Advance Engineering Mathematics(AEM)

Branch :Information Technology, Sem:IIIrd

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Vision of the Institute

To become a renowned centre of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities

Mission of the Institute

- Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.
- Identify, based on informed perception of Indian, regional and global needs, the areas of focus and provide platform to gain knowledge and solutions.
- Offer opportunities for interaction between academia and industry.
- Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders may emerge.

Course Outcomes

- **CO2:** To learn the formulation of different mathematical problems into optimization problems.
- **CO3:** Apply the principles of optimization using differential calculus.
- **CO4:** To understand the concepts of Linear Programming
- **CO1:** To learn the concepts and principles of Random variables and Probability distribution.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

Co/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	H	L	L		L	L	L		L	L		L
CO2	H	L	L		L	L	L		L	L		L
CO3	H	L	L		L	L	L		L	L		L
CO4	H	L	L		M	L	L		L	L		L

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Teaching & Examination Scheme
B.Tech. : Information Technology
2nd Year - III Semester

THEORY											
SN	Category	Course		Contact hrs/week			Marks				Cr
		Code	Title	L	T	P	Exm Hrs	IA	ETE	Total	
1	BSC	3IT2-01	Advanced Engineering Mathematics	3	0	0	3	30	120	**150**	**3**
2	HSMC	3IT1-02/ 3IT1-03	Technical Communication/ Managerial Economics and Financial Accounting	2	0	0	2	20	80	**100**	**2**
3	ESC	3IT3-04	Digital Electronics	3	0	0	3	30	120	**150**	**3**
4	PCC	3IT4-05	Data Structures and Algorithms	3	0	0	3	30	120	**150**	**3**
5		3IT4-06	Object Oriented Programming	3	0	0	3	30	120	**150**	**3**
6		3IT4-07	Software Engineering	3	0	0	3	30	120	**150**	**3**
			Sub Total	17	0	0		170	680	**850**	**17**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

II Year- III Semester: B.Tech. (Information Technology)

3IT2-01: Advanced Engineering Mathematics

Credit- 3
3L+0T+0P

Max. Marks : 150 (IA:30,ETE:120)
End Term Exam: 03 Hours

SN	CONTENTS	Hours
1	**Random Variables:** Discrete and Continuous random variables, Joint distribution, Probability distribution function, conditional distribution. Mathematical Expectations: Moments, Moment Generating Functions, variance and correlation coefficients, Chebyshev's Inequality, Skewness and Kurtosis.	7
2	**Binomial distribution**, Normal Distribution, Poisson Distribution and their relations, Uniform Distribution, Exponential Distribution. Correlation: Karl Pearson's coefficient, Rank correlation. Curve fitting. Line of Regression.	5
3	**Historical development**, Engineering Applications of Optimization, Formulation of Design Problems as a Mathematical Programming Problems, Classification of Optimization Problems	8
4	**Classical Optimization using Differential Calculus:** Single Variable and Multivariable Optimization with & without Constraints, Langrangian theory, Kuhn Tucker conditions	6
5	**Linear Programming:** Simplex method, Two Phase Method and Duality in Linear Programming. Application of Linear Programming: Transportation and Assignment Problems.	14
	TOTAL	**40**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA SYLLABUS

II Year- III Semester: B.Tech. (Information Technology)

3IT2-01: Advanced Engineering Mathematics

LECTURE PLAN

Semester Starting: 1.7.20

Credit- 3	Max. Marks : 150 (IA:30,ETE:120)		
3L+0T+0P	End Term Exam: 03 Hours		
	Year/sem: 2/3		
Unit No./ Total lec. Req.	**Topics**	**Lect. Req.**	**Lect. No.**
	Random Variables:		
Unit-1 (7)	Discrete And Continuous Random Variables	1	1
	Joint Distribution, Probability Distribution Function, Conditional Distribution	1	2
	Mathematical Expectations: Moments, Moment Generating Functions	3	5
	Variance And Correlation Coefficients	1	6
	Chebyshev's Inequality, Skewness And Kurtosis	1	7
	Binomial distribution,		
Unit-2 (8)	Normal Distribution	1	8
	Poisson Distribution and their relations	2	10
	Uniform Distribution	1	11
	Exponential Distribution	1	12
	Correlation: Karl Pearson's coefficient	3	15
	Rank correlation, Curve fitting, Line of Regression		

Unit No./ Total lec. Req.	Topics	Lect. Req.	Lect. No.
Unit-3 (5)	**Historical development**		
	Engineering Applications of Optimization	1	16
	Formulation of Design Problems as a Mathematical Programming Problems	2	18
	Classification of Optimization Problems	2	20
Unit- 4 (6)	**Classical Optimization using Differential Calculus:**		
	Single Variable and Multivariable Optimization with & without Constraints	2	22
	Langrangian theory	2	24
	Kuhn Tucker conditions	2	26
Unit- 5 (14)	Linear Programming:		
	Simplex method	3	29
	Two Phase Method and Duality in Linear Programming.	6	35
	Transportation and Assignment Problems.	5	40

Reference Books

1	Advanced Engineering Mathematics, Erwin Kreyszig, Wiley 9th Edition
2	Calculus and Analytical Geometry, Thomas and Finney, Narosa Publishing House, New Delhi.
3	A Text Book of Differential Equations, M.Ray and Chaturvedi, Students Friends & Co.Publisher, Agra
4	Higher Engineering Mathematics, B.V.Ramana, Tata Mc Graw Hill .

