DOCTORAL SCHOOL OF WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

SUPERVISOR/TEAM/ DECLARING/CONDUCTING COURSE: Lucjan Jacak
DEPARTMENT: Faculty of Basic Technical Problems W11
SCIENTIFIC DISCIPLINE: Physical Sciences

COURSE CARD

Course name in Polish: Informatyka i kryptografia kwantowa
Course name in English: Quantum Information Processing and Quantum Cryptography
Course language English*
University-wide general course type*:
The course is intended for all PhD students: YES / NO
~~**1) BASIC COURSE**~~
2) SPECIALIST COURSE
~~**3) SEMINAR**~~
~~**4) HUMANISTIC COURSE**~~
~~**5) LANGUAGE**~~

Subject code: NFQ100240W
* delete as applicable

	Lecture	Foreign language course	Seminar	Mixed forms
Number of hours of organized classes in university (ZZU)	30			
Grading	Exam	Exam	Oral presentation	Exam, inspection, evaluation classes
Number of ECTS points	**0**			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Quantum mechanics (elementary)
2. Geometrical and wave optics, electrodynamics (elementary)

COURSE OBJECTIVES

C1 Familiarizing of PhD students with main ideas of quantum information processing
C2 Familiarizing of PhD students with novel technical solutions (towards quantum computer and quantum cryptography)

PROGRAMME CONTENT

	Form of classes – lecture	Number of hours
Lec 1	Fundamental properties of classical and quantum information	2
Lec 2	Von Neumann measurement, Żurek super-selection	2
Lec 3	Theorems no-cloning, no-deleting, no-broadcasting	2
Lec 4	Tensor product, quantum entanglement, Bell inequalities	2
Lec 5	Density matrix for mixed state	2

Lec 6	Schmidt representation, number of Schmidt	2
Lec 7	Qubit geometry – Bloch sphere	2
Lec 8	Unitary evolution on the Bloch sphere	2
Lec 9	Phase and amplitude decoherence	2
Lec 10	Control of qubit, Rabi oscillations	2
Lec 11	Single-qubit quantum logic gates	2
Lec 12	Double-qubit logic gates, universal double-qubit gate	2
Lcc 13	Algorithms and quantum protocols, teleportation and seperdense coding	2
Lec 14	QKD protocols BB84 and E91, introduction to quantum cryptography	2
Lec 15	Decoherence of orbital and spin degree of freedom in quantum dots – obstacles on the way for universal quantum computer	2
	Total hours	30

Form of classes - class		**Number of hours**
	Total hours	

Form of classes - laboratory		**Number of hours**
	Total hours	

Form of classes - project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
	Total hours	

Form of classes - seminar		**Number of hours**
Sem 1		
Sem 2		
Sem 3		
Sem 4		
	Total hours	

TEACHING TOOLS USED
N1. Standard lectures N2. Additional consultations for students N3 Specially addressed written materials – text-book N4 Computer laboratory N5 Demonstration of quantum cryptography, NLTK Clavis II, Quelle

ACHIEVED SUBJECT LEARNING OUTCOMES		
Type of learning outcome	Code of learning outcome	Assessment of learning outcome
Knowledge	P8U_K	Discussion during the exam
…		
Skills	P8S_KKK	Discusiion during the exam
…		
Social competence	P8S_KO	Discusion during lessons
…		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information*, Cambridge UP, Cambridge, 2000.
[2] D. Bouwmeester, A. Ekert, and A. Zeilinger, *The Physics of Quantum Information*, Springer, Berlin, 2000.
[3] W. Jacak, J. Krasnyj, R. Gonczarek, L. Jacak, *Decoherence of orbital and spin degrees of freedom in quantum dots*, Oficyna Wydawnicza PWR, Wrocław 2010 (in Polish)
[4] J. Preskill, *Quantum information and computation*, Lecture Notes for Phys., http://www.theory.caltech.edu/~preskill/ph229, 1998.
[5] W. Jacak, L. Jacak, and W. Donderowicz, *Introduction to Quantum Information and Communication*, Printpap, Łodź, 2011.
[6] J. Jacak, L. Jacak *INTRODUCTION TO QUANTUM INFORMATION PROCESSING (SUPPLEMENTARY MATERIALS)* e-script IP WUT 2010

SECONDARY LITERATURE:

[1] current literature in journals in the field of QKD and QIP
[3] W. K. Wootters and W. H. Żurek, *A single quantum cannot be cloned,* Nature **299**, p. 802, 1982.
[4] J. Preskill, *Topological quantum computation*., Lecture Notes for Phys. 219, California Inst. Tech., 2005

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