國立雲林科技大學
九十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. If **A** is an $n \times n$ nonsingular matrix with eigenvalues $\lambda_1, \lambda_2, \cdots, \lambda_n$,

(a) prove that $|\mathbf{A}| = \lambda_1 \lambda_2 ... \lambda_n$ where $|\bullet|$ denotes the determinant of a matrix; (10%)

(b) find the product for all the eigenvalues of $(\mathbf{A}^T)^{-1}$ if $\mathbf{A} = \begin{bmatrix} 12 & 3 & 2 & 5 \\ -4 & 3 & 1 & 5 \\ -8 & 0 & 1 & 0 \\ 12 & 6 & 2 & -10 \end{bmatrix}$.

(10%)

2. If $\mathbf{A} = \begin{bmatrix} 4.8 & 2 & -0.4 \\ 2 & 9 & -1 \\ -0.4 & -1 & 4.2 \end{bmatrix}$,

(a) find the eigenvalues of **A** and their corresponding eigenvectors; (10%)

(b) determine the eigenvalues and eigenvectors of $\mathbf{B} = \begin{bmatrix} 480 & 200 & -40 \\ 200 & 900 & -100 \\ -40 & -100 & 420 \end{bmatrix}$. (5%)

3. Use Laplace transform to solve the following differential equation:

$y''' - y'' + 9y' - 9y + 4 = e^t$ with $y(0) = 0, y'(0) = 0$ and $y''(0) = 0$ (15%)

4. Find the general solution for the following equations.

(a) $\frac{d^2y(x)}{dx^2} + 4y(x) = 16\cos(2x) + 5\cos(3x)$. (10%)

(b) $x^2 \frac{d^2y(x)}{dx^2} - 5x\frac{dy(x)}{dx} + 9y(x) = 2x^3$. (10%)

5. Find the Fourier transform for the following function.

$f(t) = \frac{1}{1+it}$ (10%)

6. Find the inverse Fourier transform for the following function.

$F(\omega) = \frac{\exp i(\omega - 3)}{5 + i(w - 3)}$ (10%)

7.Find the Laurent series expansion for the following functions.

$f(z) = \frac{1}{(z-1)(z-3i)}$, about z = 1, where $z = x + iy$. (10%)

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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 the circuit shown in Fig. 1 is moved from *1* to *2* at t=0. Find v_C and v_R, for t>0.

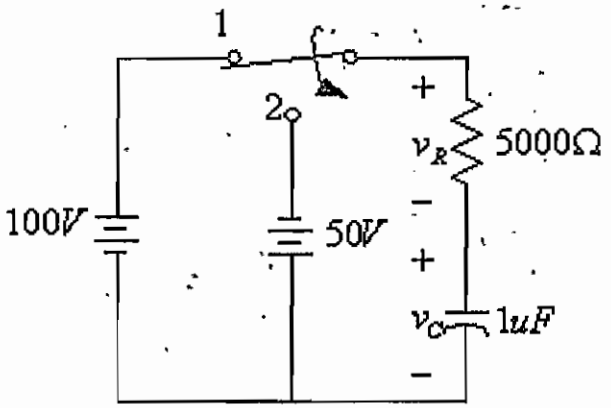

Fig. 1

2. (25%)A passive network contains resistors, a 70-mH inductor, and a 25-μF capacitor. Obtain the respective s-domain impedances for a driving voltage (a) $v = 100\sin(300t + 45^\circ)$ (V), (b) $v = 100e^{-100t}\cos 300t$ (V).

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科目：電路學

3. (25%) Obtain the voltage V_x in the network of Fig. 2, using the mesh current method.

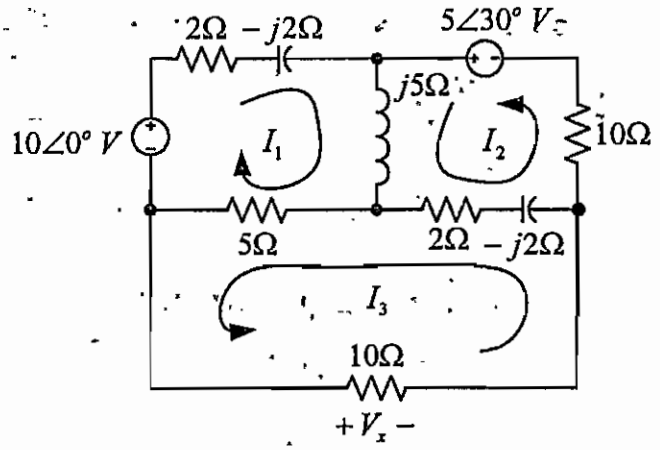

Fig. 2

4. (25%) A transformer rate at a maximum of 25kVA supplies a 12-kW load at power factor 0.60 lagging. What percent of the transformer rating does this load represent ? How many kW in additional load may be added at unity power factor before the transformer exceeds its rated kVA ?

