GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO S25 – QUESTION BANK

Subject Name & Code:

Process Modelling, Simulation and Optimization- 3170513

Unit 1: Introduction

Repeated Questions:

1. **Describe the fundamental laws used in mathematical models of chemical engineering systems.**
   - Appeared in: W24 (Q2a, 03 marks), W23 (Q1b, 03 marks), W22 (Q1b, 04 marks)
2. **Compare linear and non-linear models.**
   - Appeared in: SUM25 (Q1b, 04 marks), W23 (Q5a, 03 marks), W24 (Q4a, 03 marks)
3. **Explain the uses of mathematical models.**
   - Appeared in: S23 (Q4a, 03 marks), SUM25 (Q1a, 03 marks)

Other Important Questions:

4. **Define the following terms for optimization: Feasible solution, feasible region, optimal solution.**
   - Appeared in: S23 (Q1a, 03 marks)
5. **Define: feasible region, global minimum, convex region.**
   - Appeared in: W23 (Q4a, 03 marks), W22 (Q4a, 03 marks)
6. **Explain concavity with examples.**
   - Appeared in: W23 (Q1a, 03 marks)
7. **Differentiate between deterministic and stochastic models.**
   - Appeared in: W23 (Q2a, 03 marks), W22 (Q2a, 03 marks)
8. **Explain the meaning of Modelling, Simulation and Optimization. State its importance and applications.**
   - Appeared in: (Based on Syllabus Unit 1)
9. **What is the comparison of design and simulation?**
   - Appeared in: (Based on Syllabus Unit 1)
10. **List the six general steps for the analysis and solution of an optimization problem.**
    - Appeared in: S23 (Q1c, 07 marks)

11. **Describe the major obstacles to optimization problem.**
    - Appeared in: S23 (Q1b, 04 marks)
12. **Write the steps for solving optimization problems. Also list the common obstacles faced while solving optimization problems.**
    - Appeared in: W24 (Q1c, 07 marks)
13. **Explain the essential features of optimization problems.**
    - Appeared in: (Based on Syllabus Unit 6)
14. **Explain various applications of modelling and simulation.**
    - Appeared in: S23 (Q2a, 03 marks)

Unit 2: Modelling Aspects

Repeated Questions:

1. **Differentiate between steady state and dynamic simulation.**
   - Appeared in: W24 (Q3a, 03 marks), S23 (Q3b, 04 marks)
2. **Explain the importance of degree of freedom in model building.**
   - Appeared in: S23 (Q3a, 03 marks)
3. **Give a detailed classification of models.**
   - Appeared in: W22 (Q3c, 07 marks), W23 (Q3c, 07 marks)

Other Important Questions:

4. **Explain white box model.**
   - Appeared in: S23 (Q3b, 04 marks)
5. **Explain black box model.**
   - Appeared in: SUM25 (Q4b, 03 marks)
6. **What is a physical and mathematical model?**
   - Appeared in: (Based on Syllabus Unit 2)
7. **Describe the process to build a model.**
   - Appeared in: (Based on Syllabus Unit 2)
8. **What is an empirical model? How do you select functions to fit empirical data?**
   - Appeared in: (Based on Syllabus Unit 2)

Unit 3: Mathematical Modelling of Chemical Engineering Systems

Repeated Questions:

1. **Develop a model for a batch reactor.**
   - Appeared in: W22 (Q2b, 04 marks), W23 (Q2b, 04 marks), S23 (Q3c, 07 marks)
2. **Explain mathematical modeling of an ideal binary distillation column.**
   - Appeared in: W23 (Q4c, 07 marks), W22 (Q4c, 07 marks), SUM25 (Q5c, 07 marks)

Other Important Questions:

3. **Write a note on the transport equations used for modeling.**
   - Appeared in: W23 (Q5b, 04 marks), W22 (Q5b, 04 marks)
4. **Explain the fundamental laws of physics and chemistry with their applications to simple chemical systems.**
   - Appeared in: SUM25 (Q3b, 04 marks)
5. **State the principles of model formulation.**
   - Appeared in: (Based on Syllabus Unit 3)

