Postgraduate Diploma
CFD Techniques

tech global university

Postgraduate Diploma
CFD Techniques

- Modality: **online**
- Duration: **6 months**
- Certificate: **TECH Global University**
- Credits: **18 ECTS**
- Schedule: **at your own pace**
- Exams: **online**

Website: **www.techtitute.com/us/engineering/postgraduate-diploma/postgraduate-diploma-cfd-techniques**

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01

Introduction

Computational Fluid Dynamics has become very important nowadays due to its different applications and advantages, such as time and money saving or the level of detail it offers. In order to know the different techniques applicable in this field, it is necessary to have a broad and extensive knowledge of the subject, which is increasingly in demand in the labor market. For this reason, TECH has designed a program that seeks to provide students with a good foundation in numerical methods, to broaden their area of expertise and enable them to specialize in Fluid Mechanics Simulator Development. All this through a 100% online content that allows students to organize themselves freely.

Become an expert in Computational Fluid Mechanics Techniques in just a few months"

Within Simulation we find different computer techniques such as Computational Fluid Dynamics, which has become very important nowadays due to its multiple advantages, such as the level of detail it provides, the time saving or the cost reduction. Its different procedures simulate by means of numerical methods the real behavior of the fluids, with the objective of obtaining more information and understanding of the same. Therefore, they are applicable in multiple areas such as aerospace, automotive, environment, biomedicine or wind energy.

To get the most out of these techniques, advanced knowledge is required, which is increasingly in demand in the labor market, which is why TECH has designed a Postgraduate Diploma in CFD Techniques. This program aims to provide students with a good specialized base in the different numerical methods of CFD, so that they can face their work in this field, with the highest quality in their work.

In this way, content has been created that delves into Fluid Mechanics, High Performance Computing, Advanced Mathematics for CFD, Finite Volume Methods and Advanced Methods for CFD, among other relevant topics.

All this through a 100% online content that gives the student total freedom to organize their studies and schedules as best suits them, being able to combine the completion of the program with their other daily activities. In addition, the student will be provided with dynamic multimedia materials, practical exercises, fully updated information and the latest teaching technologies.

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

- The development of case studies presented by experts in CFD Techniques
- 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 self-assessment can be used 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

Delve into essential CFD Techniques and master an area with brilliant job potential"

Acquire new knowledge and improved skills in Finite Element Methods or Smoothed Particle Hydrodynamics"

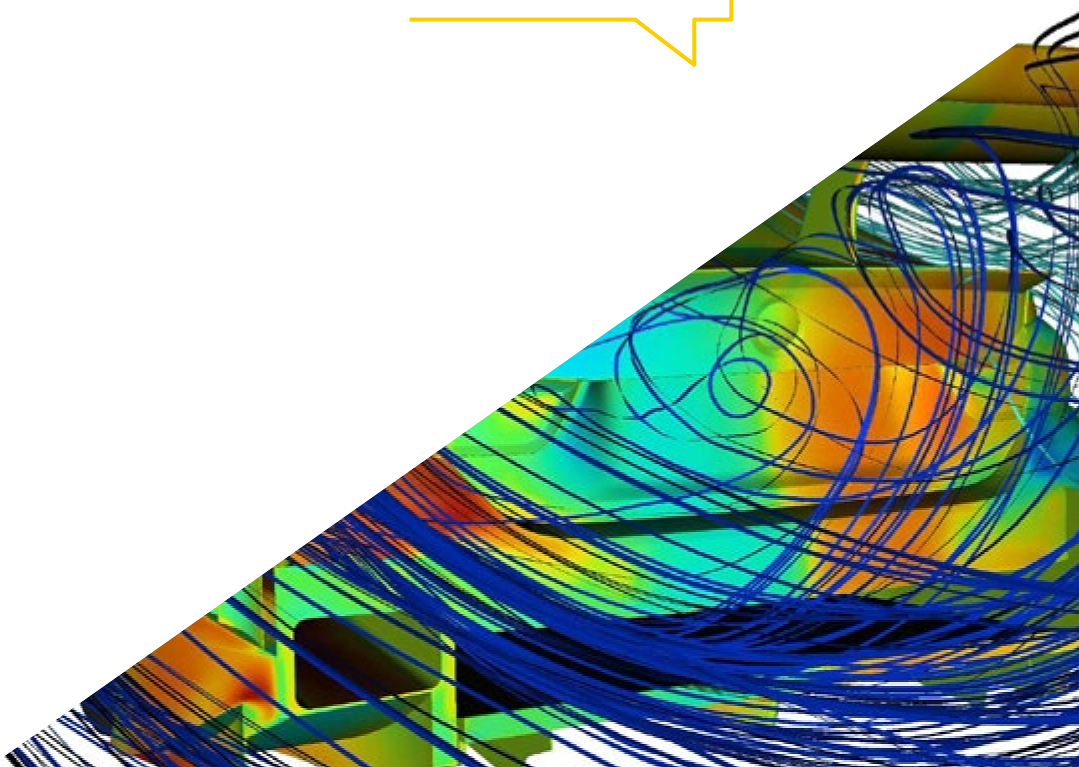
Enroll now and get access to all SPH-based Simulator Development content.

