

M. TECH. DEGREE EXAMINATIONS: OCTOBER/NOVEMBER – 2008

Third Semester

BIOTECHNOLOGY

P07BTÉ31 Bioprocess Modeling and Simulation

Time: Three Hours

Maximum Marks: 100

Answer ALL Questions:-

PART - A (20 X 1 = 20 Marks)

1. Instrumentation in a plant offers the advantage of
 - A. greater safety of operation
 - B. better quality of product
 - C. greater operation economy
 - D. all (a), (b) & (c)

2. Pick out the first order system from among the following
 - A Damping vibrator
 - B. Mercury in glass thermometer kept in boiling water
 - C. Interacting system of two tanks in series
 - D. Non- interacting system of two tanks in series

3. A stable system is one
 - A. for which the output responses is bounded for all bounded input
 - B. which exhibits an unbounded responses to a bounded input
 - C. which satisfies the conditions for a servo problem
 - D. none of these

4. If $L(Y)$ = Laplace transform of output variable and $L(X)$ = Laplace transform of Input variable, then transfer function is defined as
 - A. $L(Y)/L(X)$
 - B. $L(X)/L(Y)$
 - C. $L(X).L(Y)$
 - D. $L(X) + L(Y)$

5. The transfer function of a second order system is
 - A. $1/\tau^2 s^2 + 2\zeta\tau s + 1$
 - B. $1/\tau^2 s^2 + 2\zeta\tau + 1$
 - C. $1/\tau^2 s^2 + 2\tau s + 1$
 - D. None of these

6. The mechanism which changes the value of the manipulated variable in response to the output signal from the control unit is called

- A. final control element
- B. on-off control
- C. floating control action
- D. none of these

7. A critically damped system is one whose response to an abrupt stimulus is

- A. slow without overshoot
- B. as fast as possible without overshoot
- C. very fast with overshoot
- D. none of these

8. Frequency response of a second order system will be sinusoidal when

- A. It is underdamped
- B. It is overdamped
- C. It is critically damped
- D. Damping coefficient is zero

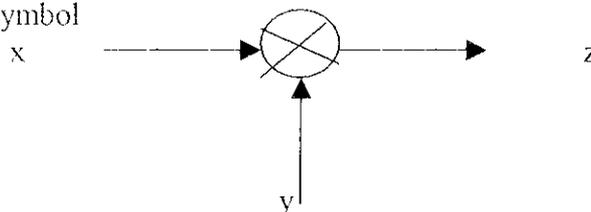
9. Laplace transform of impulse input of magnitude 'A' is

- A. A
- B. A^2
- C. $1/A$
- D. 0

10. In case of a water heater, outlet water temperature is ----- variable

- A. manipulated
- B. controlled
- C. load
- D. none of these

11. The symbol



in a block diagram stand for

- A. multiplier
- B. dynamic function
- C. summing function
- D. none of these

12. Final control element is exemplified by

- A. pneumatic controller
- B. electronic controller
- C. solenoid valve
- D. hydraulic controller

13. Laplace transform of unit step change is

- A. 1
- B. $1/S$
- C. $1/S^2$
- D. 0

14. Routh test

- A. Criterion provides information about the actual location of roots
- B. Cannot be used to test the stability of a control system containing transportation lag
- C. Criterion is not applicable to systems with polynomial characteristic equation
- D. Cannot determine as to how many roots of the characteristics equations have positive real roots

15. Inverse Laplace transform of $1/(S+a)$ is

- A. 1
- B. e^{at}
- C. e^{-at}
- D. e^t

16. Step response of a first order system is

- A. underdamped
- B. critically damped
- C. overdamped
- D. None of these

17. System having a damping coefficient of zero is

- A. underdamped
- B. critically damped
- C. overdamped
- D. undamped

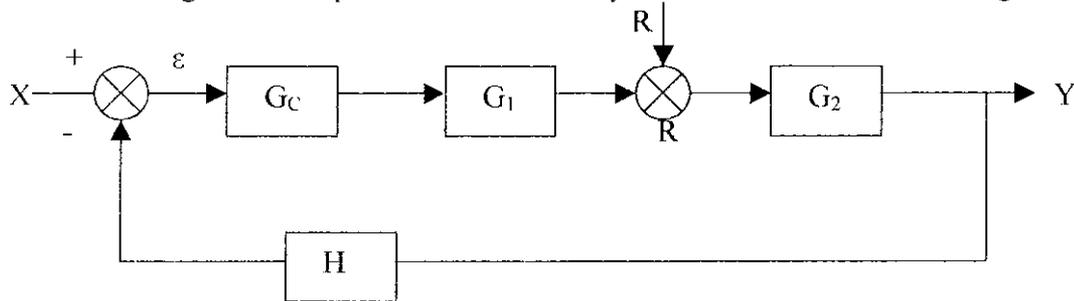
18. The unit of 'time constant' of a system is the same as that of

