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**Department of Physics / Medical**

**College of Science**

**University of Salahaddin-Erbil**

**Subject:**

 **Radiation Dosimetry& Radiological Physics**

**Course Book – (4thYear Physics)**

**Lecturer's name**

**Mr.Hallo Mahmud Kaka**

**hallo.sallay@su.edu.krd**

**Academic Year: 2023/2024**

**Course Book**

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| **1. Course name** | **Radiation Dosimetry & Radiological Physics** |
| **2. Department/ faculty** | **Department of Physics/ College of Science**  |
| **3. Contact** | **E-mail :** **hallo.sallay@su.edu.krd** |
| **4. Time (in hours) per week**  | **Theory: 3** |
| **5. Office hours** | **10 hours Availability of the lecturer to the student during the week** |
| **6. Teacher's academic profile**  | **Master in physics / nuclear physics** |
| **7. Keywords** | **Types of radiation, particle radiation (α-particle, β-particle, photons, ℓ-ray, Neutrons), Exposure, Dose Absorption, Biological Effectivness (RBE) , Energy Transfer (LET) , Effective Dose, Radiation Protection, Image Formation, x-ray production.** |
| **10. Course overview:** Throughout the course of the year, the students gain an appreciation of radiation protection and they will study many physical aspects of radiation dosimetry. In this one year course, students will also study types of radiation and the interaction of radiation with matter in addition to the basic units and quantities used in dosimetric purposes. Furthermore, the participants will be familiarized with the instrument for measuring and detectors the radiation and dosimeters as well as the health effect of radiation. Finally, the physical concept of radiology will be learned.   |
| **11. Course objective:** This course is divided into two semesters and consists of the nine chapters. The ultimate objective of this course is to provide a clear conceptual development with both fundamental of radiation dosimetry concepts and physics of radiology. Students will develop abilities necessary to meet the following learning outcomes: understand scientific inquiry, build an understanding of types of radiation, interaction of radiation with matter, quantity and unit of radiation dosimetry, biological effect of radiation, radiation detectors and dosimeters, develop an understanding of X-ray production, describe the image information construction, Film construction, express and understanding of effect of kV, mAs , FFD, Filters and Grid of image quality and Doses. During this course you will gain experience in the radiation physics and learn how these information applied to practical applications. After viewing the program and participating in the various follow up activities, students should be able to do the following:* Define particle radiation (α-particle, β-particle, photons, ℓ-ray, Neutrons.
* Explain the differences between ionizing and non-ionizing radiation.
* Describe the concepts of radiation and interaction of radiation with matter.
* Describe the quantity and unit for measuring radiation dose.
* Explain how the radiation affects the biological cell, explain acute effects and delayed effects.
* Describe direct and indirect effects.
* Describe the principle and types of detectors and dosimeters.
* Describe the x-ray production, image information, film contents.
* Explain how the kVp, mAs, FFD and Flitters effected the image quality and dose.
* Describe some of the more common of x-ray radiology types.
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| **12. Student's obligation** In the beginning the importance of the subject will be explained to the students and they have to be present in the classes in order to know and understand what they will study and understand the content of the course and then it is the lecturer responsibility to make them understand the guidance, for example; how many marks has this lesson including the division, exams, the percentage of being present in the lecture, behaviour in the class with the lecturer and student, last examinations and the ways of questions. |
| ***13. Forms of teaching*** Different forms of teaching will be used to reach the objectives: using power point presentation for the head titles, Figures, equation, result of derivation, definitions and discussion.  |
| **14. Assessment scheme** The students required to do two closed book exam and four quizzes during the year of course. Besides, Homework's for each chapter, classroom activities also take into considerations.Monthly written Examination (2) 40%Class test (4) including homework and class activities 10%Final written examination 50% |
| **15. Student learning outcome:** As part of fulfilling this mission the radiation department strives to achieve the following student learning outcomes1. 1. Students completing a diploma program in radiation will demonstrate a solid foundation in radiation which exhibits both breadth and depth of knowledge.
2. 2. The general education courses will demonstrate an understanding of the science of using radiation instruments played by physicians in society at large.
3. 3. Students completing a degree in radiation will demonstrate the ability to learn how using the instruments and protecting, to measure the amounts of radiation dose for both patients and employment in the hospital. finally the students be able to using the tools such as X- ray , CT ,MRI,
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| **16. Course materials:*** William R. Hendee, “Medical Imaging Physics” , Published simultaneously in Canada, Fourth Edition 2002.
* E.B. Podgorsak, Radiation physics for Medical Physicists, Springer-Verlag Berlin Heidelberg Printed in Germany 2006.
* E.B. Podgorsak, Radiation Oncology Physics: A Handbook for Teachers and Students, Printed by the IAEA in Austria July 2005.
* Radiation Protection and Dosimetry: An Introduction to Health Physics, 2007, 384 pages, Michael G. Stabin,
* Introduction To Radiological Physics And Radiation Dosimetry:Frank Herbert Attix 1986,

