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

Course Specification of Robotics Principles and Applications in BME (Elective 2)

Course Code (BE476)

I. Course Identification and General Information:						
1	**Course Title:**	Robotics Principles and Applications in BME				
2	**Course Code & Number:**	BE476				
3	**Credit hours:**	**C.H**				**TOTAL**
		Th.	**Seminar**	**Pr**	**Tr.**	
		2	--	2	0	3
4	**Study level/ semester at which this course is offered:**	Fifth Level / Second Semester				
5	**Pre –requisite (if any):**	Digital Control Systems (BE352), Microprocessor & Microcontrollers Interfacing(BE353), Electrical Machine (BE214), Biomedical Sensors and Measurements (BE224)				
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. Hatem Al-Dois				
11	**Reviewed by:**	Dr.Mohammed Al-Olofy				
12	**Date of Approval:**					

II. Course Description:

This course provides an introduction to robotics and its applications in various medical disciplines. The course starts by introducing the fundamental robotics principles such as kinematics, Jacobian, dynamics, trajectory planning and control. Then, the design and control of robots and associated technology for medical applications are highlighted. The focus is put on surgery, rehabilitation and intervention applications. Students' explorations of these topics will be supported by the use of computer tools such as Matlab and LabView in the modeling and simulation lab.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)		**Referenced PILOs** (Only write code number of referenced Program Intended learning outcomes)
A. Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
a1	Explain the basic concepts in kinematics, dynamics, trajectory planning and control relevant to medical robotics.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Illustrate the working principles of medical robotics, imaging techniques and contemporary surgical technologies.	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 clinical applications of medical robotic systems, their operational theories and associated clinical environments.	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.

a4	Explore the features of human-robot interaction and hence the future of robots in healthcare domain.	A4 Understand and give examples of design methods, knowledge tools, analytical skills, measurement techniques and methodologies for innovative and creative engineering solutions applied to healthcare problems and quality of life issues.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
b1	Analyze various clinical requirements and their influence on medical robotics design.	B1 Apply engineering principles; basic of life-science; mathematical theories; and modern tools professionally in modelling, analyzing, designing, and constructing physical digital systems; devices and/or processes relevant to Biomedical Engineering fields.
b2	Evaluate various designs, kinematics, dynamics and control properties of medical robotics systems.	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.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Apply knowledge of robotics and vision to biomedical applications.	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	Use mathematical and simulation models to evaluate and develop medical robotic	C2 Use a wide range of analytical tools, techniques, IT, modern engineering tools,

	systems.		software packages and develop required computer programs to solve, modeling and analyzing Biomedical Engineering problems.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:			
d1	Function effectively in different work environments as an individual, and as a member or leader in multi-disciplinary teams.	D1	Lead and motivate individuals, show capability to work in stressful environments and within constraints, collaborate effectively within multidisciplinary team.
d2	Document and communicate knowledge and skills on robotics with proper use of terminology, orally and in writing.	D5	Demonstrate efficient IT capabilities and communicate effectively both orally and in writing technical reports.

(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. Explain the basic concepts in kinematics, dynamics, trajectory planning and control relevant to medical robotics.	• Interactive lectures & examples, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Directed self- study.	• Written tests (mid and final terms and quizzes), • Short reports, • Home works and assignments, • Presentations.
a2. Illustrate the working principles of medical robotics, imaging techniques and contemporary surgical technologies.	• Interactive lectures & examples, • Interactive class discussions, • Case studies, • Computer laboratory-based sessions, • Directed self- study.	• Written tests (mid and final terms and quizzes), • Oral exams, • Short reports, • Home works and assignments, • Presentations.

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a3. Identify the clinical applications of medical robotic systems, their operational theories and associated clinical environments.	• Interactive lectures & examples, • Interactive class discussions, • Case studies, • Exercises and home works, • Directed self- study, • Problem based learning.	• Written tests (mid and final terms and quizzes), • Short reports, • Home works and assignments, • Presentations.
a4. Explore the features of human-robot interaction and hence the future of robots in healthcare domain.	• Videos demonstrations, • Interactive class discussions, • Directed self- study.	• Oral exams, • Short reports, • Presentations.