Historical Development

- Engineering Application of Optimization
- Discuss the Historical development of optimization
- Discuss the classification of Optimization
- Explain mathematics formulation of optimization problems

Introduction and Basic Concepts

Historical Development and Model Building

Objectives

- Understand the need and origin of the optimization methods.
- Get a broad picture of the various applications of optimization methods used in engineering.

Introduction

- Optimization : The act of obtaining the best result under the given circumstances.
- Design, construction and maintenance of engineering systems involve decision making both at the managerial and the technological level
- Goals of such decisions :
  - to minimize the effort required or
  - to maximize the desired benefit

Introduction (contd.)

- Optimization : Defined as the process of finding the conditions that give the minimum or maximum value of a function, where the function represents the effort required or the desired benefit.

Historical Development

- Existence of optimization methods can be traced to the days of Newton, Lagrange, and Cauchy.
- Development of differential calculus methods of optimization was possible because of the contributions of Newton and Leibnitz to calculus.
- Foundations of calculus of variations, dealing with the minimizations of functions, were laid by Bernoulli, Euler, Lagrange, and Weistrass

Historical Development (contd.)

- The method of optimization for constrained problems, which involve the inclusion of unknown multipliers, became known by the name of its inventor, Lagrange.

- Cauchy made the first application of the steepest descent method to solve unconstrained optimization problems.

Recent History

- High-speed digital computers made implementation of the complex optimization procedures possible and stimulated further research on newer methods.

- Massive literature on optimization techniques and emergence of several well defined new areas in optimization theory followed.

Milestones

- Development of the simplex method by Dantzig in 1947 for linear programming problems.
- The enunciation of the principle of optimality in 1957 by Bellman for dynamic programming problems.
- Work by Kuhn and Tucker in 1951 on the necessary and sufficient conditions for the optimal solution of problems laid the foundation for later research in non-linear programming.

Milestones (contd.)

- The contributions of Zoutendijk and Rosen to nonlinear programming during the early 1960s
- Work of Carroll and Fiacco and McCormick facilitated many difficult problems to be solved by using the well-known techniques of unconstrained optimization.
- Geometric programming was developed in the 1960s by Duffin, Zener, and Peterson.
- Gomory did pioneering work in integer programming. The most real world applications fall under this category of problems.
- Dantzig and Charnes and Cooper developed stochastic programming techniques.

Milestones (contd.)

- The desire to optimize more than one objective or a goal while satisfying the physical limitations led to the development of multi-objective programming methods; Ex. **Goal programming.**

- The foundations of game theory were laid by von Neumann in 1928; applied to solve several mathematical, economic and military problems, and more recently to engineering design problems.

- Simulated annealing, evolutionary algorithms including genetic algorithms, and neural network methods represent a new class of mathematical programming techniques that have come into prominence during the last decade.

Engineering applications of optimization.

- Design of structural units in construction, machinery, and in space vehicles.
- Maximizing benefit/minimizing product costs in various manufacturing and construction processes.
- Optimal path finding in road networks/freight handling processes.
- Optimal production planning, controlling and scheduling.
- Optimal Allocation of resources or services among several activities to maximize the benefit.

Art of Modeling : Model Building

- Development of an optimization model can be divided into five major phases.
  - Collection of data
  - Problem definition and formulation
  - Model development
  - Model validation and evaluation or performance
  - Model application and interpretation of results

Data collection

- Data collection
  - may be time consuming but is the fundamental basis of the model-building process
  - extremely important phase of the model-building process
  - the availability and accuracy of data can have considerable effect on the accuracy of the model and on the ability to evaluate the model.

Problem Definition

- Problem definition and formulation, steps involved:
  - identification of the decision variables;
  - formulation of the model objective(s);
  - the formulation of the model constraints.
- In performing these steps one must consider the following.
  - Identify the important elements that the problem consists of.
  - Determine the number of independent variables, the number of equations required to describe the system, and the number of unknown parameters.
  - Evaluate the structure and complexity of the model
  - Select the degree of accuracy required of the model

Model development

- **Model development** includes:
  - the mathematical description,
  - parameter estimation,
  - input development, and
  - software development
- The model development phase is an iterative process that may require returning to the model definition and formulation phase.

Model Validation and Evaluation

- This phase is checking the model as a whole.
- **Model validation** consists of validation of the assumptions and parameters of the model.
- The performance of the model is to be evaluated using standard performance measures such as Root mean squared error and R^2 value.
- Sensitivity analysis to test the model inputs and parameters.
- This phase also is an iterative process and may require returning to the model definition and formulation phase.
- One important aspect of this process is that in most cases data used in the formulation process should be different from that used in validation.

