Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 2
SESSION 2021/2022

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA 30703
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. PART A: ANSWER **ALL** QUESTIONS 2. PART B : ANSWER **ONE (1)** QUESTION ONLY 3. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

PART A: ANSWER ALL QUESTION

Q1 (a) What is static calibration and why it is important? As an engineer, you are requested to supervise a calibration job done by your technician. Briefly discuss on the procedure that have to be taken by your technician in calibrating a transducer (Note: you can choose any type of transducer such as temperature, pressure, flow etc).

(5 marks)

(b) **Figure Q1(b)** shows a simple temperature measurement system consists of a RTD (sensing element), a Wheatstone bridge circuit (variable conversion element), Arduino UNO board (signal processing element) and a LED display (data presentation element). The Wheatstone bridge has an output (Vo) in the range of 0 to 30mV. In order to connect the output (Vo) to analog input port of the Arduino UNO board which has a range of 0 to 5V, a suitable signal conditioning circuit is required. Using suitable resistors, propose an appropriate signal condition circuit that can serve the purpose.

(a) Sketch the proposed circuit,

(2marks)

(b) Find its associated equation,

(2 marks)

(c) Calculate value of the required resistances, and

(2 marks)

(d) prove that the output (Vo) can be matched up with the voltage range of the analog input port.

(2 marks)

(c) **Figure Q1(c)** shows a simple conveyor system used in industry to detect and count number of metal cans moving on the conveyor belt with a certain speed. Propose and elaborate the working principle of two suitable sensors that can be used to count the metal cans and measure the speed of conveyor.

(7 marks)

Q2 (a) **Figure Q2(a)** shows a Watt flyball governor system.

i. Very briefly describe how the following governor system is working.

ii. Draw a block diagram to represent the system.

iii. What is the controlled variable?

iv. Is this a closed-loop system, or an open-loop system?

(6 marks)

(b) A block diagram of a feedback control system is shown in **Figure Q2(b)**. Using the block diagram reduction technique, show that the transfer function relating $C(s)$ to $R(s)$ is

$$\frac{C(s)}{R(s)} = \frac{K(4s+1)}{2s^4 + 14s^3 + 12s^2 + 4Ks + K}$$

(6 marks)

(c) Use partial fractions to find the inverse Laplace transforms of the following basic cases:

i. $F(s) = \dfrac{1}{(s-1)(s+2)(s+4)}$

ii. $F(s) = \dfrac{s+1}{s^2(s+2)^3}$

iii. $F(s) = \dfrac{3s-2}{s^3(s^2+4)}$

iv. $F(s) = \dfrac{1}{(s+1)^2}$

(8 marks)

Q3 A translational mechanical system can be simplified in schematic diagram as in **Figure Q3**

(a) Draw the free body diagram of the system.

(5 marks)

(b) Derive the corresponding equation of motion of the system.

(7 marks)

(c) Obtain the transfer function x_1/F_e

(8 marks)

Q4 The open-loop transfer function of a control system is given by

$$\text{KGH (s)} = \frac{K}{s(s+1)(s+4)}$$

(a) Sketch the root locus using plain graph paper

(4 marks)

(b) Obtain the gain K, when the damping ratio, ζ=0.6 and the transfer function is subjected to unit step input.

(9 marks)

(c) Find time-domain specifications of overshoot, Mp, and natural frequency, ω.

(3 marks)

(d) Calculate the steady-state error, e_{ss} , due to ramp input

(4 marks)

PART B : ANSWER **ONE(1)** QUESTION ONLY

Q5 (a) Identify the meaning of frequency response.

(2 marks)

(b) Write THREE (3) advantages of the frequency response method.

(3 marks)

(c) The forward path transfer function of a unity-feedback control system is given as

$$G(s) = \frac{K}{S(1 + 0.1S)(1 + 0.5S)}$$

Draw the Bode plot of G(s) and examine the value of K so that the gain margin of the system is 20dB

(15 marks)

Q6 (a) Explain the compensation characteristics of cascade PI and PD compensators.

(5 marks)

(b) Write the first method of Ziegler-Nicholas rules for determining values of the K_p, T_i and T_d based on the transient response characteristics of the plant.