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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, where $G(s)$ is a 3rd-order transfer function. $G(s)$ has at least two poles in the left-half plane. Answer the following questions using root locus of the system.
   (A) Give an example of $G(s)$, with which the system is stable for any $k > 0$. (8%)
   (B) Give an example of $G(s)$, with which the system is unstable for any real k. (8%)
   (C) Give an example of $G(s)$, with which the system is stable if $\alpha < k < \beta$, but is unstable if $0 \le k \le \alpha$ and $k \ge \beta$, where α and β are some positive constants. (9%)

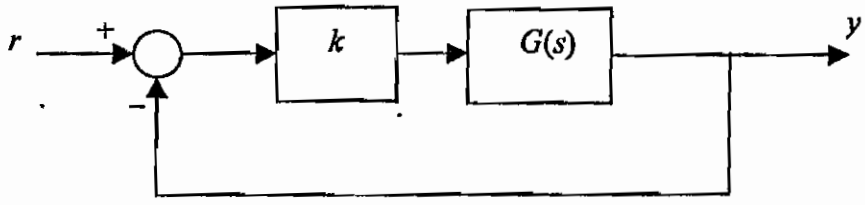

Fig. 1

2. Consider the following system,

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u$$

$$y = [1 \quad 0]\mathbf{x}$$

   (A) If y is the only measurable variable, construct a full-state observer with poles located at $-5 \pm 5i$. (18%)
   (B) Sometimes we use a full-state observer for feedback control even if all of the state variables could be directly measured, Can you explain why? (7%)

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3. The loop transfer function of a system is $G(s)H(s)=\dfrac{K}{s(s+1)(s+10)}$

(a) Draw the Bode plot of $G(s)H(s)$. (10 %)

(b) From the Bode plot, find the range of K for the system to be stable. (10 %)

4. The transfer function of a system is $G(s)=\dfrac{s^2+6s+8}{s^3+6s^2+11s+6}$

(a) Write the state equation such that the system is state controllable. (10 %)

(b) Write the state equation such that the system is state observable. (10 %)

(c) Is it possible to write the state equation such that the system is state controllable and state observable? If not, explain why. (10 %)

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所別：工程科技研究所
科目：機械設計

1. Fig. Prob. 1 shows a welded steel bracket which is to support a force F of 1300 lb as shown. The bracket is to be bolted to a smooth vertical face, now shown, by means of four SAE grade $5\ \frac{3}{8}$" - 16 UNC bolts, two on centerline (abbreviated CL) A and the other two on CL B. One way of analyzing such a connection would be to assume that the bolts on CL A carry the entire moment load and those on CL B carry the entire shear load.
   (a) Compute the external shear load carried by the bolts at B. [5%]
   (b) Compute the external tensile load carried by the bolts at A. [5%]
   (c) What are the factors of safety of the connection based on the A bolts and on shear of the B bolts, respectively? Table Prob. 1 is attached. [15%]

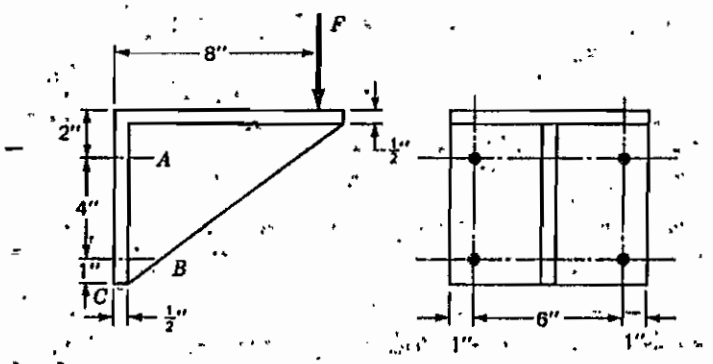

Fig. Prob. 1

2. A gear set consists of a 16-tooth pinion that mates with a 32-tooth gear. The gears have a face with of 1.25 in and a diametral pitch of 10 teeth/in; they are cut by hobbing, using the 20° full-depth system, with $b = 1.25/P$. The material is UNS G 10400 cold-drawn steel. Estimate the horsepower capacity of this gear set based on the yield strength of the material, a factor of safety of 4, and pinion speed of 1800 rpm. Table Prob. 2 is attached. [25%]

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科目：機械設計

Table Prob. 1 (a)

SPECIFICATIONS AND IDENTIFICATION MARKINGS FOR BOLTS, SCREWS, STUDS, SEMS[a] AND U BOLTS[b]
(Multiply the strengths in kpsi by 6.89 to get the strength in MPa.)

SAE grade	ASTM grade	Metric[c] grade	Nominal diameter in	Proof strength kpsi	Tensile strength kpsi	Yield[d] strength kpsi	Core hardness Rockwell min/max	Grade identification marking	Products[e]
1	A307	4.6	¼ thru 1½	33	60	36	B70/B100	None	B, Sc, St
2	···	5.8	¼ thru ¾	55	74	57	B80/B100	None	B, Sc, St
		4.6	Over ¾ thru 1½	33	60	36	B70/B100	None	B, Sc, St
4	···	8.9	¼ thru 1½	65	115	100	C22/C32	None	St
5	A449 or A325 Type 1	8.8	¼ thru 1	85	120	92	C25/C34		B, Sc, St
		7.8	Over 1 thru 1½	74	105	81	C19/C30		B, Sc, St
		8.6	Over 1½ to 3	55	90	58	···		B, Sc, St
5.1	···	8.8	No. 6 thru ⅜	85	120	···	C25/C40		Se
		8.8	No. 6 thru ½	85	120	···	C25/C40		B, Sc, St
5.2	A325 Type 2	8.8	¼ thru 1	85	120	92	C26/C36		B, Sc
7	··· A354	10.9	¼ thru 1½	105	133	115	C28/C34		B, Sc
8	Grade BD	10.9	¼ thru 1½	120	150	130	C33/C39		B, Sc, St
8.1	···	10.9	¼ thru 1½	120	150	130	C32/C38	None	St
8.2	···	10.9	¼ thru 1	120	150	130	C35/C42		B, Sc
···	A574	12.9	0 thru ½	140	180	160	C39/C45	12.9	SHCS
		12.9	⅝ thru 1½	135	170	160	C37/C45	12.9	SHCS

