材力部份(80%)

1. From the generalized Hooke's law equations, make some useful comments to clarify the distinction between plane stress and plane strain problems.(10%)

2. At a certain point on a steel machine part, measurements with an electric retangular rosette indicate that the strains in three different directions 0^0, 45^0 and 90^0 are $\varepsilon_0 = -500\mu m/m$ $\varepsilon_{45} = 200\mu m/m$ and $\varepsilon_{90} = 300\mu m/m$ respectively. Assuming that E = 200 GPa and $\nu = 0.3$, find the principal stresses at the point investigated.(15%)

3. A thin semicircular ring is hinged at each end and loaded by a central concentrated force P (Fig. 1). Determine the horizontal reaction at each hinge.(15%)

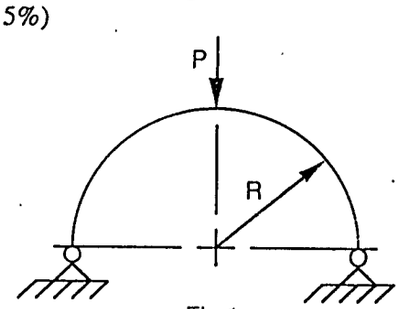


Fig.1

4. A long steel thin-walled circular tube of 200-mm diameter and 5-mm wall thickness is subjected to an interior pressure of P(MPa) and a twisting moment of $M_t = \pi \times 10^4$ (N-m). The ends of the tube are closed. The yield stress of the steel is 250 MPa. Find the interior pressure P which is needed to cause yielding of the tube, based on (i) the von Mises criterion; (ii) the Tresca criterion. (24%)

5. Compute the reactions at both supports A and C and the deflection at point B for the structure of Fig. 2 by energy method. (16%)

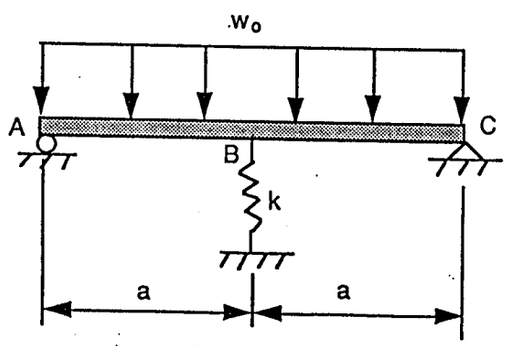


Fig. 2

熱力學部份(20%)

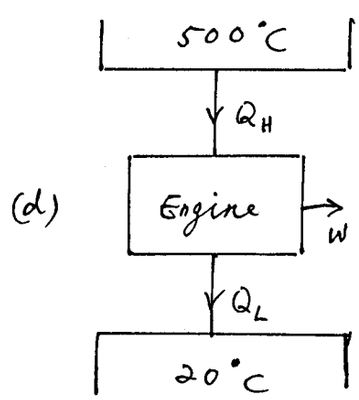
I. Explain or Answer the following terms / questions.

(a) The equation of state for an ideal gas. (2%)

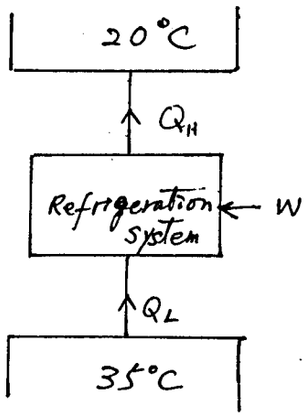
(b) The critical point of a pure substance. (2%)

(c) Wet-bulb temperature. (2%)

(d) What is the maximum thermal efficiency of an heat engine operating at two temperature reservoirs (see figure (d)). (3%)



(d)



(e)

(e) What is the maximum coefficient of performance (COP) of a refrigeration system (see figure (e)). (3%)

II. Consider the reversible adiabatic flow of steam through a nozzle. Steam enters the nozzle at 0.8 MPa, 300°C with a velocity of 15 m/s. The pressure of the steam at the nozzle exit is 0.3 MPa. Determine the exit velocity of the steam from the nozzle, assuming a reversible, adiabatic, steady-flow process, obtain properties from the attached tables. (8%)

067

(附表二份)

(題目將用本張複印製版請以黑色正楷書寫或打字並請勿超出此線)

