1 Introduction

MRTY 1036 is a Junior level unit designed specifically for students enrolled in the Bachelor of Applied Science (MRS) Diagnostic Radiography. The unit is presented by staff from the School of Physics (in the Faculty of Science) and from Medical and Radiation Sciences (in the Faculty of Health Sciences).

Together with MRTY 1031 Medical Radiation Physics in semester 1, MRTY 1036 provides the necessary background knowledge of physics for continuing study of specific radiographic techniques, leading to qualification as a diagnostic radiographer.

1.1 Assumed Knowledge and Prohibitions

It is assumed that students have completed HSC Physics and 2 unit Maths. Students without the assumed knowledge are strongly advised to enrol in the Mathematics Bridging Course and the Physics Bridging Course offered prior to the commencement of Semester 1.

2 Course Aims, Learning Objectives and Graduate Attributes

2.1 Course Aims

This unit aims to provide you with a basic knowledge and understanding of concepts in radioactivity and ultrasound, laying the foundation for understanding devices such as cyclotrons, radiation detectors and ultrasonic transducers. It also explores the effects of ionising and non-ionising radiation on biological systems, including implications for radiological protection.

The unit is also intended to help you develop appropriate methods of study that will allow you to become an independent learner, capable of organising new information into a coherent conceptual framework and applying it in both familiar and unfamiliar situations.
2.2 Learning Outcomes

After successfully completing this unit, you should be able to demonstrate:

1. an understanding of the key physics concepts related to particle radiation - the nucleus, nuclear forces and radioactivity, nuclear reactions, nuclear radiation and radiation measurement, nuclear-based imaging.
2. an understanding of dosimetry, radiation monitoring and protection, safety legislation and the biological effects of radiation.
3. an understanding of the key physical concepts related to ultrasound imaging - basic wave concepts, acoustic impedance, scattering and attenuation, Doppler shift and Doppler ultrasound.
4. an ability to apply these concepts to solve qualitative and quantitative problems in the radiographic context. You will be asked to demonstrate your growing abilities in several assignments and workshop tutorials.
5. an understanding of the instruments used to measure particle radiation and ultrasound, together with basic experimental skills in their measurement and the analysis of resulting data.
6. the ability to find and analyse information and judge its reliability and significance.
7. the ability to communicate scientific information appropriately, both orally and through written work.
8. the ability to engage in team and group work for scientific investigations and for the process of learning.
9. a sense of responsibility, ethical behaviour and independence as a learner and as a scientist.

2.3 Graduate Attributes

Graduate Attributes are generic attributes that encompass not only technical knowledge but additional qualities that will equip students to be strong contributing members of professional and social communities in their future careers. The overarching graduate attributes identified by the University relate to a graduate’s attitude or stance towards knowledge, towards the world, and towards themselves. These are understood as a combination of five overlapping skills or abilities, the foundations of which are developed as part of specific disciplinary study. For further details please refer to the Science faculty website at: [http://www.itl.usyd.edu.au/graduateAttributes/facultyGA.cfm?faculty=Science](http://www.itl.usyd.edu.au/graduateAttributes/facultyGA.cfm?faculty=Science)

<table>
<thead>
<tr>
<th>Graduate Attributes</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Research and Inquiry</strong></td>
<td></td>
</tr>
<tr>
<td>A1. Apply scientific knowledge and critical thinking to identify, define and analyse problems, create solutions, evaluate opinions, innovate and improve current practices.</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>A2. Gather, evaluate and deploy information relevant to a scientific problem.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>A3. Design and conduct investigations, or the equivalent, and analyse and interpret the resulting data.</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>A4. Critically examine the truth and validity in scientific argument and discourse, and evaluate the relative importance of ideas.</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td><strong>B Information Literacy</strong></td>
<td></td>
</tr>
<tr>
<td>B1. Use a range of searching tools (such as catalogues and databases) effectively and efficiently to find information.</td>
<td>4</td>
</tr>
<tr>
<td>B2. Access a range of information sources in the science disciplines, for example books, reports, research articles, patents and company standards.</td>
<td>4</td>
</tr>
<tr>
<td>B3. Critically evaluate the reliability and relevance of information in a scientific context.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>B5. Use information technology to gather, process, and disseminate scientific information.</td>
<td>4, 5</td>
</tr>
<tr>
<td><strong>C Communication</strong></td>
<td></td>
</tr>
<tr>
<td>C1. Explain and present ideas to different groups of people in plain English.</td>
<td>5, 6</td>
</tr>
</tbody>
</table>
C2. Write and speak effectively in a range of contexts and for a variety of different audiences and purposes.  
C4. Present and interpret data or other scientific information using graphs, tables, figures and symbols.  
C5. Work as a member of a team, and take individual responsibility within the group for developing and achieving group goals.  
C6. Take a leadership role in successfully influencing the activities of a group towards a common goal.

| **D Ethical, Social and Professional Understanding** |  
|---------------------------------------------------|------|
| **D1.** Demonstrate an understanding of the significance and scope of ethical principles, both as a professional scientist and in the broader social context, and a commitment to apply these principles when making decisions. | 7 |
| **D2.** Appreciate the importance of sustainability and the impact of science within the broader economic, environmental and socio-cultural context. | 7 |

| **E Personal and Intellectual Autonomy** |  
|----------------------------------------|------|
| **E1.** Evaluate personal performance and development, recognise gaps in knowledge and acquire new knowledge independently. | 3, 4, 7 |
| **E2.** Demonstrate flexibility in adapting to new situations and dealing with uncertainty. | 3, 7 |
| **E3.** Reflect on personal experiences, and consider their effect on personal actions and professional practice. | 7 |
| **E4.** Set achievable and realistic goals and monitor and evaluate progress towards these goals. | 7 |
| **E5.** Demonstrate openness and curiosity when applying scientific understanding in a wider context. | 7 |

For further details on course learning outcomes see the Specific Objectives listed later in this Outline.

### 3 Study Commitment

Students enrolled in this 6-credit point unit of study should consider spending at least 8 hours per week on this unit during the 13 teaching weeks and the study vacation. In MRY 1036 this involves:

**Lectures**

You will have 12 two-hour lectures divided into 3 lecture modules:

- **Radiation Physics and Nuclear-based Imaging** (Dr John Gillam - 6 lectures) - The nucleus and nucleons, nuclear forces and stability, nuclear reactions and radiation, nuclear decay equations, half-life, range of radioactivity, radiation detection and measurement, different types of detectors, introduction to semiconductors and semiconducting devices, production of radionuclides, radionuclide imaging, tomographic imaging, magnetic fields.
- **Dosimetry and Legislation** (Dr Prabhjot Juneja - 4 lectures) - Dosimetry, exposure, absorbed dose, radiation units, radiation weighting factor, equivalent dose, half lives, Man-made sources, biological effects, radiation control, detection and monitoring, ALARA, radioisotopes, radiography, non-ionising radiation, Radiation protection and safety legislation in NSW and Australia.
- **Radiation Biology** (Prof. Patrick Brennan - 2 lectures) - Why radiation is hazardous; atomic, molecular, cellular and tissue changes, effects of radiation to the whole organism, stochastic v. deterministic factors, ICRP 103.

The lectures are intended to complement your study of the textbook and any copied notes we supply.
**Tutorials/Workshops**

You will have 9 one-hour workshop tutorials based on and supporting the lectures. You will work in groups of four on a selection of qualitative and quantitative questions and problems. Tutors are present to assist you.

**Studio Lab Sessions**

You will have 9 two-hour studio lab sessions complementing the lectures. You will work in groups of 3 or 4, and sometimes in larger groups, in an interactive 'studio' environment with tutors to assist. Activities involve short quizzes, simple experiments and demonstrations, computer simulations and discussions. A mid-semester test on unit content will be held during one of the studio lab sessions.

3 of the studio lab sessions will introduce the topic of Ultrasound that is not covered in the Lectures.

- **Ultrasound** (A/Prof. John O'Byrne - 3 studio lab sessions) - Revision of sound waves, decibel scale, reflection and refraction; acoustic impedance, impedance matching, scattering and attenuation; image formation with ultrasound.

**Independent Study**

You are expected to do at least 3 hours per week of independent study. Use this time to:

- read and expand your lecture notes
- read through and understand the relevant sections of the textbook
- complete pre-lecture quiz questions and assignment questions
- study for the mid-semester test and the final examination

*The following Learning Commitment Table summarises a suggested allocation of your time to meet these commitments.*

<table>
<thead>
<tr>
<th>In class activities</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures (12 @ 2 hr each)</td>
<td>24</td>
</tr>
<tr>
<td>Workshop Tutorials (9 @ 1 hr each)</td>
<td>9</td>
</tr>
<tr>
<td>Studio lab sessions (9 @ 2 hrs each)</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Study</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 assignments (3 hrs each)</td>
<td>9</td>
</tr>
<tr>
<td>Reading of text or notes for lectures (12 @ 0.5 hr each)</td>
<td>6</td>
</tr>
<tr>
<td>Pre-lecture quizzes (11 @ 0.5 hr each)</td>
<td>5.5</td>
</tr>
<tr>
<td>Reading of lecture notes after lectures (12 @ 0.5 hr each)</td>
<td>6</td>
</tr>
<tr>
<td>Revision and self-assessment (13 @ 1 hr each week)</td>
<td>13</td>
</tr>
<tr>
<td>Preparation for Studio Lab sessions (9 @ 0.5 hr each)</td>
<td>4.5</td>
</tr>
<tr>
<td>Preparation for mid-semester test</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
</tr>
</tbody>
</table>

**Study Tips**

You are now in control of your own study strategy, and as an adult learner it is up to you to devise a study plan that best suits you. If you attend classes regularly and involve yourself in all of these learning experiences, you will gain a good understanding of the course work. This will have a considerable impact on your exam preparation and performance.

**Good study habits** are also very important - we offer some suggestions on our Learning Physics web page ([http://sydney.edu.au/science/physics/current/learningphysics.shtml](http://sydney.edu.au/science/physics/current/learningphysics.shtml)).
4 Learning and Teaching Activities

CLASS TIMETABLING

MRTY 1036 is unusual for students in the Bachelor of Applied Science in that it is held on the university's main campus. For this reason we have concentrated all the classes on one day - Friday each week. That makes Friday an intense day (for students and staff!) divided between Lectures, Studio Labs and Tutorials.

All students will attend:

One two-hour Lecture in Lecture Theatre 2, Western end of the second floor of the Physics Building
  • 10 am - 12 noon

One two-hour Studio Lab session in Room 401, Level 4 Carslaw Building, at one of the following times:
  • 1 pm - 3 pm
  • 3 pm - 5 pm

One one-hour Workshop Tutorial in SNH Seminar room 4001, Sydney Nanoscience Hub Building (NOTE new location!), at one of the following times:
  • 1 pm - 2 pm
  • 2 pm - 3 pm
  • 3 pm - 4 pm
  • 4 pm - 5 pm

[Buildings can be identified on the Uni map at http://sydney.edu.au/maps/campuses/?area=CAMDAR]

Timetable

See Table below or go to sydney.edu.au/science/physics/pdfs/current/jphys/MRTY1036_timetable.pdf
## 5 Teaching Staff and Contact Details

<table>
<thead>
<tr>
<th>Unit Coordinator</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/Prof. John O'Byrne</td>
<td><a href="mailto:john.obyrne@sydney.edu.au">john.obyrne@sydney.edu.au</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Staff</th>
<th>Email</th>
<th>Room</th>
<th>Phone</th>
<th>Note</th>
</tr>
</thead>
</table>

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### Timetable for MRTY 1036 Health Physics and Radiation Biology 2015

<table>
<thead>
<tr>
<th>Friday date Week</th>
<th>Lectures (2 hours)</th>
<th>Tutorials (1 hour)</th>
<th>Studio/Labs (2 hours)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 July Week 1</td>
<td>Radioactivity Lecture 1 (Gillam)</td>
<td>NO WORKSHOP</td>
<td>NO LAB</td>
<td></td>
</tr>
<tr>
<td>7 August Week 2</td>
<td>Lecture 2 (Gillam) Workshop 1</td>
<td>Lab 1: Half Life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 August Week 3</td>
<td>Lecture 3 (Gillam) Workshop 2</td>
<td>Lab 2: Penetration of α, β, γ Radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 August Week 4</td>
<td>Lecture 4 (Gillam) Workshop 3</td>
<td>Lab 3: Counting Statistics Assignment 1 issued Friday 21 August</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 August Week 5</td>
<td>Lecture 5 (Gillam) NO WORKSHOP</td>
<td>NO LAB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Sept. Week 6</td>
<td>Lecture 6 (Gillam) Workshop 4</td>
<td>Lab 4: Radiation Detectors Assignment 1 due Friday 4 September</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Sept. Week 7</td>
<td>Dosimetry, Radiation Protection, Safety Lecture 7 (Jungip) NO WORKSHOP</td>
<td>Mid-semester test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Sept. Week 8</td>
<td>Lecture 8 (Jungip) Workshop 6</td>
<td>Lab 5: Safety &amp; Dosimetry 1 Assignment 2 issued Friday 18 September</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Sept. Week 9</td>
<td>Lecture 9 (Jungip) Workshop 6</td>
<td>Lab 6: Safety &amp; Dosimetry 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 October Week 10</td>
<td>Legislation Lecture 10 (Jungip) Workshop 7</td>
<td>Lab 7: Ultrasound 1 Waves &amp; Sound Assignment 2 due Friday 9 October</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 October Week 11</td>
<td>Radiation Biology Lecture 11 (Brennan) Workshop 8</td>
<td>Lab 8: Ultrasound 2 Impedance, Reflection &amp; Imaging Assignment 3 issued Friday 16 October</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 October Week 12</td>
<td>NO LECTURE</td>
<td>Workshop 9</td>
<td>Lab 9: Ultrasound 3 Doppler Effect</td>
<td></td>
</tr>
<tr>
<td>30 October Week 13</td>
<td>Lecture 12 (Brennan) NO WORKSHOP</td>
<td>NO LAB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 Learning Resources

Textbook
The course content is based around the textbook - *Essential Physics for Radiographers*, 4th Edition (2008), John Ball, Adrian D. Moore and Steve Turner, Blackwell Publishing.

Studio Lab Manual
The studio lab segment of the unit is covered by: *MRTY1036 Medical Radiation Physics Studio Lab Manual*, prepared by the School of Physics. Laboratory Manuals can be purchased at the University Copy Centre/Publish Partner (https://www.publishpartner.com.au/students) for ~$12 and are also on the eLearning pages for this unit.

Recommended Reference
You will also find the following book useful as a reference for both units this year and to carry on to future years of your course: *Radiological Science for Technologists*, 10th edn, S C Boshung, Elsevier 2012 (or earlier editions).

You may also find it useful to consult current HSC Physics textbooks or one of the current Junior Physics textbooks:


Earlier editions are also quite acceptable.

Web Resources
The University eLearning system provides resources to help you with your studies, please spend time getting acquainted with this site. MyUni [http://sydney.edu.au/myuni](http://sydney.edu.au/myuni) is the student portal providing
University information and services. Access to MyUni and eLearning requires a Unikey username and password that is issued with your confirmation of enrolment. The University provides computer facilities described on the Student IT pages at [http://sydney.edu.au/ict/student/](http://sydney.edu.au/ict/student/).

**Email**

The University provides you with email access based on your Unikey username. We will use this email address to provide you with important information regarding this unit of study. **We expect you to periodically read your University email account or to forward mail from it to an email account you do read (eg. a gmail account).**

**Where to go for help**

If you need help, you can

- as a first step, always check your unit eLearning pages for information, documents and links
- ask other students using the Discussion Board on the unit eLearning page.
- go to the Physics Student Services Office, Room 210 in the Physics building, phone 9351 3037
- ask your lecturer or tutor or ask the unit coordinator, A/Prof. John O'Byrne (john.obyrne@sydney.edu.au)
- consult one of the many services provided by the University, such as the Maths Learning Centre. These can be found by choosing Junior Physics Resources and Links from the unit eLearning page or your MyUni pages [http://myuni.usyd.edu.au/](http://myuni.usyd.edu.au/).

**Providing us with feedback**

We welcome comments on all aspects of this unit. You should feel free to talk to your lecturers, tutors or the Unit Coordinator A/Prof. John O’Byrne at any time. There is also a formal opportunity for feedback at the Staff-Student Liaison meeting, held towards the end of semester.

**Changes from last year**

As a result of student feedback and other initiatives there have been a number of changes in the last couple of years. Most significant was introducing a new way of calculating your final grade that you have already experienced in semester 1. Other things to note for this year are:

- New lecturers in the 1st and 3rd modules of the unit.
- The Sydney Nanoscience Hub building project is now complete and we will take advantage of some of the new teaching spaces this semester - see [http://sydney.edu.au/science/physics/about/AIN/](http://sydney.edu.au/science/physics/about/AIN/)

**Specific Objectives**

The specific objectives define what you should learn and **understand** from the unit material. “Understanding” a term or concept means that you should be able to:

- **explain** its meaning in writing and give examples;
- **interpret** it correctly when you read or hear it;
- **use it** correctly in your own writing; and
- **apply it** correctly to examples and problems.
Module 1: Radiation Physics and Nuclear-based Imaging

Lectures: 1-6

Topics: The nucleus and nucleons, nuclear forces and stability, nuclear reactions and radiation, nuclear decay equations, half-life, range of radioactivity, radiation detection and measurement, different types of detectors; production of radionuclides, radionuclide imaging, tomographic imaging.

Specific objectives – after these lectures you should be able to:

Radiation Physics

- Understand the terms ionization and dose
- Be able to use the terms absorbed dose, equivalent dose and effective dose correctly.
- Understand what a nuclear force is and how it holds a nucleus together
- Understand the terms atomic mass and atomic number
- Know how to represent elements in the usual form - e.g. element X with superscript A and subscript Z
- Be able to work out the number of protons, neutrons and electrons present in an atom using its chemical symbol.
- Understand what the binding energy of a nucleon is.
- Understand what isotopes, isotones and isobars are.
- Understand what a stable nucleus is and why some atoms are unstable.
- Know what the line of stability is on a plot of N versus Z.
- Understand that the decay of a nuclide happens so that a nucleus can become more stable
- Understand that the decay of a nucleus is a random process
- Know how to find the decay constant of a substance

Half-life

- Understand the concept of half-life
- Understand what the activity of a substance is
- Be able to calculate the decay constant and half life of a substance
- Be able to calculate the mean life of a radioactive substance
- Understand what parent and daughter nuclei are
- Understand and describe beta decay
- Describe evidence for the existence of the neutrino
- Understand electron capture
- Understand positron decay
- Understand and describe alpha decay and gamma decay
- Describe internal conversion
- Be able to use decay equations to describe radioactive decay

Measuring Ionising Radiation

- Understand what is meant by the terms precision and accuracy
- Understand what the error of a measurement means
- Be able to calculate the mean of a set of measurements
- Know that the standard deviation describes the variation of a set of measurements
- Understand what the distribution of a set of measurements is
- Understand what a confidence level of a measurement is
- Know what variables and constants are when referring to measurement systems
- Understand how to find the mean and standard deviation of a number of nuclear counts
- Understand and calculate the effect of averaging repeated measurements
Understand and calculate gross, source and background count rates and their associated errors
Be able to calculate Minimum detectable activities (MDA)
Be able to estimate the count times required to obtain a level of confidence in a measurement of nuclear counts

**Types of detectors**
- Be able to describe the different types of detector that are commonly used for radiation detection
- Know how an ionization chamber works
- Understand the different operation of an ionization chamber depending on its operating voltage
- Understand the mechanisms of radiation detection in other common radiation detectors including cloud chambers, solid state detectors, thermoluminescent dosimeters, film and scintillation counters
- Understand why different types of detector are useful for different situations

**Semiconductors**
- how energy bands form in a periodic crystal
- the significance of conduction bands and valence bands and band-occupancy in conductors, insulators and semiconductors
- the effect of temperature on conduction
- charge carriers in semiconductors - electrons and holes
- the effect of doping on the carrier concentration in each band - n-type and p-type semiconductors
- the principles of the operation of p-n junctions
- current voltage characteristics of a p-n junction
- the use of semiconductors in x-ray detection

**Radionuclide imaging**
- Understand what radiopharmaceuticals are and how they are produced
- Know how are radiopharmaceuticals administered
- Understand and describe how a signal is detected from a patient undergoing a nuclear medicine diagnostic procedure
- Understand the process that produces light from an interaction with a photon
- Understand and describe the main components of a gamma camera and how they work
- Explain the function of a Photomultiplier tube
- Explain the function of a Pulse Height Analyser
- Explain the term ‘hot spot’ and ‘cold spot’ when referring to an image in nuclear medicine
- Know what nuclear medicine images look like and how they differ from x-ray images
- Know what types of images can be obtained and what types of scans can be performed

**Motion of charged particles in magnetic fields**
- magnetic field and magnetic field lines
- magnetic force on a charge and on a current
- motion of a moving charged particle in a magnetic field
- force between current carrying wires

**Module 2: Dosimetry and Radiation Protection and Safety**

**Lectures:** 7-10

**Topics:** Dosimetry, exposure, absorbed dose, radiation units, radiation weighting factor, equivalent dose, half lives, man-made sources, biological effects, radiation control, detection and monitoring, ALARA, radioisotopes, radiography, non-ionising radiation, radiation protection and safety legislation in NSW and Australia.
Specific objectives – after these lectures you should be able to:

**Dosimetry**

- Describe and explain the meaning of the following dosimetric terms and be able perform simple calculations involving them:
  - Activity, becquerel, curie, exposure, roentgen, kerma, absorbed dose, gray, rad, equivalent dose, rem, effective dose, radiation weighting factor (or Q factor), tissue weighting factor, relative biological effectiveness, linear energy transfer (LET), dose rate, effective half-life, physical half-life, biological half-life and cumulated activity.
- Worked examples in the lecture are a good guide to the degree of difficulty for calculations expected in the exam.
- Describe *qualitatively* how ionisation chambers (free air and thimble) can be used to measure exposure.
- Explain why the condition of electron equilibrium is important for accurate measurements of dose.
- Describe the concept of the build-up region and its connection with electron equilibrium. Use this idea to explain the function of the "air equivalent" cap on a thimble ionisation chamber.
- Explain how and why exposure measurements can be used to measure kerma and if equilibrium is established, absorbed dose in air.
- Describe the Bragg-Gray principle and how it allows a small ionisation chamber to be used to measure absorbed dose to be measured in a condensed medium (solid or liquid).
- Be able to draw a *qualitative* picture of a depth dose curve for X or grays and how that compares with a curve for kerma versus dose, and explain why they differ. The student should be able to recall that at radiographic energies (kV), the thickness of the build-up region is negligible compared with radiotherapy energies (MV).
- Describe *qualitatively* the relationship between LET and Q factor or RBE.

**Radiation Safety**

- Describe natural sources of radiation – from Earth, space and our bodies
- Describe man-made sources of radiation – medical sources, nuclear medicine and nuclear testing
- Describe biological effects of radiation on cells and DNA
- Explain the meaning of Deterministic and Stochastic effects and give examples
- Describe somatic effects of radiation
- Be aware of effective dose limits for radiation workers and the general public
- Describe radiation detectors and personal radiation monitors
- Describe the meaning of ALARA: As Low As Reasonably Achievable
- Describe the principles behind safe handling of radioactive materials
- Explain the relative risks of radiography and other activities - Benefit vs. risk
- Be aware of the International Commission on Radiological Protection (ICRP) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
- Relevant legislation surrounding Radiation Protection in Australia/NSW – Radiation Control Regulations
- Understand the nature of Radiation Accidents

**Module 3: Radiation Biology**

**Lectures:** 11-12

**Topics:** Why radiation is hazardous; atomic, molecular, cellular and tissue changes, effects of radiation to the whole organism, stochastic v. deterministic factors, ICRP 103.

**Specific objectives – after these lectures you should understand:**
Principles of radiobiology

- Explain the fundamentals of why radiation is hazardous
- Describe the response of cells to radiation
- Define fractionation and protraction
- Describe the biological factors that tissue sensitivity – oxygen effect, age, recovery, chemical agents, hormesis
- Describe radiation-dose relationships
- Explain Direct versus indirect radiation effects

Molecular and Cellular radiobiology

- Describe the effects of free radicals
- Describe the effects of radiation on DNA
- Describe and be able to calculate cell survival kinetics

Early effects of radiation

- Explain acute radiation lethality
- Explain the effects of local tissue irradiation
- Explain the difference between Hematologic and Cytogenetic effects

Early effects of radiation

- Describe local tissue effects
- Describe the risks to radiologists
- Be able to briefly discuss various cancer effects

Extra material presented in Studio labs

Topics: Revision of sound waves, decibel scale, reflection and refraction; acoustic impedance, impedance matching, scattering and attenuation; image formation with ultrasound.

Specific objectives – after these lectures you should be able:

Revision of wave concepts

- Understand and describe the difference between transverse, longitudinal and torsional waves
- Understand and use the parameters: velocity, amplitude, period, frequency, angular frequency, wave number and wavelength
- Understand the role of pressure and displacement in a sound wave
- Explain the difference between sound and ultrasound

Decibel Scale

- Understand and use the decibel scale

Reflection and Refraction

- Understand the principles of reflection and refraction and the equations describing them
- Understand and use the concepts of acoustic impedance, reflection and transmission coefficients and be able to calculate with them
- Understand and describe various ultrasound scan modes and image formation with ultrasound

Doppler shift

- Understand and describe the Doppler shift and be able to calculate it using the appropriate sign
• Describe the importance of the Doppler shift to ultrasound imaging.

7 Assessment Tasks

Assessment

Assessment tasks are intended to allow you to demonstrate what you have learned related to the goals of this unit. They also serve to encourage you to work with the material, but should not dominate your approach to learning. See them as another learning activity, accompanying and complementing those listed earlier.

Assessment of this unit of study is based on achievement of specific learning objectives (listed elsewhere in this outline) demonstrated in a combination of assignments, examinations and laboratory work. Satisfactory performance in both the theory and experimental segments of the unit of study is necessary for a pass.

In addition, students in physics must be able to express themselves accurately by clear, efficient use of the English language in their written work. Spelling, grammar, punctuation and correct use of language will be taken into account when written reports and examination work are assessed. Students should refer to the University’s WriteSite (http://writesite.elearn.usyd.edu.au/) if they are looking for guidance on grammar and other aspects of academic and professional writing.

You are responsible for understanding the University policy regarding assessment and examination, which can be found in the University Policy Register at http://sydney.edu.au/policies/

The method of combining marks from various assessment tasks is somewhat different from that used in most other units, although this should not affect your approach to each assessment task. Your final grade will be based principally on your performance in the final exam and mid-semester test. **All Summative Assessments are marked and have mark standards that must be achieved to be eligible for each grade in your final result.** Refer to section 7.2 on Assessment Grading to see exactly how marks in each assessment determine your final grade.

### 7.1 Summative Assessments

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Due Date</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1</td>
<td>Week 6 Friday, 04 September 2015</td>
<td>1, 2, 4, 6, 7, 9</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>Week 10 Friday, 09 October 2015</td>
<td>1, 2, 4, 6, 7, 9</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>Week 13 Friday, 30 October 2015</td>
<td>1, 2, 4, 6, 7, 9</td>
</tr>
<tr>
<td>Pre-lecture quizzes</td>
<td>Weekly (weeks: 2, 3, 4, 6, 7, 8, 9, 10, 11, 12 and 13)</td>
<td>1, 2, 9</td>
</tr>
<tr>
<td>Workshop Tutorials</td>
<td>Weekly (weeks: 2, 3, 4, 6, 8, 9, 10, 11, 12 and 13)</td>
<td>1, 2, 7, 8, 9</td>
</tr>
<tr>
<td>Studio Lab Sessions</td>
<td>Weekly (weeks: 2, 3, 4, 6, 8, 9, 10, 11, 12 and 13)</td>
<td>1, 2, 3, 5, 6, 7, 8, 9</td>
</tr>
<tr>
<td>Mid-semester test</td>
<td>Week 7 Friday, 11 September 2015</td>
<td>1, 2, 5, 7</td>
</tr>
</tbody>
</table>
Descriptions of Summative Assessments

Assignment 1

There are three assignments, each consisting of several questions. The assignments are designed to help you develop problem-solving skills, practice written answers and obtain some progressive feedback. The benefit to you from doing the assignments, either independently or as a member of a small group, is therefore much more important than the marks per se. There is little point in just copying the work of others.

We encourage students to discuss assignments, but we will NOT accept assignments that are simply copied between students or from any other source. You should write your final answers independently, expressing the answers in your own words and with your own working. Allowing your work to be copied is unfair to other students and ultimately, does not help the student copying from your work.

Copying the work of another person without acknowledgement is plagiarism and contrary to University policies. By signing the coversheet you are certifying that you have read and understood the University of Sydney Academic Dishonesty and Plagiarism in Coursework Policy at http://sydney.edu.au/policies/showdoc.aspx?recnum=PD2012/254&RedndNum=0.

The problem-based assignments typical of this unit are different to more essay-based assignments in other disciplines. References are generally NOT necessary unless you use a direct quote from a source. If you do reference a source, choose any style of referencing you normally use providing it is clear.

Assignments must be submitted no later than 5pm on the due date. They must be handed in at Physics Student Services (Room 210) or, for late assignments only, by email to the Student Services Office email address (physics.studentservices@sydney.edu.au).

Assignments submitted late without permission will incur an immediate late penalty equal to 10% of the maximum mark. 24 hours later a further 20% penalty will be imposed for assignments between 1 and 7 days late, with extra 20% penalties imposed after each one week period from the due date until the assignment is submitted or submissions are closed.

For example, on an assignment given a mark of 7/10, the penalty would be 1 mark if submitted up to 24 hours late, resulting in a final mark of 6/10. If the assignment is submitted up to 1 week late, the final mark would be 4/10. An assignment will not ordinarily be accepted after a solution for the assignment is released or marked assignments are returned to other students.

The School of Physics does not take responsibility for lost assignments. You are advised to keep a copy of all assignments submitted.

Pre-lecture quizzes

Pre-lecture quizzes will consist of several multiple choice questions delivered on-line using the eLearning system. They are intended to encourage you to prepare for lectures by reading the textbook and any copied notes we supply and test your understanding of material to be covered in the lectures in the coming week. Answers will be apparent from the relevant sections of the reading. You do not need to get every answer right, but only a serious attempt at a quiz will earn credit towards your final grade. To
obtain maximum credit you may only miss one quiz (i.e. 10 out of 11 quizzes).

**Workshop Tutorials**

Contributing to Workshop Tutorials is an important part of success in this Unit of Study. We measure your contribution by collecting group answer sheets and assigning an overall grade for your work during the semester. To obtain maximum credit you may only miss one Tutorial (i.e. 8 out of 9 Workshop Tutorials).

**Studio Lab Sessions**

Assessment in the studio lab sessions is based on successful completion of experimental and simulation tasks and other activities conducted in the sessions. You are awarded check points for successfully completing each activity. As a result, it is essential that you arrive on time for these sessions so you take part in the each activity. Late arrival may be penalised. To obtain maximum credit you may only miss 2 check points out of 18 (e.g. complete 8 out of 9 Studio Labs). Previous experience indicates that this is not too difficult to achieve if you apply yourself during each session. Most students get all 18 check-points.

**Mid-semester test**

A 40 minute mid-semester test on unit content from the first lecture module (Radiation Physics) will be held in the studio lab session in Week 7. It is intended to give you experience of exam-style questions in exam conditions and give you some feedback on how your understanding of the course material is developing.

**Final examination**

A two-hour examination covering the material included in the unit of study is held at the end of the semester. You will be asked to write descriptive answers to questions, to explain physical principles and to answer quantitative questions, all aimed at demonstrating your progress in achieving the goals of the unit. An ability to memorise formulae and manipulate them without understanding the associated concepts will not be rewarded.

The final exam will cover material from the entire unit, including material tested in the mid-semester test, although the second half of the unit wil have a slightly greater emphasis. See the Sample Exam papers in the eLearning pages for this unit for an accurate indication of the exam structure.

Note that you must bring your own non-programmable calculator to the examination. See the University policy on calculators at [http://www.usyd.edu.au/current_students/student_administration/examinations/students.shtml#calculators](http://www.usyd.edu.au/current_students/student_administration/examinations/students.shtml#calculators)

**7.2 Assessment Grading**

Final grades in this unit are awarded at levels of HD (High Distinction), DI (Distinction), CR (Credit), PS (Pass) and FA (Fail) as defined by the Academic Board Assessment Coursework Policy 2014. These achievement levels are described below. Details of the policy are available on the University's 'Policy

The assessments for this unit are described in this unit of study outline. This description includes the purpose, timing and weighting of each assessment item and an explanation of how the task relates to the learning outcomes of the unit. Students are responsible for actively engaging with these assessments, including carefully reading the guidance provided, spending sufficient time on the task, ensuring their work is authentic and their own (whether individual or group work), completing work on time and acting on feedback provided.

The grading system used in this unit of study is somewhat different from that used in most other units. It is based on setting appropriate standards in different types of assessment. **ALL assessments are compulsory.**

Your final grade will be based principally on your performance in the two examination-style assessments where you are working by yourself:

- final exam (80%)
- mid-semester test (20%)

The minimum standard to achieve a pass mark in this unit is:

- Final exam + mid-semester test: ≥ 50%

AND

- Lab: ≥ 14/18 checkpoints

**You must meet BOTH of these standards to pass this unit.**

However, **ALL assessments contribute to your final grade** if you want to get more than a bare pass.

Each higher grade has a minimum mark that MUST be achieved to be eligible for that Grade in your final result – i.e. to achieve a High Distinction (HD) you must achieve a HD standard in ALL assessments. If you do not meet this standard, your mark will drop to the middle of the grade below.

Standards for achievement in each assessment task are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Exam + mid-semester test (/100)</th>
<th>Assignments (/120)</th>
<th>Tutorials (/9)</th>
<th>Studio Labs (/18)</th>
<th>Quizzes (/11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD</td>
<td>85</td>
<td>105</td>
<td>8</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>DI</td>
<td>75</td>
<td>90</td>
<td>8</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>CR</td>
<td>65</td>
<td>80</td>
<td>8</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>PS</td>
<td>40</td>
<td>60</td>
<td>7</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

**Grades:**
High Distinction (HD)
At HD level, a student demonstrates a flair for the subject and comprehensive knowledge and understanding of the unit material. A ‘High Distinction’ reflects exceptional achievement and is awarded to a student who demonstrates the ability to apply subject knowledge to novel situations.

Distinction (DI)
At DI level, a student demonstrates an aptitude for the subject and a solid knowledge and understanding of the unit material. A ‘Distinction’ reflects excellent achievement and is awarded to a student who demonstrates an ability to apply the key ideas of the subject.

Credit (CR)
At CR level, a student demonstrates a good command and knowledge of the unit material. A ‘Credit’ reflects solid achievement and is awarded to a student who has a broad understanding of the unit material but has not fully developed the ability to apply the key ideas of the subject.

Pass (PS)
At PS level, a student demonstrates proficiency in the unit material. A ‘Pass’ reflects satisfactory achievement and is awarded to a student who has threshold knowledge of the subject.

8 Learning and Teaching Policies

EQUITY, ACCESS AND DIVERSITY STATEMENT
The School of Physics is strongly committed to providing equity of access and opportunity to all students, and to make our environment supportive for everyone. The School has three Equity Officers who act as a point of contact for students who may have a query or concern about any issues relating to equity, access and diversity. If you feel you have not been treated fairly, discriminated against or disadvantaged in any way, you are encouraged to talk to one of the Equity Officers or any member of the Physics staff. More information can be found at http://sydney.edu.au/science/physics/about/equity.shtml

Any student who feels she/he may need an accommodation based on the impact of a disability should contact Disability Services http://sydney.edu.au/current_students/disability/ who can help arrange support.

ACADEMIC DISHONESTY/PLAGIARISM
The School of Physics will NOT accept assessments that are simply copied. Copying the work of another person without acknowledgment is plagiarism and contrary to University policies on Academic Dishonesty and Plagiarism as described on the University Policy Register web site (https://sydney.edu.au/policy/). An outline of what constitutes Academic Dishonesty and Plagiarism can be found at https://sydney.edu.au/science/physics/local/acadhonesty.shtml.

CONSIDERATION OF FACTORS AFFECTING YOUR STUDY (MRTY)
If your academic performance in the units MRTY 1031 or MRTYY 1036 is adversely affected by illness or some other serious event, such as an accident or important commitment, you should complete an Application for Special Consideration or an Application for Special Arrangements that may be submitted via an on-line form on the Faculty of Health Sciences web site.

These two forms of Consideration should cover most allowable circumstances. However, if you have another reason for requiring the School of Physics to take account of your circumstances, you should
notify the **School of Physics Student Office** immediately.

You should not submit an application of any type if

- there is no assessment associated with a missed class, or
- you have a reasonable opportunity to make up any work you missed.

More detailed information on Special Consideration and Special Arrangements is available from [sydney.edu.au/health-sciences/current-students/coursework/special-consideration.shtml](http://sydney.edu.au/health-sciences/current-students/coursework/special-consideration.shtml)

You may also go direct to the relevant on-line form at [forms.records.sydney.edu.au/Forms/Content/Form001.aspx](http://forms.records.sydney.edu.au/Forms/Content/Form001.aspx)

**Replacement assessments for end of semester examinations**

Students who apply for and are granted either special arrangements or special consideration for end of semester examinations in units offered by the Faculty of Science will be expected to sit any replacement assessments in the two weeks immediately following the end of the formal examination period. Later dates for replacement assessments may be considered where the application is supported by appropriate documentation and provided that adequate resources are available to accommodate any later date.

**Student Appeals**

If you wish to appeal an academic decision, you should refer to the University Policy at:


**Other University Policies**

For full details of applicable university policies and procedures, see the University Policy Register web site at [sydney.edu.au/policy](http://sydney.edu.au/policy).