# BSc (Med) (Hons) Medical Physics at UCT

Postgraduate Course
BSc (Med) (Hons) in Medical Physics
160 HEQF credits
(includes research project of 40 credits)

The Department of Medical Physics at the University of Cape Town offers a one-year BSc (Med) (Honours) degree in Medical Physics.

**Course convenor:** Dr TC Kotzé

**Entrance requirements**

Entrance requirement is a BSc degree with a major in Physics. Normally the following criteria are used:

- a pass of 60% in PHY3021F (http://www.phy.uct.ac.za/courses/phy3021f/) and PHY3022S (http://www.phy.uct.ac.za/courses/phy3022s/), or equivalent; and
- a pass of 50% in MAM2000W or MAM2046W (http://www.mth.uct.ac.za/Undergrad/) or equivalent; and
- in cases where the Head of Department of Medical Physics deems it necessary, favourable referee reports.

In exceptional cases, for a student who does not meet the above criteria, set reading and study material may be assigned, and, upon satisfying the Head of Department of Medical Physics that they have mastered this material, may be admitted.

Preference may be given to UCT graduates who meet the entrance requirements. Enrolments are limited to an overall total of 5 in any one year. Acceptance will be at the discretion of the Head of Department of Medical Physics who will consult with the BSc (Physics) (Honours) course convener at the Department of Physics.

**DURATION OF THE COURSE**

Dates below are provisional, see UCT calendar for more information.

In 2012, the first semester lasts from 13 February until 8 June 2012, with a mid-term vacation from 31 March - 9 April. Some examinations will take place in the period May and June 2012.

The second semester lasts from 23 July until 17 December, with a mid term vacation from 1 - 9 September. Examinations will take place in the period October and November. Graduation will be sometime in the week of 11-14 December.

**APPLICATION DEADLINES**

- **students from the University of Cape Town**: we require your application by 1 November 2011.
- **students from other South African universities**: we require by 15 December 2011 your certified study record from the university at which you obtained your degree.
- **students from foreign universities**: students who have completed the equivalent of a BSc majoring in Physics are encouraged to apply. We require by 30 November 2011:
  - a letter of recommendation of a senior academic staff member of the department at the university at which you obtained your degree(s) and

- *either* the certified marks and short description of the courses (no. of lectures, content and course reference books) and practical projects taken at the university at which you obtained your degree(s), *or* a copy of your Vordiplom exam certificate.

To speed up the application process please fax (021-404 6269) or email (Tobie.Kotze@uct.ac.za) your application.

Based on the submitted required information, a decision can be made (often within a few days) whether or not to advise the Health Sciences Faculty that you be accepted to UCT.

**Course outline:**
The Honours course consists of 12 modules and a supervised research project counting 4 units. A module worth one unit consists of 20 lectures (45 minutes long) or equivalent; reading for each lecture; five tutorial sessions or problem sets (or equivalent).

For the final aggregation, the pass mark is 50 percent, and there are sub-minimum requirements.

The Honours course in Medical Physics consists of the following modules, all of which are compulsory:

**Department of Physics modules**
1. Solid State Physics - Lecturer Assoc. Professor M. Blumenthal (Second semester)
2. Quantum Mechanics - Lecturer Dr. W. A. Horowitz (First semester)
3. Nuclear Physics - Lecturer Dr. R. Nchodu (Second semester)
4. Computational Physics - Lecturer Dr. S. Wheaton (Second semester)
5. Interactions of Radiation with Matter – Lecturer Dr. Steve Peterson (First semester)

**Department of Medical Physics modules**
6. The Physics of Radiation Dosimetry / Diagnostic Radiology – Lecturer Dr TC Kotzé (First semester)
7. The Physics of Nuclear Medicine – Lecturer Mr C Trauernicht (Second semester)
8. The Physics of Radiotherapy - Lecturer Mr JK Hough (First semester)
9. Radiation Protection - Lecturer Dr TC Kotzé (First semester)
10. Treatment Planning - Lecturer Ms H Burger (Second semester)
11. Research Project - Lecturer Mr JK Hough (First and second semester)

**Department of Radiation Oncology module**
12. Radiobiology and Life Sciences - Lecturer Dr A Hunter (Second semester)

**Department of Human Biology – Biomedical Engineering module**
13. Introduction to Medical Imaging and Image Processing – Lecturers Prof's Tania Douglas and Ernesta Meintjes – First semester

**Duly performed (DP) requirements:** 30% for class tests and problem sets.

The Department of Medical Physics reserves the right to delete modules, or add modules, or modify the list should staffing or other factors so dictate.

