NANYANG TECHNOLOGICAL UNIVERSITY

COURSE CONTENT

Academic Year	2021/2022	**Semester**	2
Course Coordinator	Prof TEOH Swee Hin		
Course Code	CH4305/BG4240		
Course Title	Special Topics in Biotechnology/Bioengineering (Engineering Materials for Biomedical Engineering)		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	39 hours lecture		
Proposal Date	*4 Jan 2022*		

Course Aims

The goal of course is to educate students in how to apply fundamental materials science and engineering principles to solve challenging problems in medical related fields especially in implant and medical devices. Biomaterials such as titanium, polyethylene and bioglass have been used successfully in many medical devices. However, problems such as biocompabtibility, wear, fatigue fracture and tissue irritability still exist. This module exposed students to various problems in biomaterials used in applications such as in orthopedic and cardiovascular surgery. Major controversial issues in the application of biomaterials to medical problems will therefore be covered. Fundamental structure-property relationships and issues such as wear and structural integrity will be addressed. Subjects considered include introduction to biomaterials, host-tissue response, blood compatibility, control drug release polymers, bioadhesion, biodegradation, protein adsorption, corrosion, orthopaedic and cardiovascular implants, stress shielding, materials selection in artificial organs and medical device regulation. Format will utilize case studies, special invited lectures, discussion, literature research and problem base learning techniques.

It aims to provide broad base curriculum and integrates students to a new dimension in health care engineering and life science topics. Students gain an appreciation of multidisciplinary approach to problem solving Problem base learning will be used to enhance the learning out come in small groups.

Intended Learning Outcomes (ILO)

By the end of this course, the student would be able to:

1. apply fundamental materials science and engineering principles to solve challenging problems in biomedical field.
2. describe the various classifications of engineering materials for implant applications
3. understand host-tissue response
4. understand failure mechanisms such as corrosion, fatigue, wear and fracture of medical implants
5. understand the requirements of biomaterials eg biocompatibility, manufacturability and sterilizability
6. describe the principles of tissue engineering and how to bring research to clinics and spin-off a company for IPO.

Course Content

1. Introduction to biomaterials and applications (Week 1)
2. Biological materials (Week 2)
3. Cells and blood (Week 3)
4. Metallic implant materials (Week 4)
5. Polymeric implant materials (Week 5)

6. Ceramic implant materials (Week 6)
7. Composite implant materials/Problem based learning (PBL) assignment (Week 7) (Recess Week)
8. Quiz 1/Guest lecture from industry/Tissue engineering (Week 8)
9. PBL discussion (Week 9)
10. PBL discussion (Week 10)
11. PBL discussion (Week 11)
12. PBL Symposium (Week 12)
13. Quiz 2 (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 (100%) a. Part 1 Quiz (25%)	1,2, 3	EAB SLO* a, b, c, d, f	25%	Individual	Appendix 1
b. Part 2 Quiz (25%)	4, 5, 6	EAB SLO* a, b, c, d, f	25%	Individual	Appendix 1
c. Project Presentation (18%)	1, 2, 3, 4, 5, 6	EAB SLO* a, b, c, d, e, f, h, i, j, k, l	18%	Group	Appendix 2.
d. Self and Peer Evaluation (16%)	1, 2, 3, 4, 5, 6	EAB SLO* c, e, f, h, i, j, l	16%	Individual	Appendix 3
e. Class Participation (16%)	1, 2, 3, 4, 5, 6	EAB SLO* a, b, c, d, f, i, j, l	16%	Individual	Appendix 4
Total			100%		

Note:
For CA.e -- Class participation, students will be assessed on their participation in class discussions, online quizzes, online discussion, and showing of initiative in class activities.

Formative feedback

In the lecture section, lecturers will answer the questions in class or on zoom live.
For the Quiz, the lecturer will explain the tested points.
For the Peer-Evaluation, selected descriptive comments will be provided to students.
For the problem-based learning, the lecturer will explain the difficult points related to the problem and answer your questions, either right after the class, during the online discussion, or via email.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Class-room lecture	The class-room lecture will deliver the key points for the learning and explain the related knowledge points by using real-world example and real application. Course materials used in the class cover all the knowledge points that are required for your learning. (COVID19 alternative: recorded lectures)
Technology-	1. TEL will provide cartoons or videos to facilitate your understanding.

enhanced learning (TEL)	2. Design online learning materials to facilitate your learning. Online materials will be highly relevant to lectures that are delivered in class.
Problem-based learning (PBL)	Real-world related problems will be provided to exercise the knowledge integration, promote critical thinking, and sharpen problem-solving skills. Problem sets will be assigned to groups for collaborative study and presentation. Classroom / online discussion sessions on PBL questions and related topics will be organised to facilitate the learning and sharing between students. (COVID19 alternative: online zoom session and / or small group meet-up).

Reading and References

1. S.H. Teoh (ed) Engineering materials for biomedical applications, World Scientific Pub, . 2004
2. R. Lanza, R. Langer, J. Vacanti, A. Atala (Eds), Principles in Tissue Engineering, 5th edition Elsevier Science Publishing Co Inc, US, April 2020

Course Policies and Student Responsibilities

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

Continuous assessments: Students are required to attend all continuous assessments.

Absenteeism: Continuous assessments make the whole students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

PBL: All the students are required to join the assigned group and participate in the group discussion and presentation. Each student should submit both self-evaluation and the peer evaluation for their groupmates. Feedback and questions provided to other groups will also be recorded and evaluated as part of class participation.

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
Prof TEOH Swee Hin	N1.3-B5-01A	6790-4501	teohsh@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Lecture hours	Tutorial hours	Online hour (hr)
1	Introduction to biomaterials and applications	3	0	0
2	Biological materials	3	0	0
3	Cells and blood	3	0	0
4	Metallic implant materials	3	0	0
5	Polymeric implant materials	3	0	0
6	Ceramic implant materials	3	0	0
7	Composite implant materials/PBL assignment	3	0	0
	(Recess Week)			
8	Quiz 1/Guest lecture industry/Tissue Engin	3	0	0
9	PBL discussion	3	0	0
10	PBL discussion	3	0	0
11	PBL discussion	3	0	0
12	PBL symposium	3	0	0
13	Quiz 2	3	0	0
	Total Hours:	39	0	0

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Appendix 1: Assessment Criteria for Quizzes.

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Understanding the basic material classifications, properties and processing principles to biomedical applications	Lacks understanding of basic material classifications, properties and processing principles to biomedical applications. Unable to apply the theories and concepts of materials science to simple problems related to medical devices. Unable to solve quantitative problems involving principles of engineering materials.	Some understanding of basic material classifications, properties and processing principles to biomedical applications. Can apply partial theories and concepts of materials science to some problems related to medical devices Can partially solve simple quantitative problems involving principles of engineering materials; unable to fully solve moderate or complex problems.	Partial understanding of basic material classifications, properties and processing principles to biomedical applications. Can apply the theories and concepts of materials science to simple problems related to medical devices. Can solve simple quantitative problems involving principles of engineering materials; unable to fully solve moderate or complex problems.	Fully understanding of basic material classifications, properties and processing principles to biomedical applications. Can apply the theories and concepts of materials science to most problems related to medical devices. Can solve most quantitative problems involving principles of engineering materials.	Deep and complete understanding of basic material classifications, properties and processing principles to biomedical applications. Can apply the theories of materials science to all problems related to medical devices. Can solve all quantitative problems involving principles of engineering materials.
Applying materials science concepts to biomedical situations	Unable to read and understand biomedical literature. Unable to explain the underlying biological processes, biomaterial properties, and host-tissue response.	Can read very simple and partially understand basic biomedical literature. Can partially explain the underlying biological processes, biomaterial properties, and host-tissue response..	Can read and partially understand basic biomedical literature. Can partially explain the underlying biological processes, biomaterial properties, and host-tissue response..	Can read and understand biomedical literature at a moderate level. Can explain the underlying simple to moderate biological processes, biomaterial properties, and host-tissue response..	Can read and understand biomedical literature at a high level. Can explain the underlying complex biological processes, biomaterial properties, and host-tissue response..
Interpretation and representation	Did not attempt to give any explanations; makes no inferences to biocompatibility, manufacturability and sterilizability, makes major errors, and draw incorrect conclusions.	Did attempt to give some explanations; to biocompatibility, manufacturability and sterilizability, makes major errors, and draw some conclusions.	Provide reasonable explanations of information presented in scientific forms; makes adequate inferences to biocompatibility, manufacturability and sterilizability,	Provide accurate explanations of information presented in scientific forms; makes appropriate inferences to biocompatibility, manufacturability and sterilizability	Provide accurate explanations of information presented in scientific forms; demonstrates deep understanding in biocompatibility, manufacturability and sterilizability
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)

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Appendix 2: Assessment Criteria for Project Presentation

In practice, you would receive the same mark as your team. However, your mark may vary should there be evidence that you had not contributed to the team.

Criteria	**Unsatisfactory: <40%**	**Borderline: 40% to 49%**	**Satisfactory: 50% to 69%**	**Very good: 70% to 89%**	**Exemplary: >90%**
Comprehension The ability to comprehend biomedical requirements in relation to host-tissue response.	Unable to comprehend biomedical requirements to host-tissue response and could not describe their contribution to implant devices efficacy.	Partially understand the basic biomedical materials requirements to host-tissue response, and give some description on their contribution to implant devices efficacy.	Understand some of the basic biomedical materials requirements to host-tissue response, and describe their contribution to implant devices efficacy in a satisfactory level.	Able to comprehend the most basic and reasonable understanding of biomedical materials to host-tissue response requirements, and describe the basic mechanisms that contribute to implant devices efficacy..	Able to comprehend the basic and deep understanding of biomedical materials requirements to host-tissue response, and describe the basic mechanisms that contribute to implant devices efficacy
Application Applying relevant theories, principles and appropriate technologies to interpret and design applications of biomedical implants.	Unable to understand basic theories, principles, and technologies used in biomedical materials.	Can partially understand basic theories, principles, and technologies used in biomedical materials and make reasonable connection to real life scenarios.	Can understand basic theories, principles, and technologies used in biomedical materials and apply the knowledge to make reasonable connection to real life scenarios.	Understand basic theories, principles, and technologies used in biomedical materials very well, and apply the knowledge to describe and explain real life scenarios.	Can understand combination of basic theories, principles, and technologies used in biomedical materials very well, and apply the knowledge to describe, explain and make prediction in real life scenarios.

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Appendix 3: Assessment Form for Peer Evaluation

Please indicate your perceptions of other team member's contribution during the project development. Use the scale below for assessing each team member.

10-9	8-7	6-4	3-1	0
Demonstrate outstanding contributions and efforts during teamwork.	Exhibited appropriate effort in contributions during teamwork.	Made some contributions but greater effort could have been exhibited during teamwork.	Did not contribute much effort during teamwork.	Made no effort to contribute during teamwork.

Team member:											
Preparation for work accomplishment: completed readings.	10	9	8	7	6	5	4	3	2	1	0
Task-related collaborative behavior: task-focused, respectful of others, and cooperative.	10	9	8	7	6	5	4	3	2	1	0
Team adjustment behaviors: intra-team coaching, problem solving	10	9	8	7	6	5	4	3	2	1	0
Work behaviors: involved and participatory	10	9	8	7	6	5	4	3	2	1	0
Communication: information shared and exchanged, engaged in process, and made verbal contributions.	10	9	8	7	6	5	4	3	2	1	0
Provide constructive feedback for this team member. (Consisting of one to three sentences):											

Appendix 4: Class participation

Standards	Criteria
A+ (Exceptional) A (Excellent)	Important contributions to class discussion; asks insightful questions; precisely answers questions; participates in a meaningful and constructive manner including enabling other students to contribute but does not dominate; demonstrates thoughtful ideas and opinions in a convincing manner.
A- (Very good) B+ (Good)	Meaningful contributions to class discussion; ask interesting questions; accurately answer the questions; capacity to articulate and present points of view clearly; participates in a meaningful and constructive manner; evidence of having read and assimilated the class material; Capable to demonstrate ideas and opinions in a convincing manner.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Some contributions to class discussion; ask some questions; some capacity to articulate and present points of view; some evidence of constructive engagement during discussion; Capable to demonstrate ideas and opinions.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Minimal contributions to class discussion; ask very little questions; can answer a few questions; limited capacity to articulate and present points of view; limited evidence of constructive engagement during discussion.
D, F (Deeply unsatisfactory)	Very minimal or no contributions to class discussion; no questions; could not answer questions; no evidence of an individual viewpoint; failure to read the assigned reading; unexplained or unjustified absences from class activities.

Appendix 5: 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