# Welcome to the SUPA Graduate School 2022/2023

Dear SUPA Researchers,

**Welcome to the SUPA Graduate School 2022/23.**

SUPA is a research and graduate training alliance across eight Scottish universities working in partnership to create the largest cluster of physics research power in the UK as confirmed by the most recent UK research assessment exercise, REF2021.

You have joined the SUPA Graduate School, the largest for physics PhDs in the UK, offering postgraduate research students world class research opportunities, expert supervision, links to national and international facilities, advanced specialist courses, professional development training, networks, industry engagement, outreach, exchanges and placements, careers and other events, which all draw upon the knowledge and experience of the whole physics community across Scotland and beyond. This collaborative approach ensures that the SUPA Graduate School can offer the best possible opportunities for research students to acquire the skills needed to launch a successful career whether that be in academia, industry, enterprise or public and other sectors.

The SUPA Graduate School offers over 50 advanced courses, mostly delivered via the SUPA video network, as well as other events and training opportunities. Please take maximum advantage of the training offered. The SUPA Graduate School always strives to provide education and training at the highest international level in physics as well as the broader skills needed to establish you in a successful career.

I am delighted that you have chosen to pursue your post-graduate studies in Scotland. I believe your degree will open many opportunities for your future career. Welcome to our community and I wish you every success in your PhD research.

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# SUPA Graduate School

### Welcome to Graduate Studies at SUPA!

SUPA courses fall into two categories, Specialist courses and Professional Development courses. Specialist courses relate closely to a student's research interests. Professional Development courses are valuable to students in a wide range of research areas. Doctoral students are required to take a total of 40 hours of Specialist courses and 20 hours of Professional Development in the first two years of their studies. For example, a student might take a 24 credit course in their first year, and a 16 credit course in their second year to complete the Specialist requirement.

Students must enrol for any SUPA course they plan to attend. Students may also meet their course requirements through courses offered outside SUPA. Students must discuss their course selections with their advisors. Courses taken prior to enrolment in your PhD will not count toward the SUPA course requirements.

### SUPA Specialist Courses

These courses are listed by theme on pages 11 – 28. Frequently, students take courses within their research theme. However, many research topics are interdisciplinary. Students are encouraged to take the courses most relevant to their work, regardless of theme.

All specialist courses are assessed. Students must pass the assessment in order to get credit for the course. Courses are assessed by various methods. These methods include continuous assessment, dissertations and oral examinations. The assessment for a specific course can be found in the course listing. Students are advised to check the type of assessment with the lecturer at the start of a course. Typically, the final assessment for courses will be on a 0-100 point scale, where the pass mark is 50. If a SUPA course is part of an undergraduate curriculum, the pass mark may vary.

Students may audit Specialist courses. This may be appropriate if students are interested in the topic and want to attend lectures but do not have time to complete the course work. Students need to enrol for courses that they audit. However, they do not receive credit for audited classes.

Some Specialist courses run biennially. They will be offered only once in two years. Please consider these schedules carefully when planning your courses.

### SUPA Professional Development Courses

Professional Development is an important part of the graduate student experience. Professional development training can help students plan and manage their research projects and improve their writing and coding skills. Professional Development training may also broaden career options. These courses are listed on pages 29-32. Professional Development courses will have an informal or ongoing assessment.

### Course Delivery

SUPA courses are unusual in that they are delivered in a variety of ways, such as through videoconferencing, face to face, and distance learning. Each course listing describes how the course will be delivered.

### Videoconferencing

Many SUPA courses are taught via videoconferencing. In some cases, students go to the local SUPA videoconference room to attend the course. Alternately, students may participate in these classes remotely. Students can access the lectures from their personal computer and do not need to go to the videoconferencing classroom in person. Links to lectures will be shared through the MySUPA course pages. See more information on joining videoconferences remotely.

**Aberdeen**
Meston Building Room 302
Contact: Michael Chung
Tel: +44 (0)122 427 2750
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**Dundee**
Ewing Building Basement
Contact: Gary Callon
Tel: +44 (0)138 238 4695
Email: g.j.callon@dundee.ac.uk

**Edinburgh**
James Clerk Maxwell Building Room 1301
Contact: SOPA Helpdesk
Tel: +44 (0)131 650 5900
Email: sopa-helpdesk@ed.ac.uk

**Glasgow**
Kelvin Building Room 255a
Contact: Andrew Fraser
Tel: +44 (0)141 330 6420
Email: andrew.fraser@glasgow.ac.uk

**Heriot-Watt**
Earl Mountbatten Building Room EM1.27
Contact: Sean Farrell
Tel: +44 (0)131 451 3048
Email: s.j.farrell@hw.ac.uk

**St Andrews**
Physics and Astronomy Room 307
Contact: Ian Taylor
Tel: +44 (0)133 446 3141
Email: iat@st-andrews.ac.uk

**Strathclyde**
John Anderson Building Room 813
Contact: Timothy Briggs
Tel: +44 (0)141 548 3376

**UWS**
Henry Building Room F.318
Contact: Tom Caddell
Tel: +44 (0)141 848 3550
Email: tom.caddell@uws.ac.uk

### Participating in courses from the Videoconferencing rooms

### Starting Up

- SUPA videoconferences usually begin at five minutes past the hour and last 55 minutes.
- The call will be made automatically, so there is no need to dial in.
- If they are not on, use the remote or control switch to turn on the projectors or monitors.
- Initially, the SUPA rooms list will appear on a screen or monitor. When the call starts, this will shift to the Participants Screen.

### Shutting Down

- SUPA lecture calls end on the hour.
- At the end of your lecture, please switch off the monitors or projectors using the remote control, turn off the room light and lock the door.
- To end a call before the hour press the red button on the Vidyo remote control.

Assistance during videoconferences is available from local technical support at each site. The Getting Started with Video Conferencing My.SUPA page can be found at http://my.supa.ac.uk/course/view.php?id=91

Videoconference rooms are primarily used in SUPA to deliver courses, however, they are also used for other purposes such as research meetings, seminars, interviews and distinguished visitor lectures. More information on using SUPA videoconference facilities, including video tutorials, 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. If you are organising a meeting or event and would like to use the SUPA videoconference facilities, please visit the SUPA website and use the booking form to make a booking. http://www.supa.ac.uk/ room_booking

### Face to Face

Courses that are taught Face to Face, listed as F2F, are taught with participants together in one room. Students and lecturers attend in person. These courses may include tutorials, labs, or discussion sessions. Depending on the location of the course, students may have to travel and possibly stay overnight. Some lectures that are presented through VC may have tutorials, labs or discussions that students must attend in person. These will be listed as both VC and F2F. Please consider these aspects when registering for a course. If a Face to Face course spans a number of days in succession, it will be listed as Residential.

**Travel**: If you are required to travel to attend a SUPA course, SUPA will reimburse travel expenses. SUPA will cover the cost of accommodation only if there is insufficient time to travel on the day of the event. Some courses will require overnight accommodation and you should consult the lecturer if you are in doubt regarding start and end times. The accommodation allowance is up to £80 per night. Any expenses over £80 must be justified in your claim form. Follow the procedures for claiming expenses at your university and ensure you complete the departmental travel claim form clearly stating SUPA and the course name.

### Distance Learning Courses

Enrolling in Distance Learning courses will give you online access to recordings, notes, problem sheets and discussion forums. Students are expected to work independently, and participate in activities set by the course lecturer. Students will submit exercises and receive feedback. There are no live broadcasts of lectures.

### Individual Circumstances

Students may have unique, individual circumstances that affect their studies. For example, students with dyslexia may need additional time to complete exams. If you require any additional support in completing assessments, please contact the course lecturer who will follow guidelines established by the host university.

### Acccess

If you have any difficulty accessing course materials, including lectures, or if lectures do not appear to be running as scheduled, please contact admin@supa.ac.uk .

### Non-SUPA Courses

Students may complete their course requirements through courses offered outside SUPA. This applies to both Specialist and Professional Development courses. Examples of appropriate Specialist courses include Master's (MSci/MPhys/MSc) and Bachelor's courses. Attendance at National and International Summer Schools designed for research students (e.g. those organised by doctoral training centres or SUSSP) is also encouraged.

Professional Development courses may be provided by a University, Research Council, VITAE or other organisations. Students are encouraged to take these opportunities with their supervisor's agreement.

### Getting Credit for Non-SUPA Courses

For **Professional Development** courses, the student's full name, the course name, date of completion, course description, course provider and number of credits should be emailed to admin@supa.ac.uk. If someone other than the student's supervisor submits this information, the supervisor must be copied in. It is the student's responsibility to ensure the information submitted is correct.

For **Specialist** courses, students must submit all the information requested for Professional Development courses **and** additional information. The additional information required depends on whether the course was marked or unmarked.

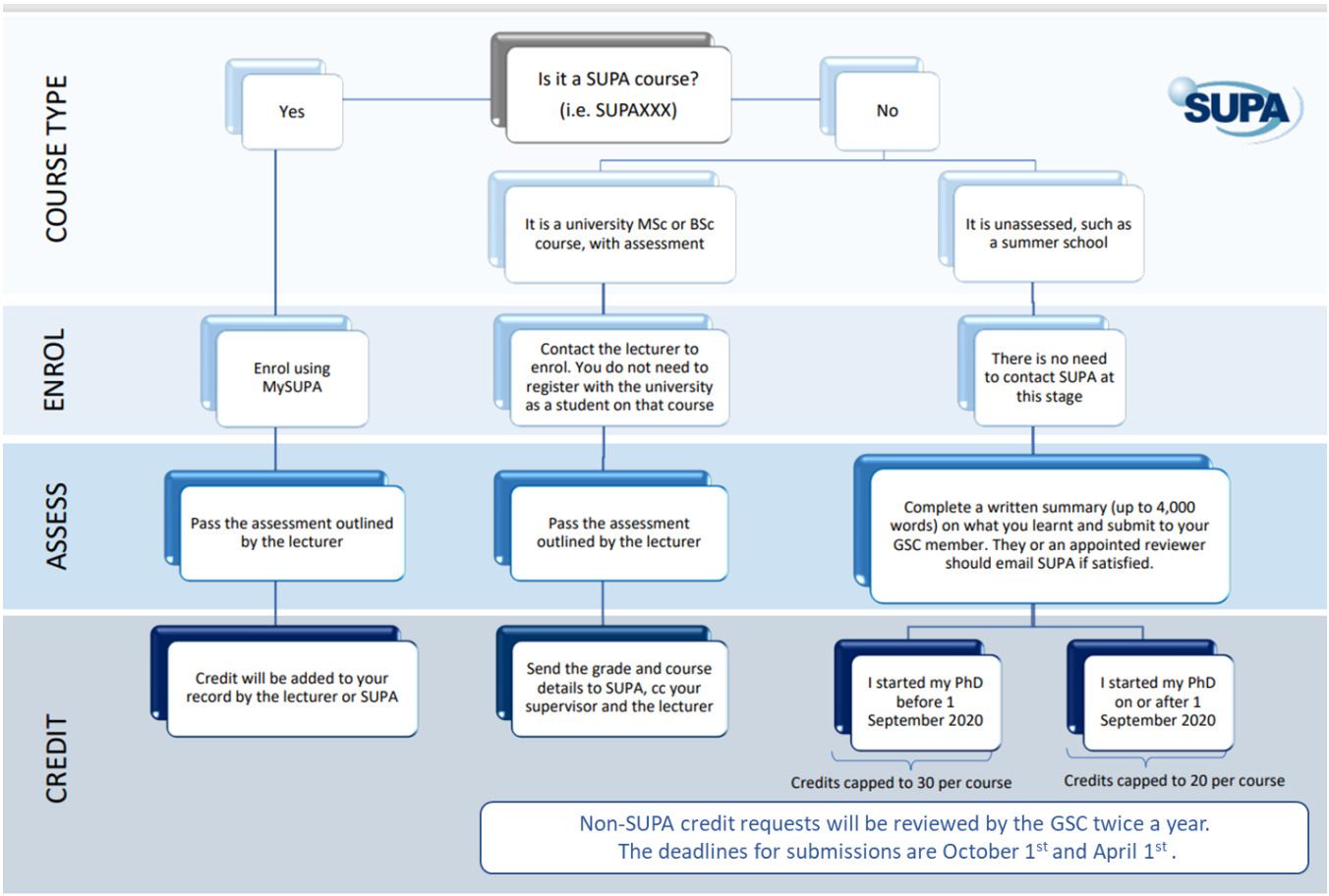
Marked courses: These include master's and bachelor's level modules. The ideal arrangement is that the course coordinator arrange an assessment for the student. Even if postgraduate students are not typically assessed, the course coordinator may have a method for assessing them and students should consult the course coordinator about this. Students are not expected to register on the course through the host university. Instead, the course coordinator should email the student's marks to admin@supa.ac.uk. The pass mark is 50%. All non-SUPA courses and marks will be reviewed by the GSC. The GSC cannot organise assessment for non-SUPA courses. Within SUPA, the number of hours awarded for a course is based on the contact hours or the total length of the lectures, in hours.

