COURSE DESCRIPTION CARD - SYLLABUS

Course name

THREE DIMENSIONAL ELECTROMAGNETIC FIELD CALCULATION IN ELECTRICAL MACHINES

Course

Proposed by Discipline

Automation, electronic, electrical engineering and space technologies

Type of studies

Doctoral School

Form of study

full-time

Year/Semester

II/4, III/6

Course offered in

English

Requirements

elective

Number of hours

Lecture	Tutorials	Projects/seminars
4		

Number of credit points

1

Lecturers

Responsible for the course/lecturer:

prof. dr hab. inż. Andrzej Demenko

email: andrzej.demenko@put.poznan.pl

phone: +48 61 665 2126

Faculty of Control, Robotics, and Electrical Engineering

Poznan University of Technology

ul. Piotrowo 3a, 60-965 Poznan, Poland

Responsible for the course/lecturer:

dr hab. inż. Rafał M. Wojciechowski, prof. PUT

mail: rafal.wojciechowski@put.poznan.pl

phone: +48 61 665 2126

Faculty of Control, Robotics, and Electrical Engineering

Poznan University of Technology

ul. Piotrowo 3a, 60-965 Poznan, Poland

Prerequisites

Knowledge: knowledge on the key developmental trends in electrical engineering software and elementary knowledge of partial differential equations and electrical machines.

Skills: use the knowledge of elementary numerical methods and basic skills in computational research environments and computational techniques.

Social competencies: acknowledge the importance of new computational methods and modern physics understanding in the development of technical sciences.

Course objective

Getting Knowledge of the modern field methods in the analysis and synthesis of electromagnetic machines and drives.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:

1) key developmental trends of the modern field methods in the analysis and synthesis of the systems with electric and magnetic field, [P8S_WG/SzD_W02]

2) the methodology of 3D electromagnetic field calculation in systems of low frequency, [P8S_WG/SzD_W03]

3) promote the new approaches in electromagnetic field calculation. [P8S_WG/SzD_W04]

Skills

A PhD student who graduated from doctoral school can:

1) promote the new approaches in electromagnetic field calculation, [P8S_UW/SzD_U01]

2) critically analyze the results of numerical method application in the design of electromagnetic systems and coupled filed problems, [P8S_UW/SzD_U02]

3) share results of electromagnetic field calculation in a popular form, [P8S_UK/SzD_U05]

4) plan research project with the application of new 3D methods of electromagnetic field calculation. [P8S_UO/SzD_U09]

Social competences

A PhD student who graduated from doctoral school is ready to:

1) critically assess the achievements in the electromagnetic field calculation, including the achievements proposed by commercial software, [P8S_KK/SzD_K01]

2) think and act in an entrepreneurial manner as a designer of modern electrical machines and drives, [P8S_KO/SzD_K06]

3) maintain the ethos of research in electromagnetism, including independent activity in the numerical methods of electric drive calculation and design. [P8S_KR/SzD_K07]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W02, W03, W04	written test (solving research problem)	assessment of knowledge and skills by the completion of test
U01, U02, U05, U09	written test (solving research problem)	assessment of knowledge and skills by the completion of test
K01, K06, K07	written test (solving research problem)	assessment of knowledge and skills by the completion of test

Programme content

1. Description of electromagnetic field (Differential equations, integral equations, constitutive equations, circuit representation of electromagnetic field equations, scalar and vector potentials).
2. New approach of finite element method for magnetic and electric field (Nodal, elements, edge elements, facet elements and volume elements, circuit representation of finite element equations, edge and facet magnetic and electric network, coupled network in the analysis of electromagnetic field, time step method, method of complex variables).
3. Description of winding in finite element space (Multiply connected conductors in the edge element and facet element space, potential T0 in the coupled field-circuit models).
4. Movement simulation and electromagnetic torque and force calculation in the finite element method (Methods of movement simulation: (a) fixed grid method, (b) moving grid method. Virtual work principle for discrete models, network representation of stress tensor method and Lorentz formula).
5. Transformation of 3D models into the 2D network (Symmetry of magnetic and electric field in electrical machines and actuators. Plane and axisymmetric magnetic field, Equivalence of nodal and edge element finite element equations for 3D and 2D field).
6. Software for electromagnetic field calculation (Preprocessor, solver, post processor and the components of these three groups of software. Formulation of input date. Mapping of electric and magnetic field).

Teaching methods

Lecture: multimedia presentation including illustrations and examples.

Bibliography

Basic

1. Silvester Peter P., Ferrari Ronald L., Finite elements for electrical engineers, Cambridge University Press; 3 edition, 1996.

2. Demenko A., Obwodowe modele układów z polem elektromagnetycznym, Wyd. Pol. Poznańskiej, 2004,(in Polish).

3. Meunier G., The finite element method for electromagnetic modeling, John Wiley & Sons, 2008.

4. Bastos João Pedro A., Sadowski Nelson, Magnetic materials and 3D finite element modeling, CRC Press, 2013.

5. Dolezel I., Karban P., Solin P., Integral methods in low-frequency electromagnetics, Wiley and Son, New Jersey, 2009.

Additional

1. Bianchi Nicola, Electrical machine analysis using finite elements, CRC Press (2005).

2. Salon Sheppard J., Finite elements analysis of electrical machines, SPRINGER (SIE), (2006).

3. Hameyer Kay, Belmans Ronnie, Numerical modelling and design of electrical machines and devices, WIT Press (1999).

4. Demenko A., Symulacja dynamicznych stanów pracy maszyn elektrycznych w ujęciu polowym, Wyd. Pol. Poznańskiej, 1997 (in Polish).

5. Demenko A., J, Sykulski J., Network equivalents of nodal and edge elements in electromagnetics, IEEE Trans. on Magnetics, Vol. 38, March, 2002.

6. Demenko A., Representation of windings in the 3d finite element description of electromagnetic converters, IEE Proceedings Science, Measurement and Technology, Vol. 149, September 2002.

7. Demenko A., Wojciechowski R., Sykulski J., 2-D versus 3-D electromagnetic field modeling in electromechanical energy converters, IEEE Trans. on Magnetics, Vol. 50, No.2, 2014.

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,0
Classes requiring direct contact with the teacher	4	0,2
Student's own work (literature studies, preparation for tutorials, project preparation, consultations with the teacher) [1]	21	0,8

[1] delete or add other activities as appropriate