Marks scored:

KATHMANDU UNIVERSITY
End Semester Examination [C]
June, 2018

Level : B. E.
Year : III

Course : CHEG 302
Semester: I

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

Registration No.: Date JUN 12 2018

SECTION "A"
[20 Q.×0.5=10 marks]

1. Mercury manometer (U-tube type) exemplifies a __________ system.
   a. zero b. first c. second d. third

2. Bode stability method uses ___________ loop transfer function.
   a. open b. closed c. neither (a) nor (b) d. either (a) or (b)

3. For a feedback control system to be stable, the
   a. roots of the characteristic equation should be real.
   b. poles of the closed loop transfer function should lie in the left half of the complex plane
   c. bode plots of the corresponding open loop transfer function should monotonically decrease.
   d. poles of the closed loop transfer function should lie in the right half of the complex plane.

4. The open loop transfer function of a control system is (K*R/(1+TS)). This represents
   a. a first order system b. dead time system
   c. a First order time lag d. a Second order system

5. The root locus method, a pole of a transfer function G(s) is the value of s for which G(s) approaches
   a. -1 b. 0 c. 1 d. ∞

6. Characteristic equation is the denominator of the _________ transfer function
   a. open b. closed c. both (a) and (b) d. neither (a) nor (b)

7. In Bode plot, Φ vs ω is plotted on a/an __________ graph paper.
   a. ordinary b. semi-log c. log-log d. triangular

8. Phase lag of the sinusoidal response of a first order system is
   a. 90° b. 180° c. 30° d. 120°

9. What is the Laplace transform of cos t ?
   a. $1/(s^2+1)$ b. $s/(s^2+1)$ c. $1/(s^2-1)$ d. $s/(s^2-1)$

10. Pick out the wrong statement.
   a. There is no transfer lag for a single first order system.
   b. Stirred tank with a water jacket exemplifies an interacting system.
   c. Transfer lag is a characteristic of all higher order systems (other than first order systems).
   d. Transfer lag decreases as the number of stages decreases.

11. Cascade system responds faster than conventional control with __________ frequency of oscillation.
   a. lower
   b. higher
   c. equal
   d. specific to the control system

12. The sensitivity is __________ for a square root valve.
   a. increasing
   b. decreasing
   c. linear
   d. none

13. A negative gain margin expressed in decibels means a/an __________ system.
   a. unstable
   b. stable
   c. critically damped
   d. none

14. 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

15. The unit impulse response of a second order system with a gain of 5 always returns a steady state value of
   a. 5
   b. 1
   c. 0
   d. 10

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. 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 = $20 \log_{e}(AR)^{0.5}$

18. Gain margin is equal to the
   a. amplitude ratio
   b. reciprocal of amplitude ratio
   c. gain in P controller
   d. gain in PI controller

19. The frequency response of a first order system has a phase shift with upper and lower bounds given by
   a. $-\infty, \pi/2$
   b. $-\pi/2, \pi/2$
   c. $-\pi/2, 0$
   d. $0, -\pi/2$

20. 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

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F.M. : 40

SECTION "B"

Attempt the following questions

1.

a. Sketch the following functions [4]

i. f(t) = u(t) - 2u(t - 1) + u(t - 3)

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

b. Find x(s) for the following differential equations. You do not need to invert the expression. [2]

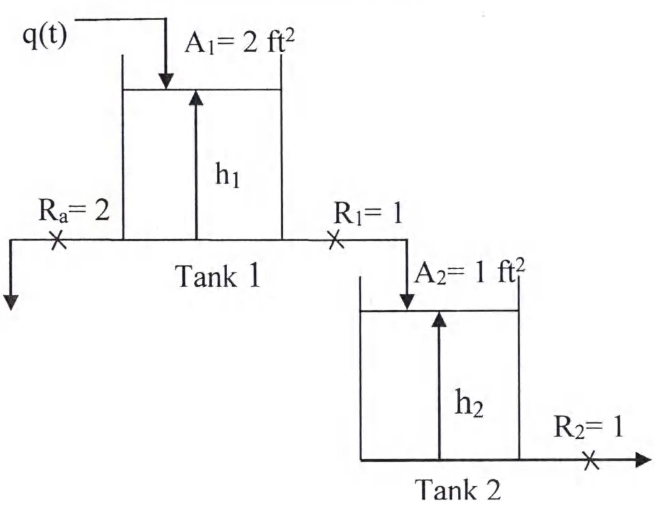
$$\frac{d^3x}{dt^3}+2\frac{d^2x}{dt^2}-\frac{dx}{dt}-2x = 4 + e^{2t}$$

