龍華技術學院
九十學年度 機械 研究所碩士班招生筆試
「工程數學」試卷（一般生）

1. Given the equation $y'' + ay' + by = 0$ .....(eq. 1)
   If $\lambda^2 + a\lambda$ +b=0 has double root λ_1, and one of the nontrivial solution of eq. 1 is $e^{\lambda_1 x}$, show how to obtain the other nontrivial solution $xe^{\lambda_1 x}$. (10%)

2. Determine the relationship between b_1 、b_2 、b_3 to make the following system has solution, if X_1 、X_2 、X_3 、b_1 、b_2 、b_3 are real numbers. (10%)
   $X_1 + 5X_2 + 2X_3 = b_1$
   $2X_1 + X_2 + X_3 = b_2$
   $X_1 + 2X_2 + X_3 = b_3$

3. Suppose $y(t) = t^2 + \int_0^t y(u)\sin(t-u)du$
   Find the Laplace transform of y(t). (15%)

4. Evaluate $I = \int_0^\infty \frac{x^2}{(x^2+9)(x^2+4)^2} dx$ (15%)

5. $A = \begin{bmatrix} 1 & 0 \\ 1 & 5 \end{bmatrix}$, find A^{16}. (15%)

6. Solve the following ordinary differential equation: (10%)
   $3x^2y' - y^2 - 3xy = 0$

7. Prove that the gamma function $\Gamma(n+1)=n!$, n=0,1, 2,3, ... (10%)
   and $\Gamma(x) = \int_0^\infty e^{-t}t^{x-1}dt, x>0$

8. We consider the vibration of an elastic string of length 1, are governed by the one-dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$, $c^2 = \frac{H}{\rho}$
   where H is the horizontal component of tension of string , and ρ is the mass per unit length. If the boundary conditions are u (0,t)=u(1,t)=0, $0 \le t < \infty$, and the initial conditions are u(x,0)=f(x)=1
   $$\frac{\partial u(x,0)}{\partial t} = g(x) = 0$$
   Please find the vertical deflection u (x,t) of the string. (15%)

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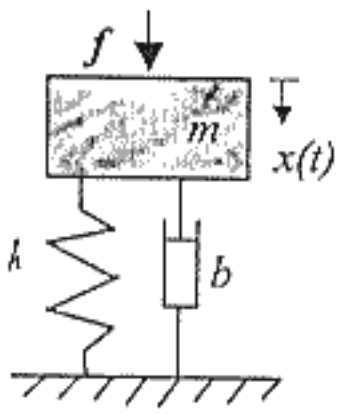
「自動控制」試卷（一般生）

1. (10% total) The equation of motion for the system shown in the following figure is $m\ddot{x}(t) + b\dot{x}(t) + kx(t) = f$.

   (a) (5%) Is this a linear system? Why? (**Please state your reasons specifically**)

   (b) (5%) Find the transfer function of the system by treating $f(t)$ as input and $x(t)$ as output.



2. (50% total) Controllers are sought to improve the dynamic response of a stable system with open-loop transfer function, $G(s) = \frac{1}{s(s+1)}$. You are asked to draw the root loci corresponding to the characteristic equation of $1 + KG(s) = 0$.

   (a) (10%) Draw the root locus of the system with G(s) given above.

   (b) (10%) If a PD controller is used, it is equivalent to adding a zero. Draw the new root locus if a zero of $s = -2$ is added. That is, the new transfer function becomes $HG(s) = \frac{s+2}{s(s+1)}$.

   (c) (10%) Instead of adding a zero, we decided to add a pole at $s = -2$. What is the resulting root locus? (*i.e.*, $HG(s) = \frac{1}{s(s+1)(s+2)}$)

   (d) (10%) A PD controller typically can be used to increase the damping of a system. Can you validate this statement by comparing the root loci from the results in Part (a) and (b)?

   (e) (10%) The stability of the system can be altered by adding poles and zeros. Discuss if the system in Part (c) is always stable from your root locus. If not, what is the critical value of K upon which the system changes stability? (Hint: You can answer this question by (i) obtaining the K value at the $j\omega$-crossing of the root locus in Part (c) or (ii) the Routh-Hurwitz criterion).