Saturated Steam: Pressure Table

Press. MPa P	Temp. °C T	Specific Volume m^3/kg Sat. Liquid v_f	Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Enthalpy kJ/kg Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Entropy kJ/kg K Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
0.225	124.00	0.001 064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001 067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001 070	0.6573	548.59	1991.9	2540.5	548.89	2172.4	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001 073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001 076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001 079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001 081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001 084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001 088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001 093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001 097	0.3427	655.32	1909.2	2564.5	655.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001 101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001 104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001 108	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001 112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001 115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001 118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001 121	0.2150	741.83	1838.6	2580.5	742.83	2031.1	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001 124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001 127	0.194 44	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001 133	0.177 53	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001 139	0.163 33	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001 144	0.151 25	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001 149	0.140 84	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001 154	0.131 77	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001 166	0.113 49	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001 177	0.099 63	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001 187	0.088 75	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001 197	0.079 98	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001 217	0.066 68	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869

Superheated Vapor

T	v	u	h	s	v	u	h	s	v	u	h	s
	P = .20 MPa (120.23)				P = .30 MPa (133.55)				P = .40 MPa (143.63)			
Sat.	.8857	2529.5	2706.7	7.1272	.6058	2543.6	2725.3	6.9919	.4625	2553.6	2738.6	6.8959
150	.9596	2576.9	2768.8	7.2795	.6339	2570.8	2761.0	7.0778	.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	.7163	2650.7	2865.6	7.3115	.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	.7964	2728.7	2967.6	7.5166	.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	.8753	2806.7	3069.3	7.7022	.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2372	3662.4	4157.3	8.9244
900	2.706	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.6563	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.3	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780
	P = .50 MPa (151.86)				P = .60 MPa (158.85)				P = .80 MPa (170.43)			
Sat.	.3749	2561.2	2748.7	6.8213	.3157	2567.4	2756.8	6.7600	.2404	2576.8	2769.1	6.6628
200	.4249	2642.9	2855.4	7.0592	.3520	2638.9	2850.1	6.9665	.2608	2630.6	2839.3	6.8158
250	.4744	2723.5	2960.7	7.2709	.3938	2720.9	2957.2	7.1816	.2931	2715.5	2950.0	7.0384
300	.5226	2802.9	3064.2	7.4599	.4344	2801.0	3061.6	7.3724	.3241	2797.2	3056.5	7.2328
350	.5701	2882.6	3167.7	7.6329	.4742	2881.2	3165.7	7.5464	.3544	2878.2	3161.7	7.4089
400	.6173	2963.2	3271.9	7.7938	.5137	2962.1	3270.3	7.7079	.3843	2959.7	3267.1	7.5716
500	.7109	3128.4	3483.9	8.0873	.5920	3127.6	3482.8	8.0021	.4433	3126.0	3480.6	7.8673
600	.8041	3299.6	3701.7	8.3522	.6697	3299.1	3700.9	8.2674	.5018	3297.9	3699.4	8.1333
700	.8969	3477.5	3925.9	8.5952	.7472	3477.0	3925.3	8.5107	.5601	3476.2	3924.2	8.3770
800	.9896	3662.1	4156.9	8.8211	.8245	3661.8	4156.5	8.7367	.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	.9017	3853.4	4394.4	8.9486	.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	.9788	4051.5	4638.8	9.1485	.7340	4051.0	4638.2	9.0153

1. From Newton's second law of motion, shows that the equation of motion of a rigid body are

$$\mathbf{F} = m\,\mathbf{a}_G \qquad (10\%)$$

and

$$\mathbf{M}_P = \mathbf{r}_{GP} \times m\mathbf{a}_G + I_G\boldsymbol{\alpha} \qquad (20\%)$$

where $\mathbf{F}$ and $\mathbf{M}_P$ are the applied force and applied moment at point P of the rigid body, respectively. $\mathbf{a}_G$ is the acceleration vector of the mass center, I_G is the mass moment of inertia related to the mass center, $\boldsymbol{\alpha}$ is the angular acceleration vector and $\mathbf{r}_{GP}$ is the position vector from point P to the mass center.
(It is allowed to derive the equation in two dimensional space.)

2. Answer the following questions: (20%)
   (a) What is the relation among the Newton's second law of motion, the principle of work and energy and the principle of impulse and momentum?
   (b) Which kinds of problem can not be solved by the principle of work and energy? Explain the reason.

