U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH5PELA3 / 22CH5PELA3 **Max Marks: 100**
Course: Optimization of Chemical Processes

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	Marks
1	a)	List the essential features of optimization and give the mathematical equation for these essential features.	*CO1*	*PO2*	**06**
	b)	A trucking company has borrowed Rs. 600,000 for new equipment and is contemplating three kinds of trucks. Truck A costs Rs.10,000, truck B Rs. 20,000, and truck C Rs. 23,000. How many trucks of each kind should be ordered to obtain the greatest capacity in ton-miles per day based on the following data? Truck A requires one driver per day and produces 2100 ton-miles per day. Truck B requires two drivers per day and produces 3600 ton-miles per day. Truck C requires two drivers per day and produces 3780 ton-miles per day. There is a limit of 30 trucks and 145 drivers. i. Formulate the objective function ii. Formulate the constraints equations iii. Make a list of the variables by names and symbol plus units.	*CO1*	*PO2*	**08**
	c)	Summarize the different methods applied to measure profitability and give the relevant equation for the same.	*CO1*	*PO2*	**06**
		OR			
2	a)	With the help of a block diagram explain the scope and hierarchy of optimization in detail.	*CO1*	*PO2*	**10**
	b)	Engineers proposed two plans for supplying water to a plant. Plan A requires a pipeline costing Rs.160,000 with annual operation and upkeep costs of Rs. 2200, and an estimated life of 30 years with no salvage. Plan B requires a flume costing Rs. 34,000 with a life of 10 years, a salvage value of Rs. 5600, and annual	*CO2*	*PO7*	**10**

			operation and upkeep cost of Rs. 4500 plus a ditch costing Rs. 58,000, with a life of 30 years and annual costs for upkeep of Rs. 2500. Using an interest rate of 12 %, compare the net present values of the two alternatives.			
			UNIT - II			
	3	a)	Plot the objective function and constraints of the following nonlinear programming problems and indicate the feasible region. i. Minimize: $f(x) = 2{x_1}^2 - 2x_1x_2 + 2{x_2}^2 - 6x_1 + 6$ Subjected to constraint: $g(x) = x_1 + x_2 \leq 2$ ii. Minimize: $f(x) = {x_1}^3 - 3x_1x_2 + 4$ Subjected to constraint 1: $g(x) = 5x_1 + 2x_2 \geq 18$ Subjected to constraint 2: $h(x) = -2x_1 + {x_2}^2 = 5$	*CO2*	*PO7*	**10**
		b)	Consider the given function $f = (x-1)^4$ i. Plot the function and bracket the initial values of the variable. ii. Apply the Newton's method and the quasi-Newton (secant) method to minimize the function.	*CO2*	*PO7*	**10**
			OR			
	4	a)	Explain steps involved in quadratic interpolation and show the postulates to bracket the minimum in quadratic interpolation.	*CO3*	*PO2*	**10**
		b)	Determine the convexity or concavity of the following objective function i. $f(x_1, x_2) = (x_1 - x_2)^2 + {x_2}^2$ ii. $f(x_1, x_2, x_3) = {x_1}^2 + {x_2}^2 + {x_3}^2$ iii. $f(x_1, x_2) = e^{x_1} + e^{x_2}$	*CO3*	*PO2*	**10**
			UNIT - III			
	5	a)	Solve the given function by graphical method to indicate the feasible region. Maximize: $f = x_1 + 3x_2$ Subjected to: $-x_1 + x_2 \leq 1$ $x_1 + x_2 \leq 2$ $x_1 \geq 0$ and $x_2 \geq 0$	*CO3*	*PO2*	**10**
		b)	Illustrate septs involved to optimize a given function using simplex method with a suitable example.	*CO3*	*PO2*	**10**
			OR			
	6	a)	Solve the given function by graphical method to find the optimum value of the of the given function.	*CO3*	*PO2*	**10**

			Minimize: $f = 40x_1 + 36x_2$ Subjected to: $5x_1 + 3x_2 \geq 45$ $0 \leq x_1 \leq 8$ and $0 \leq x_2 \leq 10$			
		b)	Solve the given function and find the optimum value of the function using simplex method. Maximize: $f = 3x_1 + 2x_2$ Subjected to: $-x_1 + 2x_2 \leq 4$ $3x_1 + 2x_2 \leq 14$ $x_1 - x_2 \leq 3$ $x_1 \geq 0$ and $x_2 \geq 0$	*CO3*	*PO2*	**10**
			UNIT - IV			
	7	a)	Consider a multiple evaporation process used for concentrating an inorganic salt in the range of 0.1 to 1.0 wt %. The plant capacity of 3 million gallons/day. Initially let us consider the number of evaporation stages 'n' as a continuous variable. Apply a suitable heat balance and formulate the objective function considering the total cost of operation.	*CO4*	*PO6*	**10**
		b)	A single pass counter-current shell and tube heat exchanger is used in the industry. Consider the outside heat transfer co-efficient and inside heat transfer co-efficient and formulate an objective function for the shell and tube heat exchanger.	*CO4*	*PO6*	**10**
			OR			
	8	a)	Formulate an objective function and constrained equations for optimal design and operation of a conventional staged distillation column for binary component separation.	*CO4*	*PO6*	**10**
		b)	An Industrial process has a boiler, turbine, generator, condenser, storage tank, and other auxiliary equipment. The process variables are listed below. Develop an objective function for optimal recovery of waste heat and illustrate method applied to minimize the resulting objective function. Data: U = f (working fluid and operating temp), cost per unit area of the heat exchanger, annual capital investment, annual capital cost for boilers, operating cost, overall system efficiency, t = operating time in h, power from the boiler, and value of the power ($/ kW. h).	*CO4*	*PO6*	**10**
			UNIT - V			
	9	a)	Consider the Haber process for synthesis ammonia. The temperature at which the reaction rate is maximum decreases as the conversion increases. Apply the energy balance and mass balance for each component considering suitable reaction in the ammonia reactor to optimize the reactor design.	*CO4*	*PO6*	**10**

		b)	Develop an objective function for operation of a fixed bed filter. Optimize the objective function to estimate the optimum amount of water removed during filtration operation.	*CO4*	*PO6*	**10**
			OR			
	10	a)	The gas is compressed adiabatically through three staged compressors connected in series. An intermediate cooler is connected after the 1st and 2nd stage compressor to cool the gas back to feed gas temperature. Determine equations to optimize the interstage pressures to minimize the work of a compressor system.	*CO4*	*PO6*	**10**
		b)	Find optimal diameter of pipe in a flow system for turbulent flow. Assume friction factor $f = 0.046Re^{-0.2}$	*CO4*	*PO6*	**10**

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