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

# Course Specification of Medical Imaging System 2

## **Course Code** (BE469)

| **I. Course Identification and General Information:** | | | | | | |
|---|---|---|---|---|---|---|
| **1** | **Course Title:** | Medical Imaging System 2 | | | | |
| **2** | **Course Code & Number:** | BE469 | | | | |
| **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):** | Medical Imaging System 1 (BE468) | | | | |
| **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. Mohammed Al-olofi | | | | |
| **11** | **Reviewed by:** | Dr. Waleed Al-Talbi | | | | |
| **12** | **Date of Approval:** | | | | | |

## II. Course Description:

The medical imaging systems 2 course aims to give the student knowledge of the basic concepts of Theory operations, calibrations and maintenance for medical imaging equipment, the block diagrams for a variety medical imaging equipment which used in radiology department, design instruments to satisfy specific needs, develop skills for analyze, calibration, repair, maintenance, and troubleshooting of medical imaging systems. This course includes the Medical ultrasound imaging

(US), Computed Tomography (CT), Magnetic Resonance Imaging (MRI). Methods of obtaining useful medical images, Image formation and display. Projection radiography. Radiation detectors. Automating diagnosis and non-invasive testing. Radiation safety of patients and personnel, and types of digital detectors using in above machines. The co-requisite practical will focus on the practical operations, calibrations, troubleshooting and maintenance for medical imaging equipment.

| **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 | Illustrate the basic concepts, and principles, physical theories for the medical imaging systems (Ultrasound, CT, and MRI). | A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context. |
| a2 | Identify the techniques, operation, and design principles of medical imaging devices (Ultrasound, CT, and MRI) which are relevant to the developments and new 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 | Describe the clinical applications of medical imaging systems (Ultrasound, CT, and MRI), their operational theories and their 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. |
| B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to: | | |

| | | |
|---|---|---|
| b1 | Design the medical imaging devices used in radiology department with considerate environmental conditions, health and safety, manufacturability and sustainability. | B3 Design the biomedical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability. |
| b2 | Categorize the medical imaging devices (Ultrasound, CT, and MRI) according to their specifications and features. | 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 mathematical, simulation models, and IT software packages to medical imaging systems (Ultrasound, CT, and MRI) effectively. | C2 Use a wide range of analytical tools, techniques, IT, modern engineering tools, software packages and develop required computer programs to solve, modeling and analyzing Biomedical Engineering problems. |
| c2 | Install, operate, troubleshooting, and maintenance the medical imaging devices (Ultrasound, CT, and MRI) by using rules and regulations of medical safety. | C4 Use rules and regulations of industrial safety as well as safe and diagnose systems at work, evaluate performance and observe the appropriate steps to manage risks concerning biomedical 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. | 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** Illustrate the basic concepts, and principles, physical theories for the medical imaging systems (Ultrasound, CT, and MRI). | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• Presentations. |
| **a2** Identify the techniques, operation, and design principles of medical imaging devices (Ultrasound, CT, and MRI) which are relevant to the | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar, | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab |

| | | |
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| developments and new technologies. | • Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | performance assessment,<br>• Coursework activities assessment,<br>• Presentations. |
| **a3** Describe the clinical applications of medical imaging systems (Ultrasound, CT, and MRI), their operational theories and their clinical environments. | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning, | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• Presentations. |

| | | |
|---|---|---|
| | • Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | |

| **(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:** | | |
|---|---|---|
| Course Intended Learning Outcomes | Teaching strategies | Assessment Strategies |
| **b1** Design the medical imaging devices used in radiology department with considerate environmental conditions, health and safety, manufacturability and sustainability. | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• Presentations. |
| **b2** Categorize the medical imaging devices (Ultrasound, | • Interactive lectures & examples, | • Written tests (mid and final terms and |

| | | |
|---|---|---|
| CT, and MRI) according to their specifications and features. | • Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• 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 mathematical, simulation models, and IT software packages to medical imaging systems (Ultrasound, CT, and MRI) effectively. | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities |

| | | |
|---|---|---|
| | experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | assessment,<br>• sPresentations. |
| **c2** Install, operate, troubleshooting, and maintenance the medical imaging devices (Ultrasound, CT, and MRI) by using rules and regulations of medical safety. | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• 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** Function effectively in different work environments as an individual, and as a member or leader in multi-disciplinary teams. | • Interactive lectures & examples,<br>• Tutorials,<br>• Videos demonstrations,<br>• Presentation/seminar,<br>• Interactive class discussions,<br>• Case studies,<br>• Laboratory/Practical experiments based session,<br>• Computer laboratory-based sessions,<br>• Workshops practices,<br>• Directed self- study,<br>• Problem based learning,<br>• Team work (cooperative learning),<br>• Field visits/training,<br>• Mini/major project. | • Written tests (mid and final terms and quizzes),<br>• Short reports,<br>• Lab\Project report<br>• Practical lab performance assessment,<br>• Coursework activities assessment,<br>• Presentations. |

## IV. Course Content:

### A – Theoretical Aspect:

| Order | Units/Topics List | Learning Outcomes | Sub Topics List | Number of Weeks | contact hours |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **1** | **Introduction to medical ultrasound imaging techniques** | a1, a2, a3 | – Introduction to ultrasound imaging and medical back ground<br>– ultrasound imaging advantages,<br>– ultrasound imaging application,<br>– ultrasound imaging modes | 1 | 2 |
| **2** | **Ultrasound Imaging System** | a1, a2, a3 | – Block diagram,<br>– components of ultrasound imaging system,<br>– ultrasound transducers, | 1 | 2 |
| **3** | **Ultrasound Imaging Physics** | a1, a2, a3, b1,b2, c1, c2 | – Echo ranging,<br>– ultrasound physics,<br>– focusing, reflection, refraction, scattering,<br>– Transducers and Beamforming | 1 | 2 |
| **4** | **B-Mode ultrasound Instrument** | a1, a2, a3, b1,b2, c1, c2 | – Processing block diagram,<br>– Pre-processing of echoes,<br>– Time-Gain Compensation,<br>– Digitization, Compression,<br>– Image reconstruction,<br>– Image Resolution,<br>– Ultrasound Safety,<br>– Maintenance and Repair | 1 | 2 |
| **5** | **Doppler Ultrasound** | a1, a2, a3, b1,b2, c1, c2 | – The Doppler effect introduction,<br>– Doppler display,<br>– Doppler ultrasound,<br>– repair and maintenance | 1 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| **6** | **Computed Tomography (CT)** | a1, a2, a3, b1,b2, c1, c2 | – Introduction,<br>– medical back ground,<br>– generations of CT | 1 | 2 |
| **7** | **Computed Tomography (CT)** | a1, a2, a3, b1,b2, c1, c2 | – principle of operation,<br>– design of CT,<br>– block diagram, and components, | 1 | 2 |
| **8** | **Mid-Term Theoretical Exam** | a1, a2, a3, b1,b2, c1, c2 | - All Previous Topics | 1 | 2 |
| **9** | **Computed Tomography (CT)** | a1, a2, a3, b1,b2, c1, c2 | – Methods of obtaining useful images of Computed Tomography (CT),<br>– maintenance and troubleshooting of Computed Tomography (CT) | 1 | 2 |
| **10** | **Introduction to medical resonance imaging (MRI) techniques** | a1, a2, a3, b1,b2, c1, c2 | – Medical background,<br>– Basic Physics,<br>– Types of Magnets,<br>– Larmor Equation,<br>– RF Pulses. | 1 | 2 |
| **11** | **Medical Resonance Imaging (MRI) System** | a1, a2, a3, b1,b2, c1, c2 | – T1 Relaxation, T2 Relaxation,<br>– Free Induction Decay (FID)<br>– Block diagram,<br>– Primary Magnetic Field,<br>– Magnet Shielding,<br>– Secondary Magnets,<br>– Coils. | 1 | 2 |
| **12** | **Report &** | a1, a2, a3, b1,b2, c1, c2, | – 3 to 4 students make report and present the seminar on the one | 1 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| | **Presentation** | d1 | medical imaging systems. | | |
| **13** | **Report & Presentation** | a1, a2, a3, b1,b2, c1, c2, d1 | – 3 to 4 students make report and present the seminar on the one medical imaging systems. | 1 | 2 |
| **14** | **Medical Resonance Imaging (MRI) System** | a1, a2, a3, b1,b2, c1, c2 | – Source of MR Contrast,<br>– Tissue Contrast,<br>– Pulse Sequences, | 1 | 2 |
| **15** | **Medical Resonance Imaging (MRI) System** | a1, a2, a3, b1,b2, c1, c2 | – Slice Selection,<br>– Frequency Encoding,<br>– Phase encoding,<br>– Image Reconstruction,<br>– K-Space and Image Space,<br>– repair and maintenance. | 1 | 2 |
| **16** | **Final Theoretical Exam** | a1, a2, a3, b1,b2, c1, c2 | - All Topics | 1 | 2 |
| **Number of Weeks /and Units Per Semester** | | | | **16** | **32** |

