1. **Title of the module**

PHYS6660 (PH666) – Nuclear and Particle Physics

1. **Division or partner institution which will be responsible for management of the module**

Division of Natural Sciences

1. **The level of the module (Level 4, Level 5, Level 6 or Level 7)**

Level 6

1. **The number of credits and the ECTS value which the module represents**

15 Credits (7.5 ECTS)

1. **Which term(s) the module is to be taught in (or other teaching pattern)**

Autumn

1. **Prerequisite and co-requisite modules**

Pre-requisite: PHYS5020 – Quantum Physics; and PHYS5030 – Atomic Physics

Co-requisite: PHYS6040 – Relativity Optics and Maxwell's Equations

1. **The course(s) of study to which the module contributes**

Compulsory for:

Physics (BSc, BSc with Foundation Year, BSc with a Year in Industry, MPhys)

Physics with Astrophysics (BSc, BSc with a Year in Industry, MPhys)

Astronomy Space Science and Astrophysics (BSc, BSc with a Year in Industry, MPhys)

This is not available as an elective module choice.

1. **The intended subject specific learning outcomes.  
   On successfully completing the module students will be able to:**

8.1 Demonstrate extensive knowledge and understanding of physical laws and principles in Nuclear and Particle Physics, and their application to diverse areas of physics.

8.2 Demonstrate the ability to identify relevant principles and laws when dealing with problems in Nuclear and Particle Physics, and to make approximations necessary to obtain solutions.

8.3 Demonstrate the ability to solve problems in Nuclear and Particle Physics using appropriate mathematical tools and the formalism of quantum mechanics.

8.4 Demonstrate the ability to use mathematical techniques and analysis to model physical behaviour in Nuclear and Particle Physics.

8.5 Demonstrate familiarity with how particle physics experiments work.

8.6 Discuss particle physics in the language of particles and fields.

8.7 Present and interpret information graphically.

8.8 Make use of appropriate physics-based texts, research-based materials or other learning resources as part of managing their own learning.

1. **The intended generic learning outcomes.  
   On successfully completing the module students will be able to:**

9.1 Demonstrate problem-solving skills, in the context of both problems with well-defined solutions and open-ended problems; an ability to formulate problems in precise terms and to identify key issues, and the confidence to try different approaches in order to make progress on challenging problems. Numeracy is subsumed within this area.

9.2 Demonstrate analytical skills, associated with the need to pay attention to detail and to develop an ability to manipulate precise and intricate ideas, to construct logical arguments and to use technical language correctly.

1. **A synopsis of the curriculum**

This module will introduce students to basic concepts in nuclear and particle physics, and will provide an understanding of how the principles of quantum mechanics are used to describe matter at sub-atomic length scales. The following concepts will be covered:

Properties of nuclei: Rutherford scattering. Size, mass and binding energy, stability, spin and parity.

Nuclear Forces: properties of the deuteron, magnetic dipole moment, spin-dependent forces.

Nuclear Models: Semi-empirical mass formula M(A, Z), stability, binding energy B(A, Z)/A. Shell model, magic numbers, spin-orbit interaction, shell closure effects.

Alpha and Beta decay: Energetics and stability, the positron, neutrino and anti-neutrino.

Nuclear Reactions: Q-value. Fission and fusion reactions, chain reactions and nuclear reactors, nuclear weapons, solar energy and the helium cycle.

Experimental methods in Nuclear and Particle Physics (Accelerators, detectors, analysis methods, case studies will be given).

Discovery of elementary particles and the standard model of particles

Leptons, quarks and vector bosons

The concept of four different forces and fields in classical and quantum physics; mediation of forces via virtual particles, Feynman Diagrams

Relativistic Kinematics

Relativistic Quantum Mechanics and Prediction of Antiparticles

Symmetries and Conservation Laws

Hadron flavours, isospin, strangeness and the quark model

Weak Interactions, W and Z bosons

1. **Reading list (Indicative list, current at time of publication. Reading lists will be published annually)**

Brehm, J.J, (1989). *Introduction to the Structure of Matter: A Course in Modern Physics*, New York: Wiley.

Griffiths, D.J. (2008). *Introduction to Elementary Particles*. New York: Wiley

Krane, K.S. (1988). *Introductory Nuclear Physics*. New York: Wiley

Lilley, J. (2001). *Nuclear Physics Principles and Applications*, New York: Wiley.

Martin, B.R. (2009). *Nuclear and Particle Physics*. New York: Wiley

Thomson, M. (2013). *Modern Particle Physics*. Cambridge: Cambridge University Press

1. **Learning and teaching methods**

Total Contact Hours: 30

Total Private Study Hours: 120

Total Study Hours: 150

1. **Assessment methods**
   1. Main assessment methods

* Take-home Assignment 1 (5 hours) – 15%
* Take-home Assignment 2 (5 hours) – 15%
* Examination (2 hours) – 70%

13.2 Reassessment methods

* Like-for-like

1. ***Map of module learning outcomes (sections 8 & 9) to learning and teaching methods (section12) and methods of assessment (section 13)***

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Module learning outcome** | *8.1* | *8.2* | *8.3* | *8.4* | *8.5* | *8.6* | *8.7* | *8.8* | *9.1* | *9.2* |
| **Learning/ teaching method** |  |  |  |  |  |  |  |  |  |  |
| Private Study | **x** | **x** |  |  | **x** | **x** |  | **x** |  | **x** |
| Lecture | **x** | **x** |  | **x** | **x** | **x** | **x** |  |  |  |
| Problem-solving |  |  | **x** | **x** |  |  | **x** |  | **x** |  |
| **Assessment method** |  |  |  |  |  |  |  |  |  |  |
| Take-home Assignment | **x** | **x** | **x** | **x** | **x** | **x** | **x** | **x** | **x** |  |
| Examination | **x** | **x** | **x** | **x** | **x** | **x** | **x** |  | **x** | **x** |

1. **Inclusive module design**

The Division recognises and has embedded the expectations of current equality legislation, by ensuring that the module is as accessible as possible by design. Additional alternative arrangements for students with Inclusive Learning Plans (ILPs)/declared disabilities will be made on an individual basis, in consultation with the relevant policies and support services.

The inclusive practices in the guidance (see Annex B Appendix A) have been considered in order to support all students in the following areas:

a) Accessible resources and curriculum

b) Learning, teaching and assessment methods

1. **Campus(es) or centre(s) where module will be delivered**

Canterbury

1. **Internationalisation**

Physics is an international discipline, and particle physics stands out particularly by its strong tradition for international collaboration: Indeed, the leading particle physics experiments, such as the LHC at CERN are international projects involving many nations. The inherent need for such collaboration in order to enable highly technical and specialised research will be highlighted in this module.

**DIVISION USE ONLY**

**Revision record – all revisions must be recorded in the grid and full details of the change retained in the appropriate committee records.**

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| --- | --- | --- | --- | --- |
| Date approved | Major/minor revision | Start date of delivery of revised version | Section revised | Impacts PLOs (Q6&7 cover sheet) |
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