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Swansea University
Prifysgol Abertawe

FACULTY OF SCIENCE AND ENGINEERING

UNDERGRADUATE STUDENT HANDBOOK

YEAR 3 (FHEQ LEVEL 6)

BSC THEORETICAL PHYSICS

DEGREE PROGRAMMES

SUBJECT SPECIFIC
PART TWO OF TWO
MODULE AND COURSE STRUCTURE
2023-24

DISCLAIMER

The Faculty of Science and Engineering has made all reasonable efforts to ensure that the information contained within this publication is accurate and up-to-date when published but can accept no responsibility for any errors or omissions.

The Faculty of Science and Engineering reserves the right to revise, alter or discontinue degree programmes or modules and to amend regulations and procedures at any time, but every effort will be made to notify interested parties.

It should be noted that not every module listed in this handbook may be available every year, and changes may be made to the details of the modules. You are advised to contact the Faculty of Science and Engineering directly if you require further information.

The 23-24 academic year begins on 25 September 2023

Full term dates can be found here

DATES OF 23-24 TERMS

25 September 2023 – 15 December 2023

8 January 2024 – 22 March 2024

15 April 2024 – 07 June 2024

SEMESTER 1

25 September 2023 – 29 January 2024

SEMESTER 2

29 January 2024 – 07 June 2024

SUMMER

10 June 2024 – 20 September 2024

IMPORTANT

Swansea University and the Faculty of Science of Engineering takes any form of **academic misconduct** very seriously. In order to maintain academic integrity and ensure that the quality of an Award from Swansea University is not diminished, it is important to ensure that all students are judged on their ability. No student should have an unfair advantage over another as a result of academic misconduct - whether this is in the form of **Plagiarism**, **Collusion** or **Commissioning**.

It is important that you are aware of the **guidelines** governing Academic Misconduct within the University/Faculty of Science and Engineering and the possible implications. The Faculty of Science and Engineering will not take intent into consideration and in relation to an allegation of academic misconduct - there can be no defence that the offence was committed unintentionally or accidentally.

Please ensure that you read the University webpages covering the topic – procedural guidance here and further information here. You should also read the Faculty Part One handbook fully, in particular the pages that concern Academic Misconduct/Academic Integrity.

Welcome to the Faculty of Science and Engineering!

Whether you are a new or a returning student, we could not be happier to be on this journey with you.

At Swansea University and in the Faculty of Science and Engineering, we believe in working in partnership with students. We work hard to break down barriers and value the contribution of everyone.

Our goal is an inclusive community where everyone is respected, and everyone's contributions are valued. Always feel free to talk to academic, technical and administrative staff, administrators - I'm sure you will find many friendly helping hands ready to assist you. And make the most of living and working alongside your fellow students.

During your time with us, please learn, create, collaborate, and most of all – enjoy yourself!

Professor David Smith
Pro-Vice-Chancellor and Executive Dean
Faculty of Science and Engineering

Faculty of Science and Engineering	
Pro-Vice-Chancellor and Executive Dean	Professor David Smith
Director of Faculty Operations	Mrs Ruth Bunting
Associate Dean – Student Learning and Experience (SLE)	Dr Laura Roberts
School of Biosciences, Geography and Physics	
Head of School	Dr Kevin Rees
School Education Lead	Dr Wendy Harris and Dr Sarah Roberts
Head of Physics	Dr Daniel Thompson and Professor Prem Kumar
Physics Programme Director	Dr Tim Burns
Year Coordinators	Head of Foundation Year: Dr Warren Perkins Head of Level 1: Dr Aled Isaac Head of Level 2: Dr Dave Dunbar Head of Level 3: Dr Sophie Shermer Head of Level M: Dr Kevin O'Keeffe

STUDENT SUPPORT

The Faculty of Science and Engineering has two **Reception** areas - Engineering Central (Bay Campus) and Wallace 223c (Singleton Park Campus).

Standard Reception opening hours are Monday-Friday 8.30am-4pm.

The **Student Support Team** provides dedicated and professional support to all students in the Faculty of Science and Engineering. Should you require assistance, have any questions, be unsure what to do or are experiencing difficulties with your studies or in your personal life, our team can offer direct help and advice, plus signpost you to further sources of support within the University. There are lots of ways to get information and contact the team:

Email: studentsupport-scienceengineering@swansea.ac.uk (Monday–Friday, 9am–5pm)

Call: +44 (0) 1792 295514 (Monday-Friday, 10am–12pm, 2–4pm).

Zoom: By appointment. Students can email, and if appropriate we will share a link to our Zoom calendar for students to select a date/time to meet.

The current student **webpages** also contain useful information and links to other resources:

https://myuni.swansea.ac.uk/fse/

READING LISTS

Reading lists for each module are available on the course Canvas page and are also accessible via http://ifindreading.swan.ac.uk/. We've removed reading lists from the 23-24 handbooks to ensure that you have access to the most up-to-date versions.
We do not expect you to purchase textbooks, unless it is a specified key text for the course.

THE DIFFERENCE BETWEEN COMPULSORY AND CORE MODULES

Compulsory modules must be **pursued** by a student.

Core modules must not only be **pursued**, but also **passed** before a student can proceed to the next level of study or qualify for an award. Failures in core modules must be redeemed.

Further information can be found under "Modular Terminology" on the following link - https://myuni.swansea.ac.uk/academic-life/academic-regulations/taught-guidance/essentialinfo-taught-students/your-programme-explained/

Year 3 (FHEQ Level 6) 2023/24
Theoretical Physics
MPhys Theoretical Physics[F340]

Compulsory Modules

Semester 1 Modules	Semester 2 Modules
PH-302 **Quantum World III** **10 Credits** **Prof TJ Hollowood**	**PH-333** **Atomic Physics and Quantum Optics II** **10 Credits** **Prof N Madsen**
PH-306 **Atomic Physics I** **10 Credits** **Prof SJ Eriksson**	**PH-335** **Particle Physics II** **10 Credits** **Prof A Armoni**
PH-307 **Condensed Matter Physics II** **10 Credits** **Dr SM Shermer**	**PH-353** **Computational Physics** **10 Credits** **Prof CR Allton**
PH-312 **Advanced Research in Physics** **10 Credits** **Dr K O'Keeffe/Dr SG Roberts**	**PH-355** **Mathematical Methods in Physics III** **10 Credits** **Prof DC Thompson**
PH-321 **Gravity** **10 Credits** **Prof TJ Hollowood**	
PH-338 **Frontiers of Nuclear Physics** **10 Credits** **Prof C Nunez**	
Total 120 Credits	

