Welcome to SUPA

SUPA is the Scottish Universities Physics Alliance. It is a research alliance between the physics and astronomy departments of eight Scottish universities.

The eight member universities in SUPA are:
- University of Aberdeen
- University of Dundee
- University of Edinburgh
- University of Glasgow
- Heriot-Watt University
- University of St Andrews
- University of Strathclyde
- University of the West of Scotland

SUPA seeks to place Scotland at the forefront of physics research globally through an inter-institutional management structure. There is a coherent resourcing strategy and a Scotland-wide research strategy. SUPA facilitates enhanced collaborative research programmes and the pooling of equipment and resources.

The SUPA Graduate School

SUPA runs a Graduate School offering graduate training initiatives and providing PhD students with access to an extensive programme of state-of-the-art video-conferenced lectures. Each year, the SUPA Graduate School offers a limited number of fully-funded Prize PhD Studentships. These prestigious and competitive awards are available to students from anywhere in the world and attract outstanding physics and astronomy students to study for a PhD in Scotland.

SUPA Research Themes

Looking for an expert?
SUPA is built around the following key research strengths:
- Astronomy and Space Physics
- Condensed Matter and Material Physics
- Nuclear and Plasma Physics
- Particle Physics
- Photonics
- Physics and Life Sciences
Dear Students,

Welcome to the SUPA Graduate School 2010-2011. With almost 450 post-graduate students in total and 100+ new first year students joining each year, we are arguably the largest Physics Graduate School in the United Kingdom - indeed the world - and definitely the best!

This year we extend a very warm welcome to each of our SUPA Prize Students who fought off competition from over 300 applicants to be one of the successful researchers to join SUPA through this world-renowned scheme. We also welcome the students joining the prestigious Scottish Doctoral Training Centre in Condensed Matter.

SUPA is an alliance of the Physics departments of eight major Scottish universities, four of which were ranked 20 or above in the last Research Assessment Exercise (RAE). The SUPA Graduate School offers world-leading education and training in post-graduate physics studies and generic skills. The physics studies are grouped by theme (Nuclear & Plasma, Astronomy & Space, Photonics, Particle Physics, Condensed Matter & Material Physics, and Physics & Life Sciences), and courses are given by videoconferenced lectures, through the My.SUPA e-learning portal, by tutorials/hands-on-sessions/labs and by residential sessions.

We ask that all PhD students undertake a minimum of 40 hours of physics studies and 20 hours of generic skills training during the first two years of their studies: this is a minimum requirement. Some themes, and in particular the Condensed Matter Doctoral Training Centre, will require their students to do more in order to best equip them for their research careers. More information about these requirements can be found in this handbook.

As new post-graduate students, you will be establishing yourselves in an exciting, vibrant research environment – meeting lots of new people, learning about a new culture (perhaps in a foreign language) and being bombarded with information on just about everything. In all of this, if I or any member of the Graduate School Management Committee (GSMC) can assist you with integrating into SUPA, your research or your university, please don’t hesitate to contact us. (Contact details are provided in this handbook.)

An important date for your diaries is **Wednesday, October 6th, 2010.** You are invited to join us at the Edinburgh e-Science Centre to meet the other new Scottish physics doctoral students at the first-year student SUPA induction and networking event with guest speaker Professor Peter Higgs. I look forward to welcoming you all in person at this exciting event.

All the very best in your studies,

Avril Manners
Director of the SUPA Graduate School
## SUPA Contacts

### Scottish Universities Physics Alliance
Room 4209
James Clerk Maxwell Building
The King's Buildings
Mayfield Road
Edinburgh, EH9 3JZ
United Kingdom
Tel: +44 (0) 131 651 7192
Web: www.supa.ac.uk

### Graduate School Director
Avril Manners
avril.manners@supa.ac.uk

### SUPA Administration Office
admin@supa.ac.uk

### SUPA Room & VC Bookings
rooms@supa.ac.uk

### Graduate School Management Committee (GSMC)

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<tr>
<th>Location</th>
<th>Name</th>
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<tr>
<td>Aberdeen</td>
<td>Alessandro De Moura</td>
<td>0122 427 2505</td>
<td><a href="mailto:a.moura@abdn.ac.uk">a.moura@abdn.ac.uk</a></td>
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<tr>
<td>Dundee</td>
<td>David Keeble</td>
<td>0138 238 4561</td>
<td><a href="mailto:d.j.keeble@dundee.ac.uk">d.j.keeble@dundee.ac.uk</a></td>
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<tr>
<td>Edinburgh</td>
<td>Malcolm McMahon</td>
<td>0131 650 5956</td>
<td><a href="mailto:mim@ph.ed.ac.uk">mim@ph.ed.ac.uk</a></td>
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<tr>
<td>Glasgow</td>
<td>David Miller</td>
<td>0141 330 4926</td>
<td><a href="mailto:d.miller@physics.gla.ac.uk">d.miller@physics.gla.ac.uk</a></td>
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<td>Heriot-Watt</td>
<td>Weiping Lu</td>
<td>0131 451 3065</td>
<td><a href="mailto:W.Lu@hw.ac.uk">W.Lu@hw.ac.uk</a></td>
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<tr>
<td>St Andrews</td>
<td>Simon Driver</td>
<td>0133 446 1680</td>
<td><a href="mailto:spd3@st-and.ac.uk">spd3@st-and.ac.uk</a></td>
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<tr>
<td>Strathclyde</td>
<td>John Jeffers</td>
<td>0141 548 3213</td>
<td><a href="mailto:john@phys.strath.ac.uk">john@phys.strath.ac.uk</a></td>
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<tr>
<td>UWS</td>
<td>John F. Smith</td>
<td>0141 848 3652</td>
<td><a href="mailto:John.F.Smith@uws.ac.uk">John.F.Smith@uws.ac.uk</a></td>
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### SUPA Videoconference Rooms

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<tr>
<td>Aberdeen</td>
<td>Regent Building, Room 17</td>
<td>01224 272961</td>
<td><a href="mailto:av@abdn.ac.uk">av@abdn.ac.uk</a></td>
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<td>Dundee</td>
<td>Ewing Building, Basement</td>
<td>01382 384 695</td>
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<tr>
<td>Edinburgh</td>
<td>James Clerk Maxwell Building, Room 6224</td>
<td>0131 650 5223</td>
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<td>Glasgow</td>
<td>Kelvin Building, Room 255a</td>
<td>0141 330 6420</td>
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<tr>
<td>Heriot-Watt</td>
<td>Earl Mountbatten Building, Room 1.27</td>
<td>0131 451 3019</td>
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<tr>
<td>St Andrews</td>
<td>Physics &amp; Astronomy, Room 307</td>
<td>0133 446 3141</td>
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<tr>
<td>Strathclyde</td>
<td>John Anderson Building, Room 813</td>
<td>0141 548 3376</td>
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<tr>
<td>UWS</td>
<td>Henry Building, Room F.318</td>
<td>0141 848 3550</td>
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### Condensed Matter Doctoral Training Centre

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<td>University of St Andrews</td>
<td>St Andrews,KY16 9AJ</td>
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<td>Web:</td>
<td><a href="http://cm-dtc.supa.ac.uk/">http://cm-dtc.supa.ac.uk/</a></td>
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<tr>
<td>Director</td>
<td>Andy Mackenzie</td>
<td>01334 463 108</td>
<td><a href="mailto:apm9@st-and.ac.uk">apm9@st-and.ac.uk</a></td>
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<tr>
<td>Director of Training</td>
<td>Chris Hooley</td>
<td>01334 463 171</td>
<td><a href="mailto:cah19@st-and.ac.uk">cah19@st-and.ac.uk</a></td>
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<tr>
<td>Administrator</td>
<td>Christine Edwards</td>
<td>01334 463 102</td>
<td><a href="mailto:cae10@st-and.ac.uk">cae10@st-and.ac.uk</a></td>
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SUPA has set course requirements for both Technical Courses (which are focused on specialised training in Physics or related scientific areas) and Generic Skills Training (which is focused on developing transferable skills for professional development).

**Technical Course Requirements:**
Every PhD student within SUPA is required to take a minimum of **40 hours** of Technical Courses during the first two years of their PhD studies. Within some themes, such as Particle Physics, there is a higher recommended number of hours of technical coursework. Please refer to the theme-specific sections of this catalogue for course listings and more information on coursework requirements and recommendations.

Technical Courses include:
- SUPA Graduate School Lectures
- SUPA Distance Learning Courses
- SUPA Residential Courses
- Summer Schools as recommended by the themes
- Non-SUPA courses where appropriate. (Please refer to ‘Non-SUPA Courses’ section for more information.)

**Generic Skills Requirements:**
Every PhD student within SUPA is required to take a minimum of **20 hours (or 4 days)** of Generic Skills Training during the first two years of their PhD studies. Please refer to the Generic Skills Training section of this handbook for more information about courses available.

Generic Skills Training includes:
- SUPA Generic Skills Training Courses
- Departmental, university or research council programmes as appropriate.

**Earning and Tracking Hours Equivalent Credit**
In order to earn Hours Equivalent Credit to satisfy the SUPA Course Requirement, students must enrol for the course on My.SUPA and, for Technical Courses, pass the assessment. No credit can be given if the student has not met these criteria.

The Hours Equivalent Credit for each SUPA course is listed in this catalogue. Students can track the amount of Hours Equivalent Credit they have earned over the course of their PhD by checking their profiles on My.SUPA. (More information about how to do this can be found in the ‘Getting Started with My.SUPA section of this handbook.)

Allocation of Hours Equivalent Credit for non-SUPA Courses will be decided by the SUPA Graduate School Management Committee. (Please see the ‘Non-SUPA Courses’ section of this handbook for more information.)

**Course Selection**
Guidance on course selection for Technical Courses can be found in the theme-specific sections of this handbook. Students generally take Technical Courses within their main theme, but all students - especially those working on interdisciplinary projects - are welcome to take Technical Courses from across the SUPA Graduate School, provided these are relevant to their studies. All students are strongly advised to discuss their plan of study and specific course selections for both the Technical Course Requirements and Generic Skills Training with their supervisors.

Students who are unsure of their ‘theme’ (this is common for those with interdisciplinary projects) are advised to consult with their supervisors to determine the most appropriate course of study.

**SUPA Assessment Policy**
Assessment for all **SUPA Technical Courses** is mandatory unless the student decides to audit the course. (In the case of auditing, the student will receive no credit towards their 40-hour requirement.) Courses are assessed by various methods as appropriate to the subject area. Examples of assessment include: written examinations, continuous assessment, dissertations, and oral examinations. Information about assessments for specific courses can be found in the course listing in this catalogue.

If a student does not take the assessment for a course, no Hours Equivalent Credit will be allocated. Students taking non-SUPA courses must agree an assessment with their lecturer(s) and get this approved by their supervisor and the Graduate School Management Committee before the start of the course. Please refer to the ‘Non-SUPA Courses’ section of this handbook for more information.

Lecturers are required to notify students of the assessment details by the start of the course and to report students’ marks by the marking deadline. All marks will be on a 0-100 point scale, with a pass mark of 50. (Where SUPA postgraduate courses are part of the final year undergraduate curriculum, the pass mark may be 40.)

There is no assessment requirement for Generic Skills Training.
### Enrolling for SUPA Courses

To enrol for SUPA courses, log on to the My.SUPA portal (http://my.supa.ac.uk) and follow the enrolment instructions posted on the front page. Before you enrol for the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

When using My.SUPA to select courses, please note that during the enrolment period, most course areas are available with read-only access to some materials. All course materials will be made available to enrolled students once registration is closed. For more information about using My.SUPA, please refer to the 'My.SUPA and Videoconferencing' section of this handbook. Students must enrol for courses in order to be eligible to earn Hours Equivalent Credit for them.

The deadlines for enrolment in 2010/11 are: 13th October (Semester I) and 7th January (Semester II). If you miss the enrolment deadlines, late enrolment may be possible but cannot be guaranteed, as the videoconference rooms may have been booked for other events. Please contact the SUPA Administration Office at admin@supa.ac.uk in this instance.