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

c. Invert the following transform: [2]

$$\frac{70 + 400s}{s(5s + 1)}$$

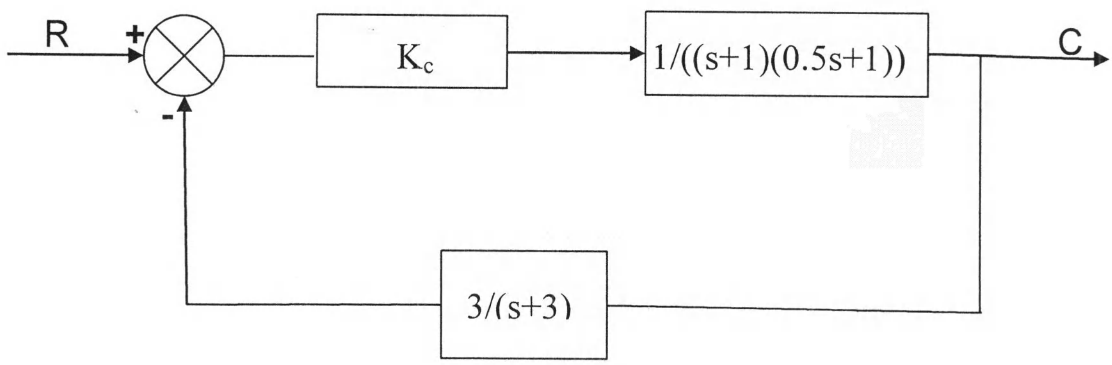
2. Starting from first principles, derive the transfer function $H_1(s)/Q(s)$ and $H_2(s)/Q(s)$ for the liquid level system shown in the figure below. The resistances are linear and $R_1 = R_2 = 1$. Note that two streams are flowing from tank 1, one of which flows into tank 2. You are expected to give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



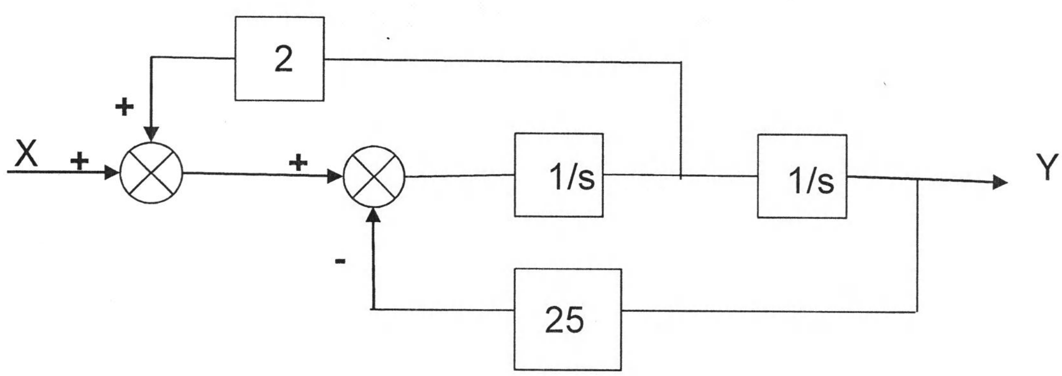
3. For the control system shown below

a. Write the characteristic equation. [2]

b. Construct the Routh array for the control system to determine if the system is stable for K_c = 9.5, 11 and 12 [4]



