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 2024			Academic year of realisation of subject		2024/2025	
Education level	second-cycle studies			Subject group		Obligatory subject group in the field of study 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	see table below

Course outcome	Subject outcome	Method of verification
[K7_U07] can apply the obtained specialist knowledge to the problems within exact sciences, natural or technical sciences.	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] can learn individually, obtain knowledge and integrate information from literature, databases and other properly selected sources (in Polish and English). Has the ability of critical analysis and selection of information.	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
[K7_W03] has general knowledge on current development directions and discoveries in physics, chemistry, technology and applications of nanostructures.	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_W02] has enhanced, theoretically supported, detailed knowledge of selected branches of nanotechnology and, according to the needs, within the scope of related fields of science and technology.	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

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:
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	