編號： 75 國立成功大學104學年度碩士班招生考試試題

系所組別：機械工程學系戊組

考試科目：自動控制

考試日期：0211，節次：1

※考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. **(15%)** Consider a translational mechanical system shown in the figure.

   (1) (5%) Solve for $x(t)$ if $f(t)$ is a unit step function, $u(t)$.

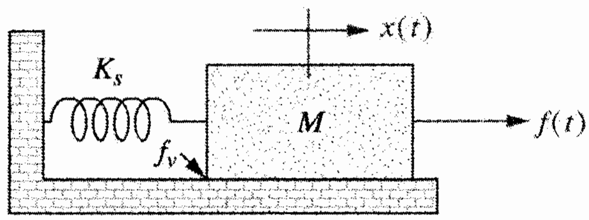
   (2) (10%) Plot the step response of the system with the indications of peak time, 2% settling time, percent overshoot, and steady-state error.

$M = 1$ kg

$K_s = 5$ N/m

$f_v = 1$ N-s/m

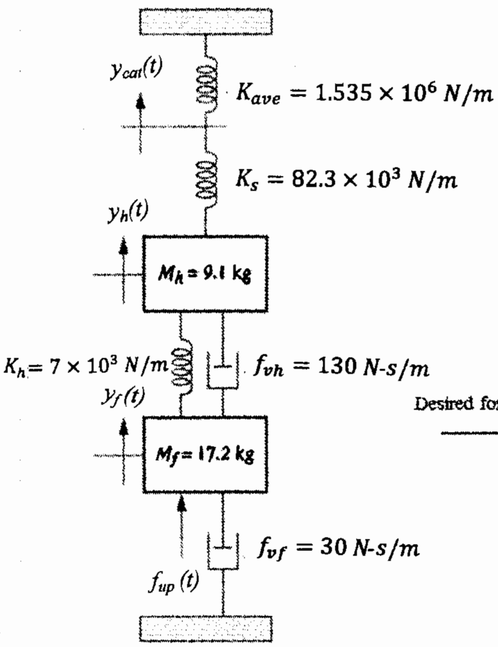
$f(t) = u(t)$ N



國立成功大學 104 學年度碩士班招生考試試題

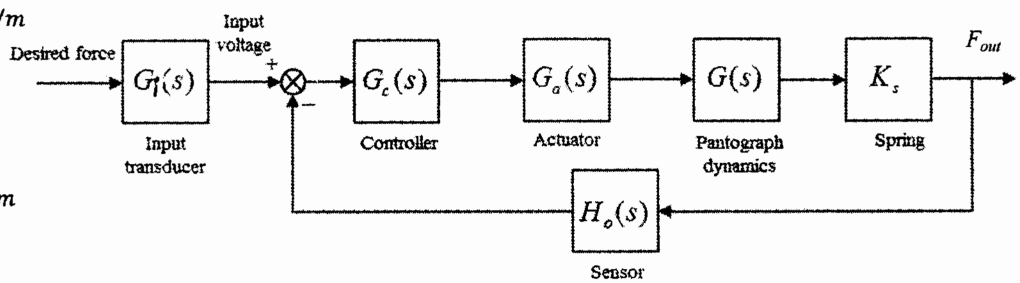
※考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

2. (35%) Some high-speed rail systems are powered by electricity supplied to a pantograph on the train's roof from a catenary overhead. The force applied by the pantograph to the catenary is regulated to avoid loss of contact due to excessive transient motion. The simplified model is shown in Figure (a), where $y_{cat}(t)$ is the catenary displacement and $f_{up}(t)$ is the upward force applied to the pantograph under active control. The transfer function of the system is $G(s)=(Y_h(s)-Y_{cat}(s))/F_{up}(s)$.



(a)

$$G(s)=\frac{0.7883(s+53.85)}{(s^2+15.47s+9283)(s^2+8.119s+376.6)}$$



(b)

(1) (10%) From the dominant poles of the transfer function $G(s)$, find natural frequency, damping ratio, and peak time.

