國立臺北科技大學

101學年第一學期電機系博士班資格考試

最佳控制 試題

注意事項：

1. 本試題共【4】題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間：二小時。

1. (25%) Consider the inconsistent system $Ax = b$ which has many solutions, where $A \in \mathrm{R}^{m \times n}$, $m < n$, and AA^T is nonsingular. Find the minimum norm solution x^*. Note that you have to check the Hessian of the cost function.

2. (25%) Consider the linear time-invariant system and the cost function

$$\dot{x}(t) = Fx(t) + Gu(t), \quad x(0) \text{ given}$$

$$J = \frac{1}{2}\int_0^\infty e^{2\alpha t}\left\{\left[x^T(t)Qx(t)\right]^5 + \left[u^T(t)Ru(t)\right]^5\right\}dt$$

where Q and R are constant positive matrices. Find a related linear system and cost function where the integrand in the cost function does not specifically depend on the time t (though it depends on x and u).

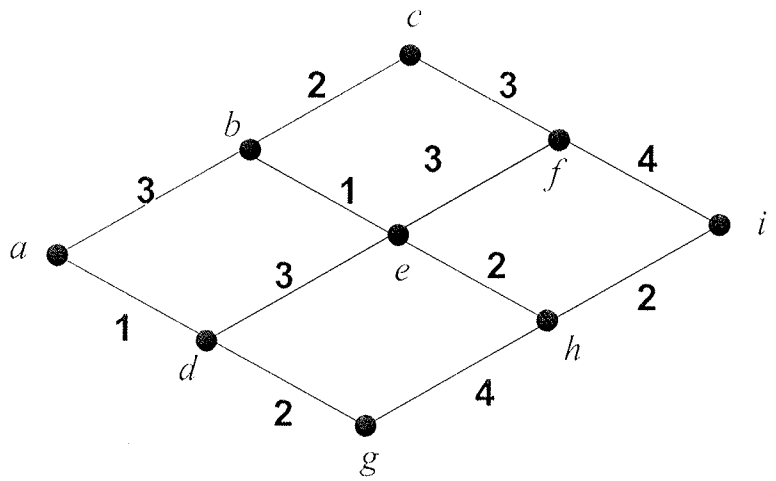
3. (25%) Consider the following system

$$\dot{x}(t) = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} v(t), \quad E\{v(t)v^T(\tau)\} = \delta(t-\tau)$$

$$y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(t) + \omega(t), \quad E\{\omega(t)\omega^T(\tau)\} = \delta(t-\tau)$$

where $v(t)$ and $\omega(t)$ are independent white noises with zero mean. There are two estimator gain matrices $K_{e1}=[-3 \quad 0]^T$ and $K_{e2}=[-10 \quad 3]^T$ designed for the system. Compare their performance by using the steady-state covariance matrix of the estimation error and examine which one outperforms.

4. (25%) Consider the aircraft routing network shown below. Intersections a, b, c, ... represent cities, and the numbers represent the fuel required to complete each path. Find the optimal control and the optima cost from a to i. Note that the control $u_k=\pm 1$ where $u_k=1$ results in a move up and $u_k=-1$ results in a move down from the present city to next city.



國立臺北科技大學

101學年第一學期電機系博士班資格考試

數位通訊理論 試題

注意事項：

1. 本試題共【4】題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。

1. Answer the following problems. (40%, each 10%)

(a) How to find the delivered power of a random process to a 1-Ω resistor if it is wide-sense stationary?

(b) What is the Manchester code (or split code)? Please plot the symbols stand for symbol 1 and symbol 0, respectively, and also describe the feature of individual power spectrum.

(c) What are the two major disadvantages of pulse-code modulation (PCM)? How to overcome those disadvantages?

(d) Why orthogonal frequency division multiplexing (OFDM) can approximately convert frequency selective fading channel into flat fading subchannels?

2. Consider a pair of quadrature-modulated processes $X_1(t) = X(t)\cos(2\pi f_c t + \Theta)$ and $X_2(t) = X(t)\sin(2\pi f_c t + \Theta)$ where $X(t)$ is a wide-sense stationary process, Θ is a random variable uniformly distributed over $[0, 2\pi]$ and is independent of $X(t)$, f_c is a constant. Answer the following problems. (20%, each 10%)

(a) Calculate the cross-correlation function of $X_1(t)$ and $X_2(t)$, which is defined as $R_{12}(\tau) = E[X_1(t)X_2(t-\tau)]$.

