The LNMIIT, Jaipur Department of Electronics and Communication Engineering Modeling and Simulation for Wireless Communications (ECE-XXX)	LNMIIT The LNM Institute of Information Technology

Programme: **Ph.D. (ECE)**	**Course Title:** **Modeling and Simulation for Wireless Communications**			**Course Code:** **ECEXXX**
Type of Course: **Elective for ECE Ph.D.**	**Prerequisites:** **Basics of wireless communication with probability theory and matrix algebra**			**Total Contact Hours:** **60**
Year/Semester: **Odd/ Even**	**Lecture Hrs/Week:** **5**	**Tutorial Hrs/Week:** **0**	**Practical Hrs/Week:** **0**	**Credits:** **4**

Learning Objective:

For any engineering domain, modeling and simulation is of utmost importance as it avoids actual experimentation, which can be costly and time-consuming. Instead, mathematical knowledge and computational power can be used to solve real-world problems in feasible and cost-effective manner. This course provides the fundamental understanding of wireless signal modeling and Monte Carlo simulations of random number generators including the concepts of probability theory, stochastic processes. The basics of Markov chains have also been introduced with applications to next generation wireless communication. Moreover, the modeling of wireless communication systems, fading channel models along with the performance evaluation of modern MIMO-OFDM wireless systems. Lastly, the notion of predictive wireless network traffic modeling is incorporated for realistic traffic data prediction through artificial neural networks.

Course outcomes (COs):

On completion of this course, the students will have the ability:		**Bloom's Level**
CO-1	**Model** a random signal through various methods	**3**
CO-2	**Analyze** and **apply** different univariate continuous and discrete models	**4, 3**
CO-3	**Generate** random numbers through Monte Carlo simulations and testify them	**6**
CO-4	**Understand** the significance of Markov chains in communication system modeling.	**2**
CO-5	**Understand** wireless channel estimation and **analyze** the behavior of MIMO-OFDM based communication system	**2, 4**
CO-6	**Design** a predictive model for a realistic wireless network data traffic	**6**

Course Topics	**Lecture Hours**	
UNIT – I (Introduction to Modeling)	**13**	
1.1 Motivation, modeling methodology, and verification.	**2**	**13**

1.2 Review of Linear Algebra, Signals and systems, Probability theory, Random variable and Stochastic processes.	**3**	
1.3 Signal modeling: Minimum mean square error technique, Pade approximation method.	**3**	
1.4 Univariate and Multivariate models: Binomial, Poisson, Gaussian, Exponential, Gamma, Chi-square.	**5**	
UNIT – II (Monte Carlo Simulation and Random Number Generation)	**12**	**12**
1.1 Basics of simulation via MATLAB/ Python	**3**	
1.2 Random number generation methods: Linear congruential generator, Box-Muller, Sum of-12, Acceptance/ Rejection.	**6**	
1.3 Testing of random number generators via Goodness-of-fit metrics (Kolmogorov-Smirnov test, Anderson-Darlington test).	**3**	
UNIT – III (Markov Chains for Communication Engineering)	**10**	**10**
1.1 Discrete-time Markov Chains (DMCs): Definition and examples of DMCs, transition-probability matrix, Gilbert-Elliot model.	**5**	
1.2 Continuous-time Markov Chains (CMCs): Introduction to CMCs, birth-death process, Time reversibility.	**5**	
UNIT-IV (Estimation and Modeling of functional blocks in various communication systems)	**13**	**13**
1.1 Estimation theory and wireless channel estimation.	**2**	
1.2 Wireless channel models and their simulation: Rayleigh, Rician, Nakagami-m, Generalized κ-μ.	**4**	
1.3 OFDM transmitter-receiver design (with MATLAB simulation).	**4**	
1.4 Simulation of MIMO-OFDM based communication system.	**3**	
UNIT-V (Predictive Traffic Modeling and Simulation)	**12**	**12**
1.1 Introduction to Deep Learning including various Neural Networks: Multilayer Perceptron (MLP) model, LSTM, CNN	**6**	
1.2 Prediction using realistic traffic data	**2**	
1.3 Wireless channel estimation via deep neural networks	**4**	

Textbook References:

Text Book:

1. *Simulation of communication systems: modeling, methodology and techniques*, Jeruchim, Michel C., Philip Balaban, and K. Sam Shanmugan, Springer Science & Business Media, 2006.
2. *Statistical and adaptive signal processing, signal modelling*, D.G.Manolokis, Artech Hosuse, London.
3. *MIMO-OFDM wireless communications with MATLAB*, Cho, Yong Soo, et al., John Wiley & Sons, 2010.

Reference books:

1. *Probability, Random variables and Stochastic Processes*, A. Papoulis and S. U. Pillai, Tata McGraw Hill Education, 4th Ed., 2002.
2. *Simulation modeling analysis*, A.Law, Tata McGraw Hill, 4th Ed.
3. *Modern Communication Systems using MATLAB*, J. G. Proakis, M. Salehi and G. Bauch, Cengage Learning, 3rd Ed., 2017
4. *Fundamentals of wireless communication*, T. David, and P. Viswanath, Cambridge University Press, 2005.

Additional Resources:

Evaluation Method	
Item	**Weightage (%)**
Quizzes	10
Project	20
Midterm	30
Final Examination	40

CO and PO Correlation Matrix

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	1	2	3				2	1		3	3	3	
CO2	3	3	2	3	3				2	1		3	3	2	
CO3	3	3	1	3	3				2	1		3	3	3	
CO4	3	3	2	3	3				2	1		3	3	3	1
CO5	3	3	1	2	3				2	1		3	3	2	
CO6	3	3	2	3	3				2	1		3	3	3	3

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Approved By: