Syllabus for BMEN 689 Section 501
Special Topics in Cancer Modeling and Stochastic Analysis
Texas A&M University

Term:	Spring 2024	**Instructor:**	Jason T. George, M.D., Ph.D.
Time:	TBD	**Office:**	ETB 5021; IBT 703
Room:	TBD	**Phone:**	(979) 845-5532
Credit Hours:	3	**E-mail:**	jason.george@tamu.edu

Office Hours: TBD.

Required Textbook: (Tentative)

1. *An Introduction to Stochastic Modeling*, 4th edition, by Mark Pinsky and Samuel Karlin.

Optional Textbooks: (Tentative)

1. *Stochastic Models with Applications to Genetics, Cancers, AIDS and Other Biomedical Systems*, 1st edition, by Wai-Yuan Tang (ISBN 978-9810248680).
2. *The Biology of Cancer* by Robert Weinberg.
3. *Elementary Probability for Applications*, 1th edition, by Richard Durrett (ISBN 978-0521867566).
4. *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics*, 8th edition, by Philip M. Gerhart, Andrew L. Gerhart, and John I. Hochstein.

Course Description: This course is designed for graduate students in engineering and covers advanced topics in cancer modeling. Major course topics include mathematical pre-requisites (probability overview, probabilistic modeling, and mathematical analysis), deterministic modeling of cancer growth, stochastic models of cancer dynamics, Markov chains, Poisson and birth-death processes, branching processes, martingales, Luria-Delbrück fluctuation analysis, stochastic numerical simulations of cancer growth and the Gillespie algorithm, cancer evolution and acquired resistance, cancer evasion and dynamic programming, diffusions, modeling the tumor microenvironment, and cancer dormancy. The course will introduce graduate students to a rigorous and comprehensive treatment of the relevant mathematical tools and their application to contemporary cancer modeling. Problem sets and exams will emphasize key principles and their application to cancer. In order to prepare students for reserach in cancer engineering, problem sets will also involve application of concepts to analyze relevant publications in the field. Students are expected to be proficient in undergraduate multivariable calculus, differential equations, linear algebra, and numerical methods (e.g. proficiency in MATLab, Python, or similar computing language).

Course Prerequisites: MATH 251; MATH 304; MATH 308; graduate classification. Prior coursework in introductory probability (MATH 411 or equivalent) and introductory analysis (MATH 409 or equivalent) is beneficial but not required.

Learning Outcomes: Upon successful completion of this course, students will be able to: Describe and analyze population dynamical mathematical models of cancer, with an emphasis on the importance of stochastic analysis for understanding tumorigenesis and cancer progression.

Grading Policy: The final grade will be determined as follows:

Assignment	Weight	Course Points	Final Letter Grade
Simulation Project	10%	90% – 100%	A
Homework	20%	80% – 90%	B
Midterm	35%	70% – 80%	C
Final Exam	35%	60% – 70%	D
Total	**100%**	<60%	F

Requests for changes to grades given on any assignment or exam should be submitted in writing within two days after the grade is returned. Regrade requests must include a statement of the specific challenge and the work in question. *Note that the entirety of an assignment or exam is subject to re-grading during such a request.* Rounding up of grades for letter grading purposes is at the professor's discretion exclusively.

Course Schedule: Anticipated list of major covered topics and course schedule as follows:

