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| **Module Specification**  **MATH431 – INTRODUCTION TO MODERN PARTICLE THEORY** |
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**1. Module Details**

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| **Module Title:** | INTRODUCTION TO MODERN PARTICLE THEORY |
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| **Short Title:** | INTRO TO MODERN PARTICLE THEOR |
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| **Module Code:** | MATH431 |
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| **Marketing Module Synopsis:** | ​Modern particle theory is combining special relativity, quantum mechanics and field theory to describe all the fundamental subatomic particles and their interactions. The module develops the relevant concepts that enter into the Standard Model of particle physics. The key concept in modern physics is that of invariance under local symmetries and the conservation laws that they give rise to. The module covers the basic elements that describe modern particle theory, including: Lorentz and Poincare symmetries, which underlie special relativity; Hamilton and Lagrange formalism of classical mechanics and fields, which underlie the modern formalism; basic elements of relativistic quantum mechanics including the Dirac and Klein-Gordon equations; field quantisation; global and local symmetries; global and local symmetry breaking and the Higgs mechanism; unitary groups and the classification of elementary particles; basic elements of grand unified theories and phenomenological aspects. The students will be introduced to many of the modern ideas in Particle Physics at an accessible level. |
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| **Credits:** | 15 |
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| **Level:** | Level 7 |
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| **Delivery Location(s)** | MUST BE COMPLETED FOR APPROVAL Online |
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| **Semester:** | Second Semester |
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| **Academic Year:** | 2020-21 |
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| **Faculty:** | Faculty of Science and Engineering |
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| **School/Institute (Level 2):** | School of Physical Sciences |
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| **Curriculum Board (level 1):** | Mathematical Sciences |
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| **Module Coordinator:** | Alon Faraggi |
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| **Other staff:** | Christopher Egan, Monika Grabias, Thomas Mohaupt, Radu Tatar, Alan Smithson, Simon Fairfax |
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| **External Examiner(s):** |  |
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| **Pre-requisites:** | N/A |
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| **Co-requisites:** | N/A |
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| **Barred Combinations:** | N/A |
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| **CE/CPD Provision:** | No |
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| **Overview:** | Costs Information:  Standard University Calculator  There are the following non-modular requirements:  MATH 325 (or equivalent for MPhys students)    Skill/Other Attribute 1: "​ ​Problem solving skills  "  How this is developed: "" |
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| **Notes:** | This module is due to commence in November 2018 |
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| **Maximum Places:** | 50 |
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| **Subject:** |  |
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| **HESA Cost Centre(s):** | MUST BE COMPLETED FOR APPROVAL Mathematics |
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| **Status:** | Approved |

**The table below is automatically completed from programme data held in Curriculum Manager; during 2019/20 it is likely to have no data or incomplete data until all programme records are in Curriculum Manager.**

| **In Programmes:** | **Programme Validation Status** | **Module Status:** | **Programme Stage / Group / / Sub-group** |
| --- | --- | --- | --- |
| Mathematical Sciences Master of Science (MSc) 2020-21 | Validated | Optional | Whole Session  Whole Session Optional Modules |
| Mathematics Master of Mathematics (MMath) 2017-18 | Validated | Optional | Year 4 Semester 2  Year 4 Semester 2 Year 4 Semester 2 |
| Mathematical Physics Master of Mathematics (MMath) 2017-18 | Validated | Optional | Year 4 Semester 2  Year 4 Semester 2 |
| Theoretical Physics Master of Physics (MPhys) 2017-18 | Validated | Optional | Year 4  Year 4 Semester 2 Optional Modules (Level 7) |

**The table below must be completed for module approval, including confirmation that there are zero costs to the student.**

| **Student Cost(s)** | | | | | |
| --- | --- | --- | --- | --- | --- |
|  | | | | **Costs range:** | |
| **Cost Type:** | **Description:** | **Value type** (exact, approximate or max/min range)**:** | **Cost** (exact or approximate): | **Minimum Cost:** | **Maximum Cost:** |

**2. Aims and Content**

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| **Educational Aims:** | |
| To provide a broad understanding of the current status of elementary particle theory. To describe the structure of the Standard Model of particle physics and its embedding in Grand Unified Theories. | |
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| **Outline Syllabus:** | |
| Classical mechanics in Lagrange and Hamilton form; Lorentz and Poincare group; elements of quantum mechanics: Klein-Gordon equation, Dirac equation; basic elements of field theory: Field quantization, Feynman diagrams; global, and local symmetries, gauge bosons; classification of elementary particles: charge, spin, mass, Isospin; Unitary groups; The quark model of Gellman and Zweig; beta decay and weak interactions; global and local symmetry breaking; Higgs mechanism; outlook onto extensions of the standard model; Pati-Salam, SU(5) and SO(10) Grand Unified Theories; phenomenological aspects of GUTs; | |
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| **Reading List:** |  |

