هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA

2024
TP-153

Course Specification
(Bachelor)

Course Title:	*Advanced Stochastic Modeling*
Course Code :	*INE 5333.*
Program:	*Bachelor Of Science in Industrial Engineering.*
Department:	*Industrial Engineering.*
College:	*College of Engineering.*
Institution:	*King Khalid University.*
Version:	*2*
Last Revision Date:	*12/12/2025*

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (3)					
2. Course type					
A.	☐ University	☐ College	X Department	☐ Track	☐ Others
B.	☐ Required		X Elective		
3. Level/year at which this course is offered: (10/5)					
4. Course General Description:					
This advanced course explores the theoretical foundations and practical applications of stochastic modeling in industrial engineering contexts. Students will develop expertise in analyzing and designing complex systems characterized by randomness and uncertainty. The course emphasizes both analytical methods and computational approaches to solve real-world industrial problems.					
5. Pre-requirements for this course (if any)**:**					
INE 4351					
6. Co-requisites for this course (if any)**:**					
NIL					
7. Course Main Objective(s):					
Upon successful completion of this course, students will be able to: ● Formulate and analyze advanced stochastic processes in industrial systems ● Apply Markov chains and Poisson processes to model complex manufacturing systems ● Develop queueing theory models for resource allocation and capacity planning ● Implement simulation techniques for stochastic system analysis ● Evaluate and optimize system performance under uncertainty ● Create data-driven stochastic models for decision-making					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning	-	-

No	Mode of Instruction	Contact Hours	Percentage
3	Hybrid ● Traditional classroom ● E-learning	-	-
4	Distance learning	-	-

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	30
2.	**Laboratory/Studio**	0
3.	**Field**	0
4.	**Tutorial**	30
5.	**Others (specify)**	0
Total		60

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	**Demonstrate comprehensive understanding of advanced stochastic processes and their industrial applications**	**K2**	● Lectures with real-world examples ● Interactive problem-solving sessions ● Case study analysis	**Written examinations Case study reports Homework assignments**
1.2	**Analyze complex probabilistic systems using appropriate mathematical and computational tools**	**K1**	● Computer lab sessions ● Guided programming exercises ● Mathematical modeling workshops	**Midterm exam Final exam Assignment reports**

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.3	Evaluate stochastic models for industrial process optimization	K 2	• Industry case presentations • Simulation exercises • Group discussions	
2.0	**Skills**			
2.1	Apply advanced analytical methods to solve complex stochastic problems in industrial systems	S1	• Problem-based learning exercises • Case study analysis sessions • Guided mathematical modeling workshops • Interactive simulation exercises	Project work Software-based assignments
2.2	Design and evaluate stochastic models for industrial process optimization	S3	• Group projects • Software training • Practical workshops	• Final Exam • Project presentations • Data visualization assignments • Technical reports
2.3	Utilize advanced computational tools for stochastic analysis	S6	• Programming tutorials • Data analysis labs	• Programming assignments • Final Lab exam
2.4	Interpret the results of stochastic simulations and translate them into actionable engineering insights.	S4	• Programming tutorials • Data analysis labs	• Programming assignments • Final Lab exam
3.0	**Values**			
3.1	Demonstrate leadership in team-based stochastic modeling projects	V4	• Group discussions • Case studies on ethic	Class participation. Group project evaluation.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
3.2	Manage complex modeling projects with professional responsibility	V2	• Team projects • Group presentations	Project outcomes.
3.3	Effectively communicate complex stochastic concepts and results	V4	• Presentations	Presentation

