GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - FALL Semester 2001

Heat Transfer
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

- **Please sign your name on the back of this page—**

Heat Transfer **Problem 1**

Air flows in crossflow over a finned tube. The inner and outer radii of the tube are R_i and R_o, respectively, and the tube length is L. N evenly spaced, rectangular fins, W by W and thickness t, are attached to the tube. (Of course, each fin has a hole the diameter of the tube in it.) The finned tube is used as an evaporator coil. Refrigerant at temperature T_R and mass flow rate $\dot{m}_R$ evaporates as it flows through the tube. The tube material has thermal conductivity k_T and the fin material has thermal conductivity k_F. The average heat transfer coefficient on the inside surface is h_i, and the average heat transfer coefficient over the outside surface and fins is h_o. The fin efficiency for a single fin is n_f. The mass flow rate of air over the finned tube is $\dot{m}_a$, the temperature of the air approaching the tube is T_a. You may assume that other needed air properties are known.

a. Start from **basic principles** and develop an expression for the overall heat transfer coefficient for the finned tube. Clearly **state all assumptions**. (Merely stating an equation that you might have memorized is **not** acceptable.)

b. Assuming that the overall heat transfer coefficient has been determined, show how one should calculate the temperature rise of the air flowing over the finned tube.

Express you results in terms of the quantities given above or other variables that you have defined in terms of the given quantities.

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Heat Transfer Problem 2

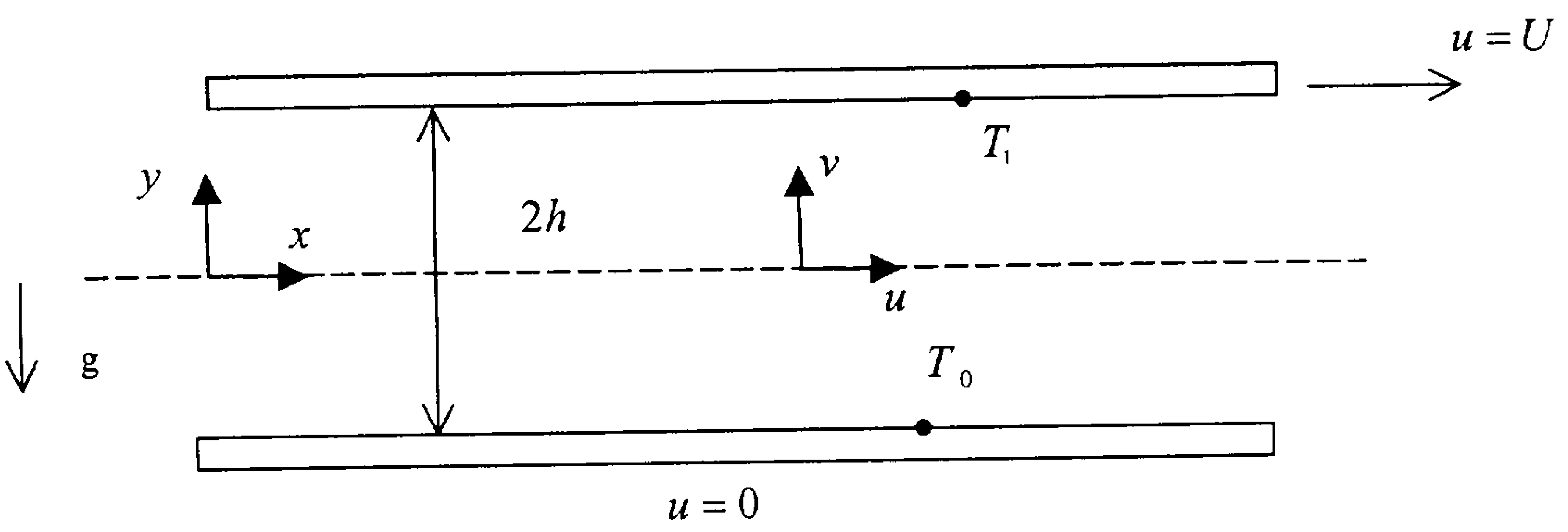
Two infinite, parallel plates, with the upper plate moving at the speed U with respect to the bottom plate, are given. The upper and lower plates are at temperatures T_1 and T_0, respectively. An incompressible, constant-property fluid flows at steady-state between the plates with a constant dP/dx.

