# 國立雲林科技大學
## 八十九學年度研究所博士班入學考試試題

所別：工程科技研究所
科目：工程數學

1. Solve the following equations:

   (a) $2x^3y' + 4x^2y = -5y^4$ (8%)

   (b) $x^2y'' - 3xy' + 4y = 0;\ y(1) = -2,\ y'(1) = 7.$ (8%)

   (c) $y''' - 2y'' - y' + 2y = 2x - 1;\ y(0) = 1,\ y'(0) = -3,\ y''(0) = 4.$ (8%)

2. Solve the following equation by Laplace transform method.

   (a) $y'' + 4y' + 13y = 26e^{-4t};\ y(0) = 5,\ y'(0) = -29.$ (8%)

   (b) $y'' + 4y = f(t);\ y(0) = 1,\ y'(0) = 0.$

$$f(t) = \begin{cases} 1 & \text{if} \quad \pi \le t \le 2\pi \\ 0 & \text{if} \quad 0 \le t < \pi, \text{ or } t > 2\pi \end{cases}$$ (8%)

3. Derive the central difference method for solving second-order ordinary differential equation using Taylor series. The central difference method is as following.

$$y'' = \frac{y(x+\Delta x) - 2y(x) + y(x-\Delta x)}{(\Delta x)^2} + O(\Delta x)^2$$ (10%)

4. Label the following statements as being *True* or *False*. If it is true, then prove it. If it is false, then provide a counterexample.

   (a) If the vectors $v_1, \ldots, v_m$ span a subspace $W$, then $\dim W = m$. (5%)

   (b) If $Ax = Ay$, then $x = y$. (5%)

   (c) If a square matrix $A$ has independent columns, so does $A^2$. (5%)

   (d) Any set of vectors which contains the *zero* vector is linearly dependent. (5%)

   (e) If an $n \times n$ matrix is invertible (nonsingular), then it is diagonalizable. (5%)

   (f) Each eigenvalue of $(A+B)$ is a sum of an eigenvalue of $A$ and an eigenvalue of $B$. (5%)

5. Find $A$ and $\mathbf{b}$ such that the general solution of the 2 by 3 system $A\mathbf{x} = \mathbf{b}$ is

$$\mathbf{x} = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} + c \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}, \qquad c \in \mathbf{R}.$$ (10%)

   **Hint:** The *row space* of $A$ is orthogonal to the *null space* of $A$.

6. (a) Suppose $A = uv^T$, where $u, v \in \mathbf{R}^n$. Show that $u$ is an eigenvector of $A$. What is the corresponding eigenvalue? (5%)

   (b) Let

$$B = \begin{bmatrix} 2 & 1 & 1 \\ 4 & 2 & 2 \\ 8 & 4 & 4 \\ -2 & -1 & -1 \end{bmatrix}.$$

   What is the *rank* of $B$ ? Write the matrix as $B = uv^T$. (5%)

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所別：工程科技研究所
科目：電路學

計算題共四題

1. (25%) The switch in Fig.1 has been in position 1 for a long time; it is moved to 2 at $t$=0. Obtain the expression for $i$, for $t$>0.

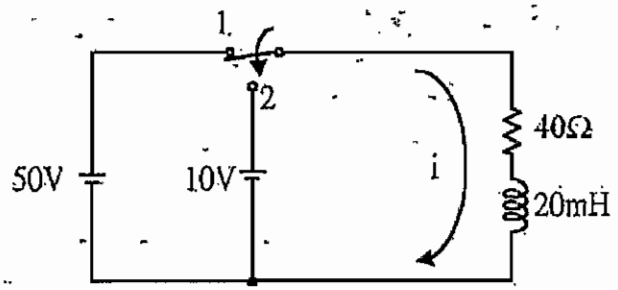


Fig.1

2. (25%) A parallel $RLC$ network, with $R$=50.0 Ω, $C$=200 $\mu$F, and $L$=55.6mH, has an initial charge $Q_0$ =5.0mC on the capacitor. Obtain the expression for the voltage across the network.

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所別：工程科技研究所
科目：自動控制

1. Consider the system shown in Fig. 1.

(A) If $G(s)=\dfrac{1}{(s^2+4s)((s+2)^2+16)}$, sketch the root locus for $k=0\sim+\infty$. (13%)

(B) If $G(s)=\dfrac{(s+2)(s^2+2s+10)}{(s+1)^2(s^2+2s+17)}$, sketch the root locus for $k=0\sim+\infty$. (12%)

(You are asked to show the general shape of locus, and are *not* required to make complicated calculations.)

