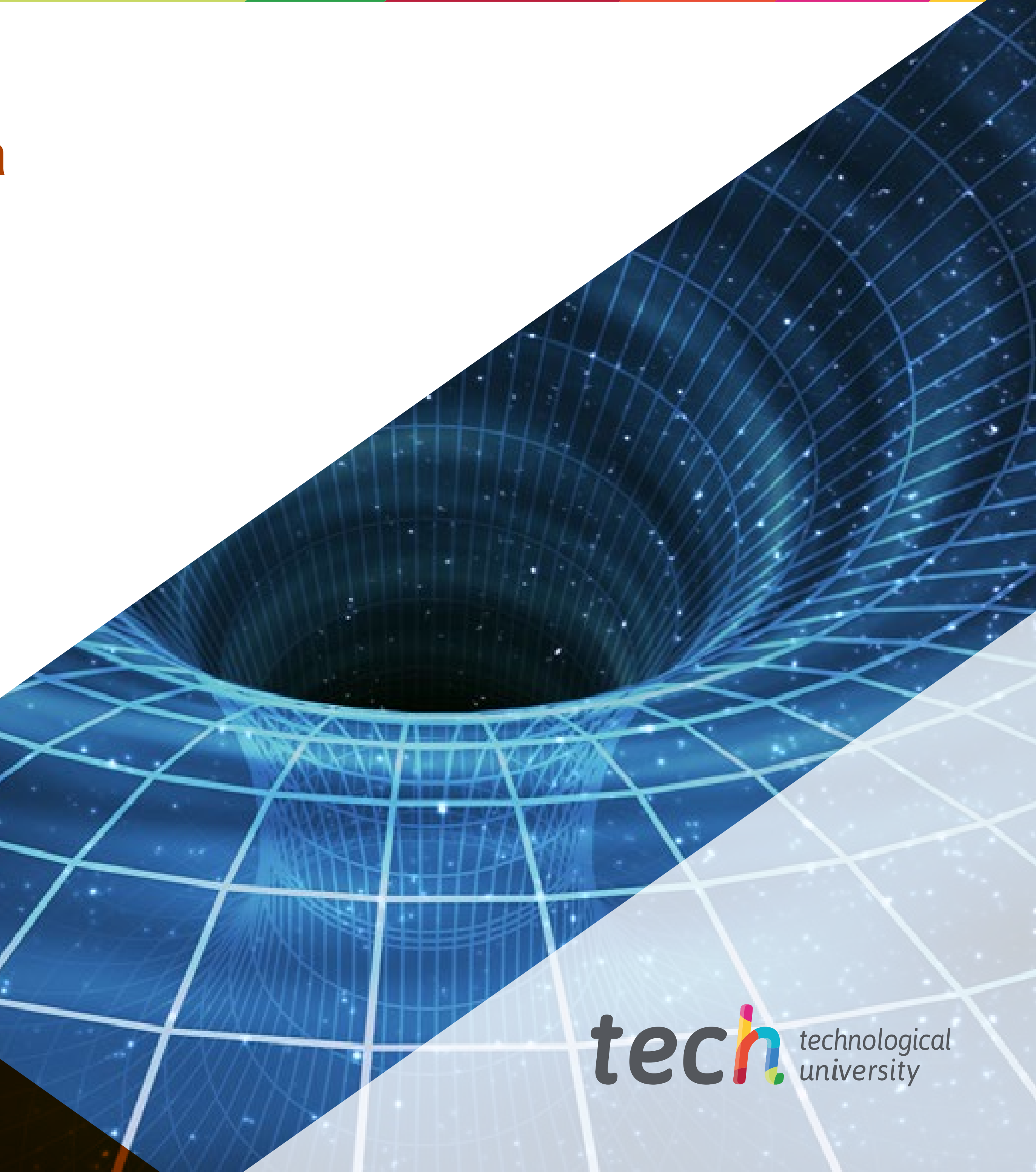
Postgraduate Diploma
Quantum Sciences



tech technological university

Postgraduate Diploma
Quantum Sciences

- Modality: **online**
- Duration: **6 months**
- Certificate: **TECH Technological University**
- Schedule: **at your own pace**
- Exams: **online**

Website: **www.techtitute.com/us/engineering/postgraduate-diploma/postgraduate-diploma-quantum-sciences**

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01

Introduction

Quantum computing furnishes a groundbreaking technological future that will enable superior calculations, more effective solutions to complex problems and more secure information transmission. A field that is still being explored, but which offers innumerable advantages for sectors such as construction, medicine, information technology and transportation. A promising scenario that poses a challenge for both Physicists and Engineers. For this reason, TECH has created a program that will lead graduates to delve into the theory of quantum fields and the current development of quantum information. All this, in a 100% online teaching format that can be accessed comfortably at any time from a computer with Internet connection.

A university program designed for people who wish to balance their professional responsibilities with a quality education”

The development of Quantum Sciences will mean a breakthrough for human beings in practically all productive sectors. Thus, work is already underway to create quantum computers that allow transmitting information at higher speeds and in a secure manner. However, the potential of quantum computing goes beyond this, and its applications can be reflected in transportation management, in the creation of batteries with higher energy density, or in the creation of materials with a better strength-to-weight ratio.

Engineering professionals are faced here with a challenge and a range of possibilities for innovation and progress of possibilities for innovation and the advancement of today's Industry 4.0: a favorable scenario for progress in a booming field, where companies are increasingly demanding highly qualified personnel. For this reason, TECH offers this Postgraduate Diploma in Quantum Sciences, where in just 6 months the students will obtain the necessary learning to progress in their careers.

A 100% online program, where students can delve into the main essential mathematical methods, to later delve more easily into quantum field theory and quantum computation. In addition, the multimedia teaching resources will provide greater dynamism to the content and facilitate the acquisition of knowledge.

Thus, the engineering professionals can obtain a university qualification that is at the cutting edge, and which can be accessed easily, whenever and wherever they wish. The students only require a computer, tablet or cell phone with Internet connection to be able to access, at any time, the syllabus hosted on the virtual platform. Also, the Relearning method, will allow you to progress through this Postgraduate Diploma in a much more agile way and reduce the long hours of study.

