Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	CONTROL ENGINEERING AND INSTRUMENTATION
COURSE CODE	:	BNJ 30703
PROGRAMME CODE	:	BNG/BNM
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 (a) Provide the control engineering definition of :
(i) Robustness
(ii) Disturbance

(4 mark)

(b) List **TWO (2)** reasons of having a thermostat in a heater system.

(2 mark)

(c) Specify **THREE (3)** differences between sensor and transducer, and gives example of instrument that is sensor, transducer or both sensor and transducer

(9 mark)

(d) Given the electrical circuit as in **Figure Q1.1** , the input is applied voltage v(t) and the output is measured as the voltage appears across the capacitor C that is $v_c(t)$. Find the transfer function of $V_c(s)/ V(s)$.

(10 mark)

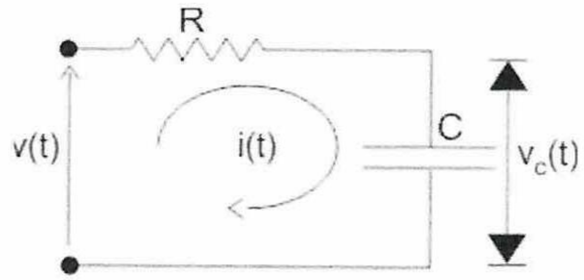

Figure Q1.1

Q2 (a) The transfer function for mechanical rotational system in **Figure Q2.1** given as $\frac{\theta(s)}{T(s)} = \frac{1}{Js^2+Cs+K}$. This system must incorporate the following specification, percent overshoot, M_p of 20% and settling time, T_S of 2s, for a step input of torque, T(t). Find the value of J and C for the above specifications.

(15 mark)

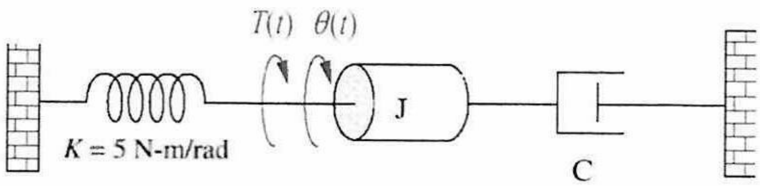

Figure Q2.1

(b) The closed-loop transfer function of a system is

$$T(s) = \frac{s^3+2s^2+7s+21}{s^4+4s^3+8s^2+20s+15}$$

Determine how many closed-loop poles lie in the left-half-plane, the right-half-plane and on the jω axis. Determine whether the system stable or not.

(10 mark)

Q3 (a) Using a suitable sketch, explain the stability conditions from Bode diagram.

(7 marks)

(b) The transfer function of an electric shredding machine system is given by

$$\frac{\theta(s)}{T(s)} = \frac{10K}{s(1 + 0.1s)(1 + 0.02s)}$$

(i) Sketch the Bode diagram for the system above if K=1.

(ii) Determine the gain and phase margins from the Bode diagram sketched in section (c)(i).

(18 marks)

Q4 (a) State **THREE (3)** components of a data acquisition (DAQ) device

(3 mark)

(b) The analog to digital (ADC) can obtain accurate presentation of the analog signal.

(i) Explain the different of using small or high value of bit of signal resolution.

(ii) Sketch the different with graph amplitude versus time.

(iii) If resolution is 1024, system voltage is 9 V and the measured analogue voltage is 3.5 V, calculate the ADC reading

(9 mark)

(c) If $u(t)$ as the controller output, write the final form of the PID algorithm. Explain how Proportional (P), Proportional plus Derivative (PD) and Proportional plus Integral and Derivative (PID) controllers affects the transient of this system. The proportional, integral, and derivative terms are summed to calculate the output of the PID controller.

(9 mark)

(d) Explain the differences (any **TWO (2)**) between artificial intelligence (AI) and machine learning.

(4 mark)

- END OF QUESTIONS -

APPENDIX A

Time Response

$$C(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{\omega_d}$$

$$\%OS = 100e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$$

$$\zeta = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$$

$$T_s = \frac{4}{\zeta\omega_n} = \frac{4}{\sigma_d}$$

$$T_r = \frac{1.321}{\omega_n}$$

Table 1.1 Test waveforms used in control systems

Name	Time function	Laplace transform
Step	$u(t)$	$\frac{1}{s}$
Ramp	$tu(t)$	$\frac{1}{s^2}$
Parabola	$\frac{1}{s}t^2$	$\frac{1}{s^3}$
Impulse	$\delta(t)$	1
Sinusoid	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
Cosine	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

Root Locus

$$K = \frac{1}{|G(s)H(s)|} = \frac{\prod \text{pole lengths}}{\prod \text{zero lengths}}$$

$$\sigma_a = \frac{\sum \text{finite poles} - \sum \text{finite zeros}}{\#\text{finite poles - }\#\text{finite zeros}}$$

$$\theta_a = \frac{(2k+1)\pi}{\#\text{finite poles - }\#\text{finite zeros}}$$

$$KG(s)H(s) = -1 = 1\angle(2k+1)180°$$

$$\theta = \sum \text{finite zero angles} - \sum \text{finite pole angles}$$

Differentiation (quotient rule)

If $u = f(x)$ and $v = g(x)$ then

$$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v(du/dx) - u(dv/dx)}{v^2} = \frac{g(x)f'(x) - f(x)g'(x)}{[g(x)]^2}$$

Steady-state Error

$$e(\infty) = e_{step}(\infty) = \frac{1}{1 + \lim_{s\to 0} G(s)}; \quad K_p = \lim_{s\to 0} G(s)$$

$$e(\infty) = e_{ramp}(\infty) = \frac{1}{\lim_{s\to 0} sG(s)}; \quad K_V = \lim_{s\to 0} sG(s)$$

$$e(\infty) = e_{parabola}(\infty) = \frac{1}{\lim_{s\to 0} s^2G(s)}; \quad K_a = \lim_{s\to 0} s^2G(s)$$