MSc Radiation Detection and Instrumentation Handbook

2010-2011 Session
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VALIDITY

1. The information in this Course Handbook should be read in conjunction with the General Regulations for Higher Awards of the University for Students Pursuing Programmes on a Modular Basis, and the general physics MSc handbook.

2. The information contained within this Course Handbook is believed to be accurate at the time of production but the University and the Faculty cannot be held responsible for errors, omissions or changes which may have occurred.

3. The information in this Course Handbook will be amplified during the course with the issue of additional material.

   This additional material shall be read as part of the overall Course Guidelines and is considered to be part of the requirements of the Course which the student is expected to satisfy.

4. The course regulations governing performance requirements for the assignments, examinations and dissertation will be implemented within the scope of the General Regulations.
SECTION A – WHO IS WHO IN THE MSc RDI PROGRAMME

COURSE SUMMARY

The University of Surrey MSc in Radiation Detection Instrumentation is offered either as a one-year full-time course or as a two-year part time course, designed to provide the student with a detailed training in the performance, characteristics and application of radiation detectors and associated instrumentation across a broad range of application areas.

Students successfully completing the course are awarded an MSc in Radiation Detection and Instrumentation. For students who do not achieve the full 180 credits, alternative awards of Postgraduate Diploma in Radiation Detection and Instrumentation or Postgraduate Certificate in Radiation Physics may be offered.

The following staff members are principally involved in the organisation of this course:

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Dr Gary Royle, External Examiner
University College London
Dept. of Medical Physics and Bioengineering

Mrs Lucie White, MSc Course Administrator
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LECTURING STAFF

The course is taught by a number of specialists, who are either staff at the University of Surrey or are based in industries related to radiation detection and instrumentation. The following paragraphs list the course lecturers and their affiliation.

University of Surrey:

Prof. David Bradley, Physics Department
Prof. Wilton Catford, Physics Department
Dr Walter Gilboy, Visiting Senior Fellow, Physics Department
Prof. Andrew Nisbet, Professor, Physics Dept. and Royal Surrey County Hospital
Dr Silvia Pani, Physics Department
Dr Zsolt Podolyak, Senior Lecturer, Physics Department
Prof. Patrick Regan, Physics Department
Dr James Scuffham, Phys. Dept. and Royal Surrey County Hospital
Prof. Paul Sellin, Reader and Course Director, Physics Department
Prof. Nicholas Spyrou, Physics Department

University of Sussex:

Dr Seb Oliver, Reader, Physics and Astronomy Department, Sussex University
Dr Anthony Smith, Research Fellow, Physics and Astronomy Department, Sussex University
Dr Pascale-Fabrizio Salvatore, Lecturer in Experimental Particle Physics, Physics and Astronomy Department, Sussex University

**External Lecturers:**

Mr Pete Burgess  
Nuvia Ltd, B351.15, Harwell Science & Innovation Campus, Didcot, Oxfordshire OX11 0RA  
Lectures on Module 4: Imaging and Remote Sensing

Dr Ian Jupp  
DSTL, Fort Halstead, Sevenoaks, Kent TN14 7BP  
Lectures on: Module 4: Imaging and Remote Sensing

Dr James Parkin  
Lab Impex Systems Ltd, Impex House, 21 Harwell Road, Nuffield Industrial Estate, Poole, Dorset BH17 0GE  
Lectures on: Module 4: Imaging and Remote Sensing

Mr Paul Seller  
Rutherford Appleton Laboratories, Harwell Science & Innovation Campus, Didcot OX11 0QX  
Lectures on: Module 3: Detector Instrumentation
SECTION B - PROGRAMME OBJECTIVES AND OUTCOMES

The detection and analysis of radiation plays a vital role in our modern society, with direct relevance to a wide range of application areas including environmental monitoring, X-ray scanning and security applications, medical physics, nuclear power industries, and synchrotron imaging. In addition, various active areas of physics research make extensive use of radiation detectors and associated instrumentation, including astronomy, particle physics and neutron physics.

Recent trends in employment and government policy indicate that there is significant growth in demand for graduates with postgraduate training in radiation and nuclear skills, and associated instrumentation. The RDI programme is designed to meet these needs, for students who either wish to develop a career in industry, or who want to carry out further research using radiation detection techniques.

The course benefits from the flourishing departmental research programmes in fundamental and applied nuclear physics and in radiation physics, and complements our existing well-established MSc programmes in Radiation and Environmental Protection (REP) and Medical Physics (MP).

The course is largely physics based and is suitable for graduates with good honours degrees in physics or electronic engineering, or in other combinations of subjects with a physical science content. Students with alternative first degrees, or equivalent accredited prior learning, will be considered on a case-by-case basis. We guide the private study of our non-physics entrants and monitor their progress in the first part of their studies.

Programme outcomes

In line with the University Descriptor for a qualification at Masters (M) level, students graduating from the MSc in Radiation Detection and Instrumentation should be able to demonstrate:

Subject knowledge and skills
- A systematic understanding of radiation detection and instrumentation in an academic and professional context together with a critical awareness of current problems and / or new insights.
- A comprehensive understanding of techniques applicable to their own research project in Radiation detection and / or instrumentation.
- Originality in the application of knowledge, together with a practical understanding of radiation-based, experimental research projects.
- An ability to evaluate and objectively interpret experimental data pertaining to radiation detection.
- Familiarity with generic issues in management and safety and their application in a professional context.

Core academic skills
- The ability to plan and execute under supervision, an experiment or investigation and to analyse critically the results and draw valid conclusions from them. Students should be able to evaluate the level of uncertainty in their results, understand the significance of uncertainty analysis and be able to compare these results with expected outcomes, theoretical predictions and/or with published data. Graduates should be able to evaluate the significance of their results in this context.
- The ability to evaluate critically current research and advanced scholarship in the discipline of radiation protection.
The ability to deal with complex issues both systematically and creatively, make sound judgements in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences.

**Personal and key skills**
- The ability to communicate complex scientific ideas, the conclusions of an experiment, investigation or project concisely, accurately and informatively.
- The ability to manage their own learning and to make use of appropriate texts, research articles and other primary sources.
- Responsibility for personal and professional development. Ability to use external mentors for personal / professional purposes.

On successful completion of the **PGDip**, it is intended that students should be able to demonstrate:

**Subject knowledge and skills**
- A systematic understanding of radiation detection and instrumentation in an academic and professional context together with a critical awareness of current problems and/or new insights.
- Originality in the application of knowledge, together with a practical understanding of radiation-based, experiments.
- An ability to evaluate and objectively interpret experimental data pertaining to radiation detection.
- Familiarity with generic issues in management and safety and their application in a professional context.

**Core academic skills**
- The ability to plan and execute under supervision, an experiment and to analyse critically the results and draw valid conclusions from them. Students should be able to evaluate the level of uncertainty in their results, understand the significance of uncertainty analysis and be able to compare these results with expected outcomes, theoretical predictions and / or with published data. Graduates should be able to evaluate the significance of their results in this context.
- The ability to deal with complex issues both systematically and creatively, make sound judgements in the absence of complete data and communicate their conclusions clearly to specialist and non-specialist audiences.

**Personal and key skills**
- The ability to communicate complex scientific ideas, the conclusions of an experiment, investigation or project concisely, accurately and informatively.
- The ability to manage their own learning and to make use of appropriate texts, research articles and other primary sources.
- Responsibility for personal and professional development. Ability to use external mentors for personal / professional purposes.
On successful completion of the **PGCert**, it is intended that students should be able to demonstrate:

**Subject knowledge and skills**
- An understanding of radiation detection and instrumentation in an academic and professional context together with a critical awareness of some current problems.
- Originality in the application of knowledge, together with a practical understanding of radiation-based experiments.
- An ability to evaluate and objectively interpret experimental data pertaining to radiation detection.
- Familiarity with generic safety issues and their application.

**Core academic skills**
- The ability to and execute, under supervision, an experiment and to analyse critically the results and draw valid conclusions from them. Students should be able to evaluate the level of uncertainty in their results, understand the significance of uncertainty analysis and be able to compare these results with published data.
- The ability to deal with complex issues and communicate their conclusions clearly.

**Personal and key skills**
- The ability to communicate complex scientific ideas and the conclusions of an experiment concisely and accurately.
- The ability to manage their own learning and to make use of appropriate texts, research articles and other primary sources.
- Responsibility for personal and professional development.
COURSE STRUCTURE

Full time students take the course over a one year period starting in September. Part-time students take the course over a two year period.

Full time students attend lectures and laboratory classes on Mondays and Thursdays during Semester 1 and Mondays, Tuesday and Thursday during Semester 2.

Students sit up to six examinations which take place in late May / early June, depending on the optional modules they have chosen, after which they undertake a summer dissertation project over 10 weeks. Satisfactory completion of both the examinations and project will lead to the award of the MSc degree in Radiation Detection and Instrumentation. Alternative exit awards also exist for students who perform less strongly in the May / June examinations, for example the Postgraduate Diploma in Radiation Detection and Instrumentation, or the Postgraduate Certificate in Radiation Physics, as described in the General Handbook.

Start date of course
Week 1 of Semester 1, Monday 4 October 2010

Finish date of course
Summer vacation period, Friday 9 September 2011

Induction Week
During Induction Week the students will be introduced to the course by the Course Director. The student will receive instruction on safety procedures, use of the University library, register for computing and will be required to participate in a photograph session. Part time students are encouraged to attend activities during the Induction Week.

Coursework
Completion of all assessed course elements is compulsory. This includes laboratory work, computing coursework, and all examinations. Laboratory experiments must be formally written up and assessed for satisfactory completion of the course. (See Appendix A for the marking criteria).

Professional Placements
Professional placement does not form part of the course. However, placement in industry or a hospital is encouraged for dissertation work. It is the responsibility of the student to obtain such a placement, but informal support will be offered by members of the department to those students who wish to pursue this option. There is no financial support for any student undertaking an external project, except for those sponsored directly by industry.
COURSE CONTENT

The MSc course in Radiation Detection and Instrumentation comprises eight taught topics and one laboratory based topic, each of which is mandatory. There is also a tutorial topic and a number of industrial visits (typically two or three) are arranged during the course. Approximately 20% of the taught modules and 50% of the laboratory modules will be co-taught with the MSc in Radiation and Environmental Protection course.

The eight modules (and the associated contact hours) are:

Module 1: Radiation Physics (PHYM014, 30 credits) [48 hours lectures, 60 hours labs] Includes the Radiation Laboratories
Module 2: Radiation Measurement (PHYM015, 15 credits) [33 hours]
Module 3: Detector Instrumentation (PHYM022, 15 credits) [30 hours]
Module 4: Imaging and Remote Sensing (PHYM023, 15 credits) [30 hours]
Module 5: Computer Interfacing and Modelling (PHYM024, 15 credits) [30 hours]
Modules 6/7: Applications of Radiation Detection (2x 15 credits) [2x 30 hours]

For Modules 6 and 7 the students choose 2 modules from this list:

Option A: Particle Physics Detector Technology (taught at University of Sussex)
Option B: Astronomy Detector Technology (taught at University of Sussex)
Option C: Radiation Protection (PHYM018)
Option D: Ionising Radiation Instrumentation for Medical Physics (PHYM033)

Module 8: Research project and dissertation (60 credits) [370 hours] (10 weeks @ 37 hrs per week)

A set of tutorials and industrial visits are given throughout the course to supplement and consolidate the taught material.

Credit weighting ascribed to the different modules

For full time students, the nominal credit weightings are arranged as follows:

Autumn Semester
Modules M1, M3, M5 (50%), equivalent to a student load of 52.5 credits

Spring Semester
Modules M2, M4, M5 (50%), M6, M7, equivalent to a student load of 67.5 credits
Summer Dissertation, 60 credits.

For part time students, the nominal credit weightings are arranged as follows:

Year 1 Autumn Semester
Modules M1, M5 (50%), equivalent to a student load of 37.5 credits

Year 1 Spring Semester
Modules M2, M4, M5 (10%), equivalent to a student load of 31.5 credits

Year 2 Autumn Semester
Modules M3, M5 (40%), equivalent to a student load of 21 credits

Year 2 Spring Semester
Modules M6, M7 equivalent to a student load of 30 credits
Summer dissertation, at end of either Year 1 or Year 2, 60 credits
Compulsory Modules
The following modules are compulsory for the award of Postgraduate Certificate in Radiation Physics and Postgraduate Diploma in Radiation Detection and Instrumentation:

- Module 1 (Radiation Physics, 30 credits)
- Module 2 (Radiation Detection, 15 credits)

Delivery at the University of Sussex
Full details of the delivery of optional modules and/or the summer dissertation at the University of Sussex are listed in the RDI Memorandum of Agreement. A summary of the key facts are listed below:

RDI students will be registered at Surrey and subject to University of Surrey Ordinances and Regulations, and will only receive a degree award from the University of Surrey.

Students taking option modules at Sussex will register at Sussex for the individual modules, and will have access to Library and computing facilities at Sussex. Students will be subject to the Ordinances and Regulations of Sussex as regards any disciplinary matters and access to and use of University of Sussex property and resources (i.e. non-academic disciplinary matters).

Any complaints regarding individual modules shall be dealt with using the procedures of the institution who teaches that module. For disputes concerning the whole programme of study, or for academic appeals, the student will be subject to the regulations and procedures of Surrey.

Two 15-credit modules, delivered by the University of Sussex in the Spring Semester/Term, will be available to Surrey students as options, namely:

- Particle Physics Detector Technology
- Astronomy Detector Technology and Instrumentation

The modules will be available on Thursday (one AM, the other PM) and will run in accordance with the Sussex term dates i.e. the Sussex Spring term commences in early/mid January and runs for a 10 week block until Easter. Other Sussex students (year 4 undergraduates and postgraduates) may also take these modules as options.

The Sussex modules will be delivered by a mixture of class attendance at Sussex, and via video conferencing. Students should expect to travel to Sussex for a minimum of 7 weeks, with the remainder taught by video conference at Surrey.

A prerequisite of a Physics honours degree will normally be required for the two elective taught modules at Sussex. Students may choose one or both of the Sussex option modules, with students confirming their spring semester option selection in early November. Following consultation between Surrey and Sussex staff, final choices will be confirmed by the end of November. Provision of Sussex modules will be subject to final student numbers and will normally require a minimum of 5 students.

The research project (60-credits) will be a Surrey module but may be supervised and undertaken at Sussex (June- August) under the same prescriptions as any off-site Surrey project. A principal supervisor will be appointed at Sussex through normal Surrey procedures. A co-supervisor from Surrey will provide guidance on Surrey dissertation requirements. The Surrey External Examiner will moderate all projects to ensure parity and consistency of marking.
Surrey and Sussex have different pass marks (50/40% respectively) and levels for distinction (70/75%). A simple linear scaling algorithm will be applied to facilitate the handling of marks, as follows:

- For Sussex marks in the range 0% - 40%: Surrey % = 1.25 x (Sussex %)
- For Sussex marks in the range 40% - 100%: Surrey % = (0.833 x (Sussex %)) + 16.67

A detailed list of scaled marks is shown overleaf.

