Lovely Professional University, Punjab

Course Code	Course Title	Course Planner	Lectures	Tutorials	Practicals	Credits
CSE327	SIMULATION AND MODELLING	11266::Janpreet Singh	3	0	0	3
Course Weightage	ATT: 5 CA: 25 MTT: 20 ETT: 50	**Exam Category: 55: Mid Term Exam: All Subjective – End Term Exam: All Subjective**				
Course Orientation	NA					

Course Outcomes :Through this course students should be able to

CO1 :: Describe the input modelling, random-number generators, generating random variates and processes.

CO2 :: Classify the aspects of a simulation study,simulation software, model verification and validation.

CO3 :: Analyze the systems where it is too expensive or risky to do live tests and the systems where predicting process variability is important.

CO4 :: solve numerical problems related to paper simulation of simple queuing models.

CO5 :: classify the simulation requirements based on the complexity of model.

	TextBooks (T)		
Sr No	**Title**	**Author**	**Publisher Name**
T-1	DISCRETE-EVENT SYSTEM AND SIMULATION	JERRY BANKS, JOHN S. CARSON II, BARRY L. NELSON, DAVID M. NICOL	PRENTICE HALL

	Reference Books (R)		
Sr No	**Title**	**Author**	**Publisher Name**
R-1	SIMULATION MODELLING AND ANALYSIS	AVERIL M. LAW	MCGRAW HILL EDUCATION
R-2	SYSTEM SIMULATION AND MODELING	SANKAR SENGUPTA	PEARSON

Other Reading (OR)	
Sr No	**Journals articles as Compulsary reading (specific articles, complete reference)**
OR-1	http://www.sciencedirect.com/science/article/pii/S0021999113002362 ,
OR-2	http://www.sciencedirect.com/science/article/pii/S1569190X14000513 ,

Relevant Websites (RW)		
Sr No	**(Web address) (only if relevant to the course)**	**Salient Features**
RW-1	http://ocw.jhsph.edu/courses/fundepiii/PDFs/Lecture17.pdf	Chi Square test
RW-2	http://www.math.utah.edu/~pa/Random/Random.html	Random Number Generation
RW-3	http://wweb.uta.edu/insyopma/baker/STATISTICS/Keller7/Keller%20PP%20slides-7/Chapter08.ppt	Continuous Probability Distributions
RW-4	web.cs.wpi.edu/~claypool/courses/533-S04/slides/simulation.ppt	Discrete Event Simulation

Virtual Labs (VL)		
Sr No	**(VL) (only if relevant to the course)**	**Salient Features**
VL-1	http://labhw.computacao.ufs.br/programas/circuitmaker/Circuit-Maker-tutor2.pdf	Circuit Maker Simulator tutorial

LTP week distribution: (LTP Weeks)	
Weeks before MTE	7
Weeks After MTE	7
Spill Over (Lecture)	7

Detailed Plan For Lectures

Week Number	Lecture Number	Broad Topic(Sub Topic)	Chapters/Sections of Text/reference books	Other Readings, Relevant Websites, Audio Visual Aids, software and Virtual Labs	Lecture Description	Learning Outcomes	Pedagogical Tool Demonstration/ Case Study / Images / animation / ppt etc. Planned	Live Examples

Week 1	Lecture 1	Introduction, General Principles and Simulation Software(Introduction to Simulation, advantages and disadvantages of simulation, application areas in communication)	T-1		L1 : Lecture Zero L2 : Introduction to basics of simulation and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	Simulations are categorized as Live - Real human beings operating real systems, e.g. a pilot flying a jet. Virtual - Real people operating simulated systems. Virtual simulations inject a Human-in-the-Loop into a central role by exercising motor control skills (e.g., flying jet or tank simulator), decision making skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a C4I team). Constructive - Simulated people operating simulated systems, or computer generated forces (CGFs) and computer models of sensors, weapons, and weapons effects. Real people can stimulate (provide inputs) to such simulations, but are not involved in determining the outcomes.

