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1. The vertical position y of a particle falling in a gravity field is determined by the differential equation

(25%) $m\frac{d^2y}{dt^2} + a\frac{dy}{dt} = mg$,

where m is the mass, a is the drag coefficient, and g the acceleration due to gravity.

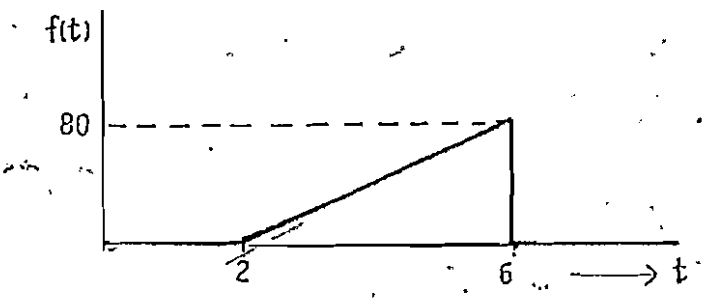
Find y(t) when $y(o) = y_o$, $\left.\frac{dy}{dt}\right|_{t=o} = 0$, and show by a limiting process that the solution for $a \to 0$ approximates the usual expression obtained when the drag coefficient is zero.

2. Solve the differential equation

$$\dot{x} + 10x = f(t);\ x(0) = 0$$

with f(t) as shown

(25%)



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3. Find the solution of the boundary-value problem:
$-u_t + u_{xx} = 0$, $0 < x < \pi$, $0 < t < \infty$, $u_x(0, t) = 0$;
$u(\pi, t) = 0$, $u(x, 0) = \sin(x)$. (25%)

4. Find the minimum surface area of a rectangular parallelepiped of volume 1 cm^3. (25%)

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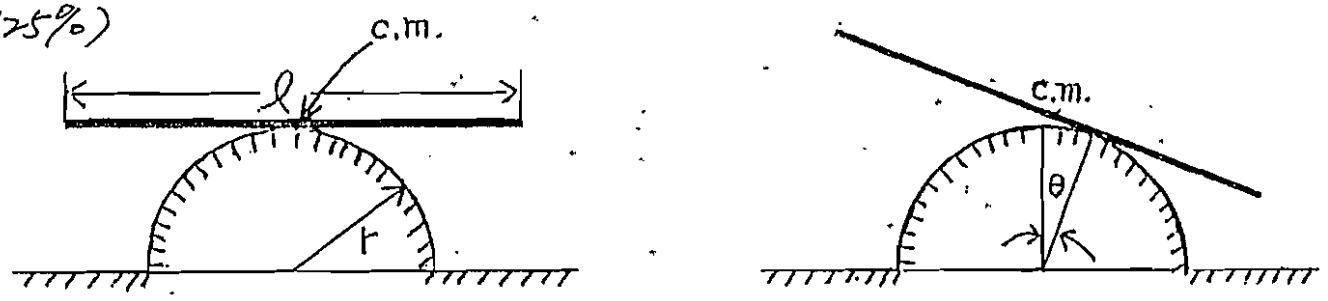
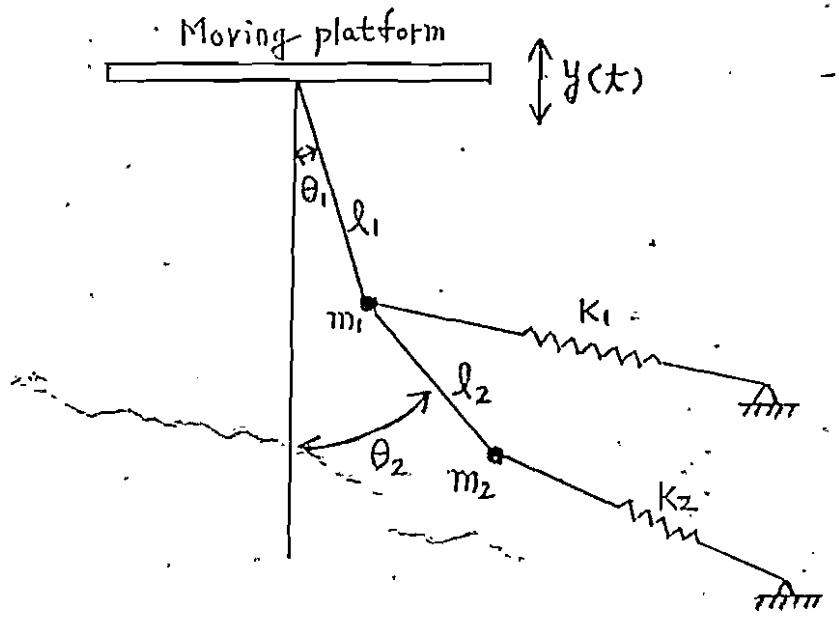
1. (25%)



A rigid rod rocks back and forth on the circular surface without slipping. Derive the governing equation for θ.

2. (25%)



Consider the motion of a double pendulum attached to a platform that has a prescribed vertical motion relative to an inertial frame as shown in above Figure. Two particles of masses m_1 and m_2 are connected to massless rods of lengths l_1 and l_2 suspended from a platform that has a prescribed vertical motion $y(t)$ with respect to the inertial frame O. The motion of the particles is constrained by springs that are initially horizontal and have the constants k_1 and k_2. The springs are unstretched when the particles lie vertically below the platform. Derive the equations of motion for this system.

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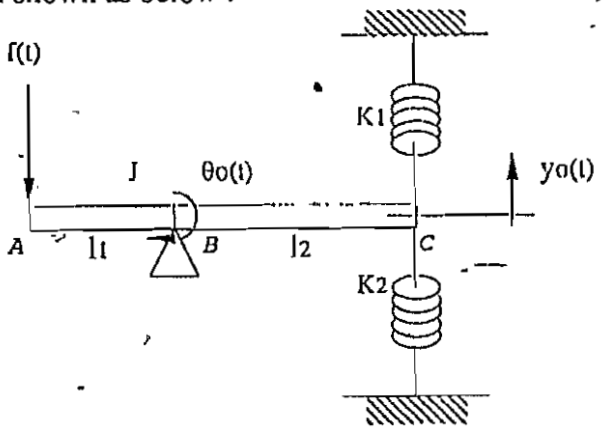
Prob 3. 請就所學的力學理論,詳細地描述一粒步槍子彈自槍膛中擊發之後飛向目標的過程,並說明槍管中膛線之作用,以及兩至三項影響子彈射程的主要因素. (25%)

Prob 4. Given a system shown as below :



where the lever is rigid with moments of inertia J, w.r.t. the hinge point B,
the force f(t) is applied at point A,
$y_o(t)$ is the position at C, $\theta_o(t)$ is the angular displacement of lever,
K_1 and K_2 are the spring constants,
l_1 and l_2 are the lengths for each side.

(1) Please derive the equation of motion for this system with input f(t) and output $y_o(t)$. (10%)

(2) Derive the transfer function by applying Laplace transformation for the result in (1). (5%)

(3) If f(t) is given by a unit step function, what is $y_o(\infty)$? (10%)

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注意：1.本試題共 5 題，共 100 分，須標明題號並依序寫在答案卷上，否則不予計分。
2.書寫答案時，由第一頁起橫自左至右橫寫，不得倒反。

1. (a) Find the Thévenin equivalent with respect to the terminals a, b for the circuit in Figure 1. (14%)
(b) If an adjustable load R_L is connected to the terminals a and b, find the maximum power transfered to R_L. (6%)

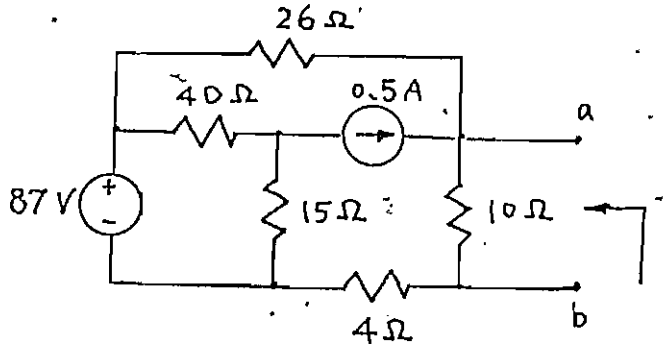

Figure 1

2. In Figure 2, switch 1 has been closed and switch 2 has been opened for a long time. At t=0, switch 1 is opened. One hundred milliseconds later switch 2 is closed. Find
(a) $v_c(t)$ for $0 \le t \le 0.1$s. (10%)
(b) $v_c(t)$ for $0.1\text{s} \le t$. (10%)

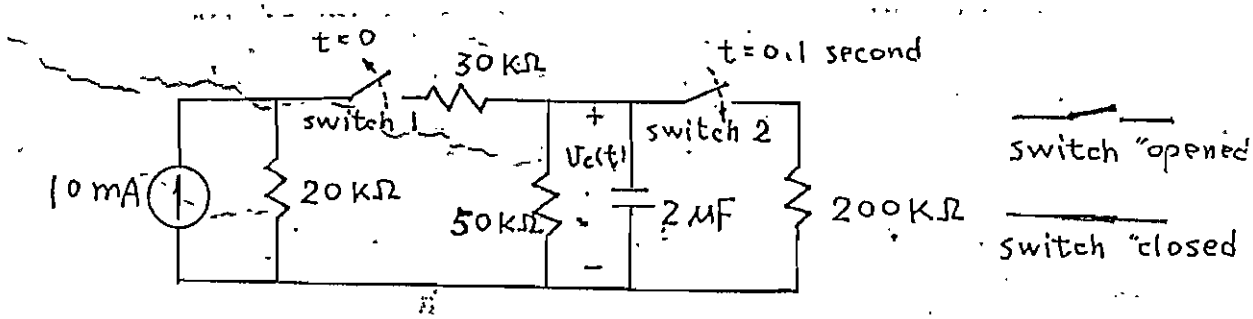

Figure 2

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3. A bipolar transistor is biased at collector current $I_C = 0.5mA$ and common-emitter forward short-circuit current gain $\beta_0 = 150$
   (a) Determine transconductance g_m at room temperature. (6%).
   (b) The input resistance $h_{ie} = 7.6K\Omega$. Find base-spreading resistance r_b. (6%)
   (c) A load resistance $R_C = 2K\Omega$ is used and the transistor is driven from a 300 Ω voltage source. Estimate the transfer voltage gain. (8%)

4. (a) Draw the low-frequency small-signal model in Figure 3. (10%)
   (b) Derive an expression for the signal component of v_o produced by the signal input v_i. (10%)

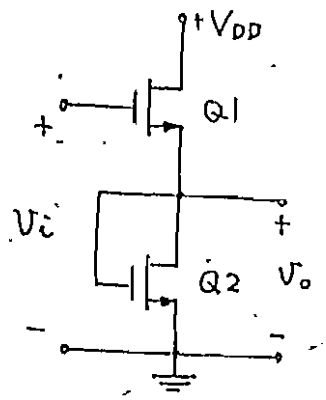

Figure 3

5. The differential- and common-mode gains of a differential amplifier can be approximated as

$$A_{DM} = \frac{-20000}{1 + s/2\pi\times10^6} \text{ and } A_{CM} = \frac{-0.5}{1+s/2\pi\times10^8}$$

   (a) Sketch the asymptotic Bode diagram of the common-mode rejection ratio CMRR. (10%)
   (b) At what frequency is the CMRR one-half its low-frequency value? (10%)

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(一) (a) 請詳細說明您自學校畢業後之實務經驗；含職位，每一職位之工作內容，及每一職位所需具備之專業技能。 20%

(b) 在達成工作目標所需之專業技能中，何者為學校未曾教授而需自學的？請詳述自學之過程。 10%

(二) 試以您所遭遇的實務性問題，舉二重要實例詳述問題之起源，解決問題之方法，學理依據，所需技術及改進之成效等(含经濟性利益)。 30%

(三) 請詳述

(a) 報考本研究所之動机？

(b) 碩士階段之學習及研究計畫？

(c) 對自己未來發展之期盼？

(d) 您工作單位对您的送訓，所能獲得的助益或提升？ 20%

(四) (a) 請說明使用座標系統之理由？並舉一實例說明之。

(b) 請說明功能單間的關係？並舉一例說明

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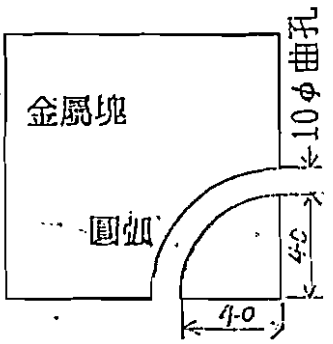
八十三學年度研究所碩士班入學考試試題

1、放電加工為何有電極消耗，原因為何？試就電極材料特性及放電加工特性論述為何銅鎢電極常使用來加工超硬合金。（10%）

2、說明切削加工時產生毛邊的原因及除去毛邊的方法有幾種？又交差內孔的毛邊如何除去。（10%）

3、說明化學切胚法（Chemical blanking），化學彫刻法(Chemical engraving)電鑄造形法.(Electroforming) 及電解研削法(Electro chemical grinding)。（15%）

4、如圖所示為一金屬塊，現要在其內部加工直徑為1 c m的曲孔，試舉2種可能達到此一目的的加工法並說明如何加工及比較兩種加工法的優缺點。（15%）



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5. (a) State the difficulties which may occur in drilling operation due to the existence of chisel edge of a drill.
   (b) Suggest at least two approaches to eliminate or at least to alleviate the difficulties you state in 6(a). (10%)

6. Name the five most used materials for making cutting tools, and describe their characteristics briefly. (10%)

7. Name any two types of (a) turning (b) milling (c) drilling (d) grinding machines, and state individually the occasion of using each machine. (10%)

8. Describe the high-frequency resistance welding process, and state its advantages and limitations. (10%)

9. (a) State the functions of rake angle, relief angle, and side cutting edge angle of a turning tool.
   (b) Discuss the effects of shear angle on the chip thickness and cutting efficiency in the orthogonal cutting model. (10%)