(6 marks)

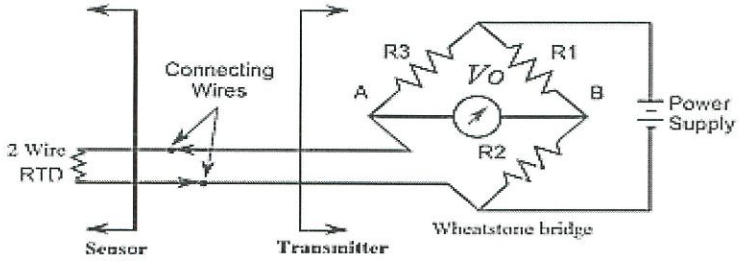
(c) Consider the control system shown in **Figure Q6.** Examine a Ziegler-Nichols tuning rule for the determination of the values of parameters K_p, T_i and T_d.

(9 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2021/2022 PROGRAMME : BDD
COURSE : CONTROL ENGINEERING COURSE CODE : BDA 30703



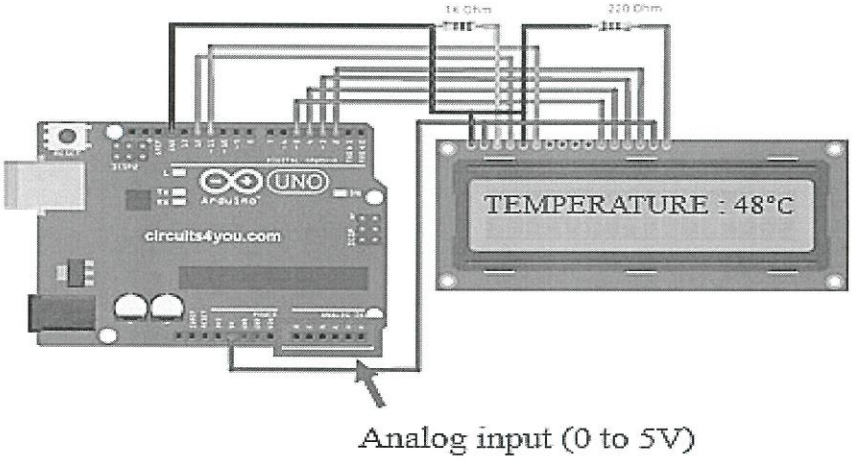


Figure Q1(b)

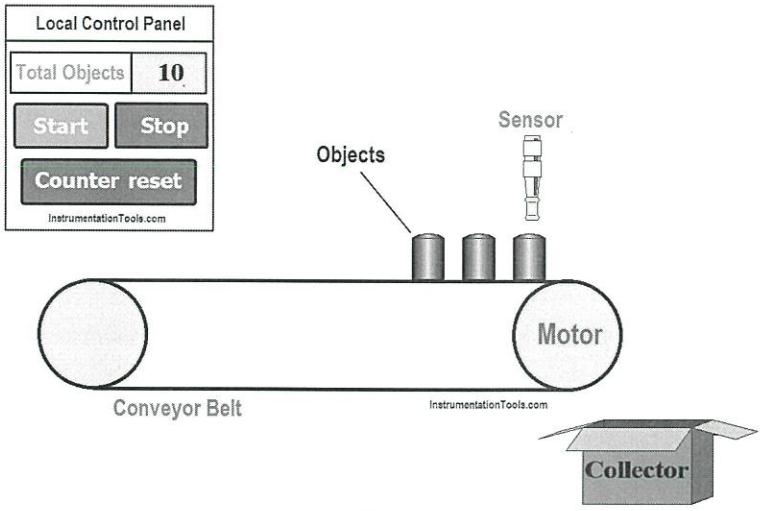


Figure Q1(c)

FINAL EXAMINATION

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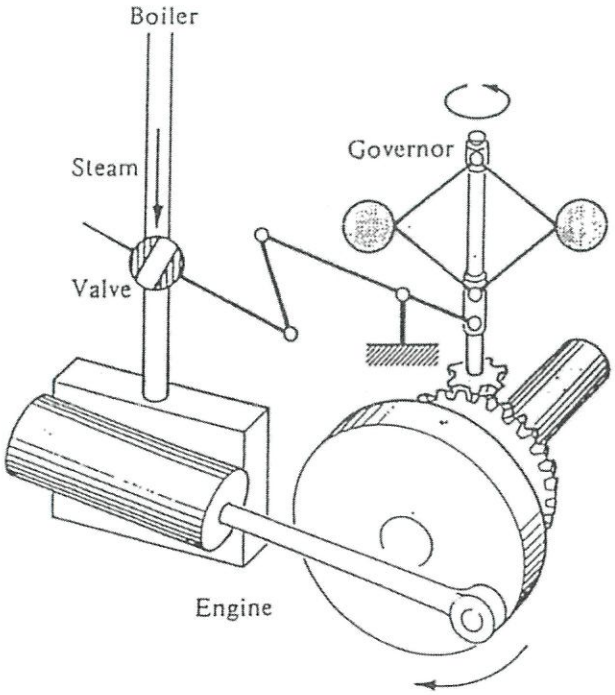

