MATHEMATICAL MODELING WITH EXCEL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mathematical Modeling with Excel	2	0	0	2	Class XII pass with Mathematics	NIL

Learning Objectives: The objective of this course is to introduce:

- The importance and significance of assumptions behind a mathematical model.
- The long–term behavior of discrete dynamical systems numerically and graphically.
- Monte Carlo simulations with real-life examples.
- Linear programming, transportation, assignment and traveling salesman problems.

Learning Outcomes: After completion of the course the learner will be able to:

- Understand the purpose and process of mathematical modeling.
- Model different scenarios with linear discrete dynamical systems.
- Formulate and solve LP, transportation and assignment problems using Excel Solver.

UNIT-I: Modeling with Proportionality and Geometric Similarity (20 hours)

Definition, purpose, process, assumptions, and examples of mathematical modeling; Charts in excel using given data, Modeling with proportionality: Population growth, Radioactive decay, and Free-falling object; Fitting straight lines analytically, Geometric similarity, and Linearizable models.

UNIT-II: Discrete-time Models (16 hours)

Discrete dynamical system concepts and examples; Long-term behavior and equilibria, Discrete logistic equation, Linear predator-prey model, SIR model of epidemics, SIS model.

UNIT-III: Simulations and Linear Optimization (24 hours)

Monte Carlo simulation: Flipping a coin, Area under a curve, Car dealership contest, and the birthday problem; Formulation of linear programming, transportation and assignment problems and their solutions using Excel Solver tool; Traveling salesman problem.

Essential Reading

1. Albright, Brian, & Fox, William P. (2020). Mathematical Modeling with Excel (2nd ed.). CRC Press, Taylor & Francis Group.

Suggested Reading

- Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). A First Course in Mathematical Modeling (5th ed.). CENGAGE Learning India.

Practical Exercises: Practical work to be performed using Excel spreadsheets for the modeling of the following type of problems:

- The data given below measures shoe length (to the nearest quarter of an inch) and height (to the nearest half inch) of ten persons, to determine if there is a relationship between shoe length and height of a person. Graph Height vs. Shoe Length and fit a straight line to the data. How well does this model fit the data?

Shoe Length	9	10	10.5	11	11.5	11.75	12	12.5	12.75	13
Height	62	64	64.5	69	70	73	72	75	74	77

- The table below contains the total length and weight of 10 black bears. Graph weight vs. length, fit different linearizable models to the data, and select the one that best fits the data. Explain.

Length	139	138	139	120.5	149	141	150	166	180	129.5
Weight	110	60	90	60	85	95	85	155	220	105

- The table below contains data on the population of foxes in a forest over a period of several years. Fit a discrete logistic equation to the data. How well does the model fit the data?

n	0	1	2	3	4	5	6	7	8	9	10
a_n	50	85	110	130	175	200	215	221	228	232	234

- Consider a disease such as the common cold where a person is *not* immune once they are 'healed.' Once healed, a person becomes susceptible again. Such a disease could be modeled with an SIS model. Implement your model in an Excel worksheet to describe the spread of the common cold through a population of 1,000 where initially 4 people have the cold and assuming that the cold lasts an average of 2 weeks (use α = 0.00167). What do you observe?
- Random number generation in Excel and then use it to simulate area under a given curve.
- An automobile repair company performs paint-less dent removal from hail damaged cars and trucks. Each vehicle must be processed in both the body assembly shop and the finishing shop. In the body shop it takes 0.5 man-hours to repair a car and 0.5 man-hours to repair a truck. There are 25 body shop man-hours available per day. In the finishing shop it takes 0.4 man-hours to finish a car and 0.6 man-hours to finish a truck. There are 24 finishing man hours available per day. Each car contributes Rs. 20000 to overall profit, and each truck contributes Rs. 22500 to overall profit. Find number of cars & trucks the company can service a day to maximize overall profit, using Solver.

Teaching Plan (SEC Paper: Mathematical Modeling with Excel)

Week 1: Definition, purpose, process, assumptions, and examples of mathematical modeling; **[1]**:Chapter 1.

Week 2: Charts in excel using given data. **[1]**: Chapter 2 (Sections 2.1, and 2.2).

Week 3: Modeling with proportionality: Population growth, Radioactive decay, and Free-falling object. [1]: Chapter 2 (Section 2.3).

Weeks 4 and 5: Fitting straight lines analytically, Geometric similarity, and Linearizable models. [1]: Chapter 2 (Sections 2.4 to 2.6).

Weeks 6, and 7: Discrete dynamical system concepts and examples; Long-term behavior and equilibria, Discrete logistic equation. [1]: Chapter 4 (Sections 4.1 to 4.3).

Weeks 8, and 9: Linear predator-prey model, SIR model of epidemics, and SIS model. [1]: Chapter 4 (Sections 4.4, and 4.6).

Weeks 10, and 11: Monte Carlo simulation: Flipping a coin, Area under a curve, Car dealership contest, and the birthday problem. [1]: Chapter 6 (Section 6.2), and Section 6.3 (Example 6.3.2 and Exercise 6.3.4 only).

Weeks 12 to 14: Formulation of linear programming, transportation and assignment problems and their solutions using Excel Solver tool. [1]: Chapter 7 (Sections 7.2 to 7.4).

Week 15: Traveling salesman problem. [1]: Chapter 8 (Section 8.8).