If you would like to unenrol from a SUPA course, you can do so by going to the relevant course page and clicking on the 'Unenrol me from SUPA[XXX]' link. Please note that if you decide not to complete a course, it is very important that you unenrol on My.SUPA. If you do not unenrol, your SUPA transcript will still contain a record of this course and your mark will be listed as 0. After unenrolling, you can also sign up for the course as an auditor (see below for more information) in order to be able to continue to attend the lectures.

Please note that if you are have not signed up through My.SUPA to enrol or audit a course, you may not attend the lectures.

### Non-Assessed SUPA Courses

In cases where a student would like to attend a course but would not like to complete the coursework, it is possible to register as a non-assessed student. It is important to note that you will NOT receive Hours Equivalent Credit for courses which you audit. Instructions for registering as a non-assessed student are posted on the My.SUPA portal (http://my.supa.ac.uk). Before you register for auditing the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

During the enrolment period (Semester I: September 8th-October 13th; Semester II: November 24th -January 7th), it is possible for students to switch from a non-assessed student to a fully enrolled student on a course. This is particularly important for students who would like to try out a course before fully committing as an enrolled student. To switch from being a non-assessed student to an enrolled student, go to the relevant course page and click on the 'Unenrol me from SUPA[XXX]' link. Then, re-register as an enrolled student.

### Attending SUPA Courses

#### Videoconferenced Lectures

Most SUPA courses are taught via videoconferencing. To attend, simply go to your local institution's SUPA videoconference room. (See the 'Contacts' page for the location of all SUPA videoconference facilities.) For more information on using the videoconference facilities, please refer to the 'Getting Started with Videoconferencing' section of this handbook. Generally, videoconference lectures start five minutes past the hour and last approximately fifty-five minutes.

#### Distance Learning Courses

Courses listed as 'Distance Learning' in this handbook have no videoconferenced lectures. Enrolment on these courses will give you online access to notes, interactive materials, slides, podcasts, video content, problem sheets and discussion forums. You will be expected to work through the materials and activities, meet deadlines negotiated with the course tutors and participate in online discussions. Opportunities will be provided for you to upload completed exercises and receive feedback from the course tutors.

#### Tutorials/Hands-on sessions/Labs

A few courses require you to attend tutorials and lab sessions in person. Please check the online timetable and My.SUPA course pages for information about where the tutorials take place and if you are required to travel to attend. SUPA will reimburse travel expenses. Please check with your local department's finance office for procedures for claiming expenses.

#### Residential Courses

Courses listed as 'Residential' are face-to-face sessions for which you may have to travel and stay overnight. SUPA organises accommodation and meals, and reimburses student travel expenses for such courses. Please check with your local department's finance office for procedures for claiming expenses.
The following is a list of key dates in the 2010/11 SUPA academic year. This calendar is subject to change. For details of upcoming guest lectures, committee meetings and other events, and to view the latest version of the SUPA calendar, please refer to [http://my.supa.ac.uk/calendar/](http://my.supa.ac.uk/calendar/).

Please note that there are some differences in holiday dates between the universities; please refer to your local university’s calendar for more information. (Note that this may mean that some graduate school lectures take place during a holiday at your university. Please check access arrangements for your local video conference room on such dates).

### September 2010
- **Wednesday, September 8:** Semester I enrolment opens
- **Monday, September 13:** SUPA Semester I begins

### October 2010
- **Wednesday, October 6:** First Year Student Induction, The National e-Science Centre, Edinburgh
- **Wednesday, October 13:** Semester I enrolment closes, deadline for students to submit Semester I Non-SUPA Credit Requests
- **Friday, October 29:** SUPA Prize Studentship Competition Opens

### November 2010
- **Wednesday, November 24:** Graduate School Management Committee Meeting
- **Wednesday, November 24:** Semester II enrolment opens

### December 2010
- **Thursday, December 23:** SUPA Central closes for Winter Holiday

### January 2011
- **Monday, January 3:** SUPA Central reopens and Semester II begins
- **Friday, January 7:** Semester II enrolment closes, deadline for students to submit Semester II Non-SUPA Credit Requests
- **Tuesday, January 25:** SUPA Prize Studentship Competition Closes
- **Friday, January 28:** Deadline for lecturers to report Semester I marks
- **Friday, January 28:** Deadline for references for SUPA Prize

### February 2011
- **Friday, February 18:** Graduate School Management Committee Meeting

### March 2011

### April 2011
- **Tuesday, April 19:** Graduate School Management Committee Meeting

### May 2011
- **Tuesday, May 24:** Graduate School Management Committee Meeting
- **Friday, May 27:** Student deadline for Non-SUPA Course credit confirmation.

### June 2011
- **Wednesday, June 1:** Deadline for lecturers to report Semester II marks
- **Tuesday, June 28:** Graduate School Management Committee Meeting
### Frequently Asked Questions

#### What is SUPA?
SUPA is the Scottish Universities Physics Alliance, a grouping of eight Physics departments across Scotland. The SUPA Graduate School facilitates shared learning across these institutions. After enrolling for post-graduate studies in a SUPA-member institution, you are automatically enrolled in the SUPA Graduate School and are subject to its academic policies.

#### Is there a timetable for the SUPA courses?
A provisional timetable can be found at the end of this handbook, but the timetable may have changed since it was printed. An updated online version of the timetable can be found on the My.SUPA website.

#### How do I use the videoconferencing equipment?
Training should be made available to all students and staff at the start of each semester. You will be informed about these sessions by email. More information can also be found in the ‘My.SUPA and Videoconferencing’ section of this handbook.

#### If you have a specific issue, please contact your local GSMC representative or a member of local support. Their contact information can be found in the ‘SUPA Contacts’ section of this handbook.

#### How do I obtain a My.SUPA password and username?
To obtain a My.SUPA login, please go to the My.SUPA portal (http://my.supa.ac.uk) and click on the ‘Request a My.SUPA login’ link. Your new login and password will soon be emailed to you with instructions.

#### How do I reset my My.SUPA password or username?
You can reset them either by following the ‘Lost Password?’ link in the login box on the My.SUPA portal or by emailing admin@supa.ac.uk.

#### Who do I contact if I am having difficulty using My.SUPA to enrol (or unenrol) for courses?
If you encounter any difficulties while enrolling or unenrolling for courses on My.SUPA, please contact the SUPA Courses Office at: admin@supa.ac.uk.

#### How can I contact my lecturer?
The easiest way to do this is through My.SUPA. You can find your lecturer’s details in the Participants box in the front page of the course area.

#### What if I am unable to attend a SUPA lecture?
If you enrol on a SUPA course, you are expected to attend the lectures. If you are ill or find you have a conflicting obligation, please contact the SUPA Courses Office at admin@supa.ac.uk.

#### How can I obtain a copy of my SUPA transcript?
An electronic copy of your transcript is available on My.SUPA on the ‘Grades’ tab of your student profile. To obtain an official copy of your transcript certified by the SUPA Graduate School Director, please write to the SUPA Courses Office at: admin@supa.ac.uk.

#### Who can I contact if I have a general question about the SUPA Graduate School?
All general enquiries about the SUPA Graduate School should be addressed to the SUPA Courses Office at admin@supa.ac.uk.

#### Who is my local SUPA representative?
On the contacts page of this handbook, you can find the names of all SUPA GSMC representatives. Do not hesitate to contact them if you have any queries or issues regarding SUPA Graduate School.

#### Where can I find out about SUPA Events?
All SUPA-sponsored events, such as distinguished visitor lectures, are posted in the SUPA calendar (http://my.supa.ac.uk/calendar/) and the SUPA Events Forum (http://my.supa.ac.uk/mod/forum/). You may receive announcements to the Events Forum via email as well.

#### I am organizing an event, can SUPA help me fund it?
Yes. SUPA does offer some funding for conferences, meetings and distinguished visitors. Applications can be found at: http://www.supa.ac.uk/Graduate_School/Graduate_School.htm

All applications are reviewed by the Graduate School Management Committee (GSMC). Completed funding applications should be sent to admin@supa.ac.uk at least one week before a GSMC meeting to ensure they are included on the agenda. Please check the SUPA Calendar (on Page 4 of this handbook or at http://my.supa.ac.uk/calendar/) for dates of GSMC meetings in 2010/11. Applications must be made before the event occurs - retrospective funding is not available.

#### I am organising an event, can SUPA help me promote it?
Yes. As long as you are a SUPA member and your event is relevant to those working in Physics in Scotland, SUPA is happy to help with promotion. Please email admin@supa.ac.uk with a succinct description of your event and electronic copies of any promotional materials (such as flyers or posters) that you may have, and SUPA Central will work with you to promote your event.

#### Can SUPA help me fund my participation in an event or course not organised by SUPA?
Unfortunately, SUPA only provides funding for SUPA-sponsored and -organised events. If you are attending an event such as a summer school or conference not organised by SUPA, no funding is available.

#### Can I claim travel expenses from SUPA?
For SUPA events to which SUPA members must travel in order to attend (such as a residential course), SUPA usually covers travel expenses. Please check My.SUPA for information about specific events to find out whether travel expenses will be covered. In cases where travel expenses can be claimed, SUPA will cover reasonable costs, defined as: public transport or mileage on shared rides equivalent to public transport costs. If further expense claims are permitted for an event (such as meals or accommodation), this information will be posted on My.SUPA.

#### How do I claim back my expenses from a SUPA event?
To claim back expenses from a SUPA event, please submit a claim form at your local department’s finance office. SUPA Central does not process these claims, unless otherwise stated.

#### Can SUPA help me fund my PhD studies?
For students who have not yet begun their PhD studies, the SUPA Prize Studentship Competition awards a limited number of fully-funded PhD places within the SUPA participating universities. For more information about this and other funding options, please refer to the ‘Student Funding’ section of the handbook.

Unfortunately, for students who have already begun their PhD studies, no further funding sources exist within SUPA.
The SUPA Graduate School runs an extensive programme of Particle Physics courses to provide new graduate students with the necessary skills required to carry out research. The Particle Physics courses are divided into categories corresponding to whether the student is undertaking theoretical or experimental research, core lectures are compulsory for first year students in both areas.

Theory students are strongly recommended to attend all the ‘Common Core’ and ‘Theory Core’ courses. Experimentalists are strongly recommended to attend all the ‘Common Core’ and ‘Experiment Core’ courses. Theory students are also welcome to attend courses in the experiment core and vice versa. Students should discuss with their supervisor which optional courses they should attend.

### Semester One

**Group Theory (SUPAGTH)**

- **Lecturer:** Jack Laiho
- **Institution:** Glasgow
- **Schedule:** Friday 10:00-11:00

**Common Core**

**Course Description:**
This course will cover the fundamentals of group theory from a particle physics perspective. We will begin with the definition of a group and its reducible and irreducible representations, and then discuss some interesting groups within the context of particle physics, such as SU(N), SO(N), the Lorentz and Poincaré groups and supersymmetry. If time permits, we will go on to cover group weights and roots, Dynkin diagrams and exceptional groups. At the end of this course students should: understand the difference between Abelian and non-Abelian groups as well as the difference between reducible and irreducible representations of a group; be able to specify the set of the generators of the SU(2), SU(3), Lorentz and Poincaré groups and the elements of the corresponding Lie groups; be able to construct the simplest representations of the SU(2), SU(3), Lorentz and SU(5) groups; understand the relation between the fundamental and adjoint representations of the SU(2) and SU(3) groups and observed gauge bosons as well as quark and lepton states; be familiar with the isospin symmetry; understand the physical meaning of Clebsch-Gordan coefficients and be able to use them for the calculation of the matrix elements of different physical processes (in particular, scattering amplitudes); understand the role of the Casimir operators and their physical meaning in the case of the SU(2) and Poincaré groups; be familiar with the concept of the unification of strong and electroweak interactions and supersymmetry; be familiar with the definition of the Cartan subalgebra of Lie algebra and Clifford algebra.

