NANYANG TECHNOLOGICAL UNIVERSITY
SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	2
Course Coordinator	Asst Prof. Song Juha / Asst Prof. Zhao Wenting		
Course Code	BG2209		
Course Title	Mechanics for Bioengineers		
Pre-requisites	CB1131/BG1131/BG1141		
No of AUs	3		
Contact Hours	26 hours lecture, 13 hours tutorial		
Proposal Date	4 Nov 2019		

Course Aims

This course is intended to offer you the opportunity to learn the fundamentals of statics of materials and biomechanics of cells/tissues, covering basic mechanics topics in bioengineering. This course also aims to help you understand the relation between applied load and deformation, and the relation between stress and strain under different loading conditions for both biomaterials and biological systems (mainly cells and tissues) and finally to help you build problem solving skills for practical problems in mechanics of both biomaterials and biological systems.

Intended Learning Outcomes (ILO)

By end of this course, you (as a student) would be able to:

1. Describe and calculate different types of stresses and strains generated within materials due to different loadings
2. Calculate various mechanical properties of biomaterials and apply them in design
3. Define the different modes of failure and apply the corresponding failure criteria
4. Describe basic cellular and tissue-level biomechanics for cell/tissue-biomaterial interfaces
5. Implement both biomechanics of cells and tissues and mechanical behaviour of biomaterials in design and evaluation of various biomedical applications

Course Content

1. General introduction: Basics and equations of equilibrium (week 1)
2. Stress-Axial loading (week 2)
3. Bending (week 3)
4. Torsion and Stress transformation (week 4)
5. Part 1 review and quiz (week 5)
6. Elasticity and plasticity (week 6)
7. Creep (week 7)
8. Liner elastic fracture mechanics and toughness (week 8)
9. Fatigue & Fatigue crack propagation (week 9)
10. Part 2 review and quiz (week 10)
11. Introduction to cell mechanics (week 11)
12. Introduction to tissue mechanics (week 12)
13. Part 3 review and key Mechanics topics in bioengineering (seminar) (week 13)

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
1. Continuous Assessment 1 (Quiz)	1, 2	EAB SLO* a, b, c, d	20%	Individual	Refer to Appendix 1
2. Continuous Assessment 2 (Quiz)	2, 3	EAB SLO* a, b, c, d	20%	Individual	Refer to Appendix 1
3. Final Examination (60%) (2hrs, Closed book)	1, 2, 3, 4, 5	EAB SLO* a, b, c, d, f, g, l	60 %	Individual	Refer to Appendix 1
Total			100 %		

Mapping of Course ILOs to EAB Graduate Attributes

Course Intended Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	Core	●	●	●	◐		š	š					◐
Describe and calculate different types of stresses and strains generated within materials due to different loadings													a, b, c
Calculate various mechanical properties of biomaterials and apply them in design													a, b, c
Define the different modes of failure and be able to apply the corresponding failure criteria													a, b, c
Describe basic cellular and tissue-level biomechanics for an understanding of cell/tissue-biomaterial interfaces													a, b, c, d
Implement both biomechanics of cells and tissues and mechanical behaviour of biomaterials in design and evaluation of various biomedical applications													a, b, c, d, f, g, l

Legend:
- ● Fully consistent (contributes to more than 75% of Intended Learning Outcomes)
- ◐ Partially consistent (contributes to about 50% of Intended Learning Outcomes)
- š Weakly consistent (contributes to about 25% of Intended Learning Outcomes)
- Blank Not related to Student Learning Outcomes

Formative feedback

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Face-to-face Lecture	The classroom lecture will deliver key concepts and points for learning and explaining the related knowledge points by using various levels of

	mechanical examples. Course materials used in the class are often incomplete handouts which enable students participate in class. Through lectures, how to carry out a procedure such as working through a mechanical problem will be clearly demonstrated with various case examples.
Tutorial	Classroom discussion sessions on tutorial questions and related topics

Reading and References

1. F. P. Bear and E. R. Johnson, Jr., *Mechanics for Engineers: Statics*, 5/E, McGraw Hill, 2019.
2. R. C. Hibeler, *Mechanics of Materials*, 7/E, Pearson, 2007.
3. N. E. Dowling, Mechanical Behavior of Materials, 3/E, Pearson, 2007.
4. C.R. Ethier and C.A. Simmons, Introductory Biomechanics, Cambridge University Press, 2007
5. C.R. Jacobs, H. Huang, R.Y. Kwon, Introductory to Cell Mechanics and Mechanobiology, 2012

Course Policies and Student Responsibilities

General: You are expected to complete all online activities and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements. You are expected to participate in all tutorial discussions and activities.