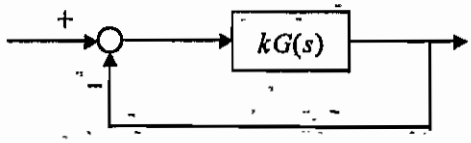


Fig. 1

2. Consider the system described by

$$\dot{\mathbf{x}}=\mathbf{A}\mathbf{x}+\mathbf{B}u$$

where $\mathbf{x}$ is the state vector, $u$ is the control input, and

$$\mathbf{A}=\begin{bmatrix}0.5 & 1.5\\ 1.5 & 0.5\end{bmatrix},\quad \mathbf{B}=\begin{bmatrix}1\\ 1\end{bmatrix}.$$

(A) Is the system controllable? (6%)

(B) Is the system stabilizable? (i.e., does there exist a feedback law, $u = -\mathbf{K}\mathbf{x}$, by which the closed-loop system is stabilized?) (8%)

(C) Suppose $u = 0$. Find an initial condition such that

$$\mathbf{x}(t)=\begin{pmatrix}-3e^{-t}\\ 3e^{-t}\end{pmatrix}.$$ (11%)

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科目：自動控制

3. Briefly explain (or definition) the following terminologies (30%)

   (a) causal systems. (5%)
   (b) adaptive control. (5%)
   (c) robust control. (5%)
   (d) stable in the Lyapunov sense. (5%)
   (e) Gain margin. (5%)
   (f) irreducible realization. (5%)

4. How many roots are in right half–plane, and on the $j\omega$ axis for the following polynomial. (20%)

   (a) $P_1(s) = s^4 + 6s^3 + 11s^2 + 6s + 200$. (10%)

   (b) $P_2(s) = s^8 + s^7 + 12s^6 + 22s^5 + 39s^4 + 59s^3 + 48s^2 + 38s + 20$. (10%).

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所別：工程科技研究所
科目：計算機系統

1. Consider the following set of processes, with the length of the CPU-burst time given in milliseconds:

| Process | Burst Time | Priority |
|---|---|---|
| $P_1$ | 10 | 3 |
| $P_2$ | 1 | 1 |
| $P_3$ | 2 | 3 |
| $P_4$ | 1 | 4 |
| $P_5$ | 5 | 2 |

The processes are assumed to have arrived in the order $P_1$, $P_2$, $P_3$, $P_4$, $P_5$, all at time 0. What is the turnaround time of each process for FCFS, SRTN, non-preemptive priority (a smaller priority number implies a higher priority), and RR (quantum=1) scheduling algorithms? (25%)

2. In a paging system using TLB, calculate the effective memory-access time when the hit ratio is 0.8 and the TLB access time is 20 times as fast as that of the main memory. (25%)

3. What are breadth-first search and depth-first search? Write each algorithm in pseudo-code, specifying the data structures used in each algorithm. Consider one example problem and apply both algorithms to the same example. Compare the two algorithms and discuss their advantages and disadvantages. (25%)

4. What is a 2-3 tree? What are its advantages and disadvantages? Write its insertion algorithm and deletion algorithm. Show the results of applying the algorithms by inserting 5, 40, 10, 20, 15, 30 (in this order) into an initially empty tree and then deleting 10. (25%)

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所別：工程科技研究所
科目：機械設計

1. Find the required length of weld in Fig.1 if an E6010 electrode is used with an $F_S$ of 2. E6010 $S_{yp} = 345MPa$, $\tau_{yp} = \frac{1}{2} S_{yp}$. (25%)

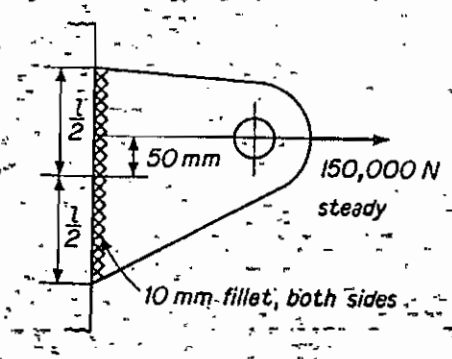


Figure 1

2. A 120° central partial bearing, 62mm in diameter and 100mm long, has a minimum film thickness of 0.015mm. SAE20 oil in Fig.2 is used; $n = 860rpm$ and $r/c = 1{,}000$. If the oil film is at 74℃, find the load the bearing is carrying. (25%)