3. (30% total) Given the closed-loop transfer function $G(s) = \dfrac{100(s+1)}{(s+0.1)(s^2+8s+100)}$,

   (a) (20%) draw the Bode diagrams including both gain and phase plots !

   (b) (10%) determine graphically the bandwidth of the system.

   Note: show all asymptotes and draw to scale.

4. (10% total) Given the forward-path transfer function of unity-feedback control system,

$$G(s) = \frac{K(s+10)(s+20)}{s^2(s+2)}$$

   Apply the Routh-Hurwiz criterion to determine the stability of the closed-loop system as a function of K.

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「自動控制」試卷（在職生）

一、已知開迴路轉移函數為 G(s)= 25/[s(s+8)],若採用單位回授,(i)試問整個閉迴路轉移函數 T(s)為何?(ii)並求閉迴路系統的阻尼 ζ 與自然頻率 ω_n。(25 %)

二、試決定 K 的範圍,可使 $G(s)= K/[s(s^2+s+1)(s+4)]$ 之單位回授閉迴路控制系統穩定。(25 %)

三、已知系統開迴路轉移函數為 G(s)= 10/[s(as+1)],a=0.001,若採用比例控制,試問(i)當輸入函數是步進函數,試問穩態誤差為何?(ii)當輸入函數是 10 的斜坡輸入時,試計算欲產生穩態誤差為 1 所需的比例控制增益值為何? (25 %)

四、考慮單位迴授系統，若開迴路轉移函數為 G(s)= K/[s(s+10)(s+20)],K>0 試求其根軌跡的分離點與位於該分離點上的 K 值。(25 %)

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「熱力學」試卷

1. A simple vapor power cycle is shown in Figure 1.
   (a) Please write the brief description of the first law of thermodynamics by Figure 1.(5%)
   (b) Please write the brief description of the Kelvin-Plank Statement and Clausius Statement by Figure 1. (10%)
   (c) Please write the equations of the thermal efficiency of this simple vapor cycle in terms of temperature and energy.(5%)
   (d) If the Carnot cycle is to process this simple vapor power cycle, please draw the p-v and T-s diagrams and describe each process using the state numbers in Figure 1.(10%)

