<table>
<tr><td>Course Title</td><td colspan="5">Medical Physics II: Medical Imaging and Radiotherapy</td></tr>
<tr><td>Course Code</td><td colspan="5">MED-107</td></tr>
<tr><td>Course Type</td><td colspan="5">Required</td></tr>
<tr><td>Level</td><td colspan="5">Undergraduate</td></tr>
<tr><td>Year / Semester</td><td colspan="5">Year 1/ Semester 2 (Spring)</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Couse Lead:
Dr Constantinos Zervides</td></tr>
<tr><td>ECTS</td><td>6</td><td>Lectures / week</td><td>3</td><td>Laboratories / week</td><td>2</td></tr>
<tr><td>Course Purpose and Objectives</td><td colspan="5">The main objectives of the course are:
To cultivate an appreciation of the importance of physics in medical imaging.
To assist students in the development of strong problem-solving skills.
To help students cultivate critical thinking in the approach to learning.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">The following list provides the learning objectives that will be covered in the lectures and tutorials of each week:

Week 1
LOBs covered during lectures:
1. Describe the production of an ultrasound beam.
2. Explain the detection of echoes with a transducer.
3. Describe the interaction of ultrasound with material.
4. Explain A, B, and M-mode imaging.
5. Describe Doppler imaging of blood flow.
6. Describe elastrography.
7. Outline the importance of safety and quality assurance of US.
LOBs covered during labs (all groups):
8. Introduce ultrasound probe selection.
9. Introduce ultrasound screen orientation.
10. Perform measurements using blood vessels.
11. Introduce spectral Doppler.

Week 2
LOBs covered during lectures:
12. Explain the Photoelectric effect.</td></tr>
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13. Explain the Compton effect.
14. Explain Pair production.
15. Describe the inverse square law of attenuation.
16. Explain how ionising radiation is measured.
17. Describe how an ionisation chamber works.
18. Describe how a G-M counter works.

Week 3

No sessions this week

Week 4

LOBs covered during lectures:

19. Describe the “anatomy” of an X-Ray tube.
20. Explain the functionality of the X-Ray tube insert.
21. Describe the X-Ray tube insert anode assembly.
22. Describe the X-Ray tube insert cathode assembly.
23. Explain the interaction of high-energy electrons with matter.
24. Explain the importance of bremsstrahlung and characteristic X-Ray radiation.
25. Describe how X-Rays are produced.
26. Describe how and X-Ray exposure is controlled.
27. Explain the importance of quality assurance.
28. Describe the health effects of exposure to ionising radiation.
29. Explain the risks associated with exposure to ionising radiation.

Tutorial (all groups):

Review of topics covered in weeks 1 & 2.

Week 5

LOBs covered during lectures:

30. Describe the health effects of exposure to ionising radiation.
31. Explain the risks associated with exposure to ionising radiation.
32. Explain the philosophy of radiation protection.
33. Describe how to build a radiation safety program.
34. List the allowable radiation doses to radiation workers and the general public

Tutorial (all groups):

Review of topics covered in weeks 4.

Week 6

LOBs covered during lectures:

35. Describe film-based imaging.
36. Explain how fluoroscopes function.
37. Outline the importance of semiconductor detectors in radiology.
38. Explain the workings of a photomultiplier tube.
39. List the factors that determine X-ray image quality.
40. Describe applications of X-rays in medicine.
41. Explain CT image formation principles.
42. Explain CT image reconstruction.

LOBs covered during labs (all groups):

43. Visualise and manipulate images on a workstation.

Week 7

MIDTERM EXAM

LOBs covered during lectures:

44. Describe the engineering aspects of CT scanners.
45. Describe how image quality is affected.
46. Distinguish between patient and machine caused artefacts.
47. Outline the importance of quality assurance and dose reduction for CT.

Week 8

LOBs covered during lectures:

48. Describe the modes of radioactive decay.
49. Explain the desirable attributes of a radiopharmaceutical.
50. Describe the importance of the Anger Camera in Nuclear Medicine.
51. Explain the principles of SPECT and list applications.
52. Explain the principles of PET and list applications.
53. Describe the multi-modality imaging used in Nuclear Medicine.

Tutorial (all groups):

Review of topics covered in weeks 5,6 & 7.

Week 9

LOBs covered during lectures:

54. Define radiotherapy.
55. Explain how radiotherapy can treat cancer.

56. Outline the purpose of conformal radiotherapy.
57. Explain the criteria for selecting suitable isotope sources for radiotherapy.
58. Describe the safety issues seen in radiotherapy.

Week 10

LOBs covered during lectures:

59. Explain paramagnetism, diamagnetism, ferromagnetism.
60. Describe the concept of electromagnetism.
61. Distinguish between different types of magnets used in clinical settings.
62. Describe nuclear alignment using the classical and quantum theories.
63. Describe precession.
64. Explain magnetic resonance.
65. Describe the production and detection of the MR signal.
66. Describe the concept of contrast in MRI.
67. Describe the concept of relaxation in MRI.
68. Describe T1 recovery and T2 decay.

Tutorial (all groups):

Review of topics covered in weeks 8 & 9.

Week 11

69. Explain T1, T2 and PD weighting in MRI.
70. Explain the use of coils in MRI.
71. Describe conventional spin echo.
72. Describe fast or turbo spin echo.
73. Describe inversion recovery
74. Explain gradient echo sequence.
75. Explain how MRI is able to track flow during image acquisition.
76. Explain Magnetic Resonance Angiography.

LOBs covered during labs (all groups):

77. Investigate the effect of beam positioning in treatment planning.
78. Describe the importance of isodose curves in treatment planning.

Week 12

LOBs covered during lectures:

79. Explain the principles of FMRI.

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<tr><td></td><td colspan="3">80. Explain the principles of diffusion imaging.
81. List safety issues in MRI.
Tutorial (all groups):
Review of topics covered in weeks 10, 11 & 12.

Revision.</td></tr>
<tr><td>Prerequisites</td><td>MED-101 Medical Physics I: The Human Body</td><td>Required</td><td>None</td></tr>
<tr><td>Course Content</td><td colspan="3">Lecture Topics:
• Ionising radiation: Dose and exposure.
• Ionising radiation: Measurements and standards.
• X-rays.
• Quality assurance.
• Radiation health effects.
• Radiation Safety.
• X-ray detectors.
• X-ray image quality.
• X-ray applications.
• CT: Image formation and reconstruction.
• CT: Image quality and artefacts.
• CT: Quality assurance and dose reduction.
• Introduction to nuclear medicine.
• Tomographic nuclear imaging.
• MRI principles and instrumentation.
• MRI pulse sequences and flow imaging.
• FMRI and diffusion imaging.
• MRI safety.
• Radiotherapy.
• Dose measurement and quality assurance in radiotherapy.
• Ultrasound theory.
• Imaging with ultrasounds.
• Ultrasound applications and safety.
• Multi-parameter medical imaging and analysis.

Laboratory Experiments and Demonstrations:
• Image processing.</td></tr>
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Radiation.
Radiotherapy treatment planning.

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<tr><td>Teaching Methodology</td><td>Lectures, Tutorials, Practical Sessions.</td></tr>
<tr><td>Bibliography</td><td>
Required Textbook:
<table>
<tr><th>Authors</th><th>Title</th><th>Edition</th><th>Publisher</th><th>Year</th><th>ISBN</th></tr>
<tr><td>M.A. Haidekker</td><td>Medical Imaging Technology</td><td>Springer</td><td>2013</td><td>9781461470724</td><td>M.A. Haidekker</td></tr>
</table>
Recommended Textbooks/Reading:
<table>
<tr><th>Authors</th><th>Title</th><th>Publisher</th><th>Year</th><th>ISBN</th></tr>
<tr><td>A.B.Wolbarst
P.Capasso
A.R.Wyant</td><td>Medical Imaging: Essentials for Physicians</td><td>Wiley-Blackwell</td><td>2013</td><td>9780470505700</td></tr>
<tr><td>J. T. Bushberg, J.A. Seibert, E.M. Leidholdt, Jr., J.M. Boone</td><td>The Essential Physics of Medical Imaging</td><td>Lippincott Williams & Wilkins</td><td>2012</td><td>9780781780575</td></tr>
<tr><td>A.P.Dhawan</td><td>Medical Imaging Analysis</td><td>Wiley-IEEE Press</td><td>2011 2nd Edition</td><td>9790470622056</td></tr>
<tr><td>S. A. Kane</td><td>Introduction to Physics in Modern Medicine (2nd Ed)</td><td>CRC Press</td><td>2009</td><td>9781584889434</td></tr>
<tr><td>B.H. Brown, R.H. Smallwood, D.C. Barber, P.V. Lawford, D.R. Hose</td><td>Medical Physics and Biomedical Engineering</td><td>Taylor and Francis Group</td><td>1999</td><td>9780750303682</td></tr>
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<tr><td>Assessment</td><td>Laboratory report (10%), Midterm Exam (30%), and Final Exam (60%). Assessment is by Single Best Answers (SBAs) and Short Answer Questions (SAQs).</td></tr>
<tr><td>Language</td><td>English</td></tr>
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