國立臺灣科技大學 108 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

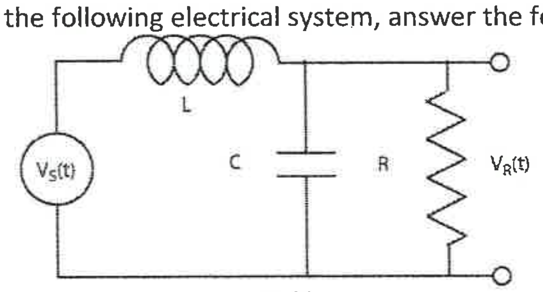
(總分為 100 分)

Problem 1. (10%) For the following characteristic equation of a closed-loop system:

$$s^3 + 2s^2 + 2s + K(s + \alpha) = 0$$

please use root locus to find the range of α so that the closed-loop system is stable for all the gain K>0. No credits will be given without proper explanation.

Problem 2. (16%) Given the following electrical system, answer the following:



2.1 What is the transfer function $G(s) = \frac{V_R(s)}{V_S(s)}$, given C (faraday), L (henry), and R (ohm)?(4%)

(a) $\frac{Cs}{RLs^2+Ls+R}$　(b) $\frac{R}{RLCs^2+Ls+R}$　(c) $\frac{Ls}{RLCs^2+Ls+R}$　(d) $\frac{s}{RCs^2+Ls+R}$

2.2 If $C = 1$ faraday, $L = 1$ henry, and $R = 1$ ohm, what is the system's natural frequency ω_n? (4%)

(a) 0.1 rad/sec　(b) 1 rad/sec　(c) 0.1 Hz　(d) 1 Hz　(e)none of the above

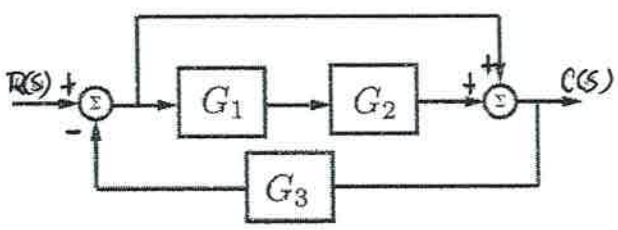
2.3 If given a unit step input for source $V_s(s)$, and $C = 1$ faraday, $L = 1$ henry, and $R = 1$ ohm, what is true for the system's transient response?(4%)

(a) peak time $T_p \cong 3.63$ sec　(b) settling time $T_s \cong 14$ sec　(c) over shoot percentage is about 25%　(d) all of the above

2.4 For this open loop transfer function, what is its system type? (4%)

(a) Type 0　(b) Type 1　(c) Type 2　(d) Type D

Problem 3. (16%) Given the following block diagram, answer the following SINGLE choice problem set:



3.1 What is the equivalent transfer function $G(s)$?(4%)

(a) $\frac{G_1G_2}{1+G_1G_2G_3}$　(b) $\frac{1+G_1G_2}{1+G_1G_2G_3}$　(c) $\frac{1+G_1G_2}{1+G_1G_2+G_3}$　(d) $\frac{1+G_1G_2}{1+G_3+G_1G_2G_3}$

3.2 If $G_1(s) = \frac{1}{s}$ and $G_2(s) = \frac{1}{(s-a)}$ and $G_3(s) = \frac{1}{(s-b)}$ That is the system type of $G(s)$? (4%)

(a) Type 0　(b) Type 1　(c) Type 2　(d) Type D

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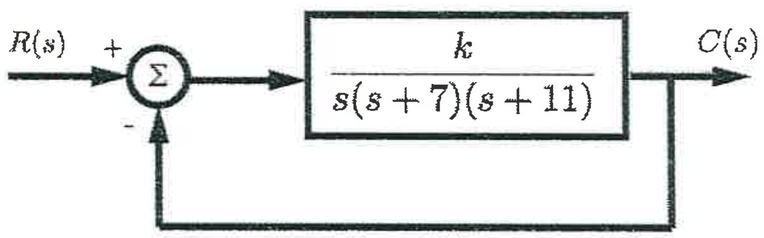
3.3 If $G_1(s) = \frac{1}{s+1}$ and $G_2(s) = \frac{1}{s+2}$ and $G_3(s) = \frac{1}{s-3}$ How many poles are located at the Right Half Plane of S-plane, for the equivalent system $G(s)$? (4%)

