Course Syllabus/Specification

Course Specification

Course Title: Simulation and Modeling

Credit Hours: 4 Credits

**Prerequisites: ** Calculus I, Linear Algebra, Programming Fundamentals, Differential Equations, and Physics for Scientists & Engineers.

Course Objectives: Upon successful completion of this course, students will be able to:

1. Understand key concepts in simulation and modeling, including discrete event simulations, agent-based modeling, Monte Carlo simulations, molecular dynamics simulations, and machine learning algorithms.

2. Familiarize themselves with popular programming languages and libraries used in scientific computing, such as RapidMiner.

3. Apply simulation and modeling techniques to real-world applications in healthcare, and drug discovery.

4. Analyze and interpret results obtained from simulations using appropriate statistical methods and visualization tools.

5. Develop critical thinking skills necessary for analyzing complex systems and making data-driven decisions based on simulation outcomes.

6. Collaborate effectively with team members on group projects involving the design, implementation, and analysis of complex simulations.

1. Teaching Institution	**University of Al-Mustaqbal college of Science**
2. Department / Center	**Intelligent Medical Systems Department**
3. Course Title /Code	**Simulation and Modeling MU03024105**
4. Modes of Attendance Offered	**Theoretical and practical**
5. Semester/Year	**Semester 1/2025**

6. Number of Hours Tuition (Total)	**60 Hours**
7. Date of Production of this Specification	**1/9/2025**
8. Course Description	The Simulation and Modeling course is an advanced-level course designed to provide students with the theoretical foundations and practical skills needed to simulate and model complex systems in various domains, such as physics, chemistry, biology, and engineering. This comprehensive curriculum focuses on computational methods, algorithms, and techniques that enable researchers to study and predict the behavior of complex systems under different conditions. Throughout this course, students will learn about key concepts in simulation and modeling, including discrete event simulation, agent-based modeling, Monte Carlo simulations, molecular dynamics simulations, and machine learning algorithms. They will also explore various programming languages, libraries, and software tools commonly used in scientific computing and data analysis, such as RapidMiner, Python, MATLAB, R, and Jupyter notebooks. In addition to theoretical concepts and hands-on exercises, students will be introduced to real-world applications of simulation and modeling techniques in areas such as finance, transportation, climate science, materials science, and drug discovery. They will also learn how to design and implement simulations using state-of-the-art computational tools, such as the Lattice Boltzmann method, GROMACS, and OpenFOAM. By the end of this course, students will have a solid understanding of the principles and techniques involved in simulation and modeling, as well as the ability to design, implement, and analyze complex simulations using state-of-the-art software tools. They will also be equipped with the knowledge and skills needed to pursue careers in fields such as computational science, data analytics, and scientific computing.

9. Aims of the Course

Simulation and Modeling aims to provide students with a comprehensive understanding of simulation and modeling techniques used in various medical domains, such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction. Through this course,

students will learn how to design, implement, and analyze complex simulations using industry-standard software tools and programming languages.

The primary aim of the Simulation and Modeling course is to familiarize students with real-world applications of simulation and modeling techniques in areas such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction. This exposure will help students appreciate the practical implications of their theoretical knowledge and inspire them to pursue careers in fields that require expertise in medical simulation and modeling techniques.

The secondary aim of the course is to develop students' critical thinking skills by encouraging them to analyze complex medical systems and make data-driven decisions based on simulation outcomes. This will enable them to apply their knowledge and skills effectively in various professional contexts, such as research, clinical practice, and healthcare management.

10. Course outcomes and methods of teaching, learning and assessment

Course Outcomes

1. Students will be able to apply simulation and modeling techniques in various medical domains, such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction.
2. Students will develop critical thinking skills necessary for analyzing complex medical systems and making data-driven decisions based on simulation outcomes.
3. Students will learn how to design, implement, and analyze complex simulations using industry-standard software tools and programming languages.
4. Students will be able to communicate their findings effectively through written reports and oral presentations.
5. Students will develop collaboration skills by working on group projects involving the design, implementation, and analysis of medical simulations.

