REM master basic syllabus

Title:
TET5100 Applied Electromagnetics in Power Engineering

Credit value:
7.5 ECTS

Mandatory/Optional:
Mandatory

Semester:
3

Lecturer/s:
Prof. Arne Nysveen, Prof. Robert Nilssen

University:
NTNU-Norwegian University of Science and Technology

Department:
Department of Electric Power Engineering

Rationale:
Modeling and dimensioning of electric power installations and apparatus requires physical understanding and knowledge of mathematical modeling. In order to calculate stresses and parameters that characterize power systems or electrical apparatus, a sound knowledge of fundamental electromagnetic field theory is essential. A continuation of electromagnetic theory with emphasis on adaption and use in electric power engineering is needed for applying static approaches when analyzing steady-state phenomena in electrical apparatus and systems. This course caters to this rationale by introducing numerical calculation tools based on Finite Element Method for analysis of electric and magnetic fields.

Objectives:
Having completed the course, the candidate should have knowledge on static and dynamic fields from:

- Maxwell's equations and how to make relevant simplifications for analysis in electrical power engineering
- Use of modern numerical software tools to solve practical problems in electric power engineering
- Recognizing phenomena related to practical problem solving and selection of the right model and calculation tools
- Calculating parameters to be used in modeling and analysis of electric power apparatus and systems

Skills: *(according to the list of skills provided)*

Subject skills	REM Master Skills						
	L2.1	L2.2	L2.3	L2.4	L2.5	L2.6	L2.7
L3.1. To perform analytical and numerical analysis of a variety of known basic topics related to electric power apparatus and systems.	x	x	x				
L3.2. To use numerical calculation tools based on finite element method for analysis of electric and magnetic fields.	x	x	x				
L3.3. To apply relevant software to determine parameters and to simulate practical problems where field analysis is important.	x	x	x				
L3.4 To work independently and in groups					x	x	x

Teaching and learning methods:
The course methodology includes various techniques, such as:
1. Lecture format with oral and audiovisual presentations.
2. Exercises and individual assignments.
3. Possible seminars of invited speakers.
4. Semester project work with report and presentation.

The course starts with traditional lectures and exercises. Then, an introduction on use of numerical calculation tools based on Finite Element Method (FEM) for analysis of electric and magnetic fields is given. This tool is the applied to some selected practical topics where the lecture deals with theoretical and technical aspects, which are important in practical analysis and design of the given topic. In the following exercises, numerical software is used extensively. Finally, the students works in groups on an examination-project eligible in the final grade. The teaching is largely based on numerical exercises where lecturers and tutors provide support to student groups.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Lectures	48 hours	48 hours
Classroom practice	18 hours	10 hours
Project	18 hours	26 hours

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Assessment:

The procedures for assessment of the course is as follows:

1. By conducting an individual project work during the semester (30% of the final grade)

2. By conducting a final written exam (70% of the final grade).

Note: The Assessment rules might vary from year to year. The students will be notified at the beginning of the semester of such changes.

Assessment Matrix:

Subject skills	**Assessment method**				
	Exam	**Presentation**	**Project**	**…**	**…**
L3.1.	70%		30%		
L3.2.	70%		30%		
L3.3.	70%		30%		
L3.4.			100%		

Programme:

Topic 1	Introduction, PDE formulation, The Finite Element Method
Topic 2	Introduction to COMSOL Multiphysics
Topic 3	Electric conductive field modelling: boundary conditions, equations, simplified calculations
Topic 4	COMSOL examples
Topic 5	Electric capacitive field modelling
Topic 6	Electric capacitive field modelling - COMSOL examples
Topic 7	Design issues: insulation coordination
Topic 8	Modelling of dielectric problems - COMSOL examples
Topic 9	Electric system parameters: analytical modelling - capacitance in power transmission lines
Topic 10	Matlab computations
Topic 11	Electric system parameters: analytical modelling - capacitance in power cables
Topic 12	Three-phase cables with shielding - COMSOL examples
Topic 13	Magnetostatics: permanent magnets, energy calculation, inductance
Topic 14	Maxwell tensor forces calculation in COMSOL
Topic 15	Design issues in magnetostatics: magnetic field amplifications, saturation, losses, magnetic and electric loading
Topic 16	COMSOL examples
Topic 17	Dynamic magnetic fields: stationary AC modelling, skin effect, proximity effect, eddy currents, induced loss and heat motion
Topic 18	COMSOL examples
Topic 19	Modelling of ODE
Topic 20	COMSOL examples
Topic 21	Inductive parameters: cables and transmission lines, analytical and numerical solution
Topic 22	COMSOL examples
Topic 23	Multiphysics
Topic 24	Revision

Resources:

Classroom, Blackboard, laptop, projector, audio, computer room.
All the material necessary to follow the course is facilitated by the course instructors during the course, through 'eLS' (e-Learning System) platform (known as 'Blackboard').

Bibliography:

Compendium: "Power Line Parameters", Arne Nysveen, NTNU

Compendium: "Electromagnetics in Power Engineering", Robert Nilssen, NTNU

Notaros, "Electromagnetics". Pearson Education, 2010.

Young & Freedman, "University Physics. Pearson Education". Ed. 12 or Ed. 13. Chap 21-31.

+ handouts distributed by the lecturer during the semester

Further comments:

Deviations: Since the teaching and learning processes are adaptive, there may arise minor deviations in the course schedule and content.