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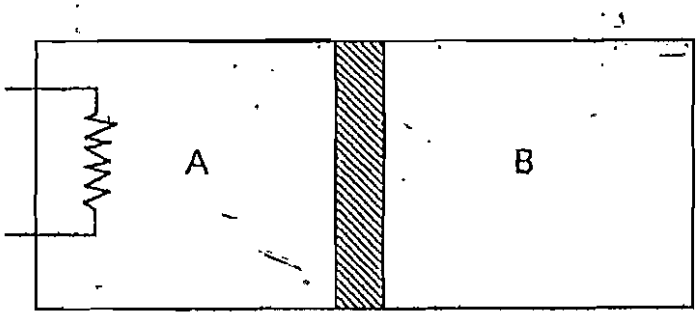
1. A rigid cylinder contains a "floating" piston, free to move within the cylinder without friction. Initially, it divides the cylinder in half, and on each side of the piston the cylinder holds 1(lb mole) of the same idea gas at 40 (°F) and 1 atm. An electrical resistance heater is installed on side A of the cylinder as shown below, and it is energized so as to cause the temperature in side A to rise slowly to 340 (°F). If the tank and the piston are perfect heat insulators and are of negligible heat capacity, calculated the amount of heat added to the system by the resistor. (25%)

   The molar heat capacities of the gas are constant and have the values $C_v = 3$ (Btu)/(lb mole)(°F) and $C_p = 5$ (Btu)/(lb mole)(°F).



2. Very pure liquid water can be subcooled at atmospheric pressure to temperatures well below 0 °C. Assume that a mass of water has been cooled as a liquid to -5 °C. A small crystal of ice (whose mass is negligible) is added to "seed" the subcooled liquid. If the subsequent change of state occurs adiabatically and at constant (atmospheric) pressure, what fraction of the system solidifies? What is the entropy change of the system? (25%)

   The following data are known;

   - The latent heat of fusion of water at 0 °C = 333.4 J/g.
   - The heat capacity of water between 0 and -5 °C = 4.22 J/g °C.

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3. During steady-state operation, a parallel shaft gearbox receives 600 kW through the high speed shaft but owing to friction and other irreversibilities delivers 588 kW through the low-speed shaft. The gearbox is cooled on its outer surface according to

$$\dot{Q} = -hA(T_b - T_0)$$

where h is the heat transfer coefficient, A is the surface area, T_b is the uniform temperature of the outer surface, and T_0 is the uniform temperature of the surroundings away from the gearbox. Evaluate the rate of entropy production $\dot{\Delta}s$ in kW/K, for

(a) the gearbox as a system.

(b)an enlarged system consisting of the gearbox and enough of its surroundings that heat transfer occurs at temperature T_0.

(Let h=0.17 kW/m^2, A=1.8 m^2 and T_0=293 K.) (25%)

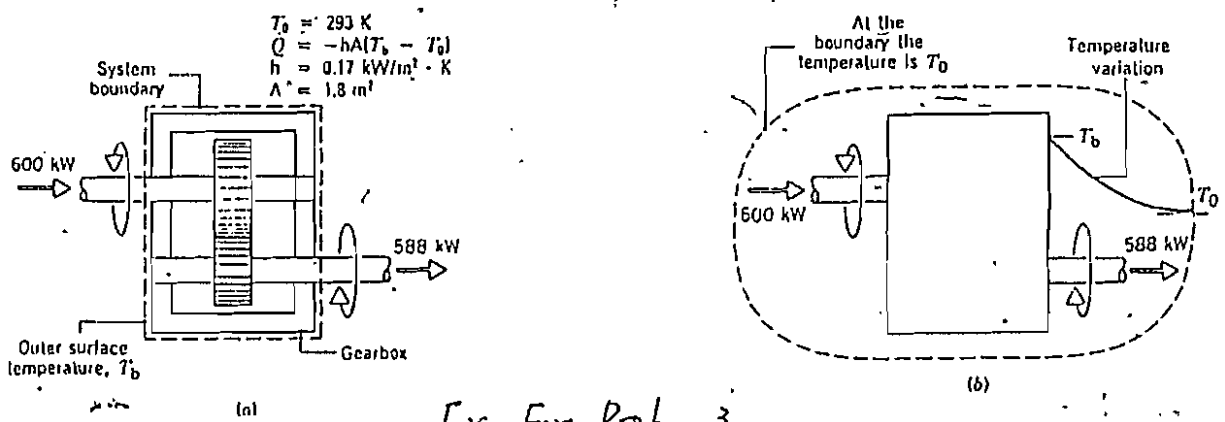

Fig for Prob. 3.

4. Using the Redlich-Kwong equation of state, $P = \dfrac{RT}{v-b} - \dfrac{a}{v(v+b)T^{1/2}}$, develop expressions for the followings

(a) C_p-C_v in terms of v, R, T, a and b.