(a) 0 pole　　(b) 1 pole　　(c) 2 poles　　(d) none of the above

3.4 From the above analysis, is the system stable? (4%)

(a) Yes　　(b) No　　(c) Maybe　　(d) I don't know

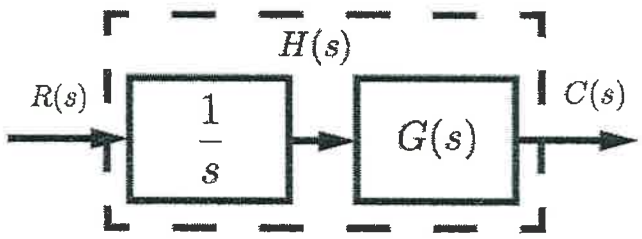
Problem 4.(18%) Given the following unit feedback system, answer the following SINGLE choice problems:



4.1 What is the range of k that stabilizes the feedback system $G(s)$?(4%)

(a) $k < 0$　　(b) $0 < k < 77$　　(c)$0 < k < 1386$　　(d) none of the above

4.2 If the feedback system is modified with an integrator, and cascaded to call system $H(s)$, like the following diagram. What is the steady state error for this system if given a ramp function as the reference signal $R(s)$? (4%)



(a) -1　　(b) 0　　(c)1　　(d) none of the above

4.3 Now given $k = 1000$, and we remove the integrator to its original $G(s)$, what can we say about the system $G(s)$? (6%)

(a) The gain margin is about -8db　　(b) gain margin is located at 100 rad/s

(c) there is no phase margin　　(d) all of the above

4.4 If $k = 1$, and we remove the integrator to its original $G(s)$, what is likely the proper Bode diagram for this system, shown in the next page? (4%)

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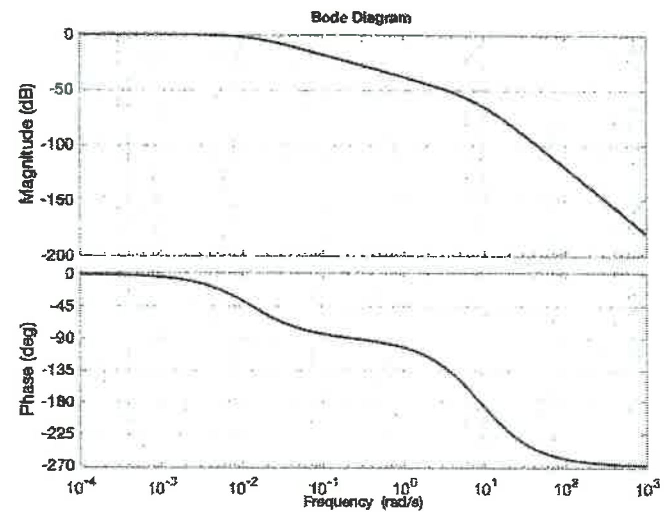
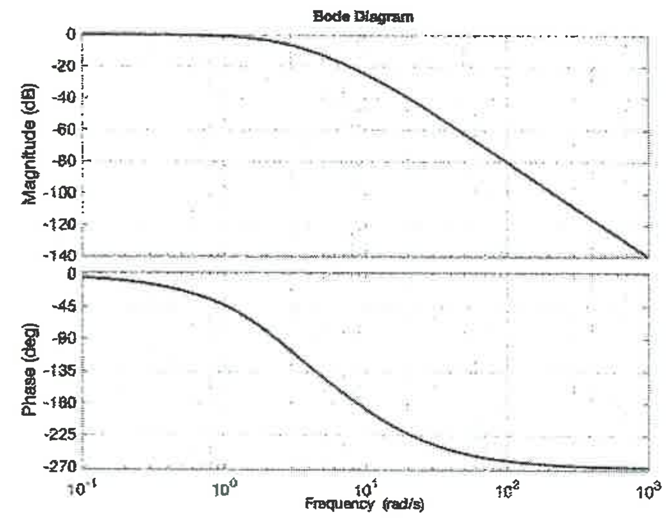
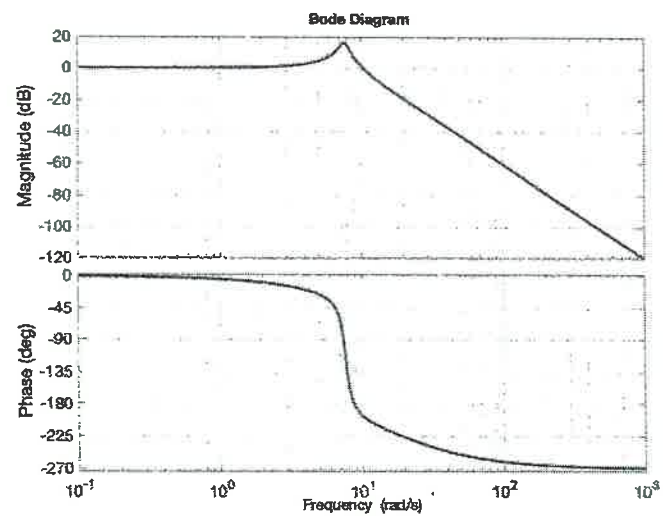
(a)	
(b)	
(c)	