(b) What condition will make $R_{12}(\tau) = 0$? What is the physical meaning of $R_{12}(\tau) = 0$?

3. Find Fourier transform ($S(f)$) for each of the following signals. (20%, each 10%)

(a) $s(t) = \sin c(2t - 20) \times e^{j100\pi t}$

(b) $s(t) = e^{j(3t-5)}$

4. Twelve different message signals, each with a bandwidth of 10 kHz, are to be multiplexed and transmitted. Determine the minimum bandwidth required if the multiplexing/modulation method used is TDM/PAM Notably, sinc pulse, that is $\sin c(x) = \frac{\sin \pi x}{\pi x}$, is employed in this transmission. (20%)

TABLE A6.3 *Fourier-transform pairs*

Time Function	*Fourier Transform*
$\text{rect}\left(\frac{t}{T}\right)$	$T\,\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}\,\text{rect}\left(\frac{f}{2W}\right)$
$\exp(-at)u(t), \quad a > 0$	$\frac{1}{a + j2\pi f}$
$\exp(-a\lvert t\rvert), \quad a > 0$	$\frac{2a}{a^2 + (2\pi f)^2}$
$\exp(-\pi t^2)$	$\exp(-\pi f^2)$
$\begin{cases} 1 - \frac{\lvert t\rvert}{T}, & \lvert t\rvert < T \\ 0, & \lvert t\rvert \geq T \end{cases}$	$T\,\text{sinc}^2(fT)$
$\delta(t)$	1
1	$\delta(f)$
$\delta(t - t_0)$	$\exp(-j2\pi f t_0)$
$\exp(j2\pi f_c t)$	$\delta(f - f_c)$
$\cos(2\pi f_c t)$	$\frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$
$\sin(2\pi f_c t)$	$\frac{1}{2j}[\delta(f - f_c) - \delta(f + f_c)]$
$\text{sgn}(t)$	$\frac{1}{j\pi f}$
$\frac{1}{\pi t}$	$-j\,\text{sgn}(f)$
$u(t)$	$\frac{1}{2}\delta(f) + \frac{1}{j2\pi f}$
$\sum_{i=-\infty}^{\infty} \delta(t - iT_0)$	$\frac{1}{T_0}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_0}\right)$

Notes: $u(t)$ = unit step function
$\delta(t)$ = delta function, or unit impulse
$\text{rect}(t)$ = rectangular function of unit amplitude and unit duration centered on the origin
$\text{sgn}(t)$ = signum function
$\text{sinc}(t)$ = sinc function

國立臺北科技大學

一百零一學年第一學期電機系博士班資格考試

高等數位訊號處理 試題

注意事項：

1. 本試題共【7】題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。
5. 可以使用計算器(計算機)

1. Determine the frequency response $H(e^{j\omega})$ and the impulse response $h[n]$ of the LTI system whose input and output satisfy the difference equation

$$y[n]-\tfrac{3}{4}y[n-1]+\tfrac{1}{8}y[n-2]=2x[n-1].$$

(15 %)

2. Prove that the z-transform of the sequence $x[n]=\alpha^{|n|}, \quad 0<|\alpha|<1,$ is

$$X(z)=\frac{z(1-\alpha^2)}{(1-\alpha z)(z-\alpha)}.$$

What is the region of convergence (ROC) of $X(z)$?

(15 %)

3. Consider the cascade of two LTI discrete-time systems. The first system is described by the

impulse response $h_1[n]=2\dfrac{\sin[0.5\pi(n-1)]}{\pi(n-1)}$ and the second system is described by the impulse response $h_2[n]=1-\dfrac{\sin[0.25\pi n)]}{\pi n}$,

(a) Determine the frequency response $H(e^{j\omega})$ of the overall frequency response over the range $-\pi \le \omega \le \pi$.

(b) Sketch the magnitude $\left|H(e^{j\omega})\right|$ and the phase $\measuredangle H(e^{j\omega})$ of the overall frequency response over the range $-\pi \le \omega \le \pi$.