(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 various clinical requirements and their influence on medical robotics design.	• 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), • Short reports, • Coursework activities assessment, • Home works and assignments.
b2. Evaluate various designs, kinematics, dynamics and control properties of medical robotics systems.	• Interactive class discussions, • Case studies, • Exercises and home works, • Computer laboratory-based	• Written tests (mid and final terms and quizzes), • Coursework activities assessment, • Home works and

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
	sessions, • Problem based learning, • Team work (cooperative learning).	assignments.

(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 knowledge of robotics and vision to biomedical applications.	• Interactive class discussions, • Case studies, • Exercises and home works, • Computer laboratory-based sessions, • Problem based learning, • Team work (cooperative learning).	• Written tests (mid and final terms and quizzes), • Lab\Project report • Coursework activities assessment, • Home works and assignments.
c2. Use mathematical and simulation models to evaluate and develop medical robotic systems.	• Case studies, • Exercises and home works, • Computer laboratory-based sessions, • Directed self- study, • Team work (cooperative learning).	• Written tests (mid and final terms and quizzes), • Practical lab performance assessment, • Home works and assignments.

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Function effectively in	• Interactive class discussions,	• Short reports,

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
different work environments as an individual, and as a member or leader in multi-disciplinary teams.	• Exercises and home works, • Team work (cooperative learning).	• Coursework activities assessment, • Home works and assignments, • Presentations.
d2. Document and communicate knowledge and skills on robotics with proper use of terminology, orally and in writing.	• Interactive class discussions, • Exercises and home works, • Presentation/seminar, • Team work (cooperative learning).	• Short reports, • Coursework activities assessment, • Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction to Robotics – Analysis of rigid body**	a1, a4	– Robotic mechanisms – Points, vectors, and coordinate frames – Rotation matrices and representation of orientation – Coordinate transformations – Future of medical robotics	1	2
2	**Kinematics of medical robots**	a1, a2, b2	– Forward Kinematics – The DH convention – Examples of popular kinematic configurations – Inverse Kinematics (Algebraic, geometric and numerical solutions)	2	4

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
3	**Differential Kinematics**	a1, a2, b2	– Velocity and acceleration kinematics – The Jacobian matrix – Kinematic singularities and redundancy	1	2
4	**Robot dynamics and simulation**	a1, a2, b2	– The generalized static force/torque relationship – Newton Euler formulation of robot dynamics – Lagrange's formulation of robot dynamics – Dynamics Simulation	1	2
5	**Trajectory generation**	a1, a2, b2	– General considerations – Joint-interpolated trajectories – Cartesian path trajectories – 3rd & 5th order polynomial trajectories planning	1	2
6	**Robot control**	a1, a2, b2	– Joint-space position control – Work-space position control – Force & impedance control	1	2
7	**Mid-Term Theoretical Exam**	a1, a2, b2	– Previous Topics	1	2
8	**Medical robotics-core concepts**	a2, a3, b1	– Robotic system concepts for medical applications – Clinical applications of robotics – Factors Affecting the Acceptance	2	4

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
			– of Medical Robots – Mechanical Design Considerations – Sensor and actuator design considerations		
9	**Tracking and surgical navigation**	a2	– Computer-Integrated Surgery – Medical Robotics System Paradigms: – Surgical CAD/CAM – Surgical Assistance – Surgical simulation	2	4
10	**Teleoperation & cooperative manipulation**	a2	– Control Paradigms: – Preprogrammed, semi-autonomous motion – Teleoperator control – Hands-on compliant control – Virtual Fixtures and Human–Machine Cooperative Systems – Safety and Sterility	2	4
11	**Closed-loop interventions**	a2, b1	– Medical imaging and image-guided interventions – Integration of robotic devices and medical imaging systems – Modelling of Patients – Registration	1	2
12	**Final Theoretical Exam**	a1, a2, a3, a4, b1, b2	All Topics	1	2

Number of Weeks /and Units Per Semester	16	32

B. Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	**Computer Lab (MatLAB):** Introduction to Robotics toolbox in MatLAB (Corke tool): Transformations;	1	2	c1, d1
2	**Computer Lab:** Robotics toolbox in MatLAB: Constructing and analyzing different robotic configurations;	1	2	b2, c1, c2, d1, d2
3	**Computer Lab:** Robotics toolbox in MatLAB: - Kinematic analysis of robot manipulators;	1	2	b2, c1, c2, d1
4	**Computer Lab (Simulating with Stage & ROS – Arduino and Raspberry Pi 3):** - ROS environment and features; - Relating Arduino and Raspberry Pi tasks with ROS architecture ; - Sketching a robotic simulation setup;	2	4	b1, b2, c2, d1, d2
5	**Computer Lab (Simulating with ROS):** - Implementing a robotic platform in ROS; - Executing Stage software in ROS.	1	2	b1, b2, c2, d1, d2
6	**Computer Lab:** Robotics toolbox in Matlab: - Dynamic analysis of robot manipulators; - Motion analysis of robotic systems.	1	2	c1, c2, d2
7	**Mid-Term Practical Exam**	1	2	b1, b2,

B. Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
				c1, c2
8	**Computer Lab:** Robotics toolbox in MatLAB: - Different control schemes of robotic Manipulators.	1	2	b1, b2, c1, c2, d2
9	**Control Lab (Simulating with ROS):** - Evaluating and improving the robot performance	2	4	b1, b2, c2, d2
10	**Computer Lab (Medical robot tool)):** - Learning and practicing different functions on a medical robot tool.	3	6	b1, b2, c1, c2, d1, d2
11	**Final Practical Exam**	1	2	b1, b2, c1, c2
Number of Weeks /and Units Per Semester		**15**	**30**	

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Exercises and home works,
- Directed self- study,
- Problem based learning.
- Case studies,
- Computer laboratory-based sessions,
- Team work (cooperative learning).

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Short reports,
- Oral exams,
- Coursework activities assessment,
- Lab\Project report
- Practical lab performance assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Aligned CILOs (symbols)	Week Due	Mark
1	**Assignment: A review of the state of the art in selected areas of medical robotics.** Students, in groups of three , will conduct a review of the state of the art in selected areas of medical robotics. The groups will choose their research subject in consultation with the instructor and from a list of potential topics that will be announced in the class. The groups have to submit a report and also present the result of their survey to the class.	a2, a4, b2, d1, d2	13	10
Total				10

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	**Assignment**	13	10	6.7%	a2, a3, a4, b2, d1

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
2	**Quiz 1**	6	5	3.3%	a2, a3, b1
3	**Mid-Term Theoretical Exam**	8	20	13.3%	a1, a2, b2
4	**Mid-Term Practical Exam**	8	20	13.3%	b1, b2, c1, c2
5	**Quiz 2**	12	5	3.3%	a2, a3, b2
6	**Final Practical Exam**	15	30	20	b1, b2, c1, c2
7	**Final Theoretical Exam**	16	60	40%	a1, a2, a3, a4, b1, b2
Total			**150**	**100%**	

IX. Learning Resources:

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

1- Schweikard, 2015, **Medical Robotics**, 1st Edition, NY, Springer

2- Craig, John J, R., 2017, **Introduction to Robotics: Mechanics and Control**, 4th Edition, Singapore, Pearson Education International Edition.

2- Essential References.

1- Bruno Siciliano & Oussama Khatib, 2008, **Springer Handbook of Robotics**, 1st Edition, NY, Springer.

2- J. Rosen, B.Hannaford & R. M. Satava, 2011, **Surgical Robotics: Systems Applications and Visions**, 1st Edition, NY, Springer.

3- Jaydev P Desai, 2018, **Encyclopedia of Medical Robotics**, 1st Edition, NY, World Scientific Publishing Co Pte Ltd.

4- J. Hunter, D. Spight, C.Sandone & J. Fairman, 2018, **Atlas of Minimally Invasive Surgical Operations**, 1st Edition, NJ, McGraw-Hill Education.

5- Nadine Barrie Smith, 2010, **Introduction to Medical Imaging (Physics, Engineering and Clinical Applications),** 1st Edition, Cambridge, Cambridge University Press.

6- T. Peters and K. Clear, 2008, **Image-Guided Interventions: Technology and**

IX. Learning Resources:

Applications, NY, Springer.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- Medical Robotics - Carnegie Mellon University
http://medrobotics.ri.cmu.edu/node/128439

2- MRes Medical Robotics and Image-Guided Intervention, Imperial College London
http://www.imperial.ac.uk/study/pg/courses/global-health-innovation/medical-robotics/

3- Peter Corke, Robotics Toolbox for Matlab
https://petercorke.com/toolboxes/robotics-toolbox/

Journals:

1- The International Journal of Medical Robotics and Computer Assisted Surgery, Wiley
http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291478-596X