3. Two jet planes are flying horizontally at the same elevation, as shown in the Figure 3. Plane A is flying along a straight-line path, and at the same instant shown it has a speed of 700 km/h and an acceleration of 50 km/h^2. Plane B is flying along a circular path having a radius of ρ_B = 400 km. Its speed is 600 km/h, which is decreasing at the rate of 100 km/h^2.
   (a) Determine the velocity and acceleration of B as measured by the pilot in A.(5%)
   (b) Determine the velocity and acceleration of A as measured by the pilot in B.(15%)

4. The uniform beam has a weight W. If it is originally at rest while being supported at A and B by cables, determine the tension in cable A if cable B suddenly fails. Assume the beam is a slender rod.(12%) (See Fig. 4)

5. Determine the kinetic energy of the 10-kg disk D and 2-kg rod CD when the assembly is rotating about the z axis at ω = 5 rad/s.(18%) (See Fig. 5)

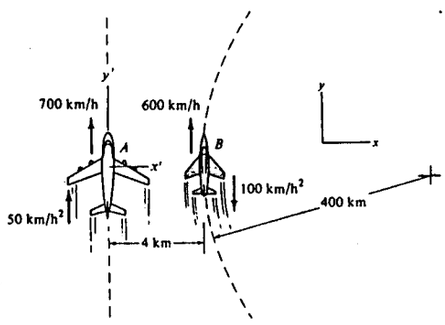


Figure 3

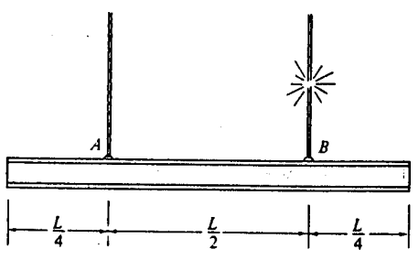


Figure 4

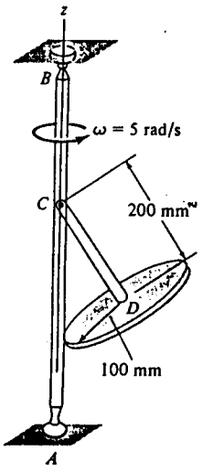


Figure 5

069

機構學 (Mechanisms) * 本科考試不得參閱任何資料

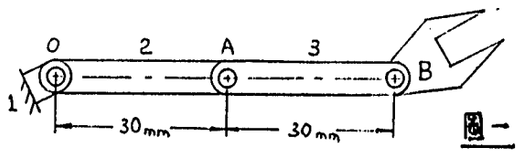
1. 請解釋「機構(Mechanisms)」與「機器(Machines)」，並說明二者之差異。(10分)

2. 請解釋「拘束運動(constrained motion)」之意義，並說明如何判斷機構是否作拘束運動。(10分)

3. 一機器手如圖一所示，構件2之角速度 $\omega_2 = 10$ rad/sec 反時針方向，構件3之角速度為 $\omega_3 = 30$ rad/sec 順時針方向，求：

(a). 點B之速度。(5分)

(b). 點B之曲率中心。(5分)

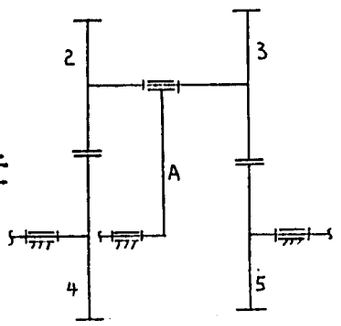


圖一

4. 一輪系如圖二所示，齒數(N)如下：$N_2 = 24$，$N_3 = 27$，$N_4 = 30$，$N_5 = 27$

(a). 若行星架(A)為固定，齒輪2之角速度為50 rpm順時針方向，求齒輪5之角速度。(5分)

(b). 若行星架(A)為固定，且行星架與齒輪之角速度皆為100 rpm順時針方向，求齒輪5之角速度。(5分)



圖二

5. (1) 請劃出凸輪(Cam)機構之設計流程圖，並加簡要之說明。[6分]

(2) 從動件運動曲線中之正弦(Sine)、擺線(Cycloidal)、凸輪机構 修正梯形(Modified Trapzoidal)、3-4-5多項式(3-4-5 polynomial)曲線，(a)用於高速時，請依其優劣順序排出；(b)請依其加速度峰值之大小，排列之(由小，至大)。[4分]

070

(題目將用本張複印製版請以黑色正楷書寫或打字並請勿超出此線)

(本測驗不得參考任何資料)

機械設計

1. What is the stress concentration factor? In what situations should we consider the stress concentration factor in mechanical design? (10%)

2. Determine the required weld size for Fig. 1 using E60 welding rod (S_y = 345 Mpa) and safety factor of 2.5. Notice that an appropriate static failure theory should be used, and the weld size should be specified as an integral number of mm. (20%)

3. A cold-drawn rectangular steel bar (see Fig. 2) of 128 Bhn is 10 mm thick; 60 mm wide and has a center hole of 10 mm diameter. Estimate the maximum tensile force that can applied to the ends and have infinite life with 90 % reliability and a safety factor of 1.3 if the force varies between zero and a maximum value. (20%)

