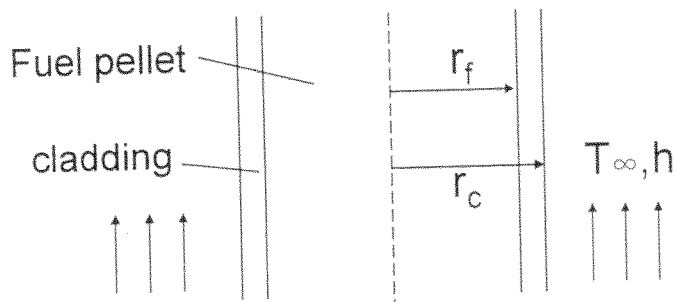


98 學年度工程與系統科學系乙組碩士班入學考試

科目 熱傳學 科目代碼 2704 共 4 頁第 1 頁 \*請在【答案卷卡】內作答

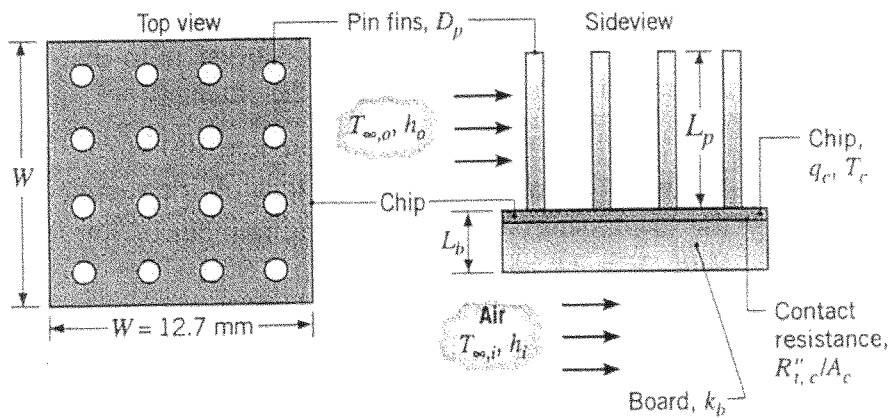
1. Please derive the time-dependent, three dimensional heat diffusion equation in Cartesian coordinates. Define the variables used clearly. Please also describe the three basic types of boundary conditions for heat conduction. (20%)
2. Consider a cylindrical fuel rod with fuel pellet inside coated with a cladding. The thermal conductivity for the pellet and cladding are  $k_f$  and  $k_c$ , respectively. The outside radius for the pellet and cladding is  $r_f$  and  $r_c$ , respectively. The volumetric heat generation in the pellet due to nuclear fission is uniformly at  $\dot{q}$ . The thermal contact resistance between the pellet and cladding is  $R''_c$  ( $m^2K/W$ ) for a unit area of interface. The fuel rod is cooled by a coolant at  $T_\infty$  with a heat transfer coefficient  $h$ . Obtain an expression for the centerline temperature of the pellet. (20%)



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科目 熱傳學 科目代碼 2704 共 4 頁第 2 頁 \*請在【答案卷卡】內作答

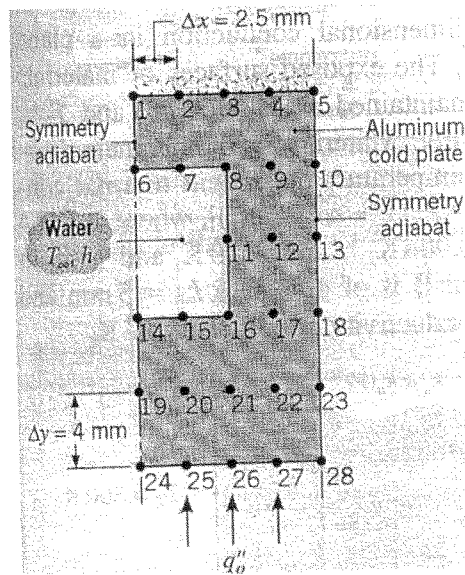
3. As more and more components are placed on a single integrated circuit. To maximize heat dissipation, it is proposed that a  $4 \times 4$  array of copper fins be metallurgically joined to the outer surface of a square chip that is 12.7 mm on a side, as shown in the following figure. Determine the maximum heat dissipation rate from the chip if the maximum allowable chip temperature is  $80^\circ\text{C}$ . The pin diameter is 1.5 mm and length is 15 mm. The fins are exposed to a dielectric liquid with  $h_o = 1000 \text{ W/m}^2\text{K}$  and  $T_{\infty,o} = 20^\circ\text{C}$ . Assume there is no heat dissipation from the tip of fins. The thermal contact resistance between the chip and the board is  $10^{-4} \text{ m}^2\text{K/W}$ , and the board thickness and thermal conductivity are  $L_b = 5 \text{ mm}$  and  $k_b = 1 \text{ W/mK}$ , respectively. The other surface is exposed to ambient air for which  $h_i = 40 \text{ W/m}^2\text{K}$  and  $T_{\infty,i} = 20^\circ\text{C}$ . The thermal conductivity for copper is  $400 \text{ W/mK}$ . (20%)



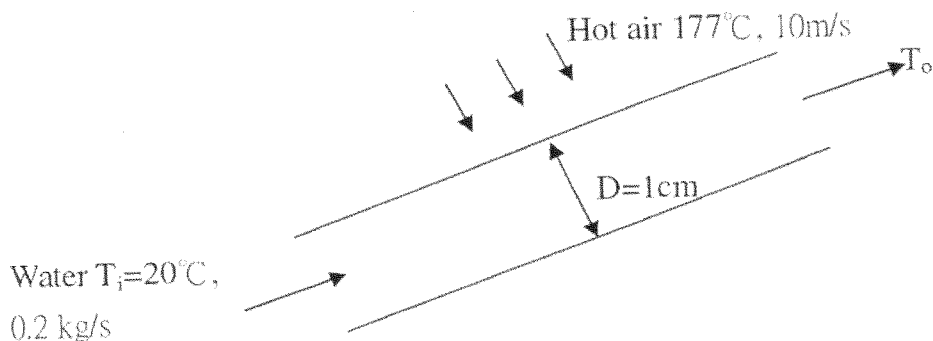
98 學年度工程與系統科學系乙組碩士班入學考試

科目熱傳學 科目代碼 2704 共 4 頁第 3 頁 \*請在【答案卷卡】內作答

4. For the nodal network shown below for a unit part of a cold plate and consider steady state heat conduction, please derive the nodal finite difference equations for  $T_{11}$  and  $T_{12}$ , respectively, based on the energy balance method. Show your derivation. (20%)



5. Waste heat of exhaust hot air from a manufacturing process may be recovered by passing water through a thin-wall tube of 1 cm diameter as shown. Assume the temperature of the hot air is  $177^\circ\text{C}$  in cross flow with a velocity of 10 m/s over the tube. The inlet and outlet temperature of water are  $20^\circ\text{C}$  and  $80^\circ\text{C}$ , respectively, and the flow rate is 0.2 kg/s. Determine the length of the tube and the total heat transfer rate from air to water. (20%)



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科目熱傳學 科目代碼 2704 共 4 頁第 4 頁 \*請在【答案卷卡】內作答

**Hint:  $Nu_D=3.66$  if the flow is laminar in the tube, and**

$$Nu_D = \frac{(f/8)(Re_D - 1000)Pr}{1 + 12.7(f/8)^{1/2}(Pr^{2/3} - 1)}, \quad f = (0.790 \ln(Re_D) - 1.64)^{-2}$$

**if the flow**

**is turbulent.**

**For external flow:**

$$\overline{Nu}_D = 0.3 + \frac{0.62 Re_D^{1/2} Pr^{1/3}}{[1 + (4/Pr)^{2/3}]^{1/4}} \left[ 1 + \left( \frac{Re_D}{282000} \right)^{5/8} \right]^{4/5}$$

**The water properties are:**

$$\rho = 992 \text{ kg/m}^3; \quad C_p = 4.18 \times 10^3 \text{ J/kgK}; \quad k = 0.631 \text{ W/mK};$$

$$\mu = 5.28 \times 10^{-4} \text{ kg/ms.}$$

The air properties are:  $\nu = 26.4 \times 10^{-6} \text{ m}^2/\text{s}; \quad k = 0.0338 \text{ W/mK};$

$$\alpha = 38.3 \times 10^{-6} \text{ m}^2/\text{s}$$