The performance of Surrey candidates in the Sussex modules will be considered by the Sussex Physics and Astronomy Undergraduate Subject Examination Sub-Board in mid June. Any scaling of marks at this stage will be carried out using the procedure applied to all Sussex physics modules. The marks awarded will be sent to Surrey and translated using the linear algorithm before being submitted to the Surrey Postgraduate Board of Examiners. All Sussex marks will be subject to approval by the Sussex Physics and Astronomy Postgraduate Subject Examination Sub-Board which is held in September.

There is some variation in the handling of Academic Misconduct and Late Submission penalties at the two Universities, although both have an escalating penalty tariff that takes into account repeat offences across more than one module, up to and including course termination. Suspected cases of plagiarism will be considered under Surrey regulations. Penalties for late submission of assignments for option modules taken at Sussex will be assigned using the Sussex scheme to ensure parity with the mark adjusted accordingly for the piece of work.
**Detailed table of Sussex/Surrey scaled marks:**

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PATTERN OF DELIVERY
The diagram below gives an overview of the structure of the complete course.

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<td>15</td>
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</tbody>
</table>

M1: Radiation Physics  
M1 GSM: Generic Skills and Methods  
M2: Radiation Measurement  
M3: Detector Instrumentation  
M4: Imaging and Remote Sensing  
M5: Computer Interfacing and Modelling  

Summer Research Project

<table>
<thead>
<tr>
<th></th>
<th>20 June –22 August 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full time</td>
<td>Research project at Surrey/Sussex, or at the student’s employer</td>
</tr>
</tbody>
</table>
Summer Reassessment period: 22 August-2 September 2011.

**End of Course date: 9 September 2011.**

The course is offered for either full-time or part-time study.

**FULL-TIME STUDENTS**
Full-time students study for 1 year. All formal teaching is held on two days per week - Mondays and Thursdays. Students can either live on campus, or can attend the University 2 days per week.

The summer project is full-time, with hours to be arranged in discussion the project supervisor. The project can be carried out at either Surrey or Sussex Universities, or at the student’s sponsoring company.

**PART-TIME STUDENTS**
Part-time students attend the University 1 day per week, for two years. In the first year teaching is on Mondays, and in the second year on Thursdays.

**Year One**

Modules 1, 2 and 4, plus the computing elements of Module 5 are completed in Year 1.

**Exams Papers** for Modules 1, 2, and 4 are sat in May of the first year

**Year Two**

Module 3, the Group Project for Module 5, plus two of Options A-D are completed in Year 2

**Exam Papers** for Module 3, plus examinations for Options C and D, are sat in May of the second year (Options A and B are 100% coursework).

**Dissertation (Module 8)** can be carried out during the summer of either Year 1 or Year 2, with submission no later than the summer resit period in August of Year 2.

**Laboratory Work (Module 1)**
In Year 1 part-time students attend the laboratory on Monday afternoons in the Autumn semester and carry out five experiments. The remaining five experiments should be completed either during the summer of Year 1 or during Thursday afternoon laboratory sessions in the Autumn semester of Year 2.

Part-time students must submit a total of four Laboratory Reports. The first two reports should be submitted by Monday Morning at 9am, week 12 (10 January 2011) to allow constructive feedback and to ensure that the Laboratory Reports are of the required standard. The remaining two reports must be submitted by the end of the Semester 2 in Year 2.

**Design Project (Module 5)** is carried out by part-time students in the Autumn semester of Year 2. The written report is submitted at the start of the Spring semester, and an oral presentation will be given in February.
SECTION D – FULL MODULE DESCRIPTIONS

Module 1: Radiation Physics

<table>
<thead>
<tr>
<th>Module Provider:</th>
<th>Physics</th>
<th>Module Code:</th>
<th>PHYM014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level:</td>
<td>M</td>
<td>Number of Credits:</td>
<td>30</td>
</tr>
<tr>
<td>Module Co-ordinator:</td>
<td>Dr Zsolt Podolyak</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Module Availability
Semester 1

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark (%)</th>
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</thead>
<tbody>
<tr>
<td>Closed book examination</td>
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</tr>
<tr>
<td>Coursework</td>
<td>50%</td>
</tr>
</tbody>
</table>

Part-time Students: Same as for full time students

Qualifying Condition(s): None

Pre-requisite/Co-requisites
None

Module Overview
Lectures provide a detailed and systematic overview of atomic and nuclear physics and the interaction of radiation with matter, plus introductory material describing detector operation and dosimetry. Laboratory sessions are designed to provide the student with practical experience in handling radioactive substances, detectors and instrumentation.

Module Aims
To provide the student with a detailed understanding of the structure of matter, radioactivity, types of radiation and the mechanisms by which radiation interacts with matter.
To provide the student with the comprehensive understanding of the experimental use of radioactive materials, radiation counting, spectroscopy equipment, dosimetry measurements and standard radiation experimental techniques.

Learning Outcomes
After completing this module, the student should be able to:-

Module Specific Skills:
- Systematic understanding of the fundamental processes involved with the interaction of X- and gamma-ray photons, charged particles and neutrons with matter
- Critical analysis and self-directed problem solving of the practical aspects of handling radioactive substances and the ability to extract qualitative and quantitative information about the emitted radiations
- Understand basic evaluation of experimental data using standard statistical methods

Discipline Specific Skills:
- Confidence in handling radioactive materials
- Application of statistical analysis techniques to specialised radiometric data through appropriate software tools
- Application of skills in an experimental context for the measurement for various radiation emissions in terms of both dosimetry and spectroscopy
- Perform a detailed investigation of radiation sources and their interactions in media

Personal and Key Skills:
- Maintain a laboratory diary at a level appropriate of a professional scientist
- Critically analyse and summarise data
- Provide concise and accurate reporting of findings, including limitations resulting from an appreciation of equipment capability and the availability of calibration standards

### Module Content

<table>
<thead>
<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
<th>Lab Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Z Podolyak</td>
<td>Interactions of radiation with matter, photons, neutrons and charged particles. Attenuation coefficients and the Mixture Rule. Concept of neutron flux and cross-section; the neutron spectrum. The interaction of electrons (and other charged particles) with matter; elastic and inelastic processes, bremsstrahlung and radiative yield, energy dependence. Measurement of radioactivity and standards. Introduction to radiation detectors, describing the basic function and operation of semiconductor, scintillator and gas detectors, counting statistics, dead time and energy resolution.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Prof P H Regan</td>
<td>Introduction to dosimetry measurements, air ionisation chambers, use of absolute standards, calculation of exposure, absorbed dose, and dose rate. Basic biological effects of radiation.</td>
<td>3</td>
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</tr>
<tr>
<td>Prof P H Regan</td>
<td>Radiation Laboratory experiments.</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Prof W N Catford</td>
<td>Laboratory demonstrations and safety instruction</td>
<td></td>
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</tr>
<tr>
<td>Prof P J Sellin</td>
<td>Scripted experiments that students undertake in pairs, one per week. Students undertake 10 one week experiments selected from a range of possible topics.</td>
<td></td>
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</tr>
<tr>
<td>Dr Z Podolyak</td>
<td>General Laboratory skills. In particular basic statistical analysis, error analysis, errors on the mean, weighted means, binomial, normal and Poisson distributions, least squares fitting.</td>
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<tr>
<td>Prof B M Murdin</td>
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</tbody>
</table>
Methods of Teaching/Learning

Selected Texts/Journals
3. Radiation Laboratory manuals, University of Surrey

Methods of Assessment
This module is assessed in three separate units of assessment: 50% of the marks of the 30 module credits are awarded for Paper 1 which will consist of 6 questions from which students answer 4 questions from 6.