Unmarked courses: Students are only given credit for specialist courses if they are assessed. However, SUPA recognises that National and International Summer schools are valuable learning experiences even though they typically do not include an assessment. In these cases, and in any non-SUPA specialist course that cannot arrange an assessment, students must write a summary of the course. The summary may be up to 4000 words and should be submitted to their GSC member. The GSC member, or someone they appoint to review the summary, should then email admin@supa.ac.uk confirming that the written summary has been completed to an acceptable level. This written summary became a requirement in September 2020. Courses taken before September 2020 do not require a written summary.

In all cases, for a single non-SUPA Specialist course, students can earn at most 20 hours of credit. Please note that this limit of 20 hours was put in place for students beginning in 2020/21. In previous years, the credit limit for a single non-SUPA course was 30 hours. Students who began their studies prior to 2020/21 will be allowed to claim up to 30 hours of credit for a single non-SUPA course.

The GSC reviews the applications they receive twice a year. The deadlines for applications are October 1st and April 1st.

# Getting Credit within SUPA




SUPA credit awarding process, 2022/2023

This chart shows the many ways students can enrol and get SUPA credit for courses. Please remember the two deadlines, October 1st and April 1st, for submitting applications to the GSC for non-SUPA course credit.

# My.SUPA

## Registering for My.SUPA and Course Enrolment

My.SUPA (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.

New students will need to register with My.SUPA before they enrol for courses. Registering for My.SUPA is a quick process that will not significantly delay your enrolment. To register:

- Go to http://my.supa.ac.uk
- • Click 'Create a new account'
- Register using your university email address
- An email will be sent to you with a verification link. If you have any questions or problems email admin@supa.ac.uk.

Or, on that site, watch the brief video called *Here's how to access our virtual learning environment*.

Students must enrol for SUPA courses in order to attend or receive credit for them. To enrol, log on to My.SUPA (http://my.supa.ac.uk) and follow the instructions. 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.)

Enrolment for Semester 1 will open in September. Enrolment for Semester 2 will open in December. Enrolment will typically stay open until the end of the first week for short courses and the end of the second week for full semester courses. After the open enrolment period, late enrolment may be possible with the lecturer's permission. Once you have permission from the lecturer to enrol late, contact the SUPA Administration team at admin@supa.ac.uk.

Once you have enroled for a course you will be able to check the course area on My.SUPA for information such as lecture notes and updates. 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. During the enrolment period, students typically have limited access to course materials. The remaining course materials will become available to enrolled students once registration is closed.

Some courses close enrolment before the course start date. Details about enrolment closing will be in the course information page on My.SUPA.

To withdraw from a SUPA course while enrolment is open, go to the course page and click the 'Unenrol me from SUPA [XYZ]' link. If you are not going to complete a course, it is important to unenrol on My.SUPA. Otherwise, your SUPA transcript will include this course with a mark of 0.

During the enrolment period, students may change their enrolment status between being assessed and non-assessed, (auditing). This may be helpful for students who want to try a course before fully committing. To make these changes, first withdraw from the course on My.SUPA and then enrol again with the new status.

After enrolment has closed, it is no longer possible to unenrol or change enrolment status through My.SUPA. Instead, contact admin@supa.ac.uk and notify the course coordinator.

## Course Availability

If a course is cancelled, students will be contacted to discuss alternatives. If a course is oversubscribed, students will be admitted in the order that they registered and students who registered later will be added to a wait list.

## Course Credit

The credit for each course is included in the course listing and course description. Students can track the amount of credit they have earned by checking their profile on My.SUPA.

Extenuating Circumstances: If unforeseen circumstances, such as an illness, adversely affect a student, course instructors and SUPA management may have some flexibility in assigning credit. The student should inform their local Graduate School Committee member and provide documentary evidence of these unforeseen events as soon as possible. The Graduate School Committee will review cases individually.

## Transcripts

You can track the number of course hours you have completed by viewing your online transcript in My.SUPA. To do so, log in to My.SUPA and 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 Coordinator, please email admin@supa.ac.uk.

## Timetable, Calendar and Events

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

## 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 contact webmaster@supa.ac.uk.

# Frequently Asked Questions

### What is SUPA?

SUPA is the Scottish Universities Physics Alliance, a collaboration 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 admitted to the SUPA Graduate School and are subject to its academic policies.

### Is there a timetable for the SUPA courses?

The SUPA timetable can be found on the My.SUPA website.

### How do I use the videoconferencing equipment?

Information can be found in the Videoconferencing section of this handbook. If you have a specific issue, please contact your local Graduate School Committee representative or a member of local support. Training is available locally.

### 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 'Create a new account' link. Follow the 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 Office at admin@supa. ac.uk.

### How can I contact my lecturer?

On My.SUPA, you can find your lecturer's details in the 'People and Locations' or 'Course Description' area 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 inform your lecturer.

### 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 Co-ordinator, please write to the SUPA Office at admin@supa.ac.uk.

### Who can I contact if I have a general question about the SUPA Graduate School?

Contact the SUPA 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 GSC representatives. Do not hesitate to contact them if you have any queries or issues regarding SUPA Graduate School.

### 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 fliers or posters) that you may have, and SUPA 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 SUPA-organised events. There is no funding available to attend Summer Schools or conferences that were not organised by SUPA.

### Can I claim travel expenses from SUPA?

Yes, if the events or courses were organised by SUPA and students must travel in order to attend (such as a residential course). SUPA will cover reasonable costs, defined as: public transport or mileage on shared rides equivalent to public transport costs, meals or accommodation.

### How do I claim back my expenses from a SUPA event?

To claim back expenses for a SUPA event, please submit a claim form to your local department's finance office, clearly stating the name of the SUPA event or course. Do not send claims to the SUPA administration team unless specifically instructed to do so.

# SUPA Contacts

## SUPA

### SUPA CEO
Alan Miller
Tel: +44 (0)141 330 8790
Email: alan.miller@supa.ac.uk

### Graduate School Coordinator
Vicky Ingram and Linda Hadfield
Email: coordinator@supa.ac.uk

### SUPA Administration Team
229, Kelvin Building
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GLASGOW,
G12 8QQ
Email: admin@supa.ac.uk

### SUPA Webmaster
Sean Farrell
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## EPSRC/STFC Centres for Doctoral Training

### Condensed Matter
Director: Prof. Phil King
Web: cm-cdt.supa.ac.uk
Email: cm-cdt@supa.ac.uk
Tel: +44(0)133 446 3102

### Quantum Materials
Director: Prof. Phil King
Web:

### Intelligent Sensing and Measurement
Director: Prof. Andy Harvey
Web: cdt-ism.org
Email: i-sensing-measurement@glasgow.ac.uk

### Applied Photonics
Director: Prof. Derryck Reid
Web: cdtphotonics.hw.ac.uk
Email: engd@hw.ac.uk
Tel: +44 (0)131 451 8245

### Soft Matter and Functional Interfaces
Deputy Director: Prof. Wilson Poon
Web: www.dur.ac.uk/soft.matter/soficdt
Email: sofi.cdt@durham.ac.uk
Tel: +44 (0)191 3342133

### The Scottish Data-Intensive Science Triangle
Director: Prof. Andy Lawrence
Web: www.scotdist.ac.uk
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## Graduate School Committee

The SUPA Graduate School Committee (GSC) oversees the operation of the SUPA Graduate School in relation to courses, induction, career events, summer schools and support for physics based doctoral training centres. The SUPA CEO assumes the role of Director of the Graduate School. The GSC assists the CEO in fulfilling the aims and objectives of the Graduate School.

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# Course List

| Course Name | Code | Host | Delivery Mode | Hours | Semes-ter | Page No |
|---|---|---|---|---|---|---|
| ***Astronomy and Space Sciences*** | | | | | | |
| **Advanced Data Analysis Astronomy** | **AAA** | St Andrews | VC | 27 | 1 | 11 |
| **Gravitational Wave Detection** | **GWD** | Glasgow | VC | 16 | 1 | 11 |
| **Astrophysical Plasmas** | **APL** | Glasgow | VC | 10 | 2 | 12 |
| **Astrobiology and the Search for Life** | **ASL** | Various | VC | 20 | 2 | 12 |
| **SUPA Observing Course** | **OBS** | St Andrews | VC | 15 | 2 | 12 |
| **The Sun's Atmosphere** | **TSA** | Glasgow | VC | 18 | 2 | 12 |
| ***Condensed Matter and Material Sciences*** | | | | | | |
| **Advanced Statistical Physics** | **ASP** | Edinburgh | VC | 22 | 1 | 13 |
| **Introduction to Computational Chemistry** | **CCH** | St Andrews | VC | 9 | 1 | 13 |
| **Quantum Field Theory** | **QFT** | St Andrews | VC | 30 | 1 | 14 |
| **Modern Topics in Condensed Matter Physics** | **TOP** | St Andrews | TBD | 35 | 1 | 14 |
| **Geometry and Physics of Soft Condensed Matter** | **GPSM** | Edinburgh | VC | 20 | 1 | 14 |
| **Chaikin & Lubensky's Principles of Condensed Matter** | **CLP** | Edinburgh | VC | 25 | 2 | 15 |
| **Electronic Structure Theory** | **EST** | Edinburgh | VC | 20 | 2 | 15 |
| **Electron Microscopy** | **ELM** | St Andrews | VC | 10 | 2 | 15 |
| **Quantum Devices** | **QMD** | Heriot-Watt | VC | 20 | 2 | 16 |
| **Non-Equilibrium Statistical Mechanics** | **NSM** | Edinburgh | VC | 14 | 2 | 16 |
| **Quantum Magnetism and Phase Transitions** | **QMPT** | St Andrews | VC | 18 | 2 | 16 |
| **Response Functions** | **RFN** | St Andrews | VC | 12 | 2 | 17 |
| **Soft Condensed Matter Physics** | **SCM** | Edinburgh | VC | 16 | 2 | 17 |
| ***Energy*** | | | | | | |
| **Solar Power** | **SPR** | St Andrews | F2F | 14 | 1 | 18 |
| **Laser Driven Plasma Acceleration** | **LDP** | Strathclyde | VC | 16 | 2 | 18 |
| ***Nuclear and Plasma Physics*** | | | | | | |
| **Accelerators** | **ACC** | Strathclyde | VC | 8 | 1 | 19 |
| **Biomedical Applications of Lasers, Beams and Radiation** | **BAL** | Strathclyde | VC | 12 | 1 | 19 |
| **Plasma Physics** | **PPH** | Strathclyde | VC | 12 | 1 | 20 |
| **Quarks and Hadron Spectroscopy** | **QHS** | Glasgow | VC | 8 | 2 | 20 |
| **Laser Driven Plasma Acceleration** | **LDP** | Strathclyde | VC | 16 | 2 | 20 |
| **Astrophysical Plasmas** | **APL** | Glasgow | VC | 10 | 2 | 20 |
| **Nuclear Instrumentation** | **NIN** | Edinburgh | VC | 6 | 2 | 21 |