Figure Q2(a)

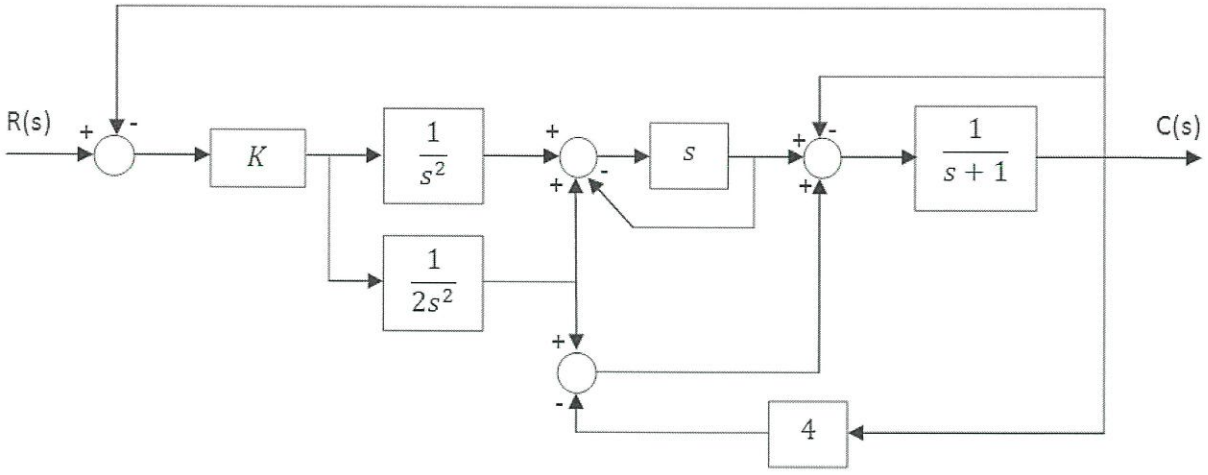

Figure Q2(b)

FINAL EXAMINATION

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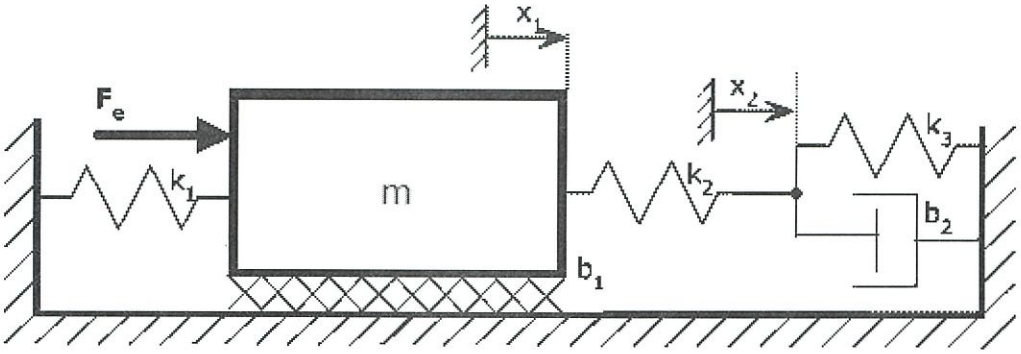

Figure Q3

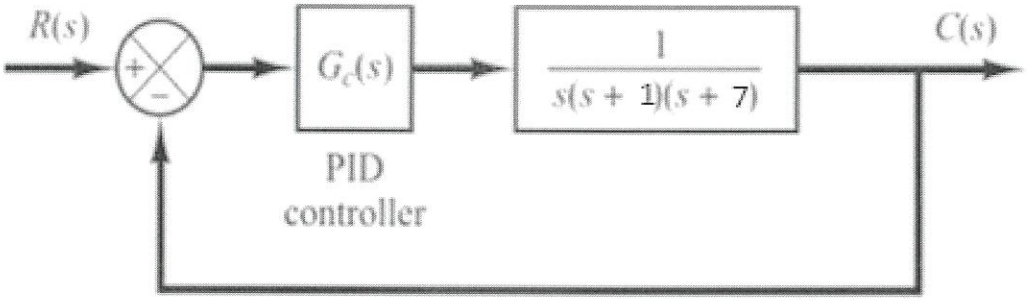

Figure Q5