UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

DEPARTMENT OF INDUSTRIAL ENGINEERING

STUDENT GUIDE

MASTER'S DEGREE IN AEROSPACE ENGINEERING

2023/2024

Napoli, July 2022

Goals and career opportunities:

The course aims to provide students deep knowledge of theoretical and scientific aspects of engineering, enabling identification, formulation and solving of complex problems with an interdisciplinary approach in the field of aerospace engineering.

Main subjects are:

- ✓ Fluid dynamics
- ✓ Flight mechanics
- ✓ Aerodynamics
- ✓ Gas dynamics
- ✓ Aerospace structures and technologies
- ✓ Aerospace systems
- ✓ Air and space propulsion

The typical professional fields for graduated aerospace engineering are those of innovation, development, and production, both in the freelance profession, manufacturing, or services, and in public administrations and research centres.

Graduates will be able to find employment in aeronautical and space industries; public and private bodies and companies for experimentation and applied research in the aerospace field and for the use of aerospace systems for application purposes; air transport companies; bodies for the regulation and management of air traffic and for the certification of aircraft; military aeronautics and aeronautical sectors of other weapons; organizations for research and development and companies for the production and operation of machines, plants and equipment where fluid dynamics, light structures, advanced modelling skills, systems control, advanced technologies are relevant.

The Master's Degree in Aerospace Engineering includes three curricula:

- Aeronautics
- Fluid Dynamics / Propulsion
- Space

Master's degree in Aerospace Engineering 2023/2024
CURRICULUM AERONAUTICS

First year		
First semester#		
Courses	**Language**	**Credits**
Mechanics applied to Aerospace Engineering OR Mathematical Methods for Engineering	**Italian**	**9**
Flight Dynamics and simulation	**Italian**	**9**
Aerospace Advanced Structures	**Italian**	**9**
Second semester#		
Reliability and risk in Aerospace Engineering OR Economy and organization of aerospace industry	**Italian**	**6**
Aircraft Aerodynamics	**Italian**	**9**
Avionics	**Italian**	**9**

Second Year			
Activities	**Language**	**Credits**	**Semester#**
Curriculum autonomous choice Courses* (2 courses of 9 credits + 2 courses of 6 credits)	**English/Italian**	**30**	**I/II**
Other autonomous choice Courses§ (1 course of 9 credits + 1 courses of 6 credits)	**English/Italian**	**15**	**I/II**
Traineeship	**English**	**12**	**II**
Thesis	**English**	**12**	**II**

(*) Curriculum autonomous choice Courses (30 Credits) – Aeronautics

*Curriculum autonomous choice Courses	Language	Credits	Semester#
Rotary wing Aerodynamics	Italian	9	II
Aerospace Constructions 2	Italian	6	I
Structural dynamics	Italian	6	I
Fluid-Structure Interaction	English	6	I
Numerical and experimental methods for Aircraft Design	English	9	I
Unmanned Aircraft Systems	English	9	I
Aeroelasticity	English	6	II
Aircraft on board systems	English	6	II
Aircraft Design	English	9	II
Air Traffic Management and Control	English	9	II
Flight Test	English	6	II

CURRICULUM FLUID DYNAMIC/PROPULSION

First year		
First semester#		
Courses	**Language**	**Credits**
Mechanics applied to Aerospace Engineering OR Mathematical Methods for Engineering	**Italian**	**9**
Flight Dynamics and simulation	**Italian**	**9**
Computational Fluid Dynamics	**Italian**	**9**
Second semester#		
Reliability and risk in Aerospace Engineering OR Economy and organization of aerospace industry	**Italian**	**6**
Aircraft Aerodynamics	**Italian**	**9**
Space Propulsion	**Italian**	**9**

Second Year			
Activities	**Language**	**Credits**	**Semester#**
Curriculum autonomous choice Courses* (2 courses of 9 credits + 2 courses of 6 credits)	**English/Italian**	**30**	**I/II**
Other autonomous choice Courses§ (1 course of 9 credits + 1 courses of 6 credits)	**English/Italian**	**15**	**I/II**
Traineeship	**English**	**12**	**II**
Thesis	**English**	**12**	**II**

(*) Curriculum autonomous choice Courses (30 Credits) – Fluid dynamic/Propulsion

Curriculum – Fluid dynamic/Propulsion			
*Curriculum autonomous choice Courses	Language	Credits	Semester#
Rotary wing Aerodynamics	Italian	9	II
Hypersonic Aerodynamics	Italian	9	I
Experimental Fluid Dynamics	English	9	I
Fluid-Structure Interaction	English	6	I
Aeroelasticity	English	6	II
Fluid Dynamic Stability	English	6	II
Space Experiments	English	6	II
Turbulence	Italian	6	II

CURRICULUM SPACE

First year		
First semester[#]		
Courses	**Language**	**Credits**
Mechanics applied to Aerospace Engineering **OR** **Mathematical Methods for Engineering**	**Italian**	**9**
Space Systems	**English**	**9**
Aerospace Advanced Structures	**Italian**	**9**
Second semester[#]		
Reliability and risk in Aerospace Engineering **OR** **Economy and organization of aerospace industry**	**Italian**	**6**
Space Propulsion	**Italian**	**9**
Space Flight Dynamics	**English**	**9**