Optional Modules
Choose exactly 20 credits

PH-300	Semiconductor Device Physics	Dr A Armin	TB2	10
PH-320	Foundations of Astrophysics	Prof SP Kumar	TB2	10
PH-322	Cosmology	Prof G Tasinato	TB2	10
PH-325	Teaching Physics via a School Placement	Dr SG Roberts	TB2	10
PH-325C	Addysgu ffiseg trwy leoliad mewn ysgol	Dr SG Roberts	TB2	10
PH-339	Climate Physics	Prof DP Van Der Werf	TB2	10

Year 3 (FHEQ Level 6) 2023/24
Theoretical Physics
BSc Theoretical Physics[F341]
BSc Theoretical Physics with a Year in Industry[F636]

Compulsory Modules

Semester 1 Modules	Semester 2 Modules
PH-302 **Quantum World III** **10 Credits** **Prof TJ Hollowood**	**PH-318** **Theoretical Physics Project** **20 Credits** **Dr SM Shermer** **CORE**
PH-306 **Atomic Physics I** **10 Credits** **Prof SJ Eriksson**	**PH-333** **Atomic Physics and Quantum Optics II** **10 Credits** **Prof N Madsen**
PH-307 **Condensed Matter Physics II** **10 Credits** **Dr SM Shermer**	**PH-335** **Particle Physics II** **10 Credits** **Prof A Armoni**
PH-312 **Advanced Research in Physics** **10 Credits** **Dr K O'Keeffe/Dr SG Roberts**	
PH-321 **Gravity** **10 Credits** **Prof TJ Hollowood**	
PH-338 **Frontiers of Nuclear Physics** **10 Credits** **Prof C Nunez**	
Total 120 Credits	

Optional Modules
Choose exactly 20 credits

PH-300	Semiconductor Device Physics	Dr A Armin	TB2	10
PH-308	Modern Laser Systems	Dr K O'Keeffe	TB2	10
PH-320	Foundations of Astrophysics	Prof SP Kumar	TB2	10
PH-322	Cosmology	Prof G Tasinato	TB2	10
PH-325	Teaching Physics via a School Placement	Dr SG Roberts	TB2	10
PH-325C	Addysgu ffiseg trwy leoliad mewn ysgol	Dr SG Roberts	TB2	10
PH-329	Quantum Information Processing	Prof GAP Aarts	TB2	10
PH-339	Climate Physics	Prof DP Van Der Werf	TB2	10
PH-355	Mathematical Methods in Physics III	Prof DC Thompson	TB2	10

Year 3 (FHEQ Level 6) 2023/24
Theoretical Physics
MPhys Theoretical Physics with a Year in Industry[F857]

Compulsory Modules

Semester 1 Modules	Semester 2 Modules
PH-302 **Quantum World III** **10 Credits** **Prof TJ Hollowood**	**PH-333** **Atomic Physics and Quantum Optics II** **10 Credits** **Prof N Madsen**
PH-306 **Atomic Physics I** **10 Credits** **Prof SJ Eriksson**	**PH-335** **Particle Physics II** **10 Credits** **Prof A Armoni**
PH-307 **Condensed Matter Physics II** **10 Credits** **Dr SM Shermer**	**PH-353** **Computational Physics** **10 Credits** **Prof CR Allton**
PH-312 **Advanced Research in Physics** **10 Credits** **Dr K O'Keeffe/Dr SG Roberts**	**PH-355** **Mathematical Methods in Physics III** **10 Credits** **Prof DC Thompson**
PH-321 **Gravity** **10 Credits** **Prof TJ Hollowood**	
PH-338 **Frontiers of Nuclear Physics** **10 Credits** **Prof C Nunez**	
Total 120 Credits	

Optional Modules
Choose exactly 20 credits

PH-300	Semiconductor Device Physics	Dr A Armin	TB2	10
PH-320	Foundations of Astrophysics	Prof SP Kumar	TB2	10
PH-322	Cosmology	Prof G Tasinato	TB2	10
PH-325	Teaching Physics via a School Placement	Dr SG Roberts	TB2	10
PH-325C	Addysgu ffiseg trwy leoliad mewn ysgol	Dr SG Roberts	TB2	10
PH-339	Climate Physics	Prof DP Van Der Werf	TB2	10

PH-300 Semiconductor Device Physics

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr A Armin

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module covers semiconductor device physics with the emphasis on the "next generation" solar cells made of disordered semiconductors.

Module Content: Brief review on semiconductors: electrons in semiconductors, density of state, holes, thermal equilibrium, doping, quasi Fermi level distributions, work function, photo-generation of electrons and holes.

Semiconductor devices: transition from vacuum valves to modern electronics, p-n junction, metal-semiconductor contact, Schottky contact, MIS contact, transistors, solar cells, LEDs and lasers, photodetectors.

Solar cells: electrochemical equilibrium of electrons in a p-n junction, current-voltage characteristics, photo-generation in excitonic and non-excitonic solar cells, organic solar cells, detailed balance theory and thermodynamic limit of photovoltaics.

Organic solar cells: organic semiconductors, donors and acceptors, device optics, charge transfer states, mechanism of recombination, charge carrier collection, scaling-up.

Intended Learning Outcomes: Demonstrate an understanding of the basic principles of semiconductor devices physics.

The ability to use those principles to solve problems of practical interest.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Sze, S. M., 1936- author., Li, Yiming (Professor of electrical engineering) author.; Ng, Kwok Kwok, 1952- author.; Sze, S. M., 1936-, Physics of semiconductor devices., Wiley, 2021.ISBN: 9781119429111
Jenny. Nelson, The physics of solar cells / Jenny Nelson., Imperial College Press, 2003.ISBN: 9781860943492
Wurfel, P, Physics of solar cells: from basic principles to advanced concepts, Wiley, 2016.ISBN: 9783527413126

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-302 Quantum World III

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules: PH-205

Co-requisite Modules:

Lecturer(s): Prof TJ Hollowood

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: Students will deepen their study of Quantum Mechanics by learning the general formalism. Students will be challenged by the strange and puzzling aspects of the theory. Students will learn various approximation techniques for solving complicated systems.

