INTERMEDIATE PHYSICS
SECOND SEMESTER, 2009

PHYS 2913
Astrophysics and Relativity (Advanced)
HANDBOOK

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1 GENERAL INFORMATION

1.1 UNIT DESCRIPTION

The School of Physics offers students in the Faculty of Science one six credit point unit in first semester (at both Normal and Advanced levels) and two in second semester (again at both Normal and Advanced levels). The outline content of these six units is given in the following Table:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Sem</th>
<th>Lectures</th>
<th>Computational Physics</th>
<th>Experimental lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 2911/2011</td>
<td>1</td>
<td>Optics 12; Nuclear Physics 10</td>
<td>Optics 9 wks</td>
<td>9 weeks</td>
</tr>
<tr>
<td>PHYS 2912/2012</td>
<td>2</td>
<td>Quantum Physics 19; EM Properties 19</td>
<td>Quantum 10 wks</td>
<td>_</td>
</tr>
<tr>
<td>PHYS 2913/2013</td>
<td>2</td>
<td>Stellar Astrophysics 12; Special Relativity 10</td>
<td>_</td>
<td>12 weeks</td>
</tr>
</tbody>
</table>

This Unit of Study Handbook describes PHYS 2913, the second semester Advanced-level ‘elective’ unit. This unit is designed for students who wish to broaden and complete their study of physics at the advanced Intermediate level, and will normally be taken by students who are also taking PHYS 2912/2012. Note that this unit cannot be counted with PHYS 2001 or 2901 or 2101 or 2103 or 2013.

The unit is split into a number of modules, combining lectures on stellar astrophysics and special relativity with sessions on Experimental Physics in the Intermediate Physics Laboratory. Some of these activities are in common with the unit of study PHYS 2013 Astrophysics and Relativity.

1.2 CONTRIBUTION OF THE UNIT TO PROGRAMS OF STUDY

Students intending to major in Physics are strongly encouraged to take all three of the above units. The Advanced versions can be taken by students who have achieved a credit or better in their previous Physics units.

Progression to Senior Physics: The prerequisites for most Senior Physics units are PHYS 2911/2011 and PHYS 2912/2012. However, students intending to major in Physics are strongly encouraged to take PHYS 2913/2013 as well. See the Senior Physics web pages for more details.

Senior Physics also assumes knowledge of Intermediate mathematics – see Section 1.4.

1.3 ENTRY REQUIREMENTS

The prerequisites for entry to PHYS 2913 are credit or better in PHYS (1003 or 1004 or 1902) and credit or better in PHYS (1001 or 1002 or 1901 or 2011 or 2911). The assumed knowledge consists of MATH 1001/1901 and 1002/1902 and 1003/1903, while MATH 1005/1905 would also be useful.

1.4 RELATED COURSES IN THE SCHOOL OF MATHEMATICS AND STATISTICS

Students should note that MATH 2961/2061 (Linear Mathematics and Vector Calculus) is a prerequisite for most Senior Physics units, and you should take this unit if you are planning to major in Physics. An acceptable alternative is MATH 2067 (Differential Equations and Vector Calculus for Engineers). Other useful units are: MATH 2963/2063 (Mathematical Computing and Nonlinear Systems), MATH 2965/2065 (Introduction to Partial Differential Equations), STAT 2911/2011 (Statistical Models) and STAT 2912/2012 (Statistical Tests).

1.5 REGISTRATION

A registration meeting will be held in your scheduled laboratory session (at 2:00 pm on Wednesday or Thursday) in the first week of the semester. At this meeting you will be organised into groups for Experimental Physics. All students MUST ATTEND one of these registration sessions. These sessions will be held in one of the Physics Lecture Theatres (LT) or in tutorial room 320/321; a notice outside the entrance to the Laboratories will direct you to the appropriate venue.

If you have not been assigned a session or there is an unresolved conflict in your timetable, attend the earliest session you can.

1.6 LECTURE ARRANGEMENTS

All Intermediate Physics lectures, practical sessions and computational physics sessions are held in the School of Physics. Room assignments are shown in section 4 of this Handbook. Please check the notice boards (see next subsection) for any last minute changes.

The Intermediate Physics Laboratory is located at the Western (‘downhill’) end of the School of Physics on level 4 (street level is level 2).

The Computational Physics Laboratory is room 359, at the Western end of level 3 (far end of corridor).

