Mark Scored:

KATHMANDU UNIVERSITY
End Semester Examination
February/March, 2019

Level : B. E.
Year : III

Course : CHEG 302
Semester: I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date : FEB 2 0 2019

SECTION "A"
[20 Q.× 0.5= 10 marks]

Select the most appropriate answer.

1. Gain margin is equal to the
   a. Reciprocal of amplitude ratio
   b. Amplitude ratio
   c. Gain in P-controller
   d. Gain in PI-controller

2. In a single tank system, the transfer function of level to inlet flow rate is
   a. $R / \tau s$
   b. $R / (\tau s + 1)$
   c. $1 / \tau s$
   d. $1 / (\tau s + 1)$

3. Response of a system to a sinusoidal input is called __________ response.
   a. Impulse
   b. Unit step
   c. Frequency
   d. None of the above

4. Transfer function of a transportation lag is
   a. $e^{\tau s}$
   b. $e^{-\tau s}$
   c. $1 / (\tau s + 1)$
   d. None of the above

5. The function of a transducer is to
   a. Modify the input signal
   b. Convert the primary signal into a more useful quantity, usually an electric impulse
   c. Amplify the input signal
   d. codify/decodify the input signal

6. A first order system with unity gain and time constant τ is subjected to a sinusoidal input of frequency $w = 1/\tau$. The amplitude ratio for this system is
   a. 1
   b. 0.5
   c. 0.25
   d. $1/\sqrt{2}$

7. Cascade system responds faster than conventional control with __________ frequency of oscillation.
   a. Lower
   b. Higher
   c. Equal
   d. Is specific to the control system

8. The sensitivity is ___________ for a equal percentage valve.
   a. Decreasing
   b. Increasing
   c. Linear
   d. None of the above

9. The frequency at which maximum amplitude ratio is attained is called the __________ frequency.
   a. Resonant
   b. Cross-over
   c. Corner
   d. Natural

10. _________ loop transfer function is used in Bode stability method.
    a. Open
    b. Closed
    c. Either (a) or (b)
    d. Neither (a) nor (b)

11. __________ loop transfer function is used in Routh stability method.

a. Open b. Closed c. Either (a) or (b) d. Neither (a) nor (b)

12. The offset introduced by proportional controller with gain K_c in response of first order system can be reduced by

a. reducing value of K_c
b. introducing integral control
c. introducing derivative control
d. none of the above

13. For five step unit decrease in the process input, the signal from the feedforward controller should be compensated by ______________ if there is to be no change in the process output.

a. one step decrease
b. one step increase
c. five step increase
d. three step decrease

14. The maximum flow through valve for a pressure drop of 100 psi is 35.6 gal/min. Find the C_v rating for a valve used to throttle the flow of glycerine for which sg = 1.26.

a. 2.0 b. 5.0 c. 10.0 d. 4.0

15. The unit step response of a second order system with a gain of 5 always returns a steady state value of

a. 2 b. 1 c. 0 d. 5

16. If a response of a control system is to be free of offset and oscillation, the most suitable controller is

a. P only b. PI c. PD d. PID

17. The characteristic equation for the control system

a. Depends only upon the open loop transfer system
b. Determines its stability
c. Is the same for set point or load changes
d. All of the above

18. Conversion formula for converting amplitude ratio (AR) into decibels is

a. Decibel = $20 \log_{10}(AR)$
b. Decibel = $20 \log_e(AR)$
c. Decibel = $20 \log_{10}(AR)^{0.5}$
d. Decibel = $20 \log_e(AR)^{0.5}$

19. Which of the following is an undesirable dynamic characteristic of an instrument ?

a. Reproducibility b. Time lag c. Dead zone d. Static error

20. Instrumentation in a plant offers the advantage of

a. Greater safety of operation
b. Better quality of product
c. Greater operation economy
d. All of the above

KATHMANDU UNIVERSITY
End Semester Examination
February/March, 2019

FEB 2 0 2019

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

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

SECTION "B"
[40 marks]

1. Draw input signals for the following. Do *ANY TWO* out of the three. [5]

a. $f(t) = -u(t-1) - (t-1)u(t-1) + (t-2)u(t-2) + 2u(t-2)$

b. $f(t) = 2u(t-2) - (t-2)u(t-2) + (t-4)u(t-4)$

c. $f(t) = 3tu(t) - 3u(t-1) - u(t-2)$

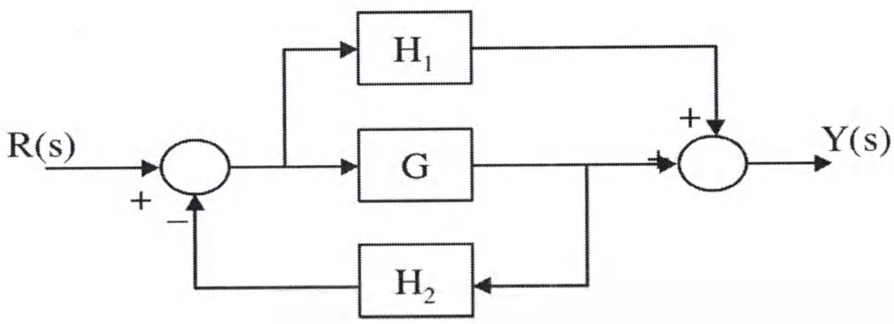
2. Find x(t) for the following differential equation. [4]

