Physics & Astronomy
Undergraduate 2018 Entry
Physics & Astronomy at St Andrews

- Students at the University of St Andrews have voted themselves the most satisfied in the UK for the quality of their higher education experience, according to the National Student Survey 2017. This is the ninth time in the past 11 years that St Andrews has been ranked at the top of universities across the UK in this survey.
- Students enjoy a wide range of activities in a student-focused community within a historic coastal town.
- Entrant students applying appropriately are virtually guaranteed a place in University accommodation.
- Our School is large enough to have major research strengths, but small enough that there is good student-staff interaction, and some small class sizes.
- Programmes are flexible, with a choice of entry and exit points and degree intention as a student proceeds.
- Well-qualified entrants may complete an Honours BSc degree in three years, or an MPhys degree in four.
- The University Observatory contains the largest operational optical telescope in the UK.
- The 2013 formal inspection of our teaching programme commended the School for being: “A collegiate and well-run School where students and staff operate as a community of scholars.”
- Internationally recognised research in astrophysics, biophotonics, lasers and optoelectronics, mm-waves, magnetism, semiconductors, solid-state and theoretical physics informs our teaching.
- In the Guardian University League Tables 2018 Physics in St Andrews was rated top in the UK.

Physics and Astronomy are key subjects for understanding the universe around us. There is a fascination and a challenge here. Why is the sky blue? What is the difference between metals and semiconductors? How are matter and energy related? How did the universe begin? How did the universe begin? Answers to these and similar questions can then lead to investigation and understanding of related phenomena, and to the development of new technologies.

We can use physics to understand aspects of systems ranging from the smallest parts of our bodies to the vast collections of galaxies. Physics is relevant in almost every human endeavour. Our teaching emphasises an understanding of these ideas. Our courses are interesting, current, relevant, and thought-provoking.

Along with several other science Schools, Physics & Astronomy lies on a pleasant modern site close to the town centre, as pictured on the back cover of this leaflet. Teaching, research, library and computing facilities are in our building, and the well-equipped University Observatory nearby has the largest operational optical telescope in the British Isles.

Having almost 40 members of teaching staff and around 150 research staff and students, the School is large enough to provide a wide coverage of physics and astronomy at undergraduate level and lively enough to produce significant research. However, the School is small enough for staff and students to get to know each other in a way that is not possible at much larger universities. Some 60-100 students per year graduate from the School. The comparatively small size of the University as a whole facilitates the ready mixing of those studying different subjects. There is a cosmopolitan feel to St Andrews, with students from all over the UK, and indeed from around the world.

The Institute of Physics 2013 accreditation report commented on the “strong commitment to high quality teaching”, and also that “students informed the panel that staff are approachable and willing to provide individual feedback and assistance when requested. The students noted that from Junior Honours onwards the lecturers get to know all students which supported the feeling of community within the School.”

Degree Options for Physics or Astronomy

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<td>Physics (BSc)</td>
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<td>Physics and Astronomy (Gateway) BSc (FH31) and MPhys (FH3C)</td>
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Joint Honours (BSc)

Physics and:
- Computer Science GF43
- Mathematics FG31
- Philosophy FV35

Note also the alternative entry route: Physics and Astronomy (Gateway) BSc (FH31) and MPhys (FH3C) (See page 6 for Entrance Requirements)
When a fine nickel powder is agitated by electric and magnetic fields, it shows dynamic co-operative effects. Honours students are investigating this ordering phenomenon using a specialised video camera and LabView software.

Investigating the phase structure of laser modes in the senior teaching labs.

Astrophysics students may use the 0.94m James Gregory telescope, amongst others. This photo used timelapse techniques to “see inside” the dome.

Discussion in quantum information theory.

Second year students exploring microcontrollers and touch-screens.

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**BSc & MPhys Programme Details**

A five-level structure is used in order to provide suitable entry and exit points tailored for students with different backgrounds and desires. These levels, which usually last an academic year each, are shown in the table on pages 6 and 7. There can be a choice of entry level depending on school qualifications and how broad you wish your entry year to be.

First year (1000-level) entry has been designed for those entering straight from Scottish Highers, those wishing to experience the traditional broad-based first year at university, and students on some joint programmes. If you have good Advanced Highers or A-Levels, and you are sure that you wish to study for a degree in physics and/or astronomy, you are invited to enter directly into second year (2000-level). Currently around one third of our entrant students take this accelerated route.

There is an alternative 1000-level entry called the Physics and Astronomy (Gateway) designed for students with high academic potential who have experienced disadvantage. Slightly lower qualifications (e.g. BBBB at Higher) are needed for entry, and although about half the entry year is with the traditional entry students, about half is on strongly tutored modules in academic skills relevant to physics and mathematics. Successful completion of this year allows progression to our second year physics, astrophysics, and mathematics modules.