The remaining 50% of the module marks will come from (a) the assessment of 4 marked laboratory experimental reports from work carried out in the radiation laboratory which make up 40% of the total module mark; and (b) a class test on the statistics and related laboratory skills which will make up 10% of the final module mark.
Module 2: Radiation Measurement

Module Provider: Physics  Module Code: PHYM015
Level: M  Number of Credits: 15
Module Co-ordinator: Prof Wilton Catford

Module Availability
Semester 2

Assessment Pattern

<table>
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<th>Unit(s) of Assessment</th>
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<td>100 %</td>
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</table>

Part-time Students: Same as for full time students
Qualifying Condition(s): None

Pre-requisite/Co-requisites
None

Module Overview

These lectures describe in detail the principles of radiation detection, measurement and dosimetry.

Module Aims

This course will give the student a detailed understanding of the physical/chemical principles underlying the operation of a wide range of techniques for detection/dosimetry of ionising radiation enabling him/her to make appropriate choices of instrumentation in practical situations.

Learning Outcomes

After completing this module, the student will have acquired the following:

Module Specific Skills:
- Comprehensive understanding of the role of fundamental processes involved with the interaction of X- and gamma-ray photons, charged particles and neutrons with matter
- Planning and implementation of the critical aspects of radiation detection and shielding
- Critical analysis of dose calculations and assessments from specific radiation sources
- Detailed knowledge of the principles of operation of solid state semi-conductor detectors, scintillation counters, gas ionization detectors

Discipline Specific Skills:
- Confidence in handling radiation monitors/detectors and dosemeters
- Critical awareness of the selection and application of radiation detectors for different types of radiation measurement and in what environments
- Select appropriate means of measurement for the various radiation emissions in terms of both dosimetry and spectroscopy
- Carry through a detailed investigation of radiation sources and their interactions

Personal and Key Skills:
- Critical analysis and ability to summarise original dosimetry data
- Comprehensive understanding of the methods required to calculate dose and radiation effects
Module Content

<table>
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<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
<th>Lab Hours</th>
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</thead>
<tbody>
<tr>
<td>Prof W N Catford</td>
<td>Principles of radiation counting and review of nuclear electronics for selection, recording and analysis of detector outputs. Action of gas filled ionisation chamber and proportional counters, gas multiplication; ion mobility, recombination, pulsed and direct current modes of operation; Geiger-Muller counter, internal and external quenching, practical devices. Scintillation counting with gases, liquids and solids; theory of operation, selection for various applications. Solid state detectors; semiconductor counters, surface barrier detectors, Si(Li), Ge(Li) and hyper-pure Ge.</td>
<td>15</td>
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<tr>
<td>Prof P H Regan</td>
<td>Thermoluminescent dosimetry, radiophotoluminescence. Relation between detection and dosimetry; concept of exposure, the Roentgen, air-kerma, exposure measurements with free air chamber. Absorbed dose, dose equivalent, Gray, Sievert, quality factor, radiation and tissue weighting factors, build-up factors, charged particle equilibrium, Bragg-Gray cavity principle, cavity chambers. Primary and secondary dosemeters, calorimetry, chemical dosimetry, gas dosimetry, W-values, stopping power ratio, matching to medium, air and tissue equivalence, interface effects.</td>
<td>12</td>
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<tr>
<td>Prof N M Spyrou</td>
<td>The activation equation and 1/v absorbers. Source standardisation and radiation spectroscopy. Neutron detection and dosimetry, mixed field dosimetry, fission track detectors, and neutron spectrometry.</td>
<td>3</td>
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</table>

Methods of Teaching/Learning

Selected Texts/Journals
Methods of Assessment
This module is assessed in Paper II which will consist of 6 questions. Students answer 4 questions from the 6. Full marks for 4 questions will be equivalent to 100 % of the total marks available in assessment of this module.
Module 3: Detector Instrumentation

Module Provider: Physics  Module Code: PHYM022
Level: M  Number of Credits: 15
Module Co-ordinator: Prof Paul Sellin

Module Availability
Autumn Semester

Assessment Pattern

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<th>Unit(s) of Assessment</th>
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</table>

Part-time Students: Same as for full time students

Qualifying Condition(s)

Pre-requisite/Co-requisites

None

Module Overview
An in-depth discussion of detector instrumentation will be covered, designed to complement experiments in the Autumn semester laboratory classes. Topics will include the performance and use of preamplifiers, spectroscopy systems and multi-channel analysers (MCAs). Digital methods for data acquisition, including digital pulse processing, pulse shape discrimination and digital MCA systems. Instrumentation for scintillators and gas detectors, including the latest developments in Si-PMT and GEM devices. The 2nd part of the module will cover digital signal processing and the role of noise in affecting detector performance, including Fano-limited noise, electronic noise and leakage current. Examples of current CMOS readout circuitry, ASIC designs and pixel detectors will be discussed.

Module Aims
This module explores the theory of operation and practical aspects of instrumentation for radiation detection, covering both traditional analogue instrumentation techniques plus the latest developments in digital pulse processing. Students will also critically evaluate the role of statistical processes in detector noise and electronic signal processing.

Learning Outcomes
After completing this module, the student will have acquired the following:

Module Specific Skills:
- A detailed understanding of the instrumentation chain used for the readout of semiconductor, scintillation and gas detectors
- A critical analysis of noise processes in detectors, with the influence of noise on detector performance.
- A knowledge of the functionality and system architecture of ASICs and pixel detectors at the forefront of current research.

Discipline Specific Skills:
- Technical expertise in handling radiation detectors, and applying a fundamental understanding of their operation to optimise detector performance.
- Ability to select the appropriate instrumentation chain for a given application.

Personal and Key Skills:
- Critical analysis and understanding of instrumentation and detector performance for a given experimental setup.
Module Content

<table>
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<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
<th>Lab Hours</th>
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<tbody>
<tr>
<td>Prof P J Sellin</td>
<td>Detector Instrumentation for Spectroscopy: Charge sensitive preamplifiers, spectroscopy amplifiers, shaping and filters, energy resolution. Analogue signal processing: Multi-channel analysers, discriminators, logic pulses and timing measurements, TACs. Digital pulse shape analysis and applications to n/π discrimination. Scintillator and gas detector instrumentation: the photomultiplier tube and APD, DC ion chambers, GM tubes and survey meters. Silicon detector systems for particle tracking, minimum ionising particle detection, drift detectors and position sensitive detectors. Large scale HEP detector – the ATLAS inner tracker.</td>
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Methods of Teaching/Learning

Selected Texts/Journals
7. “Semiconductor Detector Systems” by Helmhut Spieler

Methods of Assessment
This module is assessed in Paper 3 which will consist of 6 questions. Students answer 4 questions from the 6.
Module 4: Imaging and Remote Sensing

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<th>Module Code:</th>
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<td>Number of Credits:</td>
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<td>Module Co-ordinator:</td>
<td>Prof. David Bradley</td>
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Module Availability
Spring Semester

Assessment Pattern

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<th>Unit(s) of Assessment</th>
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<td>Closed book examination</td>
<td>100 %</td>
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Part-time Students: Same as for full time students

Qualifying Condition(s)

Pre-requisite/Co-requisites
None

Module Overview
This course describes the concepts behind Radiation Imaging and Remote Sensing, both in term of the various types of detectors used for radiation imaging, and their application to radiation monitoring and sensing. Both semiconductor and scintillators imaging detectors will be described, including the latest developments in silicon pixel detectors and CMOS pixellated devices. Imaging theory will also be reviewed, including Modulation Transfer Function and Detector Quantum Efficiency. The application of detectors for radiation imaging will be described, including Compton scatter telescopes, coded-aperture cameras and collimated detectors. The application of imaging will be explored in terms of remote sensing, with a particular emphasis on environmental measurements and security imaging.