Modeling Techniques

- Different modeling techniques are developed to meet the requirement of different type of optimization problems. Major categories of modeling approaches are:
  - classical optimization techniques,
  - linear programming,
  - nonlinear programming,
  - geometric programming,
  - dynamic programming,
  - integer programming,
  - stochastic programming,
  - evolutionary algorithms, etc.
- These approaches will be discussed in the subsequent modules.

L.P.P Problems:

Q1. A toy company manufactures two types of dolls: a basic version doll A and a deluxe version doll B. Each doll of type B takes twice as long to produce as one of type A and the company would have time to make a maximum of 2000 per day if it produces only the basic version .The supply of plastic is sufficient to produce 1500 dolls per day(both A and B combined). The deluxe version requires a fancy dress of which there are only 600 per day available. If the company makes profit Rs. 3 and Rs.5 per doll respectively of doll A and B. How many of each should be produced per day in order to maximum profit

Sol: Let x_1 and x_2 be the number of dolls produced per day of type A and B, respectively. Let the doll A require t hrs. So, that the doll B required 2t hrs. So the total time to manufacture x_1 and x_2 dolls should not exceed 2,000 t hrs. Therefore, $tx_1 + 2tx_2 \leq 2000t$. Then the linear programming problem:

$$\text{Maximise } Z = 3x_1 + 5x_2$$

Subject to the restrictions

$$X_1 + 2x_2 \leq 2000 \text{ (time restraint)}$$

$$X_1 + x_2 \leq 1500 \text{ (Plastic restraint)}$$

$$X_2 \leq 600 \text{ (dress restraint)}$$

and non–negativity restrictions

$$X_1 \geq 0 \quad x_2 \geq 0$$

Problem -2

A farmer has a 100 - acre farm. He can sell the tomatoes, lettuce, or radishes he can raise. The price he can obtain is Rs 1.00 per kilogram for tomatoes, Rs 0.75 a head for lettuce and Rs 2.00 per kilogram for radishes. The average yield per acre is 2000 kgs for radishes, 3000 heads of lettuce and 1000 kilograms of radishes. Fertilizer is available at Rs 0.50 per kg and the amount required per acre is 100 kgs each for tomatoes and lettuce and 50 kilograms for radishes. Labour required for sowing, cultivating and harvesting per acre is 5 men - days for tomatoes and radishes and 6 man – days for lettuce. A total of 400 man - days of labour are available at ₹ 20 per man - day.

Formulate this problem as a linear programming model to maximize the farmer's total profit.

Sol: Farmer's problem is to decide how much area should be allotted to each type of crop he wants to grow to maximize his total profit. Let the farmer decide to allot x_1, x_2 and x_3 acre of his land to grow tomatoes, lettuce and radishes respectively so the farmer will produce 2000 x_1 kgs of tomatoes, 3000 x_2 heads of lettuce and 1000 x_3 kgs of radishes.

Therefore, total sale will be = Rs [$2000\ x_1 + 0.75 \times 300\ x_2 = 2 \times 1000\ x_3$]

Fertilizer expenditure will be = Rs [$0.50\ \{100(x_1 = x_2) + 50x_3\}$]

Labour expenditure will be = Rs [$20 \times (5x_1 + 6x_2 + 5x_3)$]

Therefore , farmer's net profit will be

P= total sale (in Rs.) – Total expenditure (in Rs.)

$$P = [2000\ x_1 + 0.75 \times 3000\ x_2 + 2 \times 1000\ x_3]$$
$$0.50 \times [100\ (x_1 + x_2) + 50x_3] - 20 \times [5x_1 + 6x_2 + 5x_3]$$
$$P = 1850\ x_1 + 2080\ x_2 + 1875\ x_3$$

Since total area of the farm is restricted to 100 acre, $x_1 + x_2 + x_3 < 100$.

Also, the total man days labour is restricted to 400 man days, therefore, $5x_1 + 6x_2 + 5x_3 < 400$.

Hence the farmer's allocation problem can be finally put in the form :

Maximize : $= 1850\, x_1 + 2080\, x_2 + 1875\, x_3$,

Subject to the conditions :

$x_1 + x_2 + x_3 \leq 100$,

$5x_1 + 6x_2 + 5x_3 \leq 400$

$x_1,\ x_2,\ x_3 \leq 0$

Solve:

A paper mill produce two grade of paper namely A and B. it can not produce more than a 400 tons of grade A and 300 tons of B in a week. There are 160 production hours in a week. It requires 0.2 and 0.4 hours to produce a tons of products A and B respectively with corresponding profit of Rs. 200 and Rs.500 per tons .formulate the above as a LPP.

Reference:

- https://nptel.ac.in/content/storage2/courses/105108127/pdf/Module_1/M1L1slides.pdf
- Engineering Mathematics III CS/IT Engineering

Vardhan Publication

Thank You