There is a choice of exit levels with the BSc Honours degree taking three or four years and the more advanced MPhys Honours degree taking four or five years, depending on the point of entry. The MPhys (Integrated Masters) degree is particularly appropriate if you wish to go on to pursue a research or development career in physics or astronomy. Your final decision on the BSc or MPhys degree need not be made until third year.

In third and fourth year you take some or all of the mainstream modules in quantum mechanics, nuclear and particle physics, thermal and statistical physics, electromagnetism, and solid-state physics, as well as choosing additional modules in specialist areas. Depending on the degree programme these might include *Extragalactic Astronomy, Computational Astrophysics, Special Relativity and Fields, Fluids*, laboratory modules and many others. All final year students undertake a major research project, which is usually carried out within one of the School’s research groups.

The MPhys additional year contains a choice of advanced lecture modules in areas such as *Biophotonics, Group Theory, Monte Carlo Radiation Transport Techniques, Applications of Quantum Physics, Magnetofluids and Space Plasmas*, and *Contemporary Astrophysics*, as well as a major research project. All our BSc, MPhys and MSci degrees are accredited by the UK Institute of Physics.

In all modules, lectures are supplemented by tutorials. At second and third year these tutorials may be in groups comprising only four or five students. Tutorials provide the opportunity for in-depth discussions of issues arising from lectures, as well as broader topics in physics and astronomy.

Appropriate laboratory periods introduce you to a wide range of equipment and techniques. Third and fourth year lab modules, for example, contain work with scanning tunnelling microscopes, X-ray crystallography, cryogenics, and optical tweezers. Astronomy students have the use of telescopes at the Observatory.

In your final year you can participate in the extensive research activity of the School by undertaking a project which extends over a large part of the academic year. This is a great way to learn and experience the development of physics at first hand. Some projects result in scientific publications, and may include travel to international facilities. Recent projects have included the investigation of extra-solar planets, the use of our cleanroom to explore novel liquid micro-optics, the use of terahertz radiation for drug detection, and the theoretical physics of invisibility cloaks.

Advanced communication and other skills are developed in the *3000-level Transferable Skills for Physicists* module, which includes an informal weekend spent away from St Andrews, giving a talk on a chosen topic in physics or astrophysics.

Depending on the modules you have chosen to take, it is possible to postpone the final choice of degree title at least until you reach 3000-level. Many students make use of this flexibility.
First Year
Six 20-credit modules are normally taken in this first year of study. These include Physics 1A and 1B, which cover topics such as Newtonian Mechanics, Quantum Phenomena, Waves and Optics, Properties of Matter, and Lasers.

Intending astronomers must take AS1001; this is an option for others. The astronomy module contains topics on The Solar System, Stars & Elementary Astrophysics, The Galaxy, and Galaxies & Cosmology.

All these modules contain suitably graded practical work and tutorials.

Intending physics or astronomy students must include at least one or two Mathematics modules, depending on school qualifications. A wide choice of other 1000-level modules from across the University is available, subject to timetable constraints.

Second Year Direct Entry
Students take the second year Maths modules MT2501 Linear Mathematics and MT2503 Multivariate Calculus, which build on their Advanced Highers or A-Level knowledge. Astronomers take a short 1000-level Astronomy module in first semester and Astronomy 2 in second semester.

All Physics and Astronomy students take Physics 2A and Physics 2B, which build on 1000-level, Advanced Highers or A-Level work. Topics include Classical Mechanics, Relativity, Oscillations in Physics, Quantum Physics, Classical Waves, Electricity and Magnetism, and Thermal Physics. Practical work and small-group tutorials also aid learning.

Second Year Continuing Students
A total of 120 credits of 2000-level modules are taken. All our students take at least MT2501 and MT2503 as Mathematics modules. Astronomers take AS2001. This or another 2000-level module is taken by physicists.

Third Year and Fourth Year to BSc (Hons)
These two years of study can lead to the BSc Single Honours degree in:
- Physics or Astrophysics
- Physics
- Theoretical Physics
- Theoretical Physics and Mathematics

For students who have taken the appropriate modules in the second subject, the following joint BSc degrees are also available:
- Physics and Computer Science
- Physics and Philosophy
- Physics and Mathematics

Exit point with an Honours BSc Degree
The BSc Honours degree is taken in three or four years, depending on the point of entry.

Exit point with an Honours MPhys or MSci Degree
The MPhys degree is taken in four or five years, depending on the point of entry.

