University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Course Specification of Cell and Tissue Engineering

Course Code (BE477)

I. Course Identification and General Information:						
1	**Course Title:**	Cell and Tissue Engineering				
2	**Course Code & Number:**	BE477				
3	**Credit hours:**	C.H				TOTAL
		Th.	Seminar	Pr	Tr.	
		2	--	--	2	3
4	**Study level/ semester at which this course is offered:**	5th Level / 2nd Semester				
5	**Pre –requisite (if any):**	General Biology (BE101)				
6	**Co –requisite (if any):**	None				
7	**Program (s) in which the course is offered:**	Biomedical Engineering Program				
8	**Language of teaching the course:**	English				
9	**Location of Teaching the Course:**	Faculty of Engineering				
10	**Prepared by:**	Dr. Waleed Al-talabi				
11	**Reviewed by:**	Dr. Mohammed Alolofi				
12	**Date of Approval:**					

II. Course Description:

The course aims to introduce students to the fundamentals of Cell and Tissue Engineering, including the definitions, concepts, principals, latest developments, the category of cell and tissue engineering, biomaterials, fabrication of scaffolds, the use of stem cells and exemplars of tissue engineering in the context of biology and regenerative medicine. In addition to key technologies used in tissue engineering, and its applications. The course covers main topics including introduction to cell and tissue engineering, cell structure and cellular processes, fundamentals of tissue engineering, the basis of growth and differentiation, enabling technologies, biomaterials in tissue engineering, and tissue engineering applications.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)		**Referenced PILOs** (Only write code number of referenced Program Intended learning outcomes)
Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
a1	Demonstrate understanding of the principles, concepts, theories of basic knowledge related to Cell and tissue engineering.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Describe the principles and characteristics of biomaterials, fabrication of scaffolds, the use of stem cells and exemplars of tissue engineering in the context of biology and regenerative medicine.	A2 Clarify the design principles and techniques and the engineering materials characteristics and how these are relevant to the developments and technologies in a biomedical systems context.
a3	Identify the latest developments, the category of cell and tissue engineering.	A3 Recognize and explain the need for a high level of management, professional and ethical behavior, responsibility, quality assurance systems, codes of practice, standards, health

		and safety requirements, and environmental impacts in biomedical systems.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
b1	Analyze the advantages and limitations of commonly used materials, technologies and techniques in cell and tissue engineering.	B2 Identify, formulate and solve the complex problems related to the Biomedical Engineering fields in a creative and innovative manner by using a systematic and analytical thinking methods.
b2	Discuss the tissue type specific differences in approaches taken to the creation and analysis of tissue engineered constructs and devices.	B5 Distinguish the main characteristics of biomedical systems, apply diagnostic skills and technical knowledge and perform failure analysis to these systems.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Apply the principles of cellular and tissue engineering to theoretically develop processes for the production of biologics and tissue engineered medical devices.	C1 Apply integrally knowledge of mathematics, life science, IT, design, business context and engineering practice to solve problems and to design systems/processes relevant to Biomedical Engineering.
c2	Participate in team based data collection, recording and management, with an understanding of ethical limitations.	C3 Use computational facilities and techniques, measuring instruments, workshops and laboratory equipment to design and conduct experiments, collect, analyze and interpret data and present results in the biomedical systems practice.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		

d1	Demonstrate interpersonal communication skills in a professional environment through technical reports and presentations.	D1 Lead and motivate individuals, show capability to work in stressful environments and within constraints, collaborate effectively within multidisciplinary team.

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1. Demonstrate understanding of the principles, concepts, theories of basic knowledge related to Cell and tissue engineering.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Case studies.	• Written tests (mid and final terms and quizzes), • Home works and assignments.
a2. Describe the principles and characteristics of biomaterials, fabrication of scaffolds, the use of stem cells and exemplars of tissue engineering in the context of biology and regenerative medicine.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Case studies, • Directed self- study.	• Written tests (mid and final terms and quizzes), • Home works and assignments.
a3. Identify the latest developments, the category of cell and tissue engineering.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Case studies, • Directed self- study,	• Written tests (mid and final terms and quizzes), • Home works and assignments, • Presentations.

	• Team work (cooperative learning).	