Module Content: 1. Formalism of quantum mechanics: state vectors and Dirac notation, space of states, bases, operators and observables. Recovering wave mechanics.
2. Spin: Nature of spin in QM: matrix representation of states and operators, Stern-Gerlach experiment and measurement, angular momentum addition theorem.
3. Interpretation of quantum mechanics: measurement in quantum mechanics, reduction of the state vector; the EPR experiment and classical versus quantum entanglement, Bell's inequalities, other interpretations of measurement.
4. Approximation theory: the variational method, non-degenerate and degenerate time independent perturbation theory, first order formula and applications. Time dependent perturbation theory, the two-state system, radiative transitions in atoms.

Intended Learning Outcomes: Students will learn the underlying formulation of quantum mechanics, appreciate the issues involving measurement in quantum mechanics, and learn how to solve quantum problems using various kinds of approximations.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Coursework 1 (30%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Examination (70%): 2 hour written exam.
Continuous Assessment (30%): 3 pieces of coursework

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit of the exam component

Reading List: Mandl, F., Quantum mechanics / F. Mandl., Wiley,, c1992..ISBN: 9780471931553
McMurry, Sara M., Quantum mechanics / Sara M. McMurry., Addison-Wesley,, 1994.ISBN: 9780201544398

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-306 Atomic Physics I

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules: PH-205

Co-requisite Modules: PH-302

Lecturer(s): Prof SJ Eriksson

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This course describes the application of quantum mechanics to atomic structure, together with the implications for spectroscopy. The electronic structure of hydrogen (including spin, fine structure and hyperfine structure), helium and alkali metals will be discussed from first principles in quantum mechanics. The effect on energy levels of applied magnetic fields (Zeeman effect) is calculated in perturbation theory. Practical examples of spectroscopy are briefly described.

Module Content: 1. Hydrogen atom with spin, angular momentum addition.
2. Quantum mechanics of identical particles, spin-statistics theorem and Pauli principle, electron state in helium, periodic table.
3. Spectra of hydrogen, sodium, helium, selection rules, spectral line width.
4. Fine structure in hydrogen: spin-orbit coupling, relativistic energy correction, Lamb shift.
5. Zeeman effect.
6. Nuclear spin and hyperfine structure.

Intended Learning Outcomes: An appreciation of the relation of the experimental science of spectroscopy to quantum theoretical understanding of atomic structures.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment: Examination 1 (70%)
Coursework 1 (30%)
Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Examination (70%): 2 hour written exam.
Continuous Assessment (30%): 3 pieces of coursework

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit of exam component

Reading List: C. J. Foot author., Atomic physics / C.J. Foot., Oxford University Press, 2005.ISBN: 9780198506959
H. Haken Author, H. C Wolf (Hans Christoph), 1929-, Author.; William D. Brewer Translator, The physics of atoms and quanta : introduction to experiments and theory / Hermann Haken, Hans Christoph Wolf ; translated by William D. Brewer., Berlin, Heidelberg : Springer Berlin Heidelberg, 2006.ISBN: 9783540672746

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-307 Condensed Matter Physics II

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules: PH-203

Co-requisite Modules: PH-306

Lecturer(s): Dr SM Shermer

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures, problem classes, revision sessions, lab sessions (computer lab)

Module Aims: The course builds on module PH-207 and provides a theoretical and experimental overview of the thermal, electronic and magnetic properties of material.

Module Content: Review of classical Drude and quantum Sommerfeld model and their limitations.
Introduction to Monte Carlo simulations of electron dynamics.

Solution of the Schrodinger equation in periodic potentials and Bloch's theorem.
Emergence of bandgaps and bandstructure due to periodic potentials.
Energy dispersion relations in periodic potentials and effect on Fermi surfaces.
Tight-binding and nearly-free electron approximations.

Band electron dynamics, acceleration theorem, group velocities, effective mass.
Electron trajectories in electric and magnetic fields without and with scattering.
Ohm's Law with generalized conductivity tensor.

Semiconductors.
Bandstructure of semiconductors and carrier types.
Principles of charge neutrality and law of mass action.
Dependence of carrier concentrations and Fermi level on temperature.
Doped semiconductors, carrier concentrations, intrinsic and extrinsic regime, carrier freezeout
Interface between positive and negatively doped semiconductors (pn-junctions)
Carrier concentrations and bandstructure
Operation of pn-junction with forward and reverse bias.
Applications of pn-junctions: diodes and transistors -- basics of their operation and applications

Magnetic properties of matter.
Types of magnetism (dia, para, ferro, anti-ferro, ferri)
Classical explanation of diamagnetism
Quantum model of paramagnetism and Curie law
Heisenberg and Ising model of electron spins in solids
Ferro, ferri and antiferro-magnetism as a result of electron-electron interactions (J-coupling)
Phase transitions and critical temperatures
Mean-field theory and Curie-Weiss law for ferromagnetic materials.
Magnetic resonance: electron (and nuclear) spin resonance in magnetic fields

Superconductivity.
Definition and origin (Cooper-pair formation)
Meissner Effect and London equation
Applications

Intended Learning Outcomes: An understanding of the fundamental laws of condensed matter physics.
The ability to use these laws to solve problems of practical interest.
Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.
Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Coursework 1 (30%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Examination (70%): 2 hour written exam. Continuous Assessment (30%): pieces of coursework
Moderation approach to main assessment: Moderation by sampling of the cohort
Assessment Feedback: Students receive assessed work back with the point of error indicated. Students have a feedback session to go through solutions to the problems. Students can arrange with lecturer to have personal feedback on their assessments.
Failure Redemption: Re-sit of exam component
Reading List: Steven H. Simon author., The Oxford Solid State Basics / Steven H. Simon., Oxford : Oxford University Press, 2013.ISBN: 9780191502101 Kittel, Charles., Introduction to solid state physics / Charles Kittel., Wiley,, c2005..ISBN: 9780471680574 Neil W. Ashcroft, N. David Mermin, Solid state physics / Neil W. Ashcroft, N. David Mermin., Brooks/Cole Cengage Learning, 2003.ISBN: 9788131500521 Huang, Kerson,, Statistical mechanics / Kerson Huang., Wiley,, c1987..ISBN: 9780471815181
Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus. Available to visiting and exchange students.

PH-308 Modern Laser Systems

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr K O'Keeffe

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: The objective of this module is to develop a link between basic principles of laser physics and the practical realization of laser systems, which have revolutionised laser applications.