$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 1 \qquad x(0) = x'(0) = 0$$

3. Using Routh test, determine the value of K above which the system is unstable for the following characteristic equation. Also determine the two imaginary roots. [3]

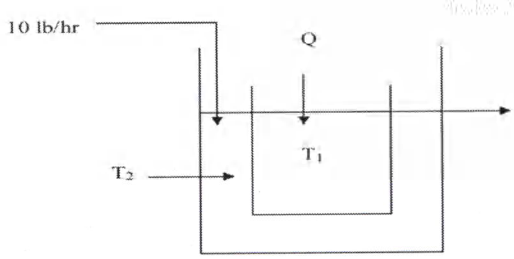
$$s^4 + 4s^3 + 6s^2 + 4s + (1 + K) = 0$$

4. Determine Y(s)/R(s) for the block diagram below. [5]



5. The heat transfer equipment shown in the figure below consists of two tanks, one nested inside the other. Heat is transferred by convection through the wall of the inner tank. The contents of each tank are well mixed. The holdup volume of both the inner and outer tank are 1 ft^3. The cross-sectional area for heat transfer between the tanks is 1 ft^2. The overall heat-transfer coefficient for the flow of heat between the tanks is 10 Btu/(h.ft^2.°F). The heat capacity of fluid in each tank is 1 Btu/(lb.°F). The density of each fluid is 50 lb/ft^3.

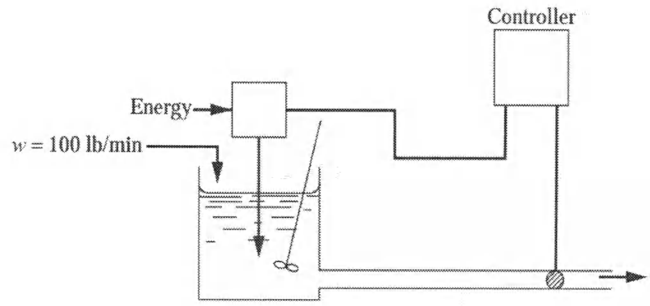
Initially the temperatures of the feed stream to the outer tank and the contents of the outer tank are equal to 100 °F. At time zero, the flow of heat to the inner tank Q is changed according to a step change from 0 to 500 Btu/h.

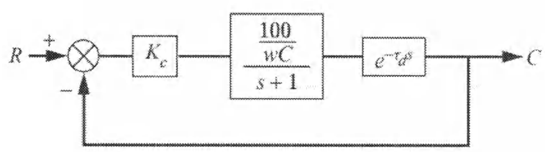


a. Obtain an expression for the Laplace transform of the temperature of the inner tank. [4]

b. Invert T(s) and obtain T for time = 0, 5 h, 10 h, and ∞. [3]

6. A stirred tank heating process and its block diagram are shown in the figures below. The control system is tuned by the Ziegler-Nichols method, and the ultimate frequency ω_u is 2 rad/min.





Data on the process:

Density of the fluid, ρ = 62 lb/ft^3
Heat capacity, C of fluid = 1.0 Btu / (lb.°F)
Inside diameter of pipe = 2.0 in

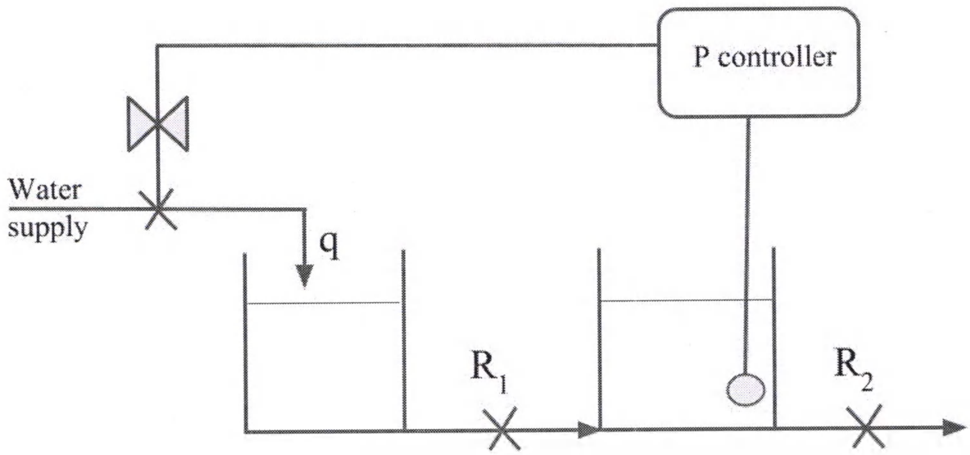
a. Determine the value of K_c by the Ziegler - Nichols method of tuning. [4]
b. What is the length of the pipe between the tank and the measuring element ? [2]
c. What are the gain margin and the phase margin for the control system when Kc is set to the Ziegler - Nichols value found in part (a) ? [3]