**Accelerators (SUAPAACC)**

- **Lecturers:** Dino Jaroszynski and Mark Wiggins
- **Institution:** Strathclyde
- **Schedule:** Tuesday 14:00-15:00 & Thursday (Tutorial) 10:00-12:00

**Experimental Core. This course is cross-listed with the Nuclear and Plasma Theme.**

**Course Description:**
The course will cover the following topics: (i) overview and history of the field and outlook for future advances including the development of laser-driven accelerators, (ii) accelerator applications including medical imaging and oncology (iii) transverse and longitudinal beam dynamics outlining beam parameters and transport and the effect of beam quality on transport and focusing, (iv) non-linear beam dynamics including resonances, betatron motion and beam instabilities, (v) RF accelerating cavities including waveguide propagation, superconducting cavities and power delivery, (vi) beam line diagnostics for characterising beam parameters such as charge, transverse profile, energy spread and emittance.

**Quarks and Hadron Spectroscopy (SUPAQHS)**

- **Lecturer:** David Ireland
- **Institution:** Glasgow
- **Schedule:** This is an intensive course, running December 2-10, 2010. Please refer to the timetable for more information.

**Experimental Core. This course is cross-listed with the Nuclear and Plasma Theme.**

**Course Description:**
The course will cover the following topics: why are models necessary when you’ve got QCD, quark model predictions of hadronic states, properties of the nucleon and its resonances, “missing” baryonic resonances, pentaquarks - salutary lesson or crucial discovery, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.
Common Core. This is a final year undergraduate course organised by the University of Edinburgh.

Course Description:
The course will cover the following topics: classical Lagrangian field theory, Lorentz covariance of relativistic field equations, quantisation of the Klein-Gordon field, quantisation of the Dirac field, the electromagnetic field, interacting fields, Feynman diagrams. Tutorial support exclusive to the SUPA Graduate School will also be provided via electronic whiteboard, allowing students to access this support from their own SUPA Institution.

In the concluding part, Andrew Blue teaches about the fabrication of semiconductors. The main production techniques and their limitations are presented including lithography, additive and subtractive processes, etching, SiO2 layers and doping. Finally, the semiconductor processing facilities at the Glasgow Electrical Engineering Department are outlined. The course is self-contained and requires no prior knowledge of the field.
Flavour Physics (SUPAFLA)

Lecturer: Eduardo Rodrigues, Paul Soler

Institution: Glasgow

Schedule: Tuesday 16:00-17:00, Wednesday 14:00-15:00 & Thursday 16:00-17:00

Common Core. This course includes two lab sessions based in Glasgow which students will be required to attend in person.

Course Description:
Flavour Physics attempts to answer some of the most profound open questions in modern physics, such as how do we understand the pattern of masses in the Standard Model and the origin of CP violation. This introduction to Flavour Physics consists of two parts, dealing separately with Flavour Physics of the quark and lepton sectors. The Heavy Flavour Physics and CP Violation part of the course will cover the rather broad topic of CP violation in the quark sector, focussing on the main historic achievements and discoveries, and on recent issues related to the search for signatures of New Physics. We will begin by discussing introductory concepts such as the C, P and T symmetries, and the CPT Theorem. We will then examine the phenomenology of CP violation in the Standard Model, and in particular, the phenomenology and experiments relevant to the K, B and D systems, current CKM-Triangle constraints and prospects, and rare B decays. The main objective of the Neutrino Physics part of the course is to try to understand some of the properties of the neutrino, one of the most fascinating particles in the Standard Model. We will cover some of the historical aspects of neutrino physics, look at different models of neutrino mass, review the theory of neutrino interactions, review experiments to determine neutrino mass and finally look at the theory and experimental evidence for neutrino oscillations and the future outlook of neutrino physics, including the search for leptonic CP violations. After taking this course, students should: understand the basic concepts of C, P and T symmetries, the CPT Theorem and the phenomenology of CP violation; understand the historic importance of these concepts in the building of the Standard Model; be able to describe CP violation experiments dealing with K, B and D mesons and their different challenges; grasp the differences in the CP violation phenomenology of K, B and D mesons; understand the current constraints on, and prospects for, the CKM-Triangle; have a general understanding of the role of Flavour Physics and CP violation in the search for New Physics beyond the Standard Model; be able to describe historical aspects of neutrino physics, including beta decay, the discovery of each of the neutrino flavours and early theories for weak interactions (Fermi theory, V-A theory); understand the physics of Standard Model neutrino interactions (neutrino-electron scattering, neutrino-nucleon quasi-elastic and resonance scattering, neutrino-nucleon deep inelastic scattering); understand the origin of neutrino mass (Dirac and Majorana mass) and the see-saw mechanism; be able to describe experiments that measure directly the mass of the neutrino; be able to describe double beta decay experiments and their importance in determining the Majorana nature of the neutrino; understand the phenomenology of neutrino oscillations, including oscillations in matter (MSW effect); be able to describe neutrino oscillation experiments (solar neutrinos, atmospheric neutrinos, accelerator and reactor based oscillation experiments); be able to understand the role of future experiments in determining leptonic CP violation.

Collider Physics (SUPACOP)

Lecturer: Samir Ferrag, Victoria Martin & Andy Buckley

Institution: Edinburgh & Glasgow

Schedule: Thursday 10:00-11:00 & 15:00-16:00

Common Core

Course Description:
SUPACOP lectures provide the common core for all particle physics students in Semester 2. The objective of the course is to provide a general overview of theoretical, phenomenological and experimental aspects of electroweak theory, QCD and BSM, concentrating on recent and future measurements from colliders. Topics covered will include collider basics, such as triggering and reconstruction, results from LEP on W and Z bosons, e+e- to hadrons and Higgs searches; top, W physics and Higgs searches at hadron colliders, deep inelastic scattering, parton density functions, jets and QCD results from HERA and hadron colliders. We will also look forward to BSM searches at the LHC. The BSM part of the course will introduce the concept of supersymmetry, and supersymmetry breaking. The minimal supersymmetric standard mode (MSSM) will be introduced and motivated. Finally, the most important collider signatures of the MSSM will be presented. At the end of the course, we expect students to be familiar with basics of collider physics and the theoretical and experimental aspects of QCD, Electroweak and MSSM physics.

Discussion Classes (SUPADCL)

Lecturers: Aidan Robson & Franz Muheim

Institution: Edinburgh & Glasgow

Schedule: Wednesday 11:00-13:00 & Friday 10:00-12:00

Common Core

Course Description:
The aim of this course is to provide students with an opportunity to investigate current topics of interest and present them in an informal atmosphere. Intended outcomes are to research a specific topic based on publication literature and preprints, to expand in some detail work that is relevant to one’s thesis topic, to convey details to an audience of non-experts and to be able to field questions on a newly researched topic competently.
Modern Quantum Field Theory (SUPAMQF)

Lecturer: Roger Horsley  
Institution: Edinburgh  
Schedule: Monday & Thursday 12:00-13:00  
Hours Equivalent Credit: 20  
Assessment: Continuous Assessment  

Course Description:
The course introduces path integral methods in Quantum Field Theory. This modern approach (as opposed to canonical quantisation) allows the relatively simple quantisation of gauge theories and forms an essential tool for the understanding and development of the Standard Model of particle physics. Topics include the path integral formalism, Feynman rules, the LSZ formalism, loop diagrams and divergences, regularisation and renormalisation, gauge theories and the running coupling constant. Upon successful completion of this course it is intended that a student will be able to: understand the notion of a path integral in quantum mechanics and field theory, be familiar with Grassmann numbers and their use for fermions in path integrals, understand the connection between the path integral formalism and the operator (scattering) formalism, understand perturbation theory and appreciate Feynmann rules, and diagrams from the path integral viewpoint, be familiar with the problem of divergencies in quantum field theories and the renormalisation method, appreciate the fundamental result of asymptotic freedom of the running coupling constant in non-abelian gauge theories leading to a theory of strong interactions - QCD, be able to apply what has been learned in the course to solve simple problems in quantum field theory.

Lattice QCD (SUPALAT)

Lecturer: Christine Davies  
Institution: Glasgow  
Schedule: Tuesday 10:00-11:00 (& 3 extra slots see Timetable for information)  
Hours Equivalent Credit: 10  
Assessment: Project

Course Description:
The course will provide an introduction into the methods of lattice QCD. In particular, we will discuss gluon actions, algorithms, quarks on the lattice, algorithms for that, how to do a lattice calculation, systematic errors and recent results.
The Nuclear and Plasma Physics (NPP) theme covers a wide range of subject areas, including a number of different specialities. Depending on their individual backgrounds and areas of research, each PhD student will therefore be required to attend a different set of SUPA courses. The decision on which courses to include should be made in consultation with the student’s PhD supervisor. Typically, a two year course program will include:

- Specific NPP lectures taken from the list below
- Core skills classes such as C++ programming and Data Analysis, where appropriate
- Transferable skills courses such as the Entrepreneurship course

During their course of study, it is anticipated that students may also wish to attend lectures outwith their direct line of research. Whilst deciding on which courses to attend, careful note should be made by students and their supervisors as to which courses they wish to be assessed on.

### Semester One

#### Plasma Physics (SUPAPPH)

<table>
<thead>
<tr>
<th>Lecturers: Alan Phelps et al.</th>
<th>Hours Equivalent Credit: 12</th>
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</thead>
<tbody>
<tr>
<td>Institutions: Strathclyde, Glasgow, Heriot-Watt</td>
<td>Assessment: Continuous Assessment and Multiple Choice Exam</td>
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<tr>
<td>Schedule: Wednesday 10:00-11:00 &amp; Thursday 14:00-15:00</td>
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**Course Description:**

This course will address fundamental concepts in plasmas, from plasma creation from a neutral gas through to full ionization. Basic plasma time-scales and length scales will be derived, such as the plasma, cyclotron and collision frequencies, skin depth, sheath extent and Larmor radius. Waves and instabilities in fully ionized (and magnetized) fluid and kinetic plasmas will also be addressed. The many natural and man-made types of plasma and their applications will be outlined and in particular magnetically confined plasmas will be discussed with examples, including tokamaks. Finally, driven plasma systems (such as microwave and rf plasmas) will be discussed, along with possible applications.

#### Quarks and Hadron Spectroscopy (SUPAQHS)

<table>
<thead>
<tr>
<th>Lecturer: David Ireland</th>
<th>Hours Equivalent Credit: 7</th>
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</thead>
<tbody>
<tr>
<td>Institution: Glasgow</td>
<td>Assessment: Continuous Assessment</td>
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<tr>
<td>Schedule: This is an intensive course, running December 2-10, 2010. Please refer to the timetable for more information.</td>
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</table>

*This course is cross-listed with the Particle Physics Theme.*

**Course Description:**

The course will cover the following topics: why are models necessary when you’ve got QCD, quark model predictions of hadronic states, properties of the nucleon and its resonances, “missing” baryonic resonances, pentaquarks - salutory lesson or crucial discovery, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.

#### Superheavy Nuclei (SUPASHN)

<table>
<thead>
<tr>
<th>Lecturer: Andrei Andreyev</th>
<th>Hours Equivalent Credit: 6</th>
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</thead>
<tbody>
<tr>
<td>Institution: UWS</td>
<td>Assessment: Continuous Assessment</td>
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<tr>
<td>Schedule: Wednesday 09:00-10:00</td>
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</table>

**Course Description:**

The course starts with a historic introduction on when and how man-made Super-Heavy Elements (SHE) have been produced in different Labs (1 lecture). It will be followed by a review of main production mechanisms and their limitations (1 lecture). The core of the course (3 lectures) will then discuss modern recoil separators and detection techniques being used for SHE production. Correlation analysis and evaluation of probability for random events will be discussed which are crucial issues when a discovery of a new element is claimed. The final lecture will discuss chemistry of SHE and new methods recently proposed for their production.

#### Accelerators (SUPAACC)

<table>
<thead>
<tr>
<th>Lecturers: Dino Jaroszynski and Mark Wiggins</th>
<th>Hours Equivalent Credit: 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution: Strathclyde</td>
<td>Assessment: Continuous Assessment</td>
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<tr>
<td>Schedule: Tuesday 14:00-15:00 &amp; Thursday (Tutorial) 10:00-12:00</td>
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</table>

*Experimental Core. This course is cross-listed with the Particle Physics Theme.*

**Course Description:**

The course will cover the following topics: (i) overview and history of the field and outlook for future advances including the development of laser-driven accelerators, (ii) accelerator applications including medical imaging and oncology (iii) transverse and longitudinal beam dynamics outlining beam parameters and transport and the effect of beam quality on transport and focusing, (iv) non-linear beam dynamics including resonances, betatron motion and beam instabilities, (v) RF accelerating cavities including waveguide propagation, superconducting cavities and power delivery, (vi) beam line diagnostics for characterising beam parameters such as charge, transverse profile, energy spread and emittance.
Nuclear Instrumentation (SUPANIN)

**Lecturer:** Tom Davinson  
**Institution:** Edinburgh  
**Hours Equivalent Credit:** 6  
**Assessment:** Continuous Assessment  
**Schedule:** Monday 10:00-11:00/12:00 (Some lectures two hours long, refer to timetable for more information.)

