Engineering Physics major 2018-2020

Professor in charge: Adam Foster
Extent: 40-65 cr
Abbreviation: EngPhys
Code: SCI3056

Objectives

The objective of the major is to give the student the chance of profiling the studies for the future professional life while providing a very strong background in physics and mathematics. The studies include a lot of hands-on experience with research. Many of the students continue with a career in research, first with PhD studies.

The core idea of the major is to maintain the rigorous training while giving a possibility for the student to tune the contents. This rigor is a main strength, traditionally, of the program, both for doctoral studies and as regards its “brand name” on the job market.

Content and structure

The Engineering Physics major consists of two parts: a core content and a flexible choice of courses selected by the student. The core courses of the major cover important topics for engineering physics, and methods from computational, theoretical, and experimental physics. The core content includes also some choices for more detailed focusing on a certain subject. The rest of the studies have a very flexible structure, and provide the student with the possibility of focusing in physics, nanoscience, energy studies, or designing a more cross-disciplinary content for the major. The student can also choose to complete a minor subject, or complete a long major (65 cr).

Compact major (40 cr)

The content of the compact major (40 cr) is: one mathematics, applied mathematics, or systems analysis course (5 cr), a choice between the Advanced Physics Laboratory or Computational Physics (5 cr), a Special Assignment (research or literature study, 10 cr), and 4 courses from the structure (together 40 cr).

In the case of the compact major the student is recommended to take 30 cr of the major courses and 30 cr of others during the first year. The special assignment can also be completed during the summer between the first and second year in the programme.

Compulsory courses (20 cr)

<table>
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<tr>
<th>CODE</th>
<th>NAME</th>
<th>CREDITS</th>
<th>PERIOD</th>
<th>YEAR</th>
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</thead>
<tbody>
<tr>
<td>PHYS-E0411</td>
<td>Advanced Physics Laboratory</td>
<td>5</td>
<td>III-V</td>
<td>1.</td>
</tr>
<tr>
<td>OR</td>
<td></td>
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</tr>
<tr>
<td>PHYS-E0412</td>
<td>Computational Physics</td>
<td>5</td>
<td>III-V</td>
<td>1.</td>
</tr>
<tr>
<td>PHYS-E0441</td>
<td>Physics Special Assignment V</td>
<td>10</td>
<td>varies</td>
<td>2.</td>
</tr>
<tr>
<td>MS-Exxx</td>
<td>One mathematics, applied mathematics or systems analysis course*</td>
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Optional courses (20 cr)

Select four courses (20 cr) from the selection below:

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<tbody>
<tr>
<td>PHYS-E0419</td>
<td>Dynamics of particles, fluids and solids</td>
<td>5</td>
<td>I-II</td>
<td>1.</td>
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<tr>
<td>PHYS-E0414</td>
<td>Advanced Quantum Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1.</td>
</tr>
</tbody>
</table>
* The mathematics courses on the MSc level include: MS-E1651 Numerical matrix computations, MS-E1652 Computational methods for differential equations, MS-E1653 Finite element method, MS-E1654 Computational inverse problems, MS-E2122 Nonlinear optimization, MS-E1 600 Probability theory.

**Long major (65 cr)**

To complete a long major (65 cr), the student selects elective physics or other relevant courses in addition to the core courses (40 cr) listed above so that the extent of the major is 65 cr. All the courses listed in the table above or in the example tracks of the long major are acceptable (see the example tracks of the long major: Materials physics and quantum technology tracks and Advanced Energy Technologies tracks).

The long major offers a chance of profiling the studies by a specialization in a topic. Examples of this are in-depth studies of theoretical/computational physics of materials, experimental physics, and energy sciences. To this end, if the student wishes to include other courses to the long major than the courses listed above or in the example tracks, the student may seek advice on the course selection with his/her teacher tutor. The student may also contact other professors according to his/her interests to discuss the course choices for the long major (emails are in the form of firstname.lastname(a)aalto.fi):

- nuclear engineering: Filip Tuomisto
- materials physics: Adam Foster
- new energy sources: Peter Lund

In addition to normal Master’s programme, engineering physics will be offered as a doctoral track, with the student's studies tailored towards a research career. Mentored by a professor of the department, the student can start working towards a PhD in one of the department’s research groups (linked to: http://physics.aalto.fi/en/groups/) already during their Master studies. Within the track there are suggested packages (see below) tailoring studies towards more computational or experimental approaches, as well as balanced options and also the possibility to focus on energy physics applications. Please note that after completing the Master’s degree, students need to apply separately for doctoral studies if they want to continue their studies towards a PhD.

In the case of a long major (65 cr) the student is recommended to take 40 cr of the major courses and 20 cr of others during the first year. The special assignment can also be completed during the summer between the first and second year in the programme.