Continuous assessments: You are required to attend all continuous assessments.
Absenteeism: Continuous assessments make up a significant portion of your course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect your overall course grade.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction: Basics and equations of equilibrium	1	Face-to-face Lecture Online tutorial
2	Stress-Axial loading	1, 2	Face-to-face Lecture Tutorial
3	Bending	1, 2	Face-to-face Lecture Tutorial
4	Torsion and Stress transformation	1, 2	Face-to-face Lecture Tutorial 3
5	Part 1 review and quiz	1, 2	CA 1 (2 hr) Tutorial
6	Elasticity and plasticity	2	Face-to-face Lecture Tutorial
7	Creep	2	Face-to-face Lecture Tutorial
	(Recess week)		
8	Linear elastic fracture mechanics and toughness	2, 3	Face-to-face Lecture Tutorial
9	Fatigue & Fatigue crack propagation	2, 3	Face-to-face Lecture Tutorial
10	Part 2 review and quiz	2, 3	CA 2 (2 hr) Tutorial
11	Introduction to cell mechanics	4	Face-to-face Lecture Tutorial
12	Introduction to tissue mechanics	4	Face-to-face Lecture Tutorial
13	Part 3 review and seminar (key mechanics topics in bioengineering)	5	Seminar Tutorial

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Understanding the basic mechanical principles	- Lacks understanding of theories, laws, concepts and terms governing the basic statics, and mechanics of materials.	- Some understanding of theories, laws, concepts and terms governing the basic statics, and mechanics of materials.	- Partial understanding of theories, laws, concepts and terms governing the basic statics, and mechanics of materials.	- Fully understanding of theories, laws, concepts and terms governing the basic statics, and mechanics of materials.	- Deep and complete understanding of theories, laws, concepts and terms governing the basic statics, and mechanics of materials.
	- Unable to apply the theories and concepts to simple problems involving principles of mechanics.	- Can apply partial theories and concepts to simple problems involving principles of mechanics.	- Can apply the theories and concepts to simple problems involving principles of mechanics.	- Can apply the theories and concepts to most problems involving principles of mechanics.	- Can apply the theories and concepts to all problems involving principles of mechanics.
	- Unable to solve quantitative problems involving principles of mechanics.	- Can partially solve simple quantitative problems involving principles of mechanics; unable to fully solve moderate or complex problems.	- Can solve simple quantitative problems involving principles of mechanics; unable to fully solve moderate or complex problems	- Can solve most quantitative problems involving principles of mechanics.	- Can solve all quantitative problems involving principles of mechanics.
Applying mechanical concepts to biomechanical situations	- Unable to read and understand biomechanics literature.	- Can read very simple and partially understand basic biomechanics literature.	- Can read and partially understand basic biomechanics literature.	- Can read and understand biomechanics literature at a moderate level.	- Can read and understand biomechanics literature at a high level.
	- Unable to explain the mechanics underlying biological processes, biomaterial properties, and biological locomotion.	- Can partially explain the mechanics underlying biological processes, biomaterial properties, and biological locomotion.	- Can partially explain the mechanics underlying biological processes, biomaterial properties, and biological locomotion.	- Can explain the mechanics underlying simple to moderate biological processes, biomaterial properties, and biological locomotion.	- Can explain the mechanics underlying complex biological processes, biomaterial properties, and biological locomotion.
Interpretation and representation	- Attempts to explain information presented in mathematical forms, but draw incorrect conclusions about what the information provides.	- Provide somewhat partially accurate explanations of information presented in mathematical forms, but makes some errors related to computation or units.	- Provide somewhat accurate explanations of information presented in mathematical forms, but occasionally makes minor errors related to computation or units.	- Provide accurate explanations of information presented in mathematical forms.	- Provide accurate explanations of information presented in mathematical forms; makes appropriate inferences based on that information.

	- Completes conversion of information but resulting mathematical portrayal is inappropriate or inaccurate.	- Completes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate.	- Completes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate.	- Completely converts relevant information into an appropriate and desired mathematical portrayal.	- Skilfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding
Calculation	Calculations are attempted but are both unsuccessful and are not comprehensive.	Calculations are attempted but only can represent a small portion of the calculations required to comprehensively solve the problem.	Calculations are attempted but represent only a portion of the calculations required to comprehensively solve the problem.	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem.	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem; calculations are also presented elegantly (clearly and concisely)

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change