Physics Lecture theatres are located as follows:-

- LT1 Eastern end, level 4
- LT2 Western end level 4 (opposite the Second Year Physics Laboratory)
- LT4 Just West of the middle of the building level 3
- LT5 West of the middle of the building level 3
- Slade Theatre (LT8) Eastern end level 2

1.7 INFORMATION ABOUT INTERMEDIATE PHYSICS

The Intermediate Physics noticeboard is located outside the Physics Student Support Office (Rm 202, Eastern end of level 2 - street level). Please check this notice board regularly for important information.

The ‘Information for Undergraduate Students’ link on the School of Physics web page provides resources to help you with your studies. Please spend time getting acquainted with this site, and the specific page relative to this unit of study. Unit webpages are

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provided under the University’s WebCT environment, which can be accessed from the Intermediate Physics webpages³ or the USYDnet site⁴. Access requires a Unikey (Extro account) Username and Password that is issued with your confirmation of enrolment. The University provides computer facilities in the Access Centres⁵. A brief introduction to web access is available on the Intermediate Physics web page.

1.8 CONSULTATION

Students who have general questions about the unit should ask at the Student Support Office. If necessary, questions about organisation and administration may be referred to the Coordinator of Intermediate Physics.

Questions about specific lecture modules should be directed to the lecturer concerned. Questions about laboratory matters should be directed to the laboratory tutors in the first instance.

1.9 PRINTED NOTES

It is highly recommended that each student of PHYS 2913 purchase the current edition of ‘Experimental Physics Notes’, which is the manual for the laboratory course⁶. Copies of these notes are available at the University Copy Centre. A suitably ruled notebook will be issued as your personal logbook for laboratory work.

Other materials (lecture handouts, assignment questions and solutions) may be handed out during lectures and will subsequently be available on WebCT and on request from the Physics Student Support Office (room 202). There is no charge for these materials.

Some more extensive lecture notes will be sold through the University Copy Centre.

1.10 SCHOLARSHIPS AND PRIZES

There are a number of scholarships and prizes available to students enrolled in Intermediate Physics courses. They are awarded at the end of the year on the basis of academic merit in units taken in both semesters.

The prizes are:-

Slade Prize for Physics (value $350) for Merit in Intermediate Experimental Physics.

Geoffrey Builder Prize (value $250) for Merit in Intermediate Experimental Physics.

Only students who take both PHYS 2011/2911 and PHYS 2013/2913 will be eligible for these prizes, which are based on Laboratory work. (Such students will normally take PHYS 2012/2912 as well.)

The scholarships are awarded on the basis of the sum of the two best marks from the three Intermediate Physics units but only to students with confirmed enrolment in at least 6 Credit Points of Senior Physics.

The scholarships are:-

⁴ http://myuni.usyd.edu.au
⁶ The same ‘Experimental Physics Notes’ were used in first semester for PHYS 2011/2911.
The School of Physics – Julius Sumner Miller Scholarship for Academic Excellence No.2 (value $800). Up to two are awarded annually.

Science Foundation for Physics Scholarships No.2 (value $800). Up to five are awarded annually.

2 GENERAL AIMS OF THE UNIT OF STUDY

The unit is made up of three modules:
• Introduction to Stellar Astrophysics lectures
• Special Relativity lectures
• Experimental Physics Laboratory sessions

The aims and specific objectives of the modules are linked to the required generic attributes of graduates of the University in knowledge skills (in stellar astrophysics and special relativity), thinking skills (the analysis of problems in physics), personal skills and attributes (the ability to work independently and in groups, and to present the results of physics experiments), and practical skills (the performance and analysis of experiments in physics).

Specific objectives of the modules making up this unit of study are given in Section 5.

3 ASSESSMENT OF THE UNIT OF STUDY

3.1 GENERAL

This unit is assessed through an examination, assignments taken throughout the semester, and marking of laboratory logbooks in experimental physics sessions as well as a talk and report late in the semester.

Proof of identification is required at all examinations.

Except where otherwise noted, candidates will not be allowed to bring books or papers into the examination room. However, examinations are not meant to be tests of rote memorisation, and formula sheets will normally be included in the examination papers.

A preliminary examination timetable is released late in the semester and students are asked to report all clashes to the Student Centre (in the Carslaw Building). The final timetable may differ from the preliminary one and it is each student’s responsibility to determine the date, time and location of their scheduled examinations.

