



Subject card

Subject name and code	Magnetism: from fundamentals to spintronics, PG_00036987						
Field of study	Nanotechnology						
Date of commencement of studies	October 2023	Academic year of realisation of subject			2023/2024		
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	<p>The student learns the basics of magnetism, the laws and equations that determine the parameters describing the magnetic field. He learns about the influence of magnetic fields on macro-, micro- and nanoscale materials. The student learns the methods of magnetic properties determination and possibilities of using magnetic materials in practice. The student also learns about spin, theoretical foundations of spintronics and practical ways of manipulation of the spin of electrons. Studies the practical applications of spintronics, e.g. spin valves and tunnelling junctions.</p>						
Learning outcomes	Course outcome	Subject outcome			Method of verification		
	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		
	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_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_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		

Subject contents	<p>1. Basic magnetic quantities 2. Magnetism of atoms and molecules, atoms in external magnetic fields 3. Solid state magnetism, types of magnetic materials (dia-, para-, and ferromagnetism) 4. Ferromagnetism and domain structures 5. Magnetism of small particles, single domain particles (StonerWohlfarth model), thin films 6. Experimental techniques of magnetic properties and magnetisation state determination. Domain structure visualisation and analysis. 7. Spin transport spin polarization, spin filters, Rashba and Dresselhaus interactions 8. 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 valves 11. Magnetic data storage (HDDs)- storage media, read/write heads, construction issues. 12. Spin transfer torque (STT) current induced magnetisation switching, nanooscillators 13. Magnetic random access memories (MRAM), STT-MRAMs 14. Spin transistors, Data and Das transistor, spin valve transistor, spin Hall effect transistor 15. Magnetic logic devices</p>								
Prerequisites and co-requisites	<p>Basic knowledge of quantum mechanics (Schrödinger's equation) and solid state physics (charge transport in the solid state).</p>								
Assessment methods and criteria	<table border="1"> <thead> <tr> <th>Subject passing criteria</th> <th>Passing threshold</th> <th>Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td>written test</td> <td>50.0%</td> <td>100.0%</td> </tr> </tbody> </table>	Subject passing criteria	Passing threshold	Percentage of the final grade	written test	50.0%	100.0%		
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written test	50.0%	100.0%							
Recommended reading	<p>Basic literature</p>	<p>1. Handbook of Spin Transport and Magnetism; Ed. E.Y. Tsymbal, I. Žutić; CRC Press 2012 2. J. Stohr, H.C. Siegmann; Magnetism From Fundamentals to Nanoscale Dynamics; Springer, 2006.</p>							
	<p>Supplementary literature</p>	<p>1. S. Bandyopadhyay, M. Cahay; Introduction to spintronics, CRC Press, 2008</p>							
	<p>eResources addresses</p>	<p>Adresy na platformie eNauczenie: Magnetism - from fundamentals to spintronics - Moodle ID: 34353 https://enauczenie.pg.edu.pl/moodle/course/view.php?id=34353</p>							
Example issues/ example questions/ tasks being completed	<p>1. On the basis of the Biot-Savart law calculate the induction of the magnetic field in the centre of conducting loop 2. Discuss the construction of spin valve 3. What criteria must meet the material used for the data storage 4. Discuss the phenomena causing spin coherence in solid body 5. Explain the process of spin transfer torque</p>								
Work placement	<p>Not applicable</p>								