A COURSE SYLLABUS – DOCTORAL SCHOOL

REGARDING THE QUALIFICATION CYCLE FROM 2019 TO 2023

REGARDING THE QUALIFICATION CYCLE FROM 2020 TO 2024

GENERAL INFORMATION ABOUT COURSE	
Course title	Condensed matter magnetism - selected issues
Name of the unit running the course	Doctoral School at University of Rzeszów
Type of course *(obligatory, optional)*	Obligatory, facultative (specialist) course
Year and semester of studies	II and III, winter semester
Discipline	Physics
Language of Course	English
Name of Course coordinator	Dr hab. Andrzej Wal, prof. UR
Name of Course lecturer	Dr hab. Andrzej Wal, prof. UR
Prerequisites	Knowledge of the general and quantum physics course as well as mathematical analysis

BRIEF DESCRIPTION OF COURSE
(100-200 words)

During the course, theories describing the magnetism of the condensed matter, both classical and quantum, will be presented. They will concern magnetism associated with localized magnetic moments. All types of interactions leading to various magnetic properties of substances will be discussed: paramagnetism, diamagnetism, ferromagnetism and antiferromagnetism. Complex magnetic systems will also be presented: superparamagnetics and spin glasses. The theoretical knowledge will be verified through appropriately selected exercises. Various Hamiltonians describing the energy of magnetic interactions as well as computational programs and numerical algorithms will be used to solve them. The problem of using different units in magnetism and the relationship between them, with particular emphasis on the SI system, will also be discussed.

COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES

Learning outcome	The description of the learning outcome defined for the course	Relation to the degree programme outcomes (symbol)	Learning Format (Lectures, classes,...)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,...)
Knowledge (no.)	**(Knows and understands)**			
(K1)	Knowledge of theoretical foundations of magnetic phenomena in condensed matter	P85-WG/1	lectures, seminars	test
(K2)	Knowledge of the main directions of development of contemporary research on condensed matter magnetism	P85-WG/2	lectures, seminars	Activity during the lectures and seminars
(K3)	Knowledge of the methodology of scientific research in the field of magnetic phenomena	P8S-WG/3	lectures, seminars	Activity during the lectures and seminars
Skills (no.)	**(Able to)**			
(S1)	Solving problems related to magnetic interactions	P85-UW/1	seminars	Activity during the seminars,

				test
(S2)	Ability to critically evaluate scientific achievements in the field of magnetic interactions	P8S-UW/2	seminars	Activity during the seminars, test
(S3)	Discussion on the application of magnetic properties of the condensed matter	P8S-UK/1 P85-UK/3 P8S-UK/4 P8S_UK/5	seminars, lectures	Activity during the lectures and seminars
(S4)	Ability to disseminate research findings, including in popular forms	P8S-UK/2	seminars, lectures	Activity during the lectures and seminars
(S5)	Analysing experimental data using the theory of magnetism.	P85-UK/4	seminars	Activity during the seminars, test
Social competence (no.)	**(Ready to)**			
(SC1)	The importance of knowledge for the growth of innovation in the industry that uses magnetic phenomena	P85-KK/3	lectures, seminars	Activity during the lectures and seminars
(SC2)	Critical evaluation of scientific achievements in relation to the classical theory of magnetism	P8S-KK/1	lectures, seminars	Activity during the lectures and seminars
(SC3)	Public interest activities	P8S-KO/2	lectures, seminars	Activity during the lectures and seminars

LEARNING FORMAT – NUMBER OF HOURS

Semester (no.)	Lectures	Seminars	Lab classes	Internships	others	ECTS
III and V	5	10	-	-	-	

METHODS OF INSTRUCTION

A LECTURE SUPPORTED BY A MULTIMEDIA PRESENTATION
CALCULATING EXERCISES WITH THE USE OF COMPUTER PROGRAMS

COURSE CONTENT

1. Lectures:
   1. Atomic magnetic moments, magnetic elements.
   2. Systems of localized magnetic moments:
   a) diamagnetism, paramagnetism,
   b) interactions between magnetic moments, magnetically ordered systems.
   3. Examples of complex magnetic systems.
   4. The use of spin in electronics - magnetoelectronics.

2. Seminars:
   1. Paramagnetic properties of substances.
   2. Hamiltonians of magnetic interactions.
   3. Magnetic dipole interaction.

4. Systems of units used in magnetism.
5. Magnetic excitations - spin waves in ferromagnetic and antiferromagnetic.

COURSE ASSESSMENT CRITERIA

lecture: activity during the lecture
seminar: pass the subject on the basis of partial grades from calculation tasks and the final test; the number of points obtained is decisive for the evaluation (> 50% of the maximum number of points): dst 51-59%, dst plus 60-69%, db 70-79%, db plus 80-89%, bdb 90-100%.

TOTAL PhD STUDENT WORKLOAD REQUIRED TO ACHIEVE THE INTENDED LEARNING OUTCOMES – NUMBER OF HOURS AND ECTS CREDITS

Activity	Number of hours
Scheduled course contact hours	15
Other contact hours involving the teacher (consultation hours, examinations)	2
Non-contact hours – student`s own work (preparation for classes or examinations, project, etc.)	30
Total number of hours	47
Total number of ECTS credits	0

INSTRUCTIONAL MATERIALS

Compulsory literature:	1) A. Szewczyk, A. Wiśniewski, P. Puźniak, H. Szymczak, Magnetism and supercocductivity (in polish), PWN, Warsaw, 2012 2) N. W. Ashcroft, N.D. Mermin, Solid state physics (in polish), PWN, Warsaw 986 3) D. D. Stancil, A. Prabhakar, Spin Waves, Theory and Application, Springer 2009.
Complementary literature:	1) S. V. Kusminsky, Quantum Magnetism, Spin Waves, and Optical Cavities, Springer, Cham 2019 2) K. Yosida, Theory of magnetism, Springer, Berlin 1998. 3) R. M. White, Quantum theory of magnetism: magnetic properties of materials, Springer, Berlin 2007 4) P. Mohn, Magnetism in the solid state: an introduction, Springer, Berlin 2003