MPhys and MSci Additional Year
This year contains advanced lecture courses, and a substantial project.

The MPhys degree titles are:
- Astrophysics
- Physics
- Theoretical Physics
- Theoretical Physics and Mathematics

The MSci degree:
- Physics and Chemistry

Pharmacy and Astronomy (Gateway) entry point
Students who have academic potential, but due to disadvantage are unlikely to quite reach our normal entry requirements, may be eligible for an alternative first year programme that leads on to the existing second year. Please see page 4 and the School web pages for more details.

Entry point for those with good Advanced Highers or A-Levels and planning a Single Honours degree in the School*
University entry as for first year entry, but to be eligible to start at second year Honours-qualified students would also need A grades at Advanced Higher in Physics and Mathematics along with Highers at AA in two other subjects.

Possible entry point for those with good Advanced Highers or A-Levels and planning a Single Honours degree in the School*

*Direct entry to second year of the joint degrees with Mathematics is also possible. Typically required grades in Advanced Highers and IB as for Single Honours, A-Level qualified applicants also need A in Further Mathematics.

This information is for guidance only. For Joint Honours degrees the subject with the higher entrance requirements determines the likely minimum grades. Admissions Officers consider all aspects of every application, particularly the Personal Statement. Remember that you must also meet the Faculty Entrance Requirements (see Undergraduate Prospectus: www.st-andrews.ac.uk/study/ug/prospectus).
Entrant Scholarships
The School offers a number of scholarships of £1,000 or more to selected students. Details are on the School website: www.st-andrews.ac.uk/physics/pandaweb/admiss/bursaries

The University has a variety of other scholarships on offer: www.st-andrews.ac.uk/study/ug/fees-and-funding

Research and Teaching Quality
In the 2014 Research Excellence Framework (REF) our research in physics and astrophysics was ranked third in the UK for quality. The submission to REF was through PHYESTA, the physics and astronomy research programme that is joint between the universities of Edinburgh and St Andrews.

An inspection of our teaching programme in 2013 commented on the School being “broadly excellent” with “good communication between a dedicated and enthusiastic staff and students”.

Overseas Links
We are pleased to welcome a number of overseas students to our School for a semester, a year, or the full degree programme. The School has an exchange fellowship for a graduate with the Georgia Institute of Technology (Atlanta) funded by the Robert T Jones Trust. Our University has exchange links with a number of overseas universities. Students may apply to be considered to spend third or fourth year at one of these institutions.

The School’s Student-Staff Council organises summer placements for selected students at international facilities such as Fermilab (Chicago) and the High Magnetic Field Facility in Grenoble.

Research links are maintained with scientists in many countries.

Visits to the University
The University organises Visiting Days for prospective students to visit the University and see for themselves the Schools in which they are interested. These take place on a number of Wednesdays through the year. They include an introduction to the University and town, as well as visits to relevant Schools. The School runs a special Visiting Day on one Saturday in February each year. Please see the School’s web pages or contact us for details. On request, visits may be organised at other times as well. Please see the back cover for contact details for arranging such visits.

Student Organisations
The School’s students run AstroSoc and PhySoc with social and academic events associated with astronomy and physics respectively. The School’s Student-Staff Council also plays an active role in academic and other events, including a dinner-dance for students and staff.

Career Opportunities
Degrees in physics and related subjects are welcomed by employers, and St Andrews graduates do well at finding employment in areas of their choice. A significant number of graduates go into some form of research or development in industry or in Government agencies, either immediately after graduation or following a higher degree. Examples of high technology industries in which physicists work include optoelectronics, computing, telecommunications, aerospace, and semiconductors. In our degree programmes we work with students to develop relevant skills such as problem solving, mathematical modelling, and the ability to communicate complicated ideas. These skills also make for graduates who are well-suited for more general careers in management, banking, and related areas. A good physics training opens the door to many different careers. We have a number of graduate profiles on our website. These include graduates who have entered careers in research (various universities and companies), software consultancy (QAS, London), intellectual property law (Bristows, London), accountancy (Deloitte), and a pair of graduates who started up a small business in scientific displays (FifeX, Tayport).
Our research team has developed polymer lasers and is exploring their use for humanitarian de-mining. The lasers are designed to be sensitive to trace amounts of explosive vapour.

