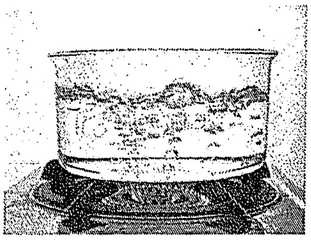
國立中山大學104學年度碩士暨碩士專班招生考試試題

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）　　　　共4頁第1頁

1. **25%**. A pot filled with water of 1.2 kg is put on a stove. With a heating power set to 1.25 kW, the water is heated up from 25 ^{0}C. Please use your knowledge of thermodynamics to answer the questions below.



(http://iab-sciencelab.wikispaces.com/)

(a)(7%) The first law of thermodynamics for transient processes is listed below:

$$\dot{Q}_{1\text{-}2} - \dot{W}_{1\text{-}2} + \sum \dot{m}_i h_i - \sum \dot{m}_o h_o = \dot{m}_2\left(u_2 + \tfrac{1}{2}V_2^2 + gZ_2\right) - \dot{m}_1\left(u_1 + \tfrac{1}{2}V_1^2 + gZ_1\right) \quad \text{(Eq. 1.1)}$$

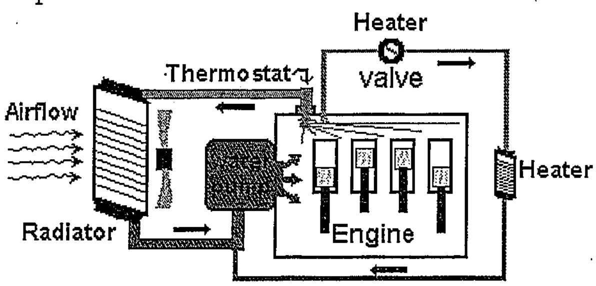
$\dot{Q}_{1\text{-}2}$ and $\dot{W}_{1\text{-}2}$ are heat transfer into the system and work done by the system during the transient process from state 1 to 2. $\dot{m}$ and h are the mass flow rate and enthalpy. The subscript i and o represent for inlet and outlet of the system. u, V, and Z represent the internal energy, velocity, and elevation. You are asked to determine the time taken to heat the water from 25 ^{0}C to a certain temperature degree, how do you ***simplify*** Equation 1.1, which allows you to deal with the problem?

(b)(7%) How do you further relate your simplified equation in (a) to the water temperature? The purpose is to make this simplified equation in (a) as a function of the water temperature.

(c)(7%) If the specific heat (C_p) of water is known (4.18 kJ/kg-K) for the working temperature, how do you rearrange your simplified equation in (b) to calculate the total time taken to heat up the water?

(d)(4%) After how long time do you expect the water temperature to be 100^{0}C?

2. **25%**. An engine coolant at 60 ^{0}C enters an engine and removes engine heat around 19 kW when leaving the engine, the coolant cannot exceed a specific temperature. Please use your knowledge of thermodynamics to answer the questions below:



(http://intecsciwri.wikidot.com/internal-combustion-engine)

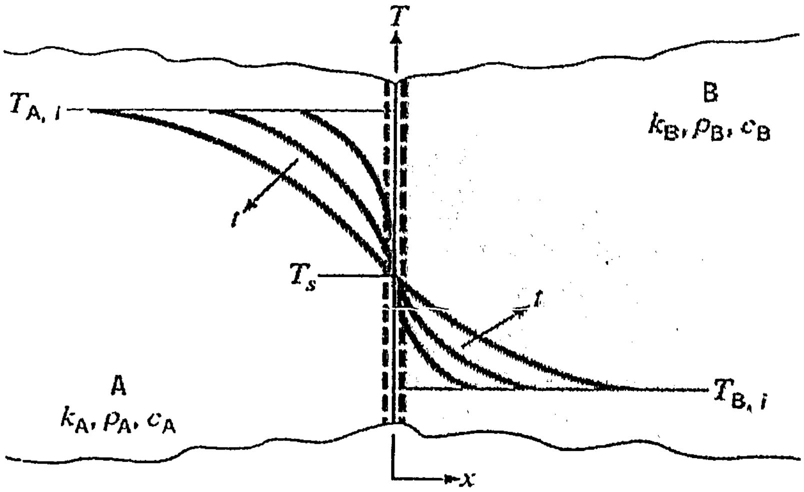
(a)(7%) You are asked to determine the required mass flow rate of the coolant, how do you simplify Eq. (1.1), which allows you to deal with the problem?

(b)(7%) How do you further relate your simplified equation in (a) to the coolant temperature? The purpose is to make this simplified equation in (a) as a function of the coolant temperature.

(c)(7%) If the specific heat (C_p) of coolant is known (2.42 kJ/kg-K) for the working temperature, how do you rearrange your simplified equation in (b) to calculate the required mass flow rate of the coolant?

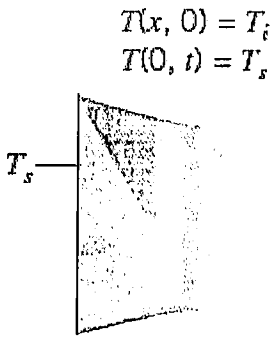
(d)(4%) What is the required mass flow rate if the coolant should come out at maximum 95 ^{0}C?

3.20%. Two semi-infinite solids A and B with uniform initial temperature $T_{A,i}$ and $T_{B,i}$ are placed side by side at x=0 from t>0 as shown in the figure. The thermal conductivity, density, heat capacity of solid A and B can be denoted as (k_A, ρ_A, c_A) and (k_B, ρ_B, c_B). The temperature profile T(x, t) is illustrated in the figure. As time t increases, the temperature difference between these two solids will decrease. The temperature T at x=0 will be independent of time t. Please calculate the temperature T at x=0.



Hint: When a single semi-infinite solid with initial condition T_i is suddenly imposed by a constant temperature T_s at x=0, the heat flux q_s', which is a function of time t, can be expressed as following equation:

$$q_s''(t) = k(T_s - T_i)/(\pi\alpha t)^{1/2}$$



4.(25%) Consider a two-dimensional square solid in Figure 4.1 with length defined as L and a uniform initial temperature T_0. Then the upper side is suddenly imposed by a constant temperature T_1. The steady state temperature $T(x,y)$ can be solved by the following heat equation and boundary conditions in Equation 4.1. The solution $T(x,y)$ is already given below as Equation 4.2:

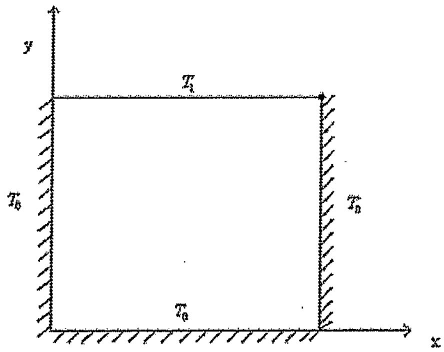


Figure 4.1

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}=0 \qquad \text{(Eq. 4.1)}$$

$$BC'S: T(x,0)=T_0,\ T(0,y)=T_0,\ T(L,y)=T_0,\ T(x,L)=T_1$$

$$\Rightarrow \frac{T(x,y)-T_0}{T_1-T_0}=\frac{2}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^{n+1}+1}{n}\cdot\sin\left(\frac{n\pi x}{L}\right)\cdot\frac{\sinh\left(\frac{n\pi y}{L}\right)}{\sinh(n\pi)} \qquad \text{(Eq. 4.2)}$$

(a)(10%) Now please consider a flow inside a channel. The representative cross section is shown in Figure 4.2. The channel has a constant cross-sectional area along z axis. The cross section is a square with length L. Initially, the flow inside the channel is stationary. Then the upper side of the channel is moving at a constant velocity U_1 along z axis while the other three side walls remain stationary.