Other Important Questions (Numerical/Model Development):

6. **A tank contains 10 lit. of fresh water. Brine (10 kg/m³ salt) is fed at 0.5 lit/min. The output is 0.4 lit/min. Evaluate the tank volume when the concentration inside is 25% of the inlet.**
   - Appeared in: W22 (Q1c, 07 marks), W23 (Q1c, 07 marks)
7. **A fluid of constant density is pumped into a cone-shaped tank of total volume $H\pi R^2/3$. The flow out is proportional to $\sqrt{h}$. Derive the equations describing the system.**
   - Appeared in: SUM25 (Q2c, 07 marks)
8. **Derive a dynamic mathematical model for the nitration of benzene in an isothermal CSTR with three sequential irreversible reactions.**
   - Appeared in: SUM25 (Q2c-OR, 07 marks)
9. **Develop a model for a series of isothermal, variable hold-up CSTRs in which a first order reaction A → B is taking place.**
   - Appeared in: W24 (Q5c, 07 marks), S23 (Q4c, 07 marks)
10. **Derive a relation for solute to be extracted in a steady state two-stage solvent extraction unit. Extend this relation for 'N' stages.**
    - Appeared in: W24 (Q5a, 07 marks)

Unit 4: Examples of Mathematical Models of Chemical Engineering Systems

Repeated Questions:

1. **Develop a model for a batch reactor.**
    - Appeared in: W22 (Q2b, 04 marks), W23 (Q2b, 04 marks), S23 (Q3c, 07 marks), W24 (Q2c, 07 marks)
2. **Explain mathematical modeling of an ideal binary distillation column.**
    - Appeared in: W23 (Q4c, 07 marks), W22 (Q4c, 07 marks), SUM25 (Q5c, 07 marks)

Other Important Questions:

3. **Develop the equations for a series of isothermal, variable holdup CSTRs.**
    - Appeared in: S23 (Q4c, 07 marks)
4. **Develop a model for a batch reactor where a series reaction A → B → C takes place. B is the desirable product. The reactor has a jacket for heating/cooling.**
    - Appeared in: W24 (Q2c, 07 marks)

Other Important Questions (Numerical):

5. **A fluid of constant density is pumped into a cone-shaped tank... Derive the equations.**
    - Appeared in: SUM25 (Q2c, 07 marks) [*Included in Unit 3 list as it's a core modelling problem*]
6. **Derive a dynamic mathematical model for the nitration of benzene in an isothermal CSTR...**
    - Appeared in: SUM25 (Q2c-OR, 07 marks) [*Included in Unit 3 list as it's a core modelling problem*]

Unit 5: Chemical Process Plant Simulation

Repeated Questions:

1. **Differentiate between steady state and dynamic simulation.**
   - Appeared in: W24 (Q3a, 03 marks), S23 (Q3b, 04 marks)
2. **Differentiate sequential modular approach and simultaneous modular approach.**
   - Appeared in: W22 (Q3a, 03 marks), W23 (Q3a, 03 marks)
3. **Write a short note on decomposition of networks.**
   - Appeared in: W23 (Q4b, 04 marks), W22 (Q4b, 04 marks), S23 (Q5b, 04 marks), SUM25 (Q4b, 04 marks)

Other Important Questions:

4. **Explain equation-oriented mode in simulation.**
   - Appeared in: SUM25 (Q2a, 03 marks)
5. **What is sequential modular approach in simulation? Explain the steps with a diagram.**
   - Appeared in: S23 (Q3c, 07 marks)
6. **Explain equation solving approach in brief.**
   - Appeared in: S23 (Q3a, 03 marks)
7. **Discuss the salient features of basic tearing algorithm with a flowchart.**
   - Appeared in: W24 (Q5b, 04 marks)
8. **Explain the features of Basic Tearing Algorithm.**
   - Appeared in: S23 (Q2c-OR, 07 marks)
9. **Describe any one chemical process simulator and its salient features.**
   - Appeared in: SUM25 (Q2b, 04 marks), W23 (Q3c, 07 marks), W22 (Q1a, 03 marks)
10. **List the process simulators used in chemical engineering. Discuss the common features of process simulators.**
    - Appeared in: W24 (Q5b, 07 marks)
11. **Differentiate between design mode and analysis mode in process simulation with a diagram.**
    - Appeared in: W24 (Q4b, 04 marks)