C. Course Content

No	List of Topics	Contact Hours
1.	Foundation Review and Course Introduction • Review of probability theory and random variables • Probability spaces, events, and measures • Conditional probability and independence • Introduction to stochastic processes • Lab: Introduction to computational tools (Python/R)	2
2.	Advanced Probability Concepts • Joint distributions and transformations • Moment generating functions • Characteristic functions • Convergence concepts • Lab: Implementing probability distributions and transformations	2
3.	Introduction to Stochastic Processes • Classification of stochastic processes • Sample paths and state spaces • Temporal and spatial dependencies • Statistical properties of stochastic processes • Lab: Visualizing and analyzing stochastic processes	2
4.	Markov Chains • Discrete-time Markov chains • Transition probabilities and matrices • Chapman-Kolmogorov equations • Classification of states and chains • Lab: Modeling manufacturing systems using Markov chains • Assignment 1 Due	2
5.	Advanced Markov Chain Applications • Steady-state analysis • Absorption probabilities • Mean first passage times • Applications in reliability engineering	2

	• Lab: Reliability modeling and analysis	
6.	Continuous-Time Markov Chains • Poisson processes • Birth-death processes • Generator matrices • Industrial applications of CTMCs • Lab: Modeling equipment failures and repairs • Midterm Project Assignment	2
7.	Renewal Theory • Renewal processes • Renewal equations • Key renewal theorems • Applications in maintenance planning • Lab: Implementing renewal process models	2
8.	Midterm Week • Midterm examination • Review of key concepts • Case study presentations • Project consultations • Midterm Project Due	2
9.	Introduction to Queueing Theory • Basic queueing concepts • Little's law • M/M/1 and M/M/c queues • Performance measures • Lab: Queueing system simulation	2
10.	Advanced Queueing Systems • Priority queues • Bulk arrival and service systems • Networks of queues • Applications in production systems • Lab: Analysis of complex queueing networks • Assignment 2 Due	2
11.	Brownian Motion and Diffusion Processes • Properties of Brownian motion • Diffusion processes • Stochastic differential equations • Financial applications • Lab: Simulating Brownian motion and diffusion	2
12.	Stochastic Optimization • Markov decision processes	2

	• Dynamic programming under uncertainty • Policy iteration and value iteration • Applications in inventory control • Lab: Implementing stochastic optimization algorithms	
13.	Simulation Techniques • Monte Carlo methods • Variance reduction techniques • Random number generation • Output analysis • Lab: Advanced simulation modeling • Assignment 3 Due	2
14.	Advanced Topics and Special Applications • Hidden Markov models • Time series analysis • Spatial stochastic processes • Industry-specific applications • Lab: Implementing real-world case studies • Final Project Presentations Begin	2
15.	Course Wrap-up and Final Projects • Final project presentations • Course review and synthesis • Advanced applications discussion • Future trends in stochastic modeling • Final Project Reports Due	2
Total		**30**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Quizzes	(3,8,11)	15%
2.	Midterm exam 1	6	15%
3.	Assignments	(4,10)	5%
4.	Midterm exam 2	12	15%
5.	Project work and presentation	15	10%
6.	Final Exam	17	40%

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Course References

Essential References

Essential References	1. Asmussen, S., & Glynn, P. W. (2023). *Stochastic Simulation: Algorithms and Analysis* (2nd Ed.). Springer. 2. Ross, S. M. (2022). *Introduction to Probability Models* (13th Ed.). Academic Press. 3. Bhat, U. N., & Miller, G. K. (2021). *Elements of Applied Probability for Engineering and Systems Science* (3rd Ed.). Springer.
Supportive References	1. Gallager, Robert G. (2013). "Stochastic Processes: Theory for Applications," Cambridge University Press. • Advanced theoretical concepts • Supplementary examples and problems • Recommended for deeper understanding 2. Banks, Jerry, et al. (2010). "Discrete-Event System Simulation," 5th Edition, Prentice Hall. • Detailed coverage of simulation techniques • Software implementation guidelines • Industrial applications 3. Boxma, O., & Zwart, B. (2021). "Queueing Theory for Engineers," Synthesis Lectures on Engineering. • Modern treatment of queueing theory • Engineering-focused applications • Recent developments in the field 4. Puterman, Martin L. (2014). "Markov Decision Processes: Discrete Stochastic Dynamic Programming," 2nd Edition, Wiley. • Advanced coverage of decision processes • Optimization under uncertainty • Algorithmic approaches 5. Ibe, Oliver C. (2013). "Elements of Random Walk and Diffusion Processes," Wiley. • Specialized coverage of continuous-time processes • Applications in industrial systems • Mathematical foundations
Electronic Materials	1. Online Resources • MIT OpenCourseWare: "Stochastic Processes, Detection, and Estimation"