Week 1	Lecture 1	Introduction, General Principles and Simulation Software(Computer and Software design, systems and systems environment, components of a system, discrete and continuous systems)	T-1 R-2		L1 : Lecture Zero L2 : Introduction to basics of simulation and and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	
		Introduction, General Principles and Simulation Software(Model of a system, types of models, dicrete-event simulation, steps in a simulation study)	T-1		L1 : Lecture Zero L2 : Introduction to basics of simulation and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	

Week 1	Lecture 2	Introduction, General Principles and Simulation Software(Introduction to Simulation, advantages and disadvantages of simulation, application areas in communication)	T-1		L1 : Lecture Zero L2 : Introduction to basics of simulation and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	Simulations are categorized as Live - Real human beings operating real systems, e.g. a pilot flying a jet. Virtual - Real people operating simulated systems. Virtual simulations inject a Human-in-the-Loop into a central role by exercising motor control skills (e.g., flying jet or tank simulator), decision making skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a C4I team). Constructive - Simulated people operating simulated systems, or computer generated forces (CGFs) and computer models of sensors, weapons, and weapons effects. Real people can stimulate (provide inputs) to such simulations, but are not involved in determining the outcomes.

Week 1	Lecture 2	Introduction, General Principles and Simulation Software(Computer and Software design, systems and systems environment, components of a system, discrete and continuous systems)	T-1 R-2		L1 : Lecture Zero L2 : Introduction to basics of simulation and and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	
		Introduction, General Principles and Simulation Software(Model of a system, types of models, dicrete-event simulation, steps in a simulation study)	T-1		L1 : Lecture Zero L2 : Introduction to basics of simulation and steps in simulation study	Students will learn about basics of simulation	Live Demonstration	
	Lecture 3	Introduction, General Principles and Simulation Software(Simulation of Queueing systems, on-demand and inventory systems, simulation for reliability analysis etc.)	T-1 R-1	OR-2	Simulation of Queuing system and Inventory system is to be described	Students will learn examples of simulation	Peer Discussion	
Week 2	Lecture 4	Introduction, General Principles and Simulation Software(General Principles-Concepts in discrete event simulation: event scheduling/time advance algorithms, world views)	T-1		Event Scheduling/ Time Advance Algorithms are to be described	Students will learn Event scheduling in simulation	Peer Discussion	Dump Truck Problem
	Lecture 5	Introduction, General Principles and Simulation Software(List Processing: properties and operations, data structures and dynamic allocation, techniques)	T-1		List Processing and introduction to Simulation Environments are to be described	Students will learn about Different simulation environments	Live Deminstration	Doctor Attending Patients in the appointment order or emergency conditions, Barber Shop, Computer executing instructions from a pool

Week 2	Lecture 6	Introduction, General Principles and Simulation Software(List Processing: properties and operations, data structures and dynamic allocation, techniques)	T-1		List Processing and introduction to Simulation Environments are to be described	Students will learn about Different simulation environments	Live Deminstration	Doctor Attending Patients in the appointment order or emergency conditions, Barber Shop, Computer executing instructions from a pool
Week 3	Lecture 7	Statistical Models in Simulation(Terms and concepts,Statistical models, review of discrete and continuous distributions, Review of Poisson (stationary and non-stationary) processes)	T-1	RW-3	L7: Discrete and Continuous Distributions L8: Review of Poisson Process	Students will learn different type of distributions	Peer Discussions	Prediction of success or number of successes when there are multiple trials of an event e.g finding the probability of sale of a product by the ninth customer coming to a shop.
	Lecture 8	Statistical Models in Simulation(Terms and concepts,Statistical models, review of discrete and continuous distributions, Review of Poisson (stationary and non-stationary) processes)	T-1	RW-3	L7: Discrete and Continuous Distributions L8: Review of Poisson Process	Students will learn different type of distributions	Peer Discussions	Prediction of success or number of successes when there are multiple trials of an event e.g finding the probability of sale of a product by the ninth customer coming to a shop.
	Lecture 9	Statistical Models in Simulation(Empirical Distribution:Elementary Queueing Theory-Basic Structure of Queueing Models, Input source (Calling Population))		RW-3	Queuing Models are to be described	Students will learn about Queue model concepts	Peer Discussion	

Week 4	Lecture 10	Statistical Models in Simulation(Queue, Queue Discipline, Service Mechanisms, Notations and relationships between L, W,Lq and Wq, Little's Formula)	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.
		Statistical Models in Simulation(Finite Calling Population cases, Queueing Models involving Non-Exponential Distributions: M/G/1, M/D/s, M/Ek/s (involving Erlang distribution))	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.
	Lecture 11	Statistical Models in Simulation(Queue, Queue Discipline, Service Mechanisms, Notations and relationships between L, W,Lq and Wq, Little's Formula)	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.

Week 4	Lecture 11	Statistical Models in Simulation(Finite Calling Population cases, Queueing Models involving Non-Exponential Distributions: M/G/1, M/D/s, M/Ek/s (involving Erlang distribution))	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.
	Lecture 12	Statistical Models in Simulation(Queue, Queue Discipline, Service Mechanisms, Notations and relationships between L, W,Lq and Wq, Little's Formula)	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.
		Statistical Models in Simulation(Finite Calling Population cases, Queueing Models involving Non-Exponential Distributions: M/G/1, M/D/s, M/Ek/s (involving Erlang distribution))	T-1		Queuing Model Basics	Students will learn about Queues basics	Peer Discussion	Queue of people at any service point such as ticketing etc Queue of processes in OS Queue of packets in data communication Queue of air planes waiting for landing instructions.
Week 5	Lecture 13	Application of Queueing Models(Review of Characterstics (calling population system capacity, arrival processes, behaviour and disciplines, service times and mechanisms etc.) and notations)	T-1	OR-1	Notations and Characteristics of Queues	Students will learn about Population and their arrival patterns	Peer Discussion	

Week 5	Lecture 14				Test 1			
	Lecture 15	Application of Queueing Models(Application of Long-Run Measures of Performance: Time average in system, average time spent per customer)	T-1		Long Run terminology of Queues are to be described	Students will derive formulas for long run variables used in Queues	Animation and Images	
Week 6	Lecture 16	Application of Queueing Models(little's Formula and Server utilization, costs)	T-1		Little's Formula in Queues is to be described	Students will apply analytically formulas like Little's formula to the Queuses	Peer Discussion	
	Lecture 17	Application of Queueing Models(Steady state behaviour of Infinite (M/G/1, M/M/c/infinity, M/M/c/N/infinity))	T-1		Different types of Queues are to be discussed	Students will learn types of Queues and their notations	Peer Discussion	
	Lecture 18	Application of Queueing Models(Finite (M/M/c/K/K) Calling Population Models)	T-1		M/M/c/K/K form of Queue is to be discussed	Students will learn M/M/c/K/K applications	Peer Discussion	
Week 7	Lecture 19	Application of Queueing Models(Use of Network of Queues)	T-1		Networked Queues are to be described	Students will learn about Networked Queues	Animation and Lecture images	A telegraph System, Time Sharing Computers, Road Traffic etc.
		SPILL OVER						
Week 7	Lecture 20				Spill Over			
	Lecture 21				Spill Over			
		MID-TERM						
Week 8	Lecture 22	Random Number Generation (Properties, Generation of Pseudo-Random Numbers:Techniques for Generation of Pseudo-Random Numbers: Linear Congruential, Combined Linear Congruential)	T-1	RW-2	Linear Congruential and Combined Linear Congruential Methods are to be described	Students will learn methods to generate Random Numbers	Peer Discussion	
	Lecture 23	Random Number Generation (Random Number streams, Tests for Random Numbers: Frequency Tests and Tests for Autocorrelation)	T-1 R-1		Test for Randomness are to described	Students will learn the way to test randomness of the number series	Peer Discussion	

Week 8	Lecture 24	Random Number Generation (Random variate Generation-Inverse Transform techniques for Exponential, Uniform, Weibull)	T-1		Basics of Random-Variate Generation	Students will learn Random Variates	Peer Discussion	
Week 9	Lecture 25	Random Number Generation (Acceptance-Rejection Techniques for Poisson(Stationary and Non-Stationary)Distribution and Gamma Distribution)	T-1		Acceptance Rejection Technique is to be described	Students will learn about Acceptance or Rejection technique of a Hypothesis	Peer Discussion	
	Lecture 26	Random Number Generation (Acceptance-Rejection Techniques for Poisson(Stationary and Non-Stationary)Distribution and Gamma Distribution)	T-1		Acceptance Rejection Technique is to be described	Students will learn about Acceptance or Rejection technique of a Hypothesis	Peer Discussion	
	Lecture 27				Test 2			
Week 10	Lecture 28	Input Modeling and Output Analysis of a Single Model (Data Collection, Identifying the Distribution with Data: Histograms, Selection of Appropriate Family of Distributions)	T-1 R-2		Input Modelling basics are to be discussed	Students will learn about Input Modelling	Peer Discussion	
	Lecture 29	Input Modeling and Output Analysis of a Single Model (Data Collection, Identifying the Distribution with Data: Histograms, Selection of Appropriate Family of Distributions)	T-1 R-2		Input Modelling basics are to be discussed	Students will learn about Input Modelling	Peer Discussion	
	Lecture 30	Input Modeling and Output Analysis of a Single Model (Goodness of Fit tests applied to Simulation inputs: Chi-square and Chi-square with Equal Probabilities, Kolmogorov-Smirnov Tests)	T-1 R-2	RW-1	Goodness of Fit tests are to be discussed	Students will learn Goodness of Fit tests	Peer Discussion	
Week 11	Lecture 31	Input Modeling and Output Analysis of a Single Model (Goodness of Fit tests applied to Simulation inputs: Chi-square and Chi-square with Equal Probabilities, Kolmogorov-Smirnov Tests)	T-1 R-2	RW-1	Goodness of Fit tests are to be discussed	Students will learn Goodness of Fit tests	Peer Discussion	