(b)$(S_2-S_1)_T$ in terms of v_1, v_2, R, T, a and b (entropy changes between two states under isothermal process) (25%)

Here, P: pressure, v: specific volume, T: temperature, R: gas constant, a, b: constants
C_p: specific heat (constant pressure) C_v: specific heat (constant volume)
S: entopy

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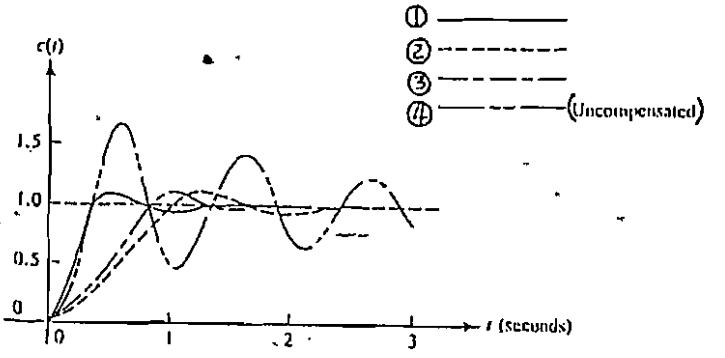
1. 簡答題：

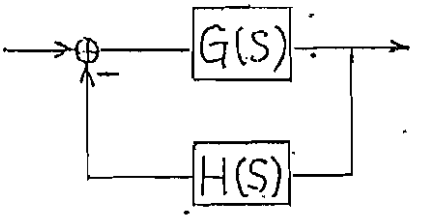
(a) PID 控制器三個增益值（Kp, Ki, Kd）分別對控制性能有何影響？（試從精度，誤差，反應快慢，...等考量）（7%）

(b) 相位超前（phaes lead）及相位落後（phase lag）控制器其特性何者近似於高通濾波器（high-pass filter）？何者近似於低通濾波器（low-pass filter）？爲什麼？（6%）

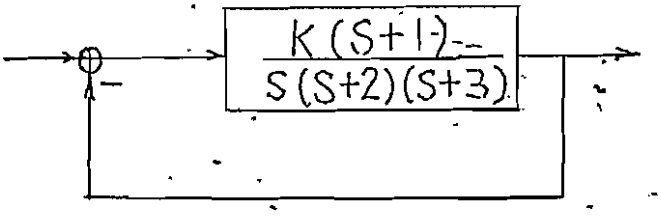
(c) 右圖中，曲線 4 爲未補償系統之閉迴路步級響應圖，其餘三曲線分別爲利用相位超前，相位落後及相位落後超前（lag-lead）控制器所得到之響應圖。請說明其對應關係；並簡要敘述你的理由。（5%）



(d) 在閉迴路系統穩定度之判斷方法中，根軌跡法（root locus method）所使用者爲閉迴路轉移函數（closed loop transfer function）1+GH(s)，而倪奈士準則（Nyquist criterion）卻只使用迴路轉移函數（loop transfer function）GH(s)，爲什麼？（7%）



2. 有一控制系統之方塊圖如下：



(a) 請決定使系統維持穩定之 K 值範圍。（10%）

(b) 請計算當閉迴路系統之極點（poles）均位於直線 σ = -0.5 之左方的最大 K 值。（15%）

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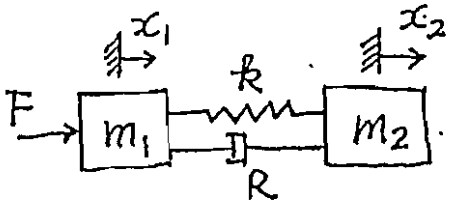
3. 右圖所示系統中，



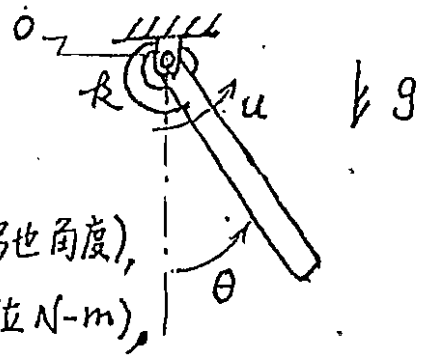
$m_1 = m_2 = 1\ kg$，
彈簧 $k = 4\ N/m$，
阻泥器 $R = 2\ N\cdot sec/m$
輸入力 F 的單位為 N (Newton)，輸出 x_1, x_2 的單位為 m。

(a) 求 $\frac{X_1(s)}{F(s)}$。 (10%)

(b) 若 $F(t) = -K_1(x_1 + 0.1\dot{x}_1)$，畫出系統的 Root locus ($K_1 = 0 \sim +\infty$)。 (7%)

(c) 若 $F(t) = -K_2(x_2 + 0.1\dot{x}_2)$，
畫出系統的 Root locus ($K_2 = 0 \sim +\infty$)。 (8%)

4. 右圖所示系統中，



均勻長桿的長度為 1 m，
長桿的質量為 3 kg，對 O 點的轉動慣量為 $I_o = 1\ kg-m^2$，
扭力彈簧 $k = 1\ N-m/rad$ ($\theta = 0$ 為鬆弛角度)，
不考慮摩擦力；輸入扭力為 u (單位 N-m)，
輸出為 θ (單位 rad)。