a) Reduce the mass, momentum and thermal energy conservation equations to the appropriate simple forms for this problem.

b) Derive algebraic expressions for dimensionless velocity and temperature distributions, where:

$$u^* = u/U, \quad T^* = (T - T_0)/(T_1 - T_0)$$

Hint: Note that $\vec{U} = u(y)$, and $T = T(y)$



Conservation Equations

$$\nabla . \vec{U} = 0$$

$$\rho D\vec{U}/Dt = -\nabla P + \mu \nabla^2 \vec{U} + \rho \vec{g}$$

$$\rho C_p DT/Dt = k\nabla^2 T + \mu\phi$$

$$\rightarrow \mu\phi = \mu\left\{\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)^2 + 2\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right]\right\}$$

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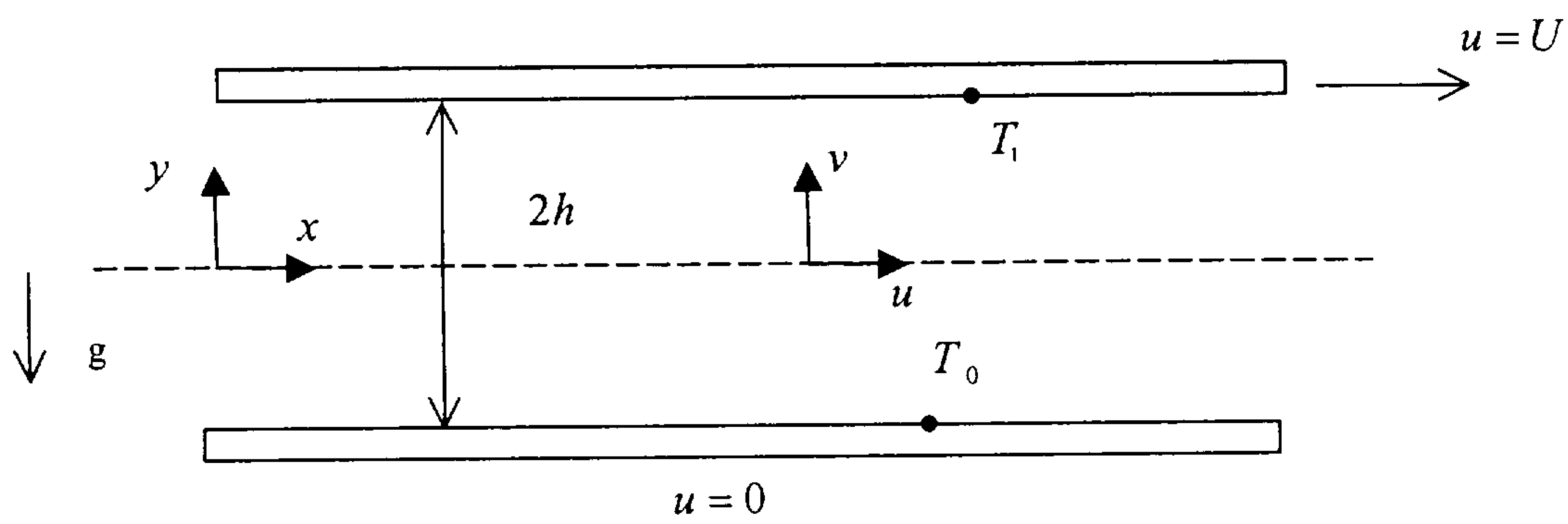

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Heat Transfer **Problem 3**

Problem statement: Liquid oxygen is stored in a thin-walled spherical container (96 cm in diameter), which is in turn enclosed in a concentric container 100 cm in diameter. The space between the storage tank and an enclosing container is evacuated, and the surfaces of both containers that are facing each other are plated and have an emittance of 0.05. The outer surface of the storage tank is kept at 95 K, and the inner surface of the enclosing container is at 280 K.

Question: What is an oxygen boil-off rate $\dot{m}$ or an amount of oxygen evaporated in the tank (in kg/s) if the enthalpy of vaporization of oxygen is 0.213 MJ/kg?

Note: Make sure to clearly state all assumptions you make in the analysis and clearly describe all the steps of your analysis.

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