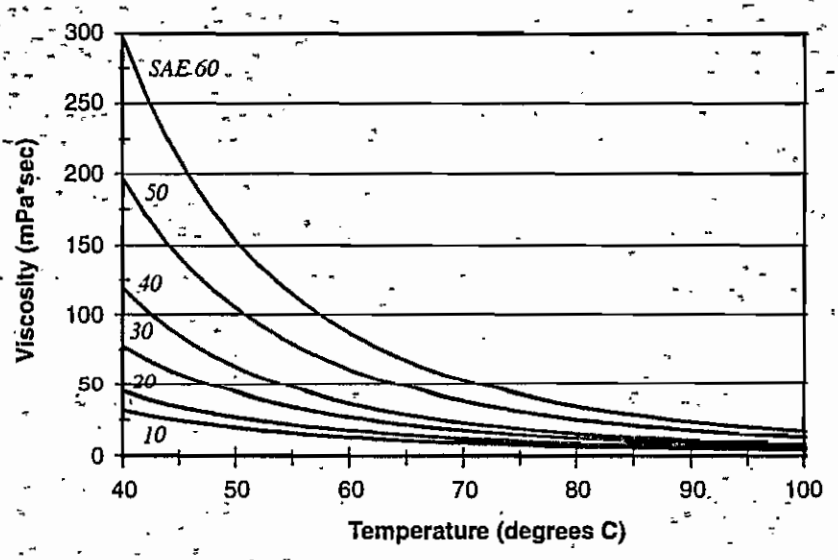


Figure 2 Absolute viscosity versus temperature for various SAE oils.

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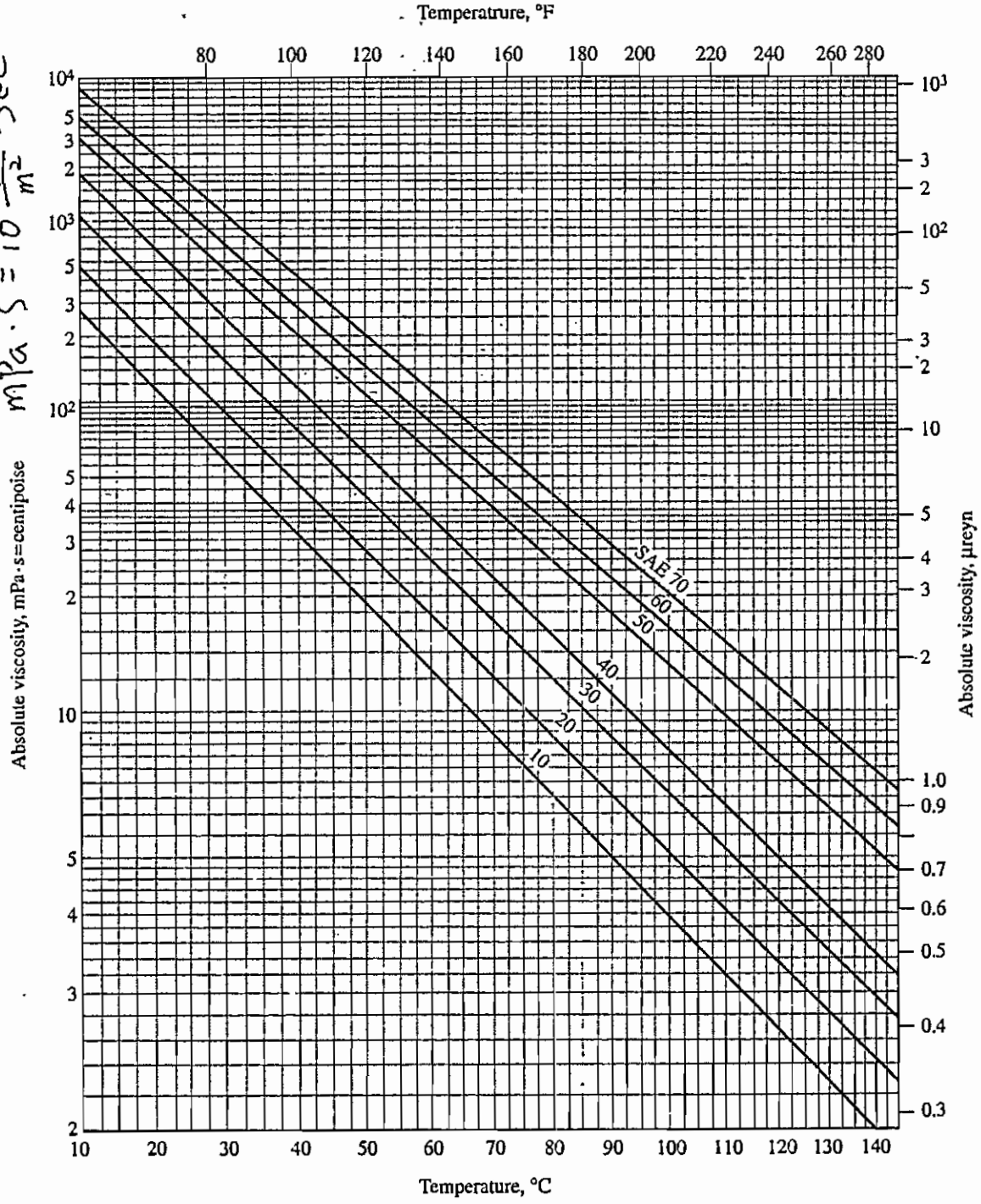
科目：機械設計