(a) 寫出系統的動態方程式。 (5%)

(b) 將系統對 $\theta = 0°$ 點做(局部)線性化，並寫出 $\frac{\Theta(s)}{U(s)}$。 (5%)

(c) 將系統對 $\theta = 180°$ 點線性化，寫出此線性方程式。 (5%)

(d) 若要將桿固定在 $\theta = 180°$ 的位置，可令
$U(s) = K_1(10 + \frac{0.1}{s} + s)(\Theta(s) - R(s))$，其中 R(s) 應為若干？$K_1$ 的穩定範圍為何？(根據(c)所求得的線性方程式作答。) (10%)

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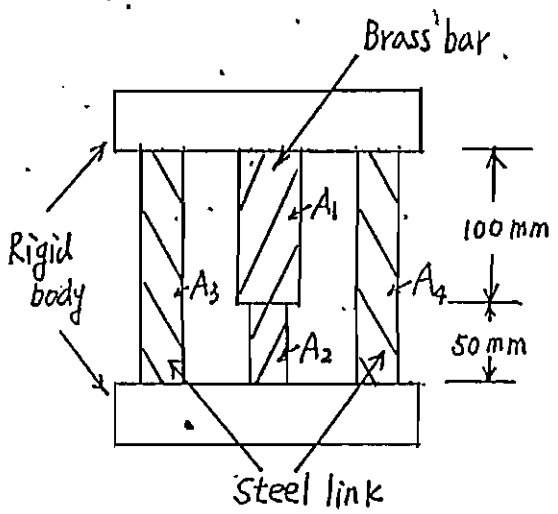
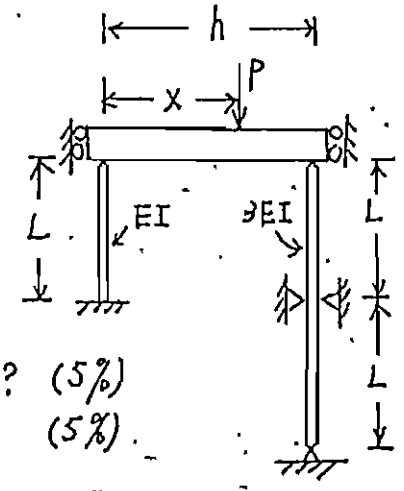
1. A stepped brass bar 150 mm long is inserted into a steel link with rigid ends as shown. Initially, no axial force exists in the bar. If the temperature increases 40°C, determine the maximum normal stress produced in the bar. Use $E_b = 105$ GPa, $\alpha_b = 20\times10^{-6}$/°C for brass bar, $E_s = 200$ GPa, $\alpha_s = 12\times10^{-6}$/°C for steel link, and the cross-sectional areas $A_1 = 500\ mm^2$, $A_2 = 400\ mm^2$, $A_3 = A_4 = 450\ mm^2$. (25%)



2. A horizontal beam loaded by normal force P is supported by two columns as shown and is restrained from lateral movement. Assume the columns can buckle only in the plane of the paper.



(a) What is the maximum of P for $x = 0$? (5%)

(b) Repeat (a) for $x = h$. (5%)

(c) Repeat (a) for $x = \frac{h}{2}$. (5%)

(d) Estimate the maximum value of P and the value of x for which it occurs. (10%)

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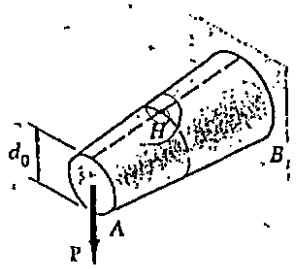
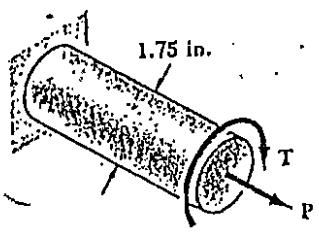
3. A transverse force P is applied as shown at end A of the conical taper AB. Denoting by d_0 the diameter of the taper at end A, show that the maximum normal stress occurs at point H, which is contained in a transverse section of diameter $d = \frac{2}{3}d_0$.



(25%)

4. A 1.75-in.-diameter shaft is made of a grade of steel with a 36-ksi tensile yield strength. Using the maximum-distortion-energy criterion, determine the magnitude of the force P at which yield first occurs when $T = 15$ kip · in.