**Course Description:**
The objective of this short course of lectures is to provide students with an insight into state-of-the-art nuclear instrumentation technology and techniques - particular emphasis will be given to topics either not found, or not well-covered, in the standard textbooks. Topics will include: noise, interference, grounding and other black arts, the origins of detector energy and time resolution, ASICS, data acquisition and analysis, and digital signal processing.

Laser Driven Plasma Acceleration (SUPALDP)

**Lecturer:** Dino Jaroszynski, Paul McKenna, Brian McNeil  
**Institution:** Strathclyde  
**Hours Equivalent Credit:** 16  
**Assessment:** Continuous Assessment  
**Schedule:** Tuesday & Friday 14:00-15:00

**Course Description:**
The course will address the topical research in laser-plasma interactions, laser-plasma acceleration and plasma based radiation sources. It will be divided into four connected parts starting with a thorough but brief introduction to the main theoretical concepts of laser-plasma interactions. The second and third parts will address the interaction of intense laser pulses with underdense and overdense plasma, respectively, with particular emphasis on laser-plasma acceleration, absorption, propagation, electron transport, plasma waves, shock waves, radiation mechanisms, non-linear optics of plasma etc. The fourth part will introduce students to the main concepts of free-electron lasers, which are important tools for scientists investigating the structure of matter. Students will proceed quickly from basic concepts to advanced and current applications such as compact radiation and particle sources, inertial fusion energy, fast ignition etc. They will gain a good introduction to laser-plasma interactions, which will provide a good basis for postgraduate research in this area.

Nuclear Reaction Theory & Nuclear Forces (SUPANRT)

**Lecturer:** Dan Watts  
**Institution:** Edinburgh  
**Hours Equivalent Credit:** 6  
**Assessment:** Continuous Assessment  
**Schedule:** This is an intensive course running January 12-14, 2011. Please refer to the timetable for more information.

**Course Description:**
This course will assume an undergraduate level knowledge of nuclear physics and quantum mechanics and will describe various theoretical descriptions of nuclei and nuclear reactions at a level relevant to a postgraduate experimental physicist. The course will introduce students to the theoretical formalisms commonly encountered in the field of nuclear and hadron physics. The students will understand basic models of nuclear structure (liquid drop model and Fermi gas model), be able to explain the origin of nuclear shapes and excitation modes, be able to outline the theoretical description of the Nucleon-Nucleon potential from boson field theory, be able to understand the terms used to parameterise phenomenological NN potentials, show understanding of the role of three-nucleon forces in the nucleus, outline the theoretical formalism for describing elastic and inelastic scattering reactions, understand the classification of reactions as compound, direct or pre-equilibrium, show understanding of the process of partial wave analysis and phase shifts in reaction theory, understand the reaction theories describing fission and fusion and their application in nuclear energy generation.

The Nuclear Fuel Cycle (SUPANFL)

**Lecturer:** David Hamilton  
**Institution:** Glasgow  
**Hours Equivalent Credit:** 5  
**Assessment:** Continuous Assessment  
**Schedule:** Monday 09:00-10:00

**Course Description:**
With policy makers around the world considering a nuclear renaissance as one of the possible solutions to society’s low-carbon energy needs in the medium-term, this course will provide an introduction to the nuclear fuel cycle. Covering the technical aspects of nuclear power production at an introductory level, the course will cover radiation interactions, reactor and fuel cycle technology and core physics. In addition, as any discussion of the nuclear fuel cycle is incomplete without some consideration of the economic, industrial and policy dimensions, the course will cover some of the most important non-technical aspects associated with nuclear energy. The course is intended for students with an interest in nuclear technology, whether as a possible future career path or simply for general interest. Specialist knowledge in nuclear or particle physics is not required for this course.
The theme of Physics and Life Sciences (PaLS) covers a large breadth of both the physical and life sciences. As students come from a wide range of backgrounds and experiences, and are pursuing diverse PhD projects, the exact courses to be taken should be discussed with the student's individual supervisor. Students are invited to select any relevant courses from any of the themes. Students are also invited to take appropriate and relevant non-SUPA courses within their home institution, but it is essential that appropriate assessment (in the form of examination, written assignment or oral assignment) be discussed and agreed with the PaLS Theme Leader (Cait MacPhee) in advance.

**Semester One**

**Physics & Life Sciences Introductory Biology School (SUPAIBS)**

- **Lecturer:** Cait MacPhee  
  - **Hours Equivalent Credit:** 15  
  - **Institution:** St Andrews  
  - **Assessment:** A short written assignment, to be submitted within two weeks.

**Scheduling:** This is a residential course run August 30-September 2, 2010.

**Enrolment:** Please contact the SUPA Courses Office at admin@supa.ac.uk as early as possible to reserve your place. The course will not be open for online enrolment and it will be restricted to 10 places.

**Course Description:**

Students entering the PaLS theme come from a variety of backgrounds, and your needs as graduate students are enormously varied. Some of you will be handling biological materials, some will be carrying out molecular experimental projects, and some will be involved almost entirely with theory or simulation. In order to be productive PhD students, however, all students need a basic grounding in Biology and the challenges of biological research. This short course is designed to give you a taster, an exposure to the language of biology, taught by biologists with extensive experience of working at the interface with the physical sciences.

The Summer School will consist of three half-days of lectures from members of the School of Biology at St Andrews that will cover the very basics (the structure of a cell, cellular contents, and how they can be manipulated). The rest of the course will consist of two half-day practical sessions, covering the basics of handling and manipulating biological cells, performing useful microscopy, and taking quantitative measurements. Many of you coming into the PaLS theme are likely to need to handle some biological materials (e.g. for microscopy or related applications), and we aim to teach you how to keep cells alive, or if tissues or samples are fixed, what to look for to ensure samples are of good quality. For those students undertaking non-experimental programmes, we hope that this exposure will demonstrate the “messy” nature of biological experiment and its associated inherent uncertainty.

**Mathematical Modelling (SUPAMMD)**

- **Lecturer:** Marco Thiel  
  - **Hours Equivalent Credit:** 16  
  - **Institution:** Aberdeen  
  - **Assessment:** Continuous Assessment  
  - **Schedule:** Wednesday & Friday 10:00-12:00

*This is a final year undergraduate course organised by the University of Aberdeen.*

**Course Description:**

Physical Sciences intend to describe natural phenomena in mathematical terms. This course bridges the gap between standard courses in physical sciences, where successful mathematical models are described, and scientific research, where new mathematical models have to be developed. Students will learn the art of mathematical modelling, which will enable them to develop new mathematical models for the description of natural systems. Examples from a wide range of phenomena will be discussed, e.g., from biology, ecology, engineering, physics, physiology and psychology.

A focus will be the critical interpretation of the mathematical models and their predictions. The applicability of the models will be assessed and their use for the respective branch of the natural sciences will be discussed.

Many different modelling techniques (ODEs, PDEs, cellular automata, stochastic models (stochastic DE, TASEP and ARMA), network based models, etc) will be taught and actively applied to different areas in physical and life sciences.

The topic of the modelling project will be agreed upon jointly by the student and the lecturer; it might well be related to the postgraduate work of the student.
Astrobiology & the Search for Life (SUPAASL)

**Lecturer:** Jane Greaves, Helen Fraser, Alan Penny, Ken Rice  
**Institution:** St Andrews & Strathclyde  
**Schedule:** Wednesday 14:00-15:00 & Friday 12:00-13:00  
**Hours Equivalent Credit:** 20  
**Assessment:** Online multiple choice test

*This course is cross-listed with the Astronomy & Space theme.*

**Course Description:**
This core course will introduce subjects relating to the potential and search for life in the universe. It is taught by a number of subject experts, with lectures in a seminar style allowing presentation of cutting-edge research questions and an interactive environment for students to pose their own questions.

Aims and objectives: To provide a broad perspective on astrobiology, including geology, biology and chemistry at an introductory level from an astronomical perspective; To give an appreciation of the conditions for life on Earth and how these may apply elsewhere in the universe; To understand the broad interdisciplinary nature of astrobiology; To have a critical outlook on the search for life and why current scientific (and political) approaches are made to the problem.

Learning outcomes: A working knowledge of the basics of the areas taught and their terminology - understanding how scientific methodologies are applied in subjects other than astronomy - appreciation of how to formulate very broad questions in research and how this could be applied to the detail in the student’s own work. Differentiating between scientific and non-scientific modes of investigation; identifying hidden assumptions; the dangers of taking mathematical rigour, in itself, for scientific truth; identifying the differences between trivial and significant studies; and understanding the sociological pressures and biases present in all branches of science. Reading lists are provided in each lecture for students wishing to undertake further study.

Syllabus: The requirements for life on Earth, in terms of extraction of energy, chemical pathways etc. Limits for life in extreme conditions; evidence for earliest life on Earth and where it originated. Drivers of evolution, survivability of changes in conditions, and how this might apply in non-Earth environments. Analogous niches for life elsewhere in the Solar System, including Mars and icy moons of the giant planets. Origins of the chemistry needed for life: interstellar molecules and transmission of chemical complexity to planets. The formation of planetary systems and carriage of 'life conditions' through the star and planet forming process. Discovery methods for extrasolar planets; diversity of known exo-planet systems and what niches for life could exist; problems different to those on Earth such as tidal locking and day/night temperature extremes. Future exo-planet detection methods and missions, and the prospects for discovering an exo-Earth analogue and investigation of its life-signs. A scientific grounding for thinking about the Search for Extra-Terrestrial Intelligence (SETI), what kinds of civilization and communication might exist, the Drake equation, the Fermi paradox, time-scales for our own civilization, and consequences of detecting other cultures to our society. Current searches for life in the radio/optical regions. Technicalities of interstellar travel.

Assessment: By online multiple-choice test after the end of the course, on a pass/fail basis. Students will need to demonstrate understanding of the fundamental points of each lecture. All lecture notes will be available online for revision and personal study to catch up if any lectures are missed. NB: no resit permitted.

Both Semesters

Physics & Life Sciences Short Research Project (SUPASRP)

**Advisor:** Cait McPhee  
**Institution:** Various SUPA Institutions  
**Scheduling:** 3 months during Year 1 or 2  
**Hours Equivalent Credit:** 40+  
**Assessment:** A short thesis, to be submitted within one month of completing the project.

**Course Description:**
Students in the PALS theme should aim to be working closely with collaborators from the Life Sciences. The purpose of this project is to allow students to immerse themselves in a Life Science laboratory for three months, learning the techniques and language of biological research and networking with their peers. The research undertaken should be relevant to the proposed area of PhD study since the duration of PhD funding cannot be extended. Projects will be offered by appropriate research laboratories in Life Science disciplines, often but not always to align with existing programmes and collaborations. The existence of an existing collaboration between research groups is not a requirement.

Students will undertake a self-contained well-defined research project, and write a short thesis describing the background, methods, and outcome of their work, appropriate for an interdisciplinary audience. Individual project descriptions will be posted on the SUPA website. Projects MUST be approved by the Graduate School Management Committee in advance, but project proposals may be put forward at any time.
Astronomy and Space Physics covers a wide range of topics aimed at broadening students' knowledge and interests. The courses range from advanced extensions of subjects covered at undergraduate level to introductions to new interdisciplinary sciences. It is recommended to take a mixture of core material, advanced courses (usually 16 - 20 Hours Equivalent Credit) plus more general topics including computing and data reduction modules, to gain a broad grounding in astronomical methods and modern research areas.

Each course is self-contained, although background reading or another SUPA course may be recommended to bring students from various backgrounds up to speed. Students from other theme areas are very welcome to take Astronomy and Space physics courses, with particular modules likely to be of interest for Life Sciences and Plasma Physics, but you should remember that some basic understanding of astronomy and astronomical terms will be assumed by the lecturers.