(15 %)

4. In the system of Figure 1, assume that

$$H(e^{j\omega}) = j\omega / T, \quad -\pi \le \omega < \pi,$$

and $T = 1/10$ sec. For the input $x_C(t) = \cos(6\pi t)$, find the corresponding output $y_r(t)$.

(15 %)

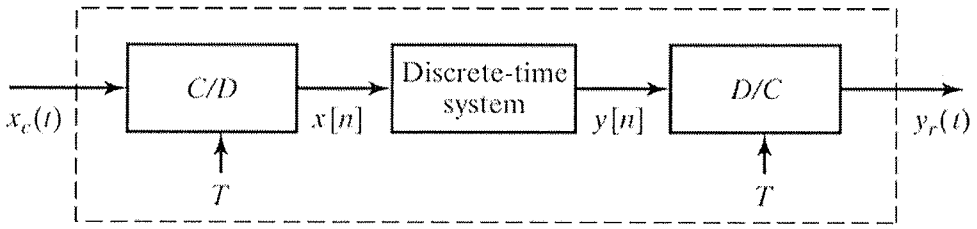


Figure 1.

5. Compute the DFT of the finite-length sequence

$$x[n]=\begin{cases}1, & n \ \ even, \quad 0 \le n \le N-1,\\ 0, & n \ \ odd, \quad 0 \le n \le N-1.\end{cases}$$

This sequence is considered to be of length *N*,where *N* is even.

(15 %)

6. A discrete-time filter can be obtained from a continuous-time filter by the bilinear transformation

$$H(z) = H_C(s)\Big|_{s=\frac{1-z^{-1}}{1+z^{-1}}}$$

(a) Show that the above transformation maps $j\Omega$-axis of s-plane onto the unit circle of z-plane.

(b) Determine the specifications on $H_C(s)$ so that the desired digital filter has specifications as follows.

$$0.8 \le \left|H(e^{j\omega})\right| \le 1, \quad 0 \le |\omega| \le 0.2\pi,$$
$$\left|H(e^{j\omega})\right| \le 0.2, \quad 0.3\pi \le |\omega| \le \pi.$$

(15 %)

7. Assume that you wish to sort a sequence $x[n]$ of length *N*=16 into bit-reversed order for input to an FFT algorithm. Give the new sample order for the bit-reversed sequence.

(10 %)

國立臺北科技大學

101學年第一學期電機系博士班資格考試

電力系統運轉與控制 試題

注意事項：

1. 本試題共【4】題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。

1. The power system reactive power can be controlled by regulating the excitation current of generator and switching the capacitor/ reactor banks. Write the associated equations to illustrate these control principles. (25%)
2. The power system voltage control near a load center is usually done by the on-load–tap-changer (OLTC) of transformer and capacitor/ reactor banks. Draw a simple equivalent circuit to illustrate the control principle. (25%)
3. What are the automatic generation control (AGC) and automatic frequency control (AFC) ? For various types of plant (thermal, hydro or nuclear), what type of plant will have the most fast response under AGC mode ? and why ? Why the AGC and AFC are in general not applied on nuclear power plant in Taiwan ? (25%)
4. A power system has two generator units, their maximum and minimum outputs (P_{max}, P_{min}) and cost functions are listed in the following table. Solve the following problems: (25%)

Gen.Unit	P_{max}(MW)	P_{min}(MW)	cost function * ($/h)
Unit 1	500	100	$561.0+7.92P_1+0.001562P_1^2$
Unit 2	400	100	$325.5+8.243P_2+0.002037P_2^2$

(1). Derive the incremental cost function dF/dP of each unit, (5%)

(2). If the total load is 630MW, determine the output power of each unit output power such that the total cost is minimum (neglect the transmission loss), (10%)

(3). Find the total saving cost by above calculation (optimum dispatch) compared with average dispatch ($P_1=P_2=$ 315MW). (10%)

國立臺北科技大學

101學年第一學期電機系博士班資格考試

現代控制理論 試題

注意事項：

1. 本試題共【3】題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。

1. Consider the state space equation of the system

$$\begin{cases} \dot{x}(t) = Ax(t) + Bu(t) \\ y(t) = Cx(t) + Du(t) \end{cases}, \text{ where } A = \begin{bmatrix} 0 & -1 \\ 1 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \end{bmatrix}, D = 0$$

10% (a) Evaluate e^{At}.

