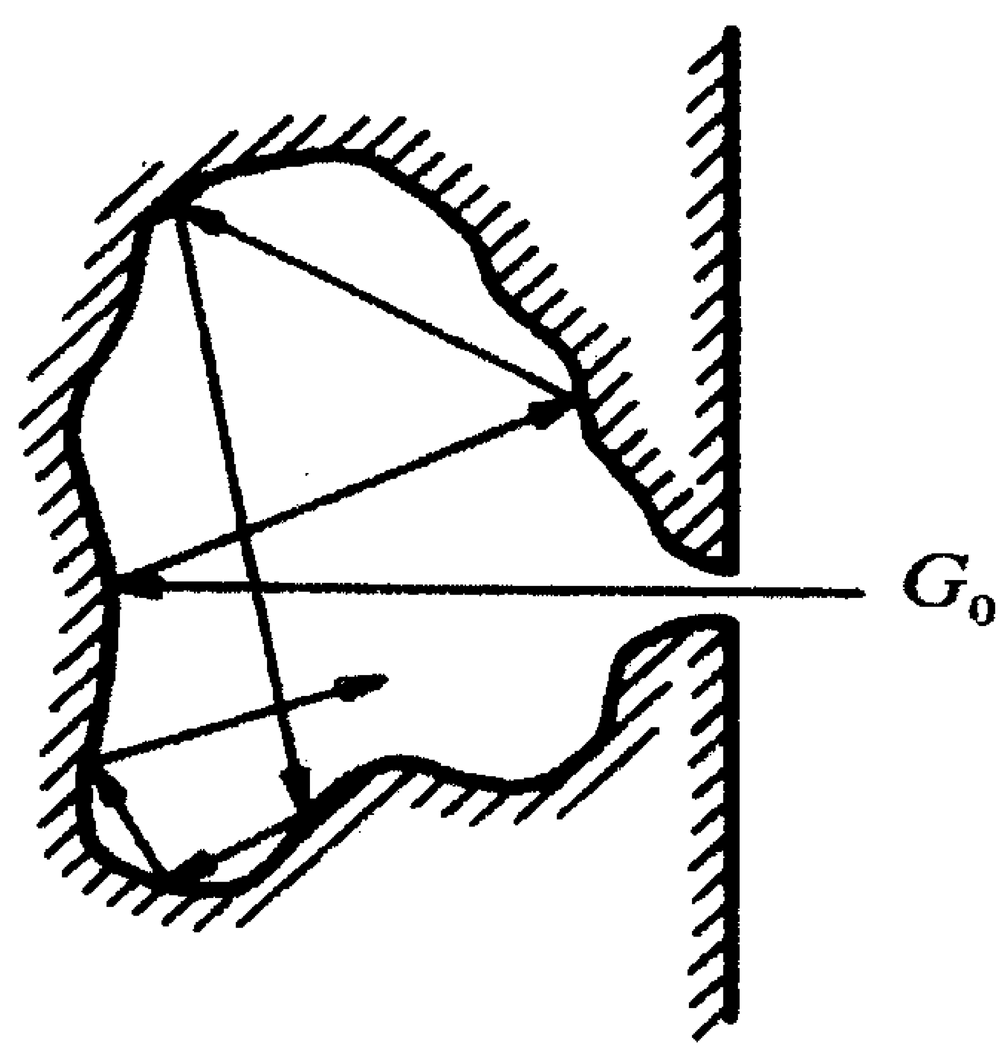
6. (15%) (a) What physical ratio determines whether a real surface is an almost-specular reflector or an almost-diffuse reflector? (5%)

   (b) A single bundle (ray) of energy is shown entering a small opening into a cavity (Hohlraum) with resulting specular reflections from the inner surfaces. If the entering energy flux is G_0, and if the material has absorptivity $\alpha_m < 1$, express the energy flux after each successive reflection. (5%)



   (c) Show that a Hohlraum approximates a blackbody. (5%)