Week 11	Lecture 32	Input Modeling and Output Analysis of a Single Model (p-Values and Best Fits, Verification and Validation of Simulation Models, Calibration, Face Validity, Validation of Assumptions, Input-Out Transformation Validation)	T-1	RW-4	p-Values and calibrations are to be described	Students will learn about Calibration and p-values	Peer discussion	
	Lecture 33	Input Modeling and Output Analysis of a Single Model (Output analysis and types of simulation, Stochastic nature of the Output Data, Measures of Performance and Estimation:Point Estimation and Confidence-Interval Estimation)	T-1		Output Analysis Basics are to be described	Students will learn basics of Output Analysis	Peer Discussion	
Week 12	Lecture 34	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems (Comparison of Two System Designs: Sampling with Equal and Unequal Variances, Common Random Numbers, Confidence Intervals with Specified Precision)	T-1		Comparison of system designs are to be described	Students will learn about Comparison of system designs	Animation and Lecture images	
	Lecture 35	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems (Comparison of Two System Designs: Sampling with Equal and Unequal Variances, Common Random Numbers, Confidence Intervals with Specified Precision)	T-1		Comparison of system designs are to be described	Students will learn about Comparison of system designs	Animation and Lecture images	
	Lecture 36				Test 3			
Week 13	Lecture 37	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems (Metamodeling: Sample Linear Regression, Testing for Significance, Multiple Linear Regression)	T-1		Linear Regression application is to be described	Students will learn about Linear Regression	Peer Discussion	

An instruction plan is only a tentative plan. The teacher may make some changes in his/her teaching plan. The students are advised to use syllabus for preparation of all examinations. The students are expected to keep themselves updated on the contemporary issues related to the course. Upto 20% of the questions in any examination/Academic tasks can be asked from such issues even if not explicitly mentioned in the instruction plan.

Week 13	Lecture 38	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems (Simulation Tools: Process Orientation and Event Orientation, Model Input: Modulated Poisson Process and Virtual-Memory Referencing)	T-1	VL-1	Virtual Memory and Simulation Tools	Students will learn about Simulation Tools	Peer Discussion	
	Lecture 39	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems(High-Level Simulation, CPU and Memory Simulations)	T-1		CPU - Memory Simulations are to be described	Students will learn about Memory Simulations	Peer Discussion	
Week 14	Lecture 40	Comparison and Evaluation of Alternative System Designs and Simulation of Computer Systems(Traffic Modeling, Media Access Control: Token-Passing Protocols and Ethernet, Data Link Layer, TCP, Model Construction)	T-1		Network Basics are to be described	Students will learn about Network Basics	Peer Discussion	
		SPILL OVER						
Week 14	Lecture 41				Spill Over			
	Lecture 42				Spill Over			
Week 15	Lecture 43				Spill Over			
	Lecture 44				Spill Over			
	Lecture 45				Spill Over			

Scheme for CA:

CA Category of this Course Code is:A0203 (2 best out of 3)

Component	Weightage (%)	Mapped CO(s)
Test 1	50	
Test 2	50	
Test 3	50	

Details of Academic Task(s)

Academic Task	Objective	Detail of Academic Task	Nature of Academic Task (group/individuals)	Academic Task Mode	Marks	Allottment / submission Week
Test 1	To identify the student understanding of random-number generators, generating random variates and processes.	Test will include subjective questions	Individual	Offline	30	4 / 5
Test 2	To evaluate the student based on problem solving skills	Test will include subjective and numerical problems	Individual	Offline	30	8 / 9
Test 3	Evaluate the student understanding of simulation requirements according to model complexity.	Test will include subjective and numerical problems	Individual	Online	30	11 / 12

List of suggested topics for term paper[at least 15] (Student to spend about 15 hrs on any one specified term paper)

Sr. No.	Topic
1	NA