The weighting of the assessments in the various components of the unit to the final mark is as follows:

Examination (2 hour paper):
- Stellar Astrophysics 50
- Special Relativity 45
Assignments: 15
Experimental Physics: 90
Maximum Total: 200

The final marks and merit grades are determined, allowing scaling of marks from separate modules, to take into account the class average of Annual Average Mark (AAM). The minimum Pass mark is never more than 50% of the final scaled mark. A Pass in PHYS2013 can be returned for students enrolled in PHYS2913.
3.2 ASSIGNMENTS

There will be two assignments from each of the two lecture modules. Assignment questions will be handed out in lectures or made available via Mastering Physics. All questions may be marked. Students will submit individual assignments. Even though students may work in groups on solving the problems, the individually submitted answers must include explanations of how each individual has understood the problem and its solution.

Each handed in assignment must have a cover page, which may be obtained from the Physics Student Support office (Room 202, Physics building). In signing the cover sheet, each student is confirming awareness of the University’s policy on plagiarism and academic honesty\(^7\), and agreement to comply with that policy.

Assignments will be handed in at the Student Support Office. **Late assignments will not be marked.**

Your answers must identify the key physical principles; marks will not be awarded for simply putting numbers into formulae without explanation. Model solutions to all the questions or problems will be posted on the unit WebCT pages when the marked assignments are returned.

Assignments will be handed back in laboratory sessions.

3.3 CONSIDERATION OF FACTORS AFFECTING YOUR STUDY

If your academic performance in a Science Faculty unit of study is adversely affected by illness or some other serious event, such as an accident, you should notify the Faculty of Science Student Information Office (level 2 of the Carslaw building) within 7 days after the period for which consideration is sought, by completing an Application for Special Consideration with accompanying documentation. This is especially important if you miss an examination.

If you have another reason for the Science Faculty to take account of your circumstances - religious commitments, legal commitments (e.g. Jury duty), elite sporting or cultural commitments (representing the University, state or country), or Australian Defence Force commitments (e.g. Army Reserve) - you should notify the Faculty of Science Student Information Office (level 2 of the Carslaw building) at least 7 days BEFORE the period for which consideration is sought, by completing an Application for Special Arrangements with accompanying documentation.

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 (room 202 in the Physics building) beforehand (or at the latest within 7 days afterwards), by completing an Application for Consideration of Special Circumstances by Physics with accompanying documentation.

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.

\(^7\) http://www.usyd.edu.au/senate/policies/Plagiarism.pdf
If, for example, you miss an assignment, an application for appropriate Consideration is required to allow late submission, but we do expect the assignment to be submitted. Sometimes catching up may be impossible, in which case we will consider a pro-rata adjustment of your marks on the basis of an application for Consideration.

3.3.1 SPECIAL CONSIDERATION OR SPECIAL ARRANGEMENTS

To submit an application for Special Consideration or Special Arrangements you should:

1. Obtain the appropriate Application pack from the Student Information Office of the Faculty of Science, the Faculty website\(^8\), or the Physics Student Office.

2. Complete the forms and obtain whatever original documentary evidence is appropriate. Note especially that the Professional Practitioner's Certificate is essential for Special Consideration on grounds of serious illness - Medical Certificates will NOT be accepted.

3. Take the original copy of all forms and documents, plus sufficient copies for each unit of study affected and yourself, to the Faculty of Science Student Information Office (NOT any other Faculty Office if you are seeking Consideration in a unit taught by Physics). They will sign/stamp both the original application form and the copies. In the case of Physics units, one copy of the documentation must then be submitted to the Physics Student Office. Keep one copy yourself. A formal decision on your application will be sent to your university email address within 14 days.

Further details on University policy regarding Considerations can be found in policy documents entitled Assessment and Examination at the University Policy web site\(^9\).

3.3.2 CONSIDERATION BY PHYSICS

An application for Consideration by Physics requires you to:

1. Obtain an Application for Consideration of Special Circumstances by Physics from the School of Physics Student Office or the Physics web page\(^10\).

2. Complete the form and obtain whatever original documentary evidence is appropriate.

3. Take the original copy of the form and supporting documents, plus a copy for yourself, to the Physics Student Office. They will sign/stamp both the original application form and the copy. A formal decision on your application will be sent to your university email address within 14 days.

Students unsure what type of Consideration is appropriate, or unhappy with a Consideration decision, should consult the Physics Student Office.

It is important to realise that the policies on Special Consideration apply throughout the University. Policies on other forms of Consideration are specific to Physics and may be different in Departments responsible for your other units of study.