4. Derive the transfer Y/X for the control system shown below. Please show all the steps for full credit. [6]



JUN 12 2018

5. 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

$V_3 = 6$ ft^3

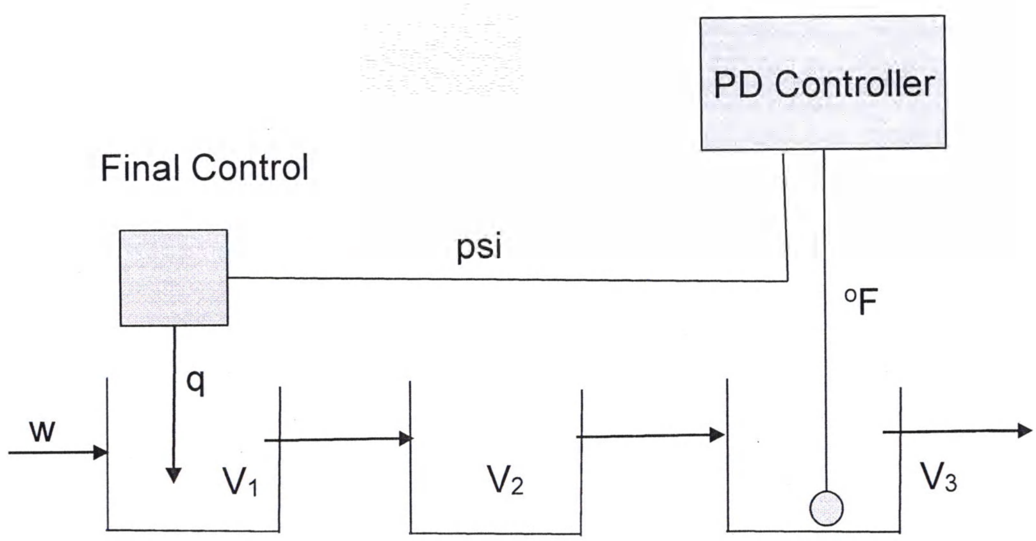
$C = 1$ Btu/(lb.^{o}F)

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 the control system with the appropriate transfer in each block. Each transfer function should contain numerical values of the parameters. [8]

b. From the block diagram, determine the overall transfer function relating the temperature in tank 3 to a change in set point. [2]

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



OR

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

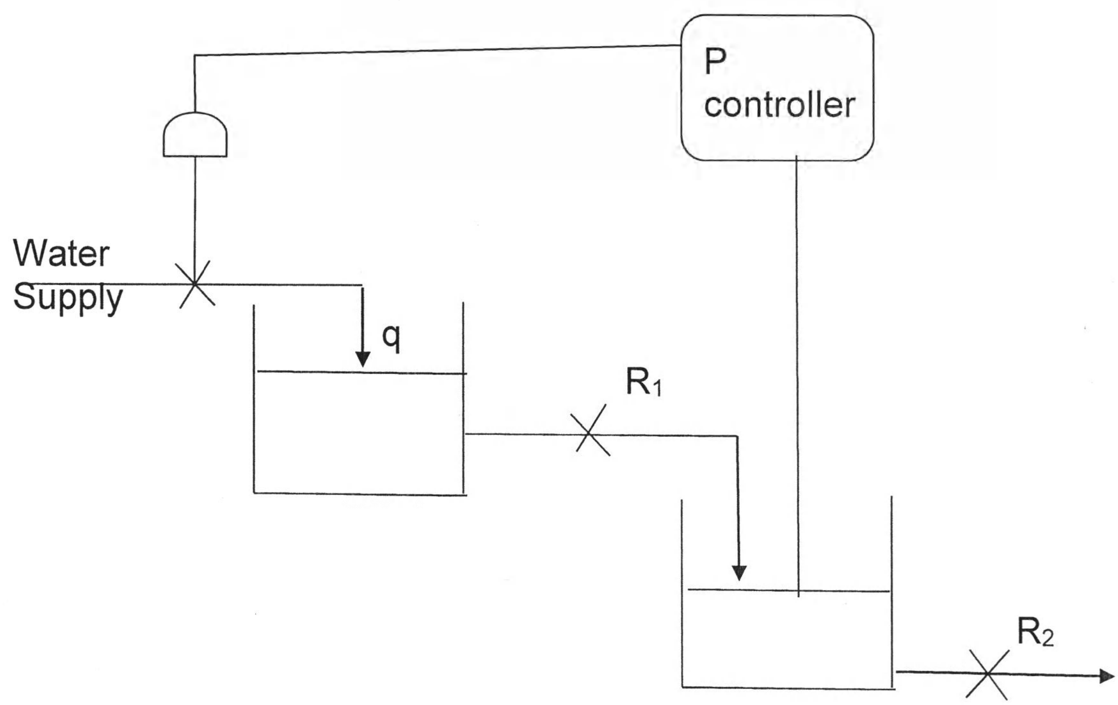
- The resistances on the tanks are linear. These resistances were tested separately, and it was found that if the steady-state flow rate q cfm is plotted against steady-state tank level h ft, the slope of the line dq/dh is 2 ft^2/min.
- The cross-sectional area of each tank is 2 ft^2.
- The control valve 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. [5]