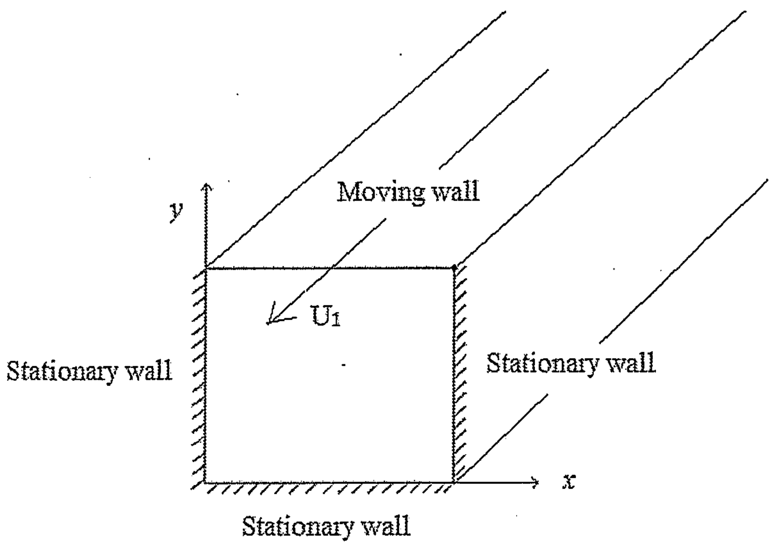


Figure 4.2

The z momentum equation of Figure 4.2 is given as Equation 4.3:

$$\frac{\partial u_z}{\partial t}+u_x\frac{\partial u_z}{\partial x}+u_y\frac{\partial u_z}{\partial y}+u_z\frac{\partial u_z}{\partial z}=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 u_z}{\partial x^2}+\frac{\partial^2 u_z}{\partial y^2}+\frac{\partial^2 u_z}{\partial z^2}\right) \qquad \text{(Eq. 4.3)}$$

Assume the flow is fully-developed in z direction, steady, incompressible, laminar, and **WITHOUT** pressure gradient. Also, u_x and u_y in x and y direction can be neglected. Please simplify Equation 4.3.

(b)(5%) Please list velocity boundary conditions of u_z in z direction for these four side walls.

(c)(10%) Comparing your results of (a) and (b) to Equation (4.1), then please utilize Equation (4.2) to give solution of $u_z(x,y)$ of Figure 4.2.

5.(5%) The thermal resistance is defined as the ratio of the temperature difference to the heat transfer rate. Similarly, flow resistance of a pipe flow can be defined as the ratio of the pressure drop to the volume flow rate. The volume flow rate Q can be obtained by pressure drop Δp of the pipe over a distance L, fluid viscosity μ, and the diameter R of the pipe. can be derived as following:

$$Q=\frac{\pi R^4 \Delta p}{8\mu L}$$

The flow resistance F then becomes:

$$F\equiv\frac{\Delta p}{Q}=\frac{8\mu L}{\pi R^4} \qquad \text{(Eq. 5.1)}$$

Recently, the mayor of Taipei City, Ko Wen-Je (柯文哲), has questioned the design of the underground passage of the Taipei Dome (台北巨蛋). From the entrance to the exit, the diameter of the underground passage varies from 80 to 6 meter. Please comment how his concern comes from by Equation 5.1. Can Equation 5.1 really applied to this design problem? Why?

國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【機電系碩士班乙組、丙組】　　　　題號：438002
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　　　共2頁第1頁

1. (15%) Solve the following ODEs. Show the details of your work.
   (a) $(6xe^{y}+4y)dx+(2x^{2}e^{y}+2x)dy=0$ (5%)
   (b) $24x^{3}y'''+30x^{2}y''+3xy'-3y=15$ (10%)

2. (10%) Model the RL-circuit in Figure 1 and solve the resulting ODE for the current *I(t)* A (amperes), where *t* is time. The circuit contains a battery of $E = 96$ V (volts) as an EMF (electromotive force), a resistor of $R = 22\ \Omega$ (ohms) and an inductor of $L = 0.2$ H (henrys) with a current initially zero.
[**Physical Laws**: A current I in the circuit causes a voltage drop RI across the resistor (Ohm's law) and a voltage drop $LI' = L\,dI/dt$ across the conductor, and the sum of these two voltage drops equals the EMF (Kirchhoff's Voltage Law, KVL).]