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\(^8\) http://www.science.usyd.edu.au/cstudent/ug/forms.shtml

\(^9\) http://www.usyd.edu.au/policy/

# TIMETABLE

**PHYS 2913  Astrophysics and Relativity (Adv)**  
**Semester 2 2009**

<table>
<thead>
<tr>
<th>Monday Date</th>
<th>Lectures</th>
<th>Lectures</th>
<th>Experimental Physics Lab.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tuesday</td>
<td>Thursday</td>
<td>Wed, Thurs 2-5pm</td>
</tr>
<tr>
<td>27 Jul 2008</td>
<td>No Class</td>
<td>No Class</td>
<td>Registration</td>
</tr>
<tr>
<td>03 Aug 2008</td>
<td>No Class</td>
<td>No Class</td>
<td>LAB-1</td>
</tr>
<tr>
<td>10 Aug 2009</td>
<td>ISA 1</td>
<td>ISA 2</td>
<td>LAB-2</td>
</tr>
<tr>
<td>17 Aug 2009</td>
<td>ISA 3</td>
<td>ISA 4</td>
<td>LAB-3</td>
</tr>
<tr>
<td>24 Aug 2009</td>
<td>ISA 5</td>
<td>ISA 6</td>
<td>LAB-4</td>
</tr>
<tr>
<td>31 Aug 2009</td>
<td>ISA 7</td>
<td>ISA 8</td>
<td>LAB-5</td>
</tr>
<tr>
<td>07 Sep 2009</td>
<td>ISA 9</td>
<td>ISA 10</td>
<td>LAB-6</td>
</tr>
<tr>
<td>14 Sep 2009</td>
<td>ISA 11</td>
<td>ISA 12</td>
<td>LAB-7</td>
</tr>
<tr>
<td>21 Sep 2009</td>
<td>REL 1</td>
<td>REL 2</td>
<td>LAB-8</td>
</tr>
<tr>
<td>28 Sep 2009</td>
<td>MSB</td>
<td>MSB</td>
<td>MSB</td>
</tr>
<tr>
<td>05 Oct 2009</td>
<td>REL 3</td>
<td>REL 4</td>
<td>LAB-9</td>
</tr>
<tr>
<td>12 Oct 2009</td>
<td>REL 5</td>
<td>REL 6</td>
<td>LAB-10</td>
</tr>
<tr>
<td>19 Oct 2009</td>
<td>REL 7</td>
<td>REL 8</td>
<td>LAB-11</td>
</tr>
<tr>
<td>26 Oct 2009</td>
<td>REL 9</td>
<td>REL 10</td>
<td>Talks</td>
</tr>
</tbody>
</table>

**MSB** Mid-semester break  
**ISA** Introduction to Stellar Astrophysics  
**REL** Special Relativity

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**Lecture Theatre:**

Note that lectures on Introduction to Stellar Astrophysics will be held in common with PHYS 2013, and will take place in the designated PHYS 2913 lecture theatre. Lectures on Special Relativity will be separate for PHYS 2913.

<table>
<thead>
<tr>
<th>Tues 12 noon</th>
<th>Thurs 12 noon</th>
</tr>
</thead>
<tbody>
<tr>
<td>All PHYS 2913 classes</td>
<td>LT 2</td>
</tr>
</tbody>
</table>
5 PHYS 2913 MODULE DESCRIPTIONS

5.1 INTRODUCTION
For each module we have defined broadly what we expect you to learn and understand. Understanding implies that you should be able to discuss and explain fundamental concepts and principles including examples of their application.

Understanding in the lecture modules on Stellar Astrophysics and Special Relativity will be tested in the end of semester examination by asking you to write descriptive answers to qualitative questions and by evaluating your explanations of physical principles and reasoning in answers to quantitative questions. Ability to memorise formulae and manipulate them without understanding the associated physics will not be rewarded.

Specific objectives define what you should learn and understand about the detailed content of each part of the module. 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,
• apply it correctly to examples and problems.

5.2 INTRODUCTION TO STELLAR ASTROPHYSICS
The 12 lectures will be given by Drs Laszlo Kiss and J.W. O’Byrne.

For over 100 years astrophysics has been one of the driving forces for the advancement of physics in general. It has been closely linked to advances in quantum mechanics and nuclear physics in particular. On the other hand, astrophysics is also firmly based in classical physics. This is particularly true for stellar astrophysics - the physics of stars. The physical principles which determine the behaviour of stars are the familiar laws of mechanics, hydrostatics and thermodynamics. For this reason, stellar astrophysics has been chosen as the main topic for this introductory course in astrophysics.