Research
The School has a successful research programme exploring a range of fundamental and applied areas of physics and astronomy. The 2014 Research Excellence Framework ranked the quality of our research third across UK physics departments. Our submission was joint with the University of Edinburgh, both Schools being part of the Scottish Universities Physics Alliance. With most teaching staff directly involved in research you can expect to find classes that are informed by the latest research in astronomy and physics, and taught in many instances by internationally recognised experts in their fields. Through their research many staff also have useful links with companies and organisations. The links between teaching and research are probably strongest for students in their final-year project, which they usually undertake within one of the research groups and with access where appropriate to specialised equipment. The main research activities of the School are in the areas of: Astronomy and Astrophysics, Laser Physics and Optoelectronics, Biophotonics, Quantum Optics, Magnetism and Superconductivity, Quantum Materials, Millimetre-wave Techniques, and Theoretical Physics. The School is a member of the Scottish Universities Physics Alliance, which is a major collaborative project enhancing physics research in Scotland.

www.supa.ac.uk

Recent research contributions to science from our School include:

- The discovery of the nearest yet seen rocky planet outside our own solar system.
- The discovery of planets around another star looking like an analogue of our solar system.
- Exploring black hole physics in a special optical fibre.
- The development of light emitting polymers for the treatment of certain skin cancers.
- Using optical forces to create the fastest man-made rotating object.
- Wide-field high-resolution imaging for neuroscience and developmental biology.
- Tracking biological cells through feeding them microlasers.
- Extreme slowing of light in micro-structured semiconductors.
- The generation and study of collective quantum states of matter, where $10^{24}$ electrons behave as a coherent group in exotic conducting oxides.
- The theory of how to build quantum materials that absorb light at a super-fast rate.
- Reproducible and quantitative detection of cancer markers using nanoplasmonic sensors.

Our research spans a wide size range. On the left we show a simulation of the spatial electronic density around two adjacent phosphorus donor nuclei (about 0.4 nm apart) in silicon. This allows us to calculate the quantum mechanical coupling of the two donors and then to design quantum computing gates. On the right we show research on star formation done by performing nested numerical simulations of how gas flows in a spiral galaxy (about $6 \times 10^4$ m across) and resolving molecular clouds and regions of star formation. The gravitational forces gather the low density interstellar gas into denser clouds. The gas shocks in the spiral arms result in dense and turbulent molecular clouds where stars can form.

Research and Students
Our undergraduate students have various opportunities to interact with the research work of the School. The most obvious is the final year project, which sees most students working with one of the research teams. The five students pictured were all working in the millimetre-wave research group for their projects. Tom is demonstrating his mm-wave motion-sensing radar, which is now being used in outreach events. After graduation these students went on to a career in scientific administration, teacher training, a Jones Fellowship to Georgia Institute of Technology, and research degrees in Imperial College and St Andrews. In 2015 two of our final year project students won first prizes in the international "Undergraduate Awards" programme, one in the physics and mathematics section for his project work on building metamaterials using DNA, and the other in the medicine section for her project work modelling blood flow in dialysis.

The School’s research informs our teaching generally. In some of our first year labs students carry out a research-style investigation, followed by a visit to a relevant research lab. There is a tour of research labs in our second year modules. A visit to the “optical black hole physics” research lab is shown opposite. Third year students can explore topics of local research and present this to the class in the Transferrable Skills for Physicists module. Final year lectures can take students to the current research frontiers and final year projects are usually within the School’s research groups. There are opportunities for funded summer internships with our research groups, and astronomers can, after suitable training, have access to some of the Observatory’s telescopes to carry out their own investigations.
Laura (Glasgow)
Theoretical Physics and Mathematics

Joe says: “I graduated from St Andrews in 2010 with a joint degree in Mathematics and Theoretical Physics. I enjoyed my time in St Andrews so much that I continued on to study for a PhD in Astrophysics. During the four years studying for my PhD I had the opportunity to travel to many conferences both in the UK and internationally and to publish multiple scientific papers.

After completion of my PhD in 2014 I accepted a research position as an astronomer at Lowell Observatory in Flagstaff, Arizona. At Lowell I continue to build on the research I began in St Andrews and actively participate in outreach to educate visitors to the observatory about Physics and Astronomy. Lowell is home to the 4.3 metre Discovery Channel Telescope, a world class research facility which I am extremely fortunate to be able to use to study the properties of extra-solar planets and their parent stars.

I could not have asked for better preparation and training for my position at Lowell than I received at St Andrews. The broad choice of courses available to me during my undergraduate degree, along with access to world class facilities during my PhD, were an integral part of my current success and have allowed me to continue my research and answer fundamental questions about the universe.”

Joe (Working in Arizona)
MPhys Theoretical Physics and Maths 2010

Joe (Working in Arizona)
MPhys Theoretical Physics and Maths 2010

Staff-student discussion on quantum mechanics.

Students relaxing during their third year conference near Edzell.