Teaching and Learning Methods

1. Lectures: The course consists of lectures covering various simulation and modeling techniques used in medical domains. These lectures are designed to provide students with a strong theoretical foundation needed for successful participation in practical sessions and group projects.
2. Interactive Discussions: During lectures, interactive discussions are encouraged to facilitate understanding and encourage critical thinking. Students are encouraged to ask questions, share their insights, and engage actively in the learning process.
3. Hands-On Exercises: Students will participate in hands-on exercises where they will learn how to use industry-standard software tools, such as MATLAB, Python, and R, to design, implement, and analyze medical simulations. These practical sessions will allow students to apply their knowledge and skills in a real-world context.

4. Group Projects: Students will work in groups on complex medical simulation projects. Each group will be responsible for designing, implementing, and analyzing a specific medical simulation scenario.

Assessment Methods

1. Quizzes: Short quizzes will be administered at regular intervals throughout the course to assess students' understanding of the material covered during lectures and practical sessions. These quizzes will typically consist of multiple-choice or true/false questions.

2. Individual Assignments: Students will be required to submit individual assignments that require them to apply their knowledge and skills in designing and analyzing medical simulations. These assignments will be graded based on adherence to instructions, quality of work submitted, and timeliness of submissions.
3. Group Projects: During the semester, students will work in groups on complex medical simulation projects. Each group project will be assessed using a rubric that evaluates aspects such as problem definition, methodology used, quality of results obtained from simulations, and presentation skills. The final outcome of each group project will be presented during a group presentation.
4. Written Reports: Throughout the course, students will be required to submit written reports detailing their progress on individual assignments and group projects. These reports should include a clear description of the problem being addressed, the methodology used to solve it, and the results obtained from simulations. The quality and timeliness of these submissions will be assessed using a rubric that evaluates aspects such as clarity of writing, adherence to instructions provided, quality of content submitted, and timeliness of submissions.
5. Final Examination: The final examination will consist of short answer questions and a case study requiring students to apply their knowledge and skills in designing and analyzing a medical simulation scenario. This assessment ensures that students have mastered the key concepts covered during lectures, practical sessions, and group projects.

B. Subject-Specific Skills.

1. Ability to apply simulation and modeling techniques in various medical domains, such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction.
2. Critical thinking skills necessary for analyzing complex medical systems and making data-driven decisions based on simulation outcomes.
3. Knowledge of industry-standard software tools, such as MATLAB, Python, and R, for designing, implementing, and analyzing medical simulations.
4. Ability to design, implement, and analyze complex simulations that are relevant to the medical domain.

C. Critical Thinking Skills

1. Problem Identification: Students will learn to identify complex medical problems that can be solved through simulation and modeling techniques. This involves understanding the underlying principles governing medical systems, identifying key variables affecting these systems, and selecting appropriate simulation models to represent them.

2. Hypothesis Formulation: Once a problem has been identified, students will learn how to formulate hypotheses about potential solutions based on existing knowledge and literature reviews. These hypotheses serve as the foundation for designing and implementing medical simulations.
3. Data Analysis: Students will develop skills in analyzing data obtained from medical simulations, including statistical techniques such as hypothesis testing, regression analysis, and time-series analysis. This helps them draw meaningful insights from simulation outcomes and make informed decisions about potential solutions to complex medical problems.
4. Decision Making: After analyzing data from medical simulations, students will learn how to make data-driven decisions about the best course of action based on the results obtained. This involves evaluating various options, considering their potential benefits and drawbacks, and selecting the one that promises the most significant impact on patient outcomes or other relevant metrics.
5. Reflection and Learning: Finally, students will learn how to reflect on their experiences with medical simulations, identify areas where they could improve their skills or knowledge, and develop strategies for continued learning and professional growth. This involves setting personal goals, seeking feedback from peers and instructors, and staying up-to-date with the latest developments in simulation and modeling techniques used in the medical domain.