Several of the experiments in the Intermediate Laboratory are particularly relevant to stellar astrophysics:

• Fine Structure of Spectral Lines
• Atomic Emission Spectra
• The Colour and Evolution of Stars

Text
This module is defined by the content of the School of Physics publication Introduction to Stellar Astrophysics (available from the Copy Centre), plus any extra material supplied in lectures. Reading beyond these notes is strongly recommended – see the list of suggested books in the introduction to the notes.

Objectives of this module
The following list outlines the broad topics of this module.

Introduction
• The place of the Solar System in the Milky Way galaxy and the galaxy in the universe at large.
• The main classes of astronomical objects – planets, stars, star clusters, gaseous nebulae and galaxies, clusters of galaxies, large scale structure.
• Conversion between standard SI units and the units commonly used in astronomy, including the arc-second, parsec, solar mass unit and light year.

**Astrophysical tools**
• The electromagnetic spectrum – especially wavelength, frequency, or energy ranges of astrophysical interest.
• Important properties of single astronomical telescopes or multi-telescope interferometers – especially sensitivity and resolution.
• Important astrophysical techniques such as spectroscopy and photometry.

**Stellar magnitudes**
• Definition of the magnitude scale – including calculations such as conversion between magnitude difference and flux ratio.
• Definition of magnitude in different colour bands and hence the colour index.
• Interstellar reddening, absorption and colour excess.
• Various types of magnitudes – apparent, absolute, bolometric.

**Measuring Stellar distances**
• Stellar parallax.
• Use of the Cepheid variable period luminosity law.
• Cosmological red shift.

**Stellar spectra**
• Types of spectra – continuous, emission, absorption.
• Planck distribution - including Wien displacement law, Stephan-Boltzmann relation, effective temperature.
• Spectral lines formation in stellar atmospheres.
• Excitation equilibrium and the Boltzmann equation.
• Ionisation equilibrium and the Saha equation.
• Line broadening mechanisms.

**Spectral classification**
• Spectral classes – basic classes O B A F G K M plus newer additions.
• Luminosity classes – Ia, Ib, II, III, IV, V,wd.

**The Hertzsprung-Russell (HR) Diagram**
• Regions of interest on an HR diagram - main sequence, turn-off point, red giant branch, horizontal branch, white dwarfs, instability strip
• Cluster HR diagrams.

**The physics of stars**
• Hydrostatic equilibrium in a star.
• Ideal gas equation of state in a star.
• Radiative transfer in a star.
• Nuclear fusion in stars - the p-p reaction, the CNO cycle and the triple-alpha process.
• The “Gamow peak”.
• Temperature dependence of the reaction rates for the p-p, CNO and triple-alpha processes.
• Ignition temperatures for the nuclear fuels: H, He, C, O, Si.

**Stellar evolution**
• Giant Molecular Clouds as sites of star formation
• Formation of protostars and their evolution to the main sequence.
• Formation of planetary systems.
• Zero age main sequence (ZAMS).
• Evolution of a star on the main sequence - how the main sequence lifetimes of stars vary with mass.
• Post-main sequence evolution of high mass stars - onset of hydrogen shell burning, core collapse, red giant branch (RGB), asymptotic giant branch (AGB), supernovae.
• Evolution of low mass stars - post-RGB evolution of low mass stars leading to the formation of planetary nebulae and white dwarfs.

**Variable stars**

• Period-mean density relation and its physical cause - leading to the period-luminosity law for Cepheids.
• Eddington's valve theory and partial ionisation.
• Helioseismology and asteroseismology.

### 5.3 SPECIAL RELATIVITY

The 10 lectures will be given by Prof. T. Bedding.

Aims: This lecture module introduces Special Relativity, one of the most important and influential theories of modern physics. Special Relativity is an extension of Newtonian mechanics to objects moving at very high speeds, and is based on the fundamental postulate that the speed of light is the same for all observers. The remarkable and often counterintuitive consequences of the theory include length contraction, time dilation and rest energy \( E=mc^2 \). This module covers the theory of Special Relativity, its predictions and applications. It also introduces the main concepts of General Relativity, the theory that describes gravity as resulting from the fact that space-time is curved by the presence of matter. This module lays the foundations for a full course on General Relativity, and is also important for future courses in electromagnetism and quantum mechanics.

#### 5.3.1 TEXT

The course is defined below in terms of the text: ‘University Physics’ (11th Ed) by Young and Freedman (Addison-Wesley).