## B - Practical Aspect: (if any)

| Order | Tasks/ Experiments | Number of Weeks | contact hours | Learning Outcomes |
|---|---|---|---|---|
| **1** | - Review on the radiology department in hospital | 1 | 2 | a1, a2, a3 |
| **2** | - Types of ultrasound equipment<br>- Components of ultrasound equipment<br>- Operation of ultrasound equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **3** | - Types of ultrasound equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |

| | | | | |
|---|---|---|---|---|
| | - Components of ultrasound equipment<br>- Operation of ultrasound equipment | | | |
| **4** | - Detection of errors, troubleshooting, repair, and maintenance of ultrasound equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **5** | - Detection of errors, troubleshooting, repair, and maintenance of ultrasound equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **6** | - Components of CT equipment<br>- Operation of CT equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **7** | - Midterm Practical Exam | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **8** | - Components of CT equipment<br>- Operation of CT equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **9** | - Detection of errors, troubleshooting, repair, and maintenance of CT equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **10** | - Components of MRI equipment<br>- Operation of MRI equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **11** | - Components of MRI equipment<br>- Operation of MRI equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **12** | - Detection of errors, troubleshooting, repair, and maintenance of MRI equipment | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **13** | - Practical Project | 1 | 2 | a1, a2, a3, b1,b2, c1, c2, d1 |

| | | | | |
|---|---|---|---|---|
| **14** | - Practical Project (Continue) | 1 | 2 | a1, a2, a3, b1,b2, c1, c2, d1 |
| **15** | - Final Practical Exam | 1 | 2 | a1, a2, a3, b1,b2, c1, c2 |
| **Number of Weeks /and Units Per Semester** | | | **15** | **30** |

## V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,
- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

## VI. Assessment Methods of the Course:

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

## VII. Assignments:

| No | Assignments | Aligned CILOs(symbols) | Week Due | Mark |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| Total | | | | |

## 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 | **Quiz 1** | 6 | 5 | 3.33% | a1, a2, a3, b2,c1, c2 |
| 2 | **Midterm Practical Exam** | 7 | 20 | 13.33% | a1, a2, a3, b2,c1, c2 |
| 3 | **Midterm Theoretical Exam** | 8 | 10 | 6.67% | a1, a2, a3, b2,c1, c2 |
| 4 | **Report, Presentation, and Project** | 12, 13 | 20 | 13.33% | a1, a2, a3, b2,c1, c2, d1 |
| 5 | **Quiz 2** | 12 | 5 | 3.33% | a1, a2, a3, b2,c1, c2 |
| 6 | **Final Practical Exam** | 15 | 30 | 20% | a1, a2, a3, b2,c1, c2 |
| 7 | **Final Theoretical Exam** | 16 | 60 | 40% | a1, a2, a3, b2,c1, c2 |
| **Total** | | | 150 | 100% | |

## IX. Learning Resources:

- *Written in the following order: ( Author - Year of publication – Title – Edition – Place of publication – Publisher).*

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

1- Peter Hoskins, Kevin Martin, Abigail Thrush, 2010, **Diagnostic Ultrasound Physics and Equipment**, 2nd Edition, Cambridge University Press,

2- Ray Hashman Hashemi, William G. Bradley, Christopher J. Lisanti, 2004, **MRI: The Basics**, 2nd Edition, Lippincott Williams & Wilkins.

**2- Essential References.**

1- Krzysztof Iniewski, 2009, **MEDICAL IMAGING Principles, Detectors, and Electronics**,2009.