b. Determine the controller gain K_c for a critically damped response. [2]

c. If the tanks were connected so that they were interacting, what is the value of Kc needed for critical damping? [3]

d. Using 1.5 times the value of K_c determined in part (c), determine the response of the level in tank 2 to a step change in set point of 1 in. of level. [2]



CHEG-302 Table

TABLE 2.1

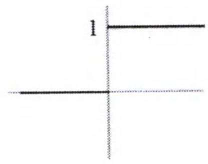
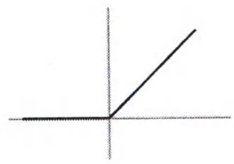
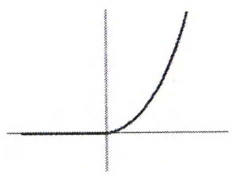
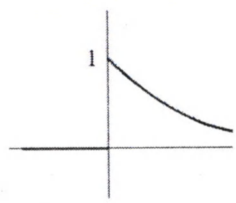
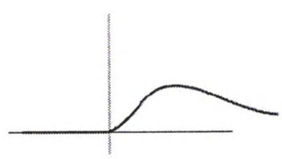
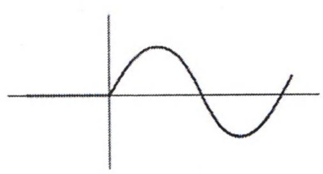
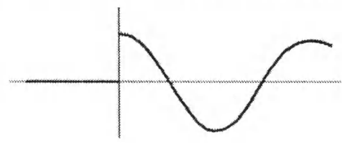
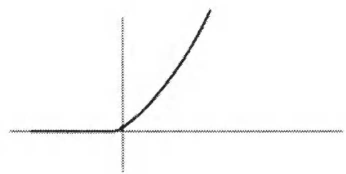
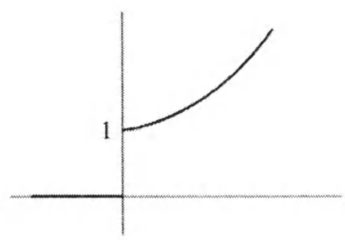
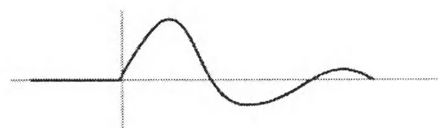
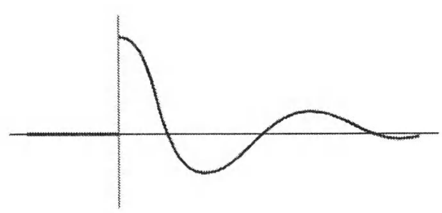
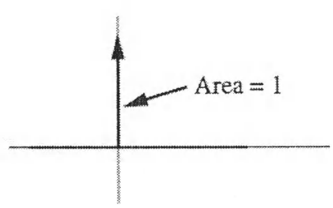
Function	Graph	Transform
$u(t)$		$\frac{1}{s}$
$tu(t)$		$\frac{1}{s^2}$
$t^n u(t)$		$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$		$\frac{1}{s+a}$
$t^n e^{-at}u(t)$		$\frac{n!}{(s+a)^{n+1}}$
$\sin kt\, u(t)$		$\frac{k}{s^2+k^2}$