- A. velocity
- B. time
- C. $(\text{time})^{-1}$
- D. None of these

19. A non-linear chemical system is exemplified by a/an

- A. Isothermal CSTR
- B. mixer
- C. non-isothermal CSTR
- D. none of these

20. Block diagram of simple standard control system is shown below in the figure



- A. The transfer functions of measuring element and the process is represented by H and G_2 respectively
- B. The overall transfer function for the change in load ($X=0$) is given by
$$Y/X_1 = G_c \cdot G_1 \cdot G_2 / (1 + G_c \cdot G_1 \cdot G_2 \cdot H)$$
- C. The overall transfer function for the change in set point ($X_1 \neq 0$) is given by
$$Y/X = G_c \cdot G_1 \cdot G_2 / (1 + G_c \cdot G_1 \cdot G_2 \cdot H)$$
- D. Manipulated variable is represented by C

PART B - (5 X 16 = 80 Marks)

21. (a) (i). Draw a simplified control block diagram and discuss in detail about the each of the steps in formulating a control problem. (8 marks)
- (ii). Write balance equations using the integral and instantaneous methods. (8 marks)

(OR)

(b) (i). Explain in detail to linearize nonlinear models for control systems design and analysis purposes (Taylor series approximation and generalization). (8 marks)

(ii). Develop a model (for heated mixing tank) consisting of both material and energy balances and illustrates the steady-state effect of the input on the output. (8 marks)

22. (a) (i). Discuss in detail about the general procedure to obtain analytical solutions for differential equation based models. (6 marks)

(ii). Consider the following state space model of an isothermal CSTR

$$dx_1/dt = -2.4048x_1 + 7u$$

$$dx_2/dt = 0.833x_1 - 2.2381x_2 - 1.1170u$$

$$y = x_2$$

where x_1 and x_2 represent the concentrations of two components (in deviation variable form) in an isothermal reactor; the initial conditions are $x_1(0) = x_2(0) = 0$. Solve for the output (concentration of component 2) response to a unit step input. (10 marks)

(OR)

(b).(i). Find the Eigen values of (1) $A = \begin{Bmatrix} 1 & -1 \\ 1 & 3 \end{Bmatrix}$

(2) $A = \begin{Bmatrix} 3 & 2 & 2 \\ 1 & 4 & 1 \\ -2 & -4 & -1 \end{Bmatrix}$

(3) Find the long term and short term behavior of the time domain function $y(t)$ using the final and initial value theorems on the laplace domain function

$$Y(s) = 4 / [s (2s+1) (3s+1)]$$

(8 marks)

(ii). Write the Routh Stability Criterion theorem and determine the stability by routh criterion for the characteristic equation $s^4 + 3s^3 + 5s^2 + 4s + 2 = 0$ (8 marks)

23. (a). Explain the following

- 1) Lead - lag Behavior
- 2) Poles and Zeros
- 3) Steps to convert general state space model to transfer function form
- 4) Comparison of first-order + dead time transfer function $G(s) = e^{-10s}/5s+1$ with first and second-order pade approximations for dead time with figure.

(16 marks)

(OR)

(b). Explain in detail about the first order, first-order + dead time (including pade approximation for dead time) and integrating system step responses.

(16 marks)

24. (a). Explain the following for the Discrete-time models

1. General form of discrete model
2. Z-Transforms for discrete systems
3. Poles/zeros of discrete models with example
4. Initial and final value theorem for discrete systems
5. Parameter estimation for discrete dynamic models.

(16 marks)

(OR)

(b). (i). With neat diagrams explain the development of control block diagrams for a level control with outlet flow rate manipulated (feedback control loops).
(10 marks)

(ii). What is cascade control? Explain the cascade-control analysis system with neat diagram of series cascade structure. (6 marks)

25. (a). Develop the material & energy balances, dynamic model, steady state condition, and state space models for stirred tank heaters with a neat diagram and control block diagram.
(16 marks)

(OR)

(b). Develop the material & energy balances, dynamic model, steady state condition, state space models for isothermal CSTR. (16 marks)
