Vectors and Tensors in Engineering Physics

General Information

Number of ECTS Credits
3

Module code
FTP_Tensors

Valid for academic year
2025-26

Last modification
2025-01-07

Coordinator of the module
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Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
Instruction					**X** E 100%		
Documentation					**X** E 100%		
Examination					**X** E 100%		

Module Category
FTP Fundamental theoretical principles

Lessons
2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge
Physics, analysis and linear algebra at Bachelor's level

Brief course description of module objectives and content

The course starts with an overview of classical engineering physics with special emphasis of balance and constitutive equations (i.e., continuity equations and material laws). The basic concepts of vector analysis are applied to electrodynamics, various transport phenomena, mechanical elasticity and piezo-electric effects. The concept of tensors enables the description of typical anisotropic effects of solid state physics. These effects are present in crystals as well as in layered material systems, which are more and more used in modern technology. The given overview facilitates the student's understanding and application of numerical simulation methods (e.g., FEA, multiphysics).

Aims, content, methods

- Students are familiar with the most important basic laws of engineering physics for isotropic materials in general view form, recognize analogies between different application areas and exploit these for analyzing systems
- Students know about the generalization of the laws for anisotropic materials and can interpret these, especially with regard to application in numerical simulation
- Students master vector analysis and the algebra of tensors together with the standard notation conventions
- Students understand the basics of electrodynamics and transport phenomena for anisotropic systems
- Students understand mechanical elasticity with 3D strain and stress states and are familiar with the material laws in general form for isotropic and anisotropic bodies
- Students understand the piezo-electric effect and its applications in engineering (sensors and actuators)

Module content with weighting of different components

- Recapitulation of isotropic material laws (Ohm, Hooke, Fourier, electric polarisation)
- Introduction to vector and tensor calculation: scalar, vectorial and tensorial parameters, tensor algebra,
- Transformation behavior of vectors and tensors
- Hands-on calculation of vector analysis and tensor algebra: electrodynamics and anisotropic transport phenomena
- Elasticity theory with emphasis on 3D stress states
- Piezo-effect: physical fundamentals

Teaching and learning methods

Frontal teaching (approx. 60 %)
Presentation and discussion of case studies and problems, individual problem solving (approx. 40 %)

Literature

[1] R.E. Newham, Properties of Materials, Oxford, 2005

[2] J.F. Nye, Physical Properties of Crystals, Oxford Science Publication, 2004

[3] J. Tichy, Fundamentals of Piezoelectric Sensorics, Springer 2010

[4] E. Kreszig, Advanced Engineering Mathematics, 10th edition, Wiley, 2011

Assessment

Additional performance assessment during the semester

The module does not contain an additional performance assessment during the semester

Basic principle for exams

As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.

Standard final exam for a module and written resit exam

Kind of exam

Written exam

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Written matter (open book), pocket calculator

Other permissible aids

No other aids permitted

Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.