







Projekt jest współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

Course title			ECTS code				
Signatures of non-classical		13.2.0419					
Name of unit administrating s	study						
Department of Mathema	tics, Physics and Informa	atics					
Studies							
Faculty	Field of study/ phd		Туре		Form		
Quantum Information	studies/doctoral school/postgraduate studies	st	stationary				
Technology	MSc studies						
Teaching staff							
Dr. Ana Belén Sainz (lectures); Dr. John Selby (recitation cl	lasses)					
Forms of classes, the realization	on and number of hours	EC	FS credits				
A. Forms of classes, in acco regulations	rdance with the UG Rector's		al: 5 ECTS				
Lecture, auditory e	exercises		of lecture - of exercise				
B. The realization of activit					ECTS point;		
	g room of the University of Gd	lańsk 60 ł	of student	's own wo	rk - 2 ECTS	points.	
blended learning							
C. Number of hours Lecture: 30, exerci	sos: 30						
,	565. 50						
The second secon							
	program						
The academic cycle According to study	v program						
According to study		age of instru	iction				
According to study	Langu	age of instru	iction				
According to study Type of course mandatory	Langu	nglish		ent and ba	sic criteria fo	or evaluation or	
According to study Type of course mandatory Teaching methods	Langu Er Form	nglish	of assessme		sic criteria fo	or evaluation or	
According to study Type of course mandatory Teaching methods problem lecture	Langu En Form ex	nglish and method camination re	of assessme equirements	8			
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese	Langu Er Form ex A. Fin	nglish and method camination re	of assessme equirements	8	sic criteria fo the UG study		
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion	entation Langu Form ex A. Fin Ez Ci	nglish and method camination re al evaluation xam redit with gr	of assessme equirements 1, in accorda ade	8			
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis	I Langu Entation Form ex A. Fin Ez Cr B. Ass	nglish and method camination re al evaluation xam redit with gr sessment met	of assessme equirements , in accorda ade hods	s ance with	the UG study	y regulations	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	entation Langu Entation A. Fin Ex Cr B. Ass Langu ex ex Cr B. Ass	nglish and method camination re al evaluation xam redit with gr essment met ecture: test (o	of assessme equirements , in accorda ade hods oral or writ	s ance with ten) with (the UG study	y regulations	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework)	nglish and method camination re al evaluation xam redit with gr essment met ecture: test (exercises: dete	of assessme equirements , in accorda ade hods oral or writtermination of	s ance with ten) with (of the fina	the UG study closed question al grade based	y regulations	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework)	nglish and method camination re al evaluation xam redit with gr ressment met ecture: test (o xercises: dete ades receive	of assessme equirements a, in accorda ade hods oral or writ ermination of d during the	s ance with ten) with o of the fina e semester	the UG study closed questional grade based r	y regulations ons. 1 on partial	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Langu Form ex A. Fin Ex C1 B. Ass Lac ex C1 B. Ass Lac Ex C1 C1 C1 C1 C1 C1 C1 C1 C1 C1	nglish and method camination re- cal evaluation xam redit with gr- redit with gr- gr- gr- gr- gr- gr- gr- gr- gr- gr-	of assessme equirements a, in accorda ade hods oral or writ ermination o d during the ia for evalu e and Exerce	s ance with ten) with o of the