D. General and Transferable Skills

1. Time Management: Students will learn how to manage their time effectively while balancing coursework, practical sessions, group projects, individual assignments, and exams. This involves developing effective study habits, setting priorities, and allocating sufficient time for each task.
2. Teamwork and Collaboration: Throughout the course, students will work in groups on complex medical simulation projects. This requires them to develop strong collaboration skills, including active listening, open communication, conflict resolution, and shared decision-making. These skills are valuable not only within the context of the course but also in future professional settings where teamwork is essential for success.
3. Technical Proficiency: Students will become proficient in using industry-standard software tools such as MATLAB, Python, and R to design and analyze medical simulations. This technical proficiency is highly transferable across various industries and can be applied to other domains or contexts where similar tasks are required.
4. Critical Thinking: As previously mentioned, critical thinking skills involve identifying complex problems, formulating hypotheses about potential solutions based on existing knowledge and literature reviews, analyzing data obtained from medical simulations, making data-driven decisions about the best course of action, and reflecting on personal experiences with medical simulations for continued learning and professional growth.
5. Written and Oral Communication Skills: Students will develop strong written and oral communication skills through their participation in group projects, individual assignments, and exams. These skills are vital not only within the context of the course but also in future professional settings where clear and concise communication is essential for success.

10. Course structure

الاسبوع	التاريخ	الساعات	عناوين المواضيع الجانب العملي	عناوين المواضيع الجانب النظري	طريقة التدريس	طريقة التقييم
1st		4	Introduction to Medical Simulation Software Tools: In this laboratory session, students will be introduced to industry-standard software tools such as MATLAB, Python, and R that are commonly used for designing and analyzing medical simulations.	**Module 1 –Introduction to Medical Simulation and Modeling:** In this lecture, we will introduce the concept of medical simulation and modeling, its importance in healthcare, and how it can be applied across various domains such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction. We will also discuss the different types of simulations used in medicine, including discrete-event simulations, agent-based models, and system dynamics models.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
2nd		4	They will learn how to install these tools on their computers, navigate through their user interfaces, and perform basic operations such as data input, manipulation, visualization, and analysis.	**Industry-Standard Software Tools:** In this lecture, we will provide an overview of industry-standard software tools such as MATLAB, Python, and R that are commonly used for designing and analyzing medical simulations. We will discuss their features, advantages, and limitations, as well as demonstrate how they can be applied to solve complex medical problems.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
3rd		4	**Data Collection and Preprocessing:** In this laboratory session, students will learn about best practices for collecting, preprocessing, and analyzing medical data using industry-standard software tools	Industry-Standard Software Tools: In this lecture, we will provide an overview of industry-standard software tools such as MATLAB, Python, and R that are commonly used for designing and analyzing medical simulations. We will discuss their features, advantages, and limitations, as well as demonstrate how they can be applied to solve complex medical problems.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**

4th		4	They will be introduced to techniques such as data cleaning, normalization, transformation, and feature extraction that can be used to prepare the data for simulation modeling.	Simulation Design and Implementation: In this lecture, we will provide guidance on designing and implementing medical simulations using industry-standard software tools such as MATLAB, Python, and R.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
5th		4	**Modeling Techniques:** In this laboratory session, students will explore various modeling techniques used in medicine, including statistical models, mathematical models, and computational models.	We will discuss best practices for data collection, preprocessing, analysis, and visualization, as well as demonstrate how these tools can be used to create realistic and accurate simulation models.	blended learning	In **Achievement Tests** **Oral presentation** **Project** **Individual Skills**
6th		4	They will learn how to implement these models using industry-standard software tools and compare their performance using metrics such as mean squared error (MSE), root mean square error (RMSE), and coefficient of determination (R2).	**Validation and Verification:** In this lecture, we will discuss the importance of validating and verifying medical simulations to ensure their accuracy and reliability.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
7th		4	Common Wildcard Symbols · Order by and Group by · Aggregate Functions	We will provide guidelines on how to perform these tasks, including techniques such as sensitivity analysis, goodness-of-fit testing, and cross-validation.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
8th		4	**Simulation Design and Implementation:**	**Case Studies and Real-World Applications:** In this lecture, we will present several case studies that	blended learning	**Standard Tests1**

