Module Descriptor

Title	Selected Topics in Theoretical Physics		
Session	2025/26	**Status**	Published
Code	PHYS10013	**SCQF Level**	10
Credit Points	20	**ECTS (European Credit Transfer Scheme)**	10
School	**Computing, Engineering and Physical Sciences**		
Module Co-ordinator	Maximilien Barbier		

Summary of Module

This is an optional SCQF Level 10 module for the Physics programme presented in the first term.

The module will cover selected topics in theoretical physics, such as advanced quantum mechanics, analytical mechanics and non-linear dynamics, advanced electrodynamics, and general relativity. The exact topics covered will vary each session but will include two subjects from the list below.

Advanced Quantum Mechanics

In this topic we will discuss in some details the mathematical formalism of Quantum Mechanics, such as the concepts of vector and Hilbert spaces as well as Dirac notation (bras and kets), the difference between discrete and continuous bases of a Hilbert space, and the position and momentum representations. We will also discuss some practical applications of the formalism such as perturbation theory, both time-independent and time-dependent. Time-dependent perturbation theory is also applied to the case of light-matter interaction, hence explaining the phenomena of absorption and stimulated emission of light by an atom.

Analytical Mechanics and Non-Linear Dynamics

The course will begin by reviewing the Lagrangian and Hamiltonian formalisms. In addition, noninertial frames will be introduced, and centrifugal and Coriolis forces will be discussed. We will then introduce the Gateaux derivative, and discuss the second variation, the Hamilton-Jacobi equations and Poisson brackets. We will elucidate the topics of symmetries and conservation laws and describe Noether's Theorem.

Nonlinear dynamics and chaos, attractors, orbits, period doubling bifurcations, Feigenbaum's number, Lyapunov exponents.

Advanced Electrodynamics

This topic will begin by reviewing Maxwell's equations. We will then discuss Helmholtz decomposition, multipole expansions, vector potentials, gauge transformations, retarded potentials, radiation, Lorentz transformation of EM fields. We will further discuss electrodynamics of continuous media, in particular, electromagnetic waves in absorptive and

dispersive media, Kramers-Kronig relations, and electromagnetic waves in inhomogeneous media.

General Relativity

Tensors, contravariance and covariance, geometry of curved spacetime (Riemannian geometry), concept of a metric, Christoffel Symbols, Schwarzschild spacetime, black holes, Robertson-Walker spacetime, Ricci Tensor, Einstein's Field Equations, Friedmann Equations.

We have defined a set of Graduate Attributes that are the skills, personal qualities and understanding to be developed through your university experience that will prepare for life and work in the 21st century (https://www.uws.ac.uk/current- students/your-graduate-attributes/). The Graduate Attributes relevant to this module are listed below.

• Graduate Attributes - Academic: critical thinker; analytical; inquiring; knowledgeable; digitally literate; problem solver; autonomous; incisive; innovative

• Graduate Attributes - Personal: effective communicator; influential; motivated

• Graduate Attributes - Professional: collaborative; research-minded; enterprising; ambitious; driven

Module Delivery Method	**On-Campus**[1] ☒	**Hybrid**[2] ☐	**Online**[3] ☐	**Work -Based Learning**[4] ☐
Campuses for Module Delivery	☐ Ayr ☐ Dumfries	☐ Lanarkshire ☐ London ☒ Paisley	☐ Online / Distance Learning ☐ Other (specify)	

Terms for Module Delivery	Term 1	☒	Term 2	☐	Term 3	☐
Long-thin Delivery over more than one Term	Term 1 – Term 2	☐	Term 2 – Term 3	☐	Term 3 – Term 1	☐

Learning Outcomes	
L1	Develop a good understanding of a broad range of topics across theoretical physics.
L2	Improve facility with the mathematical techniques that underpin the physical concepts.
L3	Synthesise knowledge from across the entire degree programme and develop deeper theoretical insights into prior knowledge.

[1] Where contact hours are synchronous/ live and take place fully on campus. Campus-based learning is focused on providing an interactive learning experience supported by a range of digitally-enabled asynchronous learning opportunities including learning materials, resources, and opportunities provided via the virtual learning environment. On-campus contact hours will be clearly articulated to students.

[2] The module includes a combination of synchronous/ live on-campus and online learning events. These will be supported by a range of digitally-enabled asynchronous learning opportunities including learning materials, resources, and opportunities provided via the virtual learning environment. On-campus and online contact hours will be clearly articulated to students.

[3] Where all learning is solely delivered by web-based or internet-based technologies and the participants can engage in all learning activities through these means. All required contact hours will be clearly articulated to students.

[4] Learning activities where the main location for the learning experience is in the workplace. All required contact hours, whether online or on campus, will be clearly articulated to students

L4	Become a fluent user of computer algebra software to aid visualisation and calculation.
L5	

Employability Skills and Personal Development Planning (PDP) Skills	
SCQF Headings	**During completion of this module, there will be an opportunity to achieve core skills in:**
Knowledge and Understanding (K and U)	**SCQF 10** Advanced topics in theoretical physics, such as from advamced quantum mechanics, advanced electrodynamics and special relativity, advanced mechanics, or general relativity. This module will equip the student with a good basis on which to build further study in theoretical physics.
Practice: Applied Knowledge and Understanding	**SCQF 10** Applying what they have learned throughout their studies to understand some of the pillars of modern theoretical physics.
Generic Cognitive skills	**SCQF 10** Advanced knowledge of mathematical physics, and fluency with physics topics in general. Studying theoretical physics at this level demonstrates strong cognitive abilities.
Communication, ICT and Numeracy Skills	**SCQF 10** A very high level of numeracy and computational skills. Students who successfully achieve the learning outcomes will be in a good position to demonstrate that they are numerically and computationally literate.
Autonomy, Accountability and Working with Others	**SCQF 10** Maintaining academic integrity throughout and will continue to foster good communication skills while working as part of a team.