mPa·S = $10^{-3}$ N/m² · sec

**Figure** Average values of viscosity for some common SAE lubricating oils.

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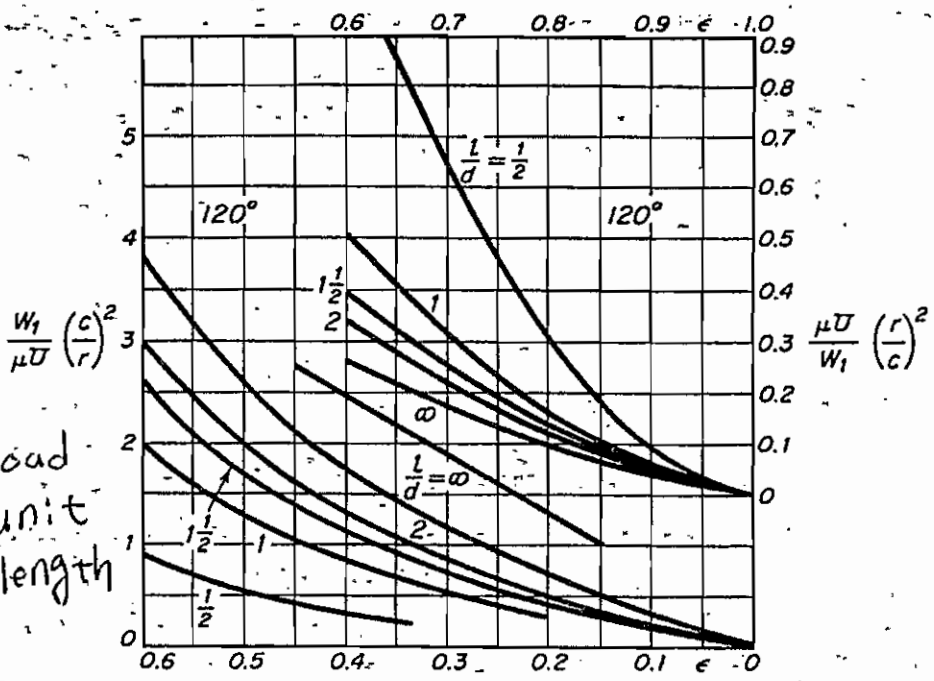
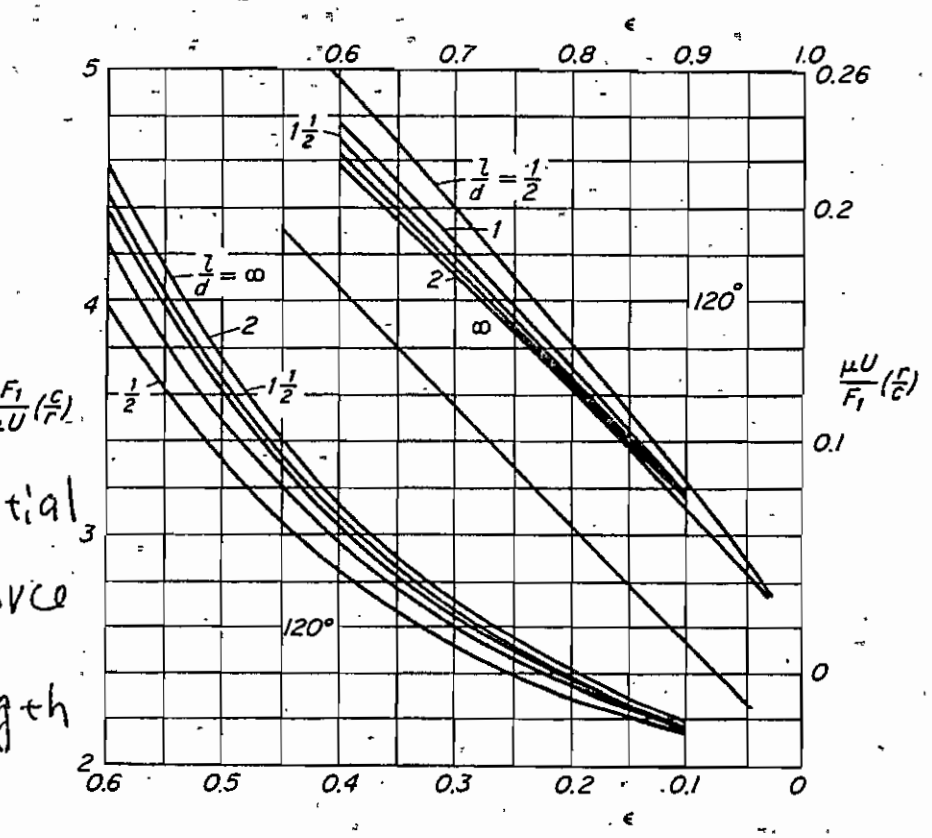
科目：機械設計






