國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：基礎熱傳學【機電系碩士班甲組】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，不得另攜帶紙張，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，其後果由考生自行負擔。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學109學年度碩士暨碩士專班招生考試試題

科目名稱：基礎熱傳學【機電系碩士班甲組】　　題號：438003

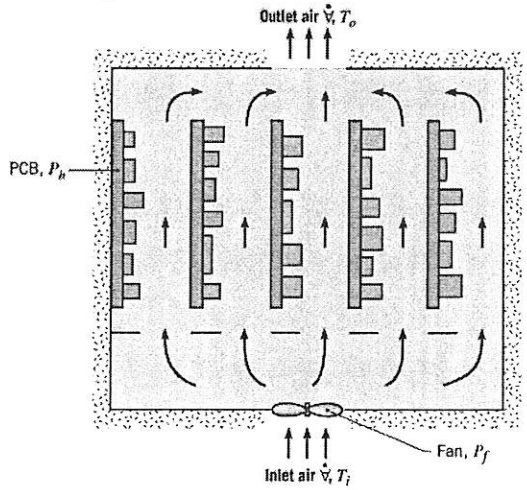
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1.(10%) The heat flux that is applied to one face of a plane wall is q"=25 W/m^2. The opposite face is exposed to air at temperature 30℃, with a convection heat transfer coefficient of 25 W/m^2·K. The surface temperature of the wall exposed to air is measured and found to be 50℃. Do steady-state conditions exist (5%)? If not, is the temperature of the wall increasing or decreasing with time (5%)?

2. (20%) A computer consists of an array of five printed circuit boards (PBCs), each dissipating P_b = 20 W of power, Cooling of the electronic components on a board is provided by the forced flow of air, equally distributed in passages formed by adjoining boards, and the convection coefficient associated with heat transfer from the components to the air is approximately h = 200 W/m^2·K. Air enters the computer console at a temperature of T_i = 20℃, and flow is driven by a fan whose power consumption is P_f = 25 W.

(a) (10%) If the temperature rise of the airflow, (To - T_i), is not to exceed 15℃, what is the minimum allowable volumetric flow rate $\dot{V}$ of the air? The density and specific heat of the air may be approximated as ρ = 1.161 kg/m^3 and c_p = 1007 J/kg·K, respectively.

(b) (10%) The component that is most susceptible to thermal failure dissipates 1 W/cm^2 of surface area. To minimize the potential for thermal failure, where should the component be installed on a PCB? What is its surface temperature at this location?



3. (10%) At a given instant of time, the temperature distribution within an infinite homogeneous body is given by the function

$$T(x, y, z) = x^2 - 2y^2 + z^2 - xy + 2yz$$

Assuming constant properties and no internal heat generation, determine the regions where the temperature changes with time.

4. (15%) The temperature distribution across a wall 0.3 m thick at a certain instant of time is

$$T(x) = a + bx + cx^2$$

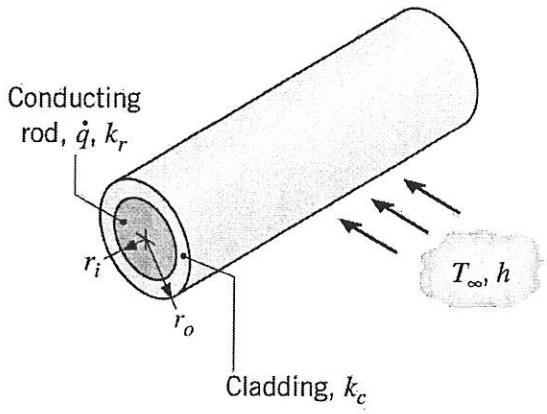
where T is in degrees Celsius and x is in meters, a = 200℃, b = -200℃/m, and c = 30℃/m^2. The wall has a thermal conductivity of 1 W/m·K.

(a) (10%) On a unit surface area basis, determine the rate of heat transfer into and out of the wall and the rate of change of energy stored by the wall.

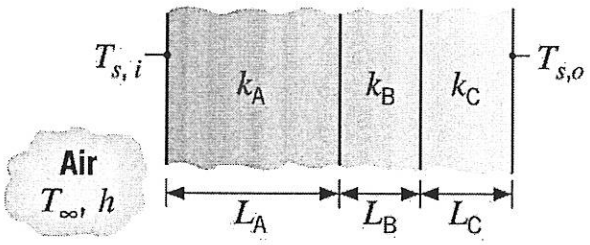
(b) (5%) If the cold surface is exposed to a fluid at 100℃, what is the convection coefficient?

5. (10%) Passage of an electric current through a long conducting rod of radius r_i and thermal conductivity k_r results in uniform volumetric heating at a rate of $\dot{q}$. The conducting rod is wrapped in an electrically nonconducting cladding material of outer radius r_o and thermal conductivity k_c, and

convection cooling is provided by an adjoining fluid. For steady-state conditions, write appropriate forms of the heat equations for the rod and cladding (5%). Express appropriate boundary conditions for the solution of these equations (5%).



6. (15%) The composite wall of an oven consists of three materials, two of which are of known conductivity, $k_A = 20$ W/m·K and $k_C = 50$ W/m·K, and known thickness, $L_A = 0.30$ m and $L_C = 0.15$ m. The third material, B, which is sandwiched between materials A and C, is of known thickness, $L_B = 0.15$ m, but unknown thermal conductivity k_B. Under steady-state operating conditions, measurements reveal an outer surface temperature of $T_{o,s} = 20$℃, an inner surface temperature of $T_{s,i} = 600$℃, and an oven air temperature of $T_\infty = 800$℃. The inside convection coefficient h is known to be 25 W/m^2·K. What is the value of k_B?



7. (20%) Steam flowing through a long, thin-walled pipe maintains the pipe wall at a uniform temperature of 600 K. The pipe is covered with an insulation blanket comprised of two different materials, A and B. The interface between the two materials may be assumed to have an infinite contact resistance, and the entire outer surface is exposed to air for which $T_\infty = 320$ K and $h = 25$ W/m^2·K.

(a) (5%) Sketch the thermal circuit of the system. Label all pertinent nodes and resistance

(b) (10%) For the prescribed conditions, what is the total heat loss from the pipe? (5%) What are the outer surface temperature $T_{s,2(A)}$ and $T_{s,2(B)}$?