Prerequisites	**Module Code** PHYS09003 PHYS09008 PHYS09012 PHYS09013	**Module Title** Electromagnetism Quantum Mechanics Mathematics for Physics 2 Atoms, Nuclei & Particles
	Other or equivalent	
Co-requisites	**Module Code**	**Module Title**

Learning and Teaching
In line with current learning and teaching principles, a 20-credit module includes 200 learning hours, normally including a minimum of 36 contact hours and maximum of 48 contact hours.

Learning Activities During completion of this module, the learning activities undertaken to achieve the module learning outcomes are stated below:	**Student Learning Hours** (Note: Learning hours include both contact hours and hours spent on other learning activities)
Lecture / Core Content Delivery	24
Laboratory / Practical Demonstration / Workshop	24
Independent Study	152
Please select	
Please select	
Please select	
TOTAL	200

Indicative Resources
The following materials form essential underpinning for the module content and ultimately for the learning outcomes: D. J. Griffiths, "Introduction to Quantum Mechanics, Second Edition", Prentice Hall, 2005. (or any later edition) D. J. Griffiths, "Introduction to Electrodynamics, Fourth Edition", Pearson, 2012. (or any later edition) J.D. Jackson, Classical Electrodynamics L. D. Landau, E. M. Lifshitz, Course of Theoretical Physics, Vols. 1-3 (Mechanics, The Classical Theory of Fields, Quantum Mechanics: Non-Relativistic Theory) B. Schutz, A First Course in General Relativity
(N.B. Although reading lists should include current publications, students are advised (particularly for material marked with an asterisk*) to wait until the start of session for confirmation of the most up-to-date material)

Attendance and Engagement Requirements
In line with the Student Attendance and Engagement Procedure, Students are academically engaged if they are regularly attending and participating in timetabled on-campus and online teaching sessions, asynchronous online learning activities, course-related learning resources, and complete assessments and submit these on time. **For the purposes of this module, academic engagement equates to the following:** The School of Computing, Engineering and Physical Sciences considers attendance and engagement to mean a commitment to attending, and engaging in, timetabled sessions. You will scan your attendance via the scanners each time you are on-campus and you will login to the VLE several times per week. Where you are unable to attend a timetabled learning

session due to illness or other circumstance, you should notify the Programme Leader that you cannot attend. Across the School an 80% attendance threshold is set. If you fall below this, you will be referred to the Student Success Team to see how we can best support your studies.

Equality and Diversity
The University's Equality, Diversity and Human Rights Procedure can be accessed at the following link: UWS Equality, Diversity and Human Rights Code. Aligned with the University's commitment to equality and diversity, this module supports equality of opportunity for students from all backgrounds and learning needs. Using the VLE, material will be presented electronically in formats that allow flexible access and manipulation of content. This module complies with University regulations and guidance on inclusive learning and teaching practice. This module has lab-based teaching and as such you are advised to speak to the Module Co-ordinator to ensure that specialist assistive equipment, support provision and adjustment to assessment practice can be put in place, in accordance with the University's policies and regulations.
(N.B. Every effort will be made by the University to accommodate any equality and diversity issues brought to the attention of the School)

Supplemental Information

Divisional Programme Board	**Engineering Physical Sciences**
Overall Assessment Results	☐ **Pass / Fail** ☒ **Graded**
Module Eligible for Compensation	☐ **Yes** ☒ **No** **If this module is eligible for compensation, there may be cases where compensation is not permitted due to programme accreditation requirements. Please check the associated programme specification for details.**
School Assessment Board	Mathematics and Physics
Moderator	G. V. Morozov
External Examiner	M. Gorman
Accreditation Details	Institute of Physics (IoP)
Module Appears in CPD catalogue	☐ **Yes** ☒ **No**
Changes / Version Number	3.0 Module descriptor amended to conform to the new template format. Module moved from T2 to T1.

Assessment (also refer to Assessment Outcomes Grids below)
Assessment 1
Class Test (80%)
Assessment 2

Coursework: Problem Sets (20%)
Assessment 3
(N.B. (i) Assessment Outcomes Grids for the module (one for each component) can be found below which clearly demonstrate how the learning outcomes of the module will be assessed. (ii) An indicative schedule listing approximate times within the academic calendar when assessment is likely to feature will be provided within the Student Module Handbook.)

Component 1							
Assessment Type	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**	**Weighting of Assessment Element (%)**	**Timetabled Contact Hours**
Class Test	☒	☒	☒	☐	☐	80	2

Component 2							
Assessment Type	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**	**Weighting of Assessment Element (%)**	**Timetabled Contact Hours**
Coursework	☒	☒	☒	☒	☐	20	0

Component 3							
Assessment Type	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**	**Weighting of Assessment Element (%)**	**Timetabled Contact Hours**
	☐	☐	☐	☐	☐		
Combined total for all components						100%	2 hours

Change Control

What	**When**	**Who**
Moved to new template	20/03/2025	M. Barbier
Moved from T2 to T1	20/03/2025	M. Barbier
Changed Module co-ordinator	20/03/2025	M. Barbier