Module Content: Besides the fundamentals of selected laser systems, aspects of assessing specific laser parameters and characteristics will be discussed, as well as some key applications in atomic and molecular physics. The following topics will be addressed:

1. The basics of laser action: 3-level and 4-level systems; simple rate equations; laser cavities (including mode structure).
2. Continuous wave lasers: exemplified for semiconductor diode and Nd:YAG lasers - fundamental principles and practical realisation; operation; wavelength and intensity distributions; wavelength selection; selected applications.
3. Pulsed solid-state laser sources: exemplified for Nd:YAG and Ti:sapphire lasers - fundamental principles and practical realisation; wavelength, intensity and time distributions (including Q-switching); selected applications.
4. Ultra-short laser pulses: generating and characterising femto-second (fs) pulses; the use of fs-laser sources in atomic and molecular physics.

Intended Learning Outcomes: To become familiar with the "new generation" of laser systems, and to understand the basic physics behind the tailoring/optimisation of individual laser sources.

To gain insight into the operation of different laser systems and their use in specific applications in atomic and molecular physics problems.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarise important terms and concepts, recall key formulae without the aid of text books or other sources.

To understand the basic operating principles, and real world applications, of a wide range of laser systems.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Coursework reassessment instrument (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: William Thomas Silfvast 1937-, Laser fundamentals / William T. Silfvast., Cambridge University Press, 2004.ISBN: 9780521541053
Demtr÷der, Wolfgang, Laser Spectroscopy 1: Basic Principles, Springer, 2014.ISBN: 9783662495421
Demtr÷der, Wolfgang, Laser Spectroscopy 2: Experimental Techniques, 2016.ISBN: 9783662517284
Trebion, R., Lectures and tutorials on fs-pulses.

Additional Notes: Available to visiting and exchange students.

PH-312 Advanced Research in Physics

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr K O'Keeffe, Dr SG Roberts

Format: 36

Delivery Method: In Person in Laboratory or PC lab

Module Aims: Experiments conducted in two weekly 3-hour laboratory sessions on topics related to advanced research themes in Physics. Students will be allocated by staff to appropriate themes.

Module Content: The option experiments will be tailored to illustrate and amplify specific topics discussed in the specialist option modules. They will include:

Operation/Characterisation of a Laser
Characterisation of solid state devices
Astronomy
Fourier optics

Intended Learning Outcomes: 1. A deeper knowledge of the Physics of the advanced research theme.
2. An ability to keep a detailed contemporaneous record or laboratory diary of the work undertaken.
3. An ability to write a detailed scientific dissemination as appropriate to current standards in research.

Assessment: Report (100%)

Assessment Description: Continuous assessment consisting of 2 individual reports.

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Feedback on the first assessment is given both in written form in the marking sheet and orally with a feedback session during one of the lab sessions. Individual feedback on second assessment in written form, orally upon student request.

Failure Redemption: Given the nature of the work there is no redemption of failure possible if the necessary hands-on material (experimental work) has not been completed by the end of term.

If sufficient lab work has been completed, failure would be redeemed by resubmission of the lab report.

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Not available to Visiting and Exchange Students.

PH-318 Theoretical Physics Project

Credits: 20 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr SM Shermer

Format: 20

Delivery Method: Project work

Module Aims: An individual project on a theoretical project.

Module Content: The project is intended to last one semester and the written reports on the work carried out must be handed in by the end of the second semester. Each project will have a supervisor and the student should liase closely with the supervisor at all times. In addition to a written report, students will give a poster presentation and answer questions on their work.

Intended Learning Outcomes: -Experience in organising and carrying out an extended theoretical project.
-An understanding of the nature of theoretical physics research.

Assessment: Progress Report (10%)
Project (70%)
Poster (20%)

Assessment Description: .

Moderation approach to main assessment: Universal Double Blind Marking of the whole cohort

Assessment Feedback: From discussions with project supervisor

Failure Redemption: N/A - final year module

Reading List: Oliver, Phil., Kantaris, Noel., Using Visual Basic / P.R.M. Oliver and N. Kantaris., Bernard Babani,, 2001.ISBN: 0859344983
Wolfram, Stephen., The mathematica book / Stephen Wolfram., Wolfram Media ;, c2003..ISBN: 1579550223
G. L. Squires (Gordon Leslie), author., Practical physics / G.L. Squires., Cambridge: Cambridge University Press, 2001.ISBN: 9780521779401

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students

PH-320 Foundations of Astrophysics

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof SP Kumar

Format: 22 lectures, 3 feedback sessions

Delivery Method: Module delivery will be in person.

Module Aims: This module will introduce students to the quantitative physics underlying the formation, evolution and eventual demise of stars. Students will learn how fundamental concepts from diverse areas of physics, such as gravity, thermodynamics, statistical physics and quantum mechanics come together to provide a complete mathematical model of stellar dynamics which is in beautiful and comprehensive agreement with observational data.

Module Content: 1. Basic stellar parameters and their observed values: Mass, luminosity, radius and typical values; Blackbody relation between luminosity and temperature, Hertzsprung-Russell diagram, etc.
2. Hydrostatic equilibrium: Condition for equilibrium between gravity and pressure, Virial theorem, bounds and estimates for stellar temperatures, pressures, etc.
3. Radiative transport: Relation between luminosity, temperature gradients, mean free path and energy production rates; equations of state.
4. Nuclear processes: Energy production by fusion, quantum tunnelling, Fusion chain reactions, etc.
5. Complete Stellar life-cycle: Charting quantitatively and qualitatively the formation of a star, evolution through Main-Sequence, Red Giant, White Dwarf/Supernova phases; Exact description of degenerate Fermi gases and White Dwarfs/Neutron Stars.