## General information

### Standard of the course

The BSc (Med) (Honours) degree course is usually taken by a student in the 4th year of study, after having graduated with a BSc in Physics at the end of the 3rd year of university study.

The BSc (Med) Honours degree will soon be accredited by the HPCSA as fulfilling the academic requirement for entry into the two year practical/experiential program required for professional registration as Medical Physicist.

The degree is also a gateway towards further postgraduate study, such as MSc and PhD degrees by dissertation. The content of the course is comparable to that of senior undergraduate BSc in Medical Physics courses in good UK or USA universities and as such prepares a student for entry into international post-graduate Medical Physics programs, provided the student has done exceptionally well.

### Workload

The BSc (Med) (Honours) course is intensive. A rough estimate of the workload (in hours) for a '20-lecture' unit is:

| | |
|---|---|
| Lectures: 20 @ 45 minutes | 15 |
| Reading before and after lecture | 20 |
| 5 problem sets at 4 hours | 20 |
| Independent study | 20 |
| | |
| **Total** | 75 |

This totals 75 hours per unit, and so a course of 12 units would take about 900 hours. Divided by 120 days (24 weeks in academic term) this equates to approximately 7½ hours a day. The actual workload, including the research project, and including preparation for examinations, will depend on student preparedness and ability, and may well be 20 percent higher than this, and will fluctuate throughout the year.

### Content of a module

The broad content of a module is decided between the Head of Department of Medical Physics, who bears ultimate responsibility for the academic content of the course and its modules, the BSc (Physics) (Honours) course convener at the Department of Physics, and the lecturer concerned. The lecturer enjoys academic freedom to decide the details of content, and the style of teaching of that module. The overall principle of reasonableness applies: the HoD, informed by the views of the BSc (Physics) (Honours) course convener at the Department of Physics, colleagues, the lecturer, external examiners, and the students, decide whether the content of a module is reasonable in quality and quantity for an BSc (Med) (Hons) course.

### Modules

A description of each module expected to be offered will be available by early February.

A student must make a choice to follow the BSc (Med) (Hons) course by 5pm on the Friday at the end of the first lecture week.

**Duly performed (DP) certificate**
Only students who receive a duly performed (DP) certificate, normally issued around 15 October, will be allowed to write the examination.

The DP certificate criteria will be published at the start of the course, and may include, inter alia, satisfactory performance in class tests, examinations written in May/June, problem sets or tutorials, and the project.

**Examination of modules**
Certain modules will be examined in the May/June examination period. Other modules will be examined in the October/November examination period. Exceptionally, by agreement with students and lecturing staff, the HoD may direct examinations to take place outside these periods.

Results of the examination of all the modules will be used in a final aggregation by the BSc (Med) (Hons) examination committee, a body whose membership is decided by the HoD, but typically will include the HoD, BSc (Physics) (Honours) course convener at the Department of Physics, lecturers, project supervisor, project reader and external examiner(s).

This BSc (Med) (Honours) examination committee is advisory to the HoD, who submits results to the Health Sciences Faculty Examination Committee (FEC) for decision, and ultimate ratification by the University Senate.

**Aggregation of marks**
A module may be excluded from final aggregation by the HoD, after consultation with the BSc (Physics) (Honours) course convener at the Department of Physics, senior colleagues and the lecturer concerned, if the HoD believes the course was not given properly, or was not given along the agreed lines (e.g. lecturer was absent for unauthorized periods; asked post-doc or post-graduate students to lecture significant portions of it; or any other event which caused the course to be poorly delivered).

The final course mark is based on the aggregation formula stipulated at the beginning of the course, unless the HoD shows good cause, in writing, for deviating from this.

The formula for aggregating the marks of the individual units i (i = 1 ... N with the number of units N = 13) is:

$$\text{mark} = \frac{1}{N}\sum_{i=1}^{N} \text{mark}_i \times \left(1 + \frac{N-12}{24}\right)$$

The pass/fail decision is based on this aggregation, the necessary pass mark being **50 percent**, and is further subject to the **subminimum criteria** of

- obtaining a minimum mark of 35 percent in the project,
- passing two thirds of all units,
- achieving a mark of at least 35 percent in all but one of the modules.

A student who fails the BSc (Med) (Honours) course may be prohibited by the HoD from readmission.

BSc (Med) Honours booklet 2012
University of Cape Town
Medical Physics Department
February 2012

**1 Contact Details**

The BSc (Med) (Honours) Coordinator
Medical Physics Department
University of Cape Town
Rondebosch 7700, South Africa
tel +27 (0)21 404 6266
fax +27 (0)21 404 6269
Tobie.Kotze@uct.ac.za

**2 Description of Modules**

**2.1 Solid State Physics**

Lecturer Assoc. Professor M. Blumenthal, mb524@cam.ac.uk
20 Lectures Second semester
5 tutorials counting 25% towards final mark
2 journal paper reviews counting 10% towards final mark
1 class test counting 15% towards final mark
1.5 hour exam to take place in November, counting 50% towards final mark

Outline
Review of Bulk Semiconductors: Crystal structure, energy band structure, doping. Introduction to Low Dimensional Systems: Length and energy scales, overview of fabrication techniques and possibilities in nano-physics, applications of low-dimensional physics. Electron Properties in Low Dimensional Systems: Band engineering, heterostructures, free electron gas, 2D electron gas, 1D electron gas, 0D electron gas, density of states. Quantum Transport: 1D wires, 0D quantum dots, Coulomb blockade, resonant tunnelling, charge detection, single-electron dots, electron pumps and turnstiles, surface-acoustic-wave current source. Electrons in magnetic fields: Landau levels, Shubnikov-De Haas effect, integer quantum Hall effect, edge states, Aharonov-Bohm effect.

Literature
[1] C. Kittel, Introduction to Solid State Physics, Wiley, 1996.
[2] N.W. Aschcroft and N. D. Mermin, Solid State Physics, Holt, Rinehard and Winston, 1976.
[3] M.J. Kelly, Low-dimensional Semiconductors: Materials, Physics, Technology, Devices, Clarendon Press, 1996.
[4] J.H. Davies, The Physics of Low-Dimensional Semiconductors: An introduction, Cambridge University Press, 1997.
[5] E.L. Wolf, Nanophysics and Nanotechnology, Wiley, 2007.

**2.2 Quantum Mechanics**

Lecturer Dr. W. A. Horowitz, WA.Horowitz@uct.ac.za
Tutor S. Bodenstein
20 lectures First semester
5 tutorials counting 20% towards final mark
1 class test counting 30% towards final mark
2 hour exam to take place in May, counting 50% towards final mark.

Outline

Postulates of QM, mathematics of QM: infinitely dimensional vector spaces; functions as vectors; Hermitian vs. self-adjoint operators; spectral decomposition; Lie algebra; generators of transformations; (some) representation theory. |Heisenberg picture, Schroedinger picture. Path integrals; Trotter formula; propagator for a free particle, simple harmonic oscillator, uniform gravity; functional analysis. Perturbation theory: time independent, non-degenerate and degenerate; time dependent, time order exponential, Dyson series; interaction picture. Scattering Theory; Lippman-Schwinger equation; Fermis Golden rule; Born cross section; Optical theorem. Quantum Statistics: Bosons vs. fermions; density matrices. Bells inequality; Einstein-Podolsky-Rosen paradox. Time permitting: WKB approximation, method of steepest descent.

Literature

[1] J.J. Sakurai, Modern Quantum Mechanics, Addison Wesley, 2010.
[2] R. Shankar, Principles of Quantum Mechanics, Springer, 1994.
[3] R.P. Feynman and A. R. Hibbs, Quantum Mechanics and Path Integrals, Dover, 2010.
[4] A. Messiah, Quantum Mechanics, Dover, 1999.
[5] R.L. Liboff, Introductory Quantum Mechanics, Addison Wesley, 2002.
[6] F. Schwabl, Quantum Mechanics, Springer, 2010.

## 2.3 Nuclear Physics

Lecturer Dr. R. Nchodu, Rudolph.Nchodu@uct.ac.za
20 lectures Second semester
Problem sets & assignments counting 50% towards final mark
1.5 hour exam to take place in November, counting 50% towards final mark

Outline

Nuclear properties: Segre plot, binding energies, nuclear shapes and sizes, magnetic moments. Radioactive decay: alpha, beta and gamma decay, fission. Semi-empirical mass formula, the liquid drop model. Cross-sections, nuclear reactions. Acceleration methods, interactions with matter, detectors, counting statistics. Deuteron. Nucleon-nucleon potential. Nuclear structure: Fermi gas, nuclear shell model, collective motion, non-spherical nuclei. Gamma spectroscopy. Nucleosynthesis. Applications: radioactive dating, fission, fusion, biomedical applications. Dosimetry.

Literature

[1] B. Martin, Nuclear and Particle Physics, Wiley, 2006.
[2] K.S. Krane, Introductory Nuclear Physics, Wiley, 1988.
[3] N.A. Jelley, Fundamentals of Nuclear Physics, Cambridge University Press, 1990.

## 2.4 Computational Physics

Lecturer Dr. S. Wheaton, Spencer.Wheaton@uct.ac.za
Tutor TBA
20 Lectures Second semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Take-home Exam to take place in November, counting 50% towards final mark. Students are expected to be familiar with at least one programming language.

Outline

Undergraduate physics students study simple problems having simple analytical solutions. Real world problems are complex. This course introduces computational methods in the context of simple physical problems which cannot be solved by analytical techniques. These methods form an introduction to problem solving in the real world. Topics to be presented will be drawn from: Motion with nonlinear damping forces (introduction to ODEs); time-independent Schroedinger equation for square well and for arbitrary potentials (roots of equations, Runge-Kutta and Numerov solutions of ODEs); solution of wave equation in periodic potential, band structure (linear algebra, eigenvalues of matrix); electrostatic potential problems (solution of Laplace equation by relaxation techniques); ray tracing in optical systems and charged-particle beam lines (linear algebra); detector response by Monte Carlo techniques (integration, random numbers); the fast Fourier transform; non-linear fitting; symbolic computation.

Literature
[1] R. de Vries, A first course in computational physics, Wiley, 1994.
[2] A.L. Garcia, Numerical methods for physics, Prentice-Hall, 1994.
[3] N.J. Giordano, Computational Physics, Prentice-Hall, 1997.
[4] W.H. Press et al., Numerical recipes, Cambridge University Press (various editions for different programming languages).

## **2.5 Radiation Interactions**

Lecturer Dr Steve Petersen
20 Lectures First semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Exam to take place in May, counting 50% towards final mark.

Outline
Radiation sources, the process of radioactive decay as source of radiation, interaction of photons and neutrons with matter, isotope production with reactors and accelerators, nuclear fission as a source of radiation, lasers and microwaves as sources of radiation.

1. Radiation sources: Units and definitions, Fast electron sources, Heavy charged particle sources, Sources of electromagnetic radiation, Neutron sources.
2. The process of radioactive decay as source of radiation: Radioactive decay series; Differential equations; "Bateman-equations"; Biological losses and radioactive decay; Effective half-lifes, Production of radioactive isotopes.
3. Interaction of photons and neutrons with matter: Emphasis is placed on energy transfer to the matter through which the radiation passes. Gamma-rays, neutrons.
4. Isotope production with reactors and accelerators: General equation for production / decay of radioactive isotopes.
5. Nuclear fission as a source of radiation: Process applications: Reactors; Criticality accidents
6. Lasers and microwaves as sources of radiation.

Outcomes of course
The aim of the course is to indicate useful, purposeful, safe and innovative application of radiation. It is a core module for advanced courses in medical physics and radiation applications in industry.

Literature
There is no prescribed handbook; reference is often made to:
[1] Edwin Podgorsak, Radiation Physics for Medical Physicists, 2006
[2] FH Attix, Introduction to Radiological Physics and Radiation Dosimetry.
[3] GF Knoll, Radiation Detection and Measurements.
[4] H Cember, Introduction to Health Physics
[5] CM Lederer et al. Table of Isotopes

**2.6 Research Project**
Lecturer Mr JK Hough, Jan.Hough@uct.ac.za

Course summary
Independent work on topics that forms part of Medical Physics, chosen in collaboration with lecturers in the Department of Medical Physics. The mark for the research project will be from the four projects performed in the Department of Medical Physics.

The research project must, in the opinion of the HoD be aligned with the academic nature of the BSc (Med) (Hons) course. The HoD will decide if each proposed research project (title, supervisor, description of nature of research project) is acceptable.

The student must submit a written project progress report by May 16. If the HoD, after consultation, feels there has not been sufficient progress, a letter will be sent to the student and supervisor, warning that the course DP may be withheld.