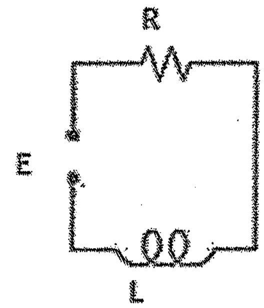


Figure 1. RL-circuit.

3. (15%) An ODE $xy''+6y'+2x^{3}y=0$ is given. Find the bases of solution by using power series method or FROBENIUS method and try to identify the series as the expansions of known functions. Show the details of your work.

4. (10%) Solve this equation by the Laplace transform. Show the details of your work.
$y''+2y'-4y=60u(t-\pi)\cos t,\ y(0)=\frac{1}{2},\ y'(0)=-1$, ($u$ is Heaviside function)

5. (10%) What are the Gauss's divergent theorem and the Stokes's theorem? (Write down the mathematical expression and simple explanation)

6. (10%) **A** is a 4x4 matrix and **B** is the inverse of **A**. if $\mathbf{A}=\begin{bmatrix}-1 & 4 & -1 & 5\\ -4 & 0 & 3 & -2\\ 1 & -3 & 1 & 1\\ -2 & 1 & 1 & -1\end{bmatrix}$, find the entries b_{22}, b_{41} and b_{23} in **B** by using Cramer's rule.

7. (15%) Find the velocity, speed, tangential acceleration (tangent to the path) and normal acceleration (normal to the path) of the motion given by $r(t)=[2\cos t, 2\sin t, t^{2}]$ (t=time).

國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【機電系碩士班乙組、丙組】　　　　題號：438002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　　　

8. (15%) Solve the partial differential equation: $\dfrac{\partial u}{\partial t}=\dfrac{\partial u}{\partial x^2}$ with initial condition: $u\big|_{t=0}=x$ and boundary conditions: $u\big|_{x=0}=0$, $\dfrac{\partial u}{\partial x}\bigg|_{x=L}=0$.

國立中山大學 104 學年度碩士暨碩士專班招生考試試題

科目名稱：工程英文【機電系碩士班丁組】 題號：438001

※本科目依簡章規定「不可以」使用計算機(混合題) 共 3 頁第 1 頁

I. 選擇題 You are to choose the word, phrase or selection that best completes the sentence or meets the meaning of the condition. Then, on your answer sheet, find the number of the question and mark your answer. (27% in total, 3% each, 單選, 共 27 分，每題 3 分)

1. (_____) is used to relate displacement, velocity, acceleration, and time, without reference to the cause of the motion. Choose the correct word between (_____). (a) Kinetics. (b) Kinematics. (c) Newton's law. (d) Statics.

2. In a game of pool, Fig. 1, ball A is moving with a velocity v_0 when it strikes balls B and C, which are at rest and aligned as shown. After the impact, what is true about the overall center of mass of the system of three balls? (a) The overall system center of gravity (CG) will move in the same direction as v_0. (b) The overall system CG will stay at a single, constant point. (c) There is not enough information to determine the CG location. (d) None of the above.

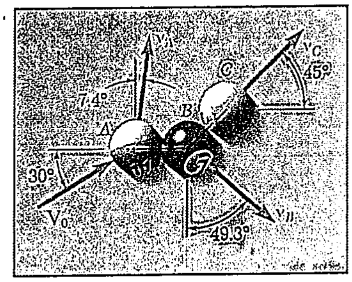


Fig. 1

3. The thin pipe P and the uniform cylinder C have the same outside radius and the same mass as shown in Fig. 2. If they are both released from rest, which of the following statements is true? (a) The pipe P will have a greater acceleration. (b) The cylinder and pipe will have the same acceleration. (c) The cylinder C will have a greater acceleration. (d) None of the above.