Graduate Profiles

Susanna says: “In the summer of 2014 I completed my Physics degree. With the enthusiasm for Physics built up in St Andrews and, keen to keep learning, I then spent some of my summer characterising materials using a vector network analyser in the School’s mm-wave group before attending a summer school in Holland on the Physics of the Climate System.

In September 2014, I started at KP Technology, working as a Graduate Research Assistant. Our specialism is the measurement of the work function and electrical characterisation of materials, with wide applications including research into (organic) semiconductors, sensors, nano-materials, solar cells and forensics. Since graduation, I have worked and collaborated with Universities, agencies and companies all around the world, accrued thousands of hours of measurement and research time, attended my first scientific conference and co-supervised some student interns! I am now studying for a PhD as part of my job and was awarded a Royal Commission for the Exhibition of 1851 Industrial Fellowship to support this research.

I have been able to build on my practical experience in the labs, theoretical knowledge gained and the thinking and transferable skills developed in St Andrews, to conduct research and assist with future equipment development within the company. An enjoyable and exciting future is just beginning!”

Susanna (Working in Wick, Caithness)
BSc Physics

Joe (Working in Wick, Caithness)
BSc Physics

Student Profiles

“I worked hard to make the dream of studying at a top-class university become a reality. I enjoy working out equations and solving different problem scenarios, which are key aspects of Theoretical Physics and Maths. Arriving at St Andrews and settling into my student accommodation was a smooth process. I spoke with my Adviser about what to expect from life in St Andrews and what lay ahead for me in direct entry to second year. He was very supportive.

Orientation Week at St Andrews is a wonderment of information about the many different societies and sports clubs that you can join. There are plenty of great things to do and all within walking distance of the student accommodation. I joined the Anime Society and love going every Friday to watch new anime and chatting with people that have the same interest as me. Who wouldn’t want to live in a place that has two beaches and everything you could possibly need on one street?

The lecturers and all other staff work hard to ensure that you feel welcome. The academic staff are friendly, very approachable and offer great advice and support if needed. I have met many people from all over the world who are studying here at St Andrews. I have struck up some great friendships in such a short space in time.”

Laura (Glasgow)
Theoretical Physics and Mathematics
“It was after attending one of the School of Physics & Astronomy’s visiting days during my sixth year at school that I was convinced that St Andrews was the university for me. Everyone in the School was very friendly and had an infectious enthusiasm for their subject. Having now spent three years studying physics, and a whole summer carrying out research in experimental physics within the School, my initial impression has not changed one bit.

The School provides a great all round learning environment. The teaching and laboratory facilities are modern and well appointed. But it is the fantastic community spirit that makes it stand out. Right from the outset I have found that all the staff take an interest in your individual studies. In my eyes it is this close relationship between the lecturers, postgrads and undergraduate students, combined with St Andrews’ outstanding reputation for physics research that makes it the perfect place to study physics. St Andrews is also a great place for a keen golfer.”

Euan (Edinburgh)
Physics

“I came to St Andrews three years ago. It was my first time in the UK and I hoped that I would get used to the completely new environment easily. I was pleasantly surprised when I found out that everybody around me was extremely friendly and helpful. St Andrews has a very international atmosphere, which makes it easy for new students from outside the UK to feel at home.

I chose this university because I wanted a good education in physics and astronomy. The approach to teaching here is a bit different from what I have seen back in my country. I love the fact that everybody makes sure that you understand the things that they are teaching you. There are always people you can ask for help and staff members are very approachable. The challenges in studying are also of a different nature. It took me quite a while to get used to the lab; this included a few group projects which put us in research-like situations. I found these very useful and satisfying, since I am hoping to do research after I finish studying.”

Maya (Bulgaria)
Astrophysics
The online version of the Undergraduate Prospectus can be seen at: www.st-andrews.ac.uk/study/ug/prospectus

The School of Physics & Astronomy
University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, Scotland, UK

T: +44 (0)1334 463111
F: +44 (0)1334 463104
E: physics@st-andrews.ac.uk

Curriculum Development
As a research intensive institution, the University ensures that its teaching references the research interests of its staff, which may change from time to time. As a result, programmes are regularly reviewed with the aim of enhancing students’ learning experience. Our approach to course revision is described at: www.st-andrews.ac.uk/media/teaching-and-learning/policies/course-revision-protocol.pdf

Photographs (unless noted in captions) by: Peter Adamson, broad daylight, Christopher Davy, Guthrie Aerial Photography, A Robotham, Rhona Rutherford, Laurence Winram, and staff of the School.
Produced by Print & Design, University of St Andrews, September 2017.
Printed by BARR printers on 150gsm Silk FSC Mix Credit paper.

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