$W_1$: load per unit axial length




$F_1$: tangential friction force per unit axial length

Figure Load and friction characteristics of 120° central partial bearing.

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科目：機械設計

3. The larger of two concentric compression helical springs is made of 38mm diam round bar stock, is 225mm outside diam of helix, and has 6 active coils. The inner spring is made of 25mm diam round bar stock, is 140mm outside diam of helix, and has 9 active coils. The free height of the outer spring is 19mm more than the inner. Find the deflection of each spring for a load of 90000N. Also find the load carried by each spring. Take G = 77000Mpa. ( $K = Gd^4/64R^3N_c$ ) ( 25% )

4. Find the tooth loads and bearing reactions for the shaft shown in Fig. 3. All gears are 20° pressure angle with diametral pitch equal to 3. Make top and front views showing the loading for the shaft. Assume frictional losses to be negligible.
AB = 6 in; BC = 20 in; CD = 5 in. ( 25% )

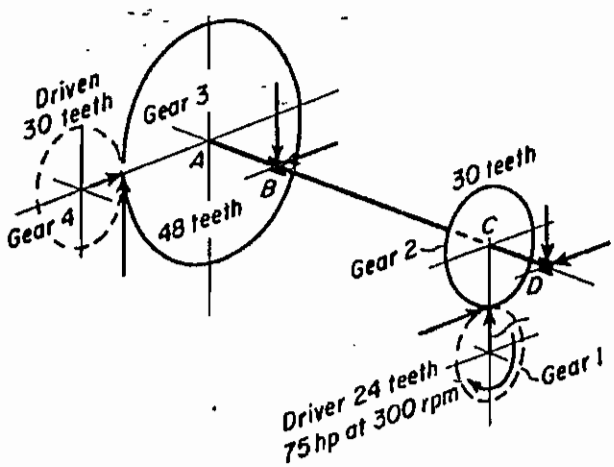


Figure 3

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所別：工程科技研究所
科目：機械製造

1. (1) 金屬切削加工用的綜合加工中心機(Machining Center)，在選購之前必須注意到哪些規格？並說明每一項規格，對於切削加工有何影響與重要性。(25%)

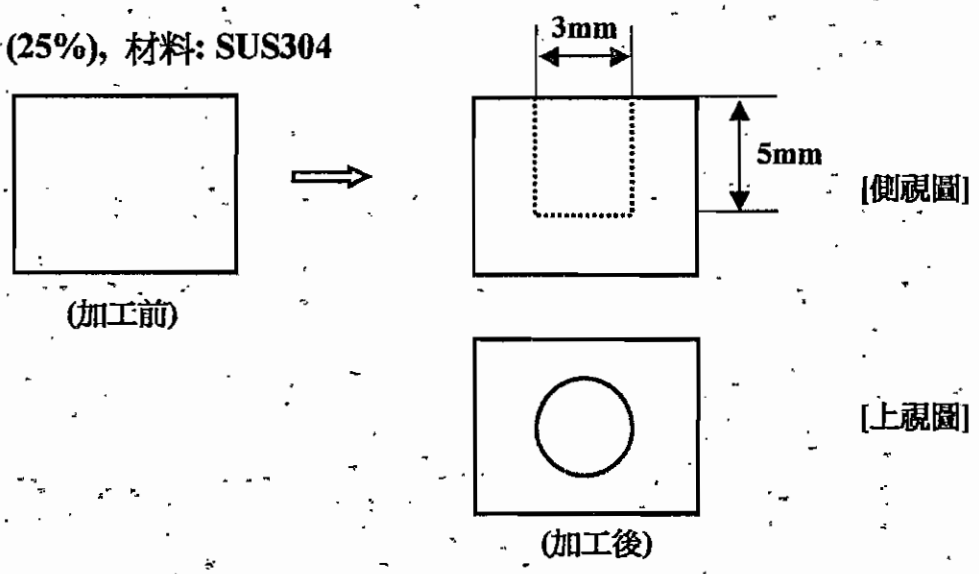
(2) 說明與比較「鍛造」和「鑄造」這兩種製造的加工法，其工件在機械強度、表面粗糙度、加工時間、形狀體積等方面有何差異，並說明造成這些差異的原因。(25%)

