30.5 - 3.6. 2016, 5 ECTS PhD course on
Permanent Magnet Technology: Materials, Machines, and Numerical Analysis

Location:	Aalto University, Otaniemi Campus, ELEC (I413a Iso Riihi)
Lecturers:	Dr Sami Ruoho, NORDMAG Oy, Finland Professor Miklós Kuczmann, Szechenyi Istvan University, Hungary
Person in charge:	Prof. Anouar Belahcen, Aalto University, Dept. of Elec. Eng. and Aut.
Language:	English
Enrolments:	By email to: anouar.belahcen@aalto.fi (please fill in the form below) The course is **free of charges** but you need to arrange for your **travel and accommodation yourself**.
Schedule:	The course will start on **Mon. 30.5 at 10.00** and ends on **Fri. 3.6 at 16.00**. During the week, the lectures and exercises are given every day from **9.00 to 17.00**. Detailed schedule is at the end of this leaflet.

Permanent magnet materials are used in **electrical machines** and other electro technical devices. There **fast development** in the last decades made them one of the most promising materials in the field of electromechanical **energy conversion**. However, Electrical engineers are not always aware of the **diversity** of the properties of these materials and especially the **mechanical, thermal, and electrical** ones. The usage of these materials in electromechanical devices combined with their **complexity** requires also a mean of analysis of these devices. The **finite element method** has proven its robustness and computation efficiency, but fast analytical **reluctance network-based method** are also widely used in the first design stage of the machines. This course is dedicated to permanent magnet materials used in the manufacturing of **electrical machines** and to the analysis methodologies related to these machines. The **manufacturing process** of permanent magnet materials and their chemical contents are explained and their effect on the properties of the material are investigated. Different **design methodologies** for electrical machines will be presented and their advantages and disadvantage will be explained. Special attention will be given to the finite element method with emphasis on material modelling.

Pre requisites: Basics in Electrical Engineering and electromagnetism

Assessment: Presence (30%), Homework (70%). Homework is due after the course.

Objectives: One objective of the course is to highlight the **diversity of permanent materials** and how it can be **efficiently and economically** used in the design of electrical machines. The other objective is to introduce the participants to the methodology needed in the design and analysis of electrical machines in general and these with permanent magnet in particular. Besides **analytical** and **semi-analytical** methodologies, the **Finite Element Method** will be extensively explained and used.

Content of the course

1. Introduction to magnetism and magnetic quantities
2. Review of different soft and hard magnetic materials.
3. Permanent magnet materials and their properties

4. The economy of permanent magnet materials
5. Design of electrical machines with permanent magnet materials
6. Losses and thermal analysis of electrical machines
7. The finite element method
8. Material modelling within the finite element method

The lecturers

Dr Sami Ruoho received the M.Sc. Degree in Applied Physics from Turku University, Turku, Finland in 1997, and D.Sc. degree (Technology) from Aalto University, Helsinki, Finland in 2011. Currently he is managing director of Nordmag Oy. His research interests are the properties of the Rare Earth magnets and electromagnetic and thermal modeling of electromagnetic devices.

Professor Miklós Kuczmann received the MSc and the PhD degree in electrical engineering from the Budapest University of Technology and Economics, Budapest, Hungary, in 2000 and in 2005. In 2011 he carried out his Habilitation in Informatics at the Széchenyi István University in Győr, where he is a full professor since 2012, the head of the Department of Automation, and the dean of the Faculty of Mechanical Engineering, Informatics and Electrical Engineering. In 2015 he received the Doctor of the Hungarian Academy of Sciences degree. His research fields are: hysteresis modeling, finite element analysis, control theory.

Tentative schedule of the course

	Monday 30.5	Tuesday 31.5	Wednesday 1.6	Thursday 2.6	Friday 3.6
9:15 - 10:00		The Finite Element Method Miklos (I413a Iso Riihi)	PM machines Sami (I413a Iso Riihi)	Eddy current field problems Miklos (I413a Iso Riihi)	Losses Sami (I413a Iso Riihi)
10:15 - 11:00	Unites, Equations, Basics Sami (I413a Iso Riihi)	FEM code in details: electrostatics Miklos (I413a Iso Riihi)	PM machines Sami (I413a Iso Riihi)	Eddy current field problems Miklos (I413a Iso Riihi)	Thermal modelling Sami (I413a Iso Riihi)
11:15:12:00	Magnetic materials Sami (I413a Iso Riihi)	Writing FEM code in SciLab Miklos (I413a Iso Riihi)	FEMM simulations Sami (I413a Iso Riihi)	Eddy current field problems Miklos (I413a Iso Riihi)	Starting the homework Sami (I413a Iso Riihi)
12:00 - 13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:15 - 14:00	Usin FEMM Sami (I413a Iso Riihi)	Writing FEM code in SciLab Miklos (I413a Iso Riihi)	FEMM simulations Sami (I413a Iso Riihi)	Eddy current field problems Miklos (I413a Iso Riihi)	Starting the homework Sami (I413a Iso Riihi)
14:15 - 15:00	Maxwell's equations and potential formulations I. Miklos (I413a Iso Riihi)	PM materials properties Sami (I413a Iso Riihi)	The Finite Element Method Miklos (I413a Iso Riihi)	Machine windings Sami (I413a Iso Riihi)	Hysteresis modeling Miklos (I413a Iso Riihi)
15:15 - 16:00	Maxwell's equations and potential formulations II Miklos (I413a Iso Riihi)	Magnetic circuits Sami (I413a Iso Riihi)	FEM code is details: static magnetic field Miklos (I413a Iso Riihi)	Machine design Sami (I413a Iso Riihi)	Nonlinearity in FEM Miklos (I413a Iso Riihi)
16:15 - 17:00	Problem solution by hand, Short on SciLab Miklos (I413a Iso Riihi)	FEMM simulations Sami (I413a Iso Riihi)	Exercise or Simulation Miklos (I413a Iso Riihi)	Performance computation Sami (I413a Iso Riihi)	Nonlinearity in FEM Miklos (I413a Iso Riihi)

Registration form (please copy and paste to the email body, then fill in the required information, email title: PhDcourse-registration)

First name*	Last name*	Organization*	Email*	Phone number