Second Year			
Activities	**Language**	**Credits**	**Semester[#]**
Curriculum autonomous choice Courses[*] (2 courses of 9 credits + 2 courses of 6 credits)	**English/Italian**	**30**	**I/II**
Other autonomous choice Courses[§] (1 course of 9 credits + 1 courses of 6 credits)	**English/Italian**	**15**	**I/II**
Traineeship	**English**	**12**	**II**
Thesis	**English**	**12**	**II**

(*) Curriculum autonomous choice Courses (30 Credits) – Space

Curriculum Space			
*Curriculum autonomous choice Courses	Language	Credits	Semester#
Hypersonic Aerodynamics	Italian	9	I
Aerospace Remote Sensing Systems	English	9	I
Space Mission Design	English	9	II
Spacecraft Dynamics and Control	English	6	II
Space Experiments	English	6	II

(§) Autonomous choice Courses (15 Credits)

Autonomous courses can be selected among the following:

1. **Aerospace Engineering Master's degree Curricula (Aeronautics, Fluid dynamic/Propulsion, Space)**
2. **Other courses**

Other courses			
Courses	**Language**	**Credits**	**Semester#**
Combustion and Fluid Dynamics of recreative systems	Italian	6	I
Chemical fundamentals of technologies	Italian	9	I
Electro-magnetic basics for Space applications	Italian	9	I
Geometrical Modelling and virtual Prototyping for Aerospace Engineering	Italian	9	I
Design Principles for wind and ocean renewable energy system	Italian	6	I
Radar System	Italian	9	I
Statistical lab for industrial data analysis	English	9	I
Signal and Image Processing	Italian	9	II
Elastodynamics and structural health monitoring principles	English	6	II
Experimental Vibroacoustic	English	6	II
Electrical basics for Aeronautics	Italian	6	II
Impact dynamics	English	6	II
Machine Learning and big data	English	9	II
Hybrid Propulsion systems	Italian	9	II
Aerospace Design Project	English	9	Annual

COURSE DETAILS

AIRCRAFT AERODYNAMICS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

INFORMAZIONI GENERALI - ATTIVITÀ

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
None.

PREREQUISITES
Basic knowledge of Aerodynamics.

LEARNING GOALS
The course aims at completing the preparation of students in the applied aerodynamic field and providing them with methods for the solution of aerodynamic problems.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should achieve adequate knowledge of the applied aerodynamics and numerical methods and their theoretical formulations.

Applying knowledge and understanding
Students should demonstrate that they are able to apply the concepts, learned in the study of the aerodynamic phenomena and related numerical methods, for the analysis of vehicles' aerodynamics.

COURSE CONTENT/SYLLABUS

[2.5 CFU] Boundary layers: Physical aspects, Boundary layer theory, Methods for the solution of laminar and turbulent boundary layers, Flat-plate case and simplified cases, Stability, Transition and Turbulence of boundary layers.

[1 CFU] Aerodynamic drag: Physical aspects, Physical decomposition of direct and indirect contributions to the aerodynamic drag, Methods for the calculation of aerodynamic drag for simplified cases, Bluff body, Roughness effects and related turbulent boundary layer behavior, Roughness-induced increased-drag estimation.

[1.5 CFU] Airfoils: Lift generation, Inviscid linearized theory, Airfoil drag, Maximum lift and separation, Airfoils with laminar flow, Low Reynolds number Airfoils, Airfoils in transonic flow, Ground effect, Airfoils design.

[2.5 CFU] Wing: General characteristics of near-field velocity and pressure fields, Spanwise load distribution, Methods for the determination of spanwise load distribution, Ground effect, Induced drag, Wingtip devices, General characteristics of far-field velocity and pressure fields, Swept wing.

[1.5 CFU] Applied aerodynamics: Small-disturbance-flow theory over 3D wing, Slender wing theory, Numerical Panel Method, Lifting-Surface Theory, Vortex Lattice Method.

READINGS/BIBLIOGRAPHY
McLean – Understanding Aerodynamics, Wiley
Anderson – Fundamentals of Aerodynamics, McGraw-Hill
Katz & Plotkin – Low Speed Aerodynamics, McGraw-Hill
Pope – Basic Wing and Airfoil Theory, McGraw-Hill
Bertin & Cummings – Aerodynamics for Engineers, Pearson

Schlichting – Boundary-Layer Theory, McGraw-Hill

TEACHING METHODS

Lectures and numerical exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) More options are allowed

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

ROTARY WING AERODYNAMICS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

None

PREREQUISITES (IF APPLICABLE)

Basic knowledge of aerodynamic physical principles.

LEARNING GOALS

The aim of the course is the introduction to the Aerodynamics of the rotary wing and in particular to the study of propellers, rotors and wind turbines. Both the theoretical and technical aspects are taken care of, which lead the student to the direct experience of design. The course includes exercises that require the use of open source software, electronic tables (Excel), programs in MatLab and the use of the commercial software ANSYS-Fluent public version for students.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student will have to demonstrate that he achieved adequate knowledge of the methodologies for modeling the aerodynamics of propellers, rotors and aircraft engines.

Applying knowledge and understanding

The student will have to demonstrate that