Enjoy the best theoretical and practical content in Advanced Methods for CFD.

The program's teaching staff includes professionals from sector who contribute their work experience to this educational program, as well as renowned specialists from leading societies and prestigious universities.

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

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



02

Objectives

The objective of this Postgraduate Diploma in CFD Techniques is to provide students with the necessary skills and knowledge to be able to exercise their professional work in Computational Fluid Dynamics with total guarantee of success. All this thanks to the most complete, dynamic and updated theoretical and practical materials available in the academic market.

Adapt your profile to the needs of the labor market and specialize in one of the most promising areas of engineering"

General Objectives

- Establish the basis for the study of turbulence
- Develop CFD statistical concepts
- Determine the main computational techniques in turbulence research
- Generate specialized knowledge in the method of Finite Volumes
- Acquire specialized knowledge in fluid mechanics calculation techniques
- Examine the wall units and the different regions of a turbulent wall flow
- Determine the characteristics of compressible flows
- Examine multiple models and multiphase methods
- Develop expertise on multiple models and methods in multiphysics and thermal analysis
- Interpret the results obtained by correct post-processing

Reach your objectives in a few months thanks to the most innovative CFD simulation tools"

Specific Objectives

Module 1. Fluid Mechanics and High-Performance Computing

- Identify the equations of turbulent flows
- Examine the closure problem
- Establish the dimensionless numbers needed for modeling
- Analyze the main CFD techniques
- Examine the main experimental techniques
- Developing the different types of supercomputers
- Show the future: GPU

Module 2. Advanced Mathematics for CFD

- Develop the mathematical concepts of turbulence
- Generate specialized knowledge on the application of statistics to turbulent flows
- Fundamental method of solving CFD equations
- Demonstrate methods of solving algebraic problems
- Analyze the multigrid method
- Examining the use of eigenvalues and eigenvectors in CFD problems
- Determine methods for solving non-linear problems

Module 3. CFD in Application Environments: Finite Volume Methods

- Analyze the FEM or MVF environment
- Specify what, where and how the boundary conditions can be defined
- Determine possible time steps
- Concretizing and designing Upwind schemes
- Develop high order schemes
- Examine convergence loops and in which cases to use each one
- Expose the imperfections of CFD results

Module 4. Advanced Methods for CFD

- Develop the Finite Element Method and the Smoothed Particle Hydrodynamics Method
- Analyze the advantages of Lagrangian versus Eulerian methods, in particular, SPH vs. FVM
- Analyze the Monte-Carlo Direct Simulation method and the Lattice-Boltzmann Method
- Evaluate and interpret spatial aerodynamics and microfluid dynamics simulations
- Establish the advantages and disadvantages of LBM versus the traditional FVM method

03

Course Management

In order to offer the highest quality education to its students, TECH has created a team with the best experts in Computational Fluid Dynamics Techniques. This group of professionals has poured their excellent background and state-of-the-art knowledge into a complete, innovative and precise curriculum that will help you achieve the most demanding goals.

TECH's excellent team of experts in CFD Techniques has designed this program for you"

Management

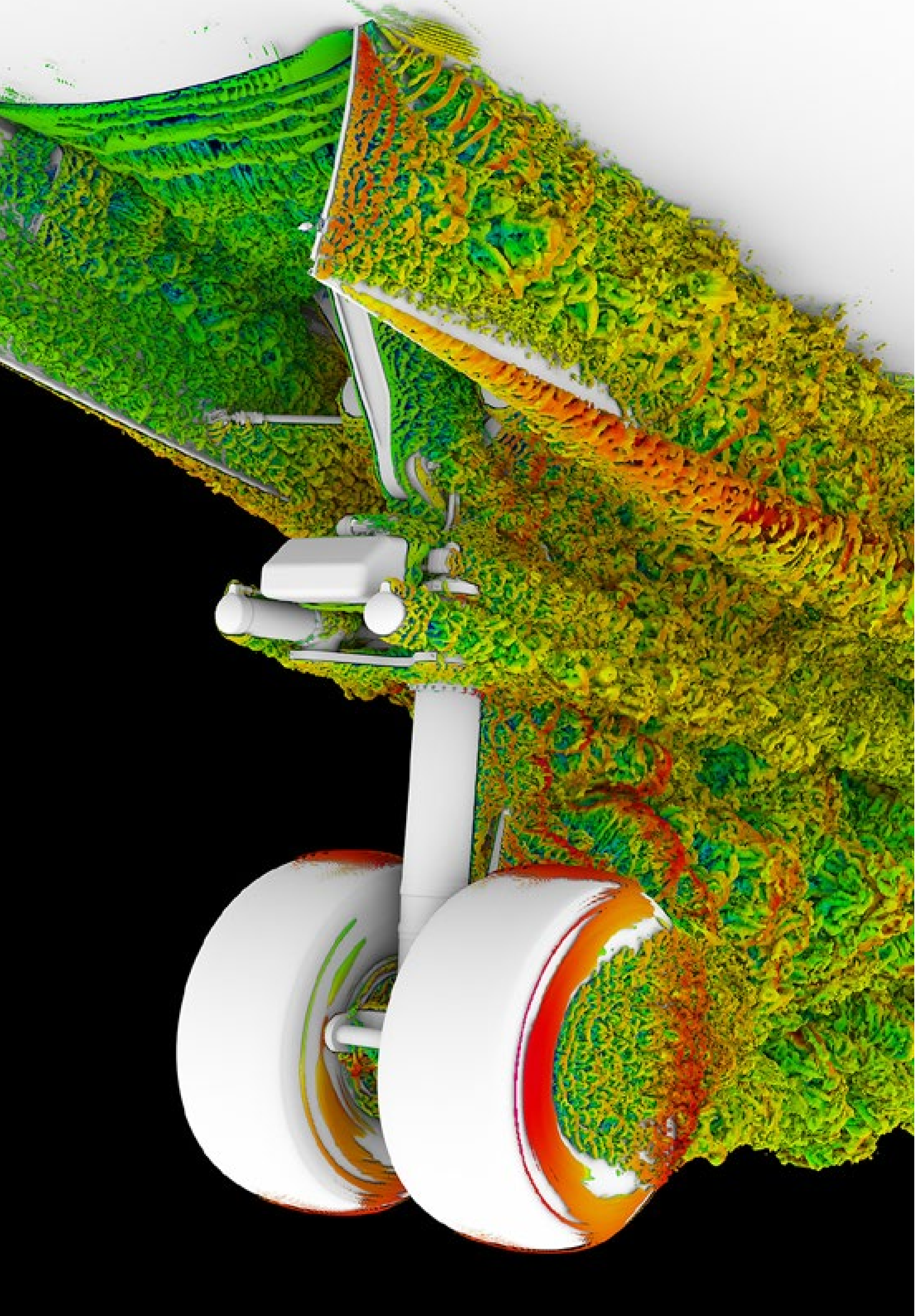
Dr. José Pedro García Galache

- XFlow Development Engineer at Dassault Systèmes
- PhD in Aeronautical Engineering from the Polytechnic University of Valencia
- Degree in Aeronautical Engineering from the Polytechnic University of Valencia
- Master's Degree in Research in Fluid Mechanics from the Von Kármán Institute for Fluid Dynamics
- Short Training Program in the Von Kármán Institute for Fluid Dynamics

Professors

Dr. Daniel Espinoza Vásquez

- Consultant Aeronautical Engineer at Alten SAU
- Freelance CFD and Programming Consultant
- CFD Specialist at Particle Analytics Ltd
- Research Assistant at the University of Strathclyde
- Teaching Assistant in Fluid Mechanics, University of Strathclyde
- Dr. in Aeronautical Engineering from the University of Strathclyde
- Master's Degree in Computational Fluid Mechanics, Cranfield University
- Degree in Aeronautical Engineering from Universidad Politécnica de Madrid



Ms. Maider Pérez Tainta

- Cement fluidization engineer at Kemex Ingesoa
- Process Engineer at J.M. Jauregui
- Researcher in hydrogen combustion at Ikerlan
- Mechanical Engineer at Idom
- Graduate in Mechanical Engineering from the University of the Basque Country (UPV)
- Master's Degree in Mechanical Engineering
- Interuniversity Master's Degree in Fluid Mechanics
- Python programming program program program

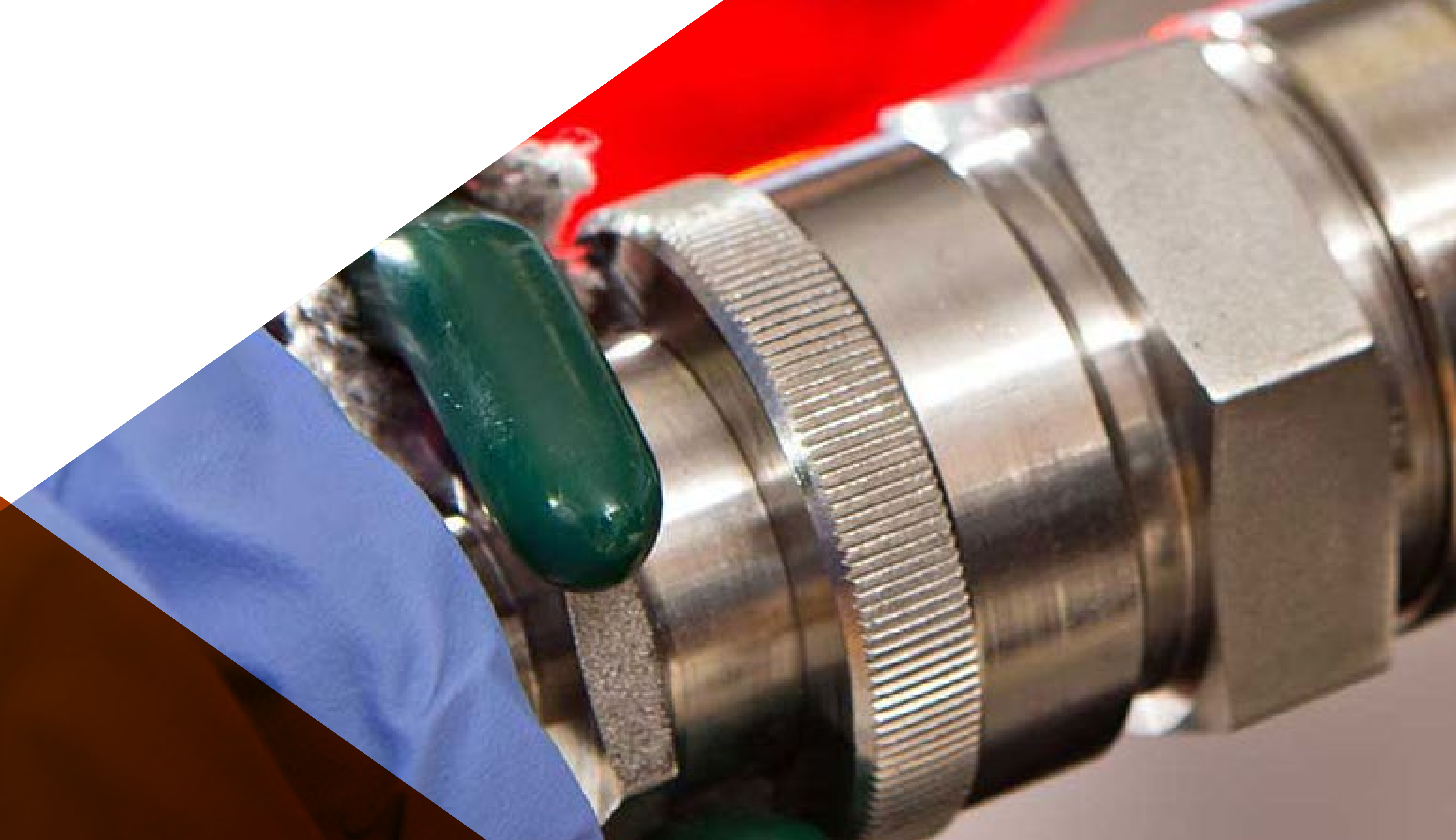
Mr. Mata Bueso, Enrique

- Senior Engineer of Thermal Conditioning and Aerodynamics at Siemens Gamesa
- Application Engineer and CFD R&D Manager in Dassault Systèmes
- Thermal Conditioning & Aerodynamics Engineer at Gamesa-Altran
- Fatigue and Damage Tolerance Engineer at Airbus-Atos
- R&D CFD Engineer at UPM
- Aeronautical Technical Engineer specializing in Aircraft at the UPM
- Master's Degree in Aerospace Engineering from the Royal Institute of Technology in Stockholm

04

Structure and Content

The structure and content of this program have been meticulously created by the professionals in CFD Techniques that make up TECH's team of subject matter experts. In this way, they have resulted in accurate multimedia materials, verified and updated information, as well as the most useful practical activities to test the new skills acquired by the students.



Quality content designed under the most efficient pedagogical methodology, Relearning, in which TECH is a pioneer"

Module 1. Fluid Mechanics and High-Performance Computing

1.1. Dynamics of computational fluid mechanics
- 1.1.1. The origin of the turbulence
- 1.1.2. The need for modeling
- 1.1.3. CFD work process

1.2. The Equations of Fluid Mechanics
- 1.2.1. The continuity equation
- 1.2.2. The Navier-Stokes equation
- 1.2.3. The energy equation
- 1.2.4. The Reynolds averaged equations

1.3. The problem of closing equations
- 1.3.1. The Bousinesq hypothesis
- 1.3.2. Turbulent viscosity in a spray
- 1.3.3. CFD Modeling

1.4. Dimensionless numbers and dynamic similarity
- 1.4.1. Dimensionless numbers in fluid mechanics
- 1.4.2. The principle of dynamic similarity
- 1.4.3. Practical example: wind tunnel modeling

1.5. Turbulence Modeling
- 1.5.1. Direct numerical simulations
- 1.5.2. Simulations of large eddies
- 1.5.3. RANS Methods
- 1.5.4. Other Methods

1.6. Experimental Techniques
- 1.6.1. PIV
- 1.6.2. Hot wire
- 1.6.3. Wind and water tunnels

1.7. Supercomputing environments
- 1.7.1. Supercomputing. Ide future
- 1.7.2. Supercomputer operation
- 1.7.3. Tools for use

1.8. Software in parallel architectures
- 1.8.1. Distributed environments: MPI
- 1.8.2. Shared memory: GPU
- 1.8.3. Data engraving: HDF5

1.9. Grid computing
- 1.9.1. Description of computer farms
- 1.9.2. Parametric problems
- 1.9.3. Queuing systems in grid computing

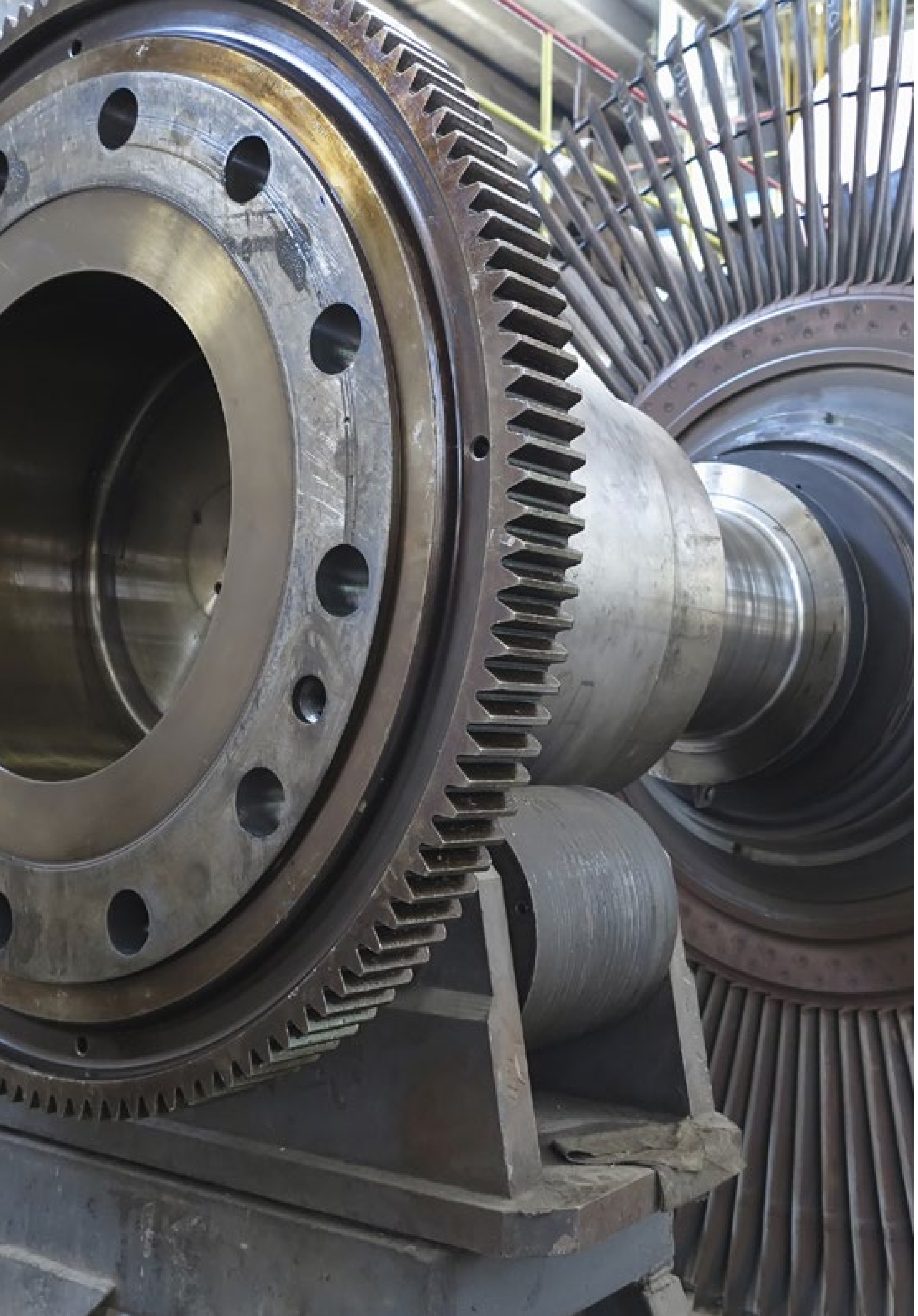
1.10. GPU, the future of CFD
- 1.10.1. GPU Environments
- 1.10.2. GPU Programming
- 1.10.3. Practical example: artificial intelligence in fluids using GPUs

Module 2. Advanced mathematics for CFD

2.1. Fundamentals of Mathematics
- 2.1.1. Gradients, divergences and rotations. Total derivative
- 2.1.2. Ordinary Differential Equations
- 2.1.3. Partial derivative equations

2.2. Statistics
- 2.2.1. Averages and moments
- 2.2.2. Probability density functions
- 2.2.3. Correlation and energy spectra

2.3. Strong and weak solutions of a differential equation
- 2.3.1. Function bases. Strong and weak solutions
- 2.3.2. The finite volume method. The heat equation
- 2.3.3. The finite volume method. Navier-Stokes



2.4. Taylor's Theorem and Discretization in time and space
2.4.1. Finite differences in 1 dimension. Error order
2.4.2. Finite differences in 2 dimensions
2.4.3. From continuous equations to algebraic equations
2.5. Algebraic problem solving, LU method
2.5.1. Algebraic problem solving methods
2.5.2. The LU method on full matrices
2.5.3. The LU method in sparse matrices
2.6. Algebraic Problem Solving, Iterative Methods I
2.6.1. Iterative methods. Waste
2.6.2. Jacobi's method
2.6.3. Generalization of Jacobi's method
2.7. Algebraic problem solving, iterative methods II
2.7.1. Multi-grid methods: V-cycle: interpolation
2.7.2. Multi-grid methods: V-cycle: extrapolation
2.7.3. Multi-grid methods: W-cycle
2.7.4. Error estimation
2.8. Eigenvalues and eigenvectors
2.8.1. The algebraic problem
2.8.2. Application to the heat equation
2.8.3. Stability of differential equations
2.9. Non-linear evolution equations
2.9.1. Heat equation: explicit methods
2.9.2. Heat equation: implicit methods
2.9.3. Heat equation: Runge-Kutta methods
2.10. Stationary non-linear equations
2.10.1. The Newton-Raphson method
2.10.2. 1D Applications
2.10.3. 2D Applications

Module 3. CFD in Application Environments: Finite Volumes Methods

3.1. Finite Volume Methods
- 3.1.1. Definitions in FVM
- 3.1.2. Historical Background
- 3.1.3. MVF in Structures

3.2. Source Terms
- 3.2.1. External volumetric forces
  - 3.2.1.1. Gravity, centrifugal force
- 3.2.2. Volumetric (mass) and pressure source term (evaporation, cavitation, chemical)
- 3.2.3. Scalar source term
  - 3.2.3.1. Temperature, species

3.3. Applications of boundary conditions
- 3.3.1. Input and Output
- 3.3.2. Symmetry condition
- 3.3.3. Wall condition
  - 3.3.3.1. Tax values
  - 3.3.3.2. Values to be solved by parallel calculation
  - 3.3.3.3. Wall models

3.4. Boundary Conditions
- 3.4.1. Known boundary conditions: Dirichlet
  - 3.4.1.1. Scalars
  - 3.4.1.2. Diseases
- 3.4.2. Boundary conditions with known derivative: Neumann
  - 3.4.2.1. Zero gradient
  - 3.4.2.2. Finite gradient
- 3.4.3. Cyclic boundary conditions: Born-von Karman
- 3.4.4. Other boundary conditions: Robin

3.5. Temporary integration
- 3.5.1. Explicit and implicit Euler
- 3.5.2. Lax-Wendroff time step and variants (Richtmyer and MacCormack)
- 3.5.3. Runge-Kutta multi-stage time step

3.6. Upwind Schematics
- 3.6.1. Riemman's Problem
- 3.6.2. Main upwind schemes: MUSCL, Van Leer, Roe, AUSM
- 3.6.3. Design of an upwind spatial scheme

3.7. High order schemes
- 3.7.1. High-order discontinuous Galerkin
- 3.7.2. ENO and WENO
- 3.7.3. High Order Schemes. Advantages and Disadvantages

3.8. Pressure-velocity convergence loop
- 3.8.1. PISO
- 3.8.2. SIMPLE, SIMPLER and SIMPLEC
- 3.8.3. PIMPLE
- 3.8.4. Transient loops

3.9. Moving contours
- 3.9.1. Overlocking techniques
- 3.9.2. Mapping: mobile reference system
- 3.9.3. *Immersed boundary method*
- 3.9.4. Overlapping meshes

3.10. Errors and uncertainties in CFD modeling
- 3.10.1. Precision and accuracy
- 3.10.2. Numerical errors
- 3.10.3. Input and physical model uncertainties

Module 4. Advanced Methods for CFD

4.1. Finite Element Method (FEM)
- 4.1.1. Domain discretization. Finite Elements
- 4.1.2. Form functions. Reconstruction of the continuous field
- 4.1.3. Assembly of the coefficient matrix and boundary conditions
- 4.1.4. Solving Systems of Equations

4.2. FEM: case study. Development of a FEM simulator
- 4.2.1. Form functions
- 4.2.2. Assembling the coefficient matrix and applying boundary conditions
- 4.2.3. Solving Systems of Equations
- 4.2.4. Post-Process

4.3. Smoothed Particle Hydrodynamics (SPH)
- 4.3.1. Fluid field mapping from particle values
- 4.3.2. Evaluation of derivatives and particle interaction
- 4.3.3. The smoothing function. The kernel
- 4.3.4. Boundary Conditions

4.4. SPH: development of a simulator based on SPH
- 4.4.1. The kernel
- 4.4.2. Storage and sorting of particles in voxels
- 4.4.3. Development of boundary conditions
- 4.4.4. Post-Process

4.5. Direct Simulation Monte Carlo (DSMC)
- 4.5.1. Kinetic-molecular theory
- 4.5.2. Statistical mechanics
- 4.5.3. Molecular equilibrium

4.6. DSMC: methodology
- 4.6.1. Applicability of the DSMC method
- 4.6.2. Modeling
- 4.6.3. Considerations for the applicability of the method

4.7. DSMC: applications
- 4.7.1. Example in 0-D: thermal relaxation
- 4.7.2. 1-D example: normal shock wave
- 4.7.3. 2-D example: supersonic cylinder
- 4.7.4. 3-D example: supersonic corner
- 4.7.5. Complex example: space Shuttle

4.8. Lattice-Boltzmann Method (LBM)
- 4.8.1. Boltzmann equation and equilibrium distribution
- 4.8.2. De Boltzmann a Navier-Stokes. Chapman-Enskog Expansion
- 4.8.3. From probabilistic distribution to physical magnitude
- 4.8.4. Conversion of units. From physical quantities to lattice quantities

4.9. LBM: Numerical approximation
- 4.9.1. The LBM algorithm. Transfer step and collision step
- 4.9.2. Collision operators and momentum normalization
- 4.9.3. Boundary Conditions

4.10. LBM: case study
- 4.10.1. Development of a simulator based on LBM
- 4.10.2. Experimentation with various collision operators
- 4.10.3. Experimentation with various turbulence models

The world's best online university offers you a tailor-made program to quickly excel in the field of Computational Fluid Dynamics"

05

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

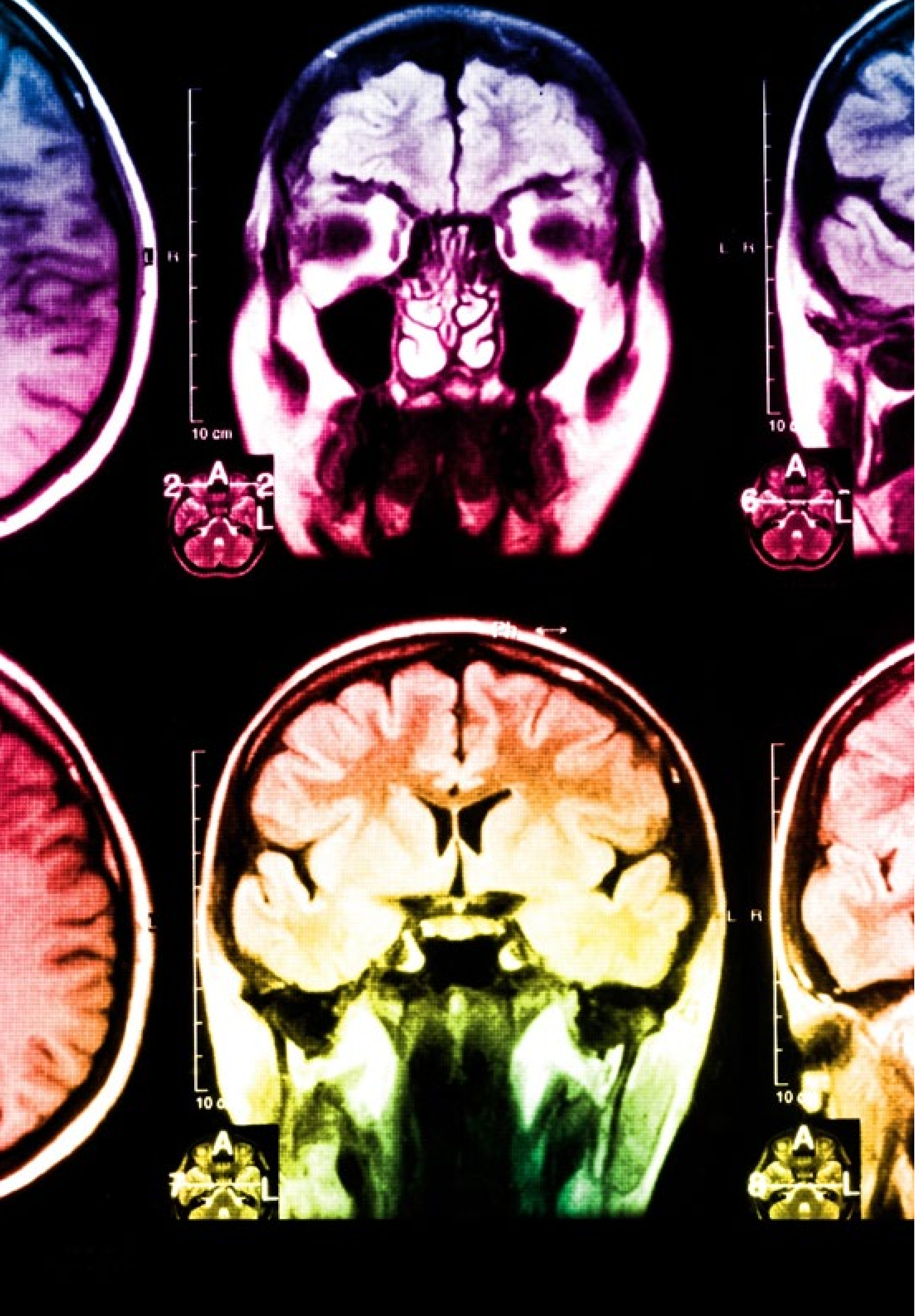
TECH effectively combines the Case Study methodology with a 100% online learning system based on repetition, which combines 8 different teaching elements in each lesson.

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.



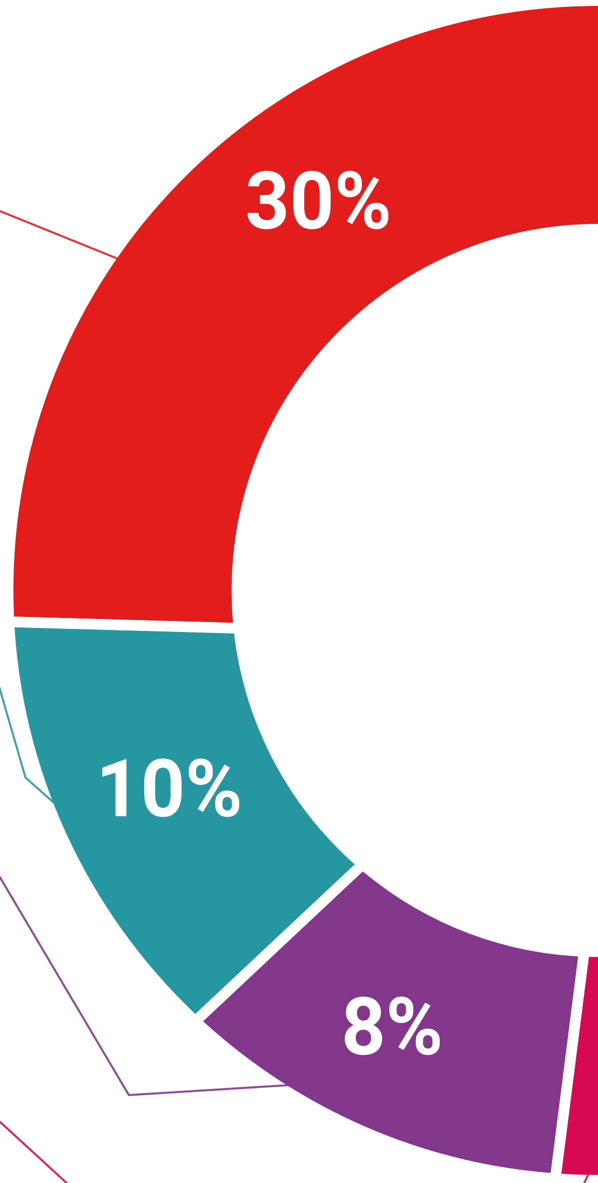
In our program, learning is not a linear process, but rather a spiral (learn, unlearn, forget, and re-learn). Therefore, we combine each of these elements concentrically. This methodology has trained more than 650,000 university graduates with unprecedented success in fields as diverse as biochemistry, 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.

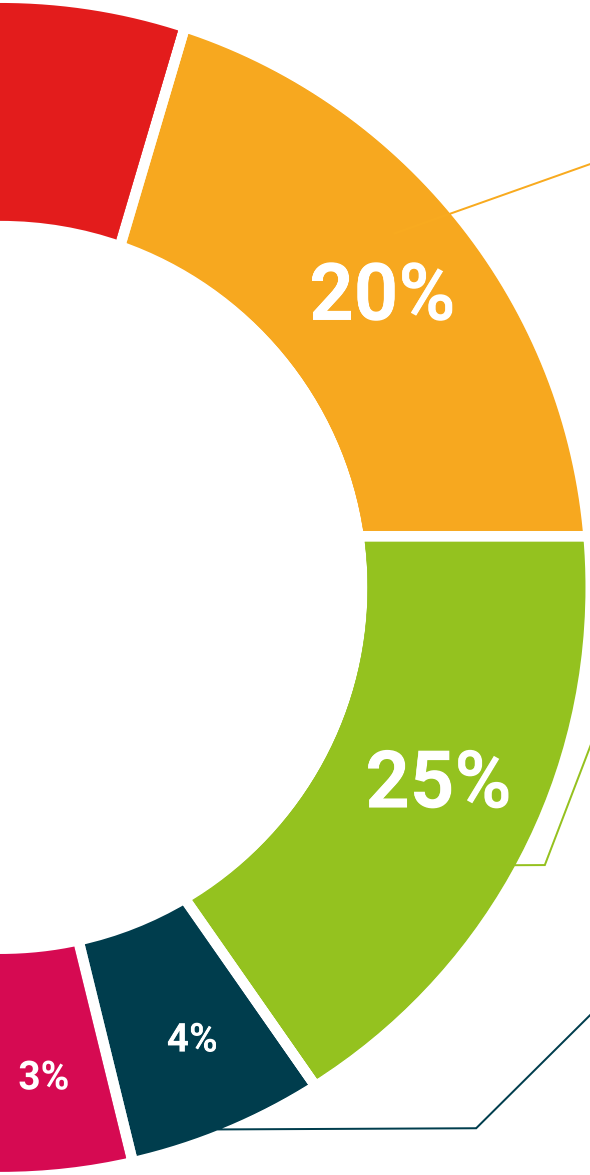
Learning from an Expert strengthens knowledge and memory, and generates confidence in future difficult decisions.

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.

06

Certificate

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

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

This program will allow you to obtain your **Postgraduate Diploma in CFD Techniques** endorsed by **TECH Global University**, the world's largest online university.

TECH Global University is an official European University publicly recognized by the Government of Andorra (***official bulletin***). Andorra is part of the European Higher Education Area (EHEA) since 2003. The EHEA is an initiative promoted by the European Union that aims to organize the international training framework and harmonize the higher education systems of the member countries of this space. The project promotes common values, the implementation of collaborative tools and strengthening its quality assurance mechanisms to enhance collaboration and mobility among students, researchers and academics.

This **TECH Global University** title is a European program of continuing education and professional updating that guarantees the acquisition of competencies in its area of knowledge, providing a high curricular value to the student who completes the program.

Title: **Postgraduate Diploma in CFD Techniques**

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tech global university

Mr./Ms. _______________, with identification document ___________
has successfully passed and obtained the title of:

Postgraduate Diploma in CFD Techniques

This is a program of 450 hours of duration equivalent to 18 ECTS, with a start date of dd/mm/yyyy and an end date of dd/mm/yyyy.

TECH Global University is a university officially recognized by the Government of Andorra on the 31st of January of 2024, which belongs to the European Higher Education Area (EHEA).

In Andorra la Vella, on the 28th of February of 2024

Dr. Pedro Navarro Illana
Rector

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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