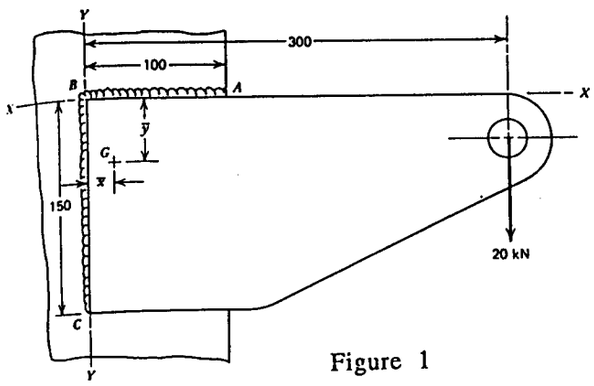


Figure 1

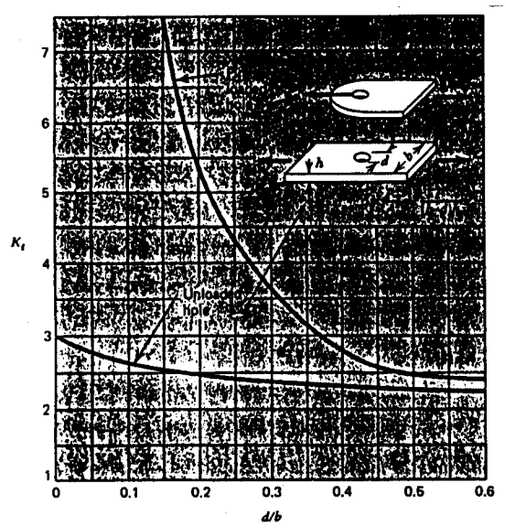


Figure 2

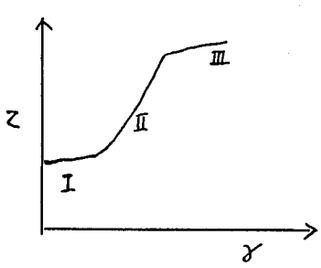
(題目將用本張複印製版請以黑色正楷書寫或打字並請勿超出此線)

機械材料部份：

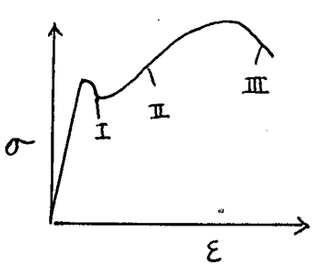
1. 金屬原子鍵結方式與其它固体原子鍵結方式有何不同？
金屬氧化物，如 SiO_2；金屬碳化物，如 SiC；金屬氮化物，如 Si_3N_4；
各屬於何种鍵結？三者之鍵結有何不同？ (10%)

2. 有四种單晶材料：(a)面心立方金屬，(b)体心立方金屬，(c)離子鍵結化合物，(d)共价鍵結化合物。請列出差排在結晶內主要滑移系統上所遇到阻力之大小之順序。 (10%)

3. 鋼材通常由許多結晶所組成，請問：
(a) 晶粒愈小，常温硬度是否愈小？ (2%)
(b) 為何如此？ (2%)
(c) 晶粒愈大，韌性是否愈佳？ (2%)
(d) 晶粒愈大，疲勞性能是否愈佳？ (2%)
(e) 晶粒愈大，高温潛变性能是否愈佳？ (2%)

4. 

左圖為某一單晶純金屬之剪切应力 (τ) 一剪切应变 (γ) 曲線。請問在 I, II, III 区域內，差排在滑移系統上之運動方式有何不同？ (10%)

5. 

左圖為某一多晶純金屬之拉伸真应力 (σ) 一真应变 (ε) 曲線。請依差排之觀点說明在 I, II, III 区域時，為何呈現如此？ (10%)

072

機械製造部份

1. A round rod of annealed 302 stainless steel is being drawn from a diameter of 10 mm to 8 mm at a speed of 0.5 m/s. Assume that the frictional and redundant work together constitute 40% of the ideal work of deformation.