A typical programme, building to the core requirement of 40 hours of Technical Courses, would include:

- **A SUPA core Astronomy course** (these generally constitute 16 - 20 Hours Equivalent Credit)
- **A core SUPA course in another field or a second Astronomy course**
- **Non-SUPA courses as appropriate** (e.g. for students changing speciality)

### Summer schools in Astronomy and Space Physics

Astronomy students should note that certain Astro courses only run biannually (e.g. Advanced Astronomical Techniques, which focuses on observational astronomy runs this year then 2012/13). Each student must consult their PhD supervisor to construct a suitable programme before registering, and students are encouraged not to over-register. The 40-hour course requirement is taken over the first and second years, although students from all years can take extra subjects for interest.

In 2010/11 a SUPA Astro orientation will be held in early October, specifically to introduce the SUPA Astro courses and the lecturers to you, and assist with your choices. We encourage all Astro staff and new students to attend - with pizza and beer as an ice-breaker.

#### Semester One

**Gravitational Wave Detection (SUPAGWD)**

- **Lecturers:** Giles Hammond et al
- **Institution:** Glasgow
- **Schedule:** Monday & Wednesday 16:00-17:00

**Course Description:**

This course is for students interested in the physics of gravitational wave detection. Starting from the fundamentals of Einstein’s General Theory of Relativity, the wave nature of weak field spacetime curvature perturbations will be derived in the transverse traceless gauge. Interactions of gravitational radiation with matter will be explored, leading to the basic principles of gravitational wave detectors. Astrophysical sources of gravitational waves will be discussed, including expectations for source strengths from coalescing compact binary systems, pulsars, etc. A full description of currently operating detectors will include instrumental noise sources, such as thermal, seismic, optical, and the standard quantum limit. Current topics discussed will include squeezing, and other non-classical light techniques for reducing optical noise in interferometric systems. Plans for detectors on the ground and in space will be presented, ending with a discussion of data analysis techniques. Proposed Assessment Method: a dissertation (or design study), of approximately 2000 words, on a current topic in gravitational wave research, to be submitted at the end of the course. Example topics include: thermal noise reduction, applications of non-classical light techniques, applications of optimal filtering techniques, applications of Bayesian inference in data analysis, astrophysical applications of gravitational wave sources. A twenty minute oral exam for each student at the end of the course. Equal weighting would be given to the two assessment areas.

#### Semester Two

**Advanced Cosmology (SUPAACO)**

- **Lecturer:** John Peacock
- **Institution:** Edinburgh
- **Schedule:** Tuesday & Friday 15:00-16:00

*This is a final year undergraduate course organised by the University of Edinburgh.*

**Course Description:**

The course will begin by reviewing basic tools and equations. In-depth studies will follow of the hot big bang, including structural effects and nucleosynthesis; inflation, addressing initial conditions, mathematical solutions, and the wide variety of possible models; and the formation of structure, emphasizing gauge issues, perturbations and varied approaches to the problem (Lagrangian, N-body simulation). Statistical cosmology will be introduced via tools such as N-point correlations and redshift space, leading into the study of fluctuations by methods including tensor modes. Anisotropy of the cosmic microwave background and its effects will then be considered in depth. Recent developments in gravitational lensing and dark matter, the nature of dark energy, and the formation of galaxies will be discussed, and the course will end with some new views on anthropics and the multiverse.
**Astrobiology & the Search for Life (SUPAASL)**

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Jane Greaves, Helen Fraser, Alan Penny, Ken Rice</th>
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<tr>
<td>Institution:</td>
<td>St Andrews &amp; Strathclyde</td>
</tr>
<tr>
<td>Schedule:</td>
<td>Wednesday 14:00-15:00 &amp; Friday 12:00-13:00</td>
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This course is cross-listed with the Physics and Life Sciences theme.

**Course Description:**

This core course will introduce subjects relating to the potential and search for life in the universe. It is taught by a number of subject experts, with lectures in a seminar style allowing presentation of cutting-edge research questions and an interactive environment for students to pose their own questions.

Aims and objectives: To provide a broad perspective on astrobiology, including geology, biology and chemistry at an introductory level from an astronomical perspective; To give an appreciation of the conditions for life on Earth and how these may apply elsewhere in the universe; To understand the broad interdisciplinary nature of astrobiology; To have a critical outlook on the search for life and why current scientific (and political) approaches are made to the problem.

Learning outcomes: A working knowledge of the basics of the areas taught and their terminology - understanding how scientific methodologies are applied in subjects other than astronomy - appreciation of how to formulate very broad questions in research and how this could be applied to the detail in the student's own work. Differentiating between scientific and non-scientific modes of investigation; identifying hidden assumptions; the dangers of taking mathematical rigour, in itself, for scientific truth; identifying the differences between trivial and significant studies; and understanding the sociological pressures and biases present in all branches of science. Reading lists are provided in each lecture for students wishing to undertake further study.

Syllabus: The requirements for life on Earth, in terms of extraction of energy, chemical pathways etc. Limits for life in extreme conditions; evidence for earliest life on Earth and where it originated. Drivers of evolution, survivability of changes in conditions, and how this might apply in non-Earth environments. Analogous niches for life elsewhere in the Solar System, including Mars and icy moons of the giant planets. Origins of the chemistry needed for life: interstellar molecules and transmission of chemical complexity to planets. The formation of planetary systems and carriage of 'life conditions' through the star and planet forming process. Discovery methods for extrasolar planets; diversity of known exo-planet systems and what niches for life could exist; problems different to those on Earth such as tidal locking and day/night temperature extremes. Future exo-planet detection methods and missions, and the prospects for discovering an exo-Earth analogue and investigation of its life-signs. A scientific grounding for thinking about the Search for Extra-Terrestrial Intelligence (SETI), what kinds of civilization and communication might exist, the Drake equation, the Fermi paradox, time-scales for our own civilization, and consequences of detecting other cultures to our society. Current searches for life in the radio/optical regions. Technicalities of interstellar travel.

Assessment: By online multiple-choice test after the end of the course, on a pass/fail basis. Students will need to demonstrate understanding of the fundamental points of each lecture. All lecture notes will be available online for revision and personal study to catch up if any lectures are missed. No re-sit permitted.

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**Advanced Astronomical Techniques (SUPAAAT)**

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Wayne Holland, et.al.</th>
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</thead>
<tbody>
<tr>
<td>Institution:</td>
<td>Glasgow, Edinburgh and ATC</td>
</tr>
<tr>
<td>Schedule:</td>
<td>Tuesday 14:00-15:00 &amp; Thursday 10:00-11:00</td>
</tr>
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</table>

**Course Description:**

Astronomy is entering an era when some of the most fundamental questions in science will be addressed such as how do galaxies, stars and planets form and evolve? To answer these Origins questions require new facilities such as 30-m class ground-based telescopes and advanced space observatories with highly sophisticated instruments that are not only able to image the faintest objects but to study their spectra and learn about their composition. Furthermore, new wavebands are emerging, such as the far-IR and submillimetre, which are crucial to study the optically obscured objects that are embryonic galaxies and stars. The SUPA lecture course on Advanced Astronomical Technology aims to bring to the fore the current ideas and designs behind the new technology advancements that are needed to address the big questions in astronomy.
The programme offered within the Photonics theme involves a selection of lecture courses which we hope will be of interest to you. Additionally there are opportunities to take part in some distance learning courses. It may also be useful for you to look at courses offered through the other themes, especially Condensed Matter and Material Physics, and the Inter-theme courses. Students are also encouraged to attend Photonics related seminars hosted across Scotland.

Semester One

Photonic Crystals & Plasmonics (SUPAPTC)

Lecturer: Thomas Krauss  
Institution: St Andrews  
Schedule: Wednesday & Friday 11:00 - 12:00  
Hours Equivalent Credit: 12  
Assessment: Exam  

This is an MSc course organised by the University of St Andrews.

Course Description:
Nanostructured materials such as photonic crystals or plasmonic metamaterials are very hot topics in contemporary photonics. The fascination arises from the fact that the properties of these materials can be designed to a significant extent via their structure. While photonic crystals are made of dielectric materials, plasmonic structures are typically made of metals. Many of the properties of these nanostructured materials can be understood from their dispersion diagram or optical bandstructure, which is a core tool that will be explored in the course. Familiar concepts such as multilayer mirrors and interference effects will be used to explain the more complex features such as slow light propagation and high Q cavities in photonic crystal waveguides, supercontinuum generation in photonic crystal fibres, or superlensing and optical cloaking in plasmonic metamaterials.

Polymer and Liquid Crystal Displays (SUPAPLC)

Lecturer: Graham Turnbull  
Institution: St Andrews  
Schedule: Distance Learning  
Hours Equivalent Credit: 13  
Assessment: Continuous Assessment  

Course Description:
This module describes the materials science and device physics that underpins modern display technologies. The module is delivered in a distance learning format. The syllabus includes an overview of types of displays and characterisation of display properties. The module then focuses on two contemporary display technologies: liquid crystals and organic semiconductors. Topics covered include:

Displays-types of displays, characterisation of display properties.

Semiconducting polymers - chemical structure; energy states; photoluminescence and electroluminescence. Factors determining OLED efficiency; light-emitting diodes and field effect transistors. Dendrimer OLEDs

Liquid crystals - nematic, smectic and cholesteric phases; director and order-parameter; splay, twist and bend distortions; anisotropy and birefringence; operation of twisted nematic display
Semester Two

**Optical Control (SUPAOCO)**

**Lecturer:** Miles Padgett & Johannes Courtial  
**Institution:** Glasgow  
**Schedule:** Monday & Thursday 16:00-17:00

**Course Description:**
The course will cover the following topics: optical fractals and the imaging properties of laser resonators, holography with light and cold atoms, spatial light modulators; how they work and their applications, algorithms for designing holograms and diffractive optics, optical momentum, linear and angular, optical vortices, the inherent features of light, optical spectroscopy, application to ultra-sensitive gas detection, optical uncertainty relationships, optical down conversion, a tool for quantum entanglement, optical tweezing.

The assessment will be short essays discussing points raised by the lecturers (should take about 1 hour to complete).

**Quantum Optics (SUPAQOP)**

**Lecturer:** Daniel Oi  
**Institution:** Strathclyde  
**Schedule:** Monday 11:00-12:00 & Tuesday 10:00-11:00

This is a final year undergraduate course organised by the University of Strathclyde.

**Course Description:**
A first course in quantum optics. Students should know classical electromagnetism and quantum mechanics before attending this course. Topics covered: quantum harmonic oscillator, field quantisation, photons, number states, coherent states, phase, beam splitters and interference experiments with photons, wave-particle duality, nonclassical light, interaction of light with two-level atoms, emission and absorption of radiation and the Jaynes-Cummings model.

**Quantum Information (SUPAQIN)**

**Lecturer:** Steve Barnett  
**Institution:** Strathclyde  
**Schedule:** Monday 15:00-16:00 & Tuesday 12:00-13:00

**Course Description:**
The aim of this course is to give a coherent introduction to the theoretical concepts involved in the new discipline of quantum information. The following topics will be covered: Probability and Information, Elements of Quantum Theory, Quantum Cryptography, Generalised Measurements, Entanglement, Quantum Information Processing, Quantum Information Theory.

**Ultrafast Photonics (SUPAUPH)**

**Lecturer:** Derryck Reid  
**Institution:** Heriot-Watt  
**Schedule:** Distance Learning

**Course Description:**
Condensed Matter and Material Physics

Condensed Matter and Material Physics (CMMP) is a diverse subject covering many different specialities and attracts PhD students with a wide range of backgrounds, with different balances of theoretical and practical training. The program of study is therefore tailored individually for each student, in consultation with his or her PhD supervisor. The overall range and level of courses offered aims to introduce students to subject areas outside the immediate confine of their thesis research, as well as providing more specialist knowledge directly relevant to each dissertation. It is envisaged that during the first two years of study every student will complete a minimum of two physics-content courses, at least one summer school, plus at least one module covering transferable skills. A typical program will comprise the following elements:

- **CMMP courses organised by SUPA**: These are either graduate-specific or advanced masters courses made available to all centres over the SUPA videoconferencing network. Courses offered are listed below and form the backbone of the CMMP graduate school programme.