Unit 6: Basic Concepts of Optimization

Repeated Questions:

1. **Explain the necessary and sufficient conditions for an extremum of an unconstrained function.**
    - Appeared in: S23 (Q5b, 04 marks)
2. **Explain convexity and its application.**
    - Appeared in: (Based on Syllabus Unit 6 - Implied by multiple questions on convexity/concavity)

Other Important Questions:

3. **Determine whether the function is convex or concave. $f(x) = 2x_1^2 - 3x_1x_2 + 2x_2^2$**
    - Appeared in: W24 (Q1a, 03 marks), S23 (Q4b, 04 marks)
4. **Find the extreme points of the function and classify them. $f(x) = x_1^3 + x_2^3 + 2x_1^2 + 4x_2^2 + 6$**
    - Appeared in: W24 (Q2c-OR, 07 marks)

Other Important Questions (Numerical):

5. **A box with a square base and open top is to hold 1000 cm^3. Find the dimensions that require the least material.**
    - Appeared in: S23 (Q2b, 04 marks), W24 (Q1b, 04 marks)

Unit 7: Optimization of Unconstrained Functions

Repeated Questions:

1. **Use Newton's method to minimize a function.**
   - Appeared in: S23 (Q5c, 07 marks), W24 (Q3a, 03 marks), W24 (Q4a, 07 marks)

Other Important Questions (Theoretical):

2. **Classify the methods to solve unconstrained multivariable problems.**
   - Appeared in: W22 (Q3a, 03 marks), W23 (Q3a, 03 marks), SUM25 (Q3a, 03 marks)
3. **Explain in brief how one-dimensional search is applied in a multidimensional problem.**
   - Appeared in: S23 (Q4c, 07 marks)
4. **Explain Random search and Grid search method for unconstrained multivariable optimization.**
   - Appeared in: W24 (Q2b, 04 marks), W23 (Q5b, 04 marks), W22 (Q5b, 04 marks), SUM25 (Q5a, 03 marks)
5. **Show the advantages and disadvantages of region elimination methods.**
   - Appeared in: W24 (Q3b, 04 marks)
6. **Explain Simplex search method.**
   - Appeared in: S23 (Q4a, 03 marks)

Other Important Questions (Numerical):

7. **Minimize function $f(x) = x^4 - x + 1$ using Newton's method for a starting point of $x = 3$. Show five iterations.**
   - Appeared in: S23 (Q5c, 07 marks)
8. **Minimize the function $f = 4x^3 + x^2 - 7x + 14$ in the interval [0, 1] using (i) Bisection method and (ii) Golden section method. Compare the methods.**
   - Appeared in: W24 (Q3c, 07 marks)
9. **Using Hooke-Jeeves method minimize $Z = f(x,y) = (x^2+y-11)^2 + (x+y^2-7)^2$. Take initial point (0,0) and increment vector $\Delta = (0.5, 0.5)$.**
   - Appeared in: SUM25 (Q3c, 07 marks)
10. **Find the minimum of the function $f(x) = 0.65 - [0.75/(1+x^2)] - 0.065x \tan^{-1}(1/x)$ using Quasi-Newton method with $x_1=0.1$, $\Delta x=0.01$, $\varepsilon=0.01$.**
    - Appeared in: SUM25 (Q1c, 07 marks)
11. **Minimize the quadratic function $f(x) = x^2 - x$ using finite difference Newton method start with $x=3$ and $h=0.001$.**
    - Appeared in: S23 (Q5a, 03 marks)

Unit 8: Linear Programming (LP) and Applications

Repeated Questions:

1. **Use the simplex method to solve a Linear Programming problem.**
    - Appeared in: SUM25 (Q4c, 07 marks), W22 (Q2c, 07 marks), W23 (Q2c, 07 marks), S23 (Q5c, 07 marks)