[a] Sems = screw and washer assemblies.
[b] Compiled from ANSI/SAE J429; ANSI B18.3.1-1978; and ASTM A307, A325, A354, A449, and A574.
[c] Metric grade is $xx.x$ where xx is approximately $0.01S_u$, in MPa and x is the ratio of the minimum S_y to S_u.
[d] Yield strength is stress at which a permanent set of 0.2% of gauge length occurs.
[e] B = bolt, Sc = screws, St = studs, Sc = Sems, and SHCS = socket head cap screws.
[f] Grade 7 bolts and screws are roll threaded after heat treatment.
[g] Entry appears to be in error but conforms to the standard ANSI/SAE J429).

Table Prob. 2 (a)

Table Prob. 1 (b)

DIAMETERS AND AREAS OF UNIFIED SCREW THREADS UNC AND UNF*

Size designation	Nominal major diameter, in	Coarse series—UNC: Threads per inch, N	Coarse series—UNC: Tensile-stress area A_t, in²	Coarse series—UNC: Minor-diameter area A_r, in²	Fine series—UNF: Threads per inch, N	Fine series—UNF: Tensile-stress area A_t, in²	Fine series—UNF: Minor-diameter area A_r, in²
0	0.0600				80	0.001 80	0.001 51
1	0.0730	64	0.002 63	0.002 18	72	0.002 78	0.002 37
2	0.0860	56	0.003 70	0.003 10	64	0.003 94	0.003 39
3	0.0990	48	0.004 87	0.004 06	56	0.005 23	0.004 51
4	0.1120	40	0.006 04	0.004 96	48	0.006 61	0.005 66
5	0.1250	40	0.007 96	0.006 72	44	0.008 80	0.007 16
6	0.1380	32	0.009 09	0.007 45	40	0.010 15	0.008 74
8	0.1640	32	0014 0	0.011 96	36	0.014 74	0.012 85
10	0.1900	24	0.017 5	0.014 50	32	0.020 0	0.017 5
12	0.2160	24	0.024 2	0.020 6	28	0.025 8	0.022 6
¼	0.2500	20	0.031 8	0.026 9	28	0.036 4	0.032 6
5/16	0.3125	18	0.052 4	0.045 4	24	0.058 0	0.052 4
⅜	0.3750	16	0.077 5	0.067 8	24	0.087 8	0.080 9
7/16	0.4375	14	0.106 3	0.093 3	20	0.118 7	0.109 0
½	0.5000	13	0.141 9	0.125 7	20	0.159 9	0.148 6
9/16	0.5625	12	0.182	1.162	18	0.203	0.189
⅝	0.6250	11	0.226	0.202	18	0.256	0.240
¾	0.7500	10	0.334	0.302	16	0.373	0.351
⅞	0.8750	9	0.462	0.419	14	0.509	0.480
1	1.0000	8	0.606	0.551	12	0.663	0.625
1⅛	1.2500	7	0.969	0.890	12	1.073	1.024
1½	1.5000	6	1.405	1.294	12	1.315	1.260

Table Prob. 2 (b)

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Table Prob. 2(a)

MECHANICAL PROPERTIES OF STEELS*

The values shown for hot-rolled (HR) and cold-drawn (CD) steels are *estimated minimum values* which can usually be expected in the size range of $\frac{3}{4}$ to $1\frac{1}{4}$ in. A minimum value is roughly several standard deviations below the arithmetic mean. The values shown for heat-treated steels are so-called *typical values*. A typical value is neither the mean nor the minimum. It can be obtained by careful control of the purchase specifications and the heat treatment, together with continuous inspection and testing. The properties shown in this table are from a variety of sources and are believed to be representative. There are so many variables which affect these properties, however, that their approximate nature must be clearly recognized.

UNS number	AISI number	Processing	Yield strength, kpsi†	Tensile strength, kpsi†	Elongation in 2 in, %	Reduction in area, %	Brinell hardness, H_B
G10100	1010	HR	26	47	28	50	95
		CD	44	53	20	40	105
G10150	1015	HR	27	50	28	50	101
		CD	47	56	18	40	111
G10180	1018	HR	32	58	25	50	116
		CD	54	64	15	40	126
	1112	HR	33	56	25	45	121
		CD	60	78	10	35	167
G10350	1035	HR	39	72	18	40	143
		CD	67	80	12	35	163
		Drawn 800°F	81	110	18	51	220
		Drawn 1000°F	72	103	23	59	201
		Drawn 1200°F	62	91	27	66	180
G10400	1040	HR	42	76	18	40	149
		CD	71	85	12	35	170
		Drawn 1000°F	86	113	23	62	235
G10450	1045	HR	45	82	16	40	163
		CD	77	91	12	35	179
G10500	1050	HR	49	90	15	35	179
		CD	84	100	10	30	197

Table Prob. 2(b)