- **Intertheme courses organised by SUPA**: Those of particular interest to CMMP students include Advanced Data Analysis and courses in different programming languages such as C++ and Python.

- **Non-SUPA course** as appropriate (eg for students changing speciality).

- **Summer schools**: Examples of appropriate summer schools include ‘Physics by the Lake’ (Ambleside, Cumbria) for those with an interest in theory and HERCULES (Grenoble, France) for those doing research involving neutron and x-ray scattering at central facilities.

- **Transferable skills modules**.

- **Courses offered by other themes**.

## Semester One

### Advanced Statistical Mechanics (SUPAASM)

**Lecturers**: Davide Marrenduzo & Alexander Morozov  
**Institution**: Edinburgh  
**Schedule**: Monday & Thursday 15:00-16:00  
**Hours Equivalent Credit**: 20  
**Assessment**: Project Report

*This is a final year undergraduate course organised by the University of Edinburgh.*

**Course Description:**  
In this course we will discuss equilibrium phase transition, of the first and second order, by using the Ising and the Gaussian models as examples. We will first review some basic concepts in statistical physics, then study critical phenomena. Phase transitions will be analysed first via mean field theory, then via the renormalisation group (RG), in real space. We will conclude with some discussion of the dynamics of the approach to equilibrium.

### Computational Chemistry (SUPACCH)

**Lecturers**: Herbert Fruchtl, Carole Morrison, Patricia Richardson, Tanja Van Mourik, Michael Buehl, John Mitchell  
**Institutions**: Edinburgh & St Andrews  
**Schedule**: Wednesday 13:00-14:00  
**Hours Equivalent Credit**: 9  
**Assessment**: Continuous Assessment

**Course Description:**  
This course will provide an introduction to practical computational chemistry techniques. The focus is on an introduction to the current state-of-the-art computational chemistry codes with the theory behind them. Ab initio, DFT and classical methods will all be introduced along with how they are used in practice by researchers in Scotland.
# Quantum Phase Transitions (SUPAQPT)

**Lecturer:** Chris Hooley  
**Institution:** St Andrews  
**Schedule:** Tuesday 15:00 -16:00 & Friday 14:00-15:00  
**Hours Equivalent Credit:** 12  
**Assessment:** Continuous Assessment

**Course Description:**
A classical phase transition is a disjunctive change of the state of matter driven (usually) by a change in temperature. Even if the underlying Hamiltonian is quantum mechanical, thermal fluctuations cut off the dynamics, so that sufficiently close to the transition a classical theory can always be used.

A quantum phase transition, by contrast, occurs (in the idealised case) at zero temperature as the result of the variation of some other control parameter: pressure, magnetic field, and chemical doping are the three most common examples. The effects of such quantum phase transitions are visible over quite a wide area of the phase diagram, and include anomalous power-law behaviour in physical response functions such as resistivity, specific heat, and magnetic susceptibility.

This course is a brief introduction to the experimental data and theoretical work on quantum phase transitions. It includes: a survey of experiments; Landau-Ginzburg theory; quantum phase transitions in insulators; and the Hertz-Millis theory for quantum phase transitions in metals.

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# Theoretical Nanophysics (SUPATNP)

**Lecturer:** Misha Titov  
**Institution:** Heriot Watt  
**Schedule:** Monday & Tuesday 9:00-10:00  
**Hours Equivalent Credit:** 24  
**Assessment:** Continuous Assessment

**Course Description:**
This course will focus on the theoretical description of nanophysics and nanodevices where the small size plays a crucial role in determining their properties and behaviours. The fundamental aim is to provide the students with a working knowledge of contemporary theoretical nanophysics. The course explains how nanophysical phenomena can be modelled and predictions for behaviour made. The course will begin with a review of solid state basics. The following topics will be covered: correlations & coulomb effects in nanostructures; coulomb blockade; coherent transport and Landauer-Büttiker formalism; density functional theory for nanostructures. On completion of this module, the learner will be able to: demonstrate a detailed knowledge and understanding of semiconductor quantum devices; integrate previous knowledge from physics courses with the topics discussed in the module; analyse advanced problems in nanophysics.

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# Experimental Nanophysics (SUPAENP)

**Lecturer:** Brian Gerardot  
**Institution:** Heriot Watt  
**Schedule:** Tuesday 10:00-11:00 & Wednesday 12:00-13:00  
**Hours Equivalent Credit:** 24  
**Assessment:** Continuous Assessment

**Course Description:**
This course will focus on the emerging techniques and ideas of nanophysics where the small size of systems plays a crucial role in determining their properties and behaviours. The fundamental aim is to provide the students with a working knowledge of contemporary nanophysics. The course explains how such structures can be fabricated, characterized, manipulated and understood. The focus is on the quantum aspects of the behaviour, properties not shared with more conventional condensed matter systems. The course will cover quantisation effects, fabrication of nanostructures, optical and electron microscopy, scanning tunnelling and atomic force microscopy, carbon nanotubes & graphene. On completion of this course, the learner will be able to: achieve a critical knowledge and understanding of nano-scale devices, their fabrication and characterization; demonstrate a detailed knowledge and understanding of advanced concepts and applications in the nano-scale regime; integrate previous knowledge from physics courses with the topics discussed in the module; analyse advanced problems in nanophysics.
Course Description:
This course will primarily involve a combination of directed reading and presentations by the participants on topics chosen from Chapters 1-6 of the graduate text ‘Principles of Condensed Matter Physics’ by P. Chaikin and T. Lubensky (Cambridge University Press). The course will also entail problem classes which will be held at Edinburgh, Heriot Watt and St Andrews on a rotating basis, in synchrony with CM-DTC group meetings. Assessment will be based on performance in both the student presentations and selected problems.

Course Description:
The aim of this course is to give an overview of developments in modern condensed matter physics. The difficulties of a full quantum mechanical treatment of electrons with strong interactions will be discussed. Common existing approaches such as the Hubbard and t-J models and Fermi liquid theory will be compared. It will be shown that, although microscopic models can explain aspects of magnetism, they have little chance of capturing many other features of the fascinating low energy physics of these systems. Instead, we introduce the principle of emergence, and show how it suggests radically new approaches to the problem of complexity in condensed matter physics and beyond.

Course Description:
The course will primarily involve a combination of directed reading and presentations by the participants on topics chosen from Chapters 1-6 of the graduate text ‘Principles of Condensed Matter Physics’ by P. Chaikin and T. Lubensky (Cambridge University Press). The course will also entail problem classes which will be held at Edinburgh, Heriot Watt and St Andrews on a rotating basis, in synchrony with CM-DTC group meetings. Assessment will be based on performance in both the student presentations and selected problems.

Course Description:
This course deals with the quantum theory of the origins and properties of magnetism in condensed matter systems. A rough syllabus (subject to confirmation) is: elementary models of magnetic response: Curie and Pauli paramagnetism; spontaneous magnetic ordering in insulators: the Heisenberg model and spin wave theory; spontaneous magnetic ordering in metals: the Stoner model and paramagnons; magnetism in low-dimensional systems.
Response Functions (SUPARFN)

**Lecturer:** Chris Hooley  
**Institution:** St Andrews  
**Schedule:** Tuesday 11:00-12:00 & Wednesday 15:00-16:00  
**Hours Equivalent Credit:** 12  
**Assessment:** Continuous Assessment

**Course Description:**
Response functions and Green's functions provide a powerful mathematical language in which to describe the physics of many-body quantum systems. This course is a short introduction to them. The first few lectures define the various Green's functions of interest, and calculate them explicitly for a few very simple systems at zero temperature. The remaining lectures give brief introductions to several more advanced topics, including Green's functions at non-zero temperature and Green's functions out of equilibrium. The lectures are supplemented by several problem sheets, in which the emphasis is on a strong grasp of the basics. The course is designed to be accessible to any graduate student (theoretical or experimental) who has a decent undergraduate education in quantum mechanics. Some - though not much - knowledge of the formalism of second quantisation (creation and annihilation operators) is required.

Probes of Condensed Matter (SUPAPCM)

**Lecturer:** Chris Hooley et. al.  
**Institution:** St Andrews  
**Schedule:** Tuesday 11:00-12:00 & Wednesday 15:00-16:00  
**Hours Equivalent Credit:** 18  
**Assessment:** Continuous Assessment

**Course Description:**
This course is an introduction to the various experimental methods that are commonly used to make measurements on condensed matter systems. The list covered in this course includes, but is not limited to: low-temperature bulk measurements (such as specific heat capacity); transport measurements (resistivity, Hall resistivity, quantum oscillations); superconducting quantum interference device (SQUID) techniques; single-electron transistors; angle-resolved photoemission spectroscopy (ARPES). This is a multi-lecturer course. Each lecturer will give two or three lectures on his/her speciality.

Disordered Systems (SUPADOS)

**Lecturer:** Chris Hooley  
**Institution:** St Andrews  
**Schedule:** TBC  
**Hours Equivalent Credit:** 6  
**Assessment:** Continuous Assessment

**Course Description:**
Most introductory condensed matter courses study mainly crystalline solids. Here Bloch’s Theorem applies, all eigenfunctions are extended, and the notion of crystal momentum applies. However, very many materials in nature are not perfectly crystalline: either because they contain impurities in an otherwise perfect crystal lattice, or because they have no long-range structural order at all. This course is a short introduction to some of the most important physics in these systems. The syllabus includes, but is not limited to: disorder physics in soft condensed matter; phonons in disordered materials; the disorder-induced metal-insulator transition and Anderson localisation.
### Intertheme Courses

Intertheme courses are Technical Courses relevant to students across themes. All Intertheme Courses count towards the 40-hour Technical Course requirement.

## Semester One

### C++/Object Oriented Programming (SUPACOO)

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Tom Doherty</th>
</tr>
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<tbody>
<tr>
<td>Institution:</td>
<td>Glasgow</td>
</tr>
<tr>
<td>Hours Equivalent Credit:</td>
<td>11 (5 lect. &amp; 3x2hr labs)</td>
</tr>
<tr>
<td>Assessment:</td>
<td>Continuous Assessment</td>
</tr>
<tr>
<td>Schedule:</td>
<td>Lectures: Monday 10:00-11:00; Labs: Monday 10:00-12:00</td>
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</table>

*This course includes four lab sessions based in Glasgow which students will need to attend in person. This course has priority booking for Particle Physics students. Please refer to the timetable and visit the My.SUPA course area for more information.*

**Course Description:**
This course introduces students to C++ via lectures and hands-on sessions. The topics covered are: C++ Syntax: standard out, in, and error, loops and conditional C++ statements, basic file streams; Objects 1: implementing objects, member functions, object-object communication, operator overloading, inheritance; Objects 2: polymorphism, templates, the Standard template library.

### Vacuum Technology (SUPAVAC)

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Kevin Prior</th>
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<tbody>
<tr>
<td>Institution:</td>
<td>Heriot Watt</td>
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<tr>
<td>Hours Equivalent Credit:</td>
<td>10</td>
</tr>
<tr>
<td>Assessment:</td>
<td>Continuous Assessment</td>
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<tr>
<td>Schedule:</td>
<td>Friday 16:00-17:00</td>
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**Course Description:**
This course will concentrate on the practical aspects of vacuum technology, and will be primarily of interest to students who are confronted with a vacuum system for the first time or are faced with using, maintaining or developing a system.

Topics which will be covered include:
1. Introduction to vacuum technology. The basic classification of vacuum grades and system types. Important gas properties relevant to vacuum systems. Sources of information.
3. Pumping: classes of pumps, and examples of different pumping mechanisms.
4. Gas flow in through a system, gas throughput and conductance, sources and pumping speed. Leaks, virtual leaks and outgassing.
5. System design, construction and troubleshooting. High vacuum and ultra high vacuum components.
7. Real system examples. Here, students will be encouraged to discuss their own systems and any problems they may have encountered.