**Program of the year:****17. The Topics;** |
| **Chapter 1- Types of Radiation and their interaction with Matters.** | **Lecturer's name** |
| Week 1:{1.1. Introduction, 1.2. Classification of Radiation 1.3 Basic definitions for atomic structure 1.4 Energy Units 1.5 Radioactivity 1.5.1 Stability and Instability 1.5.2 rate of Decay. 1.5.3 Decay constant. 1.5.4 Half life. 1.5.5 Activity. 1.6 radioactive decay models 1.6.1 Beta Minus Decay 1.6.2 Positron Decay 1.6.3 Alpha Decay 1.6.4 Electron Capture 1.6.5 Nuclear Transition - Gamma Ray Emission}Week 2 :{ 1.7. Interactions of Radiations with Matter. 1.7.1. Interaction of charge particle with matters. 1.8 Stopping Power 1.9 Range of charged particle in the matter1.9.1. Range of alpha Particles. 1.7.2 Range of protons 1.7.3 Range of light charged particle )}Week 3: {1.10 Interaction of Photon with matter 1.10.1 General aspects of photon interaction with an absorber 1.10.2 The Compton Effect 1.10.3 The Photoelectric Effect 1.10.4. Pair Production 1.11 Passage of photon through Matter 1.11.1 Measuring attenuation coefficient 1.11.2 Mixtures and Compounds} | **ex: (3hrs)****Week 1, 2,3** |
| **Chapter 2-Radiation dosimetry and Units**Week4: {2.1. Exposure 2.2. Dose Absorption. 2.3. Kerma. 2.4. Relative Biological Effectivness (RBE) 2.5. Dose Equivalent}Week5: {2.6. Absorbed Dose and Exposure. 2.7. Quality Factor. 2.8. Linear Energy Transfer(LET) 2.9 organ dose 2.10 Effective Dose }Week 6: {Ж Solving Example.} | **ex: (3hrs)****Week4,5,6** |
| **chapter 3-Radiation Protection****Week7:** {**3.1.** External Radiation Protection **3.1.1** Time **3.1.2** Distance **3.1.2.1** Inverse square law **3.1.2.2** Gamma constant **3.1.2.3** Gamma Exposure rate formula **3.1.3** Shielding **3.1.3.1** Alpha and Beta Radiation **3.1.3.2** X- and Gamma Radiation **3.1.3.3** Half Value Layer }**Week 8:** { **3.1.4** External Exposure Personnel Monitoring **3.1.4.1** Types of Personnel Dosimeters **3.1.4.2** Use of Personnel Dosimeters **3.1.4.3** Maximum Permissible Exposure Limits3.1.5 Posting and Labeling of Radioactive Materials **3.1.5.1** Cautionary Signs  **3.1.5.2** Department of Transportation Warning Labels }**Week 9** : { **3.2** Internal Radiation Protection **3.2.1** Radioactive Materials in the Body **3.2.2** Guidelines **3.2.3** Limits **3.2.4** Internal Exposure Monitoring }**Week 10** { Examination } | **ex: (3hrs)****Week7, 8, 9 and 10** |
| **Chapter 4-Biological Effects of Radiation****Week 11:**{**4.1.** Introduction. **4.2.** Direct and indirect effective **4.3**.Radiation Effect of Biological Molecule.}**Week 12:**{ **4.4.** Radiation effect of biological cells**. 4.5.** Acute Effects. **4.5.1** Blood.}**Week 13**: {4.5.2 Colon **4.5.3** Nervous system **4.5.4** Skin **4.6.** Delayed Effects and Cancer. **4.6.** The relation between dose and responsibility.}**Week 14:** {Examination} | **ex: (3hrs)****Week11,12,13 and 14** |
| **Chapter 5-Radiation Detectors and Dosimeter** **Week 15**: {**5.1.** Introduction. **5.2.** Atomic and Nuclear radiation detectors**. 5.3.** Gas-Filled Detector.}**Week 16**: {5.4**.** Ionization chambers **5.5.** Geiger counters. **5.6.** Scintillation Counters. }**Week 17:**{ **5.7.** Solid State Detectors. **5.8.** Semiconductor detectors **5.9.** Film badges **5.10.** TLD} | **ex: (3hrs)****Week15,16 and 17** |
|  **Chapter 6-Radiological Physics****Week 18:** {**6.1.** Introduction 6.2**.** The X-ray Beam **6.2.1**The X-ray Tub. **6.2.2** X-ray Production.}**Week 19:** {**6.3.** X-ray Spectrum. **6.3.1** Characteristic X-ray Spectrum. **6.3.2** Bremstrahlung X-ray Spectrum. 6.4. Factors Affecting the X-ray Spectrum.}**Week 20:**{**6.5** X-ray Emission. **6.6** X-ray Quantity **6.7** X-ray Quality. **6.7** Half-Value Layer } | **ex: (3hrs)****Week18,19 and 20** |
| **Chapter 7-Image Formation****Week 21:**{**7.1.** Differential Absorption 7.2 Dependence on Atomic Number. **7.3** Dependence on Mass Density.}**Week 22**:{**7.4.** Beam-Restricting Devices. **7.5** The Grid.}**Week 23:**{**8.1.** Radiographic Film 8.2**.** Film Construction **8.3.** Formation of the latent image. **8.4.** Film Processing } | **ex: (3hrs)****Week12,22 and 23** |
|  **Chapter 8-The Radiographic Image****Week 24** :{ **8.5** Radiographic Exposure**. 8.6** Radiographic Quality **8.7** Film Factors }**Week 25** :{ **8.8** Characteristic Curve **8.9** Optical Density. **8.10** Reciprocal law.}**Week26**:{**8.11** surface dose **8-12** dose area product } | **ex: (3hrs)****Week24,25 and 26** |
| **Chapter 9-Special Radiographic Procedures****Week 27**: {**9.1.** Fluoroscopy **9.2** Image – Intensifier tube**Week 28: 9.3.** Computed tomography**. 9.4**. Principle of Computed Topographic Image.}**Week 29**: **{9.5.** CT Dose. }**Week 30** :{ Ж Examination.} | **ex: (3hrs)****Week27,28,29 and30** |
| **18. Practical Topics (If there is any)** |  |
| In this section the lecturer shall write titles of all practical topics he/she is going to give during the term. This also includes a brief description of the objectives of each topic, date and time of the lecture  | **Lecturer's name****ex: (3-4 hrs)****ex: 14/10/2020** |