7. Consider the liquid level control system shown in figure below. The tanks are interacting. The following information is known:

- The resistances on the tanks are linear. These resistances were tested separately, and it was found that if the steady-state flow rate q cfm is plotted against steady-state tank level h ft, the slope of the line dq/dh is 2 ft^2/min.
- The cross-sectional area of each tank is 2 ft^2.
- The control valve was tested separately, and it was found that a change of 1 psi in pressure to the valve produced a change in flow of 0.1 cfm.
- There is no dynamic lag in the valve or the measuring element.

a. Draw a block diagram of this control system, and in each block give the transfer function, with numerical values of the parameters. [3]
b. Determine the controller gain K_c for a critically damped response. [2]
c. Using 1.5 times the value of K_c determined in part (b), determine the response of the level in tank 2 to a step change in set point of 1 in. of level. [2]

FEB 2 0 2019



OR

The thermal system shown in figure below is controlled by a PD controller. These data are given:

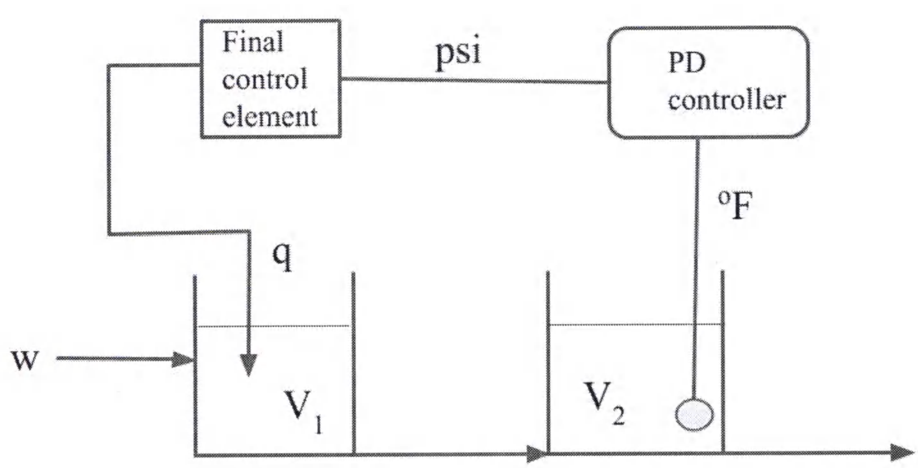
$w = 250$ lb/min
$\rho = 62.5$ lb/ft^3
$V_1 = 4$ ft^3
$V_2 = 5$ ft^3
$C = 1$ Btu/(lb.^{o}F)

A change of 1 psi from the controller changes the flow rate of heat q by 500 Btu/min. The temperature of the inlet stream may vary. There is no lag in the measuring element.

a. Draw a block diagram of this control system with transfer function and numerical values of the parameter in each block. [3]

b. From the block diagram, determine the overall transfer function relating the temperature in tank 2 to a change in set point. [2]

c. Find the offset for a five unit- step change in set point if the controller gain K_c is 3psi/^{o}F of temperature error and the derivative time is 0.5 min. [2]



Supplement Material table

CHEG - 302

Supplemental Materials for the test.