# Course List

| Course Name | Code | Host | Delivery Mode | Hours | Semes -ter | Page No |
|---|---|---|---|---|---|---|
| ***Particle Physics*** | | | | | | |
| **Accelerators** | **ACC** | Strathclyde | VC | 8 | 1 | 22 |
| **Detectors** | **DET** | GLA and EDI | TBD | 16 | 1 | 22 |
| **Advanced Statistical Physics** | **ASP** | Edinburgh | VC | 22 | 1 | 22 |
| **Relativistic Quantum Field Theory** | **RQF** | Glasgow | TBD | 20 | 1 | 22 |
| **Collider Physics** | **COP** | GLA and EDI | TBD | 18 | 2 | 23 |
| **Discussion Classes** | **DCL** | GLA and EDI | VC | 8 | 2 | 23 |
| **Flavour Physics** | **FLA** | Glasgow | VC | 16 | 2 | 23 |
| **Lattice QCD** | **LAT** | Glasgow | VC | 6 | 2 | 23 |
| **Quarks and Hadron Spectroscopy** | **QHS** | Glasgow | VC | 8 | 2 | 23 |
| ***Photonics*** | | | | | | |
| **Experimental Atomic and Quantum Optics** | **EAQ** | Strathclyde | VC | 20 | 1 | 24 |
| **Nanophotonics** | **NAN** | St Andrews | VC | 27 | 1 | 24 |
| **Quantum Technology—Experimental Techniques** | **QTE** | Strathclyde | VC | 11 | 1 | 25 |
| **Concepts in Signal and Imaging Processing** | **CSI** | Strathclyde | VC, DIST | 24 | 1 | 25 |
| **Semi Quantum Theory of Atom Light Interactions** | **STA** | Strathclyde | VC | 24 | 2 | 25 |
| **Ultrafast Photonics** | **UPH** | Heriot-Watt | DIST | 10 | 2 | 25 |
| **Solid State Lasers** | **SSL** | Strathclyde | VC | 14 | 2 | 26 |
| **Quantum Technology—Theoretical Techniques** | **QTT** | Strathclyde | VC | 18 | 2 | 26 |
| ***Physics and Life Sciences*** | | | | | | |
| **Biophotonics** | **BPH** | St Andrews | VC | 27 | 1 | 27 |
| **Biomedical Application of Lasers, Beams and Radiation** | **BAL** | Strathclyde | VC | 12 | 1 | 27 |
| **Introducing Biology to Physicists** | **IBP** | Dundee | VC | 22 | 1 | 27 |
| **Astrobiology and the Search for Life** | **ASL** | Edinburgh | VC | 20 | 2 | 28 |
| **Biological Physics** | **BPS** | Edinburgh | DIST | 12 | 2 | 28 |
| ***Professional Development*** | | | | | | |
| **C+/- Object Orientated Programming** | **COO** | Remote | VC | 12 | 1 | 29 |
| **Introductory Data Analysis** | **IDA** | West of Scotland | VC | 6 | 1 | 29 |
| **Maths Primer** | **PRI** | Heriot-Watt | VC | 6 | 1 | 30 |
| **FPGA Programming for Physicists** | **FPP** | Strathclyde | VC | 12 | 1 | 30 |
| **Power Hour of Writing** | **PHW** | West of Scotland | VC | 7 | 1 | 30 |
| **Software Carpentry** | **SWC** | Glasgow | F2F | 16 | 2 | 30 |
| **Root** | **ROO** | Glasgow | F2F | 9 | 2 | 30 |
| **Mathematical Modelling** | **MMD** | Aberdeen | VC | 33 | 2 | 30 |
| **Advanced Data Analysis for the Physical Sciences** | **ADA** | Glasgow | F2F | 14 | 2 | 31 |
| **Introduction to Python** | **PYT** | Glasgow | VC, F2F | 8 | 2 | 31 |
| **Research Ventures** | **ENT** | Glasgow | F2F | 14 | 2 | 31 |
| **Industry Skills** | **ISC** | Various | VC | 6 | 2 | 31 |
| **From Zero to Draft in Nine Weeks** | **WRI** | West of Scotland | VC | 12 | 2 | 32 |

# Astronomy and Space Sciences

**Theme Leader: Aurora Sicilia Aguilar**

Photo: TNG (Telescopio Nazionale Galileo) Dome, La Palma, Canary Islands

The Astronomy and Space Sciences courses cover a broad range of topics aimed at widening students' knowledge of the field. They range from advanced extensions of subjects covered at undergraduate level to the introduction of new interdisciplinary sciences. We recommend that students take a mixture of core material, advanced courses (usually 16-20 hours equivalent credit) and 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 Sciences courses, with particular modules likely to be of interest for Life Sciences and Plasma Physics students, but they should remember that a basic understanding of astronomy and astronomical terms will be assumed by course lecturers.

**A typical programme building to the core requirement of 40 hours of Technical courses might include:**

- A SUPA technical Astronomy course (these generally constitute 16-20 hours)
- A technical SUPA course in another field or a second Astronomy course
- Non-SUPA courses as appropriate (eg for students changing specialities).
- Summer Schools in Astronomy and Space Physics

Students should note that certain Astronomy courses only run biennially. Each student must consult their PhD supervisor to contract 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.

## Semester 1

### Advanced Data Analysis—Astronomy (SUPAAAA)

**Status:** Offered in 2022/23

**Lecturer:** Keith Horne

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 27

**Assessment:** Any 3 of 2 Homework Sets and 2 Data Analysis Projects.

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

**Course Summary**

This module develops an understanding of basic concepts and offers practical experience with the techniques of quantitative data analysis. Beginning with fundamental concepts of probability theory and random variables, practical techniques are developed for using quantitative observational data to answer questions and test hypothesis about models of the physical world. Students develop their computer programming skills, build a data analysis toolkit, and gain practical experience by analysing real data sets. The two projects involve periodogram analysis of quasi-periodic oscillations in the HST light curve of an eclipsing dwarf nova, and a cross-correlation radial velocity analysis and mass estimation for a black hole binary, based on spectra from the Keck 10m telescope.

Course: Advanced Data Analysis Astronomy (supa.ac.uk)

### Gravitational Wave Detection (SUPAGWD)

**Status:** Offered in 2022/23

**Lecturer:** Mulitple; Course Organiser: Ik Siong Heng

**Institution:** Glasgow

**Delivery:** Videoconference

**Hours Equivalent Credit:** 16

**Assessment:** Two sets of problem exercises plus Oral Examination

**Course Work** Students are expected to spend 100 hours on this course.

**Course Summary**

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. 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.

Astrophysical sources of gravitational waves will be discussed including expectations for source strengths from coalescing compact binary systems, pulsars, etc. together with a discussion of the data analysis techniques that are required for signal extraction and parameter estimation. An update will be given on the new astrophysics that has been deduced from the gravitational wave signals so far observed, and the promise of future "multi-messenger astronomy" will be explored. Plans for future detectors on the ground and in space will also be presented.

Course: Gravitational Wave Detection

# Astronomy and Space Sciences

## Semester 2

### Astrophysical Plasmas (SUPAAPL)

**Status:** This is a biennial course. It is not offered in 2022/23 but is expected in 2023/24.

**Lecturer:** Lyndsay Fletcher

**Institution:** Glasgow

**Delivery:** Video Conference

**Hours Equivalent Credit:** 10

**Assessment:** Online Quiz, worked examples, short essay

**Course Summary**

The course will give an overview of the physics of plasmas, and introduce applications in astrophysics. Beginning with basic definitions and ideas such as plasma waves and kinetic theory, the course will develop fundamental concepts in astrophysical plasma diagnostics, including cyclotron and synchrotron radiation, bremsstrahlung and recombination emission, wave-particle interactions and plasma emission (coherent and maser).

Magnetohydrodynamics will be studied as a tool for understanding dynamos, solar and solar-terrestrial environments, and magnetospheres. The course will conclude with topical lectures on plasmas in different astrophysical environments. Students are strongly advised to take the Semester 1 course on Plasma Physics in the Nuclear and Plasma Theme first.

Course: Astrophysical Plasmas (supa.ac.uk)

### Astrobiology and the Search for Life (SUPAASL)

**Status:** Not Offered in 2022/23, expected in 2023/24

**Themes:** Astronomy and Space Sciece, and Physics and Life Sciences

**Lecturer:** Charles Cockell, et al

**Institution:** Various

**Delivery:** Video Conference

**Hours Equivalent Credit:** 20

**Assessment:** Exam

**Course Summary**

This course looks into the origin, evolution and distribution of life in the Universe, broadly considered as 'astrobiology'. The objective of the course is to provide a perspective in geology, biology and chemistry at an introductory level. The course will include lectures on the limits and conditions for life on Earth through time and how these may apply elsewhere in the universe. The course looks at the current scientific approaches used to address the hypothesis of life elsewhere in the Universe. The subjects discussed include: the formation of planetary systems and the conditions required for habitability, detection methods for extrasolar planets, the diversity of known exoplanet systems, the origin of life, evidence for earliest life on Earth, the geological and biological history of the Earth, conditions past and present on Mars and the icy moons of the giant planets, and finally the Search for Extra-Terrestrial Intelligence (SETI).

Course: Astrobiology and the Search for Life (supa.ac.uk)

### SUPA Observing Course (SUPAOBS)

**Status:** Offered in 2022/23

**Lecturer:** Aleks Scholz

**Institution:** St Andrews

**Delivery:** Online

**Hours Equivalent Credit:** 15

**Assessment:** Mock observing proposal as homework

**Coursework:** Students should expect to spend 20 hours on this course

**Course Summary**

The course includes 5 lectures on the basics of professional observations, given by observatory director Dr. Aleks Scholz. This will be complemented by 5 lectures on specialised observing techniques, given by St Andrews staff members.

Students will be offered an exclusive tour of the James Gregory Telescope in St Andrews, on a voluntary basis. We will also have observing sessions using telescopes in St Andrews that students can join remotely.

Course: SUPA Observing Course

### The Sun's Atmosphere (SUPATSA)

**Status:** This course is not offered in 2022/23 but may return in 2023/24.

**Lecturer:** Nicolas Labrosse

**Institution:** Glasgow

**Delivery:** Video Conference

**Hours Equivalent Credit:** 18

**Assessment:** 25% oral midterm exam, 25% oral final exam, 50% report on computer-based project

**Course Summary**

Come and see why our closest star is still shrouded in mystery, and learn about the physical processes that solar researchers study to understand the Sun's impact on the heliosphere.