Module Aims
This module will provide the student with a more detailed understanding of the operation and performance of various semiconductor and scintillation-based imaging detectors, including silicon pixel detectors, CMOS sensors, scintillators-based cameras and neutron imaging detectors. The module will explore quantitative methods for assessing imaging detector performance, and will discuss the use of imaging and remote sensing detectors for various applications, including security imaging, remote monitoring, and environmental measurements.

Learning Outcomes
After completing this module, the student will have acquired the following:

Module Specific Skills:
- An in-depth understanding of the performance and operation of a range of semiconductor and scintillation imaging detectors.
- Critical application of methods for quantitative analysis of imaging detectors and data.
- Detailed knowledge of the application of imaging and remote-sensing detectors to a variety of applications including environmental monitoring and security imaging.
# Module Content

<table>
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<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
<th>Lab Hours</th>
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<tbody>
<tr>
<td>Dr D A Bradley</td>
<td>Semiconductor imaging detectors: Hybrid pixel, TFT, deep-depletion ccd Scintillator imaging detectors: CCD/cmos with phosphors, thick film scintillators (columnar CsI), scintillating fibres X-ray imaging and CT: X-ray transmission imaging and CT reconstruction, X-ray scatter techniques, phase contrast imaging, and energy resolved/spectroscopic techniques. Use of synchrotron beams. Analysis of image data: DQE, MTF etc.</td>
<td>9</td>
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<tr>
<td>Dr James Parkin (Lab Impex Ltd)</td>
<td>Environmental and Remote Sensing detector systems. Installed area and stack effluent monitoring systems. Field measurements: detectors and instrumentation for environmental and low background measurements Continuous air monitors – challenges and theories of operation</td>
<td>6</td>
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<tr>
<td>Dr I Jupp (DSTL)</td>
<td>Applications in security imaging (1): Compton cameras – principles of operation Coded Aperture imagers Backscatter and pinhole imaging</td>
<td>3</td>
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<tr>
<td>Dr W Gilboy</td>
<td>Neutron detection and imaging detectors: BF3 and He3 tubes, boron and lithium loaded scintillators, neutron imaging.</td>
<td>6</td>
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<tr>
<td>Dr P Burgess (Nuvia Ltd)</td>
<td>Overview of Thermo Electronic Personal Dosemeter (EPD) Purpose, choice of detectors, principles of detection for X and gamma radition, evolution of design</td>
<td>3</td>
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<tr>
<td>Prof P J Sellin</td>
<td>Applications in security imaging (2) Detection of hidden sources and isotope identification Active interrogation techniques: pulse neutron/gamma irradiation, high energy X-ray sources</td>
<td>3</td>
<td></td>
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</tbody>
</table>

## Methods of Teaching/Learning

### Selected Texts/Journals


## Methods of Assessment

This module is assessed in Paper 4 which will consist of 6 questions. Students answer 4 questions from the 6.
Module 5: Computer Interfacing and Modelling

Module Provider: Physics  Module Code: PHYM024
Level: M  Number of Credits: 15
Module Co-ordinator: Dr Silvia Pani

Module Availability
Autumn and Spring semesters

Assessment Pattern

<table>
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<th>Unit(s) of Assessment</th>
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<td>Coursework</td>
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<tr>
<td>Part-time Students:</td>
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</table>

Qualifying Condition(s)

Pre-requisite/Co-requisites
None

Module Overview
This computational module will explore the various techniques used for the interfacing of equipment and signal processing in the context of radiation detection systems, and the use of Monte Carlo simulation techniques. The module will combine taught sessions and computational/laboratory work, and is taught in three parts:

Part 1 (Autumn Semester, 14 hours): LabView programming, covering an introduction to LabView, basic instrumentation control, and data analysis including GPIB, USB and serial protocols. Signal processing topics include Fourier Transforms, Windowing and Digital Filtering.

Part 2 (Spring Semester, 4 hours): Monte Carlo simulation of radiation interactions in matter: an introduction to the use of FLUKA simulation software.

Part 3 (Spring Semester, 20 hours): a laboratory-based group project to design and implement a digital radiation detection system, based on either a scintillator or semiconductor detector in conjunction with digital pulse processing.

Module Aims
The module will provide the student with an in-depth understanding of the use of the LabView software environment for instrumentation control, data analysis and pulse processing. Through a graded set of laboratory-based lectures and hands-on sessions, students will learn the theory and application of instrumentation control and data analysis, and apply these techniques to real applications using the LabView software. Students will also learn the basic use and implementation of the FLUKA Monte Carlo simulation software. The module culminates in a group-based design project where students develop a complete radiation detector instrumentation system of their choice.

Learning Outcomes
After completing this module, the student will have acquired the following:

Module Specific Skills:
- Understand the basis of instrumentation interfacing and control using the RS-232, USB and GPIB protocols
- Be able to design and write LabView programs for basic instrument control and signal processing tasks
- Critically understand and apply topics of elementary digital filtering and pulse processing
algorithms

- Understand the basis of Monte Carlo simulation, and be able to design and write a FLUKA simulation programme.
- Perform a Design Project in a group, and orally present this work

**Discipline Specific Skills:**
- Gain expertise in digital pulse processing and multi channel analysis, and understand the principles behind radiation instrumentation control and signal processing
- Gain expertise in Monte Carlo modelling for radiation physics problems

**Personal and Key Skills:**
- Gain experience in group work through the design project
- Development of oral and communication skills in the presentation of project work

**Module Content**

This module is taught in three parts:

**Part 1** (Autumn semester, 14 hours – Dr Steve Clowes):
LabView programming:
- Introduction to LabView and data-driven programming
- Advanced LabView techniques
- LabView DAQ signal acquisition and measurement
- LabView instrumentation control using VISA
Instrumentation interfacing and control:
- Introduction to instrumentation interfacing: serial and parallel interfaces, transfer rates and handshaking
- RS-232 and USB serial interface standards
- GPIB: hardware implantation and device command language
Signal processing:
- Signal generation and wave function generators
- Signal processing and filtering using Fourier Transforms: DFT and FFT
- Data acquisition software development using LabView

**Part 2** (Spring semester, 4 hours - Dr Silvia Pani):
FLUKA Monte Carlo programming:
- Introduction to Monte Carlo techniques in radiation physics
- Use of FLUKA to carry out a simple detector modelling problem

**Part 3:** (Spring Semester, 25 hours - Prof Paul Sellin):
Design Project
Students will work together to design a radiation detection system using either a scintillation or semiconductor detector coupled to a digital pulse processing system. Using the LabView programming environment, students will design and implement the various aspects of detector instrumentation and interfacing, and assess the performance of their instrument.

**Methods of Assessment**
The module is 100% coursework assessed, based on the following programming and written assessments:
1. 2 LabView programming exercises in the Autumn Semester (20% per exercise)
2. FLUKA Monte Carlo programming exercise in the Spring Semester (20%)
3. Group Project Report (maximum 2000 words) describing the work carried out in the design project and the results obtained (30%)
4. Group Project Oral Presentation, summarising the work of the design project (10%)
The LabView and Monte Carlo assessments should be submitted electronically using ULearn.

**Selected Texts/Journals**
2. “Labview programming, Data Acquisition and Analysis”, J.Y. Beyon
Option Module A: Particle Physics Detector Technology (University of Sussex)

<table>
<thead>
<tr>
<th>Module Provider:</th>
<th>University of Sussex</th>
<th>Module Code:</th>
<th>PHYM025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level:</td>
<td>M</td>
<td>Number of Credits:</td>
<td>15</td>
</tr>
<tr>
<td>Module Co-ordinator:</td>
<td>Dr Fabrizio Salvatore (University of Sussex)</td>
<td></td>
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</tr>
</tbody>
</table>

Module Availability:
Spring Semester

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark( %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coursework (problem sheets and exercises) + Open Notes Test</td>
<td>100%</td>
</tr>
</tbody>
</table>

Part-time Students: Same as for full-time students

Qualifying Condition(s)
Physics programme regulations refer.

Pre-requisite/Co-requisites
Students should normally have an undergraduate degree in Physics or Mathematics

Module Overview
The module explores some of the scientific questions being addressed in the fields of experimental particle physics, including high energy physics, neutrino physics etc. The student is introduced to some of the experimental techniques that are used to study the particle phenomena. The focus is on the demands those scientific requirements place on the detector technology and current state-of-the-art technologies.

This module is taught at the University of Sussex.

Module Aims
Specific aims are to provide students with:
(i) An introduction to some of the basic concepts of particle physics
(ii) An overview of some of the topical cutting edge questions in the field
(iii) An understanding of some key types of experiments
(iv) A detailed understanding of the underlying detector technologies

Learning Outcomes
After successfully completing the module, the students will be able to:
(i) Demonstrate a basic understanding of the standard model of particle physics and the observable phenomena from particle interactions
(ii) Discuss some key classes of experiments and answer quantitative questions regarding their design
(iii) Critically evaluate different detector technologies
(iv) Perform basic simulations of detector behaviour

Module Content
1. Intro to particle structure (6 hours)
   (i) Particles and forces, masses and lifetimes
   (ii) Coupling strengths and interactions
   (iii) Cross sections and decays

2. Accelerators (6 hours)
   (i) Principles of acceleration
   (ii) Kinematics, center of mass
(iii) Fixed target experiments, colliders

3. Reactors (6 hours)
   (i) Nuclear fission reactors, fission reactions, types of reactors
   (ii) Neutron sources, absorption and moderation, neutron reactions
   (iii) Nuclear fusion, solar and fusion reactors

4. Detectors (9 hours)
   (i) Gaseous
   (ii) Liquid (scintillator, cerenkov, bubble chamber)
   (iii) Solid-state
   (iv) Scintillation
   (v) Calorimeters, tracking detectors
   (vi) Particle identification

5. Monte Carlo modelling (3 hours)
   Physics

Methods of Teaching/Learning
Lectures: 30 hours of formal lectures
Private study of specified articles

Selected Texts/Journals
Primary texts:
2. G.F. Knoll - Radiation Detection and Measurement, Wiley

Secondary texts:
1. R. Fernow - Introduction to Experimental Particle Physics, C.U.P. 1986
2. K. Kleinknecht - Detectors for Particle Radiation, C.U.P.

Methods of Assessment
The module is assessed via coursework (3 problem sheets – 20% each) and one Open Notes Test (40%).
Option Module B: Astronomical Detector Technology and Instrumentation

Module Provider: University of Sussex | Module Code: PHYM026
Level: M | Number of Credits: 15
Module Co-ordinator: Dr. Seb Oliver (University of Sussex)

Module Availability:
Spring Semester

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Sheets</td>
<td>20</td>
</tr>
<tr>
<td>Individual Seminars on Telescopes/Instruments</td>
<td>10</td>
</tr>
<tr>
<td>Presentations on Science requirements</td>
<td>15</td>
</tr>
<tr>
<td>Presentations on Detector selection</td>
<td>20</td>
</tr>
<tr>
<td>Report on detector selection</td>
<td>35</td>
</tr>
</tbody>
</table>

Part-time Students: Same as for full-time students

Qualifying Condition(s)
Students should normally have an undergraduate degree in Physics or Mathematics

Module Overview
The module addresses the detector technology required for Astronomical research.

This module is taught at the University of Sussex.

Module Aims
Specific aims are to provide students with:
(i) An overview of instrumentation and detectors
(ii) An overview of some of the topical cutting edge questions in the field
(iii) An appreciation of how scientific requirements translate to instrument/detector requirements and design

Learning Outcomes
After successfully completing the module, the students will be able to:
(i) Display a basic understanding of detectors in astronomy
(ii) Display communication skills
(iii) Distil technological requirements from scientific drivers
(iv) Make informed choice of detector for given application with justification

Module Content
1. A crash course in Astronomy and Astrophysics (6hrs + directed reading)
   (i) Fluxes, luminosities, magnitudes, etc.
   (ii) Radiation processes, black bodies, spectra
   (iii) Stars
   (iv) Galaxies
   (v) Planets
   (vi) Cosmology
   (vii) Key questions
   (viii) Key requirements

2. Telescopes & Instruments (3 hours student led seminars – from reading)
(i) Optical telescopes  
(ii) Interferometry  
(iii) Cameras  
(iv) Spectroscopy  
(v) Astronomy beyond the e/m spectrum

3. **Detectors by wavelength (6 hours taught & 3 hours seminars)**
   (i) Gamma  
   (ii) X-ray  
   (iii) UV  
   (iv) Optical  
   (v) NIR  
   (vi) Mid-IR  
   (vii) Sub-mm  
   (viii) FIR  
   (ix) Radio

4. **Detector selection for a future space mission X (4X3 hours)**
   (i) Scientific motivation and requirements  
   (ii) Detector options  
   (iii) External Constraints, financial, risk, etc.  
   (iv) Detector selection

**Methods of Teaching/Learning**

**Lectures:** 12 hours of formal lectures, 6 hours of student led seminars, 12 hours of problem based learning activity  
Private study of specified topics

**Selected Texts/Journals**
1. Detection of Light: Rieke  
2. Fundamental Astronomy: Karttunen  
3. Handbook of CCD astronomy: Howell  
4. Handbook of Infrared astronomy: Glass

**Methods of Assessment**
The module is 100% coursework assessed, based on open-book problem sheets, seminar presentations, and a written report.
Option Module C: Radiation Protection

Module Provider: Physics
Module Code: PHYM018
Level: M
Number of Credits: 15
Module Co-ordinator: Dr David Bradley

Module Availability
Spring Semester

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed book examination</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Part-time Students: Same as for full time students
Qualifying Condition(s): None

Pre-requisite/Co-requisites
None

Module Overview
This course describes the international legislative framework of radiation protection. From this starting point the course covers population and personal exposures to radiation, the principles of dose calculations, and example procedures for implementing radiation protection programmes.

Module Aims
To give a thorough understanding of the underlying philosophy and the practical implementation of the ICRP system of radiological protection. To encourage a quantitative approach to radiological protection; and to illustrate the need for a detailed understanding of the sources of radiation exposure and methods for applying the principles of radiation protection.

Learning Outcomes
After completing this module, the student should be able to:

Module Specific Skills:
- Demonstrate a critical analysis understanding of principles of radiation protection
- Ability to perform simplified dose calculations from original data to show problem solving aspects of such work
- Ability to understand case studies illustrating a holistic approach to radiation protection in a wide range of applications

Discipline Specific Skills:
- Critical analysis of data to gain ability to perform simplified dose calculations

Personal and Key Skills:
- Ability to understand case studies illustrating a holistic approach to radiation protection and methods for applying the principles of radiation protection
Module Content

<table>
<thead>
<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
<th>Lab Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof R Clarke</td>
<td>The history of radiation protection. Radiation risks. The ICRP system of radiological protection. Future recommendations of the ICRP</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mrs D Peet</td>
<td>Basic Safety Standards, Ionising Radiations</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mrs E Oakley</td>
<td>Environmental radiation, natural sources, man-made sources and population exposures</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mr R Kenyon</td>
<td>Practical Radiation Protection</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Dr W Gilboy</td>
<td>Radiation shielding. Gamma-ray attenuation and build-up processes. Point kernel calculations and their application to extended sources</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Dr C Elliot</td>
<td>Assessment of Risk</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mr N Smith</td>
<td>Nuclear Industry Safety Case Principles</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mr R Major</td>
<td>Phases of decommissioning, radiation sources and controls, options and assessment methods, economic considerations and examples Waste management and disposal, categorisation and arisings, disposal routes, inventory management and assay techniques</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Methods of Teaching/Learning

Selected Texts/Journals

Methods of Assessment
This module is assessed in Paper V which will consist of 6 questions. Students answer 4 questions from the 6. Full marks for a question will be equivalent to 100% of the total marks available in assessment of this module.
Option Module D: Ionising Radiation Instrumentation for Medical Physics

Module Provider: Physics  Module Code: PHYM033
Level: M  Number of Credits: 15
Module Co-ordinator: Dr Zsolt Podolyak

Module Availability
Spring Semester

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark (%)</th>
</tr>
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<tbody>
<tr>
<td>Closed book examination</td>
<td>50%</td>
</tr>
<tr>
<td>Laboratory practical report</td>
<td>25%</td>
</tr>
<tr>
<td>Essay</td>
<td>25%</td>
</tr>
<tr>
<td>Part-time Students:</td>
<td>Same as for full time students</td>
</tr>
<tr>
<td>Qualifying Condition(s)</td>
<td>None</td>
</tr>
</tbody>
</table>

Pre-requisite/Co-requisites
None

Module Overview
Ionising radiation is widely used for diagnostic and therapeutic purposes. The bulk of hospital physicists work with ionising radiation and hence the topic is fundamental for anyone entering the profession. An introduction is given to imaging systems: X-radiography, X-ray computed tomography, gamma cameras, single photon computer tomography (SPECT) and positron emission tomography (PET). The module also includes the use of radiation detectors in radiotherapy.

Module Aims
To achieve an understanding of medical X-ray and gamma ray imaging technology in terms of equipment components and their performance and to relate this to the needs of diagnostic medical imaging. To establish a basic appreciation of radiotherapy and the detectors used to validate and monitor therapeutic delivery of radiation doses to the patient. An appreciation of quality management, its aims and application to imaging and radiotherapy.

Learning Outcomes
After completing this module, the student should be able to:

Module Specific Skills:
- Describe the physical principles and key technologies which determine the performance of medical X-ray and gamma-ray imaging systems
- Describe the quality assurance cycle required for diagnostic X-ray and nuclear medicine equipment and to be familiar with test equipment commonly used for the most important measurements undertaken by physicists in an imaging department
- Describe the operation and clinical implications of radiotherapy detector instrumentation

Discipline Specific Skills:
- Use this knowledge when taking up posts within the Health Service and other related fields

Personal and Key Skills:
- Ability to use physics techniques in a multidisciplinary context
- Ability to evaluate the risks involved in a particular application
## Module Content

<table>
<thead>
<tr>
<th>Lecturer</th>
<th>Title</th>
<th>Lecture Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr K Wells (2h)</td>
<td>X-rays, γ-rays, MTF and ROC Analysis</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Mathematical formulation of the imaging system; linear operator,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>principle of superposition, impulse response function, stationarity,</td>
<td></td>
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<tr>
<td></td>
<td>line spread function, edge spread function, convolution integral,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTF. Usefulness of MTF, modulation input and output, test objects,</td>
<td></td>
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<tr>
<td></td>
<td>measure of performance, cascade MTFs. Perception of detail, visual</td>
<td></td>
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<tr>
<td></td>
<td>acuity, resolution criteria. Existence of observer, decision criteria,</td>
<td></td>
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<tr>
<td></td>
<td>confidence thresholds, conditional probabilities, types of decision.</td>
<td></td>
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<tr>
<td></td>
<td>Construction of the ROC curve and principle of ROC analysis.</td>
<td></td>
</tr>
<tr>
<td>Dr A J Britten (4h)</td>
<td>X-ray Imaging and analysis</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>The X-ray tube construction and operational needs.</td>
<td></td>
</tr>
<tr>
<td>Dr S A Sassi (2h)</td>
<td>X-ray scatter in diagnostic imaging and scatter reduction methods.</td>
<td></td>
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<tr>
<td></td>
<td>X-ray film, intensifying screens and film-screen imaging performance.</td>
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<tr>
<td></td>
<td>Non-film imaging: Image intensifiers and video X-ray images. Digital</td>
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<tr>
<td></td>
<td>Subtraction Angiography. The production and use of digital medical</td>
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<tr>
<td></td>
<td>X-ray images. Photostimulable phosphors and direct digital X-ray</td>
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<tr>
<td></td>
<td>detectors.</td>
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</tr>
<tr>
<td>Dr I Badr (4h)</td>
<td>Introduction to quality management systems. The quality</td>
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</tr>
<tr>
<td></td>
<td>assurance or life cycle of x-ray equipment. The role of the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>physicist, radiographer and engineer. Types of x-ray equipment.</td>
<td></td>
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<tr>
<td></td>
<td>Radiation safety and performance measurements on diagnostic</td>
<td></td>
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<tr>
<td></td>
<td>and fluoroscopic equipment. Test equipment for the physicist.</td>
<td></td>
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<tr>
<td></td>
<td>Published protocols. Measurement and significance of patient dose.</td>
<td></td>
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<tr>
<td></td>
<td>Radiation safety design of x-ray rooms. Optimisation of patient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>exposure.</td>
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<tr>
<td>Mr A Rust (2h)</td>
<td>The NHS Breast Screening Programme - organisation, facts and</td>
<td></td>
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<tr>
<td></td>
<td>figures. Risk/benefit analysis in mammography. The profile of</td>
<td></td>
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<tr>
<td></td>
<td>quality assurance and the role of the physicist. Elements of the</td>
<td></td>
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<tr>
<td></td>
<td>mammographic imaging system: dedicated X-ray sets, films, intensifying</td>
<td></td>
</tr>
<tr>
<td></td>
<td>screens and film processing systems. Use of various anode and filter</td>
<td></td>
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<tr>
<td></td>
<td>materials to tailor the X-ray spectrum to individual patients.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effects of film processing on image quality and patient dose. Stereotactical biopsy systems and special procedures. Introduction to digital imaging modalities and their applications in mammography.</td>
<td></td>
</tr>
<tr>
<td>Dr J Scuffham (12h)</td>
<td>Nuclear Medicine Instrumentation</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Introduction to nuclear medicine (1h)</td>
<td></td>
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<tr>
<td></td>
<td>The gamma camera: components and basics of operation (1h)</td>
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<tr>
<td></td>
<td>The gamma camera: signal processing and corrections (1h)</td>
<td></td>
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<tr>
<td></td>
<td>The gamma camera: applications and quality control (1h)</td>
<td></td>
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<tr>
<td></td>
<td>SPECT: image reconstruction, attenuation &amp; scatter correction (1h)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hospital visit and laboratory practical (4h)</td>
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</tr>
<tr>
<td></td>
<td>PET: basic principals and instrumentation (1h)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PET: applications and quality control (1h)</td>
<td></td>
</tr>
</tbody>
</table>
Methods of Teaching/Learning
The module is taught by lecturers from both the Department of Physics and from hospitals.