VALUES OF THE AGMA LEWIS FORM FACTOR Y*

Number of teeth	$\phi = 20°$ $a = 0.800$ $b = 1.000$	$\phi = 20°$ $a = 1.000$ $b = 1.250$	$\phi = 25°$ $a = 1.000$ $b = 1.250$	$\phi = 25°$ $a = 1.000$ $b = 1.350$
12	0.335 12	0.229 60	0.276 77	0.254 73
13	0.348 27	0.243 17	0.292 81	0.271 77
14	0.359 85	0.255 30	0.307 17	0.287-11
15	0.370 13	0.266 22	0.320 09	0.301 00
16	0.379 31	0.276 10	0.331 78	0.313 63
17	0.387 57	0.285 08	0.342 40	0.325 17
18	0.395 02	0.293 27	0.352 10	0.335 74
19	0.401 79	0.300 78	0.360 99	0.345 46
20	0.407 97	0.307 69	0.369 16	0.354 44
21	0.413 63	0.314 06	0.376 71	0.362 76
22	0.418 83	0.319 97	0.383 70	0.370 48
24	0.428 06	0.330 56	0.396 24	0.384 39
26	0.436 01	0.339 79	0.407 17	0.396 57
28	0.442 94	0.347 90	0.416 78	0.407 33
30	0.449 02	0.355 10	0.425 30	0.416 91
34	0.459 20	0.367 31	0.439 76	0.433 23
38	0.467 40	0.377 27	0.451 56	0.446 63
45	0.478 46	0.390 93	0.467 74	0.465 11
50	0.484 58	0.398 60	0.476 81	0.475 55
60	0.493 91	0.410 47	0.490 86	0.491 77
75	0.503 45	0.422 83	0.505 46	0.508 77
100	0.513 21	0.435 74	0.520 71	0.526 65
150	0.523 21	0.449 30	0.536 68	0.545 56
300	0.533 48	0.463 64	0.553 51	0.565 70
Rack	0.544 06	0.478 97	0.571 39	0.587 39

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科目：機械設計

3. (a) Write the expression for $\tan\alpha$ for a square thread with negligible collar friction at which the maximum efficiency will occur. (13%)

   (b) What is the value of the maximum efficiency, and the angle at which it occurs, for $\mu_1 = 0.1$? (12%)

4. The work cycle for a 304 ball bearing is as follows.

   500 lb radial and 125 lb axial at 300 rpm for one-half the cycle
   600 lb radial at 500 rpm for one-quarter of the cycle
   350 lb radial at 1000 rpm for one-quarter of the cycle

   Loads are steady; the outer ring rotates. Find the rating life at two hours per day of this bearing. (25%)

Table problem 4-1 Constants for Single-Row Radial Contact Groove Ball Bearings

$\frac{D\cos\alpha}{d_m}$	f_c	$\frac{D\cos\alpha}{d_m}$	f_c	$\frac{F_a}{iZD^2}$	X	Y
0.05	3,550	0.22	4,530	25	0.56	2.30
0.06	3,730	0.24	4,480	50		1.99
0.07	3,880	0.26	4,420	100		1.71
0.08	4,020	0.28	4,340	150		1.55
0.09	4,130	0.30	4,250	200		1.45
0.10	4,220	0.32	4,160	300		1.31
0.12	4,370	0.34	4,050	500		1.15
0.14	4,470	0.36	3,930	750		1.04
0.16	4,530	0.38	3,800	1,000		1.00
0.18	4,550	0.40	3,660			
0.20	4,550					

f_c is also valid for single- and double-row angular contact groove ball bearings.
X and Y are also valid for double-row radial contact groove ball bearings.

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Table problem 4-2 Dimension and Basic Load Ratings for Conrad-Type Single-Row Radial Ball Bearings

Bearing No.	Bore		Outside Diameter		Width		Balls		Capacity, lb	
	mm	in.	mm	in.	mm	in.	No., Z	Diam., D	Dynamic, C	Static, P_{st}
102	15	0.5906	32	1.2598	9	0.3543	9	3/16	965	550
202			35	1.3780	11	0.4331	7	1/4	1,340	760
302			42	1.6535	13	0.5118	8	17/64	1,660	930
103	17	0.6693	35	1.3780	10	0.3937	10	3/16	1,040	640
203			40	1.5748	12	0.4724	7	5/16	1,960	1,040
303			47	1.8504	14	0.5512	6	3/8	2,400	1,240
104	20	0.7874	42	1.6535	12	0.4724	9	1/4	1,620	980
204			47	1.8504	14	0.5512	8	5/16	2,210	1,280
304			52	2.0472	15	0.5906	7	3/8	2,760	1,530
105	25	0.9843	47	1.8504	12	0.4724	10	1/4	1,740	1,140
205			52	2.0472	15	0.5906	9	5/16	2,420	1,520
305			62	2.4409	17	0.6693	8	13/32	3,550	2,160
106	30	1.1811	55	2.1654	13	0.5118	11	9/32	2,290	1,590
206			62	2.4409	16	0.6299	9	3/8	3,360	2,190
306			72	2.8346	19	0.7480	8	1/2	5,120	3,200
107	35	1.3780	62	2.4409	14	0.5512	11	5/16	2,760	2,010
207			72	2.8346	17	0.6693	9	7/16	4,440	2,980
307			80	3.1496	21	0.8268	8	17/32	5,750	3,710
108	40	1.5748	68	2.6772	15	0.5906	13	5/16	3,060	2,450
208			80	3.1496	18	0.7087	9	1/2	5,640	3,870
308			90	3.5433	23	0.9055	8	5/8	7,670	5,050
109	45	1.7717	75	2.9528	16	0.6299	13	11/32	3,630	2,970
209			85	3.3465	19	0.7480	9	1/2	5,660	3,980
309			100	3.9370	25	0.9843	8	11/16	9,120	6,150
110	50	1.9685	80	3.1496	16	0.6299	14	11/32	3,770	3,260
210			90	3.5433	20	0.7874	10	1/2	6,070	4,540
310			110	4.3307	27	1.0630	8	3/4	10,680	7,350
111	55	2.1654	90	3.5433	18	0.7087	13	13/32	4,890	3,950
211			100	3.9370	21	0.8268	10	9/16	7,500	5,710
311			120	4.7244	29	1.1417	8	13/16	12,350	8,660
112	60	2.3622	95	3.7402	18	0.7087	14	13/32	5,090	4,560
212			110	4.3307	22	0.8661	10	5/8	9,070	6,890
312			130	5.1181	31	1.2205	8	7/8	14,130	10,100
113	65	2.5591	100	3.9370	18	0.7087	15	13/32	5,280	4,950
213			120	4.7244	23	0.9055	10	11/16	10,770	8,460
313			140	5.5118	33	1.2992	8	15/16	16,010	11,600
114	70	2.7559	110	4.3307	20	0.7874	14	15/32	6,580	6,080
214			125	4.9213	24	0.9449	10	11/16	10,760	8,740
314			150	5.9055	35	1.3780	8	1	18,000	13,260