**19. Examinations:**

**A sample:**

**University of Salahaddin Radiation Dosimetry Fourth year**

**College of Science Third-Examination Time: 80 minutes**

**Physics Department Date:**

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Q1/ Choose the correct answer for the following (14 marks)

**Note: two false cancel one correct.**

1- \_\_\_\_\_\_\_\_\_\_\_\_\_\_resulting from electron transitions between atomic shells.

 a. Bremsstrahlung b. gamma-rays c. beta ray d. not given

2- If the CPE condition is exist on the volume (V), then which of the following quantities are equal:

a. exposure and dose b.dose and collision kerma

c. exposure and radiative kerma d.dose and radiative kerma

3- The \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is type of indirectly ionizing radiation.

a. electrons b. alpha particles c. heavy ions d. not given

4- In the Compton effect the binding energy (EB) of bound electron is :

 b. c. d.

5- The activity of a particular radionuclide is measured as a function of time, it can be seen that radioactive decay is \_\_\_\_\_\_\_\_\_\_\_\_.

a. fluctuation b. linear c. exponential d. not given

6- \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_factors influencing stability of atoms.

 a.The mass of the atom b. The ratio of neutrons to protons

 c. Even versus odd numbers of nucleons d. all of them

7- Soft collisions occur when :

a. b a b. b >> a c. b << a d. not given

8- In the elastic scattering the \_\_\_\_\_\_\_\_\_\_\_\_\_\_are conserved.

a.Total momentum b. total kinetic energy

c. total kinetic energy and momentum d. not given

9­-The decay mode of ( ) is:

 a.α - decay b. β- decay c. nuclear transition d). β+decay

10- The unit of mass collision stopping power is:

a. Mev/cm2.g b. Mev.g/cm c. Mev.cm2/g d. Mev.cm/g

11. The decay constant of radionuclide equal 1.5 min-1 half-life of nuclide equal \_\_\_\_\_\_\_sec.

 a. 0.462 b. 0.077 c. 0.77 d. not given

12- If the collision kerma is equal to 5 mGy then the exposure is\_\_\_\_\_\_\_\_\_\_\_.

a. 0.32 R b. 0.57 R c. 0.93 R d. 1.2 R

13-Which of the following dosimetric quantity is dependent of the nature of radiation ?

 a.exposure b. equivalent dose c.absorbed dose d.all of them

14-\_\_\_\_\_\_\_\_\_\_\_\_ is the sum of all the energy entering the volume of interest minus all the energy leaving the volume.

 a.Energy imparted b.net energy transfer c.energy transfer d. not given

Q2/ Find the range of 7200 kev alpha particle in air and tissues by Bragg- Kleeman when ρtissue = 1000 kg/m3 and Atissue ≈ 9. (4 marks)

**Solution:** because of the energy of alpha particle is equal to 7.2 Mev we can use this equation

To calculate the range in tissue we can make use of the simplified Bragg- Kleeman identity

Substituting *ρtissue* = 1 g/cm3 and *A*tissue ≈ 9 in the above equation, we get

10.11 × 10−4 x 6.308 cm = 6.38 *μm.*

Q3 **Example:** Determine the dose equivalent for a working for two hours at an average distance of 0.**5 m** from a **10000**  source ? (4 marks)

when( **,C=0.95)**

**Solution**:

After two hours the exposure is **X = 96 mR**

And the absorbed Dose

Q4/Consider a beam of 3-MeV Gamma -rays perpendicularly incident on an Fe foil that is very thin in comparison with the range of the secondary electrons.

(a) What are the values of K, Kc and Kr in the foil for a fluence of 5.6 X 1015 photons/m2? (Assume .

 (4 marks)

Solution: