Problem 1 (30 %，計算題)

Consider the following equation:

$$s^2(s+10)+K(s+1)=0\,.$$

Draw the root locus of the above equation for the different values of K, from K=0 to K=∞.

Problem 2 (30 %，計算題)

Consider the transfer function of a satellite tracking antenna as follows:

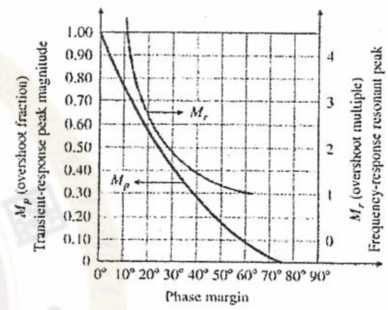
$$G(s)=\frac{1}{s(s+1)},$$

and the design specifications in time domain as follows:

(a) The steady-state error is less than 0.1 for a unit ramp input;

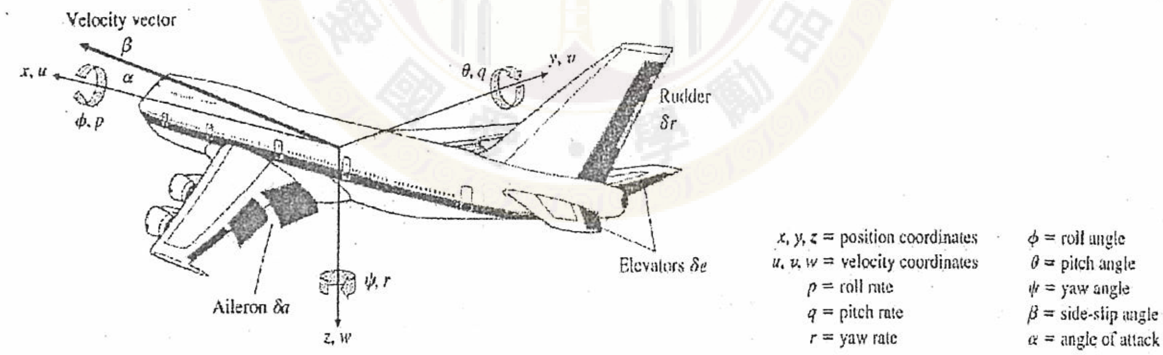
(b) An overshoot < 25%.

Please use frequency-response approach, that is, in terms of Bode plot, to design a lead compensator satisfying the above specifications. For your reference, the relationship between the overshoot and the phase margin is shown in the right-hand-side figure.



Problem 3 (20 %，申論題)

Consider the schematic picture of the Boeing 747 shown in the following figure.



Assume that the nonlinear rigid body equations of motion in body-axis coordinates are derived as follows:

$$m(\dot{U}+qW-rV)=X-mg\sin\theta+\kappa T\cos\theta$$
$$m(\dot{V}+rU-pW)=Y+mg\cos\theta\sin\phi$$
$$m(\dot{W}+pV-qU)=Z+mg\cos\theta\cos\phi-\kappa T\sin\theta$$
$$I_x\dot{p}+I_{xz}\dot{r}+(I_z-I_y)qr+I_{xz}qp=L$$
$$I_y\dot{q}+(I_x-I_z)pr+I_{xz}(r^2-p^2)=M$$
$$I_z\dot{r}+I_{xz}\dot{p}+(I_y-I_x)qp-I_{xz}qr=N$$

where m is the mass, I_i's are the inertia, [U V W] are linear velocity, [p q r] are angular velocity, [X Y Z] are aerodynamic forces, and [L M N] are aerodynamic torques. If you are the control engineer to design proper lateral and longitudinal controllers for the airplane, please discuss the procedures and/or methodologies in detail.