10% (b) Evaluate the solution $x(t)$ with $x(0) \neq 0$, and identify the zero-state response and zero-input response.

10% (c) Evaluate the transfer function of the system.

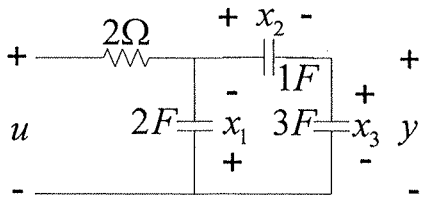
2. Consider the state space equation of the system

$$\begin{cases} \dot{x}(t) = Ax(t) + Bu(t) \\ y(t) = Cx(t) \end{cases}, \text{ where } A = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 4 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \end{bmatrix}.$$

An observer-based state feedback control $u(t) = -Kx(t)$ is employed to stabilize the system. Choose the state feedback gain K to move the system poles to $-2 \pm j2\sqrt{3}$ and observer gain K_e to let the observer modes lie at $-8, -8$.

20%

3. Considering the following network circuit.



10% (a) Find the 2-dimensional state equation of the network with input u, output y and state $[x_1 \quad x_2]^T$.

10% (b) Check the controllability and observability of the state equation in (a).

10% (c) From (b), if the state equation is not controllable, reduce it to a controllable one.

10% (d) Find the 3-dimensional state equation of the network with input u, output y and state $[x_1 \quad x_2 \quad x_3]^T$.

10% (e) Check the controllability and observability of the state equation in (d).

國立臺北科技大學

101學年第一學期電機系博士班資格考試

模糊控制 試題

注意事項：

1. 本試題共【5】題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。
5. 不准使用任何形式之計算器。

1. Suppose that a fuzzy subset A is defined by $A=\frac{1}{a}+\frac{0.6}{b}+\frac{0.3}{c}+\frac{0.1}{d}$. (a) Find α-level set (or α-cut) of A when α=0.3 and α=0.6. (b) How to reconstruct the fuzzy subset of A from the α-level sets? (10 分)

2. Consider the discrete-time nonlinear system described by the difference equation $y(k+1)=g[y(k),y(k-1)]+u(k)$, where the nonlinear function $g[y(k),y(k-1)]=\frac{y(k)y(k-1)[y(k)+2.5]}{1+y^2(k)+y^2(k-1)}$ is assumed to be unknown. Design a controller $u(k)$ such that the output $y(k)$ of the closed-loop system follows the output $y_m(k)$ of the reference model $y_m(k+1)=0.6y_m(k)+0.2y_m(k-1)+r(k)$, where $r(k)=\sin(2\pi k/25)$. That is, we want $e(k)=y(k)-y_m(k)$ converge to zero as k goes to infinity. (20 分)

3. Suppose that the process in Fig. 1 is modeled by a second-order dynamic TSK fuzzy system that is constructed from the following two rules:

   L^1: IF $x(k)$ is A_1^1 and $x(k-1)$ is A_2^1 and $u(k)$ is B^1,
   THEN $x^1(k+1)=1.5x(k)+2.1x(k-1)-u(k)$.

   L^2: IF $x(k)$ is A_1^2 and $x(k-1)$ is A_2^2 and $u(k)$ is B^2,
   THEN $x^2(k+1)=0.3x(k)-3.4x(k-1)+0.5u(k)$.

   And that the controller in Fig. 1 is a TSK fuzzy system constructed from the following two rules:

R^1: IF $x(k)$ is C_1^1 and $x(k-1)$ is C_2^1, THEN $u^1(k) = k_1^1 x(k) + k_2^1 x(k-1)$.

R^2: IF $x(k)$ is C_1^2 and $x(k-1)$ is C_2^2, THEN $u^2(k) = k_1^2 x(k) + k_2^2 x(k-1)$.