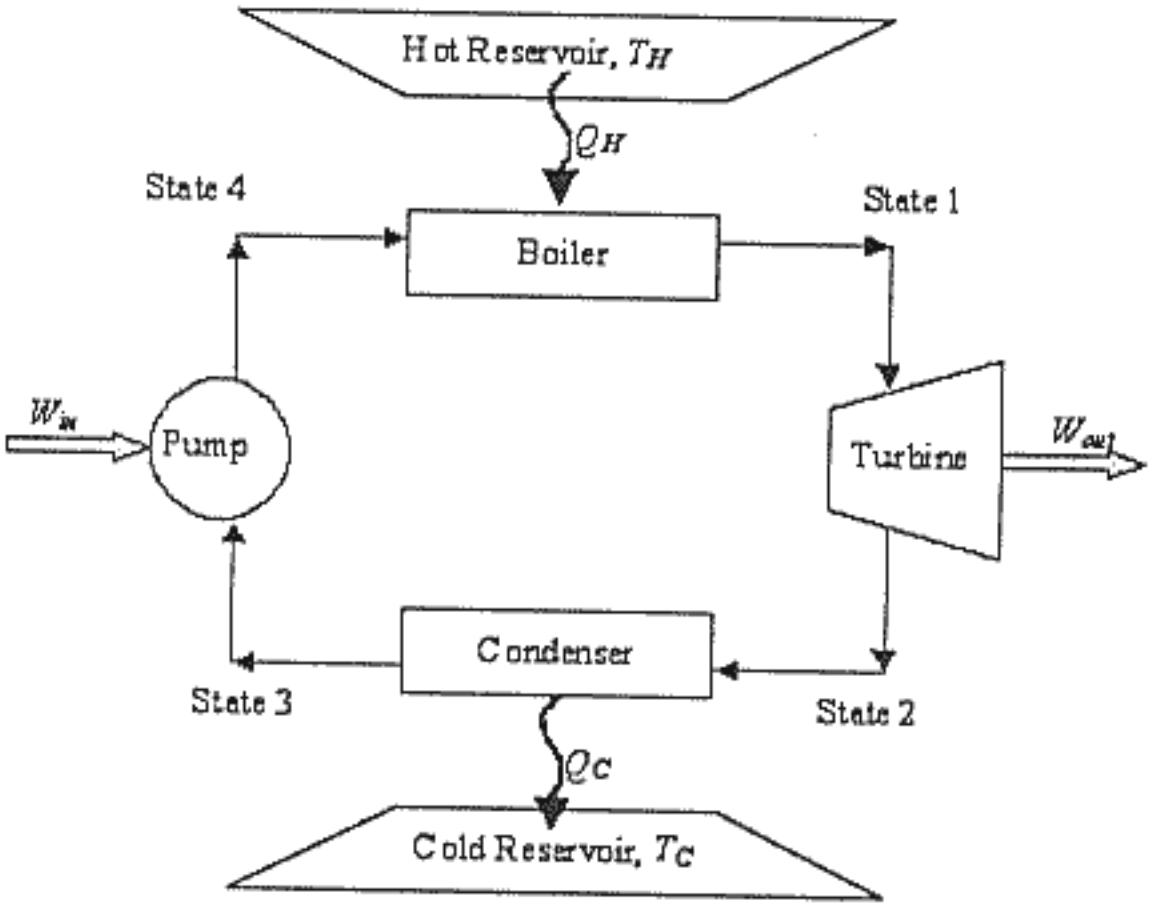

Figure 1 Simple Vapor Power Cycle

2. A closed, rigid container of volume $0.6m^3$ is placed on a hot plate. Initially, the container holds a two-phase mixture of saturated liquid water and saturated water vapor at $0.6MPa$ with a quality of 0.6. After heating, the pressure in the container is $0.8MPa$. The properties of water are listed from Table 1 to Table 3 for reference.
   (a) Please draw p-v and T-v diagrams and indicate the initial and final states on these diagrams.(5%)
   (b) Determine the temperature, in ^oC, at each state.(5%)
   (c) Determine the mass of vapor present at each state, in kg.(5%)
   (d) If heating continued, determine the pressure in MPa and temperature in ^oC, when the container holds only saturated vapor.(5%)

Table 1 Properties of Saturated Water (Liquid-Vapor): Pressure Table

Pressure	Temp.	Specific Volume m^3/kg		Specific Internal Energy kJ/kg		Specific Enthalpy kJ/kg	
MPa	*(°C)*	*Sat. Liquid* v_f	*Sat. Vapor* v_g	*Sat. Liquid* u_f	*Sat. Vapor* u_g	*Sat. Liquid* h_f	*Sat. Vapor* h_g
0.200	60	0.0	0.800	500	2500	500	2700
0.400	75	0.0	0.600	600	2550	550	2740
0.600	85	0.0	0.400	650	2600	600	2760
0.800	90	0.0	0.250	700	2700	700	2800
1.000	100	0.0	0.100	800	3000	750	3000

Table 2 Properties of Saturated Water (Liquid-Vapor): Temperature Table

Temp.	Pressure	Specific Volume m^3/kg		Specific Internal Energy kJ/kg		Specific Enthalpy kJ/kg	
(°C)	*MPa*	*Sat. Liquid* v_f	*Sat. Vapor* v_g	*Sat. Liquid* u_f	*Sat. Liquid* v_f	*Sat. Vapor* v_g	*Sat. Liquid* u_f
100	1.00	0.0	1.50	400	2500	400	2500
150	4.0	0.0	0.40	650	2600	600	2700
200	15	0.0	0.10	850	2650	850	2800
250	40	0.0	0.05	1080	2700	1000	2810

Table 3 Properties of Superheated Water Vapor

p=0.2MPa		*p=0.4MPa*		*p=0.6MPa*	
Temp.	Specific Volume	Temp.	Specific Volume	Temp.	Specific Volume
(°C)	m^3/kg	(°C)	m^3/kg	(°C)	m^3/kg
50	0.55	75	0.600	150	0.05
60	0.65	90	0.700	160	0.10
70	0.75	105	0.800	170	0.15
80	0.85	120	0.900	180	0.20
90	0.95	135	1.000	190	0.25

3. Figure 2 shows a system for collecting solar radiation and utilizing it for the production of electricity by a power cycle. The solar collector receives solar radiation at the rate of *0.125kW* per m^2 of area and provides energy to a storage unit whose temperature remains contain at 227^oC. The power cycle receives energy by heat transfer from the storage unit, generates electricity at the rate *0.5MW*, and discharges energy by heat transfer to the surrounding at 27^oC. For operation at steady state, determine the minimum theoretical collector area required, in m^2. (10%)

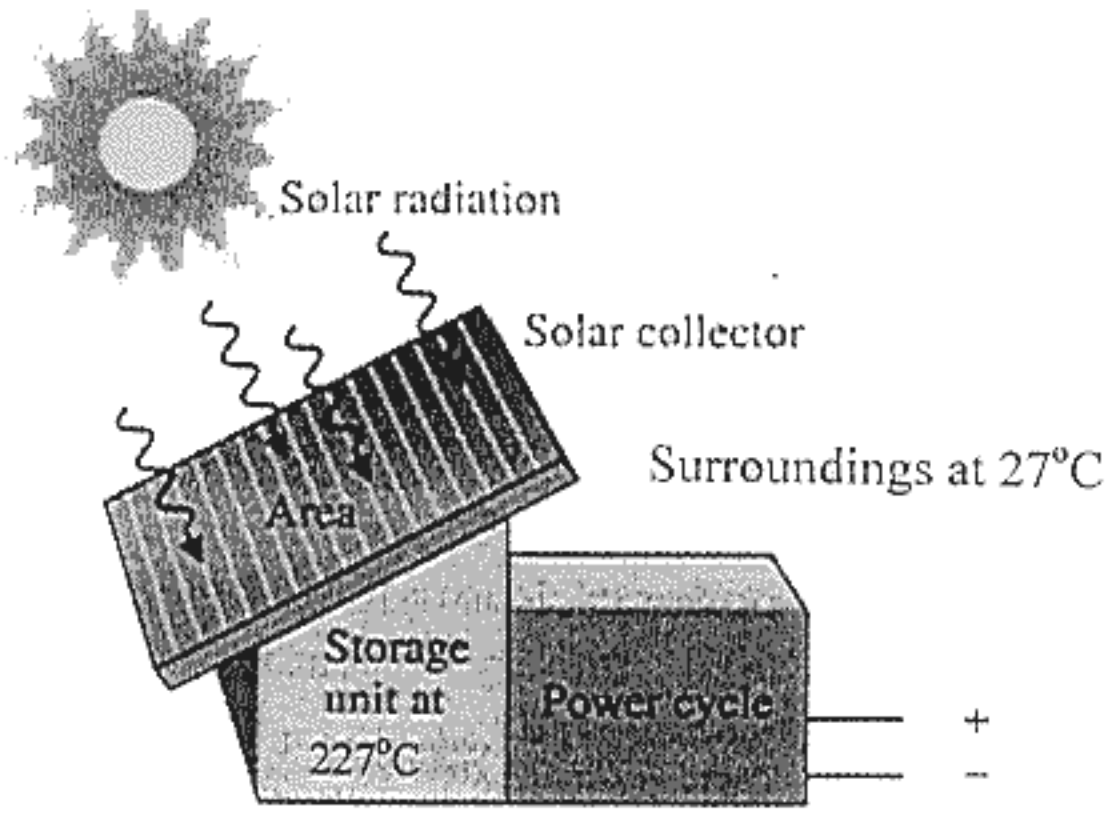

Figure 2 Problem 3

4. A gas flows through a one-inlet, one-exit control volume operating at steady state. Heat transfer at the rate $\dot{Q}_{CV}$ take place only at a location on the boundary where the temperature is T_b. For each of the following cases, determine whether the specific entropy of the gas at the exit is greater than, equal to, or less than the specific entropy of the gas at the inlet and write the reason.