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

X. Course Policies:	
	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)

Robotics Principles and Applications in BME
BE476

Information about Faculty Member Responsible for the Course:							
Name of Faculty Member:	**Dr. Hatem Al-Dois**						
Location& Telephone No.:	**774677493**						
E-mail:	**haldois@yahoo.com**	SAT	SUN	MON	TUE	WED	THU
Office Hours							

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

I. Course Identification and General Information:

1	**Course Title:**	Robotics Principles and Applications in BME				
2	**Course Code & Number:**	BE476				
3	**Credit hours:**	**C.H**				**TOTAL**
		Th.	**Seminar**	**Pr**	**Tr.**	
		2	--	2	0	3
4	**Study level/ semester at which this course is offered:**	Fifth Level / Second Semester				
5	**Pre –requisite (if any):**	Digital Control Systems (BE352), Microprocessor & Microcontrollers Interfacing(BE353), Electrical Machine (BE214), Biomedical Sensors and Measurements (BE224)				
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. Hatem Al-Dois				
11	**Reviewed by:**	Dr.Mohammed Al-Olofy				
12	**Date of Approval:**					

II. Course Description:

This course provides an introduction to robotics and its applications in various medical disciplines. The course starts by introducing the fundamental robotics principles such as kinematics, Jacobian, dynamics, trajectory planning and control. Then, the design and control of robots and associated technology for medical applications are highlighted. The focus is put on surgery, rehabilitation and intervention applications. Students' explorations of these topics will be supported by the use of computer tools such as Matlab and LabView in the modeling and simulation lab.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)	
B. Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:	
a1	Explain the basic concepts in kinematics, dynamics, trajectory planning and control relevant to medical robotics.
a2	Illustrate the working principles of medical robotics, imaging techniques and contemporary surgical technologies.
a3	Identify the clinical applications of medical robotic systems, their operational theories and associated clinical environments.
a4	Explore the features of human-robot interaction and hence the future of robots in healthcare domain.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:	
b1	Analyze various clinical requirements and their influence on medical robotics design.
b2	Evaluate various designs, kinematics, dynamics and control properties of medical robotics systems.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:	
c1	Apply knowledge of robotics and vision to biomedical applications.
c2	Use mathematical and simulation models to evaluate and develop medical robotic systems.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:	
d1	Function effectively in different work environments as an individual, and as a member or leader in multi-disciplinary teams.
d2	Document and communicate knowledge and skills on robotics with proper use of terminology, orally and in writing.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction to Robotics – Analysis of rigid body**	– Robotic mechanisms – Points, vectors, and coordinate frames – Rotation matrices and representation of orientation – Coordinate transformations – Future of medical robotics	1	2
2	**Kinematics of medical robots**	– Forward Kinematics – The DH convention – Examples of popular kinematic configurations – Inverse Kinematics (Algebraic, geometric and numerical solutions)	2	4
3	**Differential Kinematics**	– Velocity and acceleration kinematics – The Jacobian matrix – Kinematic singularities and redundancy	1	2
4	**Robot dynamics and simulation**	– The generalized static force/torque relationship – Newton Euler formulation of robot dynamics – Lagrange's formulation of robot dynamics – Dynamics Simulation	1	2
5	**Trajectory generation**	– General considerations – Joint-interpolated trajectories – Cartesian path trajectories – 3rd & 5th order polynomial trajectories planning	1	2

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
6	**Robot control**	– Joint-space position control – Work-space position control – Force & impedance control	1	2
7	**Mid-Term Theoretical Exam**	– Previous Topics	1	2
8	**Medical robotics-core concepts**	– Robotic system concepts for medical applications – Clinical applications of robotics – Factors Affecting the Acceptance – of Medical Robots – Mechanical Design Considerations – Sensor and actuator design considerations	2	4

9	**Tracking and surgical navigation**	– Computer-Integrated Surgery
		– Medical Robotics System Paradigms:
		  – Surgical CAD/CAM
		  – Surgical Assistance
		  – Surgical simulation
			2	4

10	**Teleoperation & cooperative manipulation**	– Control Paradigms:
		  – Preprogrammed, semi-autonomous motion
		  – Teleoperator control
		  – Hands-on compliant control
		– Virtual Fixtures and Human–Machine Cooperative Systems
		– Safety and Sterility
			2	4

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
11	**Closed-loop interventions**	– Medical imaging and image-guided interventions – Integration of robotic devices and medical imaging systems – Modelling of Patients – Registration	1	2
12	**Final Theoretical Exam**	All Topics	1	2
Number of Weeks /and Units Per Semester			**16**	**32**

B. Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	**Computer Lab (MatLAB):** Introduction to Robotics toolbox in MatLAB (Corke tool): Transformations;	1	2
2	**Computer Lab:** Robotics toolbox in MatLAB: Constructing and analyzing different robotic configurations;	1	2
3	**Computer Lab:** Robotics toolbox in MatLAB: - Kinematic analysis of robot manipulators;	1	2
4	**Computer Lab (Simulating with Stage & ROS – Arduino and Raspberry Pi 3):** - ROS environment and features; - Relating Arduino and Raspberry Pi tasks with ROS architecture ; - Sketching a robotic simulation setup;	2	4

B. Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
5	**Computer Lab (Simulating with ROS):** - Implementing a robotic platform in ROS; - Executing Stage software in ROS.	1	2
6	**Computer Lab:** Robotics toolbox in Matlab: - Dynamic analysis of robot manipulators; - Motion analysis of robotic systems.	1	2
7	**Mid-Term Practical Exam**	1	2
8	**Computer Lab:** Robotics toolbox in MatLAB: - Different control schemes of robotic Manipulators.	1	2
9	**Control Lab (Simulating with ROS):** - Evaluating and improving the robot performance	2	4
10	**Computer Lab (Medical robot tool)):** - Learning and practicing different functions on a medical robot tool.	3	6
11	**Final Practical Exam**	1	2
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Exercises and home works,

V. Teaching Strategies of the Course:

- Directed self- study,
- Problem based learning.
- Case studies,
- Computer laboratory-based sessions,
- Team work (cooperative learning).

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Short reports,
- Oral exams,
- Coursework activities assessment,
- Lab\Project report
- Practical lab performance assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Week Due	Mark
1	**Assignment: A review of the state of the art in selected areas of medical robotics.** Students, in groups of three , will conduct a review of the state of the art in selected areas of medical robotics. The groups will choose their research subject in consultation with the instructor and from a list of potential topics that will be announced in the class. The groups have to submit a report and also present the result of their survey to the class.	13	10
Total			**10**

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Assignment**	13	10	6.7%
2	**Quiz 1**	6	5	3.3%
3	**Mid-Term Theoretical Exam**	8	20	13.3%
4	**Mid-Term Practical Exam**	8	20	13.3%
5	**Quiz 2**	12	5	3.3%
6	**Final Practical Exam**	15	30	20
7	**Final Theoretical Exam**	16	60	40%
Total			**150**	**100%**

IX. Learning Resources:

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

1- Schweikard, 2015, **Medical Robotics**, 1st Edition, NY, Springer

2- Craig, John J, R., 2017, **Introduction to Robotics: Mechanics and Control**, 4th Edition, Singapore, Pearson Education International Edition.

2- Essential References.

1- Bruno Siciliano & Oussama Khatib, 2008, **Springer Handbook of Robotics**, 1st Edition, NY, Springer.

2- J. Rosen, B.Hannaford & R. M. Satava, 2011, **Surgical Robotics: Systems Applications and Visions**, 1st Edition, NY, Springer.

3- Jaydev P Desai, 2018, **Encyclopedia of Medical Robotics**, 1st Edition, NY, World Scientific Publishing Co Pte Ltd.

4- J. Hunter, D. Spight, C.Sandone & J. Fairman, 2018, **Atlas of Minimally Invasive Surgical Operations**, 1st Edition, NJ, McGraw-Hill Education.

5- Nadine Barrie Smith, 2010, **Introduction to Medical Imaging (Physics, Engineering and Clinical Applications),** 1st Edition, Cambridge, Cambridge University Press.

IX. Learning Resources:

6- T. Peters and K. Clear, 2008, **Image-Guided Interventions: Technology and Applications**, NY, Springer.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- Medical Robotics - Carnegie Mellon University
http://medrobotics.ri.cmu.edu/node/128439

2- MRes Medical Robotics and Image-Guided Intervention, Imperial College London
http://www.imperial.ac.uk/study/pg/courses/global-health-innovation/medical-robotics/

3- Peter Corke, Robotics Toolbox for Matlab
https://petercorke.com/toolboxes/robotics-toolbox/

Journals:

1- The International Journal of Medical Robotics and Computer Assisted Surgery, Wiley
http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291478-596X

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

	X. Course Policies:
	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.