This **Postgraduate Diploma in Quantum Sciences** contains the most complete and up-to-date program on the market. The most important features include:

- Practical case studies are presented by experts in Physics
- The graphic, schematic, and practical contents with which they are created, provide scientific and practical information on the disciplines that are essential for professional practice
- Practical exercises where the self-assessment process can be carried out to improve learning
- Its special emphasis on innovative methodologies
- Theoretical lessons, questions to the expert, debate forums on controversial topics, and individual reflection assignments
- Content that is accessible from any fixed or portable device with an Internet connection

This is an excellent opportunity to advance in your professional career thanks to this Postgraduate Diploma in Quantum Sciences. Enroll now"

Enroll now in a university program that you can easily access from your computer or tablet with Internet connection"

Video summaries, detailed videos or essential readings will allow you to go deeper into the Klein-Gordon and Dirac theories.

Access the most relevant information on quantum theory of light-matter interaction at any time.

The program includes, in its teaching staff, professionals from the sector who bring to this program the experience of their work, in addition to recognized specialists from prestigious reference societies and universities.

Its multimedia content, developed with the latest educational technology, will allow professionals to learn in professionals a situated and contextual learning, i.e., a simulated environment that will provide immersive education programmed to prepare in real situations.

The design of this program focuses on Problem-Based Learning, by means of which professionals must try to solve the different professional practice situations that arise during the academic course. For this purpose, students will be assisted by an innovative interactive video system developed by renowned experts.

02
Objectives

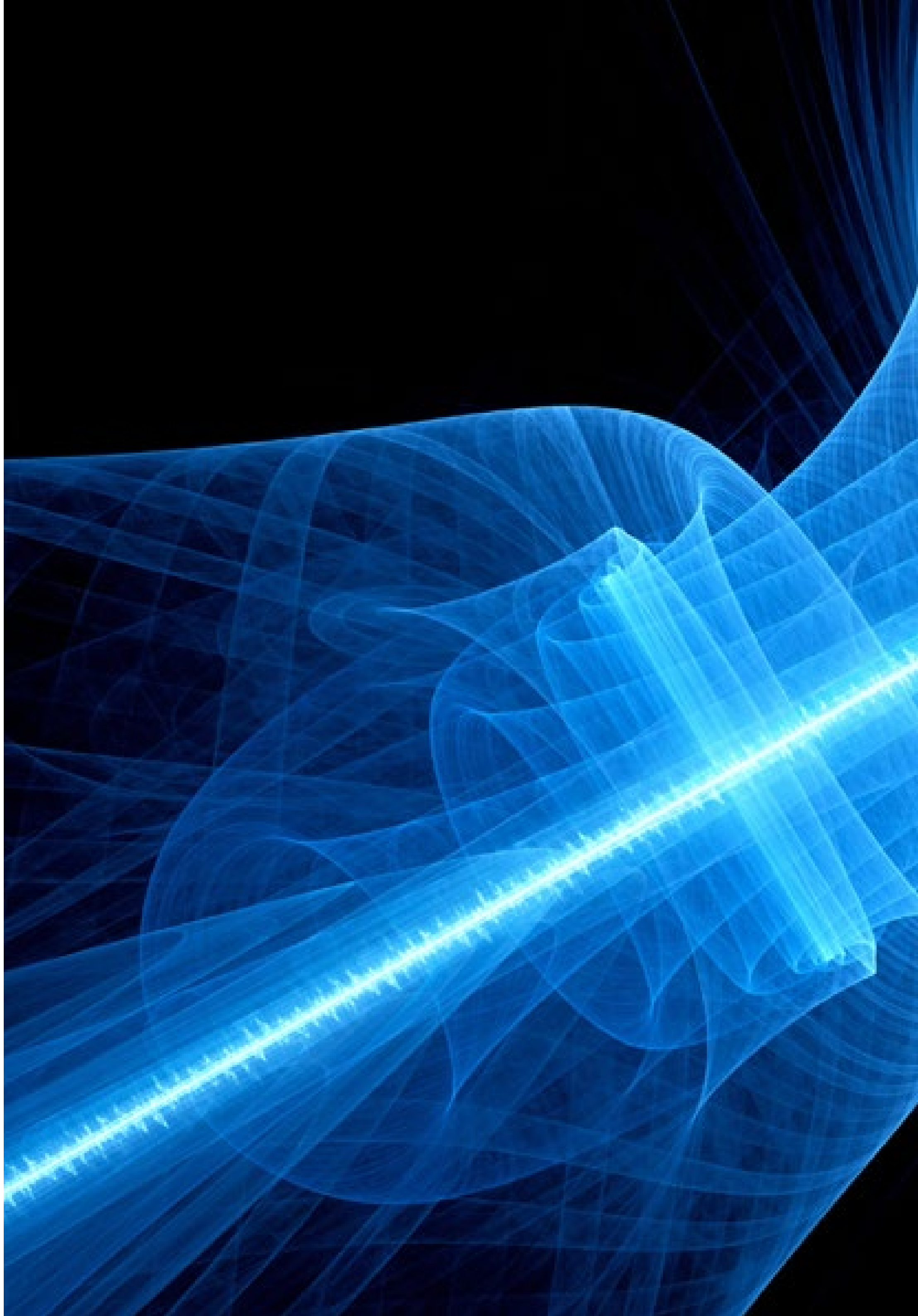
Students taking this academic option will obtain the most comprehensive information in Quantum Sciences. For this purpose, they will have a syllabus prepared by experts in the field, which will allow them to solve the main problems of quantization or to promote the most common implementations of quantum information. All this, in a flexible way, since you will be able to distribute the teaching load according to your needs.

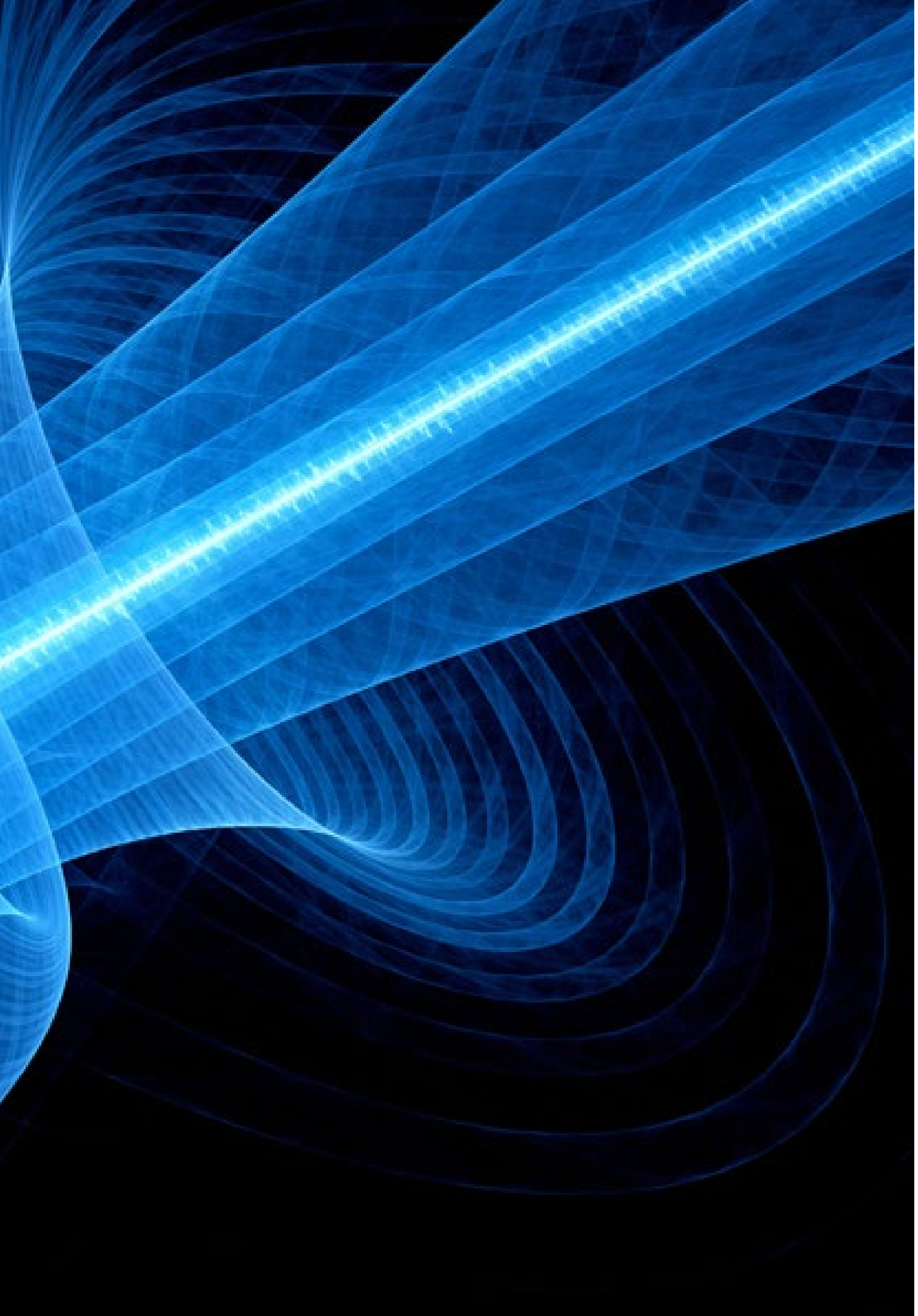
A program that will allow you to see the potential of quantum simulation in the field of engineering"

General Objectives

- Acquire basic concepts of astrophysics
- Obtain basic notions about Feynman diagrams, how they are drawn and their utilities
- Learn and apply approximate methods to study quantum systems
- Master the Klein-Gordon, Dirac and electromagnetic fields

This 100% online program will give you the knowledge you need to open professional doors in companies developing quantum computing"





Specific Objectives

Module 1. Mathematical Methods

- Obtain basic notions of metric and Hilbert spaces
- Acquire knowledge about the characteristics of linear operators and the Surm-Liouville theory
- Know the theory of groups, group representation, tensor calculus and their applications to physics

Module 2. Quantum Field Theory

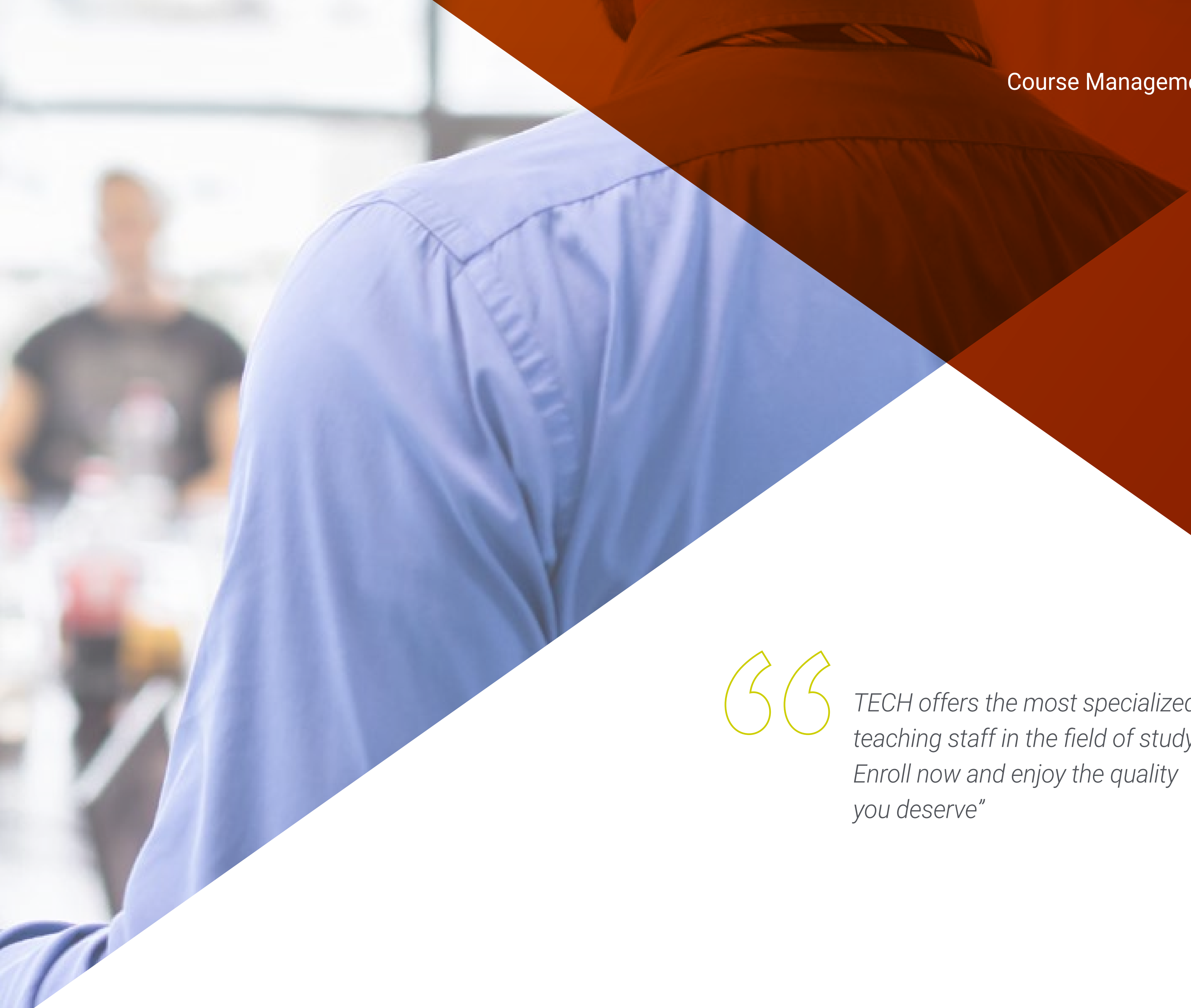
- Acquire basic notions of quantum field theory
- Know the main problems of quantization of some of the fields and how to solve them
- Know how to calculate amplitudes of interactions between particles from Feynman diagrams
- Know the C, P, T symmetries, the most common symmetry violations and the C, P, T symmetry conservation theorem

Module 3. Information and Quantum Computing

- Acquire basic notions of classical and quantum information
- Identify the most common algorithms for quantum encryption of information
- Obtain basic notions about semi quantum and quantum theories of light-matter interaction
- Know the most common quantum information implementations

03
Course Management

This academic program includes the most specialized teaching staff in the current educational market. They are specialists selected by TECH to develop the whole syllabus. In this way, starting from their own existence and the latest evidence, they have designed the most up-to-date content that provides a guarantee of quality in such a relevant subject.



TECH offers the most specialized teaching staff in the field of study. Enroll now and enjoy the quality you deserve"

International Guest Director

Dr. Philipp Kammerlander is an experienced expert in quantum physics, with high prestige among members of the international academic community. Since joining the Quantum Center in Zurich as Public Program Officer, he has played a crucial role in the creation of collaborative networks between institutions dedicated to quantum science and technology. Based on his proven results, he has assumed the role of Executive Director of that institution.

Specifically from this professional work, this expert has been involved in the coordination of various activities such as workshops and conferences, collaborating with various departments of the Swiss Federal Institute of Technology in Zurich (ETH). He has also been instrumental in fundraising and in the creation of more sustainable internal structures that help the rapid development of the functions of the center he represents.

In addition, he addresses innovative concepts such as the theory of quantum information and its processing. On these topics he has designed curricula and led their development in front of more than 200 students. Thanks to his excellence in these areas, he has received notable distinctions such as the Golden Owl Award and the VMP Assistant Award that highlight his commitment and ability in teaching.

In addition to his work at the Quantum Center and ETH Zurich, this researcher has extensive experience in the technology industry. He has worked as a freelance software engineer, designing and testing business analytics applications based on the ACTUS standard for smart contracts. He has also been a consultant at abaQon AG. His diverse background and significant achievements in academia and industry underscore his versatility and dedication to innovation and education in the field of quantum science.

Dr. Kammerlander, Philipp

- Executive Director of the Quantum Center Zurich, Switzerland
- Professor at the Swiss Federal Institute of Technology Zurich, Switzerland
- Manager of public programs between different Swiss institutions
- Freelance Software Engineer at Ariadne Business Analytics AG
- Consultant at abaQon AG
- Doctorate in Theoretical Physics and Quantum Information Theory at the ETH Zurich
- Master's Degree in Physics at the ETH Zurich

“Thanks to TECH, you will be able to learn with the best professionals in the world”

03

Structure and Content

The syllabus of this program has been designed to offer the engineering professionals the most advanced knowledge on Quantum Sciences. For this reason, the specialized teaching team of this university program has designed a 3-module program that will allow to obtain a solid and essential learning in this field. Thus, delve into mathematical methods, students will delve into quantum field theory and quantum information and computation. The video summaries of each topic, the videos in detail or the case studies will allow to advance in a much more dynamic way through this online program.

The case studies provided by specialists in quantum physics will allow you acquiring a closer knowledge of Quantum Science"

Module 1. Mathematical Methods

1.1. Prehibertian Spaces
- 1.1.1. Vector Spaces
- 1.1.2. Positive Hermitian Scalar Product
- 1.1.3. Single Vector Module
- 1.1.4. Schwartz Inequality
- 1.1.5. Minkowsky Inequality
- 1.1.6. Orthogonality
- 1.1.7. Dirac Notation

1.2. Topology of Metric Spaces
- 1.2.1. Definition of Distance
- 1.2.2. Definition of Metric Space
- 1.2.3. Elements of Topology of Metric Spaces
- 1.2.4. Convergent Successions
- 1.2.5. Cauchy Successions
- 1.2.6. Complete Metric Space

1.3. Hilbert Spaces
- 1.3.1. Hilbert Spaces: Definition
- 1.3.2. Herbatian Base
- 1.3.3. Schrödinger vs. Heisenberg. Lebesgue Integral
- 1.3.4. Continuous Frames of a Hilbert Space
- 1.3.5. Change of Basis Matrix

1.4. Linear Operations
- 1.4.1. Linear Operators: Basic Concepts
- 1.4.2. Inverse Operator
- 1.4.3. Adjoint Operator
- 1.4.4. Self-Adjoint Operator
- 1.4.5. Positive Definite Operator
- 1.4.6. Unitary Operator I: Change of Basis
- 1.4.7. Antiunitary Operator
- 1.4.8. Projector

1.5. Stumr-Liouville Theory
- 1.5.1. Eigenvalue Theorem
- 1.5.2. Eigenvector Theorem
- 1.5.3. Sturm-Liouville Problem
- 1.5.4. Important Theorems for Sturm-Liouville Theory

1.6. Introduction to Group Theory
- 1.6.1. Definition of Group and Characteristics
- 1.6.2. Symmetries
- 1.6.3. Study of SO (3), SU(2) and SU(N) Groups
- 1.6.4. Lie Algebra
- 1.6.5. Groups I and Quantum Physics

1.7. Introduction to Representations
- 1.7.1. Definitions
- 1.7.2. Fundamental Representation
- 1.7.3. Adjoint Representation
- 1.7.4. Unitary Representation
- 1.7.5. Product of Representation
- 1.7.6. Young Tables
- 1.7.7. Okubo Theorems
- 1.7.8. Applications to Particle Physics

1.8. Introduction to Tensors
- 1.8.1. Definition of Covariant and Contravariant Tensors
- 1.8.2. Kronecker Delta
- 1.8.3. Levi-Civita Tensor
- 1.8.4. Study of SO(N) i SO (3)
- 1.8.5. Study of SO(N)
- 1.8.6. Relation between tensors and representations

1.9. Group Theory Applied to Physics
- 1.9.1. Translation Group
- 1.9.2. Lorentz Group
- 1.9.3. Discrete Groups
- 1.9.4. Continuous Groups

1.10. Representations and Particle Physics
- 1.10.1. Representations of SU(N) Groups
- 1.10.2. Fundamental Representations
- 1.10.3. Multiplication of Representations
- 1.10.4. Okubo Theorem and Eightfold Ways

Module 2. Quantum Field Theory

2.1. Classical Field Theory
- 2.1.1. Notation and Conventions
- 2.1.2. Lagrangian Formulation
- 2.1.3. Euler Lagrange Equations
- 2.1.4. Symmetries and Conservation Laws

2.2. Klein-Gordon Field
- 2.2.1. Klein-Gordon Equations
- 2.2.2. Klein-Gordon Field Quantization
- 2.2.3. Lorentz Invariance in theKlein-Gordon Field
- 2.2.4. Vacuum Vacuum and Fock States
- 2.2.5. Vacuum Energy
- 2.2.6. Normal Arrangement: Agreement
- 2.2.7. Energy and Momentum of States
- 2.2.8. Study of Causality
- 2.2.9. Klein-Gordon propagator

2.3. Dirac Field
- 2.3.1. Dirac Equation
- 2.3.2. Dirac Matrices and their Properties
- 2.3.3. Representation of Dirac Matrices
- 2.3.4. Dirac Lagrangian
- 2.3.5. Solution to Dirac Equation: Plane Waves
- 2.3.6. Commuting and Anticommuting
- 2.3.7. Quantification of Dirac Field
- 2.3.8. Fock Space
- 2.3.9. Dirac Propagator

2.4. Electromagnetic Field
- 2.4.1. Classical Field Electromagnetic Theory
- 2.4.2. Quantization of the Electromagnetic Field and its Problems
- 2.4.3. Fock Space
- 2.4.4. Gupta-Bleuler Formalism
- 2.4.5. Photon Propagator

2.5. S-Matrix Formalism
- 2.5.1. Lagrangian and Hamitonian of Interaction
- 2.5.2. S Matrix: Definition and Properties
- 2.5.3. Dyson Expansion
- 2.5.4. Wick Theorem
- 2.5.5. Dirac Picture

2.6. Feinman Diagrams in the Position Space
- 2.6.1. How to Draw Feynman Diagrams? Rules Utilities
- 2.6.2. First Order
- 2.6.3. Second Order
- 2.6.4. Dispersion Processes with Two Particles

2.7. Feynman Rules
- 2.7.1. Normalization of States in Fock Space
- 2.7.2. Feynman Amplitude
- 2.7.3. Feynman Rules for QED
- 2.7.4. Gauge Invariance in the Amplitudes
- 2.7.5. Examples

2.8. Cross Section and Decay Rates
- 2.8.1. Definition of Cross Sections
- 2.8.2. Definition of Decay Rate
- 2.8.3. Example with Two Bodies in Final State
- 2.8.4. Unpolarized Cross Section
- 2.8.5. Summation on Fermion Polarization
- 2.8.6. Summation on Photon Polarization
- 2.8.7. Examples

2.9. Study of Muons and Other Charged Particles
- 2.9.1. Muons
- 2.9.2. Charged Particles
- 2.9.3. Scalar Charged Particles
- 2.9.4. Feynman Rules for Scalar Quantum Electrodynamics Theory

2.10. Symmetries
- 2.10.1. Parity
- 2.10.2. Load Conjugation
- 2.10.3. Time Reversal
- 2.10.4. Violation of Some Symmetries
- 2.10.5. CPT Symmetry

Module 3. Information and Quantum Computing

3.1. Introduction: Mathematics and Quantum
- 3.1.1. Complex Vector Spaces
- 3.1.2. Linear Operators
- 3.1.3. Scalar Products and Hilbert Spaces
- 3.1.4. Diagonalization
- 3.1.5. Tensor Product
- 3.1.6. The Role of Operators
- 3.1.7. Important Theorems on Operators
- 3.1.8. Checked Quantum Mechanics Postulates

3.2. Statistical States and Samples
- 3.2.1. The Qubit
- 3.2.2. Density Matrix
- 3.2.3. Two-Part System
- 3.2.4. Schmidt Decomposition
- 3.2.5. Statistical Interpretation of the Mixing States

3.3. Measurements and Temporary Evolution
- 3.3.1. Von Neumann Measurements
- 3.3.2. Generalized Measurements
- 3.3.3. Neumark Theorem
- 3.3.4. Quantum Channels

3.4. Interwoven and its Applications
 3.4.1. ERP States
 3.4.2. Dense Coding
 3.4.3. State Teleportation
 3.4.4. Density Matrix and its Representations
3.5. Classic and Quantum Information
 3.5.1. Introduction to Probability
 3.5.2. Information
 3.5.3. Shannon Entropy and Mutual Information
 3.5.4. Communication
  3.5.4.1. The Bynary Symmettric Channel
  3.5.4.2. Channel Capacity
 3.5.5. Shannon Theorems
 3.5.6. Difference between Classic and Quantum Information
 3.5.7. Von Neumann Entropy
 3.5.8. Schumacher Theorem
 3.5.9. Holevo Information
 3.5.10. Accessible Information and Holevo Limit
3.6. Quantum Computing
 3.6.1. Turing Machines
 3.6.2. Circuits and Classification of Complexity
 3.6.3. Quantum Computer
 3.6.4. Quantum Logic Gates
 3.6.5. Deutsch-Josza and Simon´s Algorithm
 3.6.6. Unstructured Search; Grover´s Algorithm
 3.6.7. RSA Encryption Method
 3.6.8. Factorizatión: Shor Algorithm
3.7. Quantum Theory of the Light-Matter Interaction
 3.7.1. Two-Level Atom
 3.7.2. AC-Stark Splitting
 3.7.3. Rabi Oscillations
 3.7.4. Light dipole force
3.8. Quantum Theory of the Light-Matter Interaction
 3.8.1. Quantum States of the Electromagnetic Field
 3.8.2. Jaynes-Cummings Model
 3.8.3. The Problem of Decoherence
 3.8.4. Treatment of Weisskopf-Wigner Model of Spontaneous Emission
3.9. Quantum Communication
 3.9.1. Quantum Cryptography: BB84 and Ekert91 protocols
 3.9.2. Bell Inequalities
 3.9.3. Generation of Individual Photons
 3.9.4. Propagation of Individual Photons
 3.9.5. Detection of Individual Photons
3.10. Quantum Computing and Simulation
 3.10.1. Neutral Atoms in Dipolar Traps
 3.10.2. Cavity Quantum Electrodynamics
 3.10.3. Ions in Paul Tramps
 3.10.4. Superconducting Cubits

A 100% online program that will allow you to delve, through multimedia resources, into the latest developments in quantum cryptography"

04

Methodology

This academic program offers students a different way of learning. Our methodology uses a cyclical learning approach: **Relearning.**
This teaching system is used, for example, in the most prestigious medical schools in the world, and major publications such as the **New England Journal of Medicine** have considered it to be one of the most effective.

Discover Relearning, a system that abandons conventional linear learning, to take you through cyclical teaching systems: a way of learning that has proven to be extremely effective, especially in subjects that require memorization"

Case Study to contextualize all content

Our program offers a revolutionary approach to developing skills and knowledge. Our goal is to strengthen skills in a changing, competitive, and highly demanding environment.

At TECH, you will experience a learning methodology that is shaking the foundations of traditional universities around the world"

You will have access to a learning system based on repetition, with natural and progressive teaching throughout the entire syllabus.

The student will learn to solve complex situations in real business environments through collaborative activities and real cases.

A learning method that is different and innovative

This TECH program is an intensive educational program, created from scratch, which presents the most demanding challenges and decisions in this field, both nationally and internationally. This methodology promotes personal and professional growth, representing a significant step towards success. The case method, a technique that lays the foundation for this content, ensures that the most current economic, social and professional reality is taken into account.

Our program prepares you to face new challenges in uncertain environments and achieve success in your career"

The case method is the most widely used learning system in the best faculties in the world. The case method was developed in 1912 so that law students would not only learn the law based on theoretical content. It consisted of presenting students with real-life, complex situations for them to make informed decisions and value judgments on how to resolve them. In 1924, Harvard adopted it as a standard teaching method.

What should a professional do in a given situation? This is the question that you are presented with in the case method, an action-oriented learning method. Throughout the program, the studies will be presented with multiple real cases. They will have to combine all their knowledge and research, and argue and defend their ideas and decisions.

Relearning Methodology

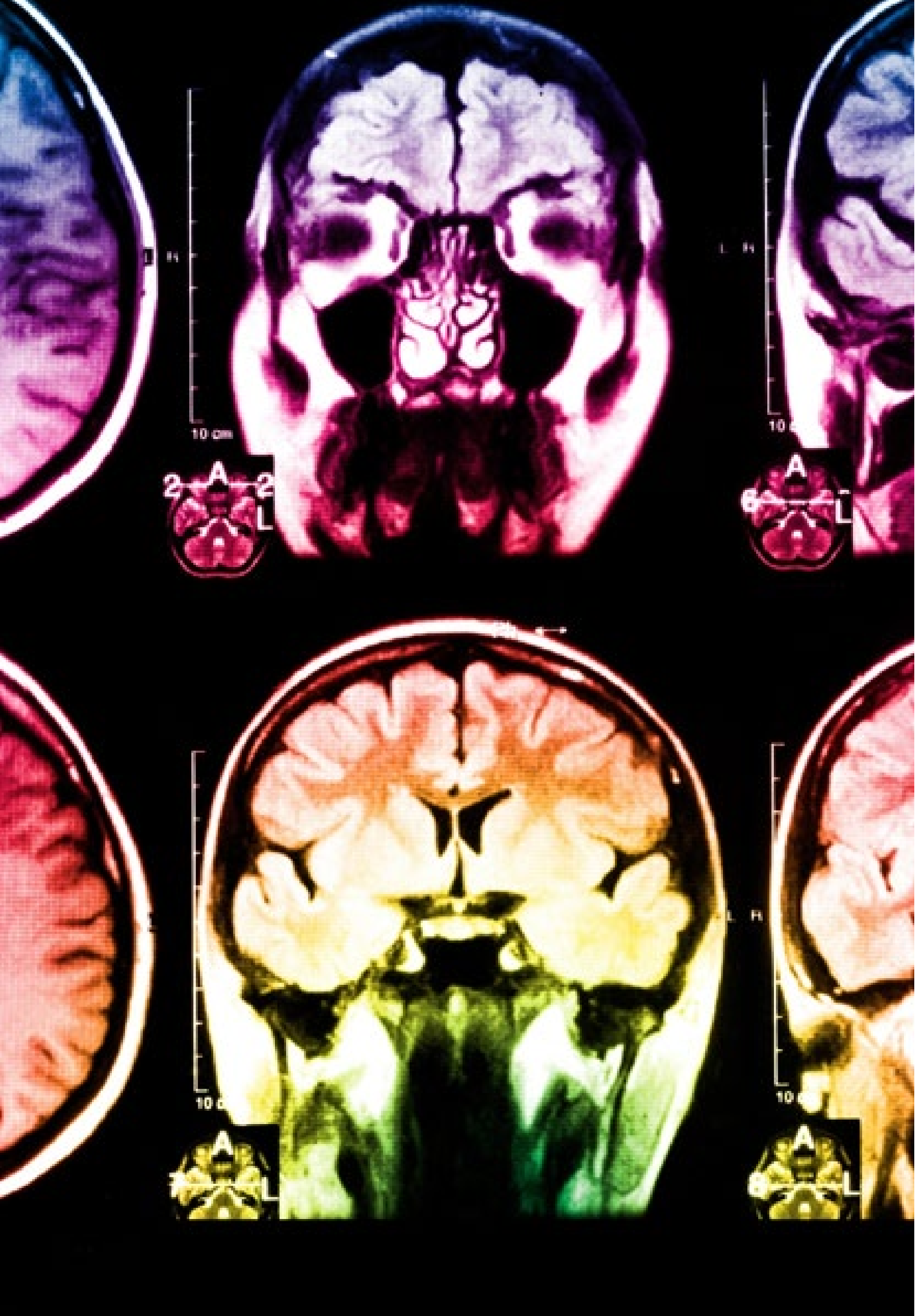
TECH effectively combines the Case Study methodology with a 100% online learning system based on repetition, which combines 8 different teaching elements in each lesson.

We enhance the Case Study with the best 100% online teaching method: Relearning.

In 2019, we obtained the best learning results of all online universities in the world.

At TECH, you will learn using a cutting-edge methodology designed to train the executives of the future. This method, at the forefront of international teaching, is called Relearning.

Our university is the only one in the world authorized to employ this successful method. In 2019, we managed to improve our students' overall satisfaction levels (teaching quality, quality of materials, course structure, objectives...) based on the best online university indicators.



In our program, learning is not a linear process, but rather a spiral (learn, unlearn, forget, and re-learn). Therefore, we combine each of these elements concentrically. This methodology has trained more than 650,000 university graduates with unprecedented success in fields as diverse as biochemistry, genetics, surgery, international law, management skills, sports science, philosophy, law, engineering, journalism, history, and financial markets and instruments. All this in a highly demanding environment, where the students have a strong socio-economic profile and an average age of 43.5 years.

Relearning will allow you to learn with less effort and better performance, involving you more in your training, developing a critical mindset, defending arguments, and contrasting opinions: a direct equation for success.

From the latest scientific evidence in the field of neuroscience, not only do we know how to organize information, ideas, images and memories, but we know that the place and context where we have learned something is fundamental for us to be able to remember it and store it in the hippocampus, to retain it in our long-term memory.

In this way, and in what is called neurocognitive context-dependent e-learning, the different elements in our program are connected to the context where the individual carries out their professional activity.

This program offers the best educational material, prepared with professionals in mind:

Study Material

All teaching material is produced by the specialists who teach the course, specifically for the course, so that the teaching content is highly specific and precise.

These contents are then applied to the audiovisual format, to create the TECH online working method. All this, with the latest techniques that offer high quality pieces in each and every one of the materials that are made available to the student.

Classes

There is scientific evidence suggesting that observing third-party experts can be useful.

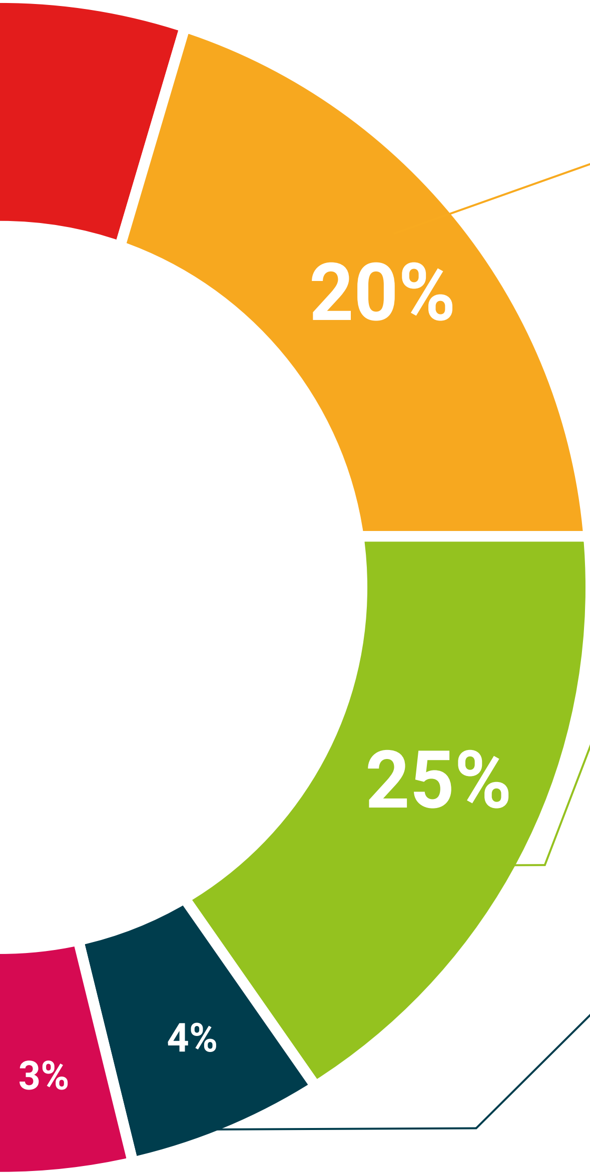
Learning from an Expert strengthens knowledge and memory, and generates confidence in future difficult decisions.

Practising Skills and Abilities

They will carry out activities to develop specific skills and abilities in each subject area. Exercises and activities to acquire and develop the skills and abilities that a specialist needs to develop in the context of the globalization that we are experiencing.

Additional Reading

Recent articles, consensus documents and international guidelines, among others. In TECH's virtual library, students will have access to everything they need to complete their course.



Case Studies

Students will complete a selection of the best case studies chosen specifically for this program. Cases that are presented, analyzed, and supervised by the best specialists in the world.

Interactive Summaries

The TECH team presents the contents attractively and dynamically in multimedia lessons that include audio, videos, images, diagrams, and concept maps in order to reinforce knowledge.

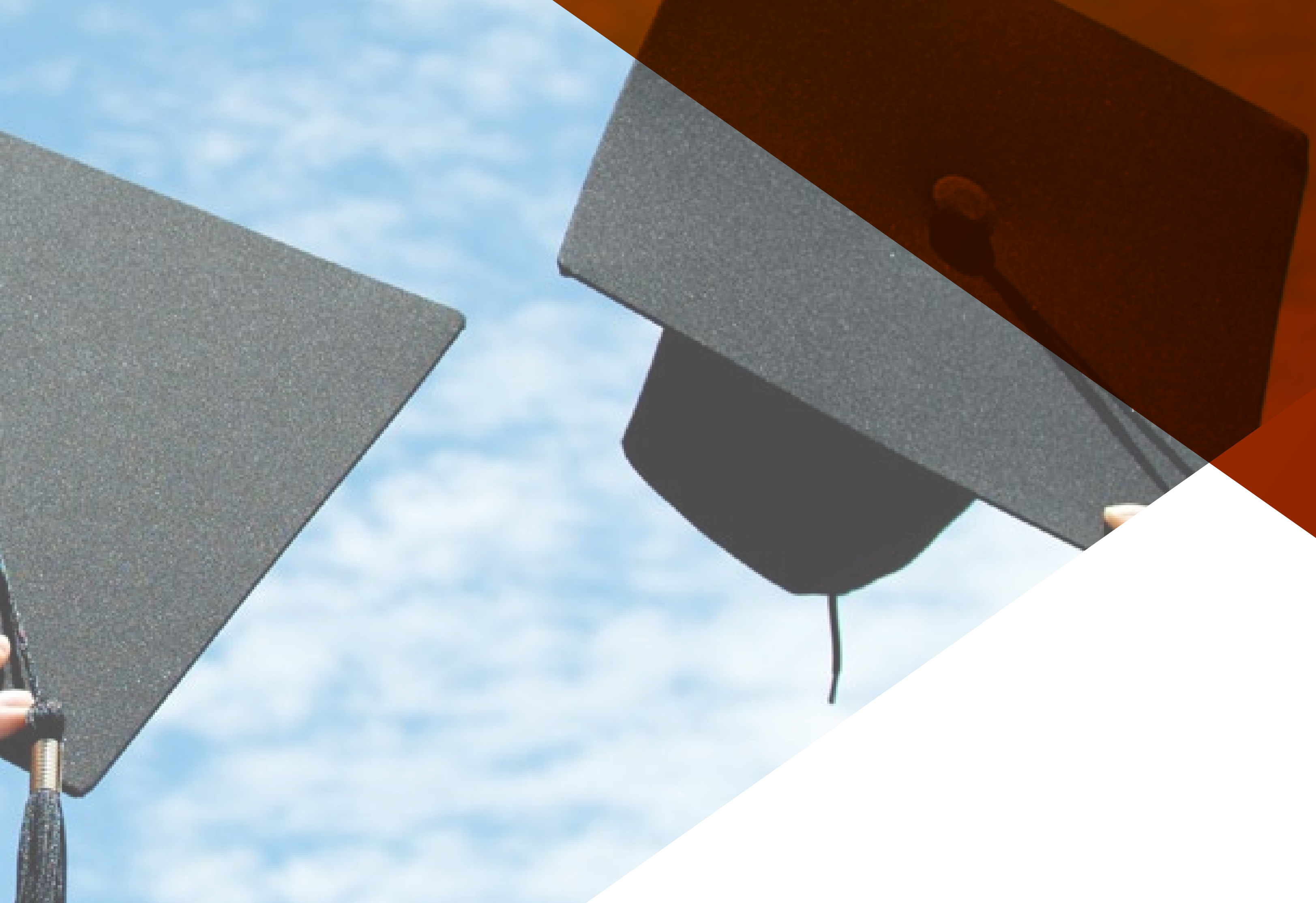
This exclusive educational system for presenting multimedia content was awarded by Microsoft as a "European Success Story".

Testing & Retesting

We periodically evaluate and re-evaluate students' knowledge throughout the program, through assessment and self-assessment activities and exercises, so that they can see how they are achieving their goals.

05
Certificate

The Postgraduate Diploma in Quantum Sciences guarantees students, in addition to the most rigorous and up-to-date education, access to a Postgraduate Diploma issued by TECH Technological University.



Successfully complete this program and receive your university qualification without having to travel or fill out laborious paperwork"

This **Postgraduate Diploma in Quantum Sciences** contains the most complete and up-to-date program on the market.

After the student has passed the assessments, they will receive their corresponding **Postgraduate Diploma** issued by **TECH Technological University** via tracked delivery*.

The diploma issued by **TECH Technological University** will reflect the qualification obtained in the Postgraduate Diploma, and meets the requirements commonly demanded by labor exchanges, competitive examinations, and professional career evaluation committees.

Title: **Postgraduate Diploma in Quantum Sciences**

Official Nº of hours: **450 h.**


tech technological university

Awards the following

DIPLOMA

to

Mr./Ms. _______________, with identification number ____________.

For having passed and accredited the following program

POSTGRADUATE DIPLOMA

in

Quantum Sciences

This is a qualification awarded by this University, equivalent to 450 hours, with a start date of dd/mm/yyyy and an end date of dd/mm/yyyy.

TECH is a Private Institution of Higher Education recognized by the Ministry of Public Education as of June 28, 2018.

June 17, 2020

Tere Guevara Navarro
Dean

This qualification must always be accompanied by the university degree issued by the competent authority to practice professionally in each country. Unique TECH Code: AFWORD23S techtitute.com/certificates

*Apostille Convention. In the event that the student wishes to have their paper diploma issued with an apostille, TECH EDUCATION will make the necessary arrangements to obtain it, at an additional cost.

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