ECTS COURSE INFORMATION FORM

Faculty	**Faculty of Engineering**	
Program	**B.Sc. in Computer Engineering**	**Elective**
	B.Sc. in Electrical-Electronics Engineering	**Elective**
	B.Sc. in Industrial Engineering	**Elective**
	B.Sc. in Civil Engineering	**Elective**
	B.Sc. in Mechanical Engineering	**Elective**

Course Code	COMP 465			
Course Title in English	Fundamentals of Quantum Computing			
Course Title in Turkish	Kuantum Hesaplama Temelleri			
Language of Instruction	English			
Type of Course	Flipped Classroom			
Level of Course	Undergraduate			
Course Category (by % of Content)	Basic Science	Basic Engineering	Engineering Design	General Education
	50	30	20	0
Semester Offered	Spring			
Contact Hours per Week	Lecture: 3 hours	Recitation: -	Lab:-	Other:-
Estimated Student Workload	146 hours per semester			
Number of Credits	6 ECTS			
Grading Mode	Standard Letter Grade			
Pre-requisites	Linear Algebra and Basic Probability			
Expected Prior Knowledge	Exposure to some form of programming			
Co-requisites	None			
Registration Restrictions	Only Undergraduate Students			
Overall Educational Objective	To learn the fundamentals of quantum information and computing and explore various application areas.			
Course Description	This course explores the fundamentals of Quantum Information Science and Computation. The following important topics are covered: superposition, entanglement, quantum teleportation and the theory of measurement. The course will review and compare classical computation against quantum computation with several examples. We also intend to give assignments to use IBM's real quantum computers available on the cloud to get students a hands-on experience on this new emerging field. Towards the end of the course, we shall provide details about few quantum algorithms and future trends such as Quantum Machine Learning (QML). In addition, some of the philosophical questions and the impact of Quantum computing to various fields of research will be discussed.			
Course Description in Turkish	Bu ders Kuantum Bilgi Bilimi ve Hesaplamanın temellerini inceleyecektir. Önemli olan şu konulara yer verilecektir: süperpozisyon, dolaşıklık, kuantum ışınlanma ve ölçüm teorisi. Ders, kuantum hesaplamaya karşı klasik hesaplamayı gözden geçirecek ve birkaç örnekle karşılaştıracaktır. Ayrıca, öğrencilere bu yeni ortaya çıkan alanda uygulamalı bir deneyim kazandırmak için IBM'in bulut üzerinde bulunan gerçek kuantum bilgisayarlarını kullanma ödevleri verilecektir. Dersin sonuna doğru, birkaç kuantum algoritması ve Kuantum Makine Öğrenimi (QML) gibi gelecekteki eğilimler hakkında ayrıntılar paylaşacağız. Ayrıca, felsefik soruların bazıları ve kuantum hesaplamanın çeşitli araştırma alanlarına etkisi tartışılacaktır.			
Course Learning Outcomes and Competences	Upon successful completion of the course, the learner is expected to: 1. describe quantum mechanics and fundamental principles of quantum computing; 2. describe and construct quantum circuits using online tools; 3. apply quantum circuits/algorithms to solve some of the hard problems; 4. analyze and apply basic principles of quantum communications; 5. describe and implement most notable quantum algorithms;			

	6. acquire and apply the knowledge of quantum technology for future trends.

Relationship of the Course with the Student Outcomes	Level	Learning Outcome(s)	Assessed by
Student Outcomes	N=None S=Supportive H=High		Exams, Project, HW, Experiment, Presentation, etc.
(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	H	1,2,4,5	Exams, Flipped Classroom Practice, Quiz
(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	S	3	
(3) an ability to communicate effectively with a range of audiences			
(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts			
(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives			
(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions			
(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	H	6	Exam, Flipped Classroom Practice, Quiz

Prepared by and Date	Assoc. Prof. Şuayb Ş. Arslan /16 July 2020	
Semester	Fall 2020-2021	
Name of Instructors	Dr. Şuayb Ş. Arslan	
Course Contents	Week	Topic
	1.	Introduction to Quantum Computing: Spin, photon, polarization
	2.	Postulates of Quantum Mechanics & linear algebra overview
	3.	Simple quantum computation model, qubit, quantum states (Ket notation), superposition, normalisation
	4.	Measurement of Quantum states
	5.	Classical Gates/Circuits and Reversible circuits
	6.	Quantum logic gates: CNOT and Hadamard gates
	7.	Universality, Unitary transformations, Phase change, rotation and Pauli gates
	8.	Quantum Entanglement and Bell's inequality. No Cloning Theorem and Implications
	9.	Quantum Circuits: The Bell Circuit
	10.	Quantum Communication: Superdense coding and Quantum Teleportation
	11.	Simple Quantum Error Correction
	12.	Quantum Algorithms I: Deutch's Algorithm, Deutsch-Jozsa Algorithm
	13.	Quantum Algorithms II: Simon's Algorithm, Grover's search Algorithm, Shor's Algorithm
	14.	The Impact of Quantum computing and advanced use cases such as QML
	15.	Final Examination/Project/Presentation Period
	16.	Final Examination/Project/Presentation Period
Required/Recommended Readings	Depending on the level of students, there are two references I frequently resort to (both are available online) • Chris Bernhardt, Quantum Computing for Everyone, MIT Press, 1st Edition (2019) [More suitable for undergraduates] • Kaye, Phillip, Raymond Laflamme, and Michele Mosca. An Introduction to Quantum	

	Computing. Oxford University Press, 2007.
Teaching Methods	Lectures/contact hours using "flipped classroom" as an active learning technique
Homework and Projects	There are 5 homeworks formulated much like small projects.
Laboratory Work	None
Computer Use	Required
Other Activities	-
Assessment Methods	Types of assessment — Number — Ratio (%) Midterm Exam — 1 — 23 Final Exam — 1 — 38 Flipped Classroom Practice — 14 — 14(1% each) HW — 5 — 25(5% each) Total — 100
Course Administration	**Instructor's office**: 5th Floor **Office hours:** Tue 16:00-17:00. **E-mail address:** arslans@mef.edu.tr, **Rules for attendance:** Classroom practice contributes to 14% of the final grade. **Missing a midterm**: Provided that proper documents of excuse are presented, each missed midterm by the student will be given the grade of the final exam. No make-up will be given. **Missing a final**: Faculty regulations. **A reminder of proper classroom behavior, code of student conduct**: YÖK Regulations **Academic dishonesty and plagiarism**: YÖK Regulations

ECTS Student Workload Estimation

Activity	No/Weeks	Hours			Calculation	Explanation
	No/Weeks per Semester (A)	Preparing for the Activity (B)	Spent in the Activity Itself (C)	Completing the Activity Requirements (D)		
Lecture/Flipped Classroom	14	1	3	1	70	A*(B+C+D)
Homework	5	6	2		40	A*(B+C+D)
Midterm(s)	1	12	1,5		13,5	A*(B+C+D)
Final Examination	1	20	2,5		22,5	A*(B+C+D)
Total Workload					146	
Total Workload/25					5,84	
ECTS					**6**	