

國立臺灣科技大學101學年度碩士班招生試題

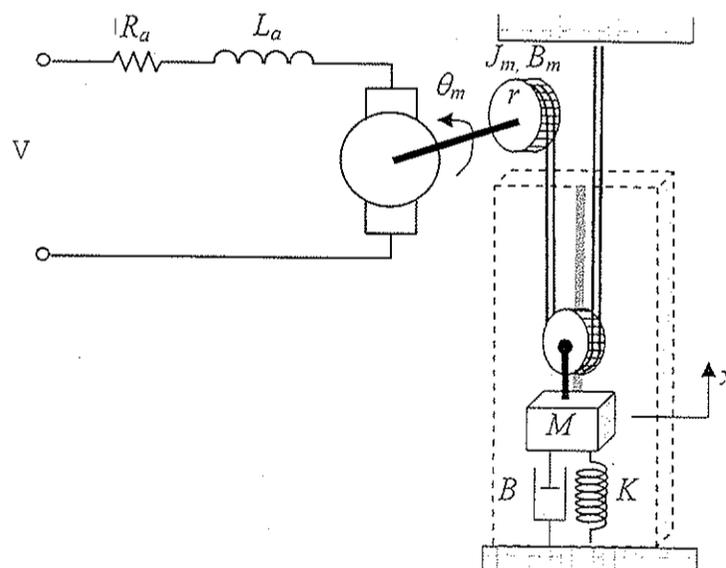
系所組別：機械工程系碩士班丁組

科目：系統控制

(總分為100分)

題目共四題，總分 100 分，每小題有標示所占分數

1. A DC motor is used to lift an object with mass (M) using a moveable pulley and belt, as shown in the figure below. The moveable pulley is guided through a slit in the back plate so that it will only move vertically. The mass is attached to the ground through a damper (B) and a spring (K). The motor is represented by the corresponding motor constants $K_t=K_b$, in consistent units, and the electrical resistance (R_a) and inductance (L_a). The fixed pulley attached to the motor shaft, with radius r , is modeled by an inertia (J_m), and a damping term (B_m) is included to model the viscous friction in the motor shaft. Neglect the inertia and friction on the moveable pulley.
- (a) Without actually writing down the transfer function from V to x , predict the order of the resulting transfer function. (5%)
- (b) Derive the transfer function from the input voltage (V) to the mass position (x), using the symbols described above. The zero position ($x=0$) is defined at the position when the belt tension is zero, i.e., the gravity force of the mass (M) is balanced by the spring force. (15%)
- (c) If the mass and moment of inertia of the moveable pulley is considered, would you expect the rise time of the system's step response to be larger or smaller? (5%)



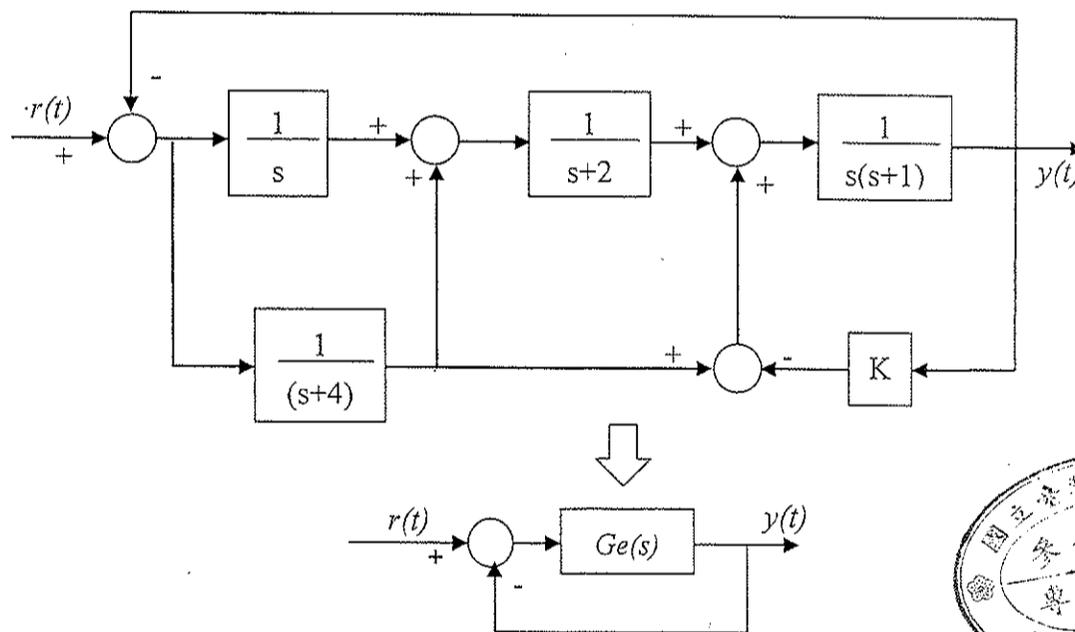
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2. For the system shown below, simplify the block diagram to standard unity feedback structure.
- (a) Derive the transfer function $Ge(s)$. (8%)
- (b) Determine the system type and the corresponding error constant. (4%)
- (c) Find the range of K such that the closed-loop system is stable. (8%)
- (d) If it is desired to analyze this system using root locus, treating the variable K as an adjustable gain, roughly sketch the root locus and compare the stability ranges with your observations found in part (c). (5%) (Hint: the roots of the polynomial: $s^4+5s^3+4s^2+s+2=0$ are: $-4.04, -1.2, 0.12+0.63j, 0.12-0.63j$.)



Standard unity feedback system structure



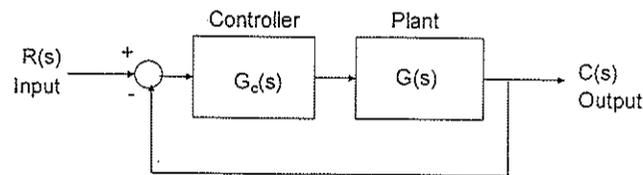
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3. Consider an unity feedback control system,



where $G(s) = \frac{(s+3)}{s(s+10)(s-1)}$ and $G_c(s) = K$.

- (a) Sketch the corresponding Nyquist plot and use Nyquist theory to find the range of the proportional control gain K to stabilize the closed loop system. (15%)
- (b) Instead of proportional control, we now change the controller to proportional-derivative (PD) control with $G_c(s) = K(1 + T_d s)$, $T_d > 0$. If the system is originally stable with a particular proportional control gain K , will the additional derivative control change the closed loop system stability? Explain the reasons using Nyquist theory. (10%)

4.

- (a) Explain the difference between block diagram and signal flow graph. (5%)
- (b) Explain what is a linear time-invariant system? (5%)
- (c) Plot the frequency response of a system with a pure 1 second delay. (5%)
- (d) What is the unit impulse response of a system with transfer function $G(s)$? (5%)

$$G(s) = \frac{s}{(s+2)^2(s+3)}$$

(e) For the polynomial,

$$s^6 + s^5 - 4s^4 - 5s^3 - 9s^2 - 4s - 4 = 0$$

how many of its roots are in the right half-plane, in the left half-plane, and on the $j\omega$ -axis respectively? (5%)