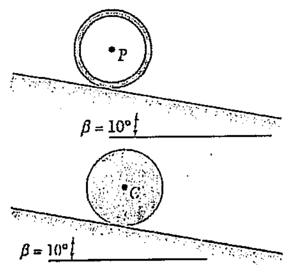


Fig. 2

4. $e = \frac{\overline{u_n} - \overline{v_n}'}{\overline{v_n} - \overline{u_n}}$; $e = \frac{w_0 - w_a}{w - w_0}$

Above equations, multiplying by r the numerator and denominator of the second expression obtained for e, and adding respectively to the numerator and denominator of the first expression, we have

(a) $e = \frac{\overline{u_n} + rw_0 - (\overline{v_n}' + rw_a)}{\overline{v_n} + rw - (\overline{u_n} + rw_0)}$; (b) $e = \frac{\overline{u_n} + rw_0 - (\overline{v_n}' + w_a)}{\overline{v_n} + rw - (\overline{u_n} + w_0)}$; (c) $e = \frac{\overline{u_n} + w_0 - (\overline{v_n}' + w_a)}{\overline{v_n} + rw - (\overline{u_n} + rw_0)}$;

(d) $e = \frac{r\overline{u_n} + w_0 - (r\overline{v_n}' + w_a)}{r\overline{v_n} + w - (r\overline{u_n} + w_0)}$.

5. What is the symbol (Fig. 3) in engineering graphics? (a) First-angle projection. (b) Second-angle projection. (c) Third-angle projection. (d) Forth-angle projection.

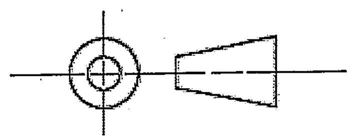


Fig. 3

6. What is the appropriate name of the component in Fig. 4? (a) Fillet. (b) Round. (c) Neck. (d) Chamfer.

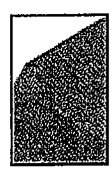


Fig. 4

7. The distortion-energy theory originated from the observation that ductile materials stressed hydrostatically exhibited yield strengths greatly in excess of the values given by the simple tension test. The distortion-energy theory is also called: (a) Maximum stress theory. (b) Von Mises theory. (c) Maximum shear stress theory. (d) Modified Mohr theory.

8. A shaft is a rotating member, usually of circular cross section, used to transmit power or motion. When a shaft is used in static or quasi-static condition, what the following items is not concerned? (a) Material selection. (b) Vibration due to natural frequency. (c) Geometric layout. (d) Stress and strength.

國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：工程英文【機電系碩士班丁組】 題號：438001

※本科目依簡章規定「不可以」使用計算機(混合題) 共3頁第2頁

9. Which one is brittle material? (a) Low carbon steel. (b) Aluminum. (c) Cast iron. (d) Polypropylene.

II. Describe the variation of the lines in the below figure in English. The following Chinese sentences describing the figure are for your reference. 參考下圖與中文內容，將中文內容翻譯成英文，寫於答案紙上。（本題23分）

下圖5顯示穩態時(steady state)的最大擺動角度(swing angle)，隨著不同的 L^* 與車輪轉速的變化，當阻尼常數(damping constant, C_7)為 0.8 N-s/kg/m 時。當 L^* 等於 0.203 m 時，滿足 $L^*=R_2$ 的條件，擺動角度會隨著不同的車輪轉速而連續性地變化。相較於其他情況，當 $L^*>R_2$ 時的最大擺動角度小於當 $L^*=R_2$ 時的最大擺動角度，這表示當 $L^*>R_2$ 時功率會下降。當 $L^*<R_2$ 時的最大擺動角度在超過臨界(critical)車輪轉速時會出現不連續的突跳(sudden discontinuous jump)。舉 L^*=0.190 m 為例，隨著車輪轉速增加，最大擺動角度在到達 a 點以前會緩慢地逐漸減少，之後車輪轉動頻率增加一點角度就會掉落到很小的值，如 b 點所示。圖中 a 點與 b 點間的狹小區域是不穩定的，超過 b 點之後，最大擺動角度的值會持續連續性的減少。經由以上的結果，當 L^* 完全等於 R_2 時，穩定的輸出功率會被呈現於各種車速之下，這證明了使用良好配重單擺(well-weighted)的優勢。