(a) no internal irreversibilities, $\dot{Q}_{CV}=0$.(2%)

(b) no internal irreversibilities, $\dot{Q}_{CV}<0$.(2%)

(c) no internal irreversibilities, $\dot{Q}_{CV}>0$. (2%)

(d) internal irreversibilities, $\dot{Q}_{CV}<0$. (2%)

(e) internal irreversibilities, $\dot{Q}_{CV}\geq 0$.(2%)

5. An industrial gas turbine engine operates on an open-cycle system, as shown in Figure 3. Air enters the compressor from the atmosphere at state 1 and is compressed to state2. The air then enters a combustion chamber where it is mixed with fuel and combustion takes place. Finally, the hot gases resulting from combustion flow through the turbine to be rejected to the atmosphere at state 4. The cycle can be modeled on the process diagram as shown in Figure 4.(30%)

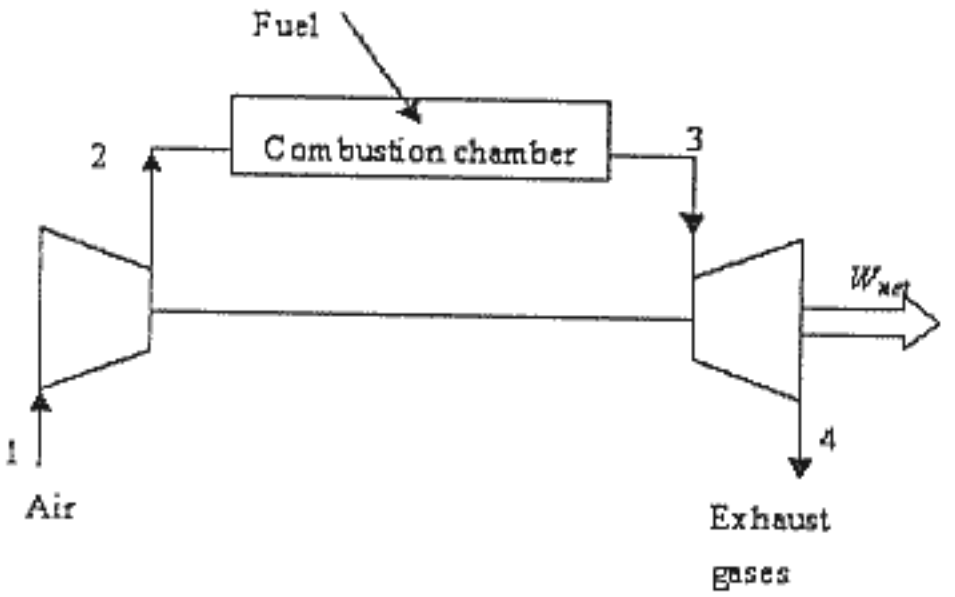

Figure 3 Open-cycle gas turbine engine

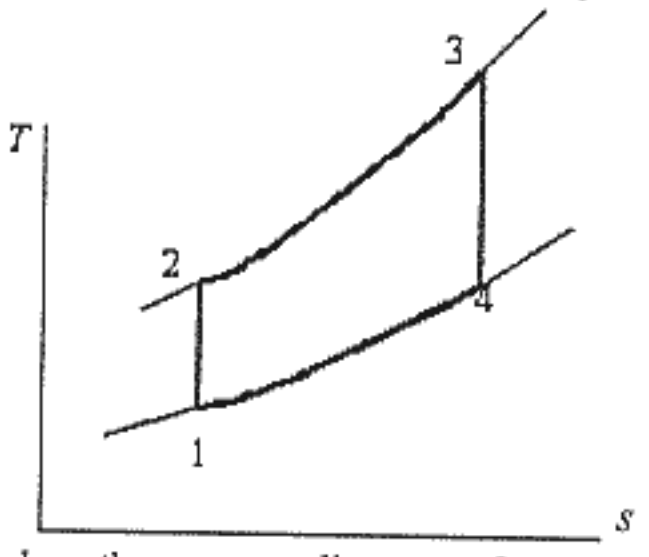

Figure 4 The cycle modeled on the process diagram of open-cycle gas turbine engine

This turbine takes in air at $15^{o}C$ and operates with the following conditions:

Mass flow rate : *10kg/s*

Pressure ratio : *12*

Turbine inlet temperature : $1000^{o}C$

Calculate the power output and thermal efficiency of the engine corresponding to three cases listing as follows:

case	*Compressor efficiency(%)*	*Turbine efficiency (%)*
1	*100*	*100*
2	*100*	*88*
3	*84*	*88*

Assume air to have the properties $C_p = 1.005kJ/kg-K, \gamma = 1.4$.