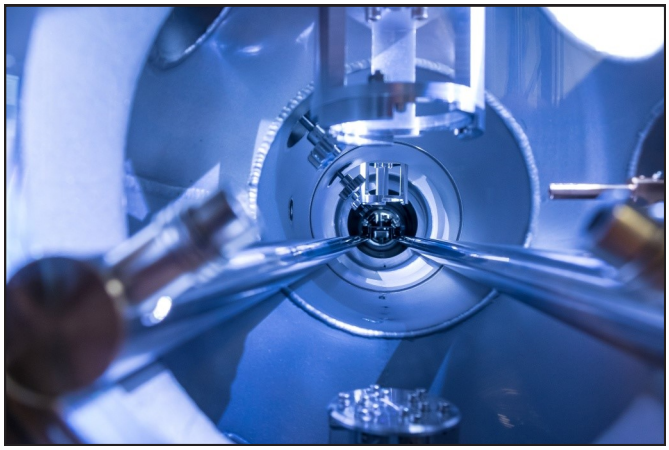
This course provides a comprehensive introduction to the physical processes at work in the solar atmosphere, and to the principles and practice of research in the physics of the solar atmosphere. It is compulsory for all students enrolled on the MSc in Astrophysics, and optional for all students on the MSc in Theoretical Physics. Its aims are:

- To develop the students' knowledge of emission processes of electromagnetic radiation; plasma physics; instrumentation; data analysis; theory and modelling – all in the context of the study of the solar atmosphere.
- To offer initial training in solar physics research which will be useful for students interested in pursuing a career in astrophysics or theoretical astrophysics.

Course: The Sun's Atmosphere (supa.ac.uk)

# Condensed Matter and Material Sciences

**Theme Leader: Stephen McVitie**
**University of Glasgow, Stephen.McVitie@glasgow.ac.uk**



Centre for Designer Quantum Materials © Tricia Malley Ross Gillespie www.broaddaylightltd.co.uk

Condensed Matter and Materials Sciences (CMMS) is a diverse subject covering many different specialities and attracts PhD students arriving from 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 aim 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 programme will comprise the following elements:

**CMMS 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 CMMS graduate school programme.

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

**Non-SUPA courses as appropriate** Summer Schools: Examples of appropriate summer schools include 'Physics by the Lake' for those with an interest in theory and HERCULES (Grenoble, France) for those doing research involving neutron and X-ray scattering at central facilities.

## Semester 1

### Advanced Statistical Physics (SUPAASP)

**Status:** Offered in 2022/23

**Lecturer:** Davide Michieletto and Tyler Shendruk

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 22

**Assessment:** Hand-in Exercises

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

**Course Summary**

In this course we will discuss equilibrium phase transitions, of 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 renormalization group (RG), in real space. Momentum space approaches will be briefly discussed. We will conclude with a study of stochastic dynamics and the approach to equilibrium and we will discuss nonequilibrium dynamics and nonequilibrium phase transitions.

Course: Advanced Statistical Physics (supa.ac.uk)

### Introduction to Computational Chemistry (SUPACCH)

**Status:** Offered in 2022/23

**Lecturer:** Herbert Fruchtl

**Institution:** St Andrews / ScotCHEM

**Delivery:** Video Conference

**Hours Equivalent Credit:** 9

**Assessment:** Continuous assessment through assignments

**Course Summary**

The 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 together with the theory behind the methods. Ab initio, DFT and classical methods for molecular systems, solids and surfaces, as well as cheminformatics, will be introduced along with how they are used in practice by researchers in Scotland.

Course: Introduction to Computational Chemistry (supa.ac.uk)

# Condensed Matter & Material Sciences

**Quantum Field Theory (SUPAQFT)**

**Status:** Offered in 2022/23

**Lecturer:** Chris Hooley

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 30

**Assessment:** Continuous assessment

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

**Course Summary**

Quantum field theory combines classical field theory with quantum mechanics and provides analytical tools to understand many-particle and relativistic quantum systems. This course aims to introduce the ideas and techniques of quantum field theory. I will use examples drawn mainly from condensed matter physics to illustrate the ideas and application of quantum field theory.

Course: MBQT 1 (Quantum Field Theory) (supa.ac.uk)

**Geometry and Physics of Soft Condensed Matter (SUPAGPSM)**

**Status:** This is a biennial course which will run in 2022/2023 but is not expected in 2023/24.

**Lecturer:** Davide Marenduzzo

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 20

**Assessment:** Problem Sheets

CDT students from St Andrews are not assessed, others are assessed through problem sheets.

This is an advanced undergraduate course at the University of Edinburgh.

**Course Summary**

In this course, we explore how to build theories for complex fluids; we will often be taking examples from the world of biology. The focus of the course will be to emphasise generic features in order to build up a repertoire of theoretical tools that are widely applicable to analyse a diversity of soft materials. Topics covered may vary from year to year depending on the specialisms of the staff involved but will include:

- Physics and nonequilibrium thermodynamics of binary mixtures
- Symmetries and phases of liquid crystals
- Topological defects in liquid crystals
- Hydrodynamic theories of complex fluids
- Topological properties of DNA: knots and supercoiling

Course: Geometry and Physics of Soft Condensed Matter (supa.ac.uk)

**Modern Topics in Condensed Matter Physics (SUPATOP)**

**Status:** Offered in 2022/23

**Lecturer:** Phil King, Peter Wahl, Chris Hooley, Bernd Braunecker

**Institution:** St Andrews

**Delivery:** By video, with lecture recordings made available

**Hours Equivalent Credit:** 35

**Assessment:** Problem Sheets, Presentations, Computational Exercises

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

**Course work** Students are expected to spend 150 hours on this course over the term.

**Course Summary**

The aim of this module is to give an introduction to a variety of contemporary topics of condensed matter physics research. Topics covered in this module include topology, Fermi liquid theory, electronic properties of surfaces and low-dimensional solids, and many body problems in condensed matter physics. This course will cover the underlying principles and introductory theory of these states of matter, will introduce the probes necessary to investigate them and their application in the study of other quantum materials, and will provide a survey of the current state of experimental results in this evolving field. The module consists of a series of 21 lectures covering these topics and includes practical computational examples to develop a numerical approach to solving physics problems and a journal club session where students present a research paper.

**Professional Development:** Many students in the Condensed Matter Theme take the Maths Primer course, SUPAPRI, for professional development credits. The Maths Primer course is listed in the professional development section, page 30.

Course: Maths Primer (supa.ac.uk)

**Quantum Mechanics for Scientists and Engineers, Discussion (SUPA)**

**Status:** Offered in 2022/23

**Lecturer:** Niclas Westerberg

**Institution:** Glasgow

**Delivery:** Zoom meetings, with recorded lectures

**Hours Equivalent Credit:** 18

**Assessment:**

**Course work** Students will spend about 55 hours on this course, including lectures

**Course Summary**

This course is a substantial introduction to quantum mechanics and is accessible to students from a wide range of science and engineering backgrounds.

Live discussion and tutorial sessions will be held twice a week through zoom. The course will also incorporate recorded lectures from Porf. David Miller at Stanford.

Course: Quantum Mechanics for Scientist and Engineers, Discussion Class (supa.ac.uk)

# Condensed Matter & Material Sciences

## Semester 2

### Chaikin and Lubensky's Principles of Condensed Matter (SUPACLP)

**Status:** This is a biennial course which will run in 2022/2023 but is not expected in 2023/24.

**Lecturer:** Alexander Morozov

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 25

**Assessment:** Continuous Assessment

**Course Summary**

This course will primarily involve a combination of directed reading and discussions 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). Assessment will be based on performance in both the student discussions and selected problems.

### Electronic Structure Theory (SUPAEST)

**Status:** This is a biennial course that will not run in 2022/23 but is expected in 2023/24.

**Lecturer:** Elton Santos

**Institution:** Edinburgh

**Delivery:** Video Conference and Face to Face

**Hours Equivalent Credit:** 20

**Assessment:** Problem Sheets, Project

**Course Summary**

This course will introduce the methods and approaches used in parameter-free descriptions of the electronic structure of materials, which aim to solve the quantum mechanical many-electron problem. We will discuss underlying ground state theories, such as wave-function based correlation methods and density functional theory, and their implementations in high-performance computing environments. We will study how to use the linear response ansatz and many-body perturbation theory to extract excited state information from those calculations, and thus accurately simulate spectroscopic and inelastic scattering experiments. Assignments will involve calculations on realistic materials on the UK's national supercomputer .

Course: Electronic Structure Theory (supa.ac.uk)

### Electron Microscopy (ELM)

**Status:** This is a biennial course. It is expected in 2022/23 but not in 2023/24.

**Lecturer:** Wuzong Zhou

**Institution:** St Andrews / ScotCHEM

**Delivery:** Video Conference

**Hours Equivalent Credit:** 10

**Assessment:** Exercises

**Course Summary**

The course will introduce the basic principles of electron microscopy and discuss several commonly used techniques for microstructural analysis of solid state materials. Lectures are given on:

- Introduction, interaction of electrons with the solid
- Scanning electron microscopy
- Energy dispersive X-ray spectroscopy
- Selected area electron diffraction
- High resolution transmission electron microscopic imaging

Course: Electron Microscopy (supa.ac.uk)

# Condensed Matter & Material Sciences

### Quantum Devices (SUPAQMD)

**Status:** Offered in 2022/23

**Lecturer:** Margherita Mazzera, Cristian Bonato

**Institution:** Heriot-Watt

**Delivery:** Video Conference

**Hours Equivalent Credit:** 20

**Assessment:** Problem Sheets (60%) and Final Oral Discussion (40%)

**Course Work:** Approximately 7 hours per week outside of class

**Course Summary**

This course introduces the techniques and approaches used to understand the physics of nanoscale materials and devices.
(1) Introduction to nanophysics, qubits and the density matrix formalism.
(2) Nanofabrication: Overview of the most common nanofabrication techniques and Nanostructure characterisation.
(3) Quantisation by confinement, effect of confinement on transport properties of solids, Effect of confinement on excitons, screening and energy renormalization.
(4) Spins in quantum mechanics, spin polarisation and readout, Nuclear spin baths , Applications to quantum sensing and quantum computing.
(5) Intro to superconductivity, macroscopic quantum model, London equation, Meissner effect, Josephson junctions, kinetic inductance.
Devices: kinetic inductance detectors, SQUIDs, SSPDs, superconducting qubits

### Non-Equilibrium Statistical Mechanics (SUPANSM)

**Status:** This is a biennial course which will run in 2022/23 but is not expected in 2023/24.

**Lecturer:** Tyler Shendruk

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Assessment:** Project

**Course Work:** In addition to lectures, students are expected to spend 10 hours doing individual course work.

**Course Summary**

The course explores the theory of systems out of equilibrium, be they relaxing to equilibrium or held out of equilibrium by external agencies. The lectures fall into two parts. The first half of the lectures cover core techniques and ideas in non-equilibrium statistical mechanics. The remaining lectures cover specialist and current topics of research. This course is assessed by means of peer-to-peer teaching, with each student presenting lectures on course content.

Course: Non-Equilibrium Statistical Mechanics (supa.ac.uk)

### Quantum Magnetism and Quantum Phase Transitions (SUPAQMPT)

**Status:** This is a biennial course. It is not offered in 2022/23 but is expected in 2023/24.

**Lecturer:** Bernd Braunecker, Jonathan Keeling

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 18

**Assessment:** Continuous Assessment

**Course Summary**

These lecturers cover two closely related themes: models of magnetism and quantum phase transitions. The two parts are strongly linked in that many of the models we will introduce to describe magnetism turn out to be paradigmatic models of quantum phase transitions. The course is intended to be relevant not just for those working on traditional solid state systems, but also those working on cold atom physics, where many of the same models and questions are also relevant.