Other Important Questions:

2. **What is a linear programming problem? State the linear programming in standard form and write down its application in chemical industries.**
    - Appeared in: W23 (Q5c, 07 marks), W22 (Q5c, 07 marks)
3. **Explain Simplex algorithm for linear programming.**
    - Appeared in: W23 (Q4b, 04 marks), W22 (Q4b, 04 marks)
4. **Explain primal-dual relationship in LP Problem.**
    - Appeared in: SUM25 (Q4a, 03 marks)
5. **Formulate a Linear Programming model.**
    - Appeared in: (Based on Syllabus Unit 8)

Other Important Questions (Numerical):

6. **Use simplex method to find the maximum value of $Z = 2x_1 - x_2 + 2x_3$ subject to constraints.**
    - Appeared in: W22 (Q2c, 07 marks), W23 (Q2c, 07 marks)
7. **A manufacturer produces three types of plastic fixtures. The time required for molding, trimming, and packaging is given. Use simplex method to find how many dozen of each type should be produced to obtain a maximum profit?**
    - Appeared in: SUM25 (Q3c, 07 marks)

Unit 9: Constrained Optimization

Repeated Questions:

1. **Use Lagrange Multipliers to solve a constrained optimization problem.**
    - Appeared in: SUM25 (Q4c, 07 marks), W22 (Q2c-OR, 07 marks), S23 (Q5a, 03 marks)

Other Important Questions:

2. **Explain the penalty methods for solving nonlinear programming with constraints.**
    - Appeared in: W23 (Q4a, 03 marks), W22 (Q4a, 03 marks), S23 (Q4b, 04 marks)
3. **Explain Lagrange multiplier method.**
    - Appeared in: S23 (Q5a, 03 marks)

Other Important Questions (Numerical):

4. **Using the Kuhn-Tucker conditions minimize $f(X) = X_1^2 - X_2$, subject to $X_1 + X_2 = 6$, $X_1 \geq 1$, $X_1^2 + X_2^2 \leq 26$.**
    - Appeared in: W23 (Q5c, 07 marks)
5. **A firm produces two goods, x and y, subject to $x + y = 42$. The firm's cost function is $c(x, y) = 8x^2 - xy + 12y^2$. Maximize using the Lagrangian method.**
    - Appeared in: W22 (Q2c-OR, 07 marks), W23 (Q2c-OR, 07 marks)
6. **Solve the following non-linear function with constraints using Lagrange multiplier method. Minimize: $f(x,y) = k\, x^2\, y^2$ subject to: $g(x,y) = x^2 + y^2 = a^2$.**
    - Appeared in: W24 (Q4b, 07 marks)

Unit 10: Application of Optimization

Repeated Questions:

1. **Discuss the optimizing recovery of waste heat with suitable figure and equations.**
    - Appeared in: W24 (Q4c, 07 marks), W22 (Q4c, 07 marks), S23 (Q2c, 07 marks)
2. **List the applications of optimization in chemical process and plants. Explain any one in detail.**
    - Appeared in: W24 (Q3c, 07 marks), W22 (Q5c, 07 marks)

Other Important Questions:

3. **Describe the role of optimization in shell and tube heat exchanger design.**
    - Appeared in: W24 (Q5a, 03 marks)
4. **Discuss the optimization of pipe diameter.**
    - Appeared in: W22 (Q3b, 04 marks), W23 (Q3b, 04 marks)
5. **Explain the application of optimization in fitting vapor-liquid equilibrium data.**
    - Appeared in: W23 (Q3b, 04 marks)
6. **Explain the steps for finding the optimum L/D ratio for a pressurized cylindrical storage vessel.**
    - Appeared in: W22 (Q3c, 07 marks)
7. **Determine the optimum L/D ratio for a cylindrical storage vessel. List the necessary assumptions.**
    - Appeared in: W24 (Q3b, 04 marks)
8. **State objective functions in terms of the adjustable variable for a chemical reactor.**
    - Appeared in: SUM25 (Q3a, 03 marks), W23 (Q5a, 03 marks), W22 (Q5a, 03 marks)

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