Işık University
Faculty of Arts and Sciences
Department of Physics

PHYS 484 - Quantum Computation and Quantum Information

COURSE SYLLABUS

Course Name	Code	Semester	Theory (hour/week)	Application (hour/week)	Laboratory (hour/week)	Local Credits	ECTS
Quantum Computation and Quantum Information	PHYS 484	Spring	**3**	0	**0**	**3**	5

Prerequisities	None

Course Language	English
Course Type	Required
Course Level	First Cycle
Course Coordinator	-
Course Lecturer(s)	-
Course Assistants	-
Course Objectives	Photonics is a one semester course that introduces the fundamental concepts of photonics. By the end of the course, students should • demonstrate a knowledge of the fundamental concepts of quantum computation and quantum information. • recognize the requirements for quantum computers. • give examples of basic quantum gates and quantum algorithms.
Course Learning Outcomes	On successful completion of this course students will be able to 1. define quantum bits (qubits), quantum registers and quantum gates. 2. demonstrate a knowledge of how quantum gates can be utilized to realize quantum algorithms by combining gates into circuits. 3. develop an insight into quantum teleportation protocol. 4. give examples of pioneering efforts to physically realize quantum computing circuits. 5. show an increased competence to effectively communicate an accomplished project in both written and verbal form.
Course Content	Special topics in physics.

WEEKLY SUBJECTS AND RELATED PREPARATION STUDIES

Week	Subject
1	Introduction to fundamental concepts: quantum-bits, representation of the qubit, single qubit gates, multiple qubit gates, quantum circuits, quantum circuit examples
2	Introduction to fundamental concepts: quantum parallelism, quantum algorithms
3	Quantum theory: linear operators and matrices, Pauli matrices, inner products, eigenvectors and eigenvalues, adjoints and Hermitian operators, tensor products, operator functions, commutator and anticommutator
4	Quantum theory: postulates of quantum mechanics, density operator, Schmidt decomposition, EPR and Bell inequality
5	Quantum theory: postulates of quantum mechanics, density operator, Schmidt decomposition, EPR and Bell inequality
6	Quantum circuits: single qubit operations, controlled operations, measurement, universal quantum gates,
7	Quantum circuits: simulation of quantum systems
8	Review
9	Quantum Fourier transform and its applications
10	Quantum search algorithms
11	Quantum computers: requirements for quantum computers, physical realization
12	Quantum information: quantum noise and quantum operations
13	Quantum information: distance measures for quantum information
14	Quantum information: quantum error-correction
15	Quantum information: quantum error-correction

TEXTBOOKS

Required Textbook(s)	M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information* (Cambridge, 2000).
Recommended Readings	• Stig Stenholm, Kalle-Antti Suominen *Quantum Approach to Informatics*, Wiley, 2005. • David J. Griffiths, *Introduction to Quantum Mechanics, 2nd ed.* Prentice-Hall, 2005. • Feynman, R.P., Leighton, R.B., Sands, M. *The Feynman Lectures on Physics, Volume III*, Addison Wesley, 1966.

EVALUATION SYSTEM

Semester Requirements	**Number**	**Percentage of Grade**
Attendance/Participation	-	-
Laboratory	-	-
Application	-	-
Field Work	-	-
Special Course Internship (Work Placement)	-	-
Quizzes/Studio Critics	4	20
Homework Assignments	8	30
Presentation/Jury	1	15
Project	1	35
Seminar/Workshop	-	-
Midterms/Oral Exams	-	-
Final/Oral Exam	-	-
Total	14	100

Percentage of Semester Work	13	85
Percentage of Final Work	1	15
Total	14	100

COURSE CATEGORY

ISCED GENERAL FIELD CODE	GENERAL FIELDS	ISCED MAIN AREA CODE	MAIN EDUCATIONAL AREAS	%
1	Eğitim	14	Öğretmen Yetiştirme ve Eğitim Bilimleri	0
2	Beşeri Bilimler ve Sanat	21	Sanat	0
2	Beşeri Bilimler ve Sanat	22	Beşeri Bilimler	0
3	Sosyal Bilimler, İşletme ve Hukuk	31	Sosyal ve Davranış Bilimleri	0
3	Sosyal Bilimler, İşletme ve Hukuk	32	Gazetecilik ve Enformasyon	0
3	Sosyal Bilimler, İşletme ve Hukuk	38	Hukuk	0
4	Bilim	42	Yaşam Bilimleri	0
4	**Bilim**	**44**	**Doğa Bilimleri**	**80**
4	**Bilim**	**46**	**Matematik ve İstatistik**	**20**
4	Bilim	48	Bilgisayar	0
5	Mühendislik, Üretim ve İnşaat	52	Mühendislik	0
5	Mühendislik, Üretim ve İnşaat	54	Üretim ve İşleme	0
5	Mühendislik, Üretim ve İnşaat	58	Mimarlık ve Yapı	0
6	Tarım	62	Tarım, Ormancılık, Hayvancılık ve Su Ürünleri	0
6	Tarım	64	Veterinerlik	0
7	Sağlık ve Refah	72	Sağlık	0
7	Sağlık ve Refah	76	Sosyal Hizmetler	0
8	Hizmet	81	Kişisel Hizmetler	0
8	Hizmet	84	Ulaştırma Hizmetleri	0
8	Hizmet	85	Çevre Koruma	0
8	Hizmet	86	Güvenlik Hizmetleri	0

THE RELATIONSHIP BETWEEN COURSE LEARNING OUTCOMES AND PROGRAM OUTCOMES

Number	Program Outcomes	Level of Contribution*				
		1	2	3	4	5
1	To have a comprehension of the core areas of physics, including classical and quantum mechanics, electromagnetism, statistical and thermal physics.					
2	To have a comprehension of basic mathematics, including differential and integral calculus, linear algebra, differential equations and complex analysis.					
3	To have a comprehension of computer programming and chemistry.					X
4	To have a comprehension of the importance and practice of good ethical standards.					
5	To have a recognition of contemporary issues in science and its applications.					X
6	To have an ability to construct theoretical models, solve problems, design and conduct experiments, as well as to analyze and interpret data.					X
7	To have an ability to demonstrate their understanding of at least one advanced topic in theoretical or experimental physics.					X
8	To have an ability to function on multi-disciplinary teams					
9	To have an ability to effectively communicate information in both written and verbal form					X
10	To have a recognition of the need for and an ability to engage in life-long learning.				X	
11	To have an ability to use modern physics techniques, skills, and computing tools necessary for physics practice (use laboratory and workshop equipment to generate data, prepare technical drawings, prepare technical reports, give technical presentations, take notes effectively, write computer programs, use mathematics and/or computational tools and packages to make models) .					X

*1 Lowest, 2 Low, 3 Average, 4 High, 5 Highest

Contribution of Course Learning Outcomes to Program Outcomes	The class contributes to the student development in terms of giving an insight into a special application of quantum theory: Quantum computation. Students will have a knowledge of quantum mechanical algorithms such as Shor's factorization algorithm and Grover's search algorithm. Students should develop problem solving abilities and enhance critical thinking and improve their written communication skills.

ECTS / WORKLOAD TABLE

Activities	**Number**	**Duration (Hour)**	**Workload (Hour)**
Course Hours (Including Exam Week: 16 x Total Hours)	15	3	45
Laboratory	-	-	-
Application	-	-	-
Special Course Internship (Work Placement)	-	-	-
Field Work	-	-	-
Study Hours Out of Class	15	1.6	24
Presentations / Seminar	1	12	12
Project	1	20	20
Homework Assignments	10	2	20
Quizzes	4	1	4
Midterms / Oral Exams	-	-	-
Final / Oral Exam	-	-	-
		Total Workload	**125**
		Total Workload/25	**5**