2- Andrew Webb, 2003, **Introduction to Biomedical Imaging**, John Wiley & Sons Inc, 200

3- Chris Guy,2005, An Introduction to the Principles of Medical Imaging, imperial college press, 2005.

4- Jerrold T. Bushberg, 2001, **The Essential Physics of Medical Imaging**, 2nd Edition, Prentice Hall.

**3- Electronic Materials and Web Sites *etc*.**

**Websites:**

1- The IEEE Transactions on Medical Imaging. Peer reviewed academic journal in the field of Medical Imaging.

http://www.ieeexplore.ieee.org/

**Journals:**

2- IEEE Transactions on Biomedical Engineering: Peer reviewed academic journal in the field of Biomedical Engineering.

http://www.ieeexplore.ieee.org/xpl

3- International Journal of Radiology and Imaging Technology

https://clinmedjournal.org/International-of-Radiology-and-Imaging-Technology

**Other Web Sources:**

4- Website: Franks Hospital Workshop

http://www.frankshospitalworkshop.com

| X. Course Policies: | |
|---|---|
| | |
| 1 | **Class Attendance:**<br>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:**<br>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:**<br>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:**<br>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:**<br>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:**<br>Plagiarism is the attending of a student the exam of a course instead of another student.<br>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. |

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|---|---|
| **7** | **Other policies**:<br>- 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.<br>- Mobile phones are not allowed in class during the examination.<br>- 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)

## Medical Imaging System 2- BE469

| I. Course Identification and General Information: | | | | | |
|---|---|---|---|---|---|
| 1 | **Course Title:** | Medical Imaging System 2 | | | |
| 2 | **Course Code & Number:** | BE469 | | | |
| 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):** | Medical Imaging System 1 (BE468) | | | |
| 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. Mohammed Al-olofi | | | |
| 11 | **Reviewed by:** | Dr. Waleed Al-Talbi | | | |
| 12 | **Date of Approval:** | | | | |

## II. Course Description:

The medical imaging systems 2 course aims to give the student knowledge of the basic concepts of Theory operations, calibrations and maintenance for medical imaging equipment, the block diagrams for a variety medical imaging equipment which used in radiology department, design instruments to satisfy specific needs, develop skills for analyze, calibration, repair, maintenance, and

troubleshooting of medical imaging systems. This course includes the Medical ultrasound imaging (US), Computed Tomography (CT), Magnetic Resonance Imaging (MRI). Methods of obtaining useful medical images, Image formation and display. Projection radiography. Radiation detectors. Automating diagnosis and non-invasive testing. Radiation safety of patients and personnel, and types of digital detectors using in above machines. The co-requisite practical will focus on the practical operations, calibrations, troubleshooting and maintenance for medical imaging equipment.

## 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 | Illustrate the basic concepts, and principles, physical theories for the medical imaging systems (Ultrasound, CT, and MRI). |
| a2 | Identify the techniques, operation, and design principles of medical imaging devices (Ultrasound, CT, and MRI) which are relevant to the developments and new technologies. |
| a3 | Describe the clinical applications of medical imaging systems (Ultrasound, CT, and MRI), their operational theories and their clinical environments. |
| **B. Intellectual Skills:** Upon successful completion of the course, students will be able to: | |
| b1 | Design the medical imaging devices used in radiology department with considerate environmental conditions, health and safety, manufacturability and sustainability. |
| b2 | Categorize the medical imaging devices (Ultrasound, CT, and MRI) according to their specifications and features. |
| **C. Professional and Practical Skills:** Upon successful completion of the course, students will be able to: | |
| c1 | Apply mathematical, simulation models, and IT software packages to medical imaging systems (Ultrasound, CT, and MRI) effectively. |
| c2 | Install, operate, troubleshooting, and maintenance the medical imaging devices (Ultrasound, CT, and MRI) by using rules and regulations of medical safety. |

| III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر) | |
|---|---|
| **D. Transferable Skills:** Upon successful completion of the course, students will be able to: | |
| d1 | Function effectively in different work environments as an individual, and as a member or leader in multi-disciplinary teams. |