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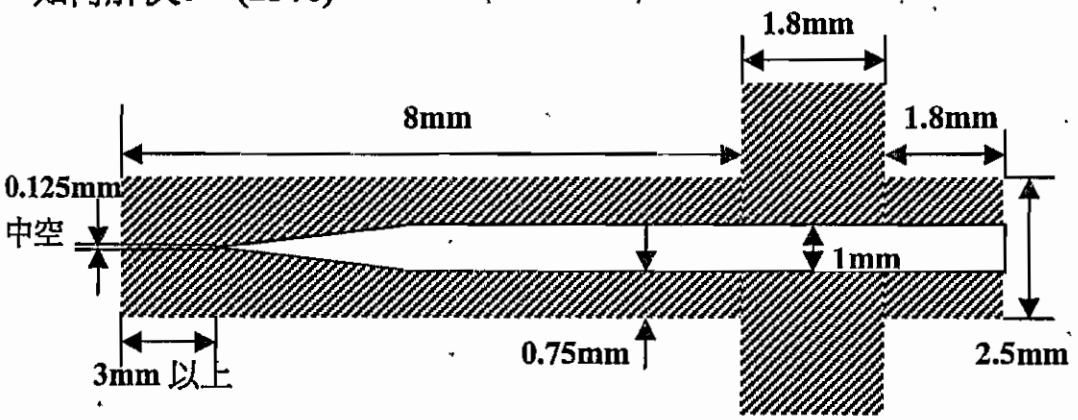
科目：機械製造

1. 試繪圖論述以下五種製程的原理。

A. Grinding　B. Lapping　C. Polishing
D. Chemical Mechanical Polishing　E. Magnetic Polishing (25%)

2.圖一所示爲陶瓷導管成品, 試繪圖舉出 2 種加工製造方法? 並比較其優缺點? 例如: 製程設備、製程方法、精度、量產速度、成本(模具、刀具、耗材、廢棄物處理、電力、空間等),必需畫出模具設計圖並說明如何加工製作?如何精密量測或較正?可能會遭遇到那些問題?如何解決?。(25%)



(其中 0.125mm 的公差±0.001mm, 同心度±0.001mm)

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3. 在熱塑型塑膠射出成型過程中，高溫熔融的塑膠(如料溫 220°c)充填入冷模(如模溫 50°c)，試繪模流時厚度方向剖面圖，說明何謂固化層(frozen layer)及噴泉效應(fountain flow effect)。固化層厚度若太厚時，如何降低？又在高速及低速充填時，模流現象有何差別？何處是剪應變最大的地方？如考慮流動粘滯熱(viscous heating)，當其效應顯著及甚小時，厚度方向塑料溫度分布情形有何變化？(25%)

4. CD 光碟片以何種製造方法大量生產？又如何維持成品平坦度及均一厚度？ 如果成品內部殘留有應力，如何加以檢測？ (25%)

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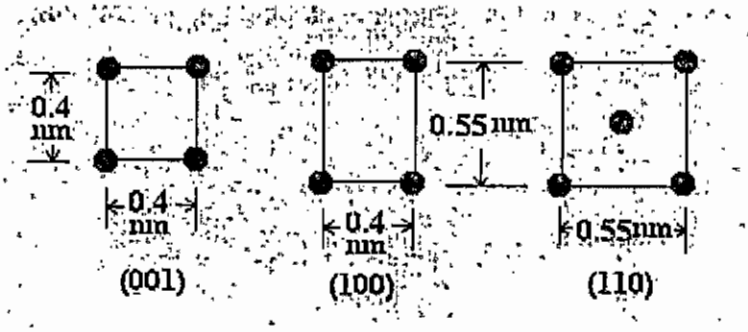
本考卷共有八大題，請依題序將答案寫在答案紙，總分共為 100 分。

1. Briefly describe or explain the following terms:
   (a) Briefly describe a twin and a twin boundary. (5%)
   (b) Compare the interstitial and vacancy atomic mechanisms for diffusion. (10%)
   (c) Briefly cite the differences between recovery and re-crystallization processes. (10%)
   (d) With regard to electron configuration, what do all the elements in Group IA of the periodic table have in common? (5%)

2. For BCC iron, compute
   (a) the interplanar spacing, and (5 %)
   (b) the diffraction angle for the (211) set of planes. (5 %)
   The lattice parameter for Fe is 0.2866 nm (2.866 Å). Assume that monochromatic radiation having wavelength of 0.1542 nm (1.542 Å) is used, and the order of reflection is 1.

3. Here are three different crystallographic planes for a unit cell of a hypothetical metal; the circles represent atoms:



   (a) To what crystal system does the unit cell belong? (5%)
   (b) What would this crystal structure be called? (5%)

4. Please state some important characteristics based on which fibers as high performance engineering materials are used. Explain the important roles of fiber, matrix, and interface to a composite material. (10 %)

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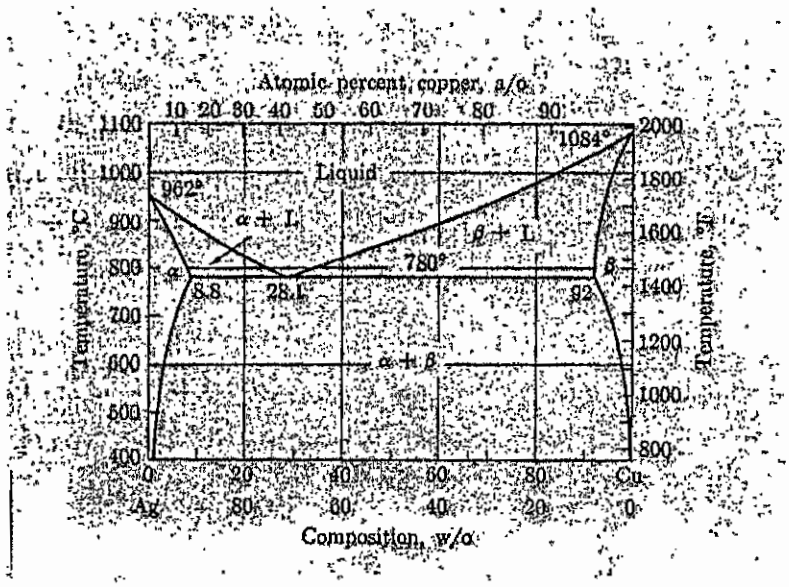
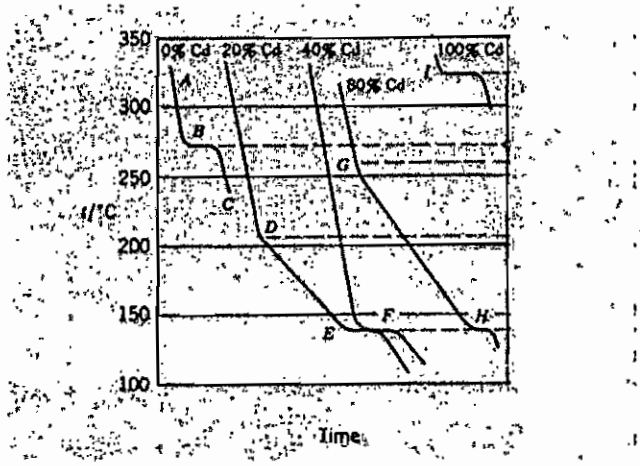
5. Please distinguish the thermoplastics and the thermosets in their significant characteristics. (10 %)

6. Sterling silver, an alloy containing approximately 92.5% silver and 7.5% copper is heated slowly from room temperature to 1000°C (1830°F). What phase(s) will be present as heating progresses? (10 %)



7. Please construct a temperature-composition phase diagram of the two-component, bismuth(Bi) and cadmium(Cd), system consisting of solid and liquid phases. The cooling curves are provided. (10 %)



8. Please schematically show the variation of elastic modulus of an amorphous polymer with temperature and identify each zone in your diagram and indicate the transition. (10 %)

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1. (25%)

With respect to 1 kg of liquid water (C_p = 4.184 kJ/kg K):

(a) Initially at 0℃, it is heated to 100℃ by contact with a heat reservoir at 100℃. What is the entropy change of the water? Of the heat reservoir? What is ΔS_{total}?

(b) Initially at 0℃, it is first heated to 50℃ by contact with a heat reservoir at 50℃ and then to 100℃ by contact with a heat reservoir at 100℃. What is the entropy change of the water? Of the heat reservoir? What is ΔS_{total}?

(c) Explain how the water might be heated from 0℃ to 100℃ so that $\Delta S_{total} = 0$.

2. (25%)

For acetone at 20℃ and 1 bar,

$\beta = 1.487 \times 10^{-3}$ /℃

$\kappa = 62 \times 10^{-6}$ /bar

$V = 1.287$ cm^3/g

(β is the volume expansivity; κ is the isothermal compressibility)

Find:

(a) The value of $(\partial P/\partial T)_V$.

(b) The pressure generated when acetone is heated at constant volume from 20℃ and 1 bar to 30℃.

(c) The volume change when acetone is changed from 20℃ and 1 bar to 0℃ and 10 bar.

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3. (25%)

A reversible power cycle R and an irreversible power cycle B operate between the same two reservoirs. (a) If each cycle receives the same amount of energy Q_H from the hot reservoir, show that cycle B necessarily discharges more energy Qc to the cold reservoir than cycle R. Discuss the implications of this for actual power cycles. (b) If each cycle develops the same net work, show that cycle B necessarily receives more energy Q_H from the hot reservoir than cycle R. Discuss the implications of this for actual power cycles.

