NANYANG TECHNOLOGICAL UNIVERSITY

CH3111 – PROCESS CONTROL AND DYNAMICS

Name:

Matric No:

Time Allowed: 60 mins.

INSTRUCTIONS

1. This paper contains FOUR (4) questions and comprises TWELVE (12) pages.
2. Answer ALL questions.
3. This is an Open Book Exam.

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Q.1 Consider a constant volume 200-gal mixing tank process (Figure 1) in which the inlet stream has salt concentration of 5 kg/$m^3$ and volumetric flow rate of 1 gal/sec. The process is initially at steady state and the outlet stream also has salt concentration of 5 kg/ $m^3$. At 3:00 PM, the shift changes at the plant. By mistake, the new operator on the unit switches the inlet flow concentration from 5 kg/$m^3$ to fresh water.

a. Write the mathematical model for the mixing process. [4 marks]

b. Derive the transfer function. Write the order and parameters for this transfer function. [6 marks]

c. What will be the concentration of the outlet stream at 3:10 PM? [10 marks]

d. What will be the final steady state concentration of the outlet stream [5 marks]

e. What should the operator do to the inlet flow rate to ensure that the exit concentration should not be less than 0.5 kg/$m^3$ in 30 mins? Support your answer by calculations. [10 marks]

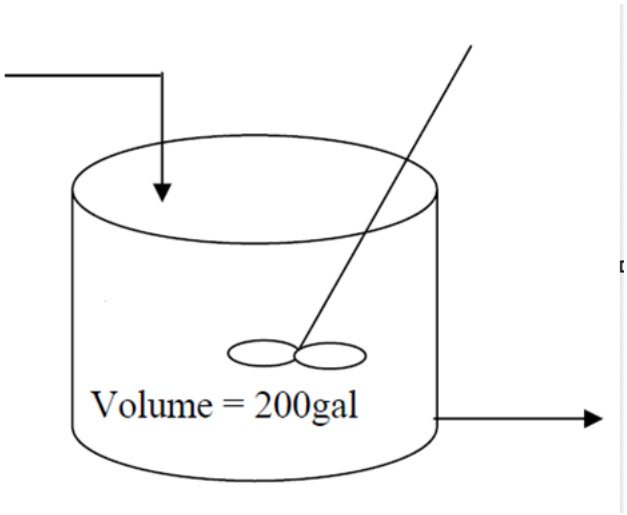


**Figure 1**

Q.2 The following transfer function models were determined from experiments.

$$G(s) = \frac{(2 - 8s)}{(3s + 1)(8s + 2)}$$

(A) Determine an approximate first order-with-dead-time transfer function model for G(s) using Skogestad Half-rule method. [10 marks]

(B) Obtain a plot of the unit step response of the original G(s) and compare it with the unit step response from the approximated G(s) (obtained in part a) showing the characteristics of the curve such as final value, etc. [15 marks]

Q.3 For each of the following questions, select the answer that is the most appropriate or closest numerically to your answer. Be sure to clearly tick only one answer in your answer book and show your workings. Multiple answers will be graded as zero.

[20 marks]

(1) A dynamic system is represented by the following differential equation with the initial conditions as y(0) = 10 and x(0) = 5

$$10\frac{dy(t)}{dt} + y(t) = x(t)$$

The corresponding transfer function is:

(a) G(s)= $\frac{1}{10s+1}$

(b) G(s)= $\frac{5}{s+5}$

(c) G(s)= $\frac{5}{10s+1}$

(d) G(s)= $\frac{10}{5s+1}$

(e) None of the options given

(2) The transfer function is $g(s)= \frac{3}{s^2+0.5s+1}$

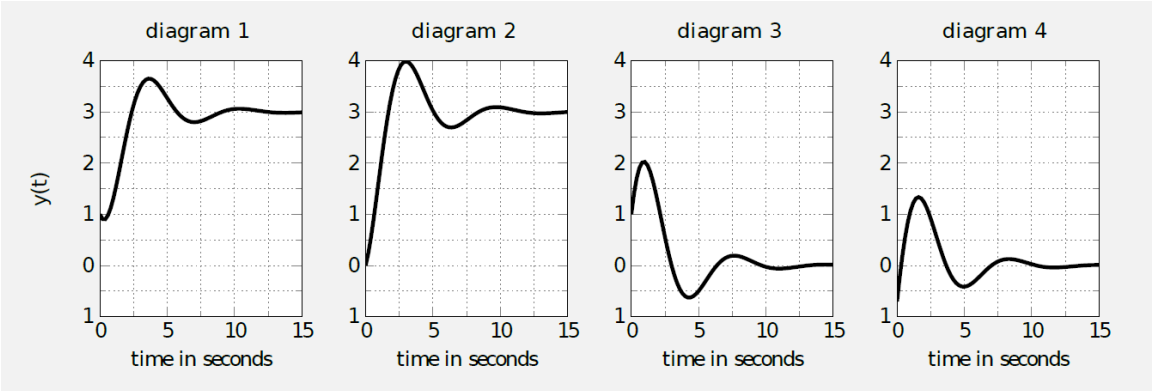


**Figure 2**

Which of the four diagrams shows the correct step response of the system?

(a) Diagram 1

(b) Diagram 2

(c) Diagram 3

(d) Diagram 4

(3) A control system has the following transfer function

F(s) = $\frac{(7s-1)(7s+1)}{s(7s-4)(7s+8)}$

The initial value of the corresponding time function is

(a) 1

(b) 1/8

(c) 0

(d) -1

(e) infinity

(4) What is the gain of the transfer function G(s) = $\frac{5(s+1)}{(S+3)^2}$ ?

a) 5/3

b) 5/9

c) 0

d) 1

Q.4 For each of the following transfer function, sketch the response to a unit step input, showing all the important details of the response such as bounded, unbounded, oscillatory, final value, etc. [20 marks]

i) $\frac{-2e^{-4s}}{10s+1}$

ii) $\frac{-7}{-20s+1}$

iii) $\frac{-0.5}{s}$

iv) $\frac{4s+5}{2s+1}$