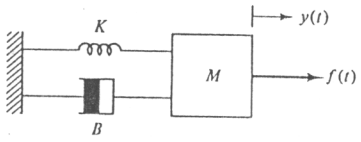
1. (30 %)For a mechanical system as following,




M: mass, K: spring constant, B: damping constant, *f(t)*: applied force, y: displacement.

(a) Write down the differential equation of the system. (3 points)
(b) Describe this system by dynamic equation. (3 points)
(c) From the energy point of view, explain these three components on the system. At the same time, point out M, B and K are analogous to RLC network. R: resistor, L: inductor, C: capacitor (5 points)
(d) Derive the transfer function of the system. (4 points)
(e) If B=0, derive and plot the impulse response of the system. (7 points)
(f) If B=0, $f(t) = \cos\varpi_0 t$ and $\varpi_0 = \sqrt{\frac{K}{M}}$ then find and plot the response of the system. (8 points)

2. (25%)Consider the following state equation and output equation

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(a) Find the transfer function. ( 5 points)
(b) Can you check the controllability from above transfer function? Why?( 5 points)
(c) Check the stability of the system.( 5 points)
(d) Design a state feedback $u = -Gx + r$ to stabilize the system. (Hint: change any positive eigenvalue to negative eigenvalue ) ( 10 points)

(背面仍有題目,請繼續作答)

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3. (15%) Show three types of common nonlinearities encountered in control system.

4. (30%)The open-loop transfer function of a unity feedback control system is

$$G(s) = \frac{K}{s(1+0.1s)(1+s)}$$

(a) Determine the value of $K$ so that the resonance peak $M_p$ of the system is equal to 1.4. ( 7 points)

(b) Determine the value of $K$ so that the gain margin of the system is 20 dB. (7 points)

(c) Determine the value of $K$ so that the phase margin of the system is 60°. (7 points)

(d) Find $\varpi_p$, resonant frequency in (a), $\varpi_c$, phase crossover frequency in (b) and $\varpi_g$, gain crossover frequency in (c). (9 points)