## IV. Course Contents:

**A. Theoretical Aspect:**

| No. | Units/Topics List | Sub Topics List | Number of Weeks | Contact Hours |
|---|---|---|---|---|
| 1 | **Introduction to medical ultrasound imaging techniques** | – Introduction to ultrasound imaging and medical back ground<br>– ultrasound imaging advantages,<br>– ultrasound imaging application,<br>– ultrasound imaging modes | 1 | 2 |
| 2 | **Ultrasound Imaging System** | – Block diagram,<br>– components of ultrasound imaging system,<br>– ultrasound transducers, | 1 | 2 |
| 3 | **Ultrasound Imaging Physics** | – Echo ranging,<br>– ultrasound physics,<br>– focusing, reflection, refraction, scattering,<br>– Transducers and Beamforming | 1 | 2 |
| 4 | **B-Mode ultrasound Instrument** | – Processing block diagram,<br>– Pre-processing of echoes,<br>– Time-Gain Compensation,<br>– Digitization, Compression,<br>– Image reconstruction, | 1 | 2 |

## IV. Course Contents:

### A. Theoretical Aspect:

| No. | Units/Topics List | Sub Topics List | Number of Weeks | Contact Hours |
|---|---|---|---|---|
| | | – Image Resolution,<br>– Ultrasound Safety,<br>– Maintenance and Repair | | |
| 5 | **Doppler Ultrasound** | – The Doppler effect introduction,<br>– Doppler display,<br>– Doppler ultrasound,<br>– repair and maintenance | 1 | 2 |
| 6 | **Computed Tomography (CT)** | – Introduction,<br>– medical back ground,<br>– generations of CT | 1 | 2 |
| 7 | **Computed Tomography (CT)** | – principle of operation,<br>– design of CT,<br>– block diagram, and components, | 1 | 2 |
| 8 | **Mid-Term Theoretical Exam** | - All Previous Topics | 1 | 2 |
| 9 | **Computed Tomography (CT)** | – Methods of obtaining useful images of Computed Tomography (CT),<br>– maintenance and troubleshooting of Computed Tomography (CT) | 1 | 2 |
| 10 | **Introduction to medical resonance imaging (MRI) techniques** | – Medical background,<br>– Basic Physics,<br>– Types of Magnets,<br>– Larmor Equation, | 1 | 2 |

## IV. Course Contents:

### A. Theoretical Aspect:

| No. | Units/Topics List | Sub Topics List | Number of Weeks | Contact Hours |
|---|---|---|---|---|
| | | – RF Pulses. | | |
| 11 | **Medical Resonance Imaging (MRI) System** | – T1 Relaxation, T2 Relaxation,<br>– Free Induction Decay (FID)<br>– Block diagram,<br>– Primary Magnetic Field,<br>– Magnet Shielding,<br>– Secondary Magnets,<br>– Coils. | 1 | 2 |
| 12 | **Report & Presentation** | – 3 to 4 students make report and present the seminar on the one medical imaging systems. | 1 | 2 |
| 13 | **Report & Presentation** | – 3 to 4 students make report and present the seminar on the one medical imaging systems. | 1 | 2 |
| 14 | **Medical Resonance Imaging (MRI) System** | – Source of MR Contrast,<br>– Tissue Contrast,<br>– Pulse Sequences, | 1 | 2 |
| 15 | **Medical Resonance Imaging (MRI) System** | – Slice Selection,<br>– Frequency Encoding,<br>– Phase encoding,<br>– Image Reconstruction,<br>– K-Space and Image Space,<br>– repair and maintenance. | 1 | 2 |
| 16 | **Final Theoretical** | - All Topics | 1 | 2 |

## IV. Course Contents:

### A. Theoretical Aspect:

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

### B. Case Studies and Practical Aspect:

| No. | Tasks/ Experiments | Number of Weeks | Contact Hours |
|---|---|---|---|
| **1** | - Review on the radiology department in hospital | 1 | 2 |
| **2** | - Types of ultrasound equipment<br>- Components of ultrasound equipment<br>- Operation of ultrasound equipment | 1 | 2 |
| **3** | - Types of ultrasound equipment<br>- Components of ultrasound equipment<br>- Operation of ultrasound equipment | 1 | 2 |
| **4** | - Detection of errors, troubleshooting, repair, and maintenance of ultrasound equipment | 1 | 2 |
| **5** | - Detection of errors, troubleshooting, repair, and maintenance of ultrasound equipment | 1 | 2 |
| **6** | - Components of CT equipment<br>- Operation of CT equipment | 1 | 2 |
| **7** | - Midterm Practical Exam | 1 | 2 |

