國立臺灣科技大學 111 學年度碩士班招生試題

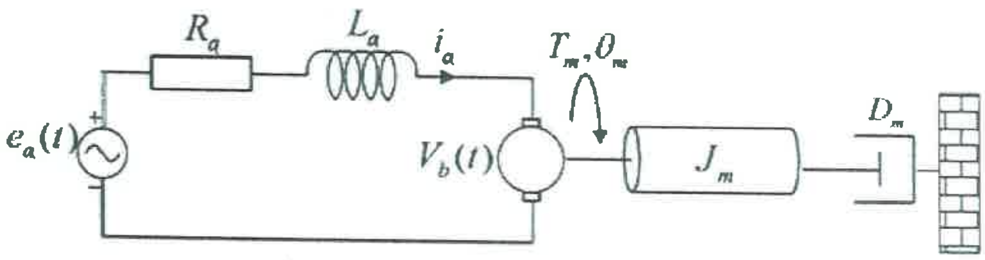
系所組別：機械工程系碩士班丁組

科　　目：系統控制

（總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分）

I. Single choice questions (50%). **Please write down your answers on the answer sheet, writing on the examination paper will give NO credits.**

Answer problems 1-5 for a DC motor system modeled as below:



1. Let input $u = e_a(t)$, output $y = \theta_m(t)$, what is the order of this dynamic system? (5%)
   (A) 1 (B) 2 (C) 3 (D) 4
2. Let input $u = e_a(t)$, output $y = \dot{\theta}_m(t)$, what is the order of this dynamic system? (5%)
   (A) 1 (B) 2 (C) 3 (D) 4
3. Suppose L_a is negligible and input $u = e_a(t)$, output $y = \theta_m(t)$, what is the number of poles of this dynamic system? (5%)
   (A) 0 (B) 1 (C) 2 (D) 3
4. Suppose L_a is negligible and input $u = e_a(t)$, output $y = \dot{\theta}_m(t)$, what is the relative order of this dynamic system? (5%)
   (A) 0 (B) 1 (C) 2 (D) 3
5. Followed by problem 4, what is the "type" of this dynamic system? (5%)
   (A) type 0 (B) type 1 (C) type 2 (D) type 3

Based on the following MATLAB code, answer problems 6-7.

```
K = 3;
num = [2 5];
den = [1 2 0];
P = tf(num,den);
G = K*P/(1+K*P);
step(G);
```

6. What are the poles of system G in the code? (5%)
   (A) $-1+2j,\ -1-2j$ (B) $0,\ -2$ (C) $-2,\ -5$ (D) $-3,\ -5$
7. After executing the MATLAB program, what is the steady-state value shown in the figure? (5%)
   (A) 1 (B) 2 (C) 2.5 (D) 3

8. What is the bandwidth of system $G(s) = \frac{1}{0.1s+1}$? (5%)
   (A) 0.1 rad/sec (B) 1 rad/sec (C) 10 rad/sec (D) 100 rad/sec

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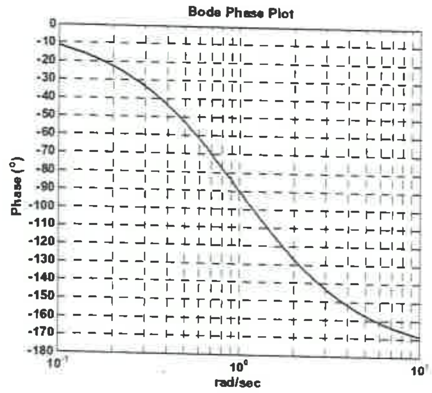
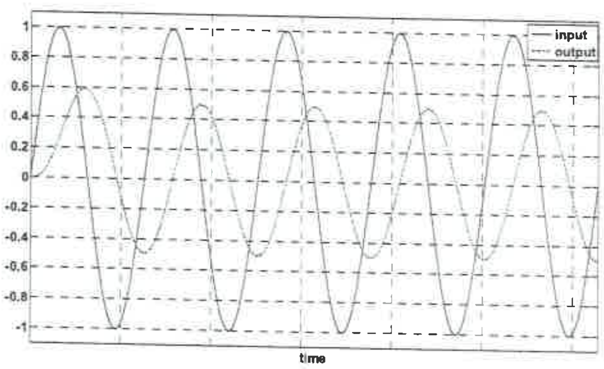
9. A sinusoidal input of unknown frequency excites a LTI system described with the Bode phase plot (in degree) shown below. Given the input (solid) and the output (dashed) graph shown below, what is the frequency of the input sinusoidal excitation? (5%)

