## Unification

<table>
<thead>
<tr>
<th>Module Code</th>
<th>PHYS97102</th>
<th>FHEQ Level</th>
<th>Level 7</th>
</tr>
</thead>
</table>

### Pre-requisites
- Advanced Classical Physics, Group Theory, Physics of the Universe

### Co-requisites
- Quantum Field Theory

### Primary Department
- Physics

### Module Leader
- Professor Arttu Rajantie

### Additional Teaching Departments
- None

### Teaching Staff
- Professor Arttu Rajantie + Course Associate

### Programmes on which the Module is delivered

<table>
<thead>
<tr>
<th>Core/Elective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective</td>
</tr>
</tbody>
</table>

All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)

### Learning Outcomes
- On completing the Unification course, students will:
  - know the properties required for the Lagrangian of a field theory
  - be able to derive the equations of motion from a field theory Lagrangian
  - know the difference between global and local symmetries
  - be able to find the conserved currents associated with a symmetry
  - be able to find the particle spectrum of a classical field theory consisting of scalars, vectors and spinors
  - understand broken and unbroken global and local symmetries are reflected in the particle spectrum
  - know how Dirac and Weyl spinors transform under Lorentz transformations
  - know the symmetry group of the Standard Model of particle physics
  - be able to write down the Standard Model Lagrangian
  - understand how the form of the Standard Model Lagrangian follows from symmetries
  - be able to determine the main parameters of the Standard Model from its particle spectrum

### Description of Content
- Scalar, spinor and vector fields
- Global and gauge symmetries
- Abelian and non-Abelian symmetries
- Noether’s theorem and conservation laws
- Yang-Mills theory
- Spontaneous symmetry breaking and Goldstone’s theorem
- Higgs mechanism and the Higgs boson
- Electroweak unification
- The Standard Model Lagrangian
- Symmetries of the Standard Model
<table>
<thead>
<tr>
<th>Assessment</th>
<th>Assessment Type</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written Exam</td>
<td>Exam</td>
<td>100%</td>
</tr>
<tr>
<td>Learning &amp; Teaching Hours</td>
<td>Independent Study Hours</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>143</td>
<td>0</td>
</tr>
<tr>
<td>ECTS Credit</td>
<td>8</td>
<td>CATS Credit</td>
</tr>
</tbody>
</table>

| Date of introduction            | October 2016    | Date of Last Revision | April 2021 |

| Total Hours                     | 200             |