(2) (10%) By creating a pantograph active-control loop, an input transducer ($G_i(s)=1/100$), a controller ($G_c(s)=K$), an actuator ($G_a(s)=1/1000$), a pantograph spring (K_s=82.3x103N/m), and a sensor ($H_o(s)=1/100$) have been added to the system. Find the closed-loop transfer function for the block diagram shown in Figure (c).

(3) (10%) For the system in part (2), find the range of controller gain, K, that will keep the system stable.

(4) (5%) For the system in part (2), find the value of controller gain, K, that minimizes the steady-state force error. What is the minimum steady-state force error?

※考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

3. (25%)

A schematic drawing of a crane is given below. The gripper can be positioned in three dimensions according to the figure. In the simplified model below we neglect the coupling between the different axes, and we assume that the load is given, i.e., the crane always transports the same weight. Furthermore, the crane is only used in its permitted working area that is given by $0 \le x \le 15m$, $0 \le y \le 4m$, $0 \le z \le 2.5m$. We will study the motion in the x-direction. The transfer function of the gripper in x-direction can be modeled as,

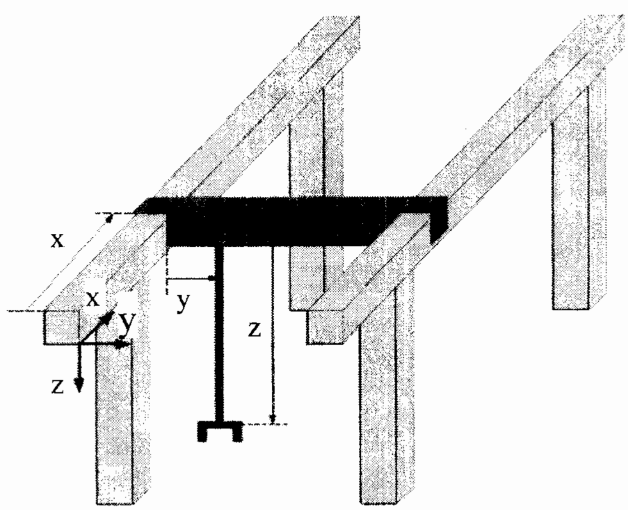
$$Y_1(s) = \frac{0.01}{s^2 + 0.2s} U_1(s),$$

for $y_1(t)$= position in x-direction [m], $u_1(t)$= applied force in x-direction [N].

(1) (10%) Suppose that the cranes position in x-direction is controlled by a P-controller i.e., $u_1(t)=K(r_1(t)-y_1(t))$ (where $r_1(t)$ is the reference signal). Describe how the step response depends quantitatively on K>0 based on root-locus analysis (Oscillatory? Fast? Stable?)

(2) (10%) Determine the range of positive K that the closed-loop system will be stable based on Nyquist-plot .

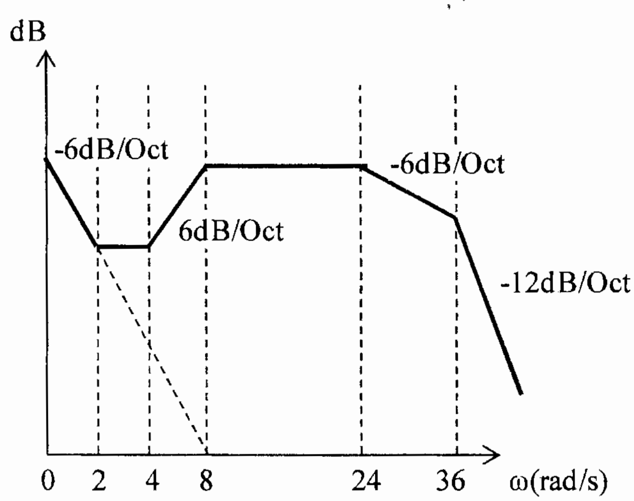
(3) (5%) If the P-controller is changed to a PI-controller which has a unit I-gain, determine the range of P-gain that guarantees the system stable.



※考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

4. (25%)

Given the Bode plot(magnitude-diagram only) of a minimum-phase system below,



(1) (15%) Find the transfer function

(2) (10%) If you have one function generator, one two-channel oscilloscope, and couple cables, explain the detailed procedure that how you remeasure and verify the Bode plot (including the phase-diagram) of this system.