PHY783 Medical Physics

First Semester 2017-2018

**Course Catalog**

3 Credit Hours. This course aims to present the physical principles of X-ray production and factors affecting its quality and intensity, absorption of x-ray in materials, making an x-ray image, processing and quality of radiographic films, producing live radiological images, radiation protection. On the other hand the course also aims to introduce the principles of Radiotherapy. It includes: radiation sources, Radiotherapy with single photon beams, Radiotherapy with particle beams, treatment planning, techniques and equipment in teletherapy and brachytherapy, dosimetry using small sealed sources and radionuclide sources, radiation protection.

**Text Book**

<table>
<thead>
<tr>
<th>Title</th>
<th>Physical Principles of Medical Imaging</th>
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<tbody>
<tr>
<td>Author(s)</td>
<td>Perry Sprawls</td>
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<tr>
<td>Edition</td>
<td>2nd Edition</td>
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<tr>
<td>Short Name</td>
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**Course References**

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<thead>
<tr>
<th>Short name</th>
<th>Book name</th>
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<th>Edition</th>
<th>Other Information</th>
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<tbody>
<tr>
<td>2</td>
<td>Applied Physics for Radiation Oncology</td>
<td>R. Stanton and D. Stinson</td>
<td>1st Edition</td>
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<td>3</td>
<td>Physics for Diagnostic Radiology</td>
<td>P P Dendy and B Heaton</td>
<td>2nd Edition</td>
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<td>4</td>
<td>Principles of Radiological Physics</td>
<td>Robin Wilks</td>
<td>2nd Edition</td>
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**Instructor**

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<thead>
<tr>
<th>Name</th>
<th>Prof. Mohammed-Ali Al-Omari</th>
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<tr>
<td>Office Location</td>
<td>PH3 L1</td>
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<tr>
<td>Office Hours</td>
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# Class Schedule & Room

Section 1:
Lecture Time: Mon, Wed: 08:30 - 10:00
Room: SF06

# Tentative List of Topics Covered

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<thead>
<tr>
<th>Weeks</th>
<th>Topic</th>
<th>References</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>X-ray tube basic design - Anode, cathode, grid, envelope, filtration, housing. Electrical quantities such as kVp and mA Production of Bremsstrahlung, characteristic radiation, Efficiency of X-ray production and Efficacy (Output). Some basic ideas about filtration.</td>
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<td>Week 2</td>
<td>Energizing and Controlling the X-ray tube. KV production (Single phase, three phase, constant potential), Rectification (Half wave, full wave), voltage waveform, capacitors, high frequency power supplies, mA control, exposure timing, X-ray tube Heating and Cooling ? Heat production, Heat capacity, Focal spot area, Anode body and construction, Tube housing. Relationship between kVp, mAs and waveform.</td>
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<td>Week 3</td>
<td>X-ray beam quality and typical x-ray spectra, from different types of radiology X-ray equipment. HVL, relationship to attenuation coefficient, and TVL Filtration. Types of filters, (Al, Cu, Mo), added filtration, spatial filtration. Concepts and principles of patient exposure reduction. Effects and benefits of Grids and Filtration</td>
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<td>Week 4</td>
<td>Characteristics of contrast-producing materials, Soft tissue, calcium and bone, Iodine, Gas and their interaction at different photon energies KV selection ? examples in mammography, extremities, vascular (iodine) Abdominal (Barium) Chest Visibility of detail, relationship to blurring and object size General overview of the photographic process ? Image contrast ? concept, units, film density units, brightness units and effect on visibility, area contrast and effect on visibility. Subject Contrast ? concept and relationship to image contrast. Image formation ? principles of projection X-ray imaging, Other characteristics such as resolution and sharpness Motion blurring, In the object plane and the receptor plane. Focal spot blurring, source, relationship to focal spot size, relationship to object location. Receptor blurring, sources of blur, types of receptors (intensifying screens), relationship to object location and magnification.</td>
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<td>Week 6</td>
<td>Film Imaging (Processing of Radiographic Images) Function, image recording, image display, image storage. Optical density, light penetration and density, density values, film structure. The photographic process, latent image formation, development, fixing, washing, silver recovery Sensitivity, composition, processing, Light color, exposure time. Contrast transfer, relationship of radiographic and subject contrast. The characteristic curve, contrast factor (slope) gamma, average gradient, Latitude. Factors that alter contrast ? exposure, film type, processing. Quality control procedures.</td>
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<td>Week 7</td>
<td>Radiographic Technique and Film Density Control Exposure controls, kVp, mAs, time, exposure charts. Receptor sensitivity, film, intensifier (screen and tube) Machine output, quantity (exposure, Quality (penetration)). Distance, patient penetration, thickness, kV, condition (composition) Field size. Technique conversion.</td>
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<td>Week 10</td>
<td>Computed Tomography X-ray tube design. Detector systems. Views ? different generations. The scan and data collection Image reconstruction ? filtered back projection. The CT image ? pixels and voxels, CT numbers. Image quality ? comparison to radiography, greater contrast sensitivity, less visibility of detail, more noise, more artifacts Examples of CT scanners and their specifications. Contrast sensitivity, tomography windowing, scattered radiation, Visibility of detail, noise, CT number accuracy, examples of CT images and artifacts. CT QA and doses. Examples of CT slides</td>
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<td>Week 11</td>
<td>Mammography Tube design, focal spot sizes, energies used, films, things specific to mammography in the design. Target design. Show examples of films. Doses in mammography. Types of machines (screening and diagnostic) Quality Assurance in mammography</td>
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<td>Week 12</td>
<td>Radiation Protection for Diagnostic Radiology International Commission on Radiological Protection (ICRP) concepts of justification, optimization and dose limitation; the ALARA principle; International Basic Safety Standards; statutory responsibilities, relevant legislation and Codes of Practice; controlled and supervised area, staff classification.</td>
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<td>Weeks 12, 13</td>
<td>Risks in Diagnostic Radiology Radiation protection quantities and units, Stochastic and deterministic effects of radiation. The linear no-threshold model, Risk vs benefit in Diagnostic Radiology, Doses in diagnostic radiology. Effective dose and its measurement Dose reduction in diagnostic Radiology</td>
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<td>Week 14</td>
<td>Radiation Protection Shielding Radiation Shielding ? Basic terminology, transmission, workload, design limits, occupancy factors Shielding ? NCRP 49 concepts Radiation Shielding examples, Practical Assessment of Shielding, Distribution of workload with kVp, Shielding for various diagnostic facilities, Shielding materials, Personnel protection.</td>
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<td>Week 15</td>
<td>General Revision</td>
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### Mapping of Course Objectives to Program Student Outcomes

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<tr>
<th>Course Objective</th>
<th>Assessment Method</th>
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<tr>
<td>Know the introduction to the important parameters in the production of X-rays for diagnostic radiology</td>
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<td>Understand the quality and intensity of X-ray beams and how they interact in matter</td>
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<td>Know the production and processing of the radiological image</td>
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<td>Know the different types of radiological images found in diagnostic radiology</td>
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<tr>
<td>Understand the radiation protection and the risks in diagnostic radiology</td>
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Become familiar with: - The principles of radiation therapy physics. - The role of radiotherapy in cancer management. - The physical process of radiation generation, transport and interaction with matter. - The physics of radiation protection in radiotherapy.

Appreciate the importance of radiation dose in radiotherapy

| Relationship to Program Student Outcomes (Out of 100%) |
|---|---|---|---|---|---|---|---|---|---|---|
| (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) | (i) | (j) | (k) |

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Medical imaging systems may be used to obtain information related to cardiovascular structure, physiology and mechanics in the individual subject. This information may be used in its own right in research and in health care. Information obtained from medical imaging is also used as input to patient-specific modelling. This chapter will provide a brief introduction to the main principles of medical imaging. Emphasis will be placed on the physical principles of image formation. Issues associated with instrumentation including detector technology and signal processing will not be considered. Text

This is a companion textbook to Physical Principles of Medical Imaging Online, Resources for Learning and Teaching http://www.sprawls.org/resources. Note: The web links are activated below as each chapter is converted to electronic format and becomes available on the web. Image Characteristics and Quality. The chapters on magnetic resonance imaging are now published in: Magnetic Resonance Imaging: Principles, Methods, and Techniques. Perry Sprawls. Medical Physics Publishing, Madison, Wisconsin.