If on the nominated project hand in date, to be set by the HoD, and being normally around 15 October, the project is not handed in, the DP will be withheld. The students must orally present the research project to staff members in October.

Course content
Independent project work that will be of an experimental nature.

Study material
Depends on the project chosen, but will involve the reading of articles in Medical Physics Journals available in the Library.

**2.7 The Physics of Radiation Dosimetry / Diagnostic Radiology**
Lecturer Dr. TC Kotzé, Tobie.Kotze@uct.ac.za
20 Lectures First semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Exam to take place in May, counting 50% towards final mark.

Outline

Radiation Dosimetry

1. Radiation Dosimetry
   Measurement of radiation, Definition of physical quantities, Energy transfer, Electronic equilibrium, Bragg-Gray cavity.
2. Interaction between Electrons and Matter
   Energy losses of electron beams, Electron scattering, Radiation quality and range, Electron dosimetry.
3. Interaction between Protons and Matter
   Energy losses of electron beams, Proton scattering, Radiation quality and range, Proton dosimetry, Interaction with human tissue.

Physics of Radiology

1. The x-ray machine
   Production of x-rays: x-ray tubes, x-ray generator; Factors influencing x-ray emission.
2. Conventional Radiography

Differential absorption; Filters; Radiographic film; Intensifying screens; Image intensifiers; Grids; Image quality; Quality assurance.

3. Computer tomography
   Basic principles; Generations of tomographs; CT-numbers; Image quality; Artifacts; Helical; computer tomography.
4. Ultrasound
   Basic principles; Production of ultra sound; Characteristics of ultra sound beams; Ultrasound imaging; Doppler techniques.
5. Magnetic Resonance Imaging
   Basic characteristics; Production and detection of the MR signal; Pulse sequences; Localisation of the MR signal; Artifacts; Instrumentation.

Outcomes of course
Radiation Dosimetry:
After completion the module, the student will be able to:

1. Describe the interactions between electron- and proton beams with matter.
2. Describe the theoretical principles of dosimetry and dose calculations.
3. Determine the absorbed dose in uniform and non-uniform mediums.

Physics of Radiology:
The objective of the course is to introduce the student to the basic principles of imaging in Diagnostic Radiology. The student will be acquainted with imaging modalities such as Computer tomography, ultrasound and Magnetic resonance imaging.

Literature
Radiation Dosimetry
[1] *The Physics of Radiology*, Fourth addition, Johns and Cunningham. Thomas Books, 1983.
[2] *Physics of electron beam therapy*, DC Klevenhagen, 1985.
[3] *Proton Therapy and Radio-surgery*, Breuer and Smit, 2000.

Physics of Radiology
[1] JT Bushberg, JA Seibert, EM Leidholdt, JM Boone, *The Essential Physics of Medical Imaging*, Second Edition, Lippincott Williams and Wilkens 2002.
[2] SC Bushong, *Radiologic Science for Technologists: Physics, Biology and Protection*, 9th Edition, Mosby, 2008.

## 2.8 The Physics of Nuclear Medicine

Lecturer Mr Chris Trauernicht, Christoph.Trauernicht@uct.ac.za
20 Lectures Second semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Exam to take place in November, counting 50% towards final mark.

Outline

1. Radiation Detectors: Types of radiation detectors, ionization chambers, Geiger counters, scintillation counters, principles of operation, concept of dead time.
2. The Gamma Camera: Principle of operation, Collimators, NaI(Tl) Crystal, Performance Parameters.
3. Quality Control of the Gamma Camera: All quality control procedures as per NEMA and Tecdoc 602, Additional procedures recommended in publications.
4. Computers in Nuclear Medicine: Organisation of Gamma Camera Computer, Programming Principles, Applications in Nuclear Medicine, Gated Cardiac Studies, Functional Images.

5. Principles of SPECT: Acquisition, Filtered Back projection, Iterative Reconstruction, Attenuation Correction, Quality Control.
6. Principles of PET: Principles of PET, Acquisition, Reconstruction, Attenuation Correction, Quality Control.
7. Statistics of Counting: Poisson Distribution, Chi-squared test, Combination of Errors.
8. Basic Principles of Tracer Studies: Terminology, Blood Volume, Fick's Principle, Cardiac Shunts, Compartmental Analysis, Kidney function investigations.
9. Whole Body Counters: Theory and Principle of Operation, Minimum Detectable Activity.

Outcomes of course

The purpose of the module is to familiarize the student with:

1. The theory and principle of operation of all medical nuclear instrumentation.
2. The quality control measures of nuclear instrumentation.
3. The practical uses of radioactive sources.
4. The theoretical principles of common tracer techniques.
5. Computer processing techniques of nuclear medicine images.

Literature

[1] Physics in Nuclear Medicine, Second Edition, J.A. Sorenson, M.E. Phelps. Grune & Stratton 1987.

[2] Basic Science of Nuclear Medicine. Second Edition. R.P. Parker, P. H. S. Smith, D. M. Taylor Churchill Livingstone 1984.

[3] Quality Control of Nuclear Medicine Instruments. IAEA Tecdoc 602, 1991

[4] Performance Measurements of Scintillation Cameras. NEMA Standards Publication NU1-2001

[5] Principle of Nuclear Medicine, (2nd edition), Henry N Wagner, 1995, WB Saunders, ISBN 0-7216-9091-2

## 2.9 The Physics of Radiotherapy

Lecturer Mr JK Hough, Jan.Hough@uct.ac.za

20 Lectures First semester

5 Tutorials counting 25% towards final mark

1 Class Test counting 25% towards final mark

Exam to take place in May, counting 50% towards final mark.

Outline

1. Dosimetry of Teletherapy: Phantom materials; Dose parameters: backscattering factor, percentage depth dose, tissue-air-ratio, tissue-phantom-ratio, isodose curves; Dose measuring.
2. Filters: Beam hardening; Shielding; Beam flatness; Compensation; Wedges.
3. Geometry of the Beam: Beam shaping; Penumbra.
4. Teletherapy units: Therapeutic x-ray units; Cobalt unit; Medical linear accelerator; Patient set-up.
5. Quality assurance: Acceptance of equipment; Calibration of a teletherapy unit; Quality control programme.
6. Electron therapy: Energy of electron beams; Characteristics of electron beams; Dose distributions; Dose measurement.
7. Brachytherapy: Techniques; Dosimetry; Radiographic techniques; Paris system; Radiation protection.
8. Unsealed sources and Beta irradiators: Radionuclides; Dosimetry; Radiation protection; Surface therapy.

Outcomes of course
The objective of the course is to introduce the student to the basic principles of dose measurements and dose calculations for teletherapy and brachytherapy. The student should further obtain knowledge on beam shaping, shielding and treatment planning of the radiotherapy patient.

Literature
[1] Faiz M Khan, The Physics of Radiation Therapy, Second Edition, Williams and Wilkens, 1994.
[2] Radiotherapy Physics in practice, JR Williams and DI Thwaites, Oxford Medical Publications, 1994.
[3] HE Johns, JR Cunningham, The Physics of Radiology, Fourth Edition, Charles C Thomas Publisher, 1984.
[4] EB Podgorsak, Radiation Oncology Physics: A Handbook for Teachers and Students, 2005

## 2.10 Radiation Protection

Co-ordinator Dr TC Kotzé, Tobie.Kotze@uct.ac.za
Lecturer Mr Johann van Rooyen (Necsa)
20 Lectures First semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Exam to take place in May, counting 50% towards final mark.

Outline

**1. Radiological protection**

The following subjects are treated, using the 2005 recommendations of the ICRP as basis:
Physical quantities used in radiological protection: The absorbed dose, equivalent dose, effective dose, and the committed effective dose.
Radiation and tissue weighting factors.
Biological aspects of radiological protection.
Deterministic and stochastic effects of ionising radiation.
The Dose and Dose-Rate Effectiveness Factor (DDREF).
Additive and multiplicative risk projection models.
Aggregated detriment.
The conceptual framework of radiological protection.
Practices and intervention.
The system of protection in practices.
Generic scientific principles of radiological protection.
The control of occupational exposure.
The control of public exposure.
Internal dosimetry calculations, using the code LUDEP.

**2. The shielding of neutrons and gamma-rays**

(i) Fundamental concepts of radiation transport: Particle density in phase space; directional fluence rate; scalar fluence rate; reaction rates; response.
(ii) Radiation transport calculations: The Boltzmann transport equation. - The multigroup approximation to the solution of the Boltzmann transport equation. Important sources of ionising radiation at radiation facilities and the nuclear industry - radionuclides, nuclear reactors, particle accelerators, accelerator-driven target bombardment facilities; neutron & proton radiotherapy facilities. - Response functions and response functionals. The fluence-rate to dose-rate response functions for neutrons and ionising photons. - Point kernel integration calculations using MathCAD, as well as QAD-CGGP. - Discrete ordinates calculations using the code XSDRN. - Monte Carlo calculations with simple MathCAD and

PC-based training codes. - An overview of the state-of-the-art radiation transport codes – MCNP, MCNPX, EGS & SCALE. - Ranges of charged particles in matter – electrons, protons & alpha particles. The optimal shielding of electrons.

(iii) Fundamental principles of neutron and gamma-ray shielding: The shielding of neutrons: neutron moderation, neutron reaction dynamics, neutron scattering kinematics, angular distribution of scattered neutrons, average energies and emission angles of scattered neutrons.

(iv) The shielding of photons: Bremsstrahlung, photo-electric absorption, Compton scattering and pair production.

(v) Complementary shielding materials.

(vi) Fundamental principles of shield optimisation.

Outcomes of course

To present a sound conceptual foundation in the theory and practice of:

1. Radiological protection
2. The shielding of ionising radiation

Literature

[1] Handout notes

[2] James E Martin, Physics for Radiation Protection: A Handbook, 2nd Edition, 2006

[3] Landolt-Bornstein, Radiological Protection, Group VIII: Advanced Materials and Technologies, Volume 4, 2005

## 2.12 Introduction to Medical Imaging and Image Processing

Lecturers from Department of Human Biology – Biomedical Engineering, Prof's Tania Douglas and Ernesta Meintjes, Tania.Douglas@gmail.com, Ernesta.Meintjes@uct.ac.za

20 Lectures First semester

Outline

An introduction to the physics and engineering principles involved in the acquisition and processing of medical images. The contents include mathematical tools of image processing, x-ray imaging, computed tomography, ultrasound and Magnetic Resonance Imaging.

There's no final exam, but a number of assignments, including a literature review.

Outcomes of course

The objective of the course is to provide an introduction to basic concepts and methodologies for digital image processing.

Literature

[1] Digital Image Processing, Gonzales & Woods

## 2.12 Treatment Planning

Lecturer Ms Hester Burger, Hester.Burger@uct.ac.za

Tutor TBA

20 Lectures Second semester

5 Tutorials counting 25% towards final mark

1 Class Test counting 25% towards final mark

Exam to take place in November, counting 50% towards final mark.

Outline
Imaging in radiotherapy, DICOM conformance, patient data acquisition, patient and organ movement, localisation, multiple beams, correction techniques, patient positioning and immobilisation, treatment planning algorithms, quality assurance, 3D conformal radiation therapy, IMRT, IGRT, VMAT, radiosurgery, LDR brachytherapy, HDR brachytherapy, treatment plan evaluation.

Outcomes of the course
To present a sound foundation in the theory and practice the radiation treatment planning process, including parameters such as target volume, dose-limiting structures, treatment volume, dose prescription, dose fractionation, dose distribution, positioning of the patient, and treatment machine settings.

Literature
[1] Faiz M Khan, Treatment Planning in Radiation Oncology, 2$^{nd}$ Edition, 2007
[2] Jane Dobbs et al, Practical Radiotherapy Planning, 3$^{rd}$ Edition,1999

## 2.13 Radiobiology and Life Sciences

Lecturer Dr Alistair Hunter, Alistair.Hunter@uct.ac.za
20 Lectures Second semester
5 Tutorials counting 25% towards final mark
1 Class Test counting 25% towards final mark
Exam to take place in November, counting 50% towards final mark.

Outline
This module will provide an introduction to basic Radiobiology, anatomy and physiology. Radiobiology will include cellular radiobiology, tumour radiobiology and radiation effects in normal tissues. An overview of radiobiological modelling of cellular and organ effects will be covered including Tumour Control Probability and Normal Tissue Complication Probability.

Outcomes of the course
A basic understanding of radiobiology, anatomy and physiology

Literature
[1] Eric Hall, Radiobiology for the Radiologist

## 3 Lecture time table

The time tables below are drafts. They might be changed to avoid clashes with courses from other departments. For updates, please check the course web site www.phy.uct.ac.za/courses/phy400nW.

All Physics courses will be given in the RW James Building, and all Medical Physics courses will be give in the Seminar Room, Department of Medical Physics, L Block, Groote Schuur Hospital.