Sections: all of Ch. 37, plus additional lecture notes on four-vectors and General Relativity

**Specific objectives.** By the end of this module, you should be able to:

• describe and discuss Einstein's two postulates
• recall that Maxwell's equations explain light as a travelling wave of electric and magnetic fields (Sec. 33-3), and appreciate that this leads to Einstein's second postulate.
• define and use the following concepts: inertial reference frames, events, simultaneity
• understand the following terms and differentiate between them: constant, conserved and invariant
• appreciate that the time interval between events depend on the reference frame and, in particular, that two events may be simultaneous in one frame but not in others
• define and use the concept of proper time
• describe the so-called twin paradox and explain its resolution
• appreciate that lengths measured in two frames of reference are different in the direction parallel to the relative motion, but not in the perpendicular direction
• solve problems involving time dilation and length contraction
• derive, explain and use the Lorentz transformations for coordinates and for velocities
• derive, explain and use the relativistic Doppler effect
• understand and use spacetime diagrams
• define the concepts of relativistic momentum and relativistic kinetic energy and use them to solve dynamical problems
• appreciate that the total energy of a particle includes both the kinetic energy and the rest energy, and use this to solve problems involving motions and collisions of particles
• appreciate that special relativity involves extending and modifying Newton's laws, not replacing them
• understand and use four-vectors for displacement, velocity and energy-momentum
• understand and describe the basic principles of General Relativity as a theory of gravity, including the Equivalence Principle, the concept of a metric to describe curved space-time and the idea that this curvature is caused by the presence of matter and energy

5.4 EXPERIMENTAL PHYSICS

5.4.1 INTRODUCTION

The coordinator of the laboratory is Dr. K. Varvell (Room 355 Physics School; email k.varvell@physics.usyd.edu.au; tel 9351 2539)

Experimental Physics is a laboratory course based on a set of individual experiments which cover many different aspects of experimental physics. In this semester each student must complete one experiment from each group (A, B and C). After that, experiments may be chosen from any group, subject to availability. Experiments already done in first semester may not be repeated. Towards the end of the semester, students may work on an (optional) project, usually in a group of four.

Students work in a partnership; usually one pair of students works together. However, all work must be recorded in individual logbooks to be issued in the laboratory.

Laboratory tutors will check your work. Unless one of the partners is away for that particular session, both students in a partnership must present their books to the tutor at the same time. If your work is unsatisfactory you will be asked to bring it up to the required standard and demonstrate that you have mastered the material, repeating parts of the experiment if necessary.

Each team will have to write a report on one of the experiments performed during the semester, and the team is also expected to make an oral presentation of the report work during the last session of the semester.

5.4.2 SESSION ARRANGEMENTS AND REGISTRATION

The Intermediate Physics Laboratory, (Rooms 419-423) is located at the western end (the end nearest to No.1 Oval) of the Physics Building on Level 4 (two floors above ground level). The laboratory sessions are from 2:00 pm to 5:00 pm on each of
Wednesday and Thursday afternoons. Students will be assigned to one of these sessions by their timetable.

*You must attend your first scheduled laboratory session,* during the first week of the first semester, which is used for registration and for an introduction to the unit of study. The sessions start at 2:00 pm and will be held in one of the Physics Lecture Theatres or tutorial rooms; a notice outside the laboratory will advise you which venue is being used. If you have not been assigned a time for laboratory work, attend the earliest session you can.

### 5.4.3 MISSED SESSIONS

Experimental Physics forms an important element of the Intermediate Physics course. Students who miss sessions or arrive late or leave early may be severely penalised. If you are unable to attend because of illness, misadventure or other difficulties you should refer to the instructions in Section 3 of this handbook.

### 5.4.4 TEXT

The module is defined in terms of the *Intermediate Physics Experimental Physics Notes*, available at the University Copy Centre and on the web. These notes contain descriptions of the experiments for both first and second semesters, so there is no need to buy a new copy if you already have one from first semester.

### 5.4.5 ASSESSMENT

A satisfactorily completed experiment is worth 13 marks. Other components of the assessment are the written report and oral presentation, and the project proposal and performance (if applicable). For details of the assessment of laboratory work see the ‘General Information’ section of the Experimental Physics Notes book.

### 5.4.6 SPECIFIC OBJECTIVES

After studying this module, you should be able to:

- Perform physics experiments, analyse and interpret data and draw conclusions from your results
- Solve experimental problems in physics and link these to appropriate theories
- Work independently and in groups
- Present the results of physics experiments orally and in the form of a written report
- Appreciate the role of computers and other equipment in experimental physics
- Make effective records in a logbook, and calculate uncertainties when appropriate