fina e semester ation or ex	the UG study closed question al grade based r xam requirement	y regulations ons. 1 on partial	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Langu Form ex A. Fin Ez Ci B. Ass La ex A. Fin Ez Ci B. Ass La Ez Ci B. Ass Ci B. Ass Ez Ci B. Ass Ez Ci B. Ass Ez Ez Ci B. Ass Ez Ez Ci B. Ass Ez Ez Ci B. Ass Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ci Ez Ez Ez Ez Ez Ez Ez Ez Ez Ez	nglish and method camination ro al evaluation xam redit with gr redit with gr ressment met ecture: test (or varcises: deto rades receive e basic criter cams (Lecture the question	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerc s.	s ance with ten) with o of the fina <u>e semester</u> ation or en sises): corr	the UG study closed questic al grade based r xam requirema rect answer to	y regulations ons. d on partial ents o at least 60%	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ntation Ex work) Ex Ex Ex Ex Ex Ex Ex Ex Ex Ex	nglish and method camination re- al evaluation xam redit with gr- cessment met ecture: test (of xercises: deter cades received to basic criter cams (Lecture the question valuation criter	of assessme equirements a, in accorda ade hods oral or writt ermination of d during the ia for evalu e and Exerc s. teria and ex	s ance with ten) with (of the fina e semester ation or e: cises): corr cams' tent	the UG study closed questic al grade based r xam requiremo rect answer to cative schedul	y regulations ons. d on partial ents o at least 60% e will be	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ntation Ex ework) Ex Contaction Ex Langu Form ex A. Fin Ex Cr B. Ass La Cr B. Ass La Cr B. Ass La Cr B. Ass La Cr B. Ass La Cr B. Ass La Cr B. Ass La Cr Cr Cr Cr Cr Cr Cr Cr Cr Cr	nglish and method camination ro al evaluation xam redit with gra redit with gra ressment met ecture: test (of xercises: deter cades received e basic criter cams (Lecture the question valuation criter communicated	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerce s. teria and ex	s ance with ten) with o of the fina e semester ation or en sises): corr cams' tent ents durin	the UG study closed questic al grade based r xam requireme rect answer to rative schedul ng the first cla	y regulations ons. d on partial ents o at least 60% e will be asses.	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ntation Ex nework) Ex Contact of the second secon	nglish and method camination re- al evaluation redit with gra- redit with gra- ressment met ecture: test (or varcises: deter rades received basic criter cames (Lecture the question valuation criter ommunicated the students w	of assessme equirements a, in accorda ade hods oral or writt ermination of d during the ia for evalu e and Exerc s. teria and ex to the stud ill be assess	s ance with ten) with o of the fina e semester ation or e: :ises): corr cams' tent ents durir ed primar	the UG study closed questic al grade based r xam requiremore rect answer to rative schedul ng the first cla rily on their c	y regulations ons. 1 on partial ents o at least 60% e will be asses. conceptual	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Langue Torm Ex Langue Form ex A. Fin Ex C B. Ass La C C C C C C C C C C C C C C C C C C	nglish and method camination re- al evaluation xam redit with gr redit w	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerce s. teria and ex to the stud ill be assess , and not or	s ance with ten) with o of the fina e semester ation or ex- cises): corr cams' tent ents durin ents durin ent primar	the UG study closed questic al grade based r xam requirement rect answer to tative schedul ag the first cla rily on their c ge of intricat	y regulations ons. 1 on partial ents o at least 60% e will be asses. conceptual e mathematical	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Langue Langue Form ex A. Fin Ex C1 B. Ass Le Ex of Ex of D. Me	nglish and method camination re- al evaluation xam redit with gr- cessment met ecture: test (or xercises: dete- ades receives e basic criter cades receives basic criter cams (Lecture the question valuation criter municated the students w aderstanding rmulae. thod of verifi	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerce s. teria and exerce s. to the stud ill be assess , and not or ication of the	s ance with ten) with o of the fina e semester ation or ex- cises): corr cams' tent ents durin ents durin ent primar	the UG study closed questic al grade based r xam requiremore rect answer to rative schedul ng the first cla rily on their c	y regulations ons. 1 on partial ents o at least 60% e will be asses. conceptual e mathematical	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Languer Languer Form ex Form ex A. Fin Ex C B. Ass La Ex of Ex of Ex of D. Me	nglish and method camination re- al evaluation xam redit with gr redit w	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerce s. teria and exerce s. to the stud ill be assess , and not or ication of the	s ance with ten) with o of the fina e semester ation or ex- cises): corr cams' tent ents durin ents durin ent primar	the UG study closed questic al grade based r xam requirement rect answer to tative schedul ag the first cla rily on their c ge of intricat	y regulations ons. 1 on partial ents o at least 60% e will be asses. conceptual e mathematical	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion case analysis problem solving	ework) Languer Languer Form ex Form ex A. Fin Ex C B. Ass La Ex of Ex of Ex of D. Me	and method camination re- cal evaluation cal evaluation cal evaluation cal evaluation cameration redit with gr- redit with gr- redit with gr- redit with gr- cassment met exercises: deter cades receiver e basic criter cades receiver e basic criter cades receiver the question valuation criter cameration criter camerati	of assessme equirements a, in accorda ade hods oral or write ermination of d during the ia for evalu e and Exerce s. teria and ex to the stud ill be assess , and not or ication of the t	s ance with ten) with o of the fina e semester ation or ex- cises): corr cams' tent cams' tent ents durir ed primar n knowled ne establis	the UG study closed questic al grade based r xam requireme rect answer to rative schedul ng the first cla rily on their c ge of intricat	y regulations ons. d on partial ents o at least 60% e will be asses. conceptual e mathematical	
According to study Type of course mandatory Teaching methods problem lecture lecture with multimedia prese discussion	ework) Languer Languer Form ex Form ex A. Fin Ex C B. Ass La Ex of Ex of Ex of D. Me	nglish and method camination re- cal evaluation xam redit with gr- redit with gr- gr- gr- gr- gr- gr- gr- gr- gr- gr-	of assessme equirements a, in accorda ade hods oral or writt ermination of d during the ia for evalu e and Exerce is. teria and ex to the stud ill be assess , and not or ication of th	s ance with ten) with o of the fina e semester ation or er sises): corr cams' tent ents durir ed primar n knowled ne establis activity	the UG study closed questic al grade based r xam requiremer rect answer to cative schedul ng the first cla rily on their c ge of intricat hed effects of tests	ons. I on partial ents o at least 60% e will be asses. conceptual e mathematical	

Projekt "Wdrożenie nowoczesnych modeli zarządzania jakością w Uniwersytecie Gdańskim (MODEL_UG)" Nr umowy: UDA-POKL.04.01.01-00-056/11-00





UNIA EUROPEJSKA EUROPEJSKI FUNDUSZ SPOŁECZNY



Projekt jest współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

					-		
			U01	-	+	+	
			U02	-	+	+	
			U03	+	+	-	
			U04	+	-	-	
Required courses and intro	ductory requirements						
A. Formal requireme	· -						
None							
B. Prerequisites							
Basic knowledge of ma	thematics at high school le	evel is	s required.				
Aims of education							
Get acquain	ted with the concept of	of no	nclassical phe	nomen	a as a fu	ndamental	property of
Nature.							
Learn about	t the traditional pheno	omer	na of Entangle	ment a	nd Bell 1	onclassical	itv. the
	ormulated notions of S		0				• •
	fied phenomena of Sp						
-	not only the foundation						-
	•		· · · · · · · · · · · · · · · · · · ·		noncias	sical plieno	mena, but
	le as resources for inf	orm	ation processi	ng.			
Course contents					II ha Jamata		
The course contents includes j • Entanglement theory	y: bipartite and multipartite						
	ions (e.g., teleportation).	cintan	giement, separabin	ity criteri	a, chiangie	incht uistmatio	ii anu
 Bell nonclassicality: Bell's theorem; Fine's theorem; Bell inequalities; Entanglement vs. Bell nonclassicality; bipartite and 						bipartite and	
	narios; activation of Bell non	classic	cality; the geometry	y of corre	lations (No	-Signalling and	Classical
	um set); applications.	4 . J			4	1:4	
	en-Specker contextuality; sta ens' contextuality; applicatio		bendent vs. state m	aepenaen	it contextua	inty; inequalitie	es from
	nd multipartite steering; stee		nequalities; applica	ations.			
	lity: brief introduction to net				s.		
Bibliography of literature							
A. Literature require							
	cki, P. Horodecki, M. Hor	rodec	ki, and K. Horod	lecki. "Q	uantum e	ntanglement"	, Rev. Mod.
	 Phys. 81, 865 (2009). N. Brunner, D. Cavalcanti, S. Pironio, V. Scarani, and S. Wehner. "Bell nonlocality", Rev. Mod. Phys. 					M. J. Dham	
• N. Brunne 86, 419 (20		10, V.	Scarani, and S.	wenner.	"Bell non	locality", Rev	. Mod. Phys.
	anti and P. Skrzypczyk. "(Ouan	tum steering: a r	eview wi	th focus o	n semidefinite	
	ning", Rep. Prog. Phys. 80						
• A. Cabello, S. Severini, and A, Winter. "(Non-)Contextuality of Physical Theories as an Axiom",				xiom",			
	0.2163 (2010).						
• A. Acín, T. Fritz, A. Leverrier, and A. B. Sainz. "A Combinatorial Approach to Nonlocality and					ty and		
 Contextuality", Comm. Math. Phys. 334, 533 (2015). R. W. Spekkens. "Contextuality for preparations, transformations, and unsharp measurements", Phys. 							
Rev. A 71, 052108 (2005).							
	ard, D. Rosset, N. Gisin, aı	nd S.	Pironio. "Bilocal	versus i	10n-biloca	l correlations	in
	ent swapping experiments						
	mbeeck, et al. "Quantum y	violat	ions in the Instru	ımental	scenario a	nd their relati	ions to the Bell
scenario", Quantum 3, 186 (2019).							
Material provided by the lecturer. B Extracurricular readings							
B. Extracurricular readings							
The learning outcomes	Knowladge						
The learning outcomes (for the field of study and	Knowledge W01:						
specialization)	Student knows and unders	stande	the basic concept	s and ter	minology	used in the aug	ntum
K_W01	foundations approach to q				uniology t	.see in the qua	
	W02						
Desister Midness	ie nowoczesnych modeli zar						

Projekt "Wdrożenie nowoczesnych modeli zarządzania jakością w Uniwersytecie Gdańskim (MODEL_UG)" Nr umowy: UDA-POKL.04.01.01-00-056/11-00





UNIA EUROPEJSKA EUROPEJSKI FUNDUSZ SPOŁECZNY



Projekt jest współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

Student has extensive knowledge of general physics and advanced knowledge in the area of quantum information theory; knows the history of	Student knows the proofs of the main facts such as Asymptotic Equipartition Property, Shanonn's theorem etc., as well as knows basic methods such as compression algorithms (K_W02, KW_04) W03 has a clear understanding of models of classicality and how Nature does not respect them. (K_W01)
the development of quantum	Skills
information theory and its	U01
importance for the progress of science, world cognition and social development	Student is able to compute the classical bounds for Bell and steering inequalities, and respective quantum violations. (K_U02) U02
K_W02	Student is able to compute and mathematically manipulate correlations and assemblages. (K_U02) U03
Student has in-depth knowledge of advanced mathematics, mathematical	Student is able to analyze and interpret nonclassical phenomena for the purpose of quantum information (K_U01, K_U02) U04
and computer methods necessary to solve physical problems of medium	Student is able to draw conclusions on the foundations of quantum physics from the studied nonclassical phenomena. (K_U01)
complexity and advanced in	Social competence
the area of quantum	
information and its	
technological aspects	
K_W04 Student knows the advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics	
K_U02	
Student can apply	
mathematical knowledge to	
formulating, analyzing and	
solving problems related to	
information theory	
Contact	
ann.sainz@ud.edu.pl	