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Study Abroad
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Faculty: Sciences, Technology and Engineering

Course: **Probability: Theory of Measurement**

Program: Study Abroad in Engineering

Semester: 1– Fall

ECTS credits: 6

Duration: 45 hours

Language of instruction: English

Instructor: Krishna Satish

Course Description:

The objective of this course is to provide engineering students with the scientific skills necessary to model and analyze random phenomena. The course covers the manipulation of the Lebesgue integral and its application in both analysis and probability. Students will also engage in computer applications using R and Python programming language to illustrate theoretical concepts.

Prerequisites:

Probability and Analysis courses

Attendance and Punctuality policies:

Attendance is mandatory for all classes. Any presentation or activity missed due to student absences can only be rescheduled in cases of certified medical or family emergencies. If a student misses more than three classes in any course half a letter grade will be deducted from the final grade for each additional absence. Seven absences in 6 ECTS courses or four absences in 3 ECTS courses will result in a Fail grade. Notice that there is a minimum of 80% attendance.

Students will be marked ABSENT from any class if they arrive more than 20 minutes late. Students will not be permitted to enter the class unless the professor specifically accepts it. Even if the instructor allows students to join the class, they will still be marked as absent for that lesson.

Absences can be justified in the following cases: Death of a first-degree relative, serious illness of the student/ first-degree relative or obligation to attend legal affairs. In all these cases a document or receipt must be sent via e-mail to studyabroad@uvic.cat adding your professor in copy. Important! In case of injury/ illness of the student, a medical document issued in Vic* needs to be provided.

*Medical documents accepted: physical doctor's notes which contain the hospital's stamp and signature in handwriting OR digital doctor's notes which contain the doctor's valid digital signature (a digital signature is valid when it shows the authentication of the person who signs and prevents the pdf to be modified after being signed).

Learning outcomes:

- **Solve Complex Problems (C10):**

  Develop new knowledge and procedures to solve complex engineering problems by integrating concepts from probability theory, measure theory, and statistical methods**.**

- **Analyze Data Using Statistical Methods (C34):**

  Utilize statistical methods to analyze data, interpret results accurately, and present findings effectively, leveraging the R programming language for practical application.

- **Develop Critical Awareness (C4):**

  Cultivate a critical awareness of knowledge within probability and analysis and understand how these fields intersect with other areas of study, fostering interdisciplinary comprehension.

- **Model Sets and Determine Measurements (C5):**

  Model sets and determine appropriate measures, applying precise techniques such as the Lebesgue integral and other measure-theoretic concepts to define the desired precision in various situations.

- **Apply Monte Carlo Methods**

  Utilize Monte Carlo methods to simulate and analyze random phenomena, implementing these techniques through the R and Python programming language to illustrate theoretical concepts in practical scenarios.

Method of presentation:

- Lectures and Discussions: Lectures with visual support, facilitating students' ability to connect readings and lectures, and analyze or apply concepts.
- Class Participation: Students are expected to engage in group activities and discussions based on course readings and cases.
- Home Exercises: Students will solve exercises during the semester, reinforcing their understanding of the material.

Required work and assessment methods:

1) **Challenges and Quizzes (20%):** Engagement in weekly challenges and quizzes to apply theoretical concepts.
2) **Mid Semester test (10%):** Scheduled in Week 8 covering Units 1 and 2
3) **Final Test (30%):** Comprehensive test covering all course material (scheduled for January 2025).
4) **Project (30%):** Final project including oral presentations and teamwork, with emphasis on practical applications using R or Python Programming Language.
5) **Participation (10%):** Active participation in discussions and a positive, proactive attitude throughout the course.

Retake exams and activities:

- The student must present the activities, challenges and exercises pending to delivery. The student must attend the mid-semester and the final test. If the student passed the test, it is not necessary to take the retake test. It is only mandatory to take the retake test if the test was not passed.

- The activities weight in the retake evaluation is the same as activities weight in the ordinary evaluation, but then the maximum grade will be 5.

Contents:

Unit One: Foundations of Probability Theory

Week 1 to 3: Basic Principles of Probability, Conditional Probability and Independence, Bayes theorem

Unit Two: Moments and Convergence of Random Variables

Week 4 to 6: Expectation, variance, and higher moments, Covariance and correlation, Types of convergence, Chebyshev's Inequality, Borel- Cantelli Lemma. Laws of large numbers, Central limit theorem

Unit Three: Characterization of Laws and Measured Spaces

*Weeks 7-8***:** Distribution functions, Characteristic functions, Moment-generating functions, Sigma-algebras, Measures, and measurable functions

Unit Four: Integration with Respect to a Measure and Construction of Measures

Weeks 9 to 10: Lebesgue integral, Comparison with the Riemann integral, Lebesgue measure, Counting measure.

Unit Five: Integration of Product Measures and Convergence Theorems

Weeks 11-12: Fubini's theorem, Applications and examples, Beppo Levi's theorem, Fatou's lemma, Dominated convergence theorem

Unit Six: Monte Carlo Methods and Applications

Weeks 13-15: Monte Carlo Methods and Applications

Recommended reading

1. P. Billingsley, "Probability and Measure" (3rd Ed.), Wiley, New York.
2. D.L. Cohn, "Measure Theory" (2nd Ed.), Birkhäuser.
3. M.H. Kalos and P.A. Whitlock, *Monte Carlo Methods (2nd Edition)*. Wiley.

Sites:

(more to be added during the course)