4. (25%)

For a gas whose p-v-t behavior is described by $Z=1+Bp/RT$, where B is a function of temperature, derive expressions for the (a) specific enthalpy change, [h(p2, T) – h(p1, T)],and (b) specific entropy change, [s(p2, T) – s(p1, T)].

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(每題 10%)

1. At the instant a 3.0 kg particle has a velocity of 6.0m/s in the direction of decreasing y, a 4.0 kg particle has a velocity of 7.0m/s in the direction of increasing x. What is the speed of the center of mass of the two-particle system?

2. Water is moving with a speed of 5.0m/s through a pipe with a cross-sectional area of 4.0 cm^2. The water gradually descends 10m as the pipe increases in area to 8 cm^2. (a)What is the speed at the lower level? (b)If the pressure at the upper level is 1.5 $\times 10^5$ Pa, what is the pressure at the lower level? (Take water density as $1 \times 10^3 kg/m^3$)

3. Two small, positively charged spheres have a combined charge of 5.0×10^{-5} C. If each sphere is repelled from the other by an electrostatic force of 1.0 N when the spheres are 2.0m apart, what is the charge on each sphere?

4. An air-filled parallel-plate capacitor has a capacitance of 1.3pF. The separation of the plates is doubled and wax is inserted between them. The new capacitance is 2.6pF. Find the dielectric constant of the wax.

5. A UHF television loop antenna has a diameter of 11 cm. The magnetic field of a TV signal is normal to the plane of the loop and, at one instant of time, its magnitude is changing at the rate 0.16T/s. The field is uniform. What is the emf in the antenna?

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6. Only one amino acid does not show enantiomerism. which one is it？ Why is it not enantiomeric？
7. An aqueous solution of $CaSO_4$ is electrolyzed using inert electrodes. How many grams each of copper metal and oxygen gas are produced if a current of 6.0A passes through the cell for a duration of 2.5 hours？ (Atomic weight of Cu is 63.5；Faraday's constant is 9.65×10^4 CF^{-1})
8. The solubility product for AgI is 8.5×10^{-17} at 25℃. What is the molar solubility of AgI in water at this temperature？
9. In a titration of 25 ml of 0.10M CH_3COOH with 0.10M NaOH, what is the pH of the solution after the addition of 20.0ml of the base(25℃)？(*Ka* of acetic acid is 1.8×10^{-5}；log 4=0.60, log 4.5=0.65, log 5.5=0.74)
10. For the equilibrium $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$, *Kp* is 1.8×10^{-7} at 25℃ and 1.8 at 249℃. What is the value of $\triangle H^\circ$ for the reaction. (*R*=8.315 $JK^{-1}mol^{-1}$)

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1. A pair of wedges is used to lift a crate as shown in Fig. 1. The create weights 3000 N , the wedge angle θ is 15 °, and the coefficient of friction is 0.25 at all surfaces. The weight of the wedges is negligible Determine
   a. The force **P** necessary to insert the wedge.
   b. If the system would be in equilibrium if the force **P** were removed.
   c. The force **P** necessary to remove the wedge (or to prevent the wedge from slipping out, depending on the answer to part b).
   d. The maximum angle θ for which the system would be in equilibrium if the force P were removed.

   (20%)

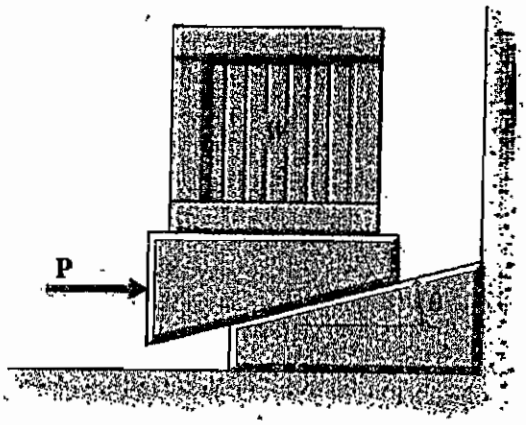

Fig. 1

2. Determine the maximum axial load *P* that can be applied to the wood compression block shown in Fig. 2 if specifications require that the shearing stress parallel to the grain not exceed 5.25 MPa, the compressive stress perpendicular to the grain not exceed 13.60 Mpa , and the maximum shearing stress in the block not exceed 8.75 MPa.

   (15%)

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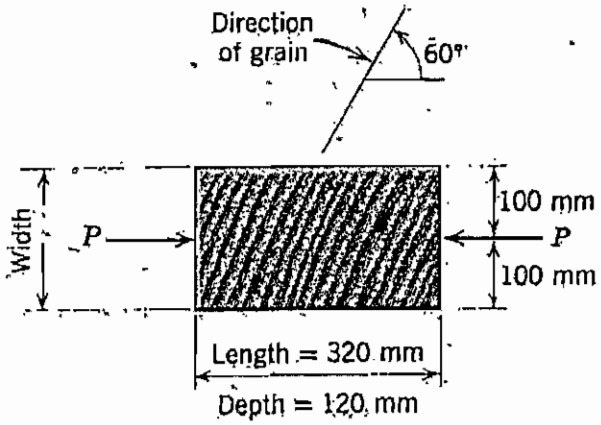