TABLE 2.1 *(Continued)*

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

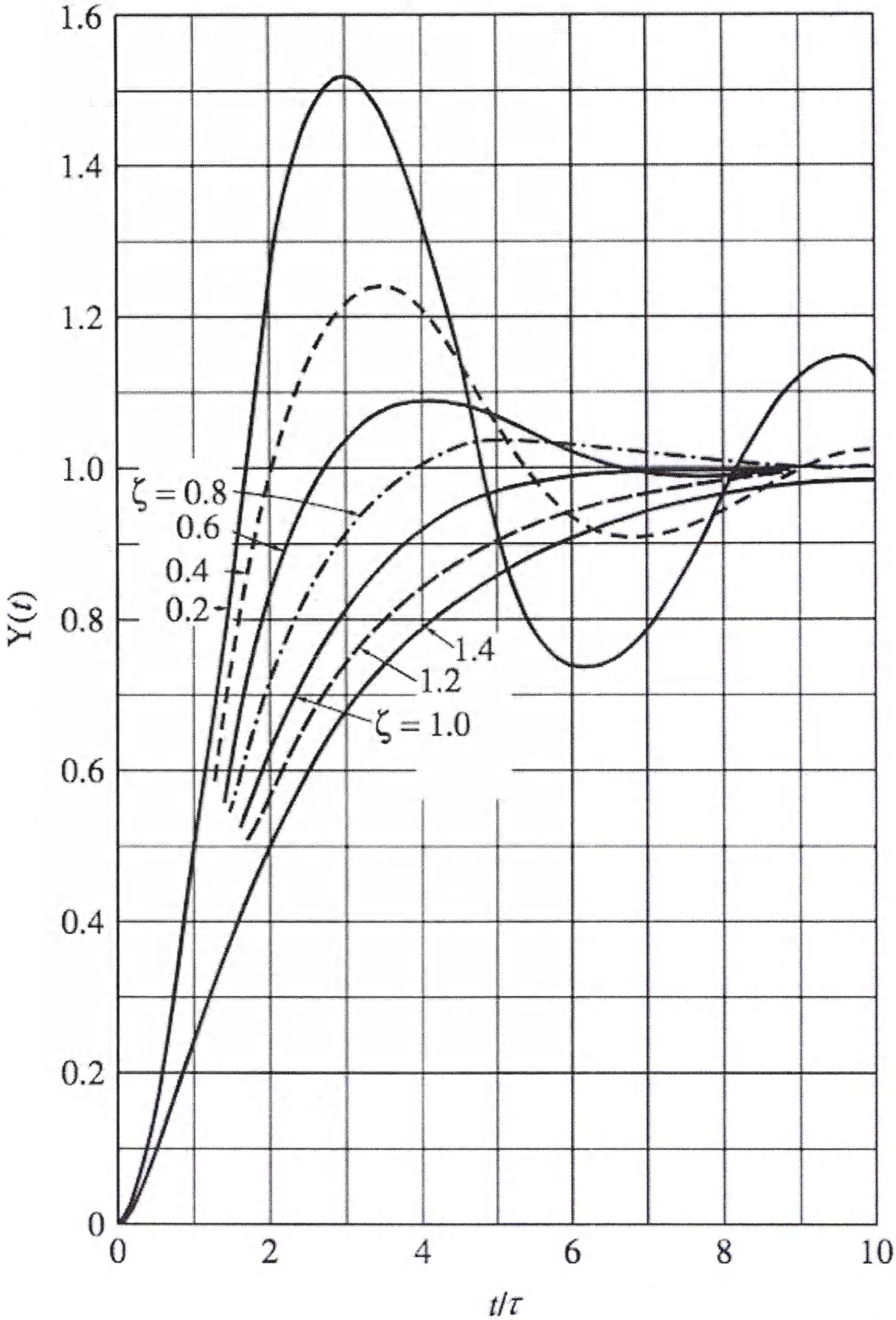


FIGURE 7–3
Response of a second-order system to a unit-step forcing function.