Design a closed-loop fuzzy control system from the dynamic TSK fuzzy system. (25 分)

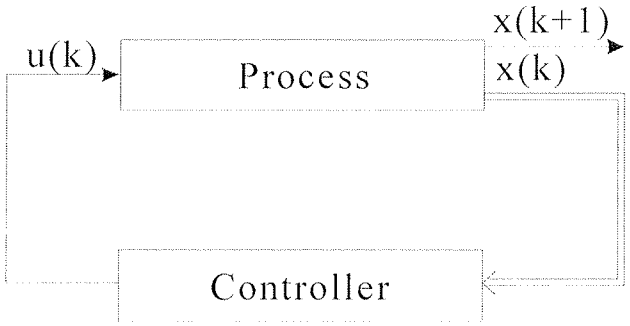


Fig. 1. Fuzzy control of fuzzy system model.

4. Design a fuzzy controller for washing machines. If inputs $x \in [0,20]$ and $y \in [0,5]$ represent the weight and ingredient of to-be-washed clothes, respectively. The corresponding output of this controller is the time $t \in [0,60]$ required to clean the clothes. Assume there were 500 data, $(x_i, y_i; t_i)$, $i \in [0,500]$, collected from different experiments before designing such a system. (a) How to derive the initial membership functions for input and output variables? (b) How to adjust the initial membership functions to achieve a feasible controller? (c) Approximately how may rules in your fuzzy rule base? Why? (25 分)

5. Assuming there are only two rules in a fuzzy rule base:

   Rule 1: If X is A_1 and Y is B_1, then Z is C_1,

   Rule 2: If X is A_2 and Y is B_2, then Z is C_2.

   Also assuming $x_0=4$ and $y_0=8$ are sensor readings for input variables X and Y, respectively. (a) Determine the antecedent firing strength of each rule and find the defuzzified output based on the following membership functions. (b) If the consequent parts of rule 1 and rule 2 become Z=0.25(X+Y) and Z=0.5X+0.25Y+2, respectively. Find the defuzzified output and compare it with the results derived in part (a). (20 分)

$$\mu_{A1} = \begin{cases} \dfrac{x-2}{3}, 2 \le x \le 5 \\ \dfrac{8-x}{3}, 5 < x \le 8 \end{cases} \quad \mu_{A2} = \begin{cases} \dfrac{x-3}{3}, 3 \le x \le 6 \\ \dfrac{9-x}{3}, 6 < x \le 9 \end{cases}$$

$$\mu_{B1} = \begin{cases} \dfrac{y-5}{3}, 5 \le y \le 8 \\ \dfrac{11-y}{3}, 8 < y \le 11 \end{cases} \quad \mu_{B2} = \begin{cases} \dfrac{y-4}{3}, 4 \le y \le 7 \\ \dfrac{10-y}{3}, 7 < y \le 10 \end{cases}$$

$$\mu_{C1} = \begin{cases} \dfrac{z-1}{3}, 1 \le z \le 4 \\ \dfrac{7-z}{3}, 4 < z \le 7 \end{cases} \quad \mu_{C2} = \begin{cases} \dfrac{z-3}{3}, 3 \le z \le 6 \\ \dfrac{9-z}{3}, 6 < z \le 9 \end{cases}$$

國立臺北科技大學

101學年第一學期電機系博士班資格考試

計算機概論(大學部)試題

注意事項：

1. 本試題共【10】題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。

1. (a) What characteristic of the human eye does JPEG's baseline standard exploit? (5%)
   (b) What characteristic of the human ear does MP3 exploit? (5%)

2. Summarize the steps performed by the CPU when an interrupt occurs. (10%)

3. Telnet and SSH are protocol systems that allow computer users to access computers remotely. Why is SSH considered superior to telnet? (10%)

4. What sequence of numbers would be printed by the following recursive procedure if we started it with *N* assigned the value 1? (10%)

```
procedure misty(N)
  print the value of N;
  if (N < 3) then (apply the procedure misty to the value N+1);
  print the value of N;
```

5. Derive the truth table of a two-input multiplexer (2×1 MUX) and draw its circuit using *NOT* gate, *AND* gate, as well as *OR* gate. The inputs of MUX are *a*, *b*, and *sel* while its output is *O*. (10%)