(25%)



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1. Determine whether it is advantageous to have thin iron fins (0.3 cm and k=55 W/ m K), on a heating surface. The heat flow through the base of a fin is given by the equation:

$$Q_1 = mKA\theta_1 \left[\frac{\frac{h_2}{mk} + \tanh mL}{1 + \left(\frac{h_2}{mk}\right) \tanh mL} \right]$$

where h_2 is the film heat transfer coefficient at the end of the fin. The $m=(hp/kA)^{1/2}$ and p is the wetted perimeter. Using following two cases to discuss:

(1) When heat is transferred to air, $10 < h < 100$ W/m^2 K

(2) When heat is transferred to water, $550 < h < 5500$ W/ m^2 K

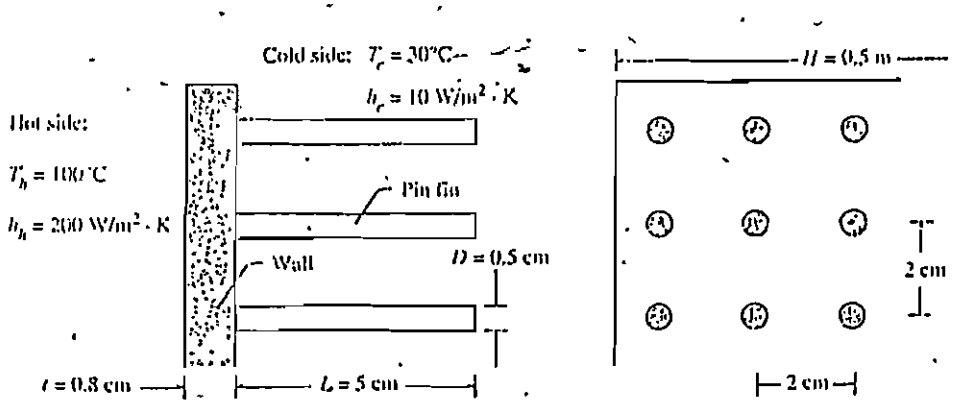
(25%)

2. The heat exchanger surface shown in the figure separates a stream of hot liquid (T_h= 100 °C, h_h=.200 W/m^2 K) from a stream of cold gas (T_c = 30 °C, h_c = 10 W/ m^2 K). This surface is made of a slab of thickness t=0.8 cm, which has the frontal area of a square with side H = 0.5 m. To offset the effect of the small heat transfer coefficient h_c ,the area of the cold side was increased by adding a number of pin fins arranged in a square pattern. The dimensions of the wall, the individual fin, and the square array are indicated directly on the figure. The wall and the fins are made of a metal whose conductivity is k=40 W/m K. The effect of fouling is negligible on both sides of the wall; in other words,

$$h_{c,h} \cong h_h \qquad h_{c,c} \cong h_c$$

(25%)

Calculate the overall thermal resistance of the heat exchanger surface($1/U_hA_h$ or $1/U_cA_c$) and the total heat transfer rate q.



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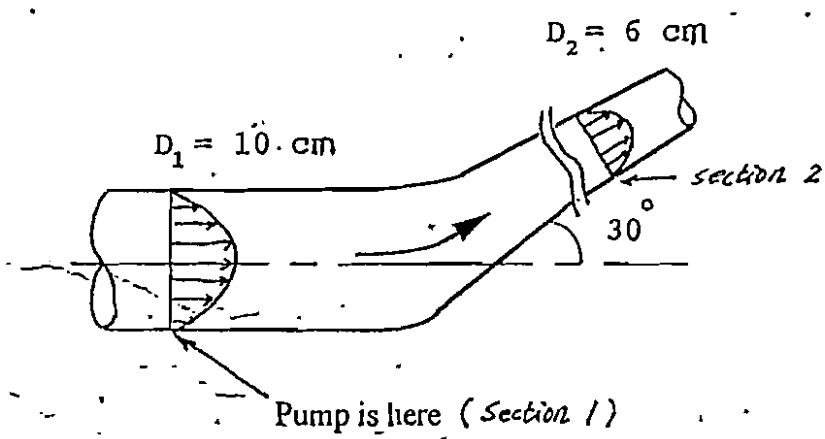
八十三學年度研究所碩士班入學考試試題

3.
(a) What are the advantages of the dimensional analysis? Why do we use nondimensional variables in fluid mechanics (and the other sciences)? (10 %)
(b) For a incompressible flow problem associated with a reference (characteristic) length L, try to nondimensionalize the continuity and momentum equations with constant viscosity. (10 %)
(c) What will be the nondimensional parameter appearing in the above nondimensional formulations? Explain its/their physical meanings. (3 %)
(d) What will this/these parameter(s) be if the flow is passing across a cylinder with diameter D? (2 %).

