

## WROCLAW UNIVERSITY OF TECHNOLOGY – PHD STUDIES

<b>FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY</b>
<b>SUBJECT CARD</b>
Course name in Polish: <b>Informatyka i kryptografia kwantowa</b>
Course name in English:
Course language
University wide general course type: 1) basic course (mathematics, physics, chemistry, other) 2) humanity course 3) managerial skills 4) English language 5) other modern language Departmental course developing professional skills: 1) specialized course 2) <del>interdisciplinary course</del> 3) <del>seminar (interdisciplinary, specialized, departmental)</del>
Type of course (obligatory, optional): obligatory
<b>Educational effects according to ZW 26/2017:</b> Categories of acquired qualifications characteristics: - Knowledge: P8U_W, P8S_WG - Skills: P8U_U, P8S_UW, P8S_UO - Social competencies: P8U_K, P8S_KK, P8S_KR (advanced level of knowledge acquired in the field of quantum information and quantum cryptography problems; preparation to scientifically solve complex problems in those fields and initial preparation for the scientific work in fields of physics related to the course topic).
Subject code: <b>INP9013</b>

\*delete as applicable

	Lecture	Laboratory	Seminar
Number of hours of organized classes in University (ZZU)	30		
Number of hours of total student workload (CNPS)	90		
Form of crediting	Exam **	Exam / crediting with grade*	Oral presentation
Number of ECTS points	3		
including number of ECTS points for practical (P) classes			
including number of ECTS points for direct teacher-student contact (BK) classes	2		

\*delete as applicable \*\*In case of didactic courses also inspections and evaluation classes

<b>PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES</b>
1. Basic knowledge of quantum mechanics

<b>SUBJECT OBJECTIVES</b>	
C1	acquire knowledge in the field of modern quantum mechanics

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C2	acquire knowledge in new field of quantum information
C3	acquire knowledge in the field of quantum cryptography

**SUBJECT EDUCATIONAL EFFECTS**

Relating to knowledge:

PEK\_W01 has knowledge in the field of quantum mechanics

PEK\_W02 has knowledge in the field of quantum information

PEK\_W03 has knowledge in the field of quantum cryptography

Relating to skills:

PEK\_U01 able to choose the proper theoretical tools for new concept of information processing

PEK\_U02 able to review current status of the field of quantum information

Relating to social competences:

PEK\_K01 understands the importance of research and teaching

**PROGRAM CONTENTS**

<b>Form of classes - lecture</b>		Number of hours
Lec1	Review of quantum mechanics ideas	4
Lec2	Pure and mixed states	2
Lec3	Density matrix and quantum entanglement	2
Lec4	Schmidt theorem	2
Lec5	Bell states and von Neumann projection	2
Lec6	Bloch sphere for qubit	2
Lec7	Rabi oscillations for light and spin	2
Lec8	Quantum teleportation and dense coding	2
Lec9	Decoherence and dephasing in nanostructures	2
Lec10	DiVincenzo criteria for QIP	2
Lec11	Three orders limit for local quantum mechanics	2
Lec12	Quantum Key Distribution	2
Lec13	Current status of QIP	2
Lec14	Demo of QKD on Clavis and Quelle	2
Total hours		<b>30</b>

**TEACHING TOOLS USED**

N1	Lectures and demo in lab. NLTK
N2	Materials prepared by the author available via internet
N3	Individual study and preparation for the exam

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EVALUATION OF ACHIEVED SUBJECT EDUCATIONAL EFFECTS		
<b>Evaluation:</b> F – forming (partial) C – concluding	Educational effect number	Way of evaluating achievement of educational effects
C	PEK_W01, PEK_W02, PEK_W03, PEK_U01, PEK_U02, PEK_K01	Examination

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

- [1] M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information*, Cambridge UP, Cambridge, 2000.
- [2] M. Jacak, I. Jóźwiak, J. Jacak, J. Gruber, W. Jacak, Wprowadzenie do kryptografii kwantowej, PWR OW Wrocław 2013
- [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, Łódź, 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 QIP and QKD
- [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.
- [5] A. Kitaev, *Quantum computations: algorithms and error correction*, Russ. Math. Surv. **52**, p. 1191, 1997.
- [6] D. Bouwmeester, A. Ekert, and A. Zeilinger, *The Physics of Quantum Information*, Springer, Berlin, 2000.

**SUBJECT SUPERVISOR**

(NAME AND SURNAME, E-MAIL ADDRESS)

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