Intended Learning Outcomes: Knowledge of basic observed properties of stars.
Ability to construct a mathematical model of a gravitating matter distribution in equilibrium.
Ability to infer scaling relations and estimates from the stellar model.
Knowledge of stellar evolution, the role of equilibrium thermodynamical constraints, equations of state, and inputs from quantum mechanics and nuclear physics.
Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.
Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key mathematical relations and derivations without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Dan Maoz author., Astrophysics in a nutshell / Dan Maoz., Princeton, New Jersey : Princeton University Press, 2016.ISBN: 9780691164793
Bradley W. Carroll, An introduction to modern astrophysics / Bradley W. Carroll., Pearson, 2014.ISBN: 9781292022932
Bradley W. Carroll author., Dale A. Ostlie author., An introduction to modern astrophysics / Bradley W. Carroll, Dale A. Ostlie., Cambridge : Cambridge University Press, 2017.ISBN: 9781108422161

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-321 Gravity

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules: PH-221

Co-requisite Modules:

Lecturer(s): Prof TJ Hollowood

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: The objective of this module is to educate students in the General Theory of Relativity in a way that introduces just enough of the mathematical tools required, namely pseudo Riemannian geometry, so that many applications of the theory can be considered. Students will learn about curved geometries mainly through simple examples and by taking the point of view of a freely falling observer. Applications will include: a discussion of the classic test of general relativity involving planetary motion and bending of light; the strange geometry of black-holes, wormholes and warp drive space-times. Finally students will learn how general relativity determines the dynamics of the whole universe.

Module Content: 1. Newtonian gravitation.
2. Special relativity - geodesics spacetime.
3. Geometry of curvature and tensor calculus.
4. General relativity - foundations, curved spacetime, geodesics, Einstein field equations
5. Classic test of GR - Schwarzchild metric, bending of light, gravitational geodesics, perihelion of mercury.
6. Black holes.
and either
7a. Cosmology - FRW metric, expanding universe, de Sitter metric, inflation
or
7b. Gravitational waves.

Intended Learning Outcomes: Students will gain an understanding of:

- the general principles of general relativity
- how curved geometry lies at the heart of gravity
- the essential mathematics of geodesics in curved space-time
- black holes, singularities and event horizons
- experimental test of general relativity
- cosmology and the dynamics of the universe

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources..

Assessment: Examination 1 (70%)
Coursework 1 (30%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Examination (70%): 2 hour written exam.
Continuous Assessment (30%): 2 pieces of coursework

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Rindler, Wolfgang,, Essential relativity : special, general, and cosmological / Wolfgang Rindler., Springer-Verlag,, [1979].
Sean Carroll, Spacetime and geometry : an introduction to general relativity/ Sean Carroll., Pearson, 2013.ISBN: 9781292026633
J. B. Hartle (James B.) author., Gravity : an introduction to Einstein's general relativity / James B. Hartle., Harlow : Pearson Education, 2014.ISBN: 9781292053530
Hartle, J. B., Gravity : an introduction to Einstein's general relativity / James B. Hartle., Addison-Wesley,, c2003..ISBN: 9780805386622

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-322 Cosmology

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules: PH-321

Lecturer(s): Prof G Tasinato

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module describes our current understanding of the origin, constituents and evolution of the universe, from the hot big bang to the present day.

Module Content: 1. Galaxies, rotation curves, dark matter

2. Observational cosmology: evidence for an expanding universe and the hot Big Bang model;

3. FRW cosmology: the expanding universe, cosmological parameters and the age of the universe, constituents - matter, dark matter, radiation, dark energy, accelerating expansion and the concordance model of cosmology;

4. The hot Big Bang: thermodynamics in the expanding universe, nucleosynthesis, neutrino decoupling, matter-radiation equality, photon decoupling and the origin of the CMB radiation;

5. Classic problems of the hot Big Bang model and the motivation for inflationary cosmology.

6. Introduction to Inflation

Intended Learning Outcomes: Students will,
Understand the motivations and evidence for the expanding universe and hot Big Bang.
Have a quantitative understanding of FRW comological models with matter, dark matter, radiation and dark energy.
Have a quantitative understanding of the evolution of the universe in the hot Big bang model, especially nucleosynthesis and the origin of the CMB radiation.
Appreciate the motivations for inflationary cosmology.
Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.
Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Coursework reassessment instrument (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Edward W. Kolb author, Michael Stanley Turner author, The early universe / Edward W. Kolb, Michael Turner, New York : Westview Press, 1994.ISBN: 9780813346458
Kolb, Edward W., Turner, Michael Stanley., The early universe / Edward W. Kolb, Michael S. Turner., Addison-Wesley,, 1994, c1990..ISBN: 0201626748
Andrew R. Liddle author., An introduction to modern cosmology / Andrew Liddle., Chichester, West Sussex : Wiley, 2015.ISBN: 9781118502143
Lecture Notes in Cosmology.

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-325 Teaching Physics via a School Placement

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr SG Roberts

Format: 40

Delivery Method: 1 day preparatory training on campus

Module Aims: This module is for students with an interest in entering teaching, and involves a weekly placement in a local school under the mentorship of a physics teacher. The student will engage both in observation and in various teaching activities. The module will be assessed on the basis of the mentor's report and on written project work.

Module Content: No formal syllabus - students will have an introductory training day to provide basic information and practical advice. Students will then spend 10 half-days in schools under the supervision of a teacher-mentor, first mainly observing, and then progressing to small-scale teaching activities.

Intended Learning Outcomes: First-hand experience of teaching in a secondary-school environment

Assessment: Coursework 1 (100%)
Resit Assessment: Coursework reassessment instrument (100%)

Assessment Description: 1) There will be a written assessment of the students performance within school by the teacher-mentor. Teachers are used to making quite detailed reports on many different aspects of the performance of PGCE students; we would seek something a little more course-grained, perhaps highlighting
(a) basic punctuality, appearance, attitude and helpfulness
(b) communication skills, to cover both formal teaching/demonstrating, and also interpersonal skills including relating with schoolchildren and maintaining order.
2)The student should maintain a diary/log of all activity during the time they are in the school, which should evidence insights based on their observation of lessons being delivered, and also show development of plans for their own teaching activities, perhaps in the form of lesson plans, exercise sheets, etc.
3i) The student should prepare some course material which could actually be distributed to pupils as a resource to assist teaching a particular component of the curriculum, eg.electrical circuits, nuclear power. The material should be illustrated, and contain both explanatory material and tests/quizzes which help to reinforce the material which has been learned.

Moderation approach to main assessment: Universal Non-Blind Double Marking of the whole cohort

Assessment Feedback: Coversheets for continuous assessment

Failure Redemption: Resubmission of project work

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Requires an enhanced Criminal Records Bureau check. Not available to visiting and exchange students.

This module has proved popular and is space limited because it is linked to particular schools in the area. If the module is over subscribed there will be a selection procedure and so it would be good to have in mind a backup choice.

PH-325C Addysgu ffiseg trwy leoliad mewn ysgol

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Dr SG Roberts

Format:

Delivery Method: 1 diwrnod o hyfforddiant ar gampws

Module Aims: Mae'r modiwl yma ar gyfer myfyrwyr sydd â diddordeb mewn dechrau dysgu; sy'n cynnwys lleoliad wythnosol mewn ysgol leol dan fentoriaeth athro ffiseg. Bydd y myfyriwr yn ymgymryd ag arsylwi ac amryw o weithgareddau addysgu. Caiff y modiwl ei asesu trwy adroddiad y mentor ac ar waith prosiect ysgrifenedig.

Module Content: Dim maes llafur ffurfiol - bydd myfyrwyr yn mynychu cwrs un dydd o hyfforddiant rhagarweiniol sy'n rhoi gwybodaeth sylfaenol ac ymarferol. Bydd myfyrwyr yn treulio 10 hanner-diwrnod yn yr ysgol dan oruchwyliaeth yr athro-mentor, i gychwyn yn arsylwi ac yna'n ymgymryd â gweithgareddau dysgu ar raddfa fach.

Intended Learning Outcomes: Profiad o addysgu ffiseg mewn ysgol uwchradd

Assessment:	Coursework 1 (100%)
Resit Assessment:	Coursework reassessment instrument (100%)

Assessment Description: 1) Bydd yna asesiad ysgrifenedig o berfformiad y myfyriwr yn yr ysgol gan yr athro-mentor. Mae athrawon wedi arfer â chreu adroddiadau manwl ar berfformiad myfyrwyr PGCE; rydyn ni am dderbyn rhywbeth llai manwl sydd efallai'n tynnu sylw at
(a) prydlondeb, ymddangosiad, agwedd a chymwynasgarwch
(b) sgiliau cyfathrebu, addysgu/arddangos ffurfiol, a hefyd sgiliau rhyngbersonol gan gynnwys ymwneud â phlant ysgol a chynnal trefn
2) Dylai'r myfyriwr cynnal dyddiadur/log o'r holl weithgareddau yn ystod ei amser yn yr ysgol sy'n dangos mewnwelediadau sy'n seiliedig ar ei arsylwadau o'r wers sy'n cael ei darparu a hefyd sy'n dangos datblygiadau ar gyfer gweithgareddau ei gwersi ei hun, efallai ar ffurf cynllun-gwers, taflen ymarfer ac ati.
3)Dylai'r myfyriwr paratoi deunyddiau cwrs gall cael ei rhoi i'r disgyblion fel adnodd i gynorthwyo wrth ddysgu rhyw agwedd o'r cwricwlwm e.e. cylchedau trydanol, per niwclear. Dylai'r deunydd bod yn ddarluniadol a chynnwys deunyddiau esboniadol a phrofion/cwisiau sy'n atgyfnerthu'r deunydd sydd wedi ei ddysgu.

Moderation approach to main assessment: Universal Non-Blind Double Marking of the whole cohort

Assessment Feedback: Taflenni clawr ar waith

Failure Redemption: Ailgyflwyno gwaith prosiect

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Gofyn am wiriad estynedig o'ch cofnodion gyda'r swyddfa cofnodion troseddol. Dim ar gael i fyfyrwyr cyfnewidio.

Mae'r modiwl hwn wedi profi'n boblogaidd ac mae gofod yn gyfyngedig oherwydd ei fod yn gysylltiedig ag ysgolion penodol yn yr ardal. Os yw'r modiwl wedi'i ordanysgrifio bydd gweithdrefn ddewis ac felly byddai'n dda cael dewis wrth gefn mewn golwg.

PH-329 Quantum Information Processing

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof GAP Aarts

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: The basic concepts of quantum mechanics, quantum algorithms and quantum computers are introduced. Students will reach an understanding of some of today's most relevant quantum algorithms, including Grover's search algorithm and Shor's algorithm for factoring, as well as quantum teleportation and quantum cryptography protocols. Various state-of-the-art experimental realisations of prototype quantum computers based on photons, trapped ions and superconducting qubits, as well as modern developments such as quantum error correction and the D-Wave quantum machine will be discussed.

Module Content: 1. Module introduction and overview

2. Brief history of quantum information and computation

3. Basics of quantum mechanics - two-state systems
• Hilbert spaces
• Spin-1/2 particles and qubits
• Bras & kets
• Quantum measurement

4. The Deutsch algorithm
• Quantum parallelism, interference and quantum speedup

5. Quantum computing basics
• Qubits and quantum logic gates
• Bell states and entanglement
• The no-cloning theorem
• Dense coding
• Universality of quantum gates

6. Quantum teleportation
• Theory and experimental realisations

7. Speeding up database search
• A brief tour through complexity classes
• Grover's quantum search algorithm

8. Quantum cryptography
• Private key cryptography
• Quantum key distribution protocols

9. Shor's quantum algorithm for fast factoring of large numbers
• Quantum Fourier transform
• Order finding and breaking RSA encryption

10. Physical realisations of quantum computers
• Photons, trapped ions, superconductors

11. Protecting quantum information: quantum error correction
• The challenge of decoherence
• Quantum error correcting codes

12. Modern Topics in Quantum Information Processing
• Adiabatic quantum computing
• The D-Wave machine – a real quantum computer? A critical assessment
• Topological quantum error correction

Intended Learning Outcomes: At the end of this module students should be able to demonstrate knowledge of quantum mechanical principles and how they can be used in quantum algorithms and to implement quantum computers.

They will have developed the ability to (i) read, understand and construct quantum circuits, and will have gained a solid understanding of (ii) algorithms and problems, which can be solved efficiently on quantum computers, (iii) basic concepts in information theory, including entanglement and quantum speedup, (iv) and of physical realisations of prototype quantum computers.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations, define and summarize important terms and concepts, recall key formulae, without the use of text books or other sources.

Thereby, students will at the end of the module also have developed a sufficiently broad background to allow them to critically assess news and articles on novel developments in the growing field of quantum computing and quantum technologies, which they come across in outreach publications, scientific media, TV, internet and social media.

Assessment:	Examination 1 (70%) Assignment 1 (10%) Assignment 2 (10%) Assignment 3 (10%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Nielsen, Michael A.; Chuang, Isaac L., Quantum computation and quantum information / Michael A. Nielsen & Isaac L. Chuang., Cambridge University Press, 2010.ISBN: 9781107002173
Gruska, Jozef, Quantum computing / Jozef Gruska., McGraw-Hill, 1999.ISBN: 0077095030
John Preskill, Course Information for Physics 219/Computer Science 219 Quantum Computation.

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Not available to visiting and exchange students.

PH-333 Atomic Physics and Quantum Optics II

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof N Madsen

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module covers the basics of modern topics in atomic physics and quantum optics.

Module Content: 1. Atom-light interactions: electric dipole approximation, absorption rates, spontaneous and stimulated emission.
2. Lasers: optical gain media, laser cavities, tunable lasers, pulsed lasers.
3. Precision measurements: Ramsey fringes and atomic clocks, Doppler-free spectroscopy, frequency combs.
4. Laser cooling and trapping.

Intended Learning Outcomes: Students will learn the basic formulation of light-atom interactions, the principles of lasers and some associated instruments, and finally how to apply this knowledge in modern atomic physics experiments such as laser spectroscopy. Laser cooling is used as an example to highlight the possibilities that open up once this knowledge is mastered.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment: Examination 1 (70%)
Assignment 1 (10%)
Assignment 2 (10%)
Assignment 3 (10%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: C. J. Foot author., Atomic physics / C.J. Foot., Oxford University Press, 2005.ISBN: 9780198506959
Silfvast, William Thomas, 1937- author., Laser fundamentals, Cambridge University Press, 2004.ISBN: 9780511616426
Demtroder, W., Laser spectroscopy : basic concepts and instrumentation, Springer-Verlag, 1996.ISBN: 038757171X
Siegman, Anthony Edward, author., Lasers, University Science Books, 1986.ISBN: 9780198557135

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-335 Particle Physics II

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof A Armoni

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module presents the structure of the standard model of particle physics and reviews current experimental developments.

Module Content: 1. Introduction to modern particle physics.
2. Symmetries and gauge theories: SU symmetry and the structure of gauge theories; QED, QCD, SU(3) x SU(2) x U(1).
3. Electroweak interactions (leptons): leptons in SU(2) x U(1); electroweak unification and the Weinberg angle; neutral currents; LEP and the Z resonance.
4. Electroweak interactions (quarks): quarks in SU(2) x U(1); CKM mixing; FCNCs, the GIM mechanism and charm; precision electroweak physics and the top and Higgs masses.
5. Higgs boson and the origin of mass: Higgs sector of the standard model; Yukawa couplings and quark masses; the Higgs boson.

Intended Learning Outcomes: At the end of this module, the students should:

have a detailed understanding of the structure and symmetries of the standard model of particle physics;
be able to deduce interactions for quarks, leptons and W,Z bosons from electroweak symmetries;
know why the Higgs boson is related to the origin of mass;
appreciate future developments in particle physics arising from the LHC experiments.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit of examination component

Reading List: B. R. Martin (Brian Robert), author., G Shaw (Graham), 1942- author., Particle physics / B.R. Martin, G. Shaw., Chichester, West Sussex, United Kingdom : John Wiley & Sons, Ltd., 2017.ISBN: 9781118912164
Martin, B. R., Shaw, G., Particle physics / B.R. Martin, G. Shaw., Wiley,, 2008.ISBN: 9780470032947

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-338 Frontiers of Nuclear Physics

Credits: 10 Session: 2023/24 September-January

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof C Nunez

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module covers nuclear physics, including applications of fission and fusion, together with modern developments in the theory of strong interactions.

Module Content: 1. Nuclear size: Rutherford scattering, form factors, diffraction.
2. Nuclear structure and stability: the strong interaction, binding energy, saturation, Semi-empirical mass formula, Shell model.
3. Radioactive decays: alpha, beta, gamma radiation, applications.
4. Nuclear fission and fusion: chain reactions, fission and fusion in power generation, weapons
5. Quark structure of hadrons: quark model, deep-inelastic scattering, colour.

Intended Learning Outcomes: At the end of this module, the students should:

Be aware of the need for phenomenological models to supplement first-principles theory in complex physical situations.
have a thorough knowledge of standard nuclear physics and its applications to power generation and nuclear weapons;
understand at a semi-quantitative level how quarks are bound into hadrons;
appreciate advanced ideas in the statistical mechanics of many-quark/gluon systems

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Coursework 1 (30%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Examination (70%): 2 hour written exam.
Continuous Assessment (30%): 2 pieces of coursework

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Krane, Kenneth S., Halliday, David,, Introductory nuclear physics / Kenneth S. Krane., Wiley,, 1987.ISBN: 9780471805533
Lilley, J. S. (John S.), Nuclear physics : principles and applications, J. Wiley, 2001.ISBN: 9780471979364
Martin, B. R., Nuclear and particle physics / B.R. Martin., Wiley,, 2009.ISBN: 9780470742754
Donald H. Perkins, Introduction to high energy physics Donald H. Perkins., Cambridge University Press, 2000.ISBN: 1316084981
Donald H. Perkins, Introduction to high energy physics / Donald H. Perkins., Cambridge University Press, 1999.ISBN: 9780521621960

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-339 Climate Physics

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof DP Van Der Werf

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module covers the Physics of Climate Change including issues related to energy generation.

Module Content: A physical description of the climate including topics such as:

Radiation balance
Atmosphere
Clouds and aerosols
Greenhouse effect
Ozone layer
Circulation models
Climate on other planets
Evidence for Climate Change

Intended Learning Outcomes: To have an understanding of the physical processes which drive climate change. Students will also have conceptual understanding of the mechanisms and processes of global climatic and environmental change and the ability to assess the evidence for past global changes and its implications for the future.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment:	Examination 1 (70%)
	Assignment 1 (10%)
	Assignment 2 (10%)
	Assignment 3 (10%)
Resit Assessment:	Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit if applicable.

Reading List: Taylor, F. W., Elementary climate physics / F.W. Taylor., Oxford University Press,, 2005.ISBN: 9780198567349
Summerhayes, C. P., author., Scott Polar Research Institute, associated with work., Earth's climate evolution, Wiley Blackwell, 2015.ISBN: 9781118897393
Hartmann, Dennis L., author., Global physical climatology, Elsevier, 2016 - 2016.ISBN: 9780123285317
Peixoto, Jose Pinto., Oort, Abraham H., Physics of climate, American Institute of Physics, 1992.ISBN: 9780883187128
Wallace, John M. (John Michael), 1940-, Hobbs, Peter Victor, 1936-2005., Atmospheric science : an introductory survey, Elsevier Academic Press, 2006.ISBN: 9780127329512

Additional Notes: Available to visiting and exchange students.