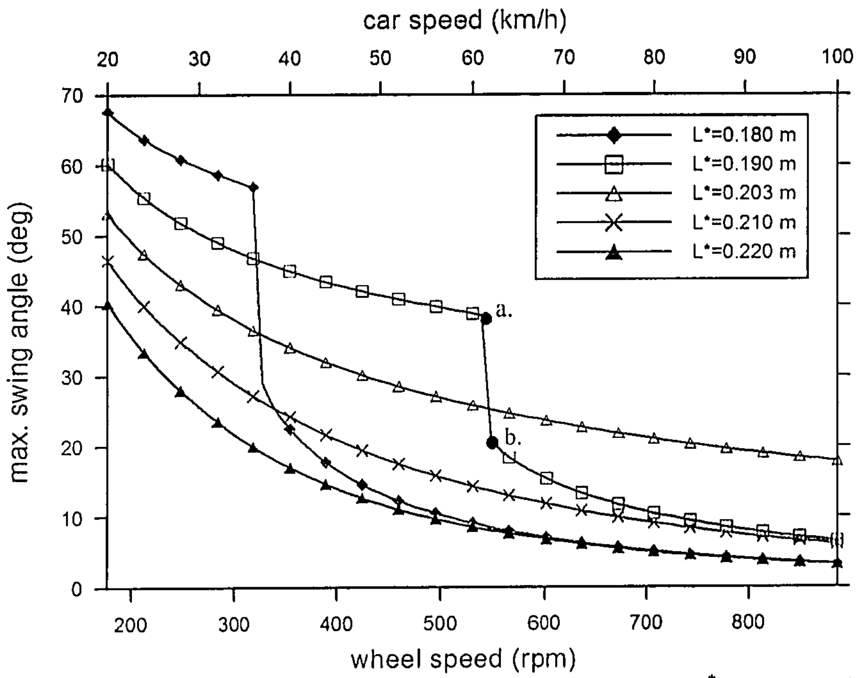


Fig. 5 Variation of the steady-state swing angle under various L^* and wheel speeds.

III. 英翻中(共17分) 請寫於答案紙上

Welding processes are divided into three basic categories: (a) fusion welding, (b) solid-state welding, and (c) brazing and soldering. Fusion welding: two (or more) parts are coalesced at their contacting surfaces by means of heat and/or pressure; filler metals may or may not be used. The basic processes in this category are arc, resistance, oxyfuel gas, electron beam, and laser beam welding. The welded joint undergoes important metallurgical and physical changes, which, in turn, have a major effect on the properties and performance of the welded component. In solid-state welding, joining takes place without fusion; consequently, there is no liquid (molten) phase in the joint. The basic processes in this category are diffusion bonding, and cold, ultrasonic, friction, and explosion welding. Brazing uses filler metal metals and involves lower temperatures than welding. Soldering uses similar filler metals (solders) and involves even lower temperatures.

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※本科目依簡章規定「不可以」使用計算機(混合題) 共3頁第3頁

IV. Questions 簡答題，回答下列問題，並寫在答案紙上，可以中文或英文回答。

第一題至第六題每題2分，第七題至第十三題每題3分，共33分

1. What is the meaning of the term "machine tool"? (2%)

2. What is the meaning of the term "tensile strength of a material"? (2%)

3. What is the meaning of the term "work hardening of a metal"? (2%)

4. What is the meaning of the term "tolerance"? (2%)

5. What is the meaning of the term "surface finish" in manufacturing processes? (2%)

6. What is the meaning of the term "chill" in casting? (2%)

7. What are the meaning of the terms "pattern and core" in sand molding? (3%)

8. What is the meaning of the term "eutectic alloy"? Give an example. (3%)

9. What are a consumer good and a capital good? Give an example in each category. (3%)

10. In manufacturing processes, what is the meaning of the term "assembly operation"? Give an example. (3%)

11. In manufacturing processes, what are net shape processes and near net shape processes? (3%)

12. What are the primary, secondary, and tertiary industries? Give an example in each category. (3%)

13. State Hooke's law. Give an equation and explain your variables in this equation. (3%)