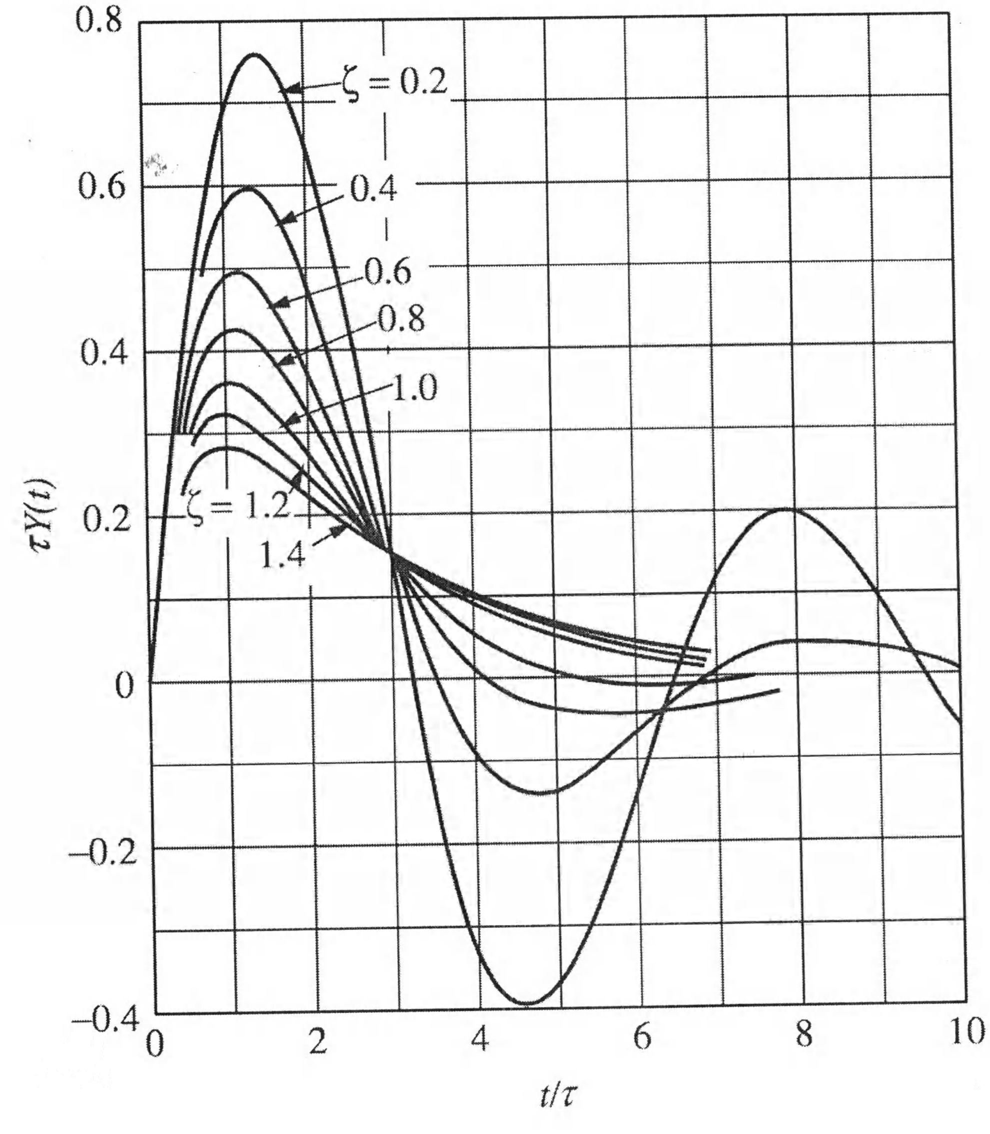


FIGURE 7–8
Response of a second-order system to a unit-impulse forcing function.