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1. Analyze the advantages and limitations of commonly used materials, technologies and techniques in cell and tissue engineering.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Case studies, • Directed self- study, • Team work (cooperative learning).	• Written tests (mid and final terms and quizzes), • Home works and assignments, • Presentations.
b2. Discuss the tissue type specific differences in approaches taken to the creation and analysis of tissue engineered constructs and devices.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Case studies, • Directed self- study, • Team work (cooperative learning).	• Written tests (mid and final terms and quizzes), • Home works and assignments, • Presentations.

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1. Apply the principles of cellular and tissue engineering to	• Interactive lectures & examples,	• Written tests (mid and final terms and

theoretically develop processes for the production of biologics and tissue engineered medical devices.	• Presentation/seminar, • Tutorials, • Interactive class discussions, • Case studies, • Directed self- study, • Team work (cooperative learning).	quizzes), • Home works and assignments, • Presentations.
c2. Participate in team based data collection, recording and management, with an understanding of ethical limitations.	• Interactive lectures & examples, • Presentation/seminar, • Tutorials, • Interactive class discussions, • Case studies, • Directed self- study, • Team work (cooperative learning), • Field visits/training.	• Written tests (mid and final terms and quizzes), • Short reports, • Home works and assignments, • Presentations.

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Demonstrate interpersonal communication skills in a professional environment through technical reports and presentations.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Team work (cooperative learning), • Field visits/training.	• Written tests (mid and final terms and quizzes), • Oral exams, • Short reports, • Home works and assignments, • Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	contact hours	Learning Outcomes
1	**Introduction**	– Introduction to the course. – Course outlines. – Project description. – History of tissue engineering.	1	2	a3, d1,
2	**Introduction to Cell and Tissue Engineering**	– Introduction. – Definitions. – Basic principles. – Structure-function relationships. – Current status and future perspectives. – From mathematical modelling and machine learning to clinical reality.	1	2	a1, a3,
3	**Cell Structure and Cellular Processes**	– Basic cell structure including organelles of eukaryotic and prokaryotic cells. – Cell membrane transport. – Cellular communication. – Energy and metabolism. – Water and basic acid/base concepts as they relate to living organisms.	1	2	a1, a3, b2
4	**Fundamentals of Tissue Engineering**	– Fundamentals of stem cell tissue engineering. – Growth factors and morphogens:	2	4	a1, a2, b2

		signals for tissue engineering. – Extracellular Matrix: Structure, function, and applications to tissue engineering. – Mechanical forces on cells. – Cell adhesion. – Cell migration. – Inflammatory and immune responses to tissue engineered devices.			
5	**The Basis of Growth and Differentiation**	– Molecular biology of the cell. – Molecular organization of cells. – The dynamics of cell-extracellular matrix interactions, with implications for tissue engineering. – Matrix molecules and their ligands. – Morphogenesis and tissue engineering. – Gene expression, cell determination, differentiation, and regeneration.	2	4	a2, b2,
6	**Mid-Term Theoretical Exam**	– All previous topics.	1	2	a1, a3, a2, b1, b2, d1
7	**Enabling Technologies**	– Polymeric scaffolds for tissue engineering applications. – Calcium phosphate ceramics for bone tissue engineering. – Biomimetic materials.	1	2	a3, b1, c1

8	**Biomaterials in Tissue Engineering**	– Cell interactions with polymers. – Polymer scaffold fabrication. – Biodegradable polymers. – Three-dimensional scaffolds.	2	4	a3, a2, c1, c2
9	**Tissue Engineering Applications**	– Bioengineering of human skin substitutes. – Bones tissue engineering. – Cartilage tissue engineering. – Engineering smooth muscle. – Cardiac tissue engineering. – Tissue engineering of heart valves.	2	4	a3, b1, b2, c1
10	**Project Presentation**	– Student's presentations.	2	4	a1, a3, c2, d1
11	**Final Theoretical Exam**	– All Topics.	1	2	a1, b1, c1, d1
Number of Weeks /and Units Per Semester			**16**	**32**	

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	These will cover similar material to the lectures.	15	30	a1, a2, a3, b1, b2, c1, c2, d1
Number of Weeks /and Units Per Semester		**15**	**30**	

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Directed self- study,
- Team work (cooperative learning),
- Field visits/training.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Lectures 1,2,3, and 4 Assignment	a1, a3,b2,d1	5	6
2	Lectures 5,6,7, and 9 Assignment	a1, a3, a2, b1, b2, c1, c2, d1	10	7
3	Lectures 10,11,12, and 13 Assignment	a1, a3, b1, c1, c2, d1	14	7
4	Project/ Presentation	a1, a3, c2, d1	15	10
Total				30

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Project/ Assignments	5,10,14,15	30	20%	a1, a3, c2, d1
2	Quiz 1	4	10	6.67%	a1, a3, a2, b1
3	Midterm Exam	8	30	20%	a1, a3, a2, b1, b2, d1
4	Quiz 2	12	10	6.67%	a1, b1, c1
5	Final Exam	16	70	46.67%	a1, b1, c1, d1
Total			150	100%	

IX. Learning Resources:

1- Required Textbook(s) (maximum two).