Major Topics (subject to change)	Hours	Week
Background and introduction, history of mathematical models applied to cancer, introduction to probability; **Problem Set 1**	3	1
Deterministic models of cancer dynamics, probability (continued), the Luria-Delbrück experiment; **Critical Reading: Luria-Delbrück experiment**	3	2
Markov chains, Random walk, Poisson and birth-death processes, the Kolmogorov forward equation; **Problem Set 2**	3	3
Gillespie algorithm for stochastic simulation, Generating functions, Branching processes and critical regimes of cancer growth dynamics ; **Problem Set 3**	3	4
Branching processes in cancer and generating functions (continued); **Critical Reading: Gillespie simulation**	3	5
Finish and review of previous concepts; **Problem Set 4**	3	6
Midterm Exam; **Assignment of Simulation Project**		7
Cancer evolution; **Critical Reading: Evolution of acquired cancer resistance**	3	8
Cancer evolution (continued), martingales, **Problem Set 5**	3	9
Continuous Martingales and diffusions, tumor microenvironment modeling	3	10
Introduction to dynamic programming, cancer dormancy, **Problem Set 6**	3	11
Stochastic dynamic programming, Simulation Project presentations	3	12
Stochastic dynamic programming (continued), Simulation Project presentations (continued)	3	13
Catch-up and final review; **Problem Set 7**	3	14
Final Exam		15

Simulation Project: The simulation project will synthesize many of the concepts that we discuss in class. The project will consist of several distinct parts that will extend topics covered in lecture and require applications of lecture topics to solving complex problems in cancer dynamics. The final portion of the project will be open-ended, giving students an opportunity to select from a list of relevant topics and problems, from which students will review the technical literature and apply principals learned in class to derive solutions. Students will share their experiences in the class at the end of the term.

General Policies:

- No late homework or projects, except relative to University policies. Specific arrangements for make-up work in approved instances will be handled on a case-by-case basis.
- No makeup exam except in cases of medical emergencies.

- Exam material will come from notes, book chapters, and homework assignments.
- Final exam will be comprehensive.
- Academic dishonesty will not be tolerated.

Attendance Policy:

- In accordance with Texas A&M University policies, only University-excused absences will be accepted for missing classes and for any makeup exams to be given.
- Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade for the reasons stated in Student Rule 7, or other reasons deemed appropriate by the instructor.
- "The instructor is under no obligation to provide an opportunity for the student to make up work misssed because of an unexcused absence" (Student Rule 7, Section 7.4.2).
- Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code (See Student Rule 24).
- It is the student's responsibility to make arrangements to reschedule exams.
- If an absence is excused, the instructor will provide the student an opportunity to make up any exam or other work that contributes to the final grade or provide a satisfactory alternative by a date proposed by the instructor.
- If the instructor has a regularly scheduled make-up exam, students are expected to attend unless they have a university-approved excuse.
- The make-up work must be completed in a timeframe not to exceed 30 calendar days from the last day of the initial absence.
- "Absences related to Title IX of the Education Ammendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).
- Refer to Student Rule 7 for ALL policies regarding excused absences. Please note: "The student is responsible for providing satisfactory evidence to the instructor to substantiate the reason for absence." In the case of injury or illness of 3 or more days, "The medical confirmation note must contain the date and time of the illness and medical professional's confirmation of needed absence."
- Also, in case of injury or illness of less than 3 days, it is the policy of this class that the student likewise will provide a medical confirmation note containing the date and time of the illness and medical professional's confirmation of needed absence.
- Having a legitimate University-excused absence does not relieve the student of responsibility for prior notification and documentation. Failure to notify and/or document properly may result in an unexcused absence. Allowable excuses and documentation thereof must be provided to the professor in a timely manner.
- Other absences may be excused at the discretion of the instructor with prior notification and proper documentation. In cases where prior notification is not feasible (e.g., accident or emergency) the student must provide notification by the end of the second working day after the absence, including an explanation of why notice could not be sent prior to the class.
- Falsification of attendance documentation is a violation of the Honor Code.

Academic Integrity Statement and Policy: The following Honor Pledge shall be printed as a prefix and signed by each student responsible for the submission of all projects, coursework, homeworks, and examinations:

"An Aggie does not lie, cheat, or steal, or tolerate those who do. On my honor, I have neither given nor received any unauthorized aid on this academic work."

Americans with Disabilities (ADA) Policy Statement: The American with Disabilities Act (ADA) is a federal anti-discrimination statue that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accomodation of their disabilities. If you believe you have

a disability requiring an accommodation, please contact Disability Services, in Cain Hall, Room B118, or call 979-845-1637.