Course: Quantum Magnetism and Quantum Phase Transitions (supa.ac.uk)

# Condensed Matter & Material Sciences

**Response Functions MBQ2 (SUPARFN)**

**Status:** Not Offered in 2022/23

**Lecturer:** Brendon Lovett

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 13

**Assessment:** Two assessed problem sheets

**Course Summary**

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.

CM-CDT students should note that Quantum Field Theory is a pre-requisite for this course

Course: MBQT 2 (Response Functions) (supa.ac.uk)

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**Soft Condensed Matter Physics (SUPASCM)**

**Status:** Offered in 2022/23

**Lecturer:** Aidan Brown

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 16

**Assessment:** Course work 50%, Exam 50%

**Course Work:** Students are expected to spend 72 hours on independent work for this course.

**Course Summary** Soft Condensed Matter Physics studies complex fluids in which intermediate level structures with length scale between small molecules and the macroscopic world exist: colloidal particles, polymers, and aggregates spontaneously formed by soap-like (surfactant) molecules. This course emphasises the generic features of these systems (most importantly, Brownian motion), and develops simple models to account for their behaviour. It will also look at how the principle of soft matter physics can give insight into biological problems.

Course: Soft Condensed Matter (supa.ac.uk)

# Energy

**Theme Leader: Job Thijssen**
**University of Edinburgh, j.h.j.thijssen@ed.ac.uk**

Our courses relate to two major aspects of the theme's activities: solar and nuclear power. They are designed to be accessible to all Energy Theme students – so that nuclear students could take the solar power course and vice versa. In addition to these courses, students are encouraged to select courses relevant to their interests and projects from other themes (particularly Condensed Matter and Materials Sciences, Photonics and Nuclear and Plasma Physics).

## Semester 1

## Semester 2

### Laser Driven Plasma Acceleration (SUPALDP)

**Status:** Offered in 2022/23

**Lecturer:** Dino Jaroszynski, Paul McKenna, Zheng-Ming Sheng, Bernhard Ersfeld

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 16

**Assessment:** Continuous Assessment

**Course Summary**

This 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 under-dense and over-dense 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.

SUPANRG: SUPALDP Laser Driven Plasma Acceleration

### Solar Power (SUPASPR)

**Status:** This is a biennial course. It is not offered in 2022/23 but is expected in 2023/24.

**Lecturer:** Ifor Samuel et al

**Institution:** St Andrews

**Delivery:** Face to Face

**Hours Equivalent Credit:** 14

**Assessment:** Problem Sheets and reports on laboratory experiments

**Course Summary**

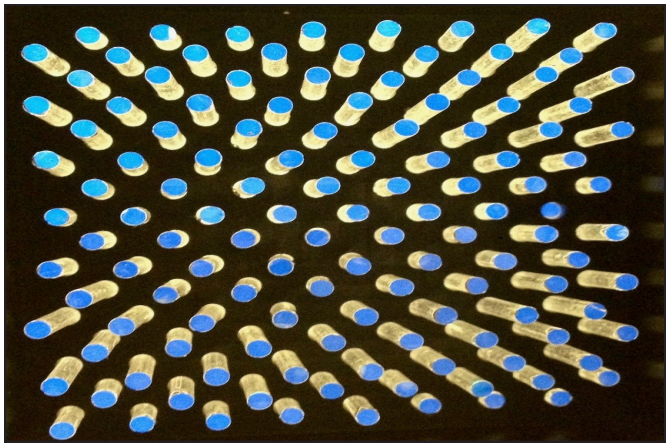
This course will provide an introduction to solar photovoltaics (PV). Lectures will introduce the problem of energy supply, and the amount of solar power potentially available. The general principles of PV will be covered, followed by lectures on a range of current and future PV technologies: crystalline, polycrystalline and amorphous silicon, thin film inorganic semiconductors, and organic semiconductor PV. Three lab sessions will enable students to explore key ideas in the lectures.

This is an intensive two-day course, using a range of invited lecturers from SUPA institutions.

SUPANRG: SUPASPR Solar Power

# Nuclear and Plasma Physics

**Theme Leader:**



POM Matrix, Muon Imaging System, University of Glasgow/Lynkeos Technology

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, PhD students will 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 course list
- Core skills classes, such as C++ Programming and Data Analysis, where appropriate
- Transferable skills courses such as an Entrepreneurship course

Where the number of courses taken exceeds the minimum requirement, students and their supervisors should agree on which courses should contribute towards the overall assessment. There are several Doctoral Training Centres that are part of NPP. PhDs in these Centres are usually four years in duration, where the whole of the first year is dedicated to formal courses and mini-projects. Students will normally decide on their PhD topic at the end of the first year.

## Semester 1

### Acceleratoors (SUPAACC)

**Status:** Not offered in 2022/23

**Lecturer:** Dino Jaroszynski

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 8

**Assessment:** Continuous Assessment

This is a postgraduate course. Undergraduates are welcome to listen but will not be examined.

This course is cross listed with the Particle Physics Theme.

**Course Summary**

Particle accelerators are a valuable tool in probing high-energy physics (up to the Large Hadron Collider at CERN) that is vital in helping us to understand the universe. They also have a wealth of more down-to-earth societal applications such as radiotherapy machines for treating cancer. This course gives a concise introduction to the field of conventional accelerators that use radio-frequency or microwave radiation in order to accelerate charged particles (electrons, protons, ions) to high energy.

Course: Accelerators (supa.ac.uk)

### Biomedical Applications of Lasers, Beams and Radiation (SUPABAL)

**Status:** Not offered in 2022/23

**Lecturer:** Bernard Hidding, Grace Gloria Manahan

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Assessment:** Continuous Assessment

This course is cross listed with the Physics and Life Sciences theme.

**Course Summary**

Lasers, particle beams and radiation such as x-rays are essential instruments for imaging, drug research and treatment in life sciences. This course will address both established and cutting edge radiation generation methods for a variety of biomedical applications, as well as the occurrence of radiation in nature and its effects. Then, the mechanisms of interaction of the different types of radiation on the nuclear, atomic, molecular, cell and system level (e.g. the patient) are discussed. Finally, fundamentals and progress in biomedical applications such as x-ray radiography, magnetic resonance tomography (MRT), positron emission tomography (PET), electron microscopy and other radiology imaging techniques, radiation-assisted drug R&D as well as laser surgery, cancer radiotherapy with photons, electrons, protons, neutrons and ions, and other treatment techniques will be covered. Next to providing an overview on the physics behind these techniques, the course will also include practical considerations and is intended to facilitate and support interdisciplinary research projects and collaborative applications.

Course: Biomedical Applications of Lasers, Beams and Radiation (supa.ac.uk)

# Nuclear and Plasma Physics

**Plasma Physics (SUPAPPH)**

**Status:** Offered in 2022/23

**Lecturer:** Adrian Cross, K. Ronald, B. Eliasson, D. Diver

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Assessment:** Multiple Choice Exam and Continuous Assessment

**Course Summary**

This course will address fundamental concepts in plasmas, from plasma creation from a neutral gas through to full ionization. Basic plasma timescales 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.

Course: Plasma Physics (supa.ac.uk)

## Semester 2

**Quarks and Hadron Spectroscopy (SUPAQHS)**

**Status:** Offered in 2022/23

**Lecturer:** Peter Hurck

**Institution:** Glasgow

**Delivery:** VC

**Hours Equivalent Credit:** 8

**Assessment:** Final exam, of approximately 2 hours

This course is cross listed with the Particle Physics theme.

**Coursework:** Approximately 1 hour per week in addition to lectures

**Course Summary**

The course will cover the following topics: Introduction to fundamentals of QCD, 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, experimental techniques, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.

**Laser Driven Plasma Acceleration (SUPALDP)**

**Status:** Offered in 2022/23

**Lecturer:** Dino Jaroszynski, Paul McKenna, Zheng-Ming Sheng and Bernhard Ersfeld

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 16

**Assessment:** Continuous Assessment

This is a final year undergraduate course. This course is cross listed with the Energy theme

**Course Summary**

This 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 under-dense and over-dense 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.

Course: Laser Driven Plasma Acceleration (supa.ac.uk)

**Astrophysical Plasmas (SUPAAPL)**

**Status:** This is a biennial course. It is not offered in 2022/23 but is expected in 2023/24.

**Lecturer:** Lyndsay Fletcher

**Institution:** Glasgow

**Delivery:** Video Conference

**Hours Equivalent Credit:** 10

**Assessment:** Online Quiz, worked examples, short essay

**Course Summary**

The course will give an overview of the physics of plasmas, and introduce applications in astrophysics. Beginning with basic definitions and ideas such as plasma waves and kinetic theory, the course will develop fundamental concepts in astrophysical plasma diagnostics, including cyclotron and synchrotron radiation, bremsstrahlung and recombination emission, wave-particle interactions and plasma emission (coherent and maser).

Magnetohydrodynamics will be studied as a tool for understanding dynamos, solar and solar-terrestrial environments, and magnetospheres. The course will conclude with topical lectures on plasmas in different astrophysical environments. Students are strongly advised to take the Semester 1 course on Plasma Physics in the Nuclear and Plasma Theme first.

Course: Astrophysical Plasmas (supa.ac.uk)

# Nuclear and Plasma Physics

**Nuclear Instrumentation (SUPANIN)**

**Status:** Offered in 2022/23

**Lecturer:** Tom Davinson

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 6

**Assessment:** Continuous Assessment

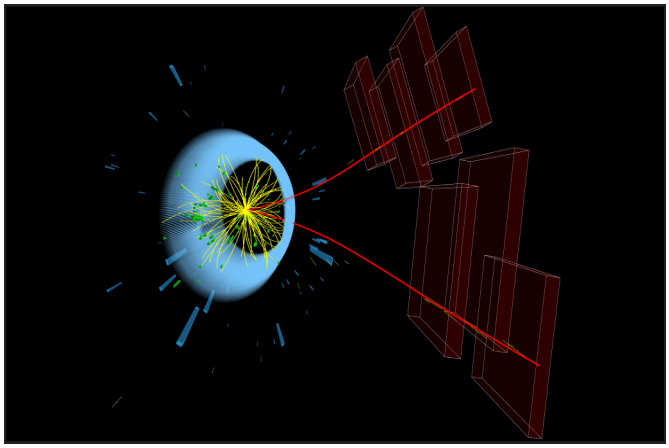
**Course Summary**

The objective of this short course of lectures is to provide students with an insight into state-of-the-art of 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.

Course: Nuclear Instrumentation (supa.ac.uk)

# Particle Physics

**Theme Leader: Victoria Martin**
**University of Edinburgh, Victoria.Martin@ed.ac.uk**



A candidate Bs meson decays into two muons, © CERN 2019

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 areas. Students should discuss with their supervisor which optional courses they should attend. All experimental particle physics students should take all of the following core courses: Detector Physics, Collider Physics, Flavour Physics & Discussion Classes, unless there is a good academic reason to make a different choice and in consultation with their supervisor.

## Semester 1

### Accelerators (SUPAACC)

**Status:** Not offered in 2022/23

**Lecturer:** Dino Jaroszynski, M Wiggins, B Ersfeld, G Vieux

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 8

**Assessment:** Continuous Assessment

This is a postgraduate course. Undergraduates are welcome to listen but will not be examined.

This course is cross listed with the Nuclear & Plasma Theme

**Course Summary**

Particle accelerators are a valuable tool in probing high-energy physics (up to the Large Hadron Collider at CERN) that is vital in helping us to understand the universe. They also have a wealth of more down-to-earth societal applications such as radiotherapy machines for treating cancer. This course gives a concise introduction to the field of conventional accelerators that use radio-frequency or microwave radiation in order to accelerate charged particles (electrons, protons, ions) to high energy.

