Birla Institute of Technology & Science, Pilani
Hyderabad Campus

January 16, 2023

In addition to Part I (General Handout for all courses appended to the time table) portion:

Course Number : **MATH F420**
Course Title : **MATHEMATICAL MODELING**
Instructor-In charge : **Santanu Koley**
Instructors : Santanu Koley

1. **Scope and objective of the course:**
   This course introduces students to fundamentals and various approaches of mathematical modeling applicable to physical systems. This course covers most of the basic aspects of modeling from theory to the application part. A wide variety of mathematical approaches associated with the modeling that are covered in the course can be characterized into statistical models and mechanistic models. This course is interdisciplinary in nature and each topic is followed by many examples from different disciplines like biology, physics and engineering. This course provides detailed concepts and framework to model and solve various physical problems arise in different branches of science and engineering.

2. **Text Books:**
   1. Edwards and Penney, Elementary Differential Equations with Boundary Value Problems, Pearson Edu. Inc, Sixth Edition.
   2. Steven M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993

3. **Reference Books:**
   1. Kai Velten, Mathematical Modeling and Simulation; Introduction for Scientists and Engineers, WI-LEY-VCH, 2009.
   2. Adriaan van den Bos, Parameter Estimation for Scientists and Engineers, Wiley Pub, 2007.

4. Lecture Plan:

Lecture	Learning Objectives	Topics to be covered	Chapter in the Text Book
1-2	To learn basic concepts behind mathematical modelling	Basic concepts of Systems and Models; Classification of mathematical models; Introductory examples from various fields.	1.1-1.7 (R1)
3-6	To learn the mathematical concepts and associated formulation of the population modelling.	Population Modelling: Linear Model, Nonlinear Model and Predator- Prey Model	7.1,7.4 (T1)
7-8	To learn the concepts of equilibrium solution and stability of ODE	Equilibrium solutions and stability of ordinary differential equation with an example of harvesting and stocking in non-linear population modelling.	7.1 (T1)
9-14	To gain knowledge on linear autonomous system and its applications to real life problems.	Linear Autonomous System, Eigenvalues and Eigenvectors, Solution methodologies with real life examples, sketching solutions and analyse the system.	7.2-7.3 (T1)
15-23	To gain knowledge on nonlinear autonomous system and its	Nonlinear autonomous system, analysis of critical points, linearization of the system around the critical	7.4-7.5 (T1)

	applications to real life problems.	points, plotting the trajectories and analyse the system.	
24-29	To learn the application of estimation theory in real engineering problems	Estimation Theory with Application to Wireless Sensor Networks: Basics– Sensor Network and Noisy Observation Model, Framework of Estimation, Estimation of complex parameters, Estimation of channel coefficient, Complex baseband channel coefficient.	1-2, 7.1-7.5 (T2)
30-32	To determine the minimum variance achievable by an unbiased estimator	Cramer Rao Bound (CRB) for parameter estimation with examples from Wireless Sensor Network	3.1-3.6 (T2)
33-36	To learn the vector parameter estimation and its application to wireless communication system	Framework for vector parameter estimation, System Model for Multi Antenna Downlink Channel Estimation, Likelihood Function and Least Squares Cost Function for Vector Parameter Estimation	3.7, 7.8, 8.1-8.3 (T2)
36-40	To learn least square estimate of vector parameter and its application to wireless communication system	Least square solution of ML estimate of the vector parameter, properties of least square estimate, Least Squares Multi Antenna Downlink Maximum Likelihood Channel Estimation, Multiple Input Multiple Output (MIMO) Channel Estimation with example	8.4-8.7 (T2)

5. Evaluation Scheme:

Evaluation Component	**Duration**	**Weightage**	**Date & Time**	**Nature of Component**
Quiz 1	To be announced in the class	10%	To be announced in the class	Open Book
Mid Semester Test	90 mins	30%	16/03 11.30 - 1.00PM	Open Book
Quiz 2	To be announced in the class	10%	To be announced in the class	Open Book
Assignment 1	To be announced in the class	10%	To be announced in the class	Open Book
Comprehensive Examination	180 mins	40%	15/05 AN	Open Book

6. Chamber consultation hour: To be announced in the class.
7. Notices: The notices concerning this course will be displayed on the CMS Notice Board only.
8. Make-up Policy: Make-up will be given only for very genuine cases and prior permission has to be obtained from the I/C.
Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.