(a) What is the engineering strain in this operation ? (2%)

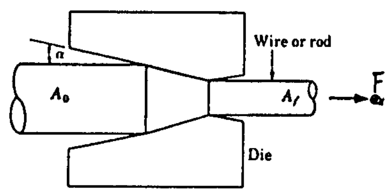
(b) What is the true strain in this operation ? (3%)

(c) If the material exhibits the true stress- true strain behavior of $\sigma = K\varepsilon^{n}$, where k= 1300 Mpa and n=0.3. What is the average flow stress $\bar{Y}$? (5%) (先導出 $\bar{Y}$ 的公式，否則只給3分)

(d) What is the drawing force F ? (2%)

(e) How much is the ideal power needed ?(3%)

(f) How much is the actual power needed ?(2%)

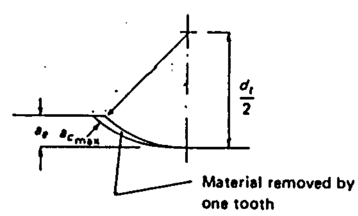


2. In a slab-milling operation, the cutter has 20 teeth and is d_t=100 mm in diameter. The rotational frequency of the cutter is 5 sec^{-1}, the workpiece feed speed is v_f = 1.3 mm/sec., the working engagement (depth of cut) is a_e= 6mm, and the back engagement (width of the workpiece) is 50mm.

(a) Find the feed per tooth a_f (2%)

(b) Derive the maximum undeformed chip thickness a_{cmax} in terms of frequency, v_f, a_e, and d_t.(5%)

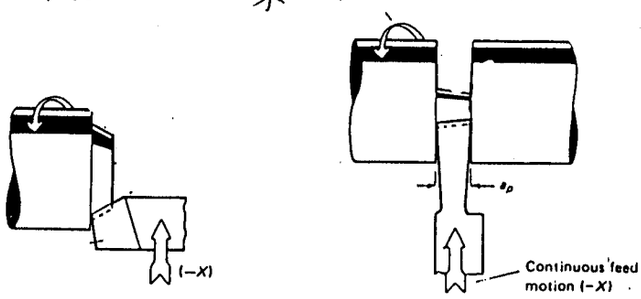
(c) Find the metal-removal rate (2%)



3. List the possible methods of making holes (5%)

073

4. Show major cutting edge, minor cutting edge, work surface, machined surface, transient surface on the following cutoff and facing operation (5%) (請畫圖於答案紙上,再作答)



5. A 9 in. wide 6061-O aluminum strip (k= 30,000 Mpa and n=0.2.) is rolled from a thickness of 1 in. to 0.8 in, If the roll radius is 12 in. and the roll rpm is 100.

(a) Find the arc of contact L=? (3%)

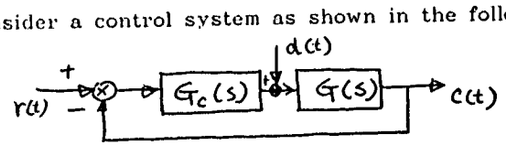
(b) Find the true strain (2%)

(c) Find the average flow stress $\bar{Y}$=?(3%)

(d)The roll force F for low frictional conditions =? (3%)

(e) The power required = ?(3%)

1. Consider a control system as shown in the following figure



where,
- Gc(s): transfer function of PID controller
- G(s): transfer function of a second-order linear time-invariant system
- r(t): input command as function of time
- c(t): output time-domain response
- d(t): disturbance as function of time

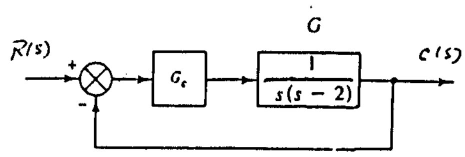
(1) Provide a time-domain procedure for identification of G(s).
(2) Explain the control action by Gc(s) in time domain.
(3) Find optimal PI gain for regulating system response such that ISE (Integral square error) can be minimized.
(4) Provide time-domain tracking specifications for ramp input by the control system.
(5) Use finite difference to approximate differential and provide a simulation algorithm to verify (3).
(50% with 10% for each question)

2. In the following feedback control system, the plant is open-loop unstable.

(a) Plot the root loci to determine whether the system can be stablized by P control $G_c = K_c$.

(b) If not, could the stable pole of G be canceled by a zero of G_c to stablize the system, and if not, why not?

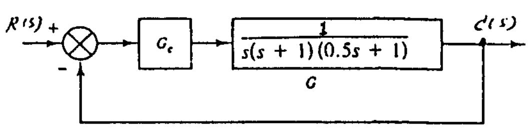
(c) Choose an idealized controller that can stabilize the system, and find the corresponding range of gains for stability. (15%)



3. (a) Describe the Nyquist Criterion and its purpose for the feedback control system.

(b) Explain the reason why that the criterion have the above function you have stated. (15%)

4. Consider a feedback control system as follows:



(a) Plot the asymptotic Bode plot, if $G_c = 1$.

(b) Find the approximate values of the phase margin and gain margin?

(c) If you want to get a larger phase margin 50°), how can you design a controller to satisfy the condition?

(d) What will be the crossover frequency and the value change of the gain margin and phase margin? (20%)