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**Department Physics-Medical Physics Branch**

**College of science**

**Salahaddin University**

**Subject: Medical Imaging**

**Course Book – (Year 4)**

**Lecturer's name: Dr. Salih Omer Haji**

**Academic Year: 2022/2023**

**Course Book**

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| **1. Course name** | **Medical imaging**  |
| **2. Lecturer in charge** | **Salih Omer Haji** |
| **3. Department/ College** | **Physics-Science** |
| **4. Contact** | **e-mail: s**alih.haji**@su.edu.krd** **Tel: (07504514643)** |
| **5. Time (in hours) per week**  | **Theory: 3** **Practical: 2**  |
| **6. Office hours** | **Tuesday** |
| **7. Course code** |  |
| **8. Teacher's academic profile**  | **https://academics.su.edu.krd/profile-admin/index.php?p=teaching** |
| **9. Keywords** | **MRI, Ultrasound, CT, X-ray** |
| **10. Course overview:** The course illustrates and explain the main principles of the radiology and give a sufficient idea about types and characteristics of radiation, the importance of the medical imaging in the medical field. Explain the several modalities of medical imaging and its components such as x-ray tube and image receptor. Explain the principles of CT scan, ultrasound, MRI, Nuclear Medicine, and digital radiography. |
| **11. Course objective:**1-Introduce basic concepts and methodologies for the formation, representation, enhancement, analysis and compression of digital medical images.2-Establish a foundation for developing applications and for research in the field of medical image processing. 3-Provide training for the design and implementation of practical algorithms for medical image processing. |
| **12. Student's obligation****Attendance**Students should make every effort to maintain good attendance in their classes. Illnesses and emergencies do occur, so it may not be possible to show up every time. Nevertheless, students should do their best to consistently attend their lectures and get there before class begins. Missing class can lower attendance grades and result in missed quizzes or assignments. If a student misses a class, it is their responsibility to ask for a friend’s notes and talk to the teacher to determine whether an important announcement was made.**Participation**Each student should participate in the classroom. Discussing relevant subjects at appropriate times can spark new conversations and produce valuable debates. If instructors ask students to share thoughts with their respective groups, each student should contribute to the assignment. Students who are shy do not have to take a leadership role, but they can offer to take notes and add a few ideas. |
| **13. Forms of teaching****Using text books chapters and viewing a summary of lectures using data show**  |
| **14. Assessment scheme**‌:**One semester examinations besides quizzes and home works** |
| **15. Student learning outcome:**The program provides an educational environment structured to develop competent health care professionals. Upon graduation, the student will: ​* Communicate effectively
* Demonstrate professional work ethics, dependability and self-confidence, and uphold the patients’ rights under all situations
* Apply the acquired knowledge to accurately demonstrate the required anatomical structures in different imaging modalities
* Use critical thinking skills to assess, analyze, and synthesize the processes required to produce diagnostic images for medical evaluation
* Apply the principles of radiation protection to patient, self and others
* Be able to evaluate the performance of imaging systems, in regard to the safe limits of operation and report any malfunction
* Evaluate images/procedures for appropriate image quality
* Exercise critical thinking and decision-making skills in critical situations
* Provide patient/public education related to imaging procedures and radiation safety
* Be dedicated to continuous learning and assimilation of knowledge through continuous professional development