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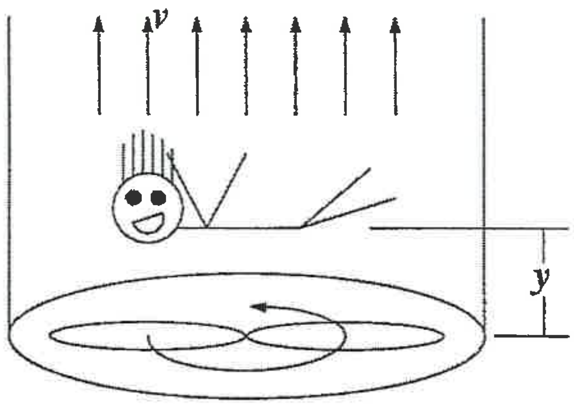
Problem 5.(40%) In a sky-diving free-fall simulator, a large fan below the floor blows air upwards to suspend a sky-diver in the air flow. The simulator controls the height (y) of the sky-diver above the floor by varying the upward velocity (v) of the air flow. In this problem, you will come up with a linearized model of this system and design a controller.



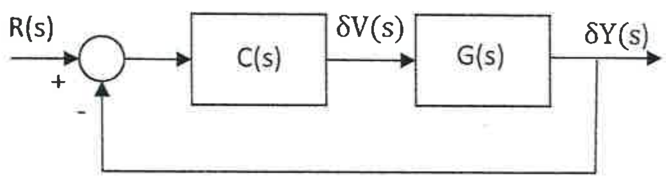
(a) Suppose the mass of the sky-diver is m and the acceleration of gravity is g. The upward drag force on the sky-diver is $C(v-\dot{y})^2$ where C is the coefficient of drag. Please draw a free body diagram (FBD) and derive the equation of motion for the vertical motion of the sky-diver (10%).

(b) Find the equilibrium (the sky-diver stays at a constant height) and linearize the nonlinear model in (a). The transfer function from air-speed deviation to the height change of the sky-diver is in the form of

$$G(s) = \frac{\delta Y(s)}{\delta V(s)} = \frac{a}{s(s+a)}$$

Find the parameter a as a function of g, C and m (10%).

If we assume $a = 4$ and a unity feedback configuration is used, answer the following questions.



(c) Please design a proportional feedback controller C(s) such that the closed-loop system achieves (i) stability, (ii) zero steady state error to a step input, (iii) less than 5% overshoot, and (iv) a ±5% settling time of no more than 1 second (10%).

(d) Please check whether a PI or a PD controller can satisfy all the closed-loop requirements specified in (c) (10%).

Note: ±5% settling time $t_s = \frac{3}{\zeta\omega_n}$

peak time $t_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$

over shoot% os $= e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}}$