國立雲林科技大學
八十九學年度研究所博士班入學考試試題

所別：工程科技研究所
科目：機械製造

2. 試繪圖論述如何利用放電加工及雷射加工兩種方法來進行材料表面改質？並比較兩種方法在原理上的差異性及優缺點。(25%)

3. Chemical Machining 和 Electrochemical Machining 的加工原理有那些異同點？如果分別使用這兩種方法來加工如圖所示的工件模穴的話(數量 1 萬個)，試比較其在加工速度、精度、成本上的差異。(25%)，材料: SUS304



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八十九學年度研究所博士班入學考試試題

所別：工程科技研究所
科目：材料科學導論

# 材 料 科 學

一、請求出由位置座標 (3/4, 0, 1/4) 至 (1/4, 1/2, 1/2) 之立方體方向的方向指數( direction indices)? ( 5 % )

二、請畫出在下列立方體單包(cubic unit cell)中的結晶平面 ( crystallographic planes) : (a) (1 0 1) (b) ( 1 1 0) (c) (2 2 1) ( 15 % )

三、請說明顆粒邊界 (grain boundary) 之結構，以及為何顆粒邊界是沉積物 (precipitates) 結晶或成長最合適的地點? (10%)

四、何謂加成反應？何謂縮合反應？何謂開環反應？並請舉例說明之。(15%)

五、何謂玻璃轉移溫度？有那些方式可量測？並請排列下列材料的玻璃轉移溫度順序，請說明排列的準則。(20%)

(a) PP (b) PE (c) PU (d) Nylon6

六、何謂損失模式？何謂儲存模式？何謂應力-應變圖？並請說明下列因素對上述性質的影響。(a) 分子量 (b) cross-linking (15%)

七、材料改質的方式有那些？形態學對材料物性有何影響？請舉例說明之 (20%)。

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所別：工程科技研究所
科目：熱力學

PART A: (共同回答部分)

1. PVT behavior of $CO_2$ gas is adequately described by the van der Waal's equation state,

$$P=\frac{RT}{V-b}-\frac{a}{V^2}$$

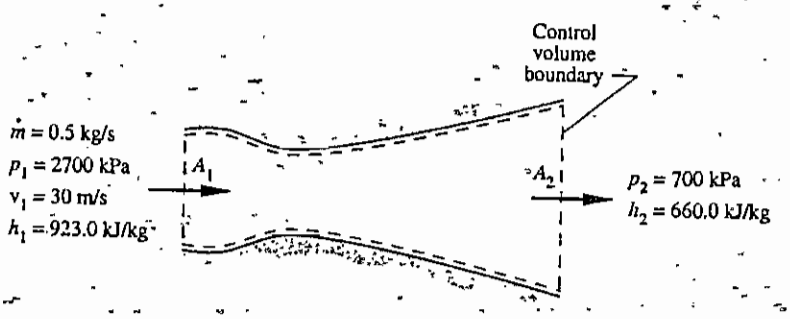
where a = 2.638x10$^6$ atm(cm$^3$/gmol)$^2$
b = 31.3 cm$^3$/gmol

Calculate the enthalpy of this gas at P = 40 atm, T = 100°C, and V = 707.7 cm$^3$/gmol, relative to its ideal state at 100 °C. Express your answer in cal/gmol. (25%)

2. A nozzle (as shown) receives 0.5 kg/s of air at a pressure of 2700 kPa and a velocity of 30 m/s and with an enthalpy of 923.0 kJ/kg, and the air leaves at a pressure of 700 kPa and with an enthalpy of 660.0 kJ/kg.

a) Determine the exit velocity from the nozzle for i) adiabatic flow; b) flow where the heat loss is 1.3 kJ/kg. (15%)

b) According to the information provided and the results you get from part a), what's the main function of a nozzle? Does work generated from (or provided to) the nozzle? What's the effects of heat transfer on the nozzle?(10%)