**Materials Physics and Quantum Technology tracks**

<table>
<thead>
<tr>
<th>CODE</th>
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<th>PERIOD</th>
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</thead>
<tbody>
<tr>
<td>PHYS-E0441</td>
<td>Physics Special Assignment</td>
<td>10</td>
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<tr>
<td>PHYS-E0415</td>
<td>Statistical Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0421</td>
<td>Solid-State Physics</td>
<td>5</td>
<td>IV-V</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0414</td>
<td>Advanced Quantum Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
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<tr>
<td>PHYS-E0415</td>
<td>Statistical Mechanics</td>
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<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0421</td>
<td>Solid-State Physics</td>
<td>5</td>
<td>IV-V</td>
<td>1./2.</td>
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<tr>
<td>PHYS-E0414</td>
<td>Advanced Quantum Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
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<tr>
<td>PHYS-E0424</td>
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<td>PHYS-E0422</td>
<td>Soft Condensed Matter Physics</td>
<td>5</td>
<td>III-IV</td>
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<tr>
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<td>III-V</td>
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<tr>
<td>PHYS-E0412</td>
<td>Computational Physics</td>
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<td>III-V</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0417</td>
<td>Experimental Methods in Physics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0419</td>
<td>Dynamics of particles, fluids and solids</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>MS-E1651</td>
<td>Numerical Matrix Computations</td>
<td>5</td>
<td>II</td>
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<tr>
<td>MS-E1654</td>
<td>Computational Inverse Problems</td>
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<td>IV</td>
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**Computational track (65 cr)**

<table>
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<tr>
<td>PHYS-E0441</td>
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<tr>
<td>PHYS-E0412</td>
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<td>1./2.</td>
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<tr>
<td>PHYS-E0419</td>
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<td>I-II</td>
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<tr>
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<td>Solid-State Physics</td>
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<td>IV-V</td>
<td>1./2.</td>
</tr>
<tr>
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<tr>
<td>PHYS-E0546</td>
<td>Density-Functional Theory for Practitioners</td>
<td>5</td>
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<td>PHYS-E0546</td>
<td>Density-Functional Theory for Experts</td>
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<tr>
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<td>MS-E1651</td>
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<td>IV</td>
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<tr>
<td>OR</td>
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<tr>
<td>MS-E1654</td>
<td>Computational Inverse Problems</td>
<td>5</td>
<td>IV</td>
<td>1./2.</td>
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**Experimental track (65 cr)**

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<tbody>
<tr>
<td>PHYS-E0441</td>
<td>Physics Special Assignment</td>
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<td>varies</td>
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<tr>
<td>CODE</td>
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<tr>
<td>PHYS-E0415</td>
<td>Statistical Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0424</td>
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<tr>
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<td>Experimental Methods in Physics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0411</td>
<td>Advanced Physics Laboratory</td>
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<td>III-V</td>
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<tr>
<td>PHYS-E0435</td>
<td>Optical Physics</td>
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<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0423</td>
<td>Surface Physics</td>
<td>5</td>
<td>III-IV (in even years)</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0551</td>
<td>Low Temperature Physics</td>
<td>5</td>
<td>varies</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0422</td>
<td>Soft Condensed Matter Physics</td>
<td>5</td>
<td>III-IV</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0421</td>
<td>Solid-State Physics</td>
<td>5</td>
<td>IV-V</td>
<td>1./2.</td>
</tr>
<tr>
<td>MS-E1651</td>
<td>Numerical Matrix Computations</td>
<td>5</td>
<td>II</td>
<td>1./2.</td>
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<tr>
<td>OR</td>
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</tr>
<tr>
<td>MS-E1654</td>
<td>Computational Inverse Problems</td>
<td>5</td>
<td>IV</td>
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Theoretical track (65 cr)

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<th>YEAR</th>
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<tbody>
<tr>
<td>PHYS-E0441</td>
<td>Physics Special Assignment</td>
<td>10</td>
<td>varies</td>
<td>2.</td>
</tr>
<tr>
<td>PHYS-E0415</td>
<td>Statistical Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1.</td>
</tr>
<tr>
<td>PHYS-E0414</td>
<td>Advanced Quantum Mechanics</td>
<td>5</td>
<td>I-II</td>
<td>1.</td>
</tr>
<tr>
<td>PHYS-E0421</td>
<td>Solid-State Physics</td>
<td>5</td>
<td>IV-V</td>
<td>1.</td>
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<td>PHYS-E0435</td>
<td>Optical Physics</td>
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<td>I-II</td>
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<tr>
<td>PHYS-E0416</td>
<td>Quantum Physics</td>
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<td>III-IV</td>
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<tr>
<td>PHYS-E0551</td>
<td>Low Temperature Physics</td>
<td>5</td>
<td>varies</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0419</td>
<td>Dynamics of particles, fluids and solids</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
</tr>
<tr>
<td>PHYS-E0412</td>
<td>Computational Physics</td>
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<td>III-V</td>
<td>1.</td>
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<tr>
<td>PHYS-E0418</td>
<td>Advanced Statistical Physics</td>
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<td>III-V (in even years)</td>
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Choose two of the mathematics courses:

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<th>YEAR</th>
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</thead>
<tbody>
<tr>
<td>MS-E1651</td>
<td>Numerical matrix computations</td>
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<td>II</td>
<td>1./2.</td>
</tr>
<tr>
<td>MS-E1652</td>
<td>Computational methods for differential equations</td>
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<td>I</td>
<td>1./2.</td>
</tr>
<tr>
<td>MS-E1600</td>
<td>Probability theory</td>
<td>5</td>
<td>III</td>
<td>1./2.</td>
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</table>


In order to tailor the Engineering Physics major towards the energy sector, the student is advised to include following courses in the core part of the major:

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>PHYS-E0441</td>
<td>Physics Special Assignment</td>
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<tr>
<td>PHYS-E0411</td>
<td>Advanced Physics Laboratory</td>
<td>5</td>
<td>III-V</td>
<td>1.</td>
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<tr>
<td>OR</td>
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<tr>
<td>PHYS-E0412</td>
<td>Computational Physics</td>
<td>5</td>
<td>III-V</td>
<td>1.</td>
</tr>
<tr>
<td>MS-Exxxx</td>
<td>One mathematics, applied mathematics or systems analysis course*</td>
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</table>

Recommended optional courses (20 cr):

<table>
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<th>CREDITS</th>
<th>PERIOD</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-E0419</td>
<td>Dynamics of particles, fluids and solids</td>
<td>5</td>
<td>I-II</td>
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<tr>
<td>PHYS-E0460</td>
<td>Introduction to Reactor Physics</td>
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<tr>
<td>PHYS-E0483</td>
<td>Advances in New Energy Technologies</td>
<td>5</td>
<td>III-IV</td>
<td>1.</td>
</tr>
<tr>
<td>PHYS-E0461</td>
<td>Introduction to Plasma Physics for Fusion and Space Applications</td>
<td>5</td>
<td>I-II</td>
<td>1.</td>
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</tbody>
</table>

* The mathematics courses on the MSc level include: MS-E1651 Numerical matrix computations, MS-E1652 Computational methods for differential equations, MS-E1653 Finite element method, MS-E1654 Computational inverse problems, MS-E2122 Nonlinear optimization, MS-E1600 Probability theory.

For completing the long major, the student can choose 25 cr from the following courses, and also include special assignments and other individual studies, upon agreement with Profs. Tuomisto, Lund or Groth. Further courses relevant to this major can be found in the course listings of the Aalto Nuclear Safety Minor and Multidisciplinary Energy Studies Minor.

Courses in Nuclear Science and Technology (choose 25 cr):

<table>
<thead>
<tr>
<th>CODE</th>
<th>NAME</th>
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<th>PERIOD</th>
<th>YEAR</th>
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</thead>
<tbody>
<tr>
<td>PHYS-E0460</td>
<td>Introduction to Reactor Physics</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
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<tr>
<td>PHYS-E0562</td>
<td>Nuclear Engineering, advanced course</td>
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<td>IV-V</td>
<td>1./2.</td>
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<tr>
<td>PHYS-E0461</td>
<td>Introduction to Plasma Physics for Fusion and Space Applications</td>
<td>5</td>
<td>I-II</td>
<td>1./2.</td>
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<tr>
<td>PHYS-E0566</td>
<td>Advanced course in plasma physics with computational emphasis</td>
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<td>PHYS-E0483</td>
<td>Fusion Energy Technology</td>
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<tr>
<td>PHYS-E0564</td>
<td>Nuclear competence portfolio</td>
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<tr>
<td>PHYS-E0565</td>
<td>Programming course on Monte Carlo particle transport simulations</td>
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<td>I-II</td>
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Advanced Energy Technologies tracks

Courses in Nuclear Science and Technology (choose 25 cr):
+ Through JOO at LUT:

<table>
<thead>
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<th>CODE</th>
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<tbody>
<tr>
<td>BH30A1900</td>
<td>Thermal Hydraulics of Nuclear Power Plants</td>
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<td>BH30A2000</td>
<td>Modelling of Thermal Hydraulics of Nuclear Power Plants</td>
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<td>BH30A2200</td>
<td>Experimental Nuclear Thermal Hydraulics</td>
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</table>

Internationally, students can take courses available through the European Nuclear Education Network ENEN (http://www.enen.eu). An additional benefit provided by ENEN is the European Master of Science in Nuclear Engineering Certification EMSNE (requires a 300 ECTS-MSc-level degree where 60 ECTS are in nuclear science and technology, preferably engineering, including a MSc thesis project in the nuclear field, and 20 ECTS need to be earned in a country other than that of the home university). For further information, contact Prof. Filip Tuomisto.

Courses in Renewable Energy Technologies (choose 25 cr):

<table>
<thead>
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<tr>
<td>PHYS-C1380</td>
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