Mark Scored:

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

Level : B. E.
Year : III
Course : CHEG 302
Semester: I

Exam Roll No. :
Time: 30 mins.
F. M. : 10

Registration No.:
Date 30 MAY 2019

SECTION "A"
[20Q. × 0.5= 10 marks]

Encircle the most appropriate answer among the given choices.

1. For two non-interacting first order systems connected in series, the overall transfer function is the ________ of the individual transfer functions.
   a. Product b. Sum c. Ratio d. Difference

2. Phase lag of the frequency response of a second order system to a sinusoidal forcing function
   a. Is 30°
   b. Is 90° at the most
   c. Approaches 180° asymptotically
   d. Is 120°

3. Which of the following controllers has the maximum offset?
   a. P b. PI c. PID d. PD

4. $1/(\omega^2T^2 + 1)^{1/2}$ represents
   a. A.R. of the first order system
   b. A.R. of the second order system
   c. Phase lag of the first order system
   d. Phase lag of the second order system

5. Which of the following controllers requires the minimum stabilizing time?
   a. P b. PI c. PD d. PID

6. According to Bode stability criterion, a system is unstable if the open loop frequency response exhibits an amplitude ratios exceeding unity at the frequency for which phase lag is
   a. 0° b. 45° c. 90° d. 180°

7. The transfer function of a process is $1/(16s^2 + 8s + 4)$. If a step change is introduced into the system, then the response is
   a. Under damped
   b. Critically damped
   c. Over damped
   d. Over critically damped

8. A pneumatic valve is said to contribute negligible dynamic lag if the time constant of the valve is
   a. 1 b. Very small c. Very high d. ∞

9. The open loop transfer function of a process is $K*[(s+1)(s+4)] / [(s+2)(s+3)]$. In the root locus diagram, the poles will be at
   a. -1, -4 b. 1, 4 c. -2, -3 d. 2, 3

10. _______ is an undesirable static characteristics of instruments.

a. Drift
b. Dead Zone
c. Static error
d. Reproducibility

11. What is the Laplace transform of impulse input having magnitude of X?

a. X
b. X^2
c. 1/X
d. 1

12. The transfer function of a pure dead time system with dead time τ_d is

a. $1/(\tau_d s + 1)$
b. $\tau_d s + 1$
c. $e^{-\tau ds}$
d. $e^{\tau ds}$

13. The second order system with the transfer function $4 / (s^2 + 2s + 4)$ has a damping ratio of

a. 2.0
b. 0.5
c. 1.0
d. 4.0

14. The frequency response of a first order system has a phase shift with lower and upper bounds given by

a. $-\infty, \pi/2$
b. $-\pi/2, \pi/2$
c. $-\pi/2, 0$
d. $0, \pi/2$

15. The inverse Laplace transform of the function $f(s) = 1 / [s(s+1)]$ is

a. $1 + e^t$
b. $1 - e^t$
c. $1 + e^{-t}$
d. $1 - e^{-t}$

16. The maximum flow through a valve ($C_v = 4$) is 35.6 gal/min. Calculate the pressure drop in the valve to throttle the flow of glycerine. Specific gravity of glycerine is 1.26.

a. 120 psi
b. 100 psi
c. 115 psi
d. 130 psi

17. The unit impulse response of a first order process is given by 2e-0.5t. The gain and time constant for the process are

a. 4 and 2
b. 2 and 2
c. 2 and 0.5
d. 2 and -0.5

18. Response due to a sinusoidal input is

a. Exponentially increasing
b. Exponential decreasing
c. Sinusoidal
d. An impulse function

19. A proportional controller will have an offset difference between set point and control point

a. That depends on the process load
b. At all times
c. That will eventually vanish
d. Equal to the proportional band setting

20. Overshoot of a second order system

a. Decreases with increasing value of damping coefficient from 0 to 1
b. Increases with increasing value of damping coefficient from 0 to 1
c. Remains constant as damping coefficient changes from 0 to 1
d. Unpredictable

KATHMANDU UNIVERSITY
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Level : B. E.
Year : III
Time : 2 hrs. 30 mins.

Course : CHEG 302
Semester: I
F. M. : 40

SECTION "B"
[40 marks]

Attempt *ALL* questions.

1. Draw input signals for the following. [4]
   a. f(t) = u(t - 1) - (t - 3)u(t - 3) + (t - 4)u(t - 4)
   b. f(t) = u(t - 1) + (t - 2)u(t - 2) - (t - 2)u(t - 3) - (t - 5)u(t - 5) + (t - 6)u(t - 6)

2. Find x(s) for the following differential equations. Do not invert the expression. [2]

$$\frac{d^3x}{dt^3} + 2\frac{d^2x}{dt^2} - \frac{dx}{dt} + 2x = 4 + e^{2t}$$

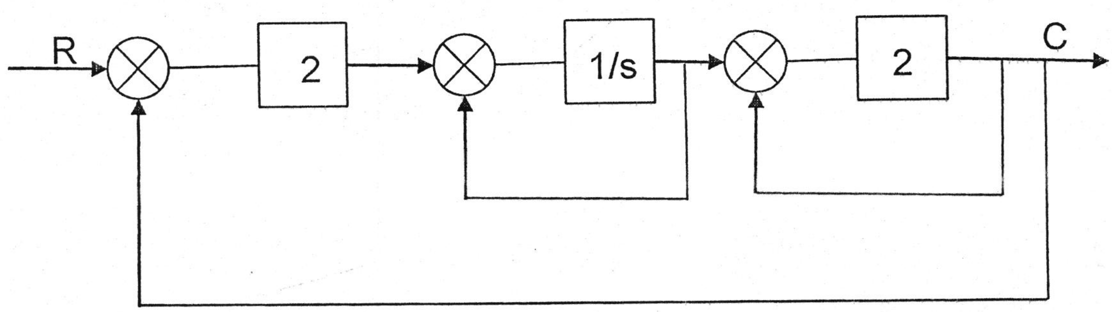
$$x(0) = 1 \quad x'(0) = 0 \quad x''(0) = -1$$

3. Invert the following transform [2]

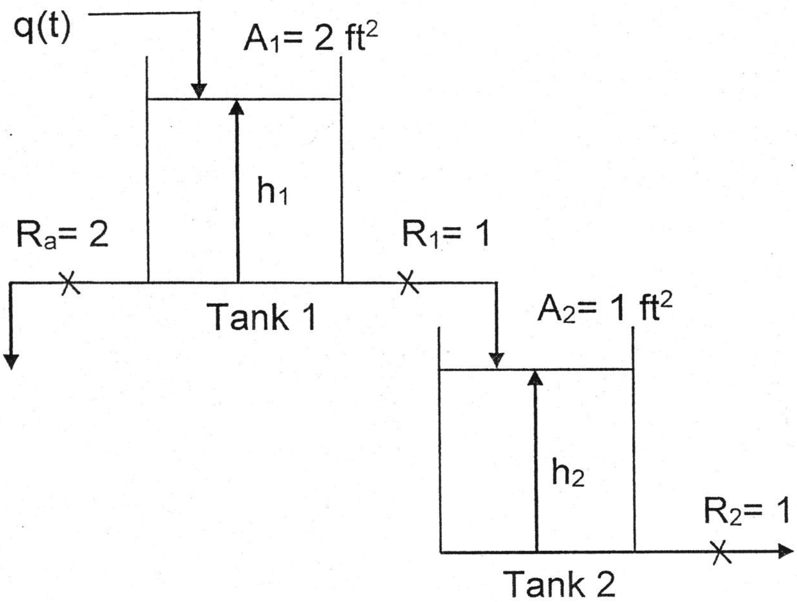
$$\frac{3s}{(s^2+1)(s^2+4)}$$

4. A thermometer having a time constant of 1 min is initially at 50 °C. It is immersed in a bath maintained at 100 °C at t = 0. Determine
   a. The temperature reading at t = 1.2 min. [2]
   b. If at t = 1.5 min the thermometer is removed from the bath and put in a bath at 75 °C, determine the maximum temperature indicated by the thermometer. [2]

5. Determine the transfer function C(s) / R(s) for the control system shown below. Please show all the steps for full credit. [4]



6. Starting from first principles, derive the transfer function $H_1(s)/Q(s)$ and $H_2(s)/Q(s)$ for the liquid level system shown in the figure below. The resistances are linear and $R_1 = R_2 = 1$. Note that two streams are flowing from tank 1, one of which flows into tank 2. Please give numerical values of the parameters in the transfer functions and clearly show how you derived the transfer functions for full credit. [8]



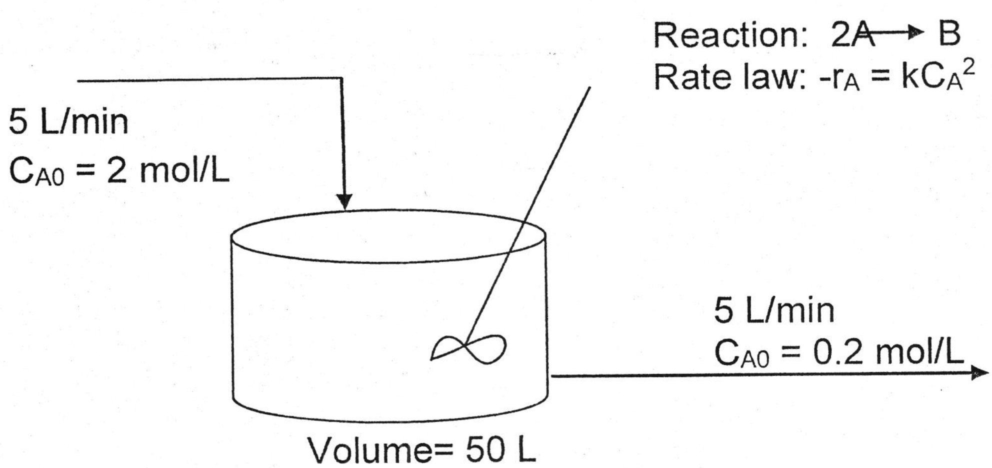
OR

a. Determine the transfer function that relates the exit concentration from the reactor to the changes in feed concentration for the CSTR reactor shown below. [4]

b. What is the new exiting concentration 1 min later if we instantaneously double the feed concentration from 2 to 4 mol/L? [2]

c. What is the new steady state reactor concentration? The rate constant is $k = 2\ (\text{mol/L})^{-1}(\text{min})^{-1}$. [2]

The reaction rate law is $-r_A = kC_A^2$, where r_A is the production rate of A in moles per liter per minute.



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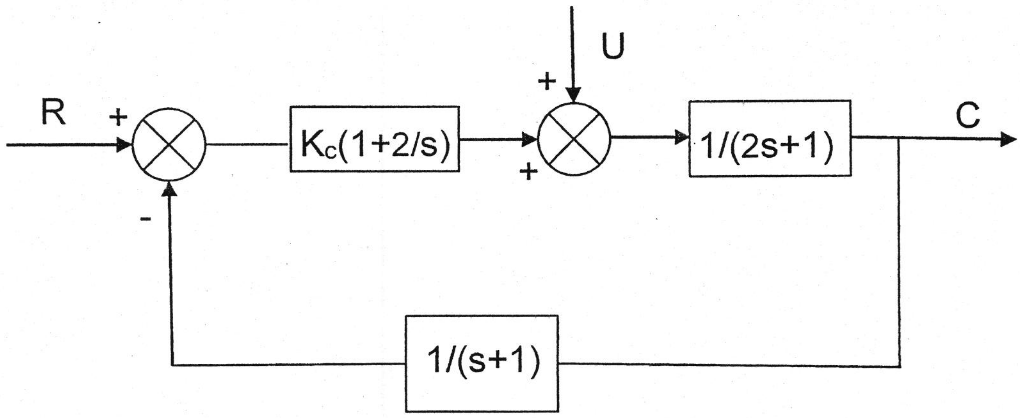
7. For the control system shown below

a. Write the characteristic equation. [2]

b. Use the Routh test to determine if the system is stable for $K_c = 4$. [2]

c. Determine the ultimate value of K_c above which the system is unstable. [2]