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| **16. Course Reading List and References‌:**1- Smith, N., & Webb, A. (2010). Introduction to Medical Imaging: Physics, Engineering and Clinical Applications (Cambridge Texts in Biomedical Engineering). Cambridge: Cambridge University Press. doi:10.1017/CBO97805117609762-“Digital Image Processing, Second edition”, by R. Gonzalez and R. Woods, Prentice Hall, 2002.3-Stewart Carlyle Bushong, ScD, FAAPM, FACR, RADIOLOGIC SCIENCE for TECHNOLOGISTS PHYSICS, BIOLOGY, and PROTECTION,2012. |
| **17. The Topics:** | **Lecturer's name** |
| **Imaging Modalities** | Lecture 1ex: (2 hrs) |
| **Introduction to the Medical Imaging** | Lecture 2 (3 hrs) |
| **Medical Imaging X-ray system** | Lecture 3 (1 hrs) |
| **X-ray Production** | Lecture 4ex: (2 hrs) |
| **X-ray Emission** | Lecture 5ex: (1 hrs) |
| **Screen-Film Radiography** | Lecture 6ex: (3 hrs) |
| **Computed Tomography (CT)** | Lecture 7ex: (1 hrs) |
| **CT Instrumentation** | Lecture8ex: (2 hrs) |
| **CT Imaging** | Lecture9ex: (1 hrs) |
| **Signal-to-noise ratio, Contrast-to-noise ratio, Image filtering** | Lecture10ex: (3 hrs) |
| **Image****Reconstruction** | Lecture 8ex: (2 hrs) |
| **CT generations** | Lecture 9ex: (3 hrs) |
| **CT instrumentation** | Lecture 10ex: (1 hrs) |
| **Hounsfield Units or** **CT numbers** | Lecture 11ex: (2 hrs) |
| **Fundamentals of Magnetic Resonance Imaging**Magnetic resonance imaging (MRI), Introduction, Effects of a strong magnetic field on protons in the body, | Lecture 12ex: (2 hrs) |
| **Quantum Mechanical description of MRI** | Lecture 13ex: (1 hrs) |
| **MRI Image forming-1** | Lecture 14ex: (2 hrs) |
| **MRI Image forming-2** | Lecture15ex: (2 hrs) |
| **Ultrasound Imaging(3)** | Lecture16ex: (1 hrs) |
| **A Few Terminology in Optics** | Lecture 17ex: (2 hrs) |
| **Ultrasound-Instrumentation** | Lecture 18ex: (2 hrs) |
| **Transducer arrays** | Lecture 19ex: (2 hrs) |
| **Transducer arrays-2** | Lecture 20ex: (2 hrs) |
| **Doppler ultrasound**Image characteristics, Doppler ultrasound for blood flow measurements, Ultrasound contrast agents | Lecture 21ex: (2 hrs) |
| **Revision** | Lecture 22ex: (2 hrs) |
| **18. Practical Topics (If there is any)** |  |
| X-rar1  | Lecture 1ex: (3 hrs) |
| X-rar2 | Lecture 2ex: (3 hrs) |
| X-rar3 | Lecture3ex: (3 hrs) |
| X-rar4 | Lecture 4ex: (3 hrs) |
| X-rar5 | Lecture 5ex: (3 hrs) |
| X-rar6 | Lecture 6ex: (3 hrs) |
| X-rar7 | Lecture 7ex: (3 hrs) |
| X-rar8 | Lecture 8ex: (3 hrs) |
| X-rar9 | Lecture 9ex: (3 hrs) |
| CT1 | Lecture 10ex: (3 hrs) |
| CT2 | Lecture 11ex: (3 hrs) |
| CT3 | Lecture 12ex: (3 hrs) |
| CT4 | Lecture13ex: (3 hrs) |
| CT5 | Lecture 14ex: (3 hrs) |
| Ultrasound 1 | Lecture 15ex: (3 hrs) |
| Ultrasound 2 | Lecture 16ex: (3 hrs) |
| Ultrasound 3 | Lecture 17ex: (3 hrs) |
| Ultrasound 4 | Lecture 18ex: (3 hrs) |
| Ultrasound 5 | Lecture 19ex: (3 hrs) |
| Ultrasound 6 | Lecture 20ex: (3 hrs) |
| Ultrasound 7 | Lecture 21ex: (3 hrs) |
| Ultrasound 8 | Lecture 22ex: (2 hrs) |
| MRI1 | Lecture 23ex: (3 hrs) |
| MRI2 | Lecture 25ex: (3 hrs) |
| MRI3 | Lecture 26ex: (3 hrs) |
| MRI4 | Lecture 27ex: (3 hrs) |
| MRI5 | Lecture 28ex: (3 hrs) |
| MRI6 | Lecture 29ex: (3 hrs) |
| MRI7 | Lecture 30ex: (3 hrs) |
| **19. Examinations:** |