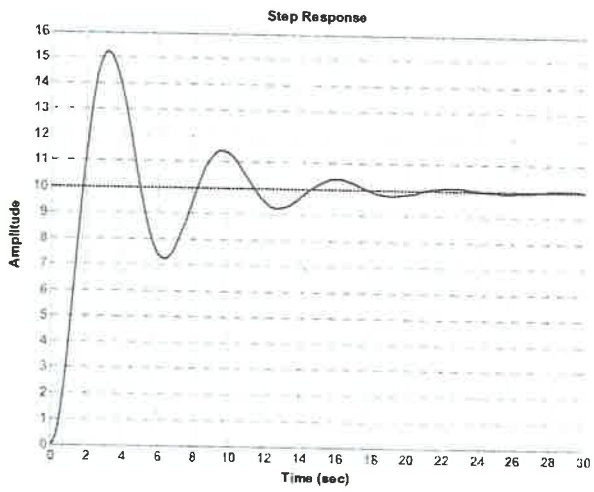
(A) 0.1 rad/sec (B) 0.3 rad/sec (C) 1 rad/sec (D) 10 rad/sec





10. Which one of the following transfer function generates the unit step response shown below? (5%)

(A) $\frac{100}{s^2+18s+100}$ (B) $\frac{50}{5s^2+2s+5}$ (C) $\frac{10}{100s^2+4s+1}$ (D) $\frac{50}{5s^2+7s+5}$



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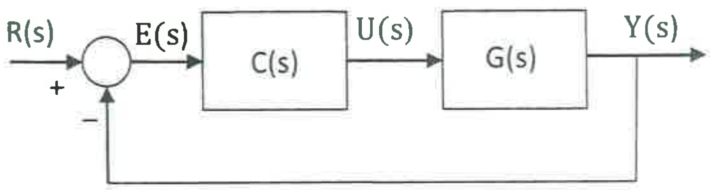
II. Multiple choice questions (25%). **Please write down your answers on the answer sheet. NO credits will be given if you write down the answers on this examination paper.** **(下列各題需答案完全正確該題方給分)**

Based on the unity feedback system shown below, assuming $G(s) = \frac{1}{s^3+s^2-2}$, answer problems 11-13.

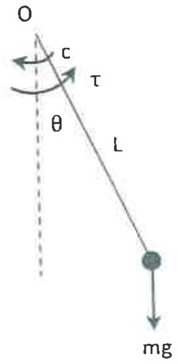


11. To design a controller $C(s)$ that stabilize the closed-loop system, which types of controller can be used? (5%)
(A) Proportional controller (B) Proportional-Derivative controller
(C) Proportional-Integral controller (D) Proportional-Derivative-Integral controller
(E) Lead compensator (F) Lag compensator

12. If a controller $C(s) = K(s + \alpha)$ is used, what are the values of α so that the closed-loop system has at most one pole in the right half plane for all the gain $K > 0$? (5%)
(A) $\alpha = 0.1$ (B) $\alpha = 0.3$ (C) $\alpha = 0.5$ (D) $\alpha = 0.7$ (E) $\alpha = 0.9$ (F) $\alpha = 1.1$

13. Following the previous question, if $\alpha = 2$, what are the values of gain K so that the closed-loop system is stable? (5%)
(A) K=0.2 (B) K=0.7 (C) K=1.2 (D) K=1.7 (E) K=2.2 (F) K=2.7

14. For the pendulum shown, a particle of mass m is attached to a massless rod of length L. An external torque τ is applied to the pendulum in the plane about the fixed point O with rotational damping coefficient c, and the acceleration of gravity is g. The input of the pendulum system is the torque τ and the output is the angle θ. Which of the following statements are **TRUE**? (5%)



(A) The pendulum system is linear.
(B) The pendulum system is of second order.
(C) The pendulum system has multiple equilibrium points if torque $\tau = 0$.
(D) The equilibrium points of the pendulum system are independent of torque τ.
(E) All the equilibrium points of the pendulum system given $\tau = 0$ are stable.
(F) Linearized model around one equilibrium describes the global behaviors of the pendulum system.

