NanoMagnetism September

Subject area: Physics

University:	TU/e
Level:	MA1, MA2, MA all years
Teaching mode:	hybrid: some students participate online, other students attend real-life
Instructor(s):	Reinoud Lavrijsen

Short description

The course Nanomagnetism introduces you to a field within physics where revolutionary discoveries have led to conceptual new magnetic phenomena and industrial applications. This course gives a general introduction to the physical phenomena and applications related to magnetism and ferromagnetic (nano) materials. The concepts and theory describing magnetism are treated in detail.

Full description

"The first part of the course treats the rich history of magnetism and introduces the first critical concepts. A general overview of the application field of magnetism will be given and we will shortly delve into the current societal impact the understanding of magnetism brings. This is then quickly followed with a recap of the basic physics you should be fairly familiar with; dipole fields, Maxwell equations, permeability, susceptibility, hysteresis, coercivity and units used in magnetism, etc. This is slowly expanded with more involved concepts such as demagnetizing fields and the thermodynamics of magnetism. As a first step to understanding ferromagnetism we will treat the magnetism of a single electron. A recap of the classical (angular momentum!) and quantum mechanical (spin!) description of the magnetic moment of an electron will be given.
We will then switch to magnetism of localized electrons on the atom and treat paramagnetism. This is followed by the treatment of ferromagnetic ordering and exchange in real materials. Associated physical phenomena will be discussed such as magnetic anisotropy, magneto elasticity, magneto-optic and magneto-transport effects. A few of these phenomena will be measured directly by you in the FNA labs, where thin film magnetic films will be used as case studies. After this firm basic treatment of magnetism we will turn to the second part of the course where we will treat advanced concepts in solid state ferromagnetism such as, different magnetic orderings, magnetism at different length scales and magnetization dynamics, these concepts will be where applicable, exemplified with experimental demonstrations.
In the third and last part of the course, we will switch to applications, materials, spin-electronics (spintronics), spin-(orbi)-tronics, magnetic resonance, and treat a few exotic applications of magnetism."

Learning outcomes

"The application of conceptual knowledge (i) analytical (written) calculations and (ii) when performing and interpreting experimental tasks in the field of:
1. Classical and quantum mechanical description of magnetism (emphasis on dia- and paramagnetism).
2. Magnetic ordered systems and the role of different length scales (emphasis on ferro- and antiferromagnetism).
3. Micro- and nano-magnetic phenomena, and the role of different length scales (focus on anisotropy, domains, and hysteresis).
4. Experimental techniques in the field of nano- magnetism (emphasis on thin-film technology and characterization)
5. Magneto-electrical phenomena in relation to nanomagnetism (emphasis on spintronics and industrial applications)."

General information

Contact hours per week:	2
Total workload:	140 (in student hours for the whole course)
ECTS credits:	5
Language:	English
Course start date:	05 September 2022
Course end date:	12 November 2022
Add. info about start date:	This course is given preferably in the Quartile system of the TU/e (i.e. 4x per year). However it can be started at any time, only the exams can be taken during the official exam moments as registered by the TU/e (oral or written).
Weekly teaching day/time:	Q&A session with lecturer 2 hours every 2 weeks. Self-Study and literature study and/or practicals (3x2 hours at the TU/e labs).
Time zone:	CET (Denmark, Germany, France, Netherlands, Switzerland, Czech Republic)
Further information:	This is a pilot, make sure you have the pre-requisites for the course. A basic knowledge in condensed matter physics and a basics of quantum mechanics is required.
Prerequisites:	Quantum Mechanics, Condensed Matter, Condensed Matter at the nanoscale
Activities and methods:	Self-study, Practices, Exercises, Tutorial sessions, Pre recorded lectures, quizzes, and Q&A sessions. (when possible to come to TUe Lab-Work)
Presence on campus:	

Final examination

Form:	If limited amount of students then oral exam (this will be annouced at the start of every student).
Date:	
Location/format:	Depending on type of exam (oral/written) this will be decided.
Re-sit possibility:	yes
Transcript available:	on request
Add. info/requirements:	

Registration

To register for this course, follow the registration requirements of your **home university** as specified here: www.euroteq.eu/courses-registration.

Administration

Number of places:	7 per quartile
Minimum participants:	5 (including local students)
Internal course code:	3MN150
Contact:	Reinoud Lavrijsen (lecturer; r.lavrijsen@tue.nl) for Euroteq context contact the local representative.

This course is part of the EuroTeQ Engineering University joint course catalogue 2022/2023. This is a collaborative activity of the partner universities DTU, L'X, TU/e, TalTech, CTU, TUM as well as Technion. Students from these universities can participate in the offered courses. It is the responsibility of the student to check if you fulfil the requirements to participate in a specific course. Students are also advised to check with their home institution how to get recognition of the ECTS credits gained in courses of the EuroTeQ course catalogue. For further information about EuroTeQ Engineering University, visit www.euroteq.eu or get in touch with the above-mentioned point of contact.