	• Stanford Online: "Stochastic Systems"
	• Coursera: "Stochastic Processes and Applications"
	2. Software Tutorials and Documentation
	• Python Libraries:
	  ○ NumPy (numerical computing)
	  ○ SciPy (scientific computing)
	  ○ SimPy (simulation framework)
	  ○ Pandas (data analysis)
	• R Packages:
	  ○ queueing (queueing theory analysis)
	  ○ markovchain (Markov chain analysis)
	  ○ simmer (discrete-event simulation)
	3. Digital Libraries and Repositories
	• IEEE Xplore Digital Library
	• INFORMS PubsOnLine
	• Science Direct (Operations Research section)
	• SpringerLink (Industrial Engineering collection)
	4. Interactive Learning Tools
	• Jupyter Notebooks with example implementations
	• Online simulation tools
	• Interactive visualization modules
	• Practice problem sets with solutions
	5. Industry Resources
	• Case study databases
	• Technical reports from leading companies
	• Industry standards and guidelines
	• Professional society publications
	6. Course-Specific Materials
	• Lecture slides and notes
	• Lab manuals and tutorials
	• Assignment guidelines
	• Project templates
	• Sample code repositories
	• Past examination papers with solutions

Other Learning Materials	1. Statistical Computing Environments
	• R Studio Desktop (Free Version)
	  ○ Core statistical analysis
	  ○ Visualization capabilities

	○ Packages for stochastic modeling • Python Distribution (Anaconda) ○ Integrated development environment ○ Package management ○ Interactive notebooks 2. Simulation Software • Arena Simulation (Student Version) ○ Process modeling ○ System analysis ○ Performance metrics • AnyLogic (Personal Learning Edition) ○ Multi-method simulation ○ Visual modeling environment ○ Industry-specific libraries

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	• Flexible seating arrangement for group work • Adequate lighting • Whiteboard
Technology equipment (projector, smart board, software)	□ Ceiling-mounted projector □ Interactive smartboard □ Core Statistical Software • R Studio Desktop (latest version) • Python (Anaconda distribution) • MATLAB (with Statistics and Optimization Toolboxes) • SAS University Edition □ Simulation Software • Arena Simulation Software (Academic Version) • AnyLogic (University Edition) • SimPy (Python library) • Simmer (R package) □ Mathematical Tools • Mathematica • Maple • GeoGebra • Wolfram Alpha Pro □ Development Tools • Visual Studio Code

Items	Resources
	• PyCharm Educational Edition • Jupyter Notebook • Git for version control Visualization Tools • Tableau Desktop (Academic) • Power BI Desktop • Plotly • D3.js
Other equipment (depending on the nature of the specialty)	• Printing facilities • Reference books and manuals

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	Student course evaluation surveys (Indirect)
Effectiveness of Students assessment	Faculty members	Analysis of grade distributions (Direct)
Quality of learning resources	Students Faculty member	Resource utilization surveys (Indirect) Faculty feedback on resource adequacy (Direct)
The extent to which CLOs have been achieved	Course instructor	Course learning outcome assessment reports (Direct
Other	Industry partners	Industry feedback on curriculum relevance (Indirect)
	Alumni	Alumni feedback surveys (Indirect)

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	**REVIEWED BY CURRICULUM COMMITTEE** **APPROVED BY QUALITY COMMITTEE**
REFERENCE NO.	**9-6-47**
DATE	**25/06/1447**