1. Lanza, Robert, Langer, Robert, and Joseph P. Vacanti, eds. 2020. "**Principles of Tissue Engineering"**. 5th Ed. UK, Elsevier Inc.: Academic Press.
2. John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, 2007. "**Tissue Engineering"**, USA, CRC Press: Taylor & Francis Group.

2- Essential References.

1. Joseph D. Bronzino, Donald R. Peterson, 2015, "**Molecular, Cellular, and Tissue Engineering**", USA, CRC Press: Taylor & Francis Group .
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3- Electronic Materials and Web Sites *etc*.

Websites:

1- Tissue and Cell Engineering Society, furthering knowledge, research and dissemination of information on Cell and Tissue Engineering.
https://tces.org/

	2- Advancing tissue engineering & regenerative medicine worldwide to generate knowledge with a view to improving patient outcomes globally. https://www.termis.org/ **Journals:** 1- *Journal of Tissue Engineering (JTE)* is a peer reviewed, open access journal which focusses on scientific research in the field of tissue engineering and its clinical application. https://journals.sagepub.com/home/tej 2- International Journal of Tissue Engineering https://www.hindawi.com/journals/ijte/ *Journal of Tissue Engineering and Regenerative Medicine* is a multidisciplinary journal that publishes research and reviews on the development of therapeutic approaches which combine stem/progenitor cells with biomaterials and scaffolds, and growth factors and other bioactive agents. https://onlinelibrary.wiley.com/journal/19327005

X. Course Policies:

1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam

4	**Assignments & Projects**: In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
5	**Cheating**: For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university or according to the university roles.
7	**Other policies**: - Mobile phones are not allowed to use during a class lecture. It must be closed; **otherwise** the student will be asked to leave the lecture room. - Mobile phones are not allowed in class during the examination. - Lecture notes and assignments might be given directly to students using soft or hard copy.

University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Template for Course Plan (Syllabus)

Cell and Tissue Engineering
BE477

I. Course Identification and General Information:					
1	**Course Title:**	Cell and Tissue Engineering			
2	**Course Code & Number:**	BE477			
3	**Credit Hours:**	**Credit Hours**	**Theory Hours**		**Lab. Hours**
			Lecture	**Exercise**	
		3	2	2	--
4	**Study Level/ Semester at which this Course is offered:**	5th Level / 2nd Semester			
5	**Pre –Requisite (if any):**	General Biology (BE101)			
6	**Co –Requisite (if any):**	None			
7	**Program (s) in which the Course is Offered:**	Bachelor of Biomedical Engineering			
8	**Language of Teaching the Course:**	English			
9	**Location of Teaching the Course:**	Faculty of Engineering			
10	**Prepared by:**	Dr. Waleed Al-talabi			
11	**Reviewed by:**	Dr. Mohammed Al-olofi			
12	**Date of Approval:**				

II. Course Description:

The course aims to introduce students to the fundamentals of Cell and Tissue Engineering, including the definitions, concepts, principals, latest developments, the category of cell and tissue engineering, biomaterials, fabrication of scaffolds, the use of stem cells and exemplars of tissue engineering in the context of biology and regenerative medicine. In addition to key technologies used in tissue engineering, and its applications. The course covers main topics including introduction to cell and tissue engineering, cell structure and cellular processes, fundamentals of tissue engineering, the basis of growth and differentiation, enabling technologies, biomaterials in tissue engineering, and tissue engineering applications.