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15. Assume the variable $t \geq 0$ represents the time, $u(t)$ represents the input to each system and $y(t)$ represents the output of each system. Which of the following systems have **only one equilibrium** when u(t)≡0. (5%)?

(A) $\ddot{y}(t) + \dot{y}(t)y(t) = u(t)$

(B) $\dot{y}(t) + y^3(t) = u(t)$

(C) $\dot{x}_1(t) = x_2(t)$

$\dot{x}_2(t) = -x_1^2(t) + 2x_1(t) - x_2(t) + u(t)$

$y(t) = x_1(t)$

(D) $\ddot{y}(t) + 2\dot{y}(t) + ty(t) = u(t)$

(E) Transfer function: $G(s) = \frac{Y(s)}{U(s)} = \frac{s+5}{s^3+2s^2+3s+1}$

(F) Impulse response: $g(t) = e^{-2t}\sin t,\ G(s) = \mathcal{L}[g(t)] = \frac{Y(s)}{U(s)}$

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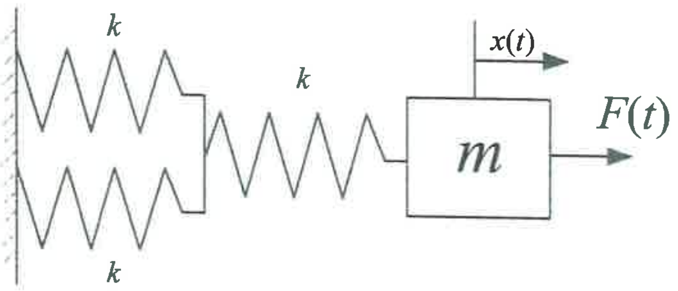
III. A mass-spring system is given below. The spring part contains two parallel springs cascaded with a single spring. (25%).

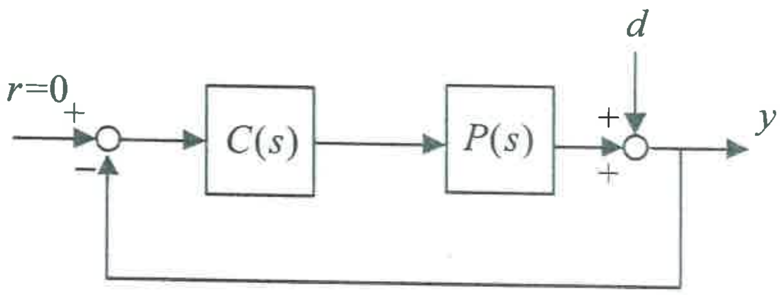


The spring constant $k = 3$ N/m; mass $m = 1$ kg. Input is force $F(t)$ and output is position $x(t)$.

(a) What is the **natural frequency** ω_n of this dynamic system? (5%)

(b) Suppose $F(t) = \sin(\omega t)$, where $\omega = 1$ rad/sec. What is the **amplitude** of the output response at steady state? (5%)

(c) Suppose $C(s) = K_p + K_d s$ is a stabilizing controller in the following feedback control system ($K_p = 8$, $K_d = 2$ in (c)(d)), where $P(s)$ is the mass-spring system.



Given a unit step disturbance d, what is the **steady state output** y value (response)? (5%)

(d) Given a unit sinusoidal disturbance d with natural frequency ω_n, what is the **steady state output** y value (response)? (5%)

(e) **Roughly sketch the root locus** and **describe** how to find control parameters K_p and K_d (No calculation please) that satisfy (1) closed loop system is stable; (2) damping ratio is 0.707. (5%)