MASTER OF SCIENCE IN ENGINEERING

Module Description, available in: EN

Vectors and Tensors in Engineering Physics

General Information

Number of ECTS Credits

3

Module code

FTP_Tensors

Valid for academic year

2024-25

Last modification

2018-10-27

Coordinator of the module

Lorenz Martin (BFH, lorenz.martin@bfh.ch)

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, linear algebra at Bachelor's level ,
- The mathematical prerequisites are covered by the chapter 7-9 of [4]. The summaries of these chapters are in the appendix of this document.

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 important 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

Learning objectives and acquired competencies

- 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)

Contents of module with emphasis on teaching content

- Recapitulation of isotropic material laws (Ohm, Hook, electric polarization, heat conduction)
- 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 tensoralgebra: electrodynamics and anisotropic transport phenomena
- Elasticity theory with emphasis on 3D stress states
- Piezo-effect: physical fundamentals

Week	**Subject**
MW1	Introduction, motivation, repetition of fundamental physical laws from engineering physics
MW2	Scalars, vectors, divergence, gradient, curl
MW3	Integral theorems and applications of vector analysis in physics
MW4	Maxwell I: Electro- and magnetostatics
MW5	Fundamental mathematical properties of tensors, transformations of tensors
MW6	Transport phenomena, Ohm’s law, heat conduction and diffusion
MW7	Elasticity: stress and distortion tensor, thermal expansion
MW8	Elasticity: Hooke’s law, tensors of the fourth rank, engineering diagram
MW9	Elasticity: 3D stress and distortion states
MW10	Elasticity: 3D stress and distortion states
MW11	Reserve
MW12	Maxwell II: Electrodynamics
MW13	Maxwell III: Waves, Maxwell
MW14	Piezoelectricity

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

Certification requirements

Module does not use certification requirements

Basic principle for exams

As a rule, all the standard final exams for modules and also all resit exams are to be in written form

Standard final exam for a module and written resit exam

Kind of exam

written

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Personal formula collection, pocket calculator, courseware

Other permissible aids

No other aids permitted

Special case: Resit exam as oral exam

Kind of exam

oral

Duration of exam

30 minutes

Permissible aids

No aids permitted