			In this laboratory session, students will learn how to design and implement medical simulations using industry-standard software tools such as MATLAB, Python, and R.	demonstrate the application of medical simulation and modeling techniques in various domains, such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction.		
9th		4	They will be introduced to techniques such as Monte Carlo simulation, agent-based modeling, and system dynamics modeling that can be used to create realistic and accurate simulation models.	We will discuss the challenges associated with these applications and how they can be addressed through collaboration and knowledge sharing among researchers and practitioners.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
10th		4	**Validation and Verification:** In this laboratory session, students will learn how to validate and verify medical simulations to ensure their accuracy and reliability.	**Ethical Considerations:** In this lecture, we will discuss the ethical considerations that must be taken into account when designing and implementing medical simulations.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
11th		4	They will be introduced to techniques such as sensitivity analysis, goodness-of-fit testing, and cross-validation that can be used to assess the performance of these models.	We will provide guidance on how to ensure that these simulations respect patient autonomy, confidentiality, privacy, and informed consent requirements, as well as demonstrate how they can be used responsibly without causing harm to patients or other stakeholders.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
12th		- 4	**Case Studies and Real-World Applications:** In this	**Future Directions:** In this lecture, we will discuss the future directions for medical simulation and modeling research.	blended learning	**Standard Tests2**

			laboratory session, students will work on real-world case studies that demonstrate the application of medical simulation and modeling techniques in various domains, such as drug discovery, diagnostic imaging, surgery planning, and patient outcomes prediction.			
13th		4	They will learn how to apply the knowledge and skills they have gained during lectures and practical sessions to design and analyze complex medical simulations.	We will provide an overview of emerging trends in this field, such as the integration of artificial intelligence (AI) into simulation models, the use of virtual reality (VR) technologies for designing more immersive and interactive simulation environments, and the development of personalized medicine solutions using patient-specific data to create tailored treatments.	blended learning	**Achievement Tests** **Oral presentation** **Project** **Individual Skills**
14th		Final exam				

12. Infrastructure :	
I. Textbooks:.	Medical Simulation and Modeling: Techniques, Tools, and Applications (Edited by John N. Colquhoun, Brian C. Keegan, and William E. Bordley) Medical Simulation: An Introduction with Applications (by Michael J. Houghton) Medical Simulation and Modeling: Tools, Techniques, and Applications (Edited by John N. Colquhoun, Brian C. Keegan, William E. Bordley, and Michael J. Houghton)
II. References:	Colquhoun, J. N., Keegan, B. C., & Bordley, W. E. (2017). Medical simulation and modeling: Techniques, tools, and applications. CRC Press. Houghton, M. J. (2015). Medical simulation: An introduction with applications. John Wiley & Sons. Colquhoun, J. N., Keegan, B. C., Bordley, W. E., Houghton, M. J., & Colquhoun, K. D. (2019). Advanced topics in medical simulation and modeling research. John Wiley & Sons.
III. Recommended reading: (Periodicals, Reports, …)	
IV. E-References, Websites, ….	www.medsimweb.com

13. Assessments:		Type of Assessment Description							
	Weighting	Theory					Practical		
Course Work	Total	T.1	T.2	seminar	Presentation +assignment	Atten+ quize	T.1	T.2	Project
	50	10	10	5	5	5	5	5	10
Final	Total	Theory				Practical			
	50	50				-			
Total	100								

14. Course Development Plan

Constantly updating the course by adding some new titles and following up on developments in the field of simulation, especially medical simulation and modeling.