***Q1.*** **(18 points)** Organ has four tissues as shown in the figure below, to be scanned by CT-Scanner that gives Ir1 about 70% of I0 and Ic2 is about 56% of I0. If the linear attenuation coefficient µ11 =0.169 at 100 Kev for adipose tissue. If the length of each tissue is d=0.125 m. Find the linear attenuation coefficients µ12 and µ22?



Q1.

$e^{-(}µ$*11d+* $µ$*12d)*

Ir= Io = 0.7I0=I0 e-(0.169 \*0.125+µ12\*0.125) µ12 =( 0.12 )

$e^{-(}µ$*12d+* $µ$*22d)*

 Ic2= = 0.56I0=I0 e-(0.12\*0.125+µ22\*0.125) µ22= ( )

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| ***Q2.*** **(14pts)** Consider CT-Scan process. The Brain has the following Tissues with their own attenuation factors listed in the table below with the transformation function: (Hint: μwater=0.1cm-1).

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| **Tissue** | **μ(cm-1)** | **Equation of Line** | **Transformation Function** |
| **White Matter**  | **0.103** | $$m=\frac{∆y}{∆x}=\frac{y\_{2-}y\_{1}}{x\_{2}-x\_{1}}$$$$y=m\left(x-x\_{1}\right)+y\_{1}$$ |  |
| **Gray matter** | **0.1045** |
| **Cerebrospinal fluid** | **0.1015** |
| **Blood** | **0.104** |
| **Bone** | **0.2** |

1. Find the CT# (Hounsfield units) for each tissue in brain indicated in the table above.
2. Calculate the gray level value in CT image Using the transformation below (Which converts each CT# for each tissue calculated in A to its Corresponding image gray level value).
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| ***Q3.*** **(4+6+6+4pts) Answer each of the following:**1. What are the factors that affect MRI signal intensity then give the mathematical argument for MRI signal intensity?
2. Define the Time of Repetition (TR) and the echo time (TE) then state the conditions that must be offered to generate: (Justify your answer with all needed graphs and curves).
3. T1-weighted MRI-Image
4. T2-weighted MRI-Image
5. Proton density (PD) MRI-Image
6. What are the typical values of the Long-TR, Short -TR, Long- TE, and Short –TE.
7. The radiographic technique for a kidneys, ureters, and bladder (KUB) examination uses 74 kVp/60 mAs. The result is a patient exposure of 2.5 mGya (250 mR). What will be the exposure if the mAs can be reduced to 45 mAs?
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| ***Q4.* (8+6+8 pts)** **Answer each of the following:**1. How does the Transducer work and what is its job in Ultrasound imaging modality?
2. What are the factors that the size of MRI signal is depending on?
3. What type of filter is represented by the following kernel? Then apply it to the image into the right:

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| ***Q5***. **(16 pts)** Calculate the transmission intensity coefficient, TI, Reflection intensity coefficient RI, reflection pressure coefficient RP, and transmission pressure coefficient TP for interface between (muscle/kidney), assuming that the ultrasound beam is **exactly perpendicular** to the interface.  Hint:Make use of the table indicated.For the speed, density, and Compressibility of some organs  |
| ***Q6. (10 pts***) In Figure below calculate the ration between X-ray incident intensities (I1,I2,I3) , and the transmitted intensities(T1,T2,T3) that reaches the detector for each of the three X-ray beams indicated, if the dark-shaded area represents bone, and the light-shaded area represents tissue. The linear attenuation coefﬁcients at the effective X-ray energy of 68 Kev are10 cm-1 and 1cm-1 for bone and soft tissue, respectively. |