國立中山大學106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）　　共2頁第1頁

1.(10%) As we know, the thermal energy transfers from higher to lower temperatures. Please describe how this physics law is fulfilled in the mathematical model for heat conduction and convection phenomenon (Hint: Fourier's Law and Newton's law of cooling).

2.(15%) Please use the first law of thermodynamics to determine the temperature change of a 128 m waterfall from one sufficient large body of water to another such that the bulk velocity can be neglected (The heat capacity c of water is 4200 J/kg·K).

3.(25%) The energy transfer between human skin and surrounding atmosphere can be approximated as one-dimensional heat transfer problem. Consider a layer of human fatty tissue（脂肪組織）that is 3 mm thick with constant interior temperature of 36°C ($T_{s,1}$), which is the normal human body temperature. On a calm day, the convection heat transfer coefficient h between human skin and the surrounding atmosphere is 25 W/m^2·K. Moreover, it reaches 65 W/m^2·K in a windy day. Assume the thermal conductivity of human fatty tissue k is 0.2 W/ m·K.

(a) (10%) What is the ratio of the heat loss per unit area from the skin for the calm day to that for the windy day assuming that the ambient air temperature is maintained as -15°C (T_∞) for both cases?

(b) (10%) What the new ambient temperature T_∞' would the air have to assume on the calm day (h=25 W/m^2·K) to produce the same heat loss occurring on the windy day (T_∞= -15°C, h=65 W/m^2·K)? T_∞' is exactly the so-called "wind chill temperature(風寒溫度)".

(c) (5%) From the answers in (a) and (b), please explain why you will feel colder when you are riding a motorcycle with a faster speed.

Hint: Please assume one-dimensional conduction in a plane wall as shown in Figure 1, and solve this problem with equivalent thermal circuit.

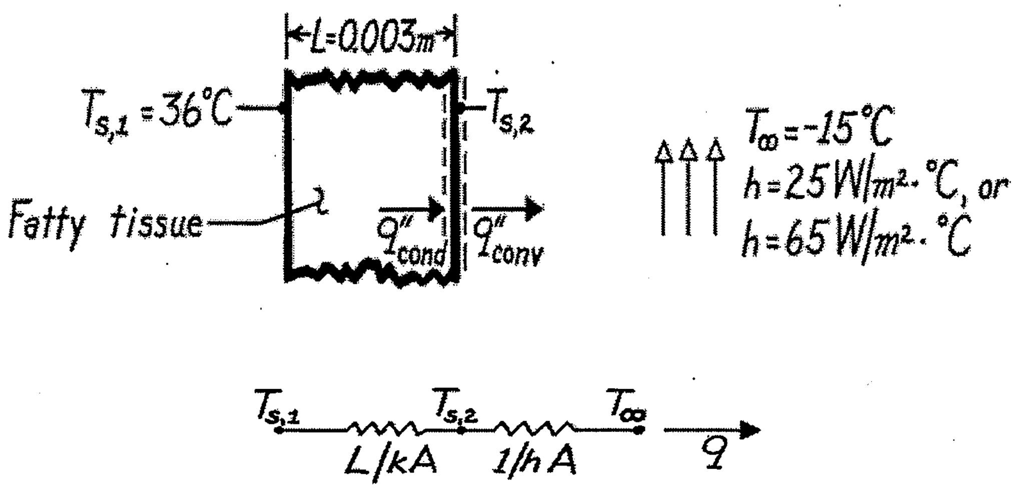

Figure 1

4.(20%) Consider a homogeneous solid medium with an internal heat generation $\dot{q}$ (W/m^3), and its temperature distribution $T(x,y,z,t)$ is expressed under Cartesian coordinates (x,y,z) and time t. Please draw a control volume to derive the heat equation, which is:

$$k\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)+\dot{q}=\rho c\frac{\partial T}{\partial t}$$

背面有題

Please only consider the conduction and assume all the material properties, such as the thermal conductivity k, density ρ, and heat capacity c, are constant.

5.(30%) As shown in Figure 2, the width w of a long copper bar of rectangular cross section is much greater than thickness L. Its lower surface is maintained as T_0 by a heat sink, and the initial temperature throughout the bar is also equal to T_0. Suddenly, an electric current is passed through the bar to provide an internal heat generation $\dot{q}>0$ (W/m^3), and an airstream of temperature T_∞ ($>T_0$) is passed over the top surface, while the bottom surface continues to be maintained as T_0. Please assume all the material properties, such as the thermal conductivity k, density ρ, and heat capacity c, are constant.

(a) (6%) The one-dimensional simplification can be utilized in the direction parallel to that of width ($T(x,y,z,t)= T(x,t)$). Why?

(b) (8%) List a partial differential equation with suitable boundary conditions that can solve temperature distribution $T(x,t)$.

(c) (10%) Assume $\dot{q}$ is a positive constant, and solve the partial differential equation in (b) under "**steady state**".

(d) (6%) Please sketch the temperature distribution $T(x,t)$ as t goes by from t=0 to $t\to\infty$. Is this possible that the $T(x,t)$ is higher than T_∞?

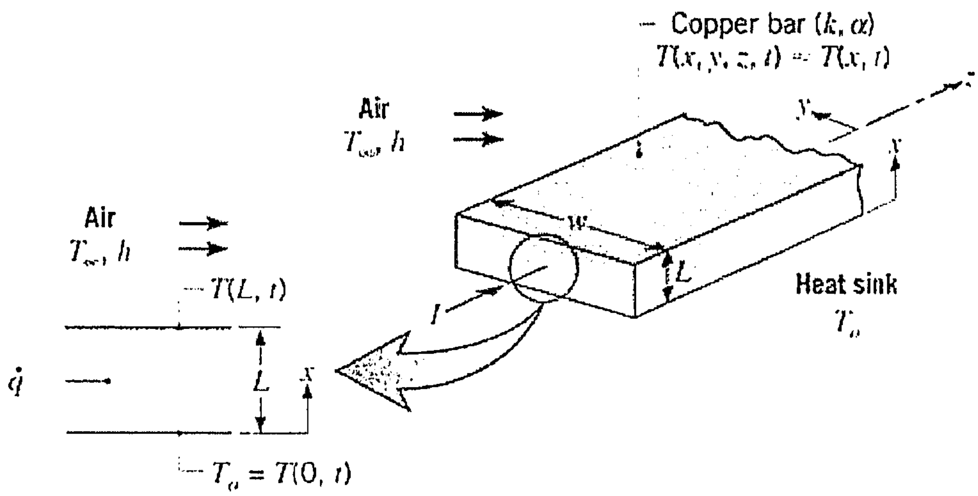

Figure 2