Course: Accelerators (supa.ac.uk)

### Detectors (SUPADET)

**Status:** Offered in 2022/23

**Lecturer:** Kenneth Wraight, Dima Maneuski, Stephan Eisenhardt, Richard Bates, Andrew Blue

**Institution:** Glasgow and Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 16

11 lectures, 1x2hr lab & 1x3 hr lab (TBD)

**Assessment:** Assignment Sheets

**Course Summary**

The course will give a comprehensive overview on the many techniques and technologies utilised in the building of particle physics detectors. The series of 11 hours of video lectures is complemented by 5 hours of residential laboratory sessions. The course is self-contained and requires no prior knowledge of the field. Students will be assessed using problem sheets.

Course: Detectors (supa.ac.uk)

### Advanced Statistical Physics (SUPAASP)

**Status:** Offered in 2022/23

**Lecturer:** Davide Michieletto, Tyler Shendruk

**Institution:** Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 22

**Assessment:** Hand-in Exercises

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

**Course Summary**

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. Momentum space approaches will be briefly discussed. We will conclude with a study of stochastic dynamics and the approach to equilibrium and we will discuss nonequilibrium dynamics and nonequilibrium phase transitions.

Course: Advanced Statistical Physics (supa.ac.uk) Course: Advanced Statistical Physics (supa.ac.uk)

### Relativistic Quantum Field Theory (SUPARQF)

**Status:** Offered in 2022/23

**Lecturer:** Christoph Englert

**Institution:** Glasgow

**Delivery:** Videoconferencing/ recorded lectures

**Hours Equivalent Credit:** 20

**Assessment:** Open Book Exam

Joint Master's and PhD course

**Course Summary**

The course will cover the following topics: classical Lagrangian field theory, Lorentz covariance of relativistic field equations, quantisation of the Klein-Gordon, Dirac and electromagnetic fields, interacting fields, Feynman diagrams, S-matrix expansion and calculating all lowest order scattering amplitudes and cross sections in Quantum Electrodynamics (QED).

Course: Relativistic Quantum Field Theory (supa.ac.uk)

# Particle Physics

## Semester 2

### Collider Physics (SUPACOP)

**Status:** Offered in 2022/23

**Lecturer:** Giuseppe Callea, Liza Mijovic

**Institution:** Edinburgh and Glasgow

**Delivery:** Video Conference and Face to Face

**Hours Equivalent Credit:** 18 (16 Lectures & 2 Tutorials)

**Assessment:** Problem Sets (40%), Literature Review (60%)

**Coursework:** An assignment in 2 parts, requiring approximately 2 to 3 hours per week of individual work

**Course Summary**

The SUPACOP lectures provide the common core for all particle physics students in semester 2. The course covers three main subject areas:

- Electroweak and Higgs Physics
- QCD
- Beyond the Standard Model (BSM) Physics (including Supersymmetry)

The objective of the course is to provide a general overview of theoretical, phenomenological and experimental aspects of electroweak theory, QCD and BSM physics, concentrating on the most influential and/or recent measurements from colliders.

### Discussion Classes (SUPADCL)

**Status:** Offered in 2022/23

**Lecturer:** Cheryl Patrik

**Institution:** Glasgow and Edinburgh

**Delivery:** Video Conference

**Hours Equivalent Credit:** 8

**Assessment:** Presentation

**Course Summary**

This course provides students with an opportunity to investigate current topics of interest relating to current Particle Physics research, and to present them. Presentations are recorded and participants receive staff and peer feedback.

### Flavour Physics (SUPAFLA)

**Status:** Offered in 2022/23

**Lecturer:** Mark Whitehead and Phillip Lichtfield

**Institution:** Glasgow

**Delivery:** Video Conference

**Hours Equivalent Credit:** 16

**Assessment:** Continuous Assessment

**Coursework:** 5 hours of work per week, or 50 hours total

**Course Summary**

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 what is 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.

### Lattice QCD (SUPALAT)

**Status:** Offered in 2022/23

**Lecturer:** Brian Colquhoun

**Institution:** Glasgow

**Delivery:** Video Conference

**Hours Equivalent Credit:** 6

**Assessment:** Project

**Course Summary**

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.

Course: Lattice QCD (supa.ac.uk)

### Quarks and Hadron Spectroscopy (SUPAQHS)

**Status:** Offered in 2022/23

**Lecturer:** Peter Hurck

**Institution:** Glasgow

**Delivery:** VC

**Hours Equivalent Credit:** 8

**Assessment:** Final exam, of approximately 2 hours

This course is cross listed with the Nuclear & Plasma theme

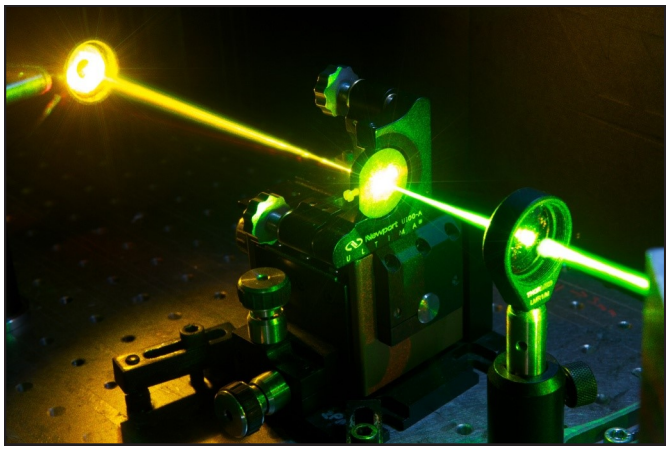
**Course work:** Approximately 1 hour per week in addition to lectures

**Course Summary**

The course will cover the following topics: Introduction to fundamentals of QCD, 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, experimental techniques, partial wave analysis, the search for exotic states: hybrid mesons, glueballs.

# Photonics

**Theme Leader: Robert Thomson,**
**Heriot-Watt University, R.R.Thomson@hw.ac.uk**



A diamond microlens Raman laser being pumped by a green laser. Image courtesy of Prof Alan Kemp, University of Strathclyde.

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 other themes, especially Condensed Matter and Material Physics and the Core courses. Students are also encouraged to attend Photonics related seminars hosted across Scotland.

**Professional Development:** Many students in the Photonics Theme take the Maths Primer course, SUPAPRI, for professional development credits. The Maths Primer course is listed in the professional development section, page 30.

## Semester 1

### Experimental Atomic & Quantum Optics (SUPAEAQ)

**Status:** Offered in 2022/23

**Lecturer:** Paul Griffin, Jonathan Pritchard

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 20

**Assessment:** Continuous Assessment

**Course Work:** 10 hours lecture, 10 hours tutorial, approximately 20 hours homework

**Course Summary**

The course will provide graduate-level training focused on providing the core knowledge needed for early career researchers and is designed to complement material covered in other courses such as SUPASTA. There is an emphasis on self-teaching, with the guidance of having clearly identified relevant reference materials to use as a starting point, and on learning basic coding skills for practical computing in the lab. The course will cover Atomic Structure, Atoms in Magnetic Field, Atom-Light Interactions, Interactions in Hot Atomic Media, Optical Dipole Trapping, Laser Cooling, Atomic Metrology, Data Analysis, and Experimental Electronics.

Course: Experimental Atomic & Quantum

### Nanophotonics (SUPANAN)

**Status:** Offered in 2022/23

**Lecturer:** Andrea DiFalco

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 27

**Assessment:** Tutorials and Exam

**Coursework:** Students are expected to spend 30 hours on lecturers and tutorials and 120 hours on guided independent study.

**Course Summary**

Nanophotonics deals with structured materials on the nanoscale for the manipulation of light. Photonic crystals and plasmonic metamaterials are hot topics in contemporary photonics. The properties of these materials can be designed to a significant extent via their structure. 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 module. Familiar concepts such as optical waveguides and cavities, multilayer mirrors and interference effects will be used to explain more complex features such as slow light propagation and high Q cavities in photonic crystal waveguides. Propagating and localised plasmons will be explained and will include the novel effects of super-lensing and advanced phase control in metamaterials.

Course: Nanophotonics (supa.ac.uk)

# Photonics

### Quantum Technology—Experimental Techniques (SUPAQTE)

**Status:** Not offered in 2022/23

**Lecturer:** E.Riis, E.Haller, M. Weides, A. Fedrizzi, A. Sinclair

**Institution:** Strathclyde, Glasgow, Heriot-Watt

**Delivery:** Video Conference

**Hours Equivalent Credit:** 11

**Assessment:** Essay

**Course Summary**

This course will provide an introduction to Quantum Technologies with a focus on experimental techniques and platforms. The course will start with an overview of experimental techniques in Quantum Technology, aimed to give a conceptual understanding of the key areas: Quantum Measurement and Sensing, Quantum Computation and Quantum Simulation, and Quantum Communications and Networks. In the field of Quantum Computing we will cover ion traps and the underlying physics, as well as superconducting qubits and platforms. For the latter, we will present various types of quantum circuits, control and readout techniques, nanofabrication and electronic hardware, and highlight current development towards realization of quantum advantage in computing. In Quantum Communication and Networks, we will provide an overview of state-of-the-art protocols, photonic platforms and experimental techniques. As an example for Quantum Simulation platforms, we will cover ultracold atoms in optical lattices and Rydberg arrays. We will also provide an introduction to Quantum Sensing and Metrology, by explaining the workings of atomic clocks, magnetometers and interferometers.

Course: Quantum Technology - Experimental Techniques (supa.ac.uk)

### Concepts in Signal and Image Processing (SUPACSI)

**Status:** Offered in 2022/23

**Lecturer:** Stankovic

**Institution:** Strathclyde

**Delivery:** Video Conference and Distance Learning

**Hours Equivalent Credit:** 24

**Assessment:** Lab Worksheets, Group Project

**Course Summary**

This course introduces aspects of both signal and image processing with a greater emphasis on image coding, processing and compression.

Class size is limited.

Course: Concepts in Signal and Image Processing (supa.ac.uk)

## Semester 2

### Semi-quantum Theory of Atom Light Interactions (SUPASTA)

**Status:** Offered in 2022/23

**Lecturer:** Gian-Luca Oppo

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 24

**Assessment:** Essay (60%) and Presentation (40%)

**Coursework:** Attendance during the first 6 weeks of SUPASTA is compulsory for SUPA students. The assessment is an essay on recent research topics closely connected to the course material.

The remaining 4 weeks are available to the SUPA students but are NOT compulsory. The final 4 weeks cover material that can expand the choice of the essay topics if desired by the SUPA students.

**Course Summary**

The course is beneficial to students interested in the interaction of laser light with atoms and materials. It provides useful theoretical and numerical skills that have become basics in many research fields in quantum optics, photonics, quantum information processes, light matter interaction and their applications. Topics covered include: second quantization, raising and lowering operators, density matrix approach, the Lindblad form of decay rates, two and three level atoms, Rabi oscillations, electromagnetically induced transparency, coherent population trapping, enhanced refractive indices, slow light, sub-natural line widths, self-focusing, spatial solitons during propagation, light-matter interaction in optical cavities, Maxwell-Bloch equations, optical bistability, cavity solitons, parametric down-conversion and optical parametric oscillators.

