GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Magnetism: from fundamentals to spintronics, PG_00036987		
Field of study	Nanotechnology		
Date of commencement of studies	October 2022	Academic year of realisation of subject	2022/2023
Education level	second-cycle studies	Subject group	Optional subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	English
Semester of study	1	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Instytut Nanotechnologii i Inżynierii Materiałowej -> Faculty of Applied Physics and Mathematics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Leszek Piotrowski	
	Teachers	dr hab. inż. Leszek Piotrowski	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	0.0	0.0	0.0	30

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	30	2.0	18.0	50

Subject objectives

The student learns the basics of magnetism, the laws and equations that determine the parametersdescribing the magnetic field. He learns about the influence of magnetic fields on macro-, micro- andnanoscale materials. The student learns the methods of magnetic properties determination and possibilitiesof using magnetic materials in practice. The student also learns about spin, theoretical foundations ofspintronics and practical ways of manipulation of the spin of electrons. Studies the practical applications ofspintronics, e.g. spin valves and tunnelling junctions.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K7_W02	Student knows how to describe the behaviour of spin in quantum mechanics, understand the concept of spinor and spin matrix. He also knows the problems associated with spin decoherence and manipulation of spin orientation.	[SW1] Assessment of factual knowledge
K7_W03	The student understands the principles of operation of spintronic devices. Student can explain such issues as e.g. the phenomenon of giant magnetoresistance (GMR) or the principle of operation of magnetic tunnel junctions (MTJ).	[SW1] Assessment of factual knowledge
K7_U07	Student can propose the application of magnetic nanoparticles in other areas of science such as e.g. medicine.	[SU2] Assessment of ability to analyse information
K7_U01	Student can carry out the analysis of the available literature (on-line databases) and discuss selected issue (from the field of magnetism) described there.	[SU2] Assessment of ability to analyse information

Subject contents	1. Basic magnetic quantities2. Magnetism of atoms and molecules, atoms in external magnetic fields3. Solid state magnetism, types of magnetic materials (dia-, para-, and ferromagnetism)4. Ferromagnetism and domain structures5. Magnetism of small particles, single domain particles (StonerWohlfarth model), thin films6. Experimental techniques of magnetic properties and magnetisation state determination. Domain structurevisualisation and analysis.7. Spin transport spin polarization, spin filters, Rashba and Dresselhaus interactions8. Two currents model, spin injection and coherence length, spin dependent Hall effects.9. Magnetoresistance anisotropic magnetoresistance (AMR), gigantic magnetoresistance (GMR),tunnelling magnetoresistance (TMR) and colossal magnetoresistance (CMR).10. Spin valves11. Magnetic data storage (HDDs)- storage media, read/write heads, construction issues.12. Spin transfer torque (STT) current induced magnetisation switching, nanooscillators13. Magnetic random access memories (MRAM), STT-MRAMs14. Spin transistors, Data and Das transistor, spin valve transistor, spin Hall effect transistor15. Magnetic logic devices
Prerequisites and co-requisites	Basic knowledge of quantum mechanics (Schrödinger's equation) and solid state physics (charge transportin the solid state).

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
written test	50.0%	100.0%

Recommended reading

Basic literature	1. Handbook of Spin Transport and Magnetism; Ed. E.Y. Tsymbal, I.Žutić; CRC Press 20122. J. Stohr, H.C. Siegmann; Magnetism From Fundamentals toNanoscale Dynamics; Springer, 2006.
Supplementary literature	1. S. Bandyopadhyay, M. Cahay; Introductioon to spintronics, CRCPress, 2008
eResources addresses	Adresy na platformie eNauczanie: Magnetism ffrom fundamentals to spintronics 22/23 - Moodle ID: 26309 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=26309

Example issues/ example questions/ tasks being completed	1. On the basis of the Biot-Savart law calculate the induction of the magnetic field in the centre ofconducting loop2. Discuss the construction of spin valve3. What criteria must meet the material used for the data storage4. Discuss the phenomena causing spin coherence in solid body.5. Explain the process of spin transfer torque
Work placement	Not applicable