### Introductory Data Analysis (SUPAIDA)

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Andrei Andreyev</th>
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<tr>
<td>Institution:</td>
<td>UWS</td>
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<tr>
<td>Hours Equivalent Credit:</td>
<td>6</td>
</tr>
<tr>
<td>Assessment:</td>
<td>Continuous Assessment</td>
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<tr>
<td>Schedule:</td>
<td>Monday 12:00-13:00</td>
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</tbody>
</table>

**Course Description:**
This course provides an introduction to uncertainty in measurement and how to understand and deal with data. Topics will include: random error and relation to statistics; probability distributions and their properties; calculation of uncertainty; least squares model; applications of data analysis.
Semester Two

Shell Scripts (SUPASSC)

Lecturer: Chris Collins-Tooth
Institution: Glasgow
Schedule: Lecture January 19 11:00-12:00 & Lab: January 26 11:00-13:00

This course includes a lab session based in Glasgow which students will need to attend in person. This course has priority booking for Particle Physics students. Please visit the My.SUPA course area for more information.

Course Description:
This course is intended for PhD students who intend to work with LINUX/UNIX systems. The course introduces the concepts of Shell programming and then focuses on Bash and Perl. Examples of each of the key concepts are given and discussed in detail. At the end of the course, students should walk away with a working knowledge of Bash and Perl, together with a toolkit of examples which they can implement to solve their own problems and automate tasks. The course is given as a 1hr lecture and an interactive tutorial. This course assumes no prior knowledge of Shell programming.

Advanced Data Analysis (SUPAADA)

Lecturer: Martin Hendry
Institution: Glasgow
Schedule: This is a 2-day residential course, provisionally scheduled for January 5-6, 2011. Please refer to My.SUPA for confirmation of the date and location.

Course Description:
The course will cover the following topics: theoretical foundations and the nature of probability; the essentials of line and curve fitting; an introduction to Bayesian inference; hypothesis testing and goodness of fit; an advanced toolbox for Bayesian inference; covariance and the Fisher information matrix; Bayesian evidence and model selection; assigning prior probabilities; analysis of very large datasets; data compression and principal component analysis; efficient techniques for generating random numbers; Markov chain Monte Carlo methods. Learning Outcomes: to acquire a working knowledge of advanced data analysis methods – i.e. to a level sufficient to permit their successful application to real data analysis problems, as might be encountered in students’ own research projects; to gain familiarity with the key differences between a frequentist and Bayesian approach to data analysis: the assumptions upon which each approach is founded and the circumstances in which each is applicable. To develop awareness of the current literature on advanced data analysis for the physical sciences, and the software available to support its application to real problems.

Introduction to Python (SUPAPYT)

Lecturer: Eduardo Rodrigues
Institution: Glasgow
Schedule: Monday 16:00-17:00; Wednesday 12:00-13:00; Friday 11.00-13.00

Course Description:
A first course to introduce the powerful and flexible scripting language Python. The course is intended to anyone with an interest in using this alternative scripting language for general use. The course will explain the working environment and some commonly-used tools for writing Python scripts. It will cover basic concepts such as the main data types, functions, looping techniques, modules, classes, how to deal with files and exceptions. Intended Learning Outcomes: to become familiar with Python and grasp its main language characteristics and philosophy; to be able to solve everyday problems with simple Python scripts; to trigger interest in Python-based solutions.

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All SUPA students are required to complete 20 hours (or four days) of Generic Skills Training during the first two years of their PhD studies. These do not need to be assessed. SUPA sponsors the Generic Skills Training listed on the following page. However, students are also encouraged to participate in Generic Skills Training run by their local departments and universities or run by Vitae, which is a UK-wide organisation sponsoring Generic Skills Training.

Please note that enrolment for SUPA-sponsored Generic Skills Training is often run separately from enrolment procedures for Technical Courses. Information about enrolment procedures for each course will be posted on their My.SUPA course areas and announced to all students via email. If you have any questions about enrolment for SUPA Generic Skills Training, please email admin@supa.ac.uk.

In order to receive credit for Generic Skills Training courses not run by SUPA, please complete a **Non-SUPA Generic Skills Training Credit Request Form** and submit it to SUPA Central. These forms must be submitted before the deadlines (The submission deadlines for 2010/11 are: Semester I: 13 October 2010; Semester II: 7 January 2011.). A hard copy of this form is included in the Non-SUPA Courses section of this catalogue. Electronic copies are also available at [http://my.supa.ac.uk](http://my.supa.ac.uk).

More information about Generic Skills courses run by Vitae and individual universities can be found at the following websites:

- **University of Aberdeen**: [http://www.abdn.ac.uk/rsd/](http://www.abdn.ac.uk/rsd/)
- **University of Dundee**: [http://www.dundee.ac.uk/genericskills/](http://www.dundee.ac.uk/genericskills/)
- **University of Edinburgh**: [http://www.transkills.ed.ac.uk/](http://www.transkills.ed.ac.uk/)
- **University of Glasgow**: [http://www.gla.ac.uk/researcherdevelopment/](http://www.gla.ac.uk/researcherdevelopment/)
- **Heriot Watt University**: [http://www.hw.ac.uk/edu/research/index.html](http://www.hw.ac.uk/edu/research/index.html)
- **University of St Andrews**: [http://www.st-andrews.ac.uk/GRADskills/about_skills.php](http://www.st-andrews.ac.uk/GRADskills/about_skills.php)
- **University of Strathclyde**: [http://www.strath.ac.uk/careers/pgr/](http://www.strath.ac.uk/careers/pgr/)
- **University of the West of Scotland**: [http://www.uws.ac.uk/schoolsdepts/training/innovation-research.asp](http://www.uws.ac.uk/schoolsdepts/training/innovation-research.asp)
Course Description:
This course is designed to introduce students to research commercialisation, focusing on issues such as patenting, licensing and venture capital. It is relevant to researchers with an interest in exploring: the challenges of setting up their own company; how their research might attract interest or funding from industrial sources; career opportunities outside of academia; or collaboration with researchers from other fields or universities. An expert tutor will lead students through the basics of business planning, finance, marketing and project management. Invited speakers from a variety of backgrounds will share own experiences of research commercialisation. During course, students will also work on case-studies and group activities that will help to build their commercial awareness as well as develop vital entrepreneurial skills, such as negotiation and pitching ideas.

Course Description:
This event is designed to give students information about Physics careers outside of academia. Physics PhDs from universities across Scotland will give a series of presentations on their careers. This is followed by a panel discussion and opportunities for networking. Past speakers have included a Patent Attorney, a Scottish Government Policy Civil Servant, a Business Development Manager, a Mathematical Researcher, a Medical Physicist and a Financier.
In exceptional circumstances, SUPA students may find that the Technical Courses offered by the SUPA Graduate School do not fully meet their academic needs. In this instance, students are allowed to earn credit towards their 40-hour Technical Course requirement by taking courses outwith the SUPA Graduate School, provided the courses meet the appropriate criteria and the student follows appropriate procedures (outlined below).

Students are also permitted to take Non-SUPA courses to fulfil their 20-hour Generic Skills Training requirement. Please refer to the ‘Generic Skills Training’ section of this handbook for more information on the appropriate procedures for requesting Non-SUPA Generic Skills Training Credit.

Criteria for Non-SUPA Technical Courses

Assessment:
All Non-SUPA Technical Courses must be assessed to be eligible for credit. If no assessment procedure exists for the course, it is the student’s responsibility to agree an assessment method with the lecturer and their supervisor.

Relevance:
For credit to be granted, the student must be able to demonstrate that the non-SUPA course is relevant to their course of studies. Students are encouraged to use the ‘Case for Support’ in their application to give specific reasons for why the course is essential to their studies.

Lack of SUPA Alternative:
Students must clearly demonstrate to the Graduate School Management Committee that existing SUPA Graduate School offerings do not satisfy their academic needs.

Identifying Appropriate Non-SUPA Technical Courses

It remains the student’s responsibility to identify appropriate Non-SUPA Technical Courses. Students are encouraged to research course options available at their respective institutions and to consult with their supervisors.

Applying for Non-SUPA Technical Course Credit

To apply for non-SUPA Technical Course credit, students must submit the following to the SUPA Courses Office by the deadline specified below:

1. A completed copy of the Non-SUPA Technical Course Credit Request Form (A hard copy of this form is available in this handbook. It can also be obtained electronically at http://my.supa.ac.uk.)

2. A syllabus or course description for the course in question.

3. A 200-word Case for Support outlining why this course is relevant to their studies and why the current SUPA Technical Course offerings do not meet their academic needs.

Incomplete and late applications will not be accepted. Credit will not be given retrospectively, so applications must be made before the student completes the course. Forms should either be submitted email to admin@supa.ac.uk or sent by post to the SUPA Courses Office. Please see the ‘Contacts’ section of this handbook for the appropriate mailing address.

2010/11 Non-SUPA Credit Request Deadlines:
Semester I: Wednesday, October 13th, 2010
Semester II: Friday, January 7th, 2011

Non-SUPA Credit Decisions

Once an application is submitted, it will be reviewed by the Graduate School Management Committee (GSMC). All students will be notified of the outcome of their application shortly thereafter. If the application is approved, the student will be provisionally granted Hours Equivalent Credit, conditional on successful completion of the course and submission of marks to SUPA Central by the reporting deadline.

To report marks, students must submit a completed copy of the ‘Non-SUPA Course Marking Report’ form. (A hard copy of this form along with instructions will be sent to all successful Non-SUPA Technical Course Credit applicants. An electronic copy can be found at http://my.supa.ac.uk.) If marks are not reported, the student will not receive credit for the course, it is the student’s responsibility to ensure marks are reported. In the case that the student requires an extension of the deadline, they must notify the SUPA Courses Office at least one week in advance.

The 2010/11 deadline for reporting marks is:
Friday, May 27th, 2011
In order to request credit for non-SUPA Technical Courses, please complete the form below. For a credit request to be considered by the Graduate School Management Committee, the student must be assessed.

All forms must be submitted by the appropriate deadline. (The submission deadlines for 2010/11 are: Semester I: 13 October 2010; Semester II: 7 January 2011.) Incomplete and late submissions will not be accepted. For more information, please consult the Student Handbook or email admin@supa.ac.uk.

Supporting materials required with this application form are:
1. A course description or syllabus
2. A 200-word statement describing why this course is relevant to your studies and why the existing SUPA Graduate School offerings do not satisfy your academic needs.

### Student Information

<table>
<thead>
<tr>
<th>Student Name:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution:</td>
<td></td>
</tr>
<tr>
<td>PhD Start Date:</td>
<td></td>
</tr>
<tr>
<td>Supervisor:</td>
<td></td>
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</tbody>
</table>

### Course Information

<table>
<thead>
<tr>
<th>Course Name:</th>
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</thead>
<tbody>
<tr>
<td>Lecturer(s):</td>
<td></td>
</tr>
<tr>
<td>Institution:</td>
<td></td>
</tr>
<tr>
<td>Institutional Code (If Known):</td>
<td></td>
</tr>
<tr>
<td>Course Hours (Face-to-Face only):</td>
<td></td>
</tr>
<tr>
<td>Means of Assessment</td>
<td></td>
</tr>
</tbody>
</table>

I confirm that the information given on this form and in my supporting materials is correct to the best of my knowledge. I understand that no Non-SUPA Credits will be allocated by the SUPA Graduate School Management Committee unless this application is approved and my marks are reported to the Committee by the specified deadline.

<table>
<thead>
<tr>
<th>Student Signature:</th>
<th>Date:</th>
</tr>
</thead>
</table>

I confirm that this student will be taking my course. It has been agreed that the student will be assessed by the means listed above.

<table>
<thead>
<tr>
<th>Lecturer Signature:</th>
<th>Date:</th>
</tr>
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</table>

As the above named student’s supervisor, I confirm that this course is relevant and necessary to their course of study.

<table>
<thead>
<tr>
<th>Supervisor Signature:</th>
<th>Date:</th>
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</thead>
</table>
In order to request credit for non-SUPA Generic Skills Training, please complete the form below. Incomplete submissions will not be accepted. All forms must be submitted by the appropriate deadline. (The submission deadlines for 2010/11 are: Semester I: 13 October 2010; Semester II: 7 January 2011.) Incomplete and late submissions will not be accepted. For more information, please consult the Student Handbook or email admin@supa.ac.uk. For more information on Generic Skills Training, please consult the SUPA Student Handbook or visit http://my.supa.ac.uk.