Fig. 2

3. A post and bracket is used to support a pulley as shown in Fig. 3 . A cable passing over the pulley transmits a 500-lb load as shown in the figure. Determine the reaction at A of the post.
(15%)

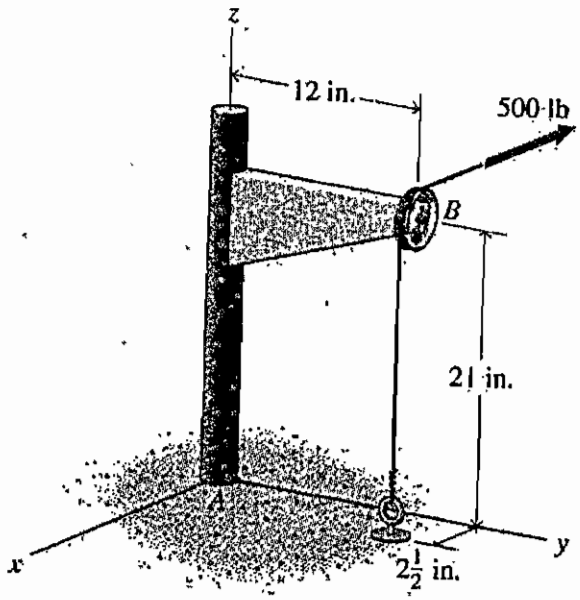

Fig. 3

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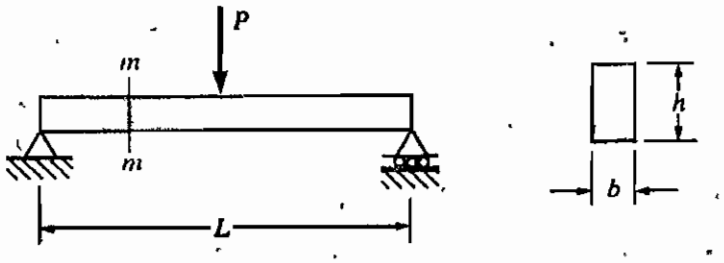
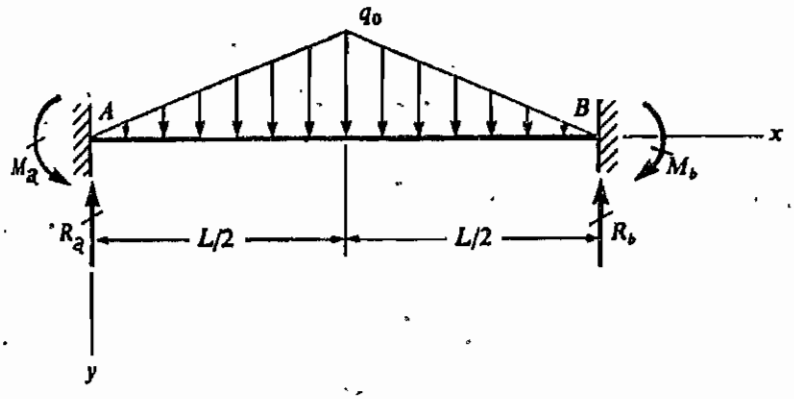
4. 一矩形斷面簡支梁跨距爲 $L = 50$ in，在梁中點處承受一集中荷重 $P = 12$ Kips（見圖）。梁高 $h = 6$ in，寬 $b = 2$ in，截面 mm 位於距左支點 14 in 處，畫圖顯示此截面沿梁高度之主應力 σ_1 及 σ_2，以及最大平面內剪應力 τ_{max} 如何變化。〔25 分〕



5. 固定端梁 AB 承受一最大強度爲 q_0 之對稱三角形分佈載重（見圖），假設梁的撓曲剛度 EI 爲定值，推導其撓度曲線方程式，並求出所有反力及最大撓度 δ_{max}。〔25 分〕



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1. Describe the differences between a direct-energy bandgap and an indirect-energy bandgap semiconductor. **(20%)**

2. Describe the differences between an abrupt and a linearly graded p-n junction. **(20%)**

3. Consider a MOS capacitor made on a p-type silicon substrate with a doping of 2×10^{16} cm^{-3}. The SiO_2 thickness is 500Å and the gate is made from aluminum. Calculate the oxide capacitance, the capacitance at flat band, and the minimum capacitance at threshold. **(20%)**

4. Consider a metal to n-type semiconductor contact. Φ is the work function.
   (a) Draw the thermal equilibrium charge distribution for $\Phi_M > \Phi_S$ and $\Phi_M < \Phi_S$. **(10%)**
   (b) Draw the energy band diagram under forward bias for $\Phi_M > \Phi_S$ and $\Phi_M < \Phi_S$. **(10%)**

5. Consider a silicon npn transistor at $T = 300$ °K. Assume the following parameters:
   neutral base width $x_B = 0.72$ μm,
   minority carrier diffusion coefficient in the base $D_n = 25$ cm^2/sec.
   (a) Calculate the base transit time τ_b. **(10%)**
   (b) If the total emitter-to-collector delay time is 150 *p*sec, calculate the cutoff frequency. **(10%)**

List of physical constants:

Intrinsic carrier concentration of Si at 300 K: $n_i(Si) = 1.5\times10^{10}$ cm^{-3}
Boltzmann's constant: $k = 1.38\times10^{-23}$ J/K
Dielectric constants: $\varepsilon(Si) = 11.7$, $\varepsilon(SiO_2) = 3.9$, $\varepsilon_0 = 8.85\times10^{-14}$ F/cm.