Selected Texts/Journals
(i) Essential Reading
- The Essential Physics of Medical Imaging, Ed J T Bushberg, Williams & Wilkins, 1994
- The Physics of Medical Imaging, Ed S Webb, IoPP, 2002
- Radiation Detection and Measurement, Knoll, Wiley, 1999
- Medical Radiation Detectors, Editor N F Kember, IoPP, 1994
- Physics for Radiologists. Dendy & Heaton, Taylor & Francis; 2nd Edn, 1999
- Christensens Diagnostic Radiology, Lippincott Williams & Wilkins; 4th Edn, 1990
- Practical Nuclear Medicine, Sharp, Gemmell & Smith. OUP 2nd Edn, 1998
- Physics in Nuclear Medicine, Cherry, Sorenson, Phelps. Saunders, 3rd Edn, 2003
- Radiation Oncology Physics. Ed. E.B. Podgorsak, IAEA, 2005
- Linear Accelerators for Radiotherapy, Greene D, Adam Hilger (Medical Physics Handbook 17) 1986,

(ii) Supplementary Reading
- Screen Film Mammography. G T Barnes & G D Frey. Medical Physics Publishing
- Film Processing in Medical Imaging A G Haus. Medical Physics Publishing
- QA Guideline for Medical Physics Services NHS BSP Pub 33, 2nd Edn, 2005
- Consolidated Guidance on Standards for the NHS Breast Screening Programme NHS BSP Pub 60, 2005
- European Standard EN ISO 9001, European Committee for Standardisation, Brussels, 2000
• Quality Control of Gamma Camera Systems, IPEM Report 86, 2003
• Radioactive Sample Counting – Principals and Practice, IPEM Report 85, 2002
• IAEA Quality Control Atlas for Scintillation Camera Systems

Methods of Assessment
This module is assessed by examination, practical work and an essay.

The examination (Paper III) will consist of 6 questions; students answer 2 questions from the 6. The examination covers the “X-rays, γ-rays, MTF and ROC Analysis” and “X-ray imaging and analysis” sections of the module. Full marks for a question will be equivalent to 25% of the total marks available for this module.

The “Nuclear Medicine” section of the module is assessed by a written report on a hospital-based practical session, full marks for which will be equivalent to 25% of the total marks available for this module.

The “Radiotherapy” section of the module is assessed by an essay, which carries a maximum contribution of 25% to the total marks available for this module.
Module 8: Summer Project and Dissertation

Module Provider: Physics
Module Code: PHYM029
Level: M
Number of Credits: 60
Module Co-ordinator: Dr Zsolt Podolyak

Module Availability
Summer

Assessment Pattern

<table>
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<th>Weighting Towards Module Mark (%)</th>
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<tbody>
<tr>
<td>Coursework</td>
<td>Dissertation (100 %)</td>
</tr>
<tr>
<td>Part-time Students:</td>
<td>Same as for full-time students</td>
</tr>
</tbody>
</table>

Qualifying Condition(s)

Pre-requisite/Co-requisites
None

Module Overview
For the summer project the students will work full time over 10 week period from June to August. The project will be offered at either Surrey or Sussex, with topics chosen from a range of research areas that complement the elective modules offered in the spring semester. Alternatively students can elect to do the project with their employer, by mutual agreement between the department and the company.

All students aiming for the MSc degree qualification undertake an MSc dissertation project. Students choose a project either from a list of proposed topics within the University, or in some cases arrangement is made for the project to be undertaken in industry. The majority of part-time students arrange to undertake the project in their place of work.

Students are assigned a supervisor relating to the project chosen. Students undertaking their project outside of the University are assigned both an internal and an external supervisor.

The work is assessed as follows:

Project write-up
A write up of no more than 40 pages in total, including title page, brief abstract, text, diagrams and references must be submitted in accordance with the procedures written in the General Handbook. Supervisors will give guidance on the layout of the project and the first draft of material where appropriate.

Module Aims
This module provides exposure to independent research at postgraduate level.

Learning Outcomes
After completing this module, the student should be able to:

Module Specific Skills:
- Application of research techniques to demonstrate problem independent solving ability, critical analysis and (where possible) original research of relevance to radiation physics work
- Perform a literature search
- Development of experimental / computation technical skills associated with radiation protection based project work

Discipline Specific Skills:
- Time management
- Report writing
- IT skills and communication
- Data evaluation and critical analysis

**Personal and Key Skills:**
- Written presentation of a formal report

**Methods of Assessment**
This module is assessed via a formal write up of the project undertaken in the form of an MSc dissertation. The Dissertation is awarded 60 credits.
Industrial Visits

<table>
<thead>
<tr>
<th>Module Provider:</th>
<th>Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level:</td>
<td>M</td>
</tr>
<tr>
<td>Number of Credits:</td>
<td>0</td>
</tr>
<tr>
<td>Module Co-ordinator:</td>
<td>Prof Paddy Regan</td>
</tr>
</tbody>
</table>

Module Availability
Autumn and Spring Semester

Assessment Pattern

<table>
<thead>
<tr>
<th>Unit(s) of Assessment</th>
<th>Weighting Towards Module Mark (%)</th>
</tr>
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<tbody>
<tr>
<td>None</td>
<td>-</td>
</tr>
</tbody>
</table>

Part-time Students:
Same as for full-time students

Qualifying Condition(s)

Pre-requisite/Co-requisites

None

Module Overview

Industry visits are organised so as to give the student an insight into the types of working environment that they may choose to go into following the MSc course.

Supervised visits, with guided tours of some of the following organisations:

- NUVIA
- GE Healthcare
- Health Protection Agency (HPA)

Module Aims

To give students an insight into Industry and to build depth in understanding of Radiation Detection and Instrumentation.

Learning Outcomes

After completing this module, the student should be able to:

**Module Specific Skills:**
- Have knowledge of industrial applications of Radiation Detection and Instrumentation

**Personal and Key Skills:**
- Direct access to ‘real life’ industrial environments associated with radiation physics and protection

Methods of Assessment

None
SECTION E – PRIZES AND SPONSORSHIP

PRIZES

The Lab Impex Prize
A prize of £300 is awarded annually for the best research dissertation on the MSc in Radiation Detection and Instrumentation course.

The Studsvik UK Ltd Prize
A prize of £400 is awarded annually for the best overall student performance on the MSc in Radiation Detection and Instrumentation course.

Winners will be announced at the Postgraduate Reception on Graduation Day in April 2012

SPONSORSHIP

Industrial Sponsorship

Lab Impex Systems

Studsvik