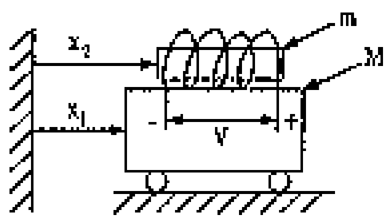
1. (10%) Consider a standard mass-spring-damper system,

$$m\ddot{x} + c\dot{x} + kx = u,$$

where m, c, k are mass, damping coefficient and spring constant, respectively, and x and u are mass position and input force. Is the condition, $x = x_d > 0$, $\dot{x} = 0$ and $u = 0$, stable? Why?

2. Consider the system as shown below, where mass m is a magnetic bar moving frictionlessly in a massless solenoid mounted on mass M. Let x_1 and x_2 be the absolute position of M and m, respectively. A linear force F is applied to m in the positive x direction if a positive voltage V is applied to the solenoid, and $F = \mu V$, where μ is a constant. For simplicity, let $\mu = 1$.



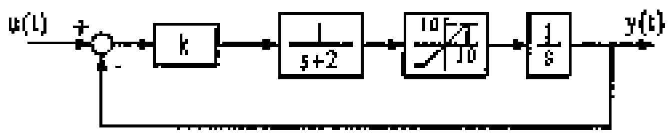
(a) (5%) Derive the governing equation and the state space realization, $\dot{x} = Ax + BV$, of the system.

(b) (6%) Is the system stable? Why?

(c) (7%) Assume zero initial condition, what is the controllable subspace of the system?

(d) (7%) Based on Newton's law of motion, give a physical explanation of your answer to problem (c).

3. (15%) Consider the following 2^{nd} order system



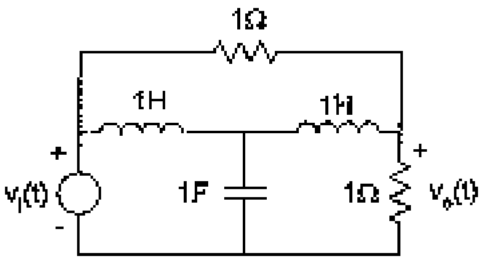
This system has a nonlinear device which saturate at 10. This system is to be excited by a sinusoidal input of the following form

$$u(t) = A(\omega)\sin\omega t$$

Find the range of the amplitude A as a function of frequency ω and k, so that the nonlinear device won't saturate in steady state response.

(背面仍有題目,請繼續作答)

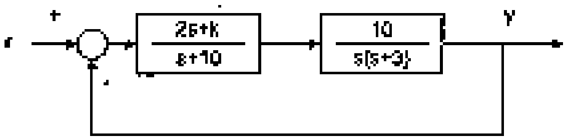
4. Determine the transfer function $\frac{V_o(s)}{V_i(s)}$ of the following network. (12%)



5. Draw the locus of the following closed-loop system poles on the s-plan with respect to the tuning parameter k (k > 0) and find the following: (20%)

(a). Asymptotes (b). Breakaway and break-in points (c). The range of k for system stability

(d). The value of k to yield a 0.5 damping ratio for the dominant second-order pair



6. Read the following system characteristics from the gain-phase plot of an open-loop stable system shown below. (18%)

(a). Gain margin (b). Phase margin (c). Closed-loop bandwidth with unity feedback

(d). Gain crossover frequency (e). Phase crossover frequency

(f). What kind of the controller can be used to increase the closed-loop bandwidth with the same phase margin ?