Course: Semi-quantum Theory of Atom Light Interactions (supa.ac.uk)

### Ultrafast Photonics (SUPAUPH)

**Status:** Offered in 2022/23

**Lecturer:** Derryck Reid

**Institution:** Heriot-Watt

**Delivery:** Distance Learning

**Hours Equivalent Credit:** 10

**Assessment:** Online Assessment

**Course Summary**

This is a short distance learning course operated by Heriot-Watt University via their Vision virtual learning environment. It has a formal accredited value of 5 SCQF credits. To complete the course students must carry out an online assessment using the Vision system, which means they must first register for an account. Details for doing this appear on the my.SUPA page.

Course: Ultrafast Photonics (supa.ac.uk)

# Photonics

**Solid State Lasers (SUPASSL)**

**Status:** Not offered in 2022/23

**Lecturer**:

**Institution:**

**Delivery:** Video Conference

**Hours Equivalent Credit:** 14

**Assessment:** Assessed Tutorial Assignment

**Course Summary**

An introduction to the physics, engineering, and thermal management of solid-state lasers, in particular diode-pumped solid-state lasers. Topics include: the underlying science and properties of lasers, e.g. energy levels, stimulated emission, population inversion, gain, threshold and slope efficiency; laser rate equations; common solid-state laser designs, including gain media, optical pumping schemes, operational modes (continuous wave, tuneable and pulsed); approaches to and modelling of thermal management in solid-state and semiconductor lasers; and laser case studies, including semiconductor disk lasers (VECSELs), and the uses of diamond in lasers.

Course: Solid State Lasers (supa.ac.uk)

**Quantum Technologies—Theoretical Techniques (SUPAQTT)**

**Status:** Offered in 2022/23

**Lecturer:** John Jeffers, Andrew Daley, Sarah Croke (Glasgow) and Ross Donaldson (Heriot-Watt)

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 18

**Assessment:** Essay

**Course work:** Students are expected to spend 40 hours on this course, including lectures and assignments.

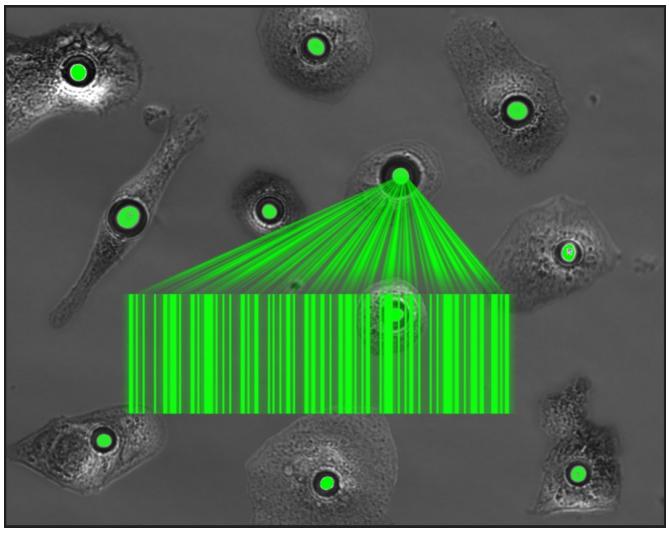
**Course Summary**

The course will provide important theoretical techniques relevant to Quantum Technologies. Part I - Basic Photonic Quantum Optics: Field quantisation, single-mode fields and quantum states, beam splitters and interferometers, non-classical light and its generation. Part II - Interacting Systems of Cold Atoms: Microscopic description of interacting cold atoms from first principles (pseudopotentials for two-particle scattering; second-quantised field operator Hamiltonian), introduction of approximate methods to treat cold atoms (Bogliubov theory; classical fields and Gross-Pitaevskii equation) and cold atoms in optical lattices (Hubbard models and corresponding phase diagrams).

Course: Quantum Technology - Theoretical Techniques (supa.ac.uk)

# Physics & Life Sciences

**Theme Leader: Stuart Reid**
**University of Strathclyde**



Barcode-type tag of a cell for non-contact tracking of cells. Malte Gather and Marcel Schubert, University of St Andrews.

The Theme of Physics and Life Sciences (PaLS) covers a large breadth of both 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 also invited to select relevant courses from any of the themes or to take appropriate and relevant non-SUPA courses within their home institution, but it is essential that the appropriate assessment (in the form of examination, written assignment or oral assignment) be discussed and agreed with the PaLS Theme Leader (Gail McConnell) in advance.

## Semester 1

### Biophotonics (SUPABPH)

**Status:** Offered in 2022/2023

**Lecturer:** Kishan Dholakia, Carlos Penedo-Esteiro, Graham Bruce

**Institution:** St Andrews

**Delivery:** Video Conference

**Hours Equivalent Credit:** 27

**Assessment:** Attendance, news and views article, assessed problem sheet, presentation

This is a final year undergraduate course organised by University of St Andrews.

**Coursework** Students are expected to spend 27 hours on lectures and 115 hours on independent work.

**Course Summary**

The module will expose students to the exciting opportunities offered by applying photonics methods and technology to biomedical imaging, sensing and detection. A rudimentary biological background will be provided where needed. Topics include fluorescence microscopy and assays including time resolved applications, super-resolution imaging, optical tweezers for cell sorting and DNA manipulation, single molecule studies, optogenetics and methods to measure forces in biology.

### Biomedical Applications of Lasers, Beams and Radiation (SUPABAL)

**Status:** Not offered in 2022/23

**Lecturer:** Bernard Hidding, Grace Gloria Manahan

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Assessment:** Continuous Assessment

This course is cross listed with the Nuclear & Plasma theme.

**Course Summary**

Lasers, particle beams and radiation such as x-rays are essential instruments for imaging, drug research and treatment in life sciences. The course would address both established and cutting edge radiation generation methods for a variety of biomedical applications, as well as occurrence of radiation in nature and their effects. Then, the mechanisms of interaction of the different types of radiation on the nuclear, atomic, molecular, cell and system level (e.g. the patient) are discussed. Finally, fundamentals and progress in biomedical applications such as x-ray radiography, magnetic resonance tomography (MRT), positron emission tomography (PET), electron microscopy and other radiology imaging techniques, radiation-assisted drug R&D as well as laser surgery, cancer radiotherapy with photons, electrons, protons, neutrons and ions, and other treatment techniques will be covered. Next to providing an overview on the physics behind these techniques, the course will also include practical considerations and is intended to facilitate and support interdisciplinary research projects and collaborative applications.

Course: Biomedical Applications of Lasers, Beams and Radiation (supa.ac.uk)

### Introducing Biology to Physicists (SUPAIBP)

**Status:** Offered in 2022/23

**Lecturer:** Andrei Pisliakov

**Institution:** Dundee

**Delivery:** Video Conference, Recorded lectures with interactive tutorials

**Hours Equivalent Credit:** 22

This is an undergraduate course run by the University of Dundee.

**Assessment:** Mainly, an essay at the end of term with short quizzes during the term

**Course Summary**

An overview of fundamental areas of biology for students with little biology background, emphasizing evolution, connections between length and time scales in biology, and the potential role of physics to inform biology at all of these different scales. Introduction: what is life? Darwin's theory of evolution, Mendelian genetics, tree of life, basics of prokaryotic cells, basics of eukaryotic cells. Biochemistry and molecular biology: structure and functions of proteins, structure of DNA, DNA replication, transcription, translation, protein folding. Cell biology: membrane structure, membrane transport, metabolism and mitochondria, cytoskeleton, cell cycle. Multicellular organisms: germ cells, fertilisation, development. Populations: introduction to ecology, population genetics and evolution.

# Physics & Life Sciences

## Semester 2

### Astrobiology and the Search for Life (SUPAASL)

**Status:** Not Offered in 2022/23, expected in 2023/24

**Lecturer:** Charles Cockell, et al

**Institution:** Various

**Delivery:** Video Conference

**Hours Equivalent Credit:** 20

**Assessment:** Exam

This course is cross-listed with the Astronomy and Space Sciences Theme.

**Course Summary**

This course looks into the origin, evolution and distribution of life in the Universe, broadly considered as 'astrobiology'. The objective of the course is to provide a perspective in geology, biology and chemistry at an introductory level. The course will include lectures on the limits and conditions for life on Earth through time and how these may apply elsewhere in the universe. The course looks at the current scientific approaches used to address the hypothesis of life elsewhere in the Universe. The subjects discussed include: the formation of planetary systems and the conditions required for habitability, detection methods for extrasolar planets, the diversity of known exoplanet systems, the origin of life, evidence for earliest life on Earth, the geological and biological history of the Earth, conditions past and present on Mars and the icy moons of the giant planets, and finally the Search for Extra-Terrestrial Intelligence (SETI).

Course: Astrobiology and the Search for Life (supa.ac.uk)

### Biological Physics (SUPABPS)

**Status:** Offered in 2022/23

**Lecturer:** Chris Brackley and Gavin Melaugh

**Institution:** Edinburgh

**Delivery:** Distance Learning

**Hours Equivalent Credit:** 12

**Assessment:** Written Assessment

This is a level 11 undergraduate course organised by the University of Edinburgh. It would provide a physics-based introduction to Biological Physics for students who have not taken such a course as undergraduates. This course will be taught to SUPA students as a Distance Learning course.

**Coursework:** Students will spend 10—20 hours on self-directed coursework. The amount of time depends on the subject students choose. If students choose a subject that they are already very familiar with, they may need less time to complete the report.

**Course Summary**

Physics can provide a very real - and very valuable - insight into the behaviour of complex biological systems and a physical approach to biological problems can provide a new way of looking at the world. This course will introduce the students to the basics of biological systems, and then provide examples of how familiar physical principles (thermodynamics, statistical mechanics) underlie complex biological phenomena. This course will introduce you to the wonders of biology: the organisms, cells and molecules that make up the living world. We will demonstrate the power of physical concepts to understand and make powerful predictions about biological systems, from the folding of a protein into a unique three-dimensional structure within a reasonable timeframe, through the motions of proteins to drive biological processes, to the locomotion of bacterial cells. The physical concepts will be substantially familiar, but their applications will be novel. Where possible, examples will be drawn from the recent scientific literature.

**Professional Development:** Many students in the Physics and Life Sciences theme take the Mathematical Modelling course, SUPAMMD, for professional development credits. The Mathematical Modelling course is listed in the professional development section, page 31.

Course: Mathematical Modelling (supa.ac.uk)

# Professional Development

SUPA Careers event, January 2020

All SUPA students are required to complete 20 hours of Professional Development Training during the first two years of their PhD studies. SUPA Professional Development Training Courses are listed in this section. In addition, students may also participate in Professional Development Training run by their local departments and universities or run by Vitae (a UK-wide organisation sponsoring Skills Training) or their Research Councils.

Please note that enrolment times for Professional Development Training are often different from Specialist Courses. Information about enrolment for each course will be posted on My.SUPA course areas and announced to all students via email. If you have any questions about enrolment, please email admin@supa.ac.uk.

Courses run by Vitae and individual universities can be found at the following websites:

Vitae: https://www.vitae.ac.uk/doing-research

University of Aberdeen: https://www.abdn.ac.uk/pgrs

University of Dundee: https://www.dundee.ac.uk/opd

University of Edinburgh:
https://www.ed.ac.uk/institute-academic-development

University of Glasgow:
https://www.gla.ac.uk/myglasgow/ris/researcherdevelopment/

Heriot-Watt University:
https://www.hw.ac.uk/services/research-futures.htm

University of St Andrews:
https://www.st-andrews.ac.uk/ceed/

University of Strathclyde:
https://www.strath.ac.uk/theresearcherdevelopmentprogramme/

University of the West of Scotland:
https://www.uws.ac.uk/about-uws/academic-life/uws-academy

## Semester 1

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

**Status:** Offered in 2022/23

**Lecturer:** Federica Fabbri

**Institution:** Glasgow

**Delivery:** Remote Video Conference

**Hours Equivalent Credit:** 12 (4 x 1 hour Lectures and 4 x 2 hour Tutorials)

**Assessment:** Continuous Assessment

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 Summary**

This course introduces C++ via four lectures. Each lecture is paired with a computer lab. The course will be entirely remote so everyone is encouraged to use their own laptop with Linux or Mac OS to work directly in the day to day work environment. It's possible also to install a virtual machine/ Linux emulator on windows systems. If a personal/university computer with a C++ compiler installed is not available, there may be alternatives in the computer lab.