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<table>
<thead>
<tr>
<th>Course Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Name:</td>
</tr>
<tr>
<td>Lecturer(s) or Course Organiser:</td>
</tr>
<tr>
<td>Institution:</td>
</tr>
<tr>
<td>Institutional Code (If Known):</td>
</tr>
<tr>
<td>Course Hours (Face-to-Face only):</td>
</tr>
<tr>
<td>Date(s) of Course:</td>
</tr>
</tbody>
</table>

Please write a short statement (50-100 words) about what you hope to gain or have already gained from this training. (Attach a separate sheet if necessary.)

I confirm that the information given on this form is correct to the best of my knowledge. I understand that no Non-SUPA Credits will be allocated by the SUPA Graduate School Management Committee unless this application is approved and the training is successfully completed.

Student Signature: Date:

I confirm that this student will be participating in or has already participated in the above-named Generic Skills Training.

Lecturer Signature: Date:

As the above named student’s supervisor, I confirm that this training is relevant to their studies.

Supervisor Signature: Date:
This page details the possibilities for funding available to the students within SUPA and its affiliated departments and organisations. Further information about funding options for students is available from the funding councils and from the funding offices of individual institutions.

**Funding Councils:**
Science & Technology Facilities Council (STFC): [http://www.scitech.ac.uk/](http://www.scitech.ac.uk/)
Scottish Funding Council (SFC): [www.sfc.ac.uk](http://www.sfc.ac.uk)
Engineering & Physical Sciences Research Council (EPSRC): [www.epsrc.ac.uk](http://www.epsrc.ac.uk)

**Institutional Funding Offices:**
University of Aberdeen: [http://www.abdn.ac.uk/postgraduate/funding.php](http://www.abdn.ac.uk/postgraduate/funding.php)
University of Dundee: [http://www.dundee.ac.uk/postgraduate/fees_funding/](http://www.dundee.ac.uk/postgraduate/fees_funding/)
University of Edinburgh: [http://www.ed.ac.uk/studying/postgraduate/fees-finance/scholarships](http://www.ed.ac.uk/studying/postgraduate/fees-finance/scholarships)
University of Glasgow: [http://www.gla.ac.uk/postgraduate/feesandfunding/fundingyourstudies/](http://www.gla.ac.uk/postgraduate/feesandfunding/fundingyourstudies/)
Heriot Watt University: [http://www.postgraduate.hw.ac.uk/scholarships/index.htm](http://www.postgraduate.hw.ac.uk/scholarships/index.htm)
University of Strathclyde: [http://www.strath.ac.uk/search/scholarships/index.jsp](http://www.strath.ac.uk/search/scholarships/index.jsp)
University of St Andrews: [http://www.st-andrews.ac.uk/admissions/scholarships/](http://www.st-andrews.ac.uk/admissions/scholarships/)
University of the West of Scotland: [http://www.uws.ac.uk/international/finance.asp](http://www.uws.ac.uk/international/finance.asp)

**SUPA Prize Studentships**

**Background:** The SUPA Prize Studentships are prestigious and competitive awards intended to attract outstanding physics students from around the world, irrespective of nationality, to study for a PhD in Scotland. Every year, SUPA offers a limited number of fully funded Prize Studentships. These provide tuition fees, an annual maintenance grant and RTSG, normally for a three-and-a-half year period. Studentships in certain research areas also cover expenses for Essential Travel. For more information please visit: [http://www.supa.ac.uk/Graduate_School/prize](http://www.supa.ac.uk/Graduate_School/prize)

**Application process:** Applications should be made using the online application form at [www.supa.ac.uk](http://www.supa.ac.uk). The 2009 competition will open on Friday, October 30th, 2009, and close on Sunday, January 31st, 2010. Students are advised to ensure that their applications are complete by the deadline, as no further materials, including references, will be accepted beyond Monday, February 1st, 2010.

**Condensed Matter Doctoral Training Centre Studentships**

**Background:** The Scottish Doctoral Training Centre in Condensed Matter Physics is a tri-institutional collaboration between the Universities of St Andrews, Edinburgh and Heriot-Watt, providing international-level doctoral training in the core discipline of condensed matter physics. It offers more than ten 4-year PhD fully funded studentships per annum. For more information, please visit [http://cm-dtc.supa.ac.uk/](http://cm-dtc.supa.ac.uk/).

**Application process:** Doctoral Training Centre places will be allocated to outstanding students on a rolling basis until 25 January 2011. Applications should be made using the online application form at [www.supa.ac.uk](http://www.supa.ac.uk). To ensure fair consideration, students are strongly advised to apply early. After 25 January, late applications may be considered if places are unfilled. Informal enquiries are welcome and should be sent to the Manager, Christine Edwards at cm-dtc@supa.ac.uk. (Contact information can be found in the ‘Contacts’ section of this handbook).

**Other Student Funding**

**Background:** Individual Physics departments within SUPA (Aberdeen, Dundee, Edinburgh, Glasgow, Heriot Watt, St Andrews, Strathclyde & UWS) also have various departmental funding sources available to students. PhD studentships generally provide tuition fees, an annual maintenance grant and RTSG, normally for a three-and-a-half year period. Most of these are for eligible UK and EU applicants, but some universities have dedicated studentships to support overseas students.

**Application process:** Qualified candidates who meet the funding eligibility criteria should contact the physics department of the university they wish to attend directly. Applicants are advised to check their eligibility for certain types of funding by consulting the websites of STFC, EPSRC and the participating universities.
# Getting Started with My.SUPA

My.SUPA ([http://my.supa.ac.uk](http://my.supa.ac.uk)) is an online space for managing all your SUPA-related activities. We strongly encourage you to check My.SUPA regularly as this is our main tool for contacting you with important information such as requirements for your lectures, changes to the course timetable and event announcements.

## Obtaining a Password and Username

To obtain a My.SUPA login, please go to My.SUPA portal ([http://my.supa.ac.uk](http://my.supa.ac.uk)) and click on the ‘Request a My.SUPA login’ link. Your new login and password will soon be emailed to you with instructions.

If you forget your My.SUPA username or password, you can reset them either by following the ‘Lost Password?’ link in the login box on the My.SUPA portal or by emailing admin@supa.ac.uk.

For incoming first-year PhD students, SUPA should automatically create an account for you and contact you via email with your account details in early September. However, occasionally we do not receive complete details for incoming students and so cannot create accounts for them. If you have not received an email with your username and password by the time you are registering for SUPA courses, please email admin@supa.ac.uk.

## Courses and My.SUPA

In order to register for SUPA courses, either as an enrolled or non-assessed student, you will need to use My.SUPA. Go to the My.SUPA portal ([http://my.supa.ac.uk](http://my.supa.ac.uk)) and follow the enrolment instructions posted on the front page. Before you register for the first time, you will be informed about SUPA's videoconference recording policy and asked for your consent. (For more information about this policy, please email admin@supa.ac.uk)

When selecting courses on My.SUPA, please note that most courses are only available with read-only access to some once registration is closed. You will be expected to participate fully in the courses for which you have enrolled, whereas non-assessed students will simply be required to attend the courses. Please consult your supervisor and refer to the ‘SUPA Graduate School Basics’ and theme-specific sections of this handbook for more guidance on selecting appropriate courses.

The end dates of the SUPA registration periods are: October 13th (Semester I) and January 7th (Semester II). If you miss the deadlines, late registration may be possible but cannot be guaranteed. Please contact the SUPA Courses Office at admin@supa.ac.uk in this instance.

Once you have registered for a course (either as non-assessed or enrolled), you will be able to check the course area on My.SUPA for information such as lecture notes and changes to the course schedule. You will also be able to communicate with your classmates and lecturer(s) individually (through the ‘People and Locations’ tab) and as a group (by using the News Forum). Messages posted on the course area News Forum will be automatically sent to the email address you have provided to SUPA.

If you would like to unregister from a SUPA course, either as a non-assessed student or as a fully enrolled student, you can do so by going to the relevant course page and clicking on the ‘Unenrol me from SUPA[XXX]’ link. If you would like to change between auditing and full enrolment, please un-register for the course and then re-register in the alternate role. This will only be possible during enrolment, at all other times should you wish to unenrol, please contact admin@supa.ac.uk. For fully enrolled students, it is crucial that you unenrol if you decide not to complete the course, or else your transcript will retain a record of the course.

## Transcripts and My.SUPA

As noted in the ‘Graduate School Basics’ section of this handbook, all SUPA students are required to complete 40 hours of Technical Courses and 20 hours of Generic Skills Training in the first two years of their PhD. You can track the number of course hours you have completed by viewing your online transcript in My.SUPA. To do so, after logging in to My.SUPA, click on your name in the upper right hand corner of the screen. (The link should say: You are logged in as [NAME]). This will take you to your user profile. Click on the ‘Grades’ tab to view your transcript.

To obtain an official copy of your transcript certified by the Graduate School Director, please email admin@supa.ac.uk.

## Timetable, Calendar & Events Forum

The latest version of the Graduate School Timetable, the SUPA Events Forum and the SUPA Calendar can be found on the My.SUPA homepage. If you would like to advertise an event through the Events Forum, please email admin@supa.ac.uk.

## Connect.SUPA

Some SUPA events and courses may be run through Connect.SUPA ([http://connect.supa.ac.uk](http://connect.supa.ac.uk)), especially those open to participants outside of SUPA. Generally, you will not need to log in to access materials posted on Connect.SUPA. If you do need to log in, please follow the instructions for My.SUPA account holders. (You **do not** need to create a separate Connect.SUPA account. Doing so may result in you not being allocated appropriate Hours Equivalent Credit for participating in a course or event.)

## Further Training and Support

If you experience any difficulties while using My.SUPA, please email the SUPA Administration Office at admin@supa.ac.uk. To report errors on the site or to request technical help, please write to webmaster@supa.ac.uk.
This page gives an introduction to using the videoconference facilities across the SUPA institutions. Videoconferences are primarily used in SUPA to deliver courses. However, they are also used for a variety of other purposes, such as research meetings, seminars, interviews and distinguished visitor lectures. More information on using SUPA videoconference facilities can be found in Getting Started with Video-Conferencing at: http://my.supa.ac.uk/.

Making a Booking
SUPA videoconferences must be booked in advance by SUPA Central. If you are attending a scheduled SUPA course or event, the booking has already been made for you. If you are organising a meeting or event and would like to use the SUPA videoconference facilities, please email rooms@supa.ac.uk to make a booking.

Setting Up
SUPA videoconferences usually begin at five minutes past the hour. As the bookings are made in advance, the videoconference call will be made automatically, so there is no need to dial in.

Although there are slight differences in the layout of the videoconference rooms at each institution, they are all operated in the same way.

When you arrive in the room:
• If the projectors are not turned on, press the touchscreen firmly. You’ll see the Intro Screen: select “Video Conferencing”
• This will take you to the Call Waiting Screen - Wait here for the incoming call. When the call starts, you’ll be automatically taken to the In Conference Screen.

Adjusting Camera view and Microphones:
• Camera: Press the button marked “Sending Presenter” to switch to Audience view. The button will change to “Sending Audience”.
• Microphone: If during the conference you cannot be heard, you may need to press the “Ceiling Mics” button to activate the ceiling microphone.

Connecting Laptops:
• Before the conference, turn your laptop on and change the resolution to 1024x768@70Hz. Attach to the flying VGA cable. Set your laptop to output to both local screen and external monitor. (This is normally done by pressing fn-F5, fn-F7 or fn-F8.)
• Once the conference begins, press Laptop on the In Conference screen. Check that you can see your laptop screen projected on the screen locally, and then check that the other sites can see it as well.

Shutting Down
If there is not another videoconference directly after yours, please turn off the projectors by returning to the Intro Screen and choosing “Both Off”. Please also turn off the room lights and lock the door. To check whether there is a conference following yours, please refer to the SUPA timetable (posted on the door of the videoconference room and online at http://my.supa.ac.uk/).

Further Training and Support
Further training in the use of the videoconference facilities and assistance during videoconferences is available from Local technical support at each site.

( Please see the ‘Contacts’ section of this handbook for local technical support contacts.)