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PART B: (在以下四題中任選兩題作答)

3. The following vapor-liquid equilibrium data are available for methyl ethyl ketone:

Heat vaporization at 75 °C: 31.6 kJ/mol

Molar volume of saturated liquid at 75°C: $9.65\times10^{-2}$ $m^3$/kmol

$$\ln P^{vap} = 43.552 - \frac{5622.7}{T} - 4.70504 \ln T$$

where $P^{vap}$ is the vapor pressure in bar and T is in K. Assuming the saturated vapor obeys the volume-explicit form of the virial equation,

$$V = \frac{RT}{P} + B$$

Calculate the second virial coefficient, B, for methyl ethyl ketone at 75°C. (Note: $1J=10^{-5}$ bar-$m^3$) (25%)

4. (a) Show that the minimum amount of work, $W_s^{min}$, necessary to separate 1 mole of a binary mixture into its pure components at constant temperature and pressure is

$$W_s^{min} = x_1 RT \ln \frac{f_1(T,P)}{f_1(T,P,x_1)} + x_2 RT \ln \frac{f_2(T,P)}{f_2(T,P,x_2)} \qquad (13\%)$$

(b) Show that this expression reduces to

$$W_s^{min} = -x_1 RT \ln x_1 - x_2 RT \ln x_2$$

for (i) an ideal liquid mixture or (ii) a gaseous mixture for which the Lewis-Randall rule is obeyed. (12%)

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5. Briefly answers the following questions.
   a) Consider two geothermal wells whose energy contents are estimated to be the same. Will the exergy (availability) of these wells necessarily be the same? Why? (10%)
   b) When two fluid streams are mixed in a mixing chamber, can the mixture temperature be lower than the temperature of both streams? Why? Also, under what conditions will the amount of heat lost by one fluid be equal to the amout of heat gained by the other in a steady-flow heat exchanger? (15%)

6. Steam enters the turbine of a cogeneration plant at 7 MPa and 500°C. One-fourth of the steam is extracted from the turbine at 600 kPa for process heating. The remaining steam continues to expand to 10 kPa. The extracted steam is then condensed and mixed with feedwater at constant pressure and the mixture is pumped to the boiler pressure of 7 MPa. The mass flow rate of steam through the boiler is 30 kg/s. Disregarding any pressure drops and heat losses in the piping, and assuming the turbine and the pump to be isentropic.
   a) Draw the system schematic and the corresponding T-s diagram, with proper numbering. (10%)
   b) What's the mass flow rate at each numbered stations? (5%)
   c) Explain clearly that how are you going to determine the steam properties at each numbered stations. (10%)

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八十九學年度研究所博士班入學考試試題

所別：工程科技研究所
科目：半導體元件

1. Explain the following terms:
   (a) The Fermi level of electrons in a semiconductor (5%)
   (b) The effective mass of electrons in a semiconductor (5%)
   (c) Electron mobility (5%)
   (d) The Fermi-Dirac distribution function of electrons (5%)

2. Consider a reverse-biased GaAs *pn* junction at $T = 300$ °K. Assume that a reverse-bias voltage of 6 volts is applied. Calculate (a) the ideal reverse saturation current density, and (b) the reverse-biased generation current density. Assume parameter values: $N_a = N_d = 5\times10^{16}$ cm$^{-3}$; $D_p = 10$ cm$^2$/sec, $D_n = 200$ cm$^2$/sec, $\tau_{p0} = \tau_{n0} = \tau_0 = 10^{-8}$ sec. (20%)

3. Consider a gold Schottky diode at $T = 300$ °K formed on *n*-type GaAs doped at $N_d = 10^{17}$ cm$^{-3}$. Determine (a) the theoretical barrier height, $\phi_{B0}$, (b) $\phi_n$, (c) $V_{bi}$, and (d) the space charge width, $x_n$, for $V_R = 6$ volts. The work function for gold = 5.1 volts; and the electron affinity for GaAs = 4.07 volts. (20%)

4. (a) Describe the carrier components of current flowing in an *npn* bipolar junction transistor operated in forward active region. (10%)
   (b) Explain the Early effect in a bipolar junction transistor. (10%)

5. For an *n*-channel MOSFET, describe how threshold voltage shift due to (a) short-channel effects, and (b) substrate bias effects. Explain the reasons for both cases. (20%)

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**List of physical constants:**

Intrinsic carrier concentration of Si at 300 °K: $n_i(\text{Si}) = 1.5\text{x}10^{10}$ cm$^{-3}$

Boltzmann's constant: $k = 1.38\text{x}10^{-23}$ J/K

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# 國立雲林科技大學

八十九學年度研究所博士班入學考試試題

所別：工程科技研究所

科目：物理及化學

〔本試題共10題，每題10分，共100分〕

1. The human lungs can operate against a pressure differential of up to about 1/20 of an atmosphere. If a diver uses a snorkel for breathing, about how far below water level can she or he swim? (*hint*: the water density is 1g/cm$^3$ and 1ATM is 1.0x10$^5$ Pa).