The topics covered are the basic C++ that you need to get going in your research. Object-oriented notions, such as classes and inheritance, will not be covered in this introductory C++. The topics covered include: basic C++ syntax; standard C++ data types (bool, float, char, etc); standard C++ streams (cout, cin, error, etc); standard C++ operators (==, &&, %, etc); conditionals and loops (if, for, while, switch, case, etc); standard templated library types (string, vector, map, list, stringstream, etc); pointers and references; functions; overloading functions; passing argument to a function by reference; templated functions; how to compile your code as an executable or a shared library to be used by another piece of code; how to convert one data type to another data type; how to compute the time it takes to run your code; how to pass arguments at the command line.

Course: C++/Object Oriented Programming (supa.ac.uk)

### Introductory Data Analysis (SUPAIDA)

**Status:** Offered in 2022/23

**Lecturer:** Carlos Garcia Núñez

**Institution:** UWS

**Delivery:** Video Conference

**Hours Equivalent Credit:** 6

**Assessment:** Continuous Assessment

**Course Summary**

This course provides an introduction to uncertainty in measurement. Topics will include: random error and relation to statistics; probability distributions and their properties; calculation and estimation of uncertainty; least squares model; applications of data analysis.

Course: Introductory Data Analysis (supa.ac.uk)

# Professional Development

### Maths Primer (SUPAPRI)

**Status:** Offered in 2022/2023

**Lecturer:** Patrik Öhberg

**Institution:** Heriot-Watt

**Delivery:** Video Conference, Lectures are pre-recorded and class time is used for questions and discussion.

**Hours Equivalent Credit:** 6 Professional Development Credits

**Assessment:** Continuous Assessment

**Course Summary**

The course will be in the form of a maths primer intended for beginning PhD students in condensed matter, solid state and photonics. The topics which will be covered include: Matrix diagonalisation, functional derivatives, complex integration and residues, Fourier transforms, and a discussion on different notations which the students will encounter during their studies.

Course: Maths Primer (supa.ac.uk)

### FPGA Programming for Physicists (SUPAFPP)

**Status:** Offered in 2022/23

**Lecturer:** Johannes Hernsdorf

**Institution:** Strathclyde

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Assessment:** Continuous Assessment

**Course Work:** Students are expected to spend 2.5 hours per week on this course, in addition to lectures

**Summary**

Field programmable gate arrays (FPGAs) are configurable digital electronic devices capable of providing high-speed, low-latency and controlled latency digital interfaces to experiments. For example, FPGAs have been used in fluorescence lifetime measurements, various imaging methods, detection of photon correlations, gravitational wave detectors, and gravimeters. This course will equip students with the basic knowledge of how to interface physics experiments to digital electronics, and how to program FPGAs. An introduction to hardware description languages (HDLs) is given on the example of Verilog. HDLs are fundamentally different from computer programming languages and understanding them is crucial for the use of FPGAs. After completion, participants will be able to integrate FPGAs into their own experiments, create simple FPGA configurations, understand common problems and strategies to overcome them, and be aware of resources to help extend these skills.

### Power Hour of Writing (SUPAPHW)

**Status:** Offered in 2022/23

Starts Friday 9th September 12:50-14:10

**Lecturer:** Stephanie Zihms

**Institution:** UWS

**Delivery:** Video Conference

**Hours Equivalent Credit:** 7

**Assessment:** Continuous

**Course Summary**

This course supports students in their writing projects. Students must have a writing project to work on and will spend most of the time working on their own writing. These sessions will help students set goals for themselves and make progress. Students are welcome to work on a paper, their thesis, or a presentation.

## Semester 2

### Software Carpentry (SUPASWC)

**Status:** Offered in 2022/23

**Lecturer:** Daniel Williams with Norman Gray

**Institution**: Glasgow

**Delivery:** Face to Face

**Hours Equivalent Credit:** 16

**Assessment:** Continuous Assessment

**Course Summary**

Many researchers need to write (computer) code of some type or other, though typically as an auxiliary activity – researchers should not turn into 'programmers'. It is useful for researchers to do that part of their work effectively, now and in the (transferrable) future. The Software Carpentry course (SWC) aims to instil pragmatic good practice in scientists.

Course: Software Carpentry (supa.ac.uk)

### ROOT (SUPAROO)

**Status:** Offered in 2022/23

**Lecturer:** Dwayne Spiteri

**Institution:** Glasgow

**Delivery:** Face to Face

**Hours Equivalent Credit:** 9 (2 x 3 hour Labs)

**Assessment:** Continuous Assessment

**Course Summary**

ROOT is a primary data analysis framework tool developed by CERN and used in experimental particle physics and, increasingly, many other fields. This course is based on hands-on sessions in which you will learn the basic features of ROOT, through to producing a publication-quality plot from raw data.

Course: ROOT (supa.ac.uk)

### Mathematical Modelling (SUPAMMD)

**Status:** Offered in 2022/23

**Lecturer:** Marco Thiel

**Institution:** Aberdeen

**Delivery:** Video Conference

**Hours Equivalent Credit:** 32

**Assessment:** Informal assessment; This is a final year undergraduate course organised by the University of Aberdeen. While students at Aberdeen are assessed, those taking the course through SUPA will not be formally assessed but will receive feedback on their work.

Coursework: Over the term, students are expected to spend about 100 hours on coursework outside of lectures.

**Course Summary:** This course shows you how to develop mathematical descriptions of phenomena. We use mathematical techniques to describe a large variety of "real-world" systems: spreading of infectious diseases, onset of war, opinion formation, social systems, reliability of a space craft, patterns on the fur of animals, (morphogenesis), formation of galaxies, traffic jams and others. This course boosts your employability and teaches tools that are highly relevant for almost every researcher.

# Professional Development

### Advanced Data Analysis for the Physical Sciences (SUPAADA)

**Status:** Offered in 2022/23

**Lecturer:** Ik Siong Heng

**Institution:** Glasgow

**Delivery:** Face to Face if possible, otherwise videoconferencing

**Hours Equivalent Credit:** 14

**Assessment:** Series of multiple choice questions throughout lectures

**Course Summary**

This course will provide a comprehensive introduction to the principles and practice of advanced data analysis, with particular focus on their application within the physical sciences and on the (rapidly growing) use of Bayesian Inference methods.

Over the past few decades Bayesian inference methods, as a powerful tool for analyzing data, have been growing ever more common across a diverse range of fields of physics. Bayesian inference provides a natural framework in which to address key quantitative questions, constrain the parameters of physical models and measure how well competing models can describe the available data. They also provide an objective and straightforward framework in which to incorporate prior information about those models, obtained e.g. from previous analyses or from theory. Moreover, recent advances in computational methods also offer simple algorithms in which to implement Bayesian methods – even with very large and complex data sets – on a standard desktop computer.

These lectures will give a comprehensive introduction to Bayesian inference methods. The lectures will include some practical exercises designed to introduce some useful codes and algorithms – as well as to showcase the vast array of online resources available to support the "virgin Bayesian" seek to apply these methods to their data.

Course: Advanced Data Analysis (supa.ac.uk)

### Introduction to Python (SUPAPYT)

**Status:** Offered in 2022/23

**Lecturer:** Albert Borbely

**Institution:** Glasgow

**Delivery:** Video Conference and Face to Face

**Hours Equivalent Credit:** 8 (4 Lectures and 2 x 2 hour Tutorials)

**Assessment:** Assignment Problem

**Course Summary**

This course serves as a first introduction to the powerful, object-oriented scripting language Python, which combines ease of use with extensive functionality and simple extensibility. After completion, it's intended that users will be familiar with the concepts and philosophy of Python, be able to use it to solve a wide range of everyday problems and be able to extend its functionality with user defined classes and modules for more specialised problems.

Course: Introduction to Python (supa.ac.uk)

### Research Ventures (SUPAENT)

**Status:** Not offered in 2022/23

**Lecturer:** Various

**Institution:** Glasgow

**Delivery:** Face to face at a location to be determined. This course will be organised by the Researcher Development Department at the University of Glasgow

**Hours Equivalent Credit:** 2 days (14 hours)

**Course Summary**

This two-day course will provide an insight into the process of research commercialisation, starting a business, finding funding and self-employment).

Course: Research Ventures (supa.ac.uk)

### Industry Skills (SUPAISC)

**Status:** Offered 2022/23

**Lecturer:** Various external speakers

**Institution:** Various

**Delivery:** Video Conference

**Hours Equivalent Credit:** 6

**Assessment:** Written summaries

**Course Summary**

The SUPA industry skills course is delivered by representatives from industry and will focus on essential skills for future careers. NPL, Marks and Clerk, Optos, Thales, Coherent, Leonardo and Aridhia Informatics have been instrumental in the creation of this course. Topics covered in previous years have included Intellectual Property and Patents, Product Line Management, Risk Management, Decision Making Skills and Written Communication.

Course: Industry Skills Course (supa.ac.uk)

# Professional Development

**From Zero to Draft in Nine Weeks (SUPAWRI)**

**Status:** Offered in 2022/23

Thursday 19th January until 16th March, 9:30-11:00

**Lecturer:** Stephanie Zihms

**Institution:** UWS

**Delivery:** Video Conference

**Hours Equivalent Credit:** 12

**Course Summary**

This course will support students through the process of writing a journal paper. Each week will follow the structure of a typical science journal paper – each session has 30min writing built-in so you can make progress during the course. There is also time to ask questions, get feedback and learn how others write. This course works best if you are working on a paper or have an idea for a paper, however the tips and sessions are also useful for thesis writing.

Each session is recorded and you can catch-up or rewatch sessions to support your progress.

Participants are encouraged to meet outside the scheduled sessions to continue working on their paper. The SUPA Power Hour of Writing on Fridays might be something you want to try. It is up to you how much time you make for writing. To make progress in parallel to the course I recommend blocking at least 90min of writing time each week to work on the writing for this course.

100% of students who provided feedback said they would recommend the course – below are some quotes.

*Over the course I have learnt lots of tips that has helped me write the bulk of my paper*

*I have a book to refer to but this course provided dedicated time to learn and act on what I learnt- so I have a draft at the end of the 8 weeks. It was the structure and info/support that I needed.*

Course: From 0 to draft in 9 weeks (supa.ac.uk)

# Researcher Development Framework

## The Researcher Development Framework

The Researcher Development Framework describes the knowledge, behaviours and attributes of successful researchers and encourages you to aspire to excellence through achieving higher levels of development. It is invaluable for planning, promoting and supporting your personal, professional and career development. Further information can be found online at: www.vitae.ac.uk/rdf

You can use the RDF to identify strengths and prioritise your professional development, considering the skills and experiences that will enhance your career prospects. It will also support you to articulate your knowledge, behaviors and attributes to employers.

As you start your doctorate, consider looking at the 'Getting Started' lens of the RDF, which will help you consider the right questions to identify the training you should consider for the best possible start. The lens can be found at https://www.supa.ac.uk/courses.