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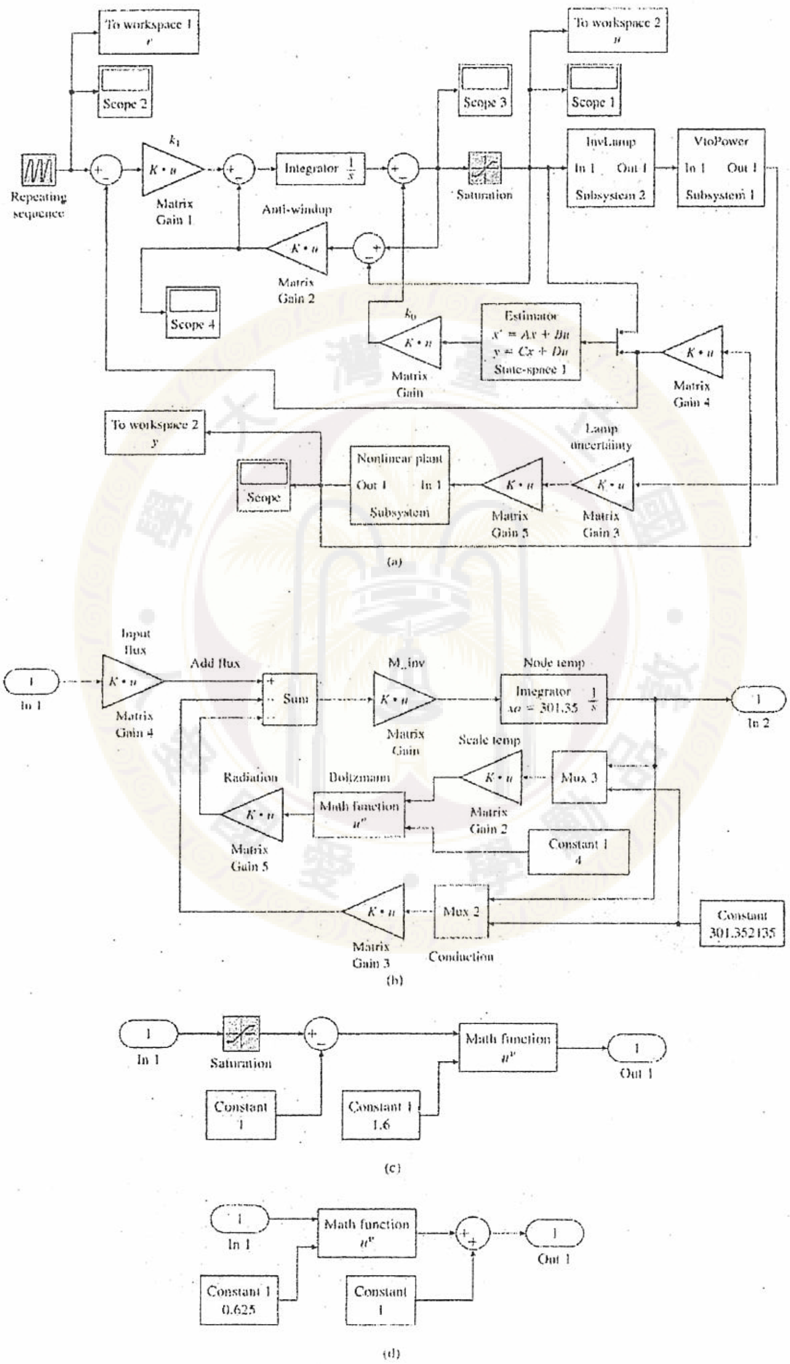
Problem 4 (20 %，申論題)

Consider the following Simulink diagram for one closed-loop system:



where (a) denotes the closed-loop system; (b) is the detail of the subsystem: nonlinear plant in (a); (c) is the detail of the subsystem: VtoPower in (a); and (d) is the detail of the subsystem: InvLamp in (a). If you are a control engineer and your task is to analyze the above Simulink diagram and diagnose the closed-loop system. Please discuss your analysis in detail.

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