6. What is the difference between a class and an object? (10%)

7. In a traditional file structure, what are the steps required when retrieving a record from an indexed file? (10%)

8. In computer graphics, rendering is a step before displaying image.
   (a) What is rendering? (5%)
   (b) What is frame buffer? (5%)

9. After executing the following program segment, what is the value of each element in the array frequency ? (10%)

```
int frequency[6] = {0};
int response[10] = {1, 3, 5, 2, 4, 1, 2, 3, 4, 3};
for ( int answer = 0; answer < 10; answer ++)   ++frequency[response[answer]];
```

10. Suppose a C/C++ program uses an integer variable called Rate and Rate is stored at memory address 500. Besides, intPointer is a pointer variable for integer data.
    (a) Explain the distinction in the program between Rate and &Rate. (5%)
    (b) After the following statement, what is the value of intPointer? (5%)

```
intPointer = &Rate;
```

國立臺北科技大學

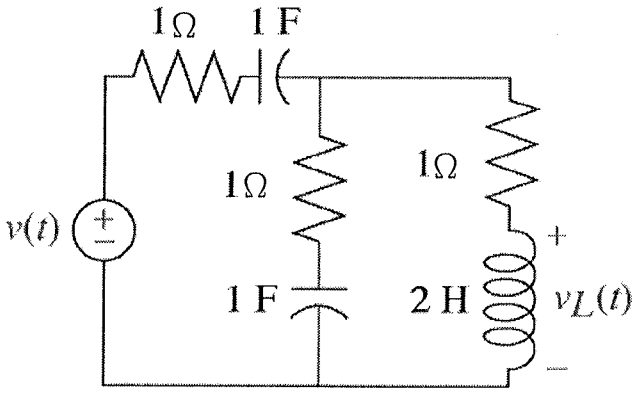
101學年第一學期電機系博士班資格考試

控制系統(大學部)試題

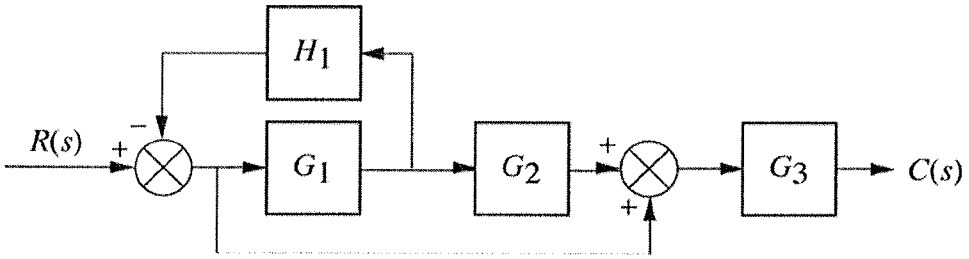
注意事項：

1. 本試題共5題，配分共100分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。
5. 可用計算機。

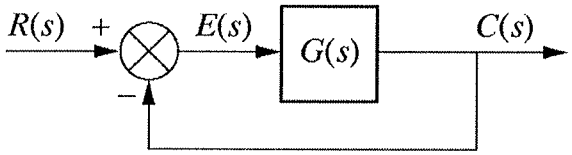
1. (20%) Find the transfer function, $G(s) = V_L(s) / V(s)$, for the electrical network.



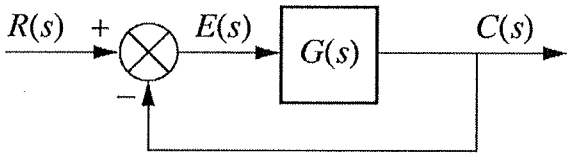
2. (20%) Find the transfer function $T(s) = C(s)/R(s)$ of the following system.



3. (20%) For the following unity feedback system with $G(s) = \dfrac{K(s+1)}{s(s+2)(s+3)(s+4)}$, determine the range of K for stability.



4. (20%) For the following unity feedback system with $G(s) = \dfrac{20(s+3)(s+4)(s+8)}{s^2(s+2)(s+15)}$, find the steady-state error if the input is $30t^2u(t)$.



5. (20%) Sketch the root locus for the following unity feedback system with $G(s) = \dfrac{K(s+2)(s+6)}{s^2+8s+25}$.