**3. Module Outcomes (learning outcomes, skills and other attributes)**

| **Ref No.** | **Learning Outcome / Skill:** | **Category:** |
| --- | --- | --- |
| LO1 | To understand the Lorentz and Poincare groups and their role in classification of elementary particles. | Learning Outcomes |
| LO2 | ​To understand the basics of Langrangian and Hamiltonian dynamics and the differential equations of bosonic and fermionic wave functions. | Learning Outcomes |
| LO3 | ​To understand the basic elements of field quantisation. | Learning Outcomes |
| LO4 | ​ ​To understand the Feynman diagram pictorial representation of particle interactions. | Learning Outcomes |
| LO5 | ​To understand the role of symmetries and conservation laws in distinguishing the strong, weak and electromagnetic interactions. | Learning Outcomes |
| LO6 | ​To be able to describe the spectrum and interactions of elementary particles and their embedding into Grand Unified Theories (GUTs) | Learning Outcomes |
| LO7 | To understand the flavour structure of the standard particle model and generation of mass through symmetry breaking​. | Learning Outcomes |
| LO8 | ​To understand the phenomenological aspects of Grand Unified Theories. | Learning Outcomes |
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| S1 | ​​Problem solving skills | Skills |
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**4. Assessments**

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| **Assessment Strategy:** |
| MUST BE COMPLETED FOR APPROVAL  1x 50% class test – open book and remote  1x 50% final assessment – open book and remote  The module will be delivered in hybrid delivery mode. Asynchronous learning materials (notes/videos/exercises etc) will be made available to students through the VLE. The module will have regular synchronous sessions in active learning mode.  We are planning no changes to module content compared to previous years, and expect students to spend a similar amount of time-on-task compared to previous years. These changes will mainly constitute a rebalancing of hours from scheduled directed learning hours to unscheduled directed learning hours as students will have some flexibility as to when they access asynchronous materials. |

**All fields in the table below must be completed for module approval.**

| **Method** | **Description** | **Type** | **Units of Length** | **Length** | **Min** | **Max** | **Description (re length)** | **Weighting** | **Assessment period(s)** | **Group Work** | **Must Pass** | **Final Assessment** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Written exam, unseen, managed by SAS  Final Assessment | Final Assessment – open book and remote There is a resit opportunity.  Standard UoL penalty applies for late submission.  This is an anonymous assessment.  Assessment Schedule (When) :Semester 2 | Summative | Other | N/A | N/A | N/A | 1h time on task | 50% | S2 | No | MUST BE COMPLETED  No | Yes |
| Coursework | Class Test 1 | Summative | Other | N/A | N/A | N/A | Around 60-90 minutes | 50% | S2 | No | No | No |
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***Please see Appendix 1 for details of the outcomes tested by the above assessments.***

**5. Learning and Teaching Methods**

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| **Summary of Learning and Teaching Methods:** |
| The module will be delivered in hybrid delivery mode. Asynchronous learning materials (notes/videos/exercises etc) will be made available to students through the VLE. The module will have regular synchronous sessions in active learning mode.  We are planning no changes to module content compared to previous years, and expect students to spend a similar amount of time-on-task compared to previous years. These changes will mainly constitute a rebalancing of hours from scheduled directed learning hours to unscheduled directed learning hours as students will have some flexibility as to when they access asynchronous materials.  Synchronous: 12 hours (scheduled, directed)  Asynchronous: 36 hours (unscheduled, directed)  Independent Learning: 102 hours (undirected) |

**The following table must be completed for module approval, accounting for all hours associated with the credit value of the module, e.g. for 15 credits there should be 150 hours of learning and teaching activity, including independent learning.**

| **Learning and Teaching Method:** | **Length (Minutes):** | **Times per Week** (if applicable): | **Number of Weeks** (if applicable): | **Calculated Hours** (if applicable): | **Hours:** |
| --- | --- | --- | --- | --- | --- |
| Lecture | N/A | N/A | N/A | N/A | 36 |
| Self-Directed Learning | N/A | N/A | N/A | N/A | 102 |
| Tutorial | N/A | N/A | N/A | N/A | 12 |

**6. Supplementary Information**

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| **If a risk assessment is required for this module for students under 18, please record a summary of the risks:** | N/A |