4.
(a) A pump at section 1 delivers fluid with an average velocity 200 m/s and exits at a 30^0 angle at section 2. It is known that the density of the fluid is given by

$$\rho = \rho_0 [\, 1 + (1 - r/R)^{1/3} \,]/2$$

where R is the radius of the pipe and ρ_0 is 1000 kg/m^3. Section 1 has the laminar profile $u_1 = u_{m1}(1 - r/R)^{1/2}$, while section 2 has changed to a turbulent profile $u_2 = u_{m2}(1 - r/R)^{1/7}$. What are the maximum velocities u_{m1} and u_{m2} in meters per section? (13 %)



(b) It is known that section 2 is 10 m higher than the pump and the losses between 1 and 2 are given by a head loss $h_f = Ku_2^2/2g$, where K = 8 is a nondimensional loss coefficient and g is the gravitational acceleration. Estimate the power required to drive the pump if it is 75 percent efficient. You must clarify all the assumptions made in the calculation. (12 %).

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注意：1.本試題共 5 題，共 100 分，須標明題號並依序寫在答案卷上，否則不予計分。
2.書寫答案時，由第一頁起橫自左至右依寫，不得倒反。

1. (a) Find the Thévenin equivalent with respect to the terminals a; b for the circuit in Figure 1. (14%)
(b) If an adjustable load R_L is connected to the terminals a and b, find the maximum power transfered to R_L. (6%)

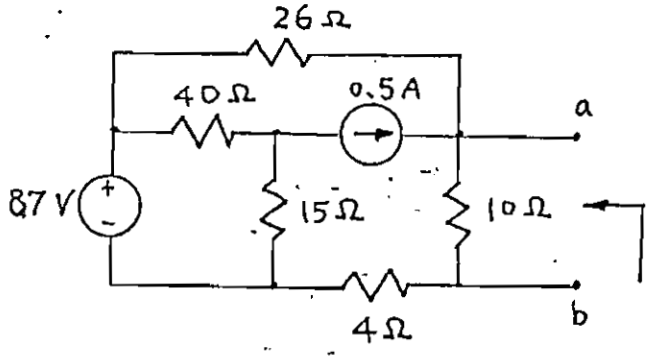

Figure 1

2. In Figure 2, switch 1 has been closed and switch 2 has been opened for a long time. At t=0, switch 1 is opened. One hundred milliseconds later switch 2 is closed. Find
(a) $v_c(t)$ for $0 \le t \le 0.1$s. (10%)
(b) $v_c(t)$ for 0.1s ≤ t. (10%)

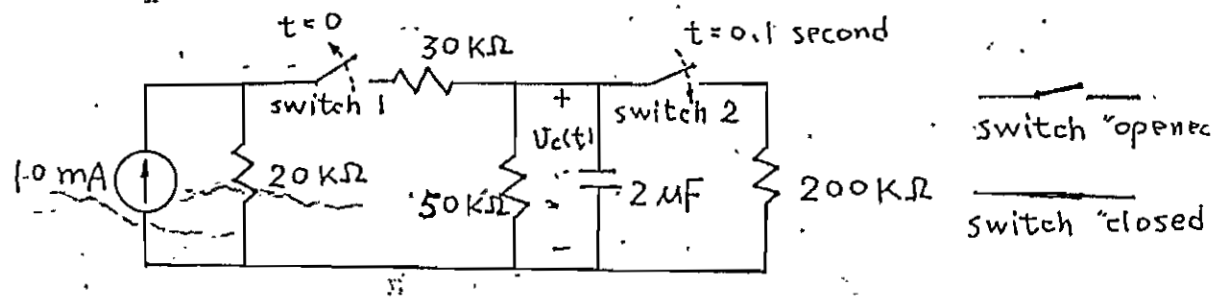

Figure 2

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3. A bipolar transistor is biased at collector current $I_C = 0.5mA$ and common-emitter forward short-circuit current gain $\beta_0 = 150$
   (a) Determine transconductance g_m at room temperature. (6%)
   (b) The input resistance $h_{ie} = 7.6K\Omega$. Find base-spreading resistance r_b. (6%)
   (c) A load resistance $R_C = 2K\Omega$ is used and the transistor is driven from a 300 Ω voltage source. Estimate the transfer voltage gain. (8%)

4. (a) Draw the low-frequency small-signal model in Figure 3. (10%)
   (b) Derive an expression for the signal component of v_o produced by the signal input v_i. (10%)

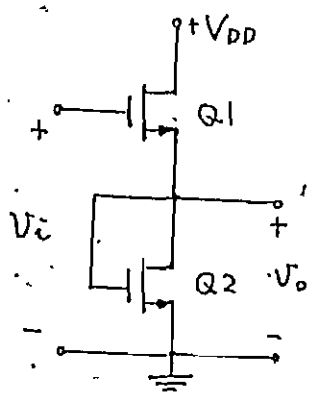

Figure 3

5. The differential- and common-mode gains of a differential amplifier can be approximated as

$$A_{DM} = \frac{-20000}{1 + s/2\pi\times10^6} \text{ and } A_{CM} = \frac{-0.5}{1+s/2\pi\times10^8}$$

   (a) Sketch the asymptotic Bode diagram of the common-mode rejection ratio CMRR. (10%)
   (b) At what frequency is the CMRR one-half its low-frequency value? (10%)