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)

A. Knowledge and Understanding: Upon successful completion of the course, students will be able to:	
a1	Demonstrate understanding of the principles, concepts, theories of basic knowledge related to Cell and tissue engineering.
a2	Describe the principles and characteristics of biomaterials, fabrication of scaffolds, the use of stem cells and exemplars of tissue engineering in the context of biology and regenerative medicine.
a3	Identify the latest developments, the category of cell and tissue engineering.
B. Intellectual Skills: Upon successful completion of the course, students will be able to:	
b1	Analyze the advantages and limitations of commonly used materials, technologies and techniques in cell and tissue engineering.
b2	Discuss the tissue type specific differences in approaches taken to the creation and analysis of tissue engineered constructs and devices.
C. Professional and Practical Skills: Upon successful completion of the course, students will be able to:	
c1	Apply the principles of cellular and tissue engineering to theoretically develop processes for the production of biologics and tissue engineered medical devices.
c2	Participate in team based data collection, recording and management, with an understanding

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)	
	of ethical limitations.
D. Transferable Skills: Upon successful completion of the course, students will be able to:	
d1	Demonstrate interpersonal communication skills in a professional environment through technical reports and presentations.

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction**	– Introduction to the course. – Course outlines. – Project description. – History of tissue engineering.	1	2
2	**Introduction to Cell and Tissue Engineering**	– Introduction. – Definitions. – Basic principles. – Structure-function relationships. – Current status and future perspectives. – From mathematical modelling and machine learning to clinical reality.	1	2
3	**Cell Structure and Cellular Processes**	– Basic cell structure including organelles of eukaryotic and prokaryotic cells. – Cell membrane transport. – Cellular communication. – Energy and metabolism.	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– Water and basic acid/base concepts as they relate to living organisms.		
4	**Fundamentals of Tissue Engineering**	– Fundamentals of stem cell tissue engineering. – Growth factors and morphogens: signals for tissue engineering. – Extracellular Matrix: Structure, function, and applications to tissue engineering. – Mechanical forces on cells. – Cell adhesion. – Cell migration. – Inflammatory and immune responses to tissue engineered devices.	2	4
5	**The Basis of Growth and Differentiation**	– Molecular biology of the cell. – Molecular organization of cells. – The dynamics of cell-extracellular matrix interactions, with implications for tissue engineering. – Matrix molecules and their ligands. – Morphogenesis and tissue engineering. – Gene expression, cell	2	4

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		determination, differentiation, and regeneration.		
6	**Mid-Term Theoretical Exam**	All previous topics.	1	2
7	**Enabling Technologies**	– Polymeric scaffolds for tissue engineering applications. – Calcium phosphate ceramics for bone tissue engineering. – Biomimetic materials.	1	2
8	**Biomaterials in Tissue Engineering**	– Cell interactions with polymers. – Polymer scaffold fabrication. – Biodegradable polymers. – Three-dimensional scaffolds.	2	4
9	**Tissue Engineering Applications**	– Bioengineering of human skin substitutes. – Bones tissue engineering. – Cartilage tissue engineering. – Engineering smooth muscle. – Cardiac tissue engineering. – Tissue engineering of heart valves.	2	4
10	**Project Presentation**	– Student's presentations.	2	4
11	**Final Theoretical Exam**	– All Topics.	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
Number of Weeks /and Units Per Semester			**16**	**32**

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours
1	These will cover similar material to the lectures.	15	30
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
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- Interactive class discussions,
- Case studies,
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- Team work (cooperative learning),
- Field visits/training.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Home works and assignments,
- Presentations.

VII. Assignments:

No.	Assignments	Week Due	Mark
1	**Lectures 1,2,3, and 4 Assignment**	5	**6**
2	**Lectures 5,6,7, and 9 Assignment**	10	**7**
3	**Lectures 10,11,12, and 13 Assignment**	14	**7**
4	**Project/ Presentation**	15	**10**
Total			**30**

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Project/ Assignments**	5,10,14, 15	30	20%
2	**Quiz 1**	4	10	6.67%
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https://tces.org/

2- Advancing tissue engineering & regenerative medicine worldwide to generate knowledge with a view to improving patient outcomes globally.
https://www.termis.org/

Journals:

1- *Journal of Tissue Engineering (JTE)* is a peer reviewed, open access journal which focusses on scientific research in the field of tissue engineering and its clinical application.
https://journals.sagepub.com/home/tej

2- International Journal of Tissue Engineering
https://www.hindawi.com/journals/ijte/

3- *Journal of Tissue Engineering and Regenerative Medicine* is a multidisciplinary journal that publishes research and reviews on the development of therapeutic approaches which combine stem/progenitor cells with biomaterials and scaffolds, and growth factors and other bioactive agents.
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