TABLE 2.1

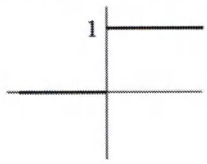
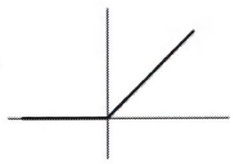
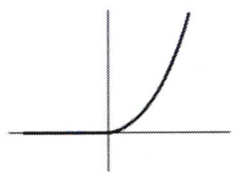
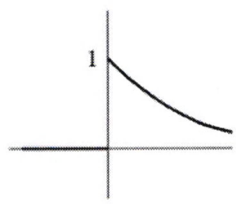
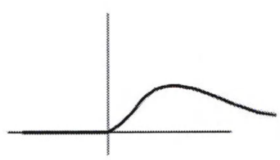
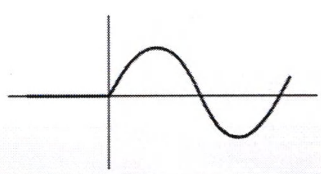
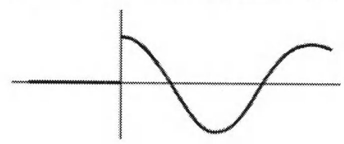
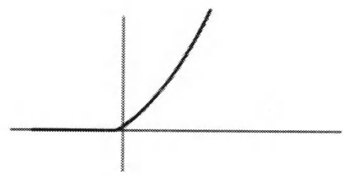
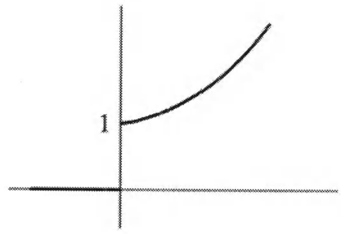
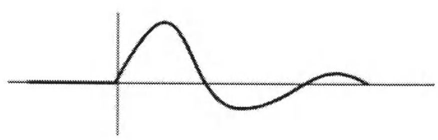
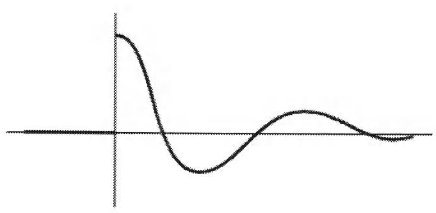
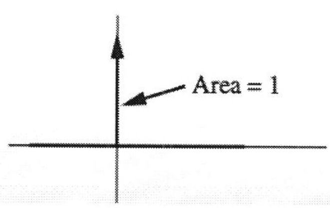
Function	Graph	Transform
$u(t)$		$\frac{1}{s}$
$tu(t)$		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$
$\sin kt\, u(t)$		$\frac{k}{s^2+k^2}$

TABLE 2.1 *(Continued)*

Function	Graph	Transform
$\cos kt\, u(t)$		$\dfrac{s}{s^2 + k^2}$
$\sinh kt\, u(t)$		$\dfrac{k}{s^2 - k^2}$
$\cosh kt\, u(t)$		$\dfrac{s}{s^2 - k^2}$
$e^{-at} \sin kt\, u(t)$		$\dfrac{k}{(s + a)^2 + k^2}$
$e^{-at} \cos kt\, u(t)$		$\dfrac{s + a}{(s + a)^2 + k^2}$
$\delta(t)$, unit impulse		1

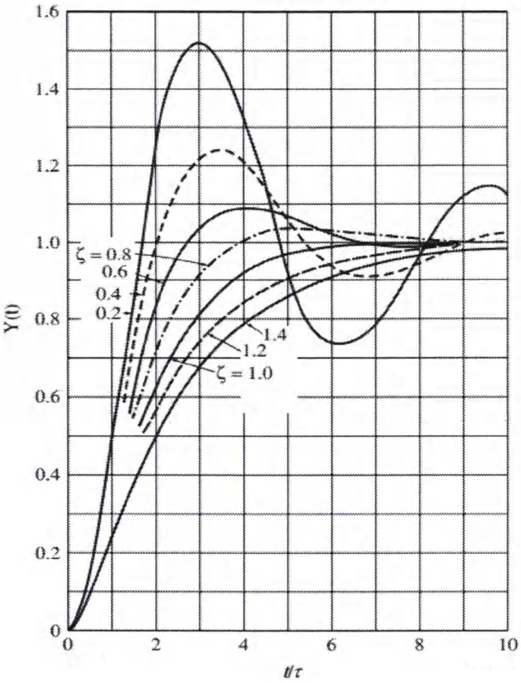


FIGURE 7–3
Response of a second-order system to a unit-step forcing function.

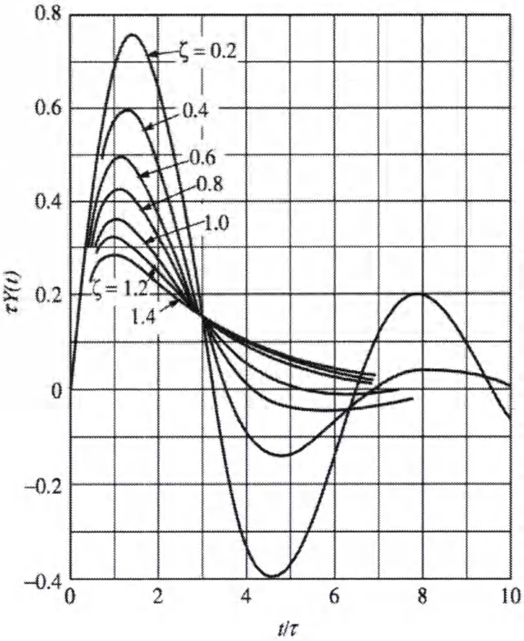


FIGURE 7–8
Response of a second-order system to a unit-impulse forcing function.