1) What are the advantages and disadvantages of an open-loop system vs a closed-loop system? (15%)

2) Solve the following equation using Z-transform (20%)

$y(k+2) + 0.5y(k+1) + 0.2y(k) = u(k)$

where $u(k) = 1$ for $k = 0, 1, 2, \ldots$ and initial conditions $y(0)=y(1)=0$

3) The linearized model of a robot arm system driven by a DC motor is shown in the following figure. The system parameters and variables are given as follows: (35%)

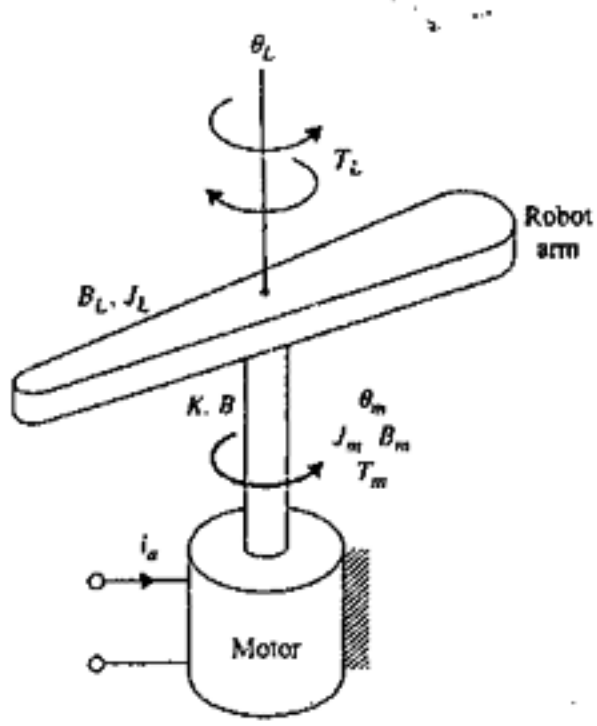
DC MOTOR

- T_m = motor torque = $K_i i_a$
- K_i = torque constant
- i_a = armature current of motor
- J_m = motor inertia
- B_m = motor viscous-friction coefficient
- θ_m = motor-shaft displacement

ROBOT ARM

- J_L = inertia of arm
- T_L = disturbance torque on arm
- θ_L = arm displacement
- K = torsional spring constant
- B = viscous-friction coefficient of shaft between the motor and arm
- B_L = viscous-friction coefficient of the robot arm shaft

(a) Write the differential equations for the system with $i_a(t)$ and $T_L(t)$ as input and $\theta_m(t)$ and $\theta_L(t)$ as outputs.



(b) Draw a SFG using $I_a(s)$, $T_L(s)$, $\Theta_m(s)$, and $\Theta_L(s)$ as node variables.

(c) Express the transfer-function relations as

$$\begin{bmatrix} \Theta_m(s) \\ \Theta_L(s) \end{bmatrix} = \mathbf{G}(s) \begin{bmatrix} I_a(s) \\ -T_L(s) \end{bmatrix}$$

Find $\mathbf{G}(s)$.

(背面仍有題目,請繼續作答)

4) What are the three methods for the determination of stability of a linear continuous system? Please explain briefly. (15%)

5) What are the PD, PI, and PID controllers? Write down their input-output transfer functions. (15%)