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# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2016/2017

| | | |
|---|---|---|
| COURSE NAME | : | INSTRUMENTATION AND PROCESS CONTROL |
| COURSE CODE | : | BNL 30603 |
| PROGRAMME | : | 3 BNL |
| EXAMINATION DATE | : | JUNE 2017 |
| DURATION | : | 2 HOUR 30 MINUTES |
| INSTRUCTION | : | ANSWER **FOUR (4)** QUESTIONS ONLY. |



THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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**Q1** (a) A ***closed control loop*** exists where a process variable is measured, compared to a set point, and action is taken to correct any deviation from set point.

(i) Under what circumstances does an ***open control loop*** exist?

(ii) Describe an example of appliance where open control loop is used.

(6 marks)

(b) Feedforward and feedfback control is widely used in process control applications.

(i) Illustrate with appropriate diagram where feedforward and feedback control are used.

( 5 marks)

(ii) Give **ONE (1)** advantages and disadvantages each of applying feedforward and feedback control strategy in process control.

( 4 marks)

(c) Transfer the following s-domain equation into time domain equation using inverse Laplace transformation technique.

$$F(s) = \frac{10s+8}{s(s^2+3s+2)}$$

(10 marks)

**Q2** (a) Obtain the Laplace transform of the differential equation below with initial condition $y(0) = -1,\ \dot{y}(0) = 2$

$$\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y(t) = 2x(t)$$

(5 marks)

(b) A general second-order transfer function can be written as:

$$G(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

Define the meaning of $\omega_n$ and $\zeta$.

(4 marks)

(c) For the following transfer function, find the value of $\zeta$ and $\omega_n$. Analyze the response of the system based on the result obtained.

$$G(s) = \frac{30}{s^2 + 8s + 30}$$

(5 marks)

(d) Consider a well-stirred tank in **Figure Q2(d)**. Assume in this process, constant and equal inlet and outlet volumetric flows, liquid densities and heat capacities. The liquid in the tank is assumed to be well mixed, tank is well insulated.

(i) Develop a mathematical model for the system.

( 5 marks)

(ii) Determine the transfer function of the system.

( 3 marks)

(iii) What is the order of the system? Sketch the response of the system.

( 3 marks)

**Q3** (a) Using appropriate diagram explain **THREE (3)** signal types that are used in the process control industry.

(6 marks)

(b) As a plant engineer, propose **FIVE (5)** important consideration in modelling and selection of control valves for a particular process control applications.

(10 marks)

(c) Differentiate the concept of interacting and non-interacting system with appropriate examples and diagrams.

(9 marks)

**Q4** (a) Describe the kind of signal that is transmitted out from the temperature transmitter shown in **Figure Q4(a)**.

(3 marks)

(b) The open loop transfer function of a robot arm control system for a process control tank manipulation system is given by;

$$G(s) = \frac{K(s+3)}{s^2+3s+6}, \qquad H(s)=1$$

Referring to robot arm control system,

(i) Determine the angle of departure from the complex-conjugate open-loop poles

(5 marks)

(ii) Determine the break-in point

(3 marks)

(iii) Sketch the root locus plot based on the information from (i) and (ii).

(5 marks)

(c) There are three different control strategies namely P, PI and PID controllers. Differentiate the control action of these controllers.

(9 marks)

**Q5** (a) Define the concept of two level cascade systems with supported diagrams.

(5 marks)

(b) Reduce the transfer function of $\frac{C(s)}{R(s)}$ for the system shown in **Figure Q5 (b)**.

(10 marks)

(c) **Figure Q5 (c)** shows an example of single loop control of an oleo tank system. Propose a cascade control system to improve the performance of the original system. Support your design with appropriate diagram and elaboration.

(10 marks)

**- END OF QUESTIONS –**

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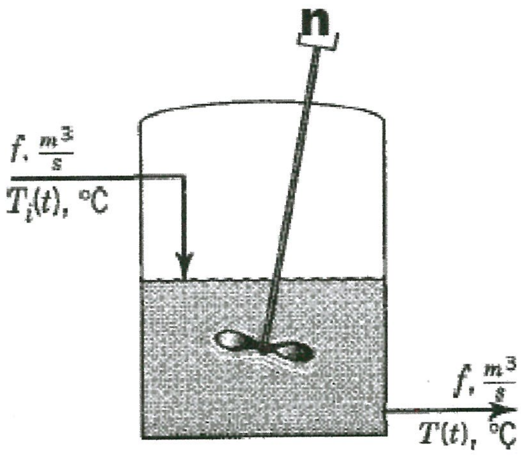


**Figure Q2 (d)**

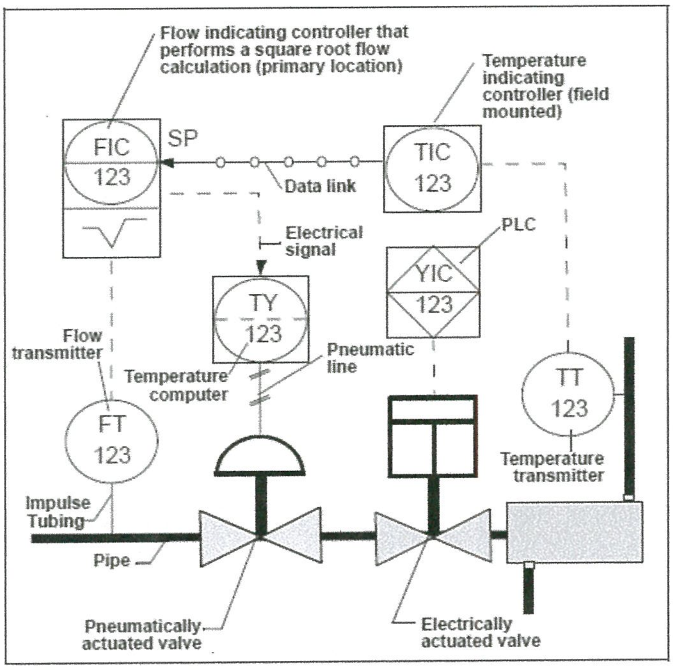


**Figure Q4(a)**

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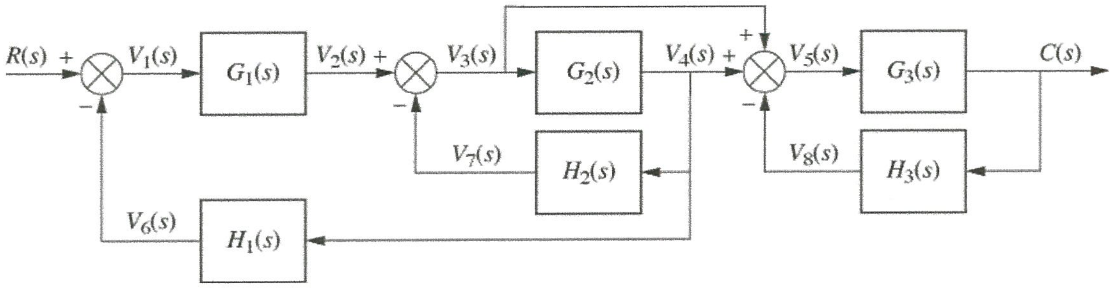


**Figure Q5 (b)**

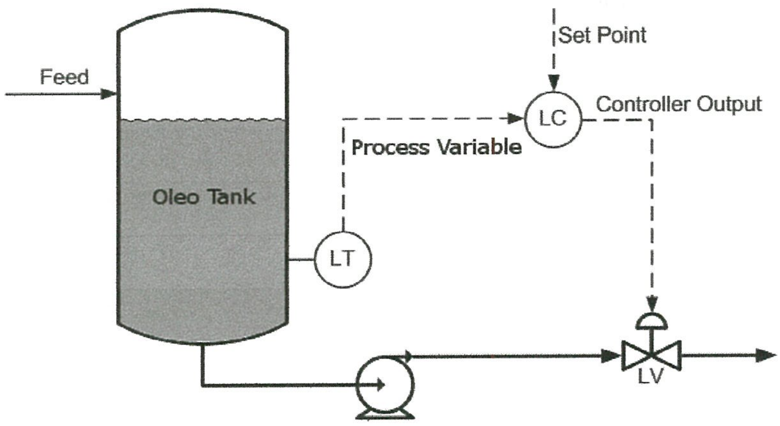


**Figure Q5 (c)**

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## General Laplace Transformation Table

| | $f(t)$ | $F(s)$ | 11 | $\cos \omega t$ | $\frac{s}{s^2+\omega^2}$ |
|---|---|---|---|---|---|
| 1 | Unit impulse $\delta(t)$ | 1 | 12 | $\sinh \omega t$ | $\frac{\omega}{s^2-\omega^2}$ |
| 2 | Unit step $1(t)$ | $1/s$ | 13 | $\cosh \omega t$ | $\frac{s}{s^2-\omega^2}$ |
| 3 | $t$ | $1/s^2$ | 14 | $\frac{1}{a}\left(1-e^{-at}\right)$ | $\frac{1}{s(s+a)}$ |
| 4 | $\frac{t^{n-1}}{(n-1)!}$ $(n-1,2,3,.$ | $\frac{1}{s^n}$ | 15 | $\frac{1}{b-a}\left(e^{-at}-e^{-bt}\right)$ | $\frac{1}{(s+b)(s+a)}$ |
| 5 | $t^n (n=1,2,3,\ldots)$ | $\frac{n!}{s^{n+1}}$ | 16 | $\frac{1}{b-a}\left(be^{-bt}-ae^{-at}\right)$ | $\frac{s}{(s+b)(s+a)}$ |
| 6 | $e^{-at}$ | $\frac{1}{s+a}$ | 17 | $\frac{1}{ab}\left[1+\frac{1}{a-b}\left(be^{-at}-ae^{-bt}\right)\right]$ | $\frac{1}{s(s+b)(s+a)}$ |
| 7 | $te^{-at}$ | $\frac{1}{(s+a)^2}$ | 18 | $\frac{1}{a^2}\left(1-e^{-at}-ate^{-at}\right)$ | $\frac{1}{s(s+a)^2}$ |
| 8 | $\frac{1}{(n-1)!}t^{n-1}e^{-at}$ $(n=1,2,$ | $\frac{1}{(s+a)^n}$ | 19 | $\frac{1}{a^2}\left(at-1+e^{-at}\right)$ | $\frac{1}{s^2(s+a)}$ |
| 9 | $t^n e^{-at}$ $(n=1,2,3,\ldots$ | $\frac{n!}{(s+a)^{n+1}}$ | 20 | $e^{-at}\sin \omega t$ | $\frac{\omega}{(s+a)^2+\omega^2}$ |
| 10 | $\sin \omega t$ | $\frac{\omega}{s^2+\omega^2}$ | 21 | $e^{-at}\cos \omega t$ | $\frac{s+a}{(s+a)^2+\omega^2}$ |