2. A 2.00 kg block hangs from a spring. A 300g body hung below the block stretches the spring 2.00 cm farther. (a) What is the spring constant ? (b) If the 300g body is removed and the block is set into oscillation, find the period of the motion.

3. Diagnostic ultrasound of frequency 4.5 MHz is used to examine tumors in soft tissue. (a) What is the wavelength in air of such a sound wave ? (b) If the speed of sound in tissue is 1500 m/s, what is the wavelength of this wave in tissue? (the speed of sound in air is about 343 m/s)

4. Calculate the de Broglie wavelength of (a) a 1.00 keV electron, (b) a 1.00 keV photon, and (c) a 1.00 keV neutron. ( The neutron mass is about 1.671x10$^{-27}$ kg ).

5. We have seen that a gamma-ray dose of 3 Gy (1 Gy = 1 J/kg) is lethal to half of those people exposed to it. If the equivalent energy were absorbed as heat, what rise in body temperature would result? Assume that the specific heat of human body is the same as that of water (=4180 J/kgK). (*hint:* use formula $\Delta T_C = Q/m$).

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科目：物理及化學

6. A glass vessel weighs 50.1305 g when clean, dry and evacuated; 148.2410 g when filled with water (density of water = 0.997 g/mL); and 50.2959 g when filled with propylene gas at 740 mmHg and 25°C. What is the molecular mass of propylene? ($R = 0.082\ L \cdot atm \cdot mol^{-1} \cdot K^{-1}$)

7. What is the pH of a solution that is 0.00250M $HNO_2$ (aq)? ($K_a = 7.2 \times 10^{-4}$)

8. The activation energy for the reaction $2\ NO_2(g) \rightarrow 2\ NO(g) + O_2(g)$ is 27,200 cal. At 600K, $k = 0.75\ (mol/liter)^{-1} \cdot sec^{-1}$. Calculate $k$ at 700K. ($R = 1.987\ cal/g\ mole \cdot K$)

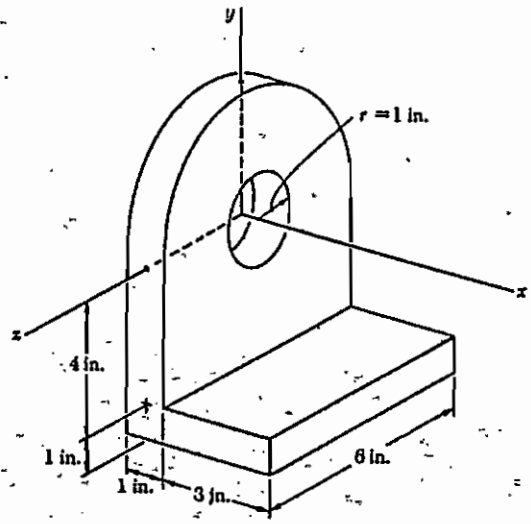
9. What is a fatty acid? and what is a lipid?

10. Will a precipitate of $PbCl_2$ form in a solution having a $Pb(NO_3)_2$ concentration of 0.010M and an HCl concentration of 0.010M? (for $PbCl_2$, $K_{sp} = 1.6 \times 10^{-5}$).

# 國立雲林科技大學
## 八十九學年度研究所博士班入學考試試題

所別：工程科技研究所
科目：工程力學

一、計算圖示鋼製機械元件對於 $x$ 軸之質量慣性矩(mass moment of inertia)。(鋼的比重爲 490 lb/ft$^3$) 〔25 分〕




二、一根直徑爲 d = 3 in 的實心圓棒，同時承受軸向拉力 P = 45 kips 和扭力 T = 30 in-kips，求此圓棒內之最大拉應力、最大壓應力和最大剪應力。〔25 分〕

三、一根梁，定義長度方向爲 $x$ 座標，下垂量爲 $y$，若只考慮小變形，$y$ 對 $x$ 微分一、二、三及四次，各代表或正比於何種物理量？〔25 分〕

四、在推導梁之 σ (軸向應力) = M (彎矩) y (與中性軸距離) / I (moment of inertia) 過程中，有作那些假設？〔25 分〕