



## Lahore University of Management Sciences

### CS501 / EE515 / MATH439 – Applied Probability

Fall 2023

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Course URL (if any)	

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	0	Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week	1	Duration	60 minutes (if needed)

Course Distribution	
Core	MS Computer Science, MS Electrical Engineering Area 1 (Signals, Communications, and Intelligent Systems)
Elective	BS Computer Science, MS Electrical Engineering (all other areas), BS Electrical Engineering
Open for Student Category	Anyone with the required pre-requisite
Close for Student Category	Anyone not fulfilling the required pre-requisite

COURSE DESCRIPTION
<p>This is a first-year graduate level course in probability, random variables, and random processes. Besides fundamental concepts in random variables, density functions, and expectations, the course will also include coverage of moderately advanced topics in random processes. The course contents will be complemented with important applications of these concepts to diverse areas of science and engineering disciplines including, but not limited to, computer communication networks, statistical inference and data analysis, estimation theory, and machine learning.</p>

COURSE PREREQUISITE(S)	
<ul style="list-style-type: none"><li>•</li><li>•</li><li>•</li></ul>	<p>Enforced: MATH 101 Calculus -1 Recommended: An undergraduate-level probability course (e.g., MATH 230) Sound background in undergraduate-level calculus and linear algebra.</p>

Grading Breakup and Policy
<p>Assignment(s): Will be assigned but students will not be required to submit solutions. Quiz(s): <b>20%</b> (5-6 in total. N-2 policy will be applied.) Midterm Examination: <b>40%</b> Project: Final Examination: <b>40%</b></p>



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### Course Teaching Methodology

- Teaching Methodology: In-person.

### Course Learning Outcomes

**CLO1**  
**CLO2**  
**CLO3**

By the end of the course, the students should

Be able to characterize random variables

Be able to evaluate operations on random variables and their characterizations

Be able to characterize random processes and their properties

### Relation to EE Program Outcomes

EE-564 CLOs	Related PLOs	Levels of Learning	Teaching Methods	CLO Attainment checked in
CLO1		Cog4	Instruction, Homework	Midterm, Final
CLO2		Cog4	Instruction, Homework	Midterm, Final
CLO3		Cog6	Instruction, Homework	Midterm, Final

### Examination Detail

Exams	Yes/No: Yes Combine Separate: Combined Duration: TBA Preferred Date: TBA Exam Specifications: TBA

### Textbook(s)/Supplementary Readings

#### Suggested Textbooks.

- Probability and Random Processes, Second Edition by Scott Miller and Donald Childers (ISBN: 978-93-81269-52-7)
- Introduction to Probability Models by Sheldon Ross (11th Edition, 2014)



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### Harassment Policy

Harassment of any kind is unacceptable, whether it be sexual harassment, online harassment, bullying, coercion, stalking, verbal or physical abuse of any kind. Harassment is a very broad term; it includes both direct and indirect behavior, it may be physical or psychological in nature, it may be perpetrated online or offline, on campus and off campus. It may be one offense, or it may comprise of several incidents which together amount to sexual harassment. It may include overt requests for sexual favors but can also constitute verbal or written communication of a loaded nature. Further details of what may constitute harassment may be found in the LUMS Sexual Harassment Policy, which is available as part of the university code of conduct.

LUMS has a Sexual Harassment Policy and a Sexual Harassment Inquiry Committee (SHIC). Any member of the LUMS community can file a formal or informal complaint with the SHIC. If you are unsure about the process of filing a complaint, wish to discuss your options or have any questions, concerns, or complaints, please write to the Office of Accessibility and Inclusion (OAI, [oi@lums.edu.pk](mailto:oi@lums.edu.pk)) and SHIC ([shic@lums.edu.pk](mailto:shic@lums.edu.pk)) —both of them exist to help and support you and they will do their best to assist you in whatever way they can.

To file a complaint, please write to [harassment@lums.edu.pk](mailto:harassment@lums.edu.pk).

### SSE Council of Equity and Belonging

In addition to LUMS resources, **SSE's Council on Belonging and Equity** is committed to devising ways to provide a safe, inclusive and respectful learning environment for students, faculty and staff. To seek counsel related to any issues, please feel free to approach either a member of the council or email at [cbe.sse@lums.edu.pk](mailto:cbe.sse@lums.edu.pk).



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## List of Topics (Tentative)

Week	Topics	Related CLOs
1	<b>Course Overview</b>	CLO1
1	<b>Basic building blocks of probability theory</b> <ul style="list-style-type: none"> <li>Experiments, Events, Outcomes, Sample space</li> <li>Meaning of probability, probability axioms</li> <li>Joint and conditional probability</li> <li>Baye's rule</li> <li>Independence</li> </ul>	CLO1
2	<b>Discrete random variables</b> <ul style="list-style-type: none"> <li>Probability mass functions</li> <li>Common discrete random variables</li> </ul>	CLO1
3-4	<b>Continuous random variables</b> <ul style="list-style-type: none"> <li>Cumulative distribution functions</li> <li>Probability density functions,</li> <li>Conditional distribution and density functions</li> <li>Common continuous random variables</li> </ul>	CLO1
4-6	<b>Operations on single random variables</b> <ul style="list-style-type: none"> <li>Expected values</li> <li>Moments</li> <li>Central moments</li> <li>Conditional expected values</li> <li>Transformation of random variables</li> <li>Evaluating tail probabilities</li> </ul>	CLO2
7	<b>Pairs of random variables</b> <ul style="list-style-type: none"> <li>Joint and conditional PMFs, CDFs, and PDFs</li> <li>Expectations involving pairs of random variables</li> <li>Correlation and covariance</li> <li>Independent random variables</li> <li>Transformations involving pairs of random variables</li> <li>Gaussian random variables in two dimensions</li> </ul>	CLO1, CLO2
<b>Mid-term Exam</b>		
8-10	<b>Multiple random variables</b> <ul style="list-style-type: none"> <li>Joint and conditional PMFs, CDFs, and PDFs</li> <li>Expectations involving multiple random variables</li> <li>Transformations involving multiple random variables</li> <li>Gaussian random variables in multiple dimensions</li> <li>Estimation and detection (ML / MMSE/ LMMSE Estimation)</li> <li>Sample mean and parameter estimation</li> <li>Law of large numbers</li> <li>Central limit theorem</li> </ul>	CLO1, CLO2
11-13	<b>Random Processes</b> <ul style="list-style-type: none"> <li>Basic Concepts</li> <li>Mean, autocorrelation, autocovariance and cross correlation functions</li> <li>Stationary and Ergodic Random processes</li> <li>Important Random Processes <ul style="list-style-type: none"> <li>Gaussian process</li> <li>Random telegraph signal</li> <li>Random walk</li> <li>Poisson process</li> <li>Markov processes</li> </ul> </li> </ul>	CLO3
14	<b>Markov Chains</b> <ul style="list-style-type: none"> <li>Calculating state transition and state probabilities in Markov Chains</li> <li>Characterization of Markov Chains</li> <li>Applications to computer communication network</li> </ul>	CLO3
<b>Final Exam</b>		