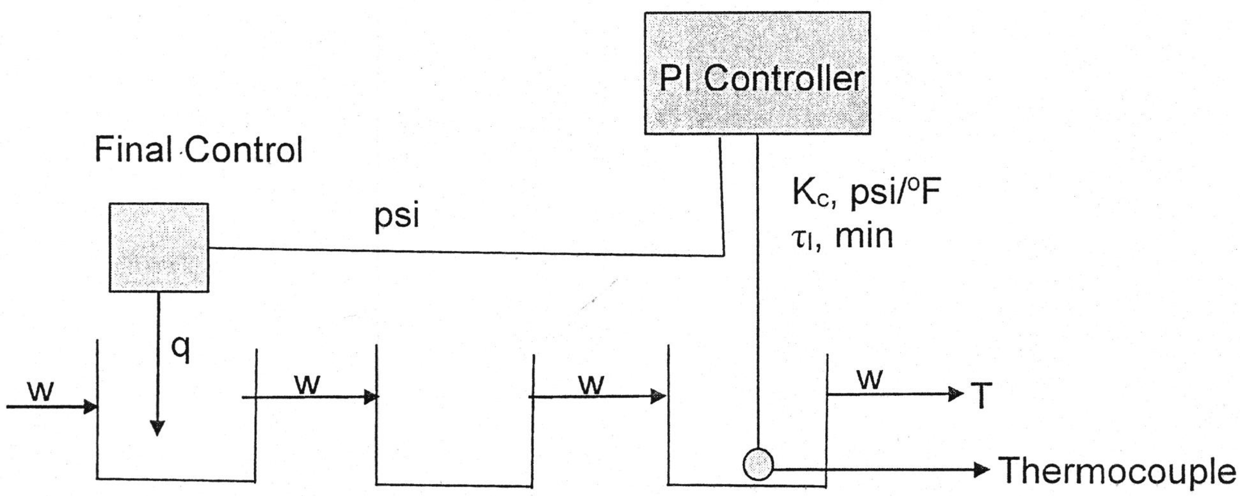
8. The stirred tank heater system shown in the figure below is controlled by a PI controller. The following data apply:

Flow rate ω of liquid through the tanks: 250 lb/min

Holdup volume of each tank: 10 ft^3

Density of liquid: 50 lb/ft^3

Final control element: A change of 1 psi from the controller changes the heat input q by 100 Btu/min. The final control element is linear.



a. Draw a block diagram of the control system. Show in detail such things as units and numerical values of the parameters. [4]

b. Determine the controller settings by Ziegler-Nichols rules. [3]

c. If the control system is operated with proportional mode only, using the value of K_c found in part (b), determine the flow rate w at which the system will be on the verge of instability and oscillate continuously. What is the frequency of this oscillation? [3]

CHEG-302 -Table

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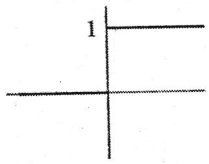
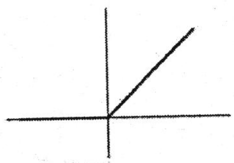
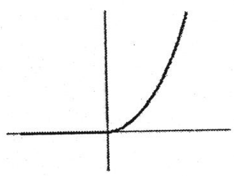
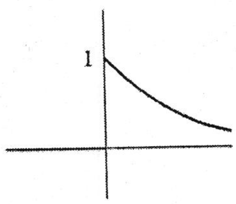
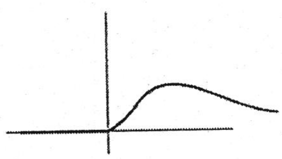
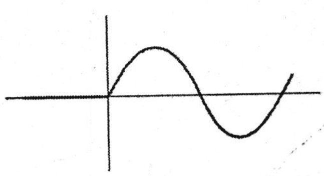
Supplemental Materials for the test.

TABLE 2.1

Function	Graph	Transform
$u(t)$		$\frac{1}{s}$
$tu(t)$		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$
$\sin kt\, u(t)$		$\frac{k}{s^2+k^2}$