| B. Case Studies and Practical Aspect: | | | |
|---|---|---|---|
| **No.** | **Tasks/ Experiments** | **Number of Weeks** | **Contact Hours** |
| **8** | - Components of CT equipment<br>- Operation of CT equipment | 1 | 2 |
| **9** | - Detection of errors, troubleshooting, repair, and maintenance of CT equipment | 1 | 2 |
| **10** | - Components of MRI equipment<br>- Operation of MRI equipment | 1 | 2 |
| **11** | - Components of MRI equipment<br>- Operation of MRI equipment | 1 | 2 |
| **12** | - Detection of errors, troubleshooting, repair, and maintenance of MRI equipment | 1 | 2 |
| **13** | - Practical Project | 1 | 2 |
| **14** | - Practical Project (Continue) | 1 | 2 |
| **15** | - Final Practical Exam | 1 | 2 |
| **Number of Weeks /and Units Per Semester** | | **15** | **30** |

## V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,

## V. Teaching Strategies of the Course:

- Case studies,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,
- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

## VI. Assessment Methods of the Course:

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

## VII. Assignments:

| No | Assignments | Aligned CILOs(symbols) | Week Due | Mark |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

| | | | | |
|---|---|---|---|---|
| 5 | | | | |
| **Total** | | | | |

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

| No. | Assessment Method | Week Due | Mark | Proportion of Final Assessment |
|---|---|---|---|---|
| **1** | **Quiz 1** | 6 | 5 | 3.33% |
| **2** | **Midterm Practical Exam** | 7 | 20 | 13.33% |
| **3** | **Midterm Theoretical Exam** | 8 | 10 | 6.67% |
| **4** | **Report, Presentation, and Project** | 12, 13 | 20 | 13.33% |
| **5** | **Quiz 2** | 12 | 5 | 3.33% |
| **6** | **Final Practical Exam** | 15 | 30 | 20% |
| **7** | **Final Theoretical Exam** | 16 | 60 | 40% |
| **Total** | | | **150** | **100%** |

## IX. Learning Resources:

- *Written in the following order:*
  - *Written in the following order: ( Author - Year of publication – Title – Edition – Place of publication – Publisher).*

**1- Required Textbook(s) (maximum two):**

1- Peter Hoskins, Kevin Martin, Abigail Thrush, 2010, **Diagnostic Ultrasound Physics and Equipment**, 2nd Edition, Cambridge University Press,

2- Ray Hashman Hashemi, William G. Bradley, Christopher J. Lisanti, 2004, **MRI: The Basics**, 2nd Edition, Lippincott Williams & Wilkins.

**2- Essential References:**

1- Krzysztof Iniewski, 2009, **MEDICAL IMAGING Principles, Detectors, and Electronics**,2009

## IX. Learning Resources:

2- Andrew Webb, 2003, **Introduction to Biomedical Imaging**, John Wiley & Sons Inc, 2003.

3- Chris Guy,2005, An Introduction to the Principles of Medical Imaging, imperial college press, 2005.

4- Jerrold T. Bushberg, 2001, **The Essential Physics of Medical Imaging**, 2nd Edition, Prentice Hall.

### 3- Electronic Materials and Web Sites etc.:

**Websites:**

1- The IEEE Transactions on Medical Imaging. Peer reviewed academic journal in the field of Medical Imaging.

http://www.ieeexplore.ieee.org/

**Journals:**

2- IEEE Transactions on Biomedical Engineering: Peer reviewed academic journal in the field of Biomedical Engineering.

http://www.ieeexplore.ieee.org/xpl

3- International Journal of Radiology and Imaging Technology

https://clinmedjournal.org/International-of-Radiology-and-Imaging-Technology

**Other Web Sources:**

4- Website: Franks Hospital Workshop

http://www.frankshospitalworkshop.com

## X. Course Policies:

| | |
|---|---|
| 1 | **Class Attendance:**<br>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:**<br>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:**<br>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**:<br>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**:<br>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**:<br>Plagiarism is the attending of a student the exam of a course instead of another student.<br>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**:<br>- 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.<br>- Mobile phones are not allowed in class during the examination.<br>- Lecture notes and assignments might be given directly to students using soft or hard copy. |