PH-353 Computational Physics

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof CR Allton

Format: 66 hours

Delivery Method: Lecture based with guided practical sessions.

Module Aims: Computer simulations play a fundamental role in Physics. This course will introduce the the main techniques used in the field; in particular, Monte Carlo calculations. The student will also be equipped with the needed computing skills.

Module Content: The module is intended as a planned practical course in Monte Carlo methods. The teaching will take place in the Faculty's computer facilities with a 'hands-on' approach. After an introduction to the Python programming language, and various software skills software development and revision control systems, the student will work on a variety of problems in statistical and quantum physics, including the Gaussian model, and the harmonic and anharmonic oscillators. It is intended that the assignments are progressive in complexity.

Intended Learning Outcomes: To be able to write programs to perform numerical computations in the Python language, based on specifications given symbolically.
To have an introductory understanding of a software development and revision control system.
To use Monte Carlo methods, be able to apply them to systems of physical interest, and understand their limitations.
To appreciate data-specific skills such as sampling, statistical uncertainty, handling bias, and effective visualisation
To present results in an accurate, comprehensible and visually appealing manner.

Assessment:	Assignment 1 (30%)
	Assignment 2 (50%)
	Assignment 3 (20%)
Resit Assessment:	Coursework reassessment instrument (100%)

Assessment Description: Computer simulations in Physics.
The continuous assessment will consist of 3 assessed pieces of work broken down as below:

Assessment 1: General programming exercise on Canvas (30%)
Assessment 2: Programming exercise on Monte Carlo methods on Canvas (50%)
Assessment 3: Presentation on Monte Carlo methods (20%)

Moderation approach to main assessment: Not applicable

Assessment Feedback: Written feedback.

Failure Redemption: Revision and resubmission of the reports related to the practical sessions.

Reading List: Christian Hill 1974- author., Learning scientific programming with Python / Christian Hill., Cambridge : Cambridge University Press, 2020.ISBN: 9781108778039
Christian Hill 1974- author., Learning scientific programming with Python / Christian Hill., Cambridge, United Kingdom : Cambridge University Press, 2015.ISBN: 9781107075412
Bradley Efron author., Robert Tibshirani author., An introduction to the bootstrap / Bradley Efron and Rob Tibshirani., Boca Raton, FL : Chapman & Hall, 1994.ISBN: 0412042312
Jan Smit 1943-, Introduction to quantum fields on a lattice 'a robust mate' / Jan Smit., Cambridge University Press, 2002.ISBN: 9780511020783
Jens Gustedt, Modern C.
Department of Electrical and Electronic Engineering, University of Surrey, UNIX Tutorial for Beginners.
Physics Practical Course, University of Oxford, Handbook: Physics C programming course.
Keith Waclena, A Tutorial Introduction to GNU Emacs.
Roger Dudler, git - the simple guide.
Colin Morningstar, Lecture notes on Monte Carlo Methods.
Bernd A Berg, Lecture notes on Monte Carlo simulation of the Gaussian system.
A Statistical Approach to Quantum Mechanics, 1981.
Aleksandra Sapik, Willian M Serenone, Lattice Monte Carlo Study of the Harmonic Oscillator in the Path Integral Formulation.
Schaefer, Thomas, Instantons and Monte Carlo Methods in Quantum Mechanics, 2004-11-08.
Press, William H, Numerical recipes in C / William H. Press ... [et al.]., Cambridge University Press, 1992.

Additional Notes: Delivery of both teaching and assessment will be blended including live and self-directed activities online and on-campus.

Available to visiting and exchange students.

PH-355 Mathematical Methods in Physics III

Credits: 10 Session: 2023/24 January-June

Pre-requisite Modules:

Co-requisite Modules:

Lecturer(s): Prof DC Thompson

Format: 22 lectures, 3 feedback sessions

Delivery Method: Lectures and feedback sessions.

Module Aims: This module introduces a range of important mathematical skill for physicists including advanced techniques for solving differential equations, variational method and group theory. These ideas will be illustrated with applications to well known physical systems.

Module Content: Variational methods: Stationary-value (SV) problems, SV problems with constraints, Lagrange's method of undetermined multipliers. The Euler-Lagrange equation basic form and generalisations, Classical problems (brachistochrone, etc.) Rayleigh-Ritz methods, examples in quantum mechanics.

-Group theory: Group operations, discrete groups, types of groups (permutation, dihedral, etc.) group relationships (subgroups, isomorphisms, co-sets, generators, etc.). Continuous groups, rotations, orthogonal and Unitary groups, Physical applications.

-advanced solutions to DE's, Sturm Liouville Theory, Special Functions.

Intended Learning Outcomes: Students will extend their knowledge of advanced mathematical techniques in preparation for their level M modules.

Students will be able to perform calculations and solve problems based on the content of this module taking the form of analytical and/or numerical calculations without the use of text books or other sources.

Students will be able to demonstrate that they have mastered the content of the module by being able to define and summarize important terms and concepts, recall key formulae without the aid of text books or other sources.

Assessment: Examination 1 (70%)
Assignment 1 (10%)
Assignment 2 (10%)
Assignment 3 (10%)

Resit Assessment: Examination (Resit instrument) (100%)

Assessment Description: Assignments and Examination

Moderation approach to main assessment: Moderation by sampling of the cohort

Assessment Feedback: Students receive assessed work back with the point of error indicated.
Students have a feedback session to go through solutions to the problems.
Students can arrange with lecturer to have personal feedback on their assessments.

Failure Redemption: Re-sit of examination component

Reading List: Riley, K. F., Hobson, M. P., Essential Mathematical Methods for the Physical Sciences [print and electronic book]., Cambridge University Press,, 2011.ISBN: 9780521761147
Carl M. Bender, Steven A Orszag, Advanced mathematical methods for scientists and engineers / Carl M. Bender, Steven A. Orszag., McGraw-Hill, 1978.
Robert Gilmore 1941-, Lie groups, Lie algebras, and some of their applications / Robert Gilmore., Krieger, 1994.ISBN: 0894647598
H. F. Jones (Hugh F.), Groups, representations and physics / H.F. Jones., Hilger, 1990.ISBN: 0852740301

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