試題卷

龍華技術學院
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「機械製造」試卷（一般生）

問答題（每題十分）：

一、一般陶瓷材料的抗拉強度與抗壓強度何者較大？何故？

二、說明熱塑性塑膠與熱固性塑膠的差別？

三、什麼是金屬玻璃？

四、繪出金屬鑄造流路系統鑄件圖並說明？

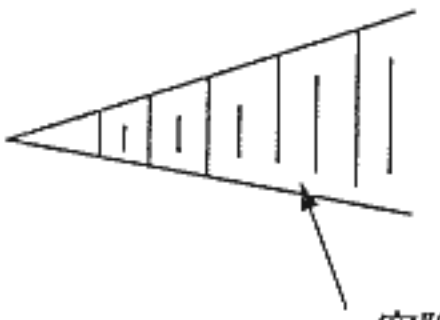
五、以壓力與時間關係圖，說明射出成型製程？

六、音波磨料加工 (ultrasonic abrasive machining) 的原理？ 適用的工件材料及工件設計須有那些考量？

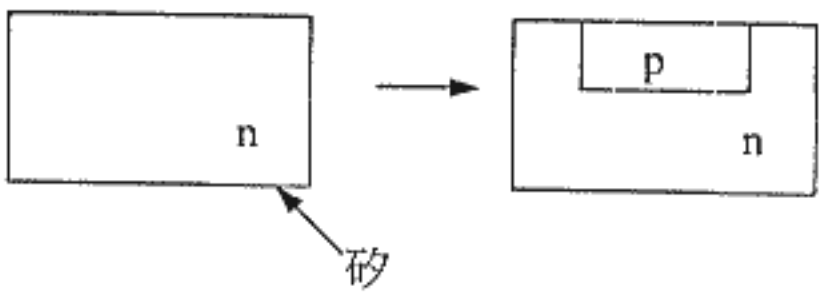
七、比較逆銑及順銑兩種進刀方式的特點？

八、說明雷射加工 (laser beam machining) 的原理？並說明工件的那些物理特性會影響雷射加工的效果？

九、飛機之操縱面大多數為蜂巢膠合件，於製造或使用一段期限後，蒙皮與蜂巢間會有空隙 (Gap) 出現，請說明如何利用非破壞檢測 (Nondestructive testing) 法，檢驗出工件內部空隙？



十、大多數半導體中 pn 接面二極體為重要元件，請繪圖並敘述如何在 n 型矽晶上製出 p 型區域？



試題卷

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「機械製造」試卷（在職生）

問答題（每題 12.5 分）：

一、一般陶瓷材料的抗拉強度與抗壓強度何者較大？何故？

二、說明熱塑性塑膠與熱固性塑膠的差別？

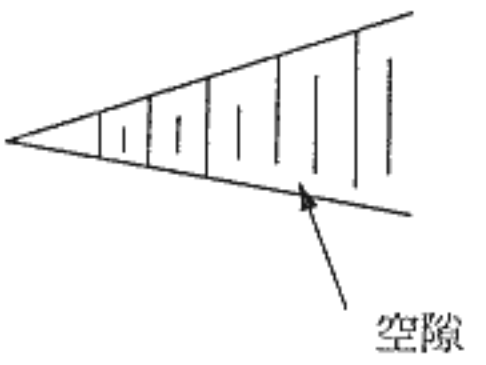
三、繪出金屬鑄造流路系統鑄件圖並說明？

四、以壓力與時間關係圖，說明射出成型製程？

五、超音波磨料加工 (ultrasonic abrasive machining) 的原理？ 適用的工件材料及工件設計須有那些考量？

六、比較逆銑及順銑兩種進刀方式的特點？

七、飛機之操縱面大多數為蜂巢膠合件，於製造或使用一段期限後，蒙皮與蜂巢間會有空隙 (Gap) 出現，請說明如何利用非破壞檢測 (Nondestructive testing) 法，檢驗出工件內部空隙？



八、大多數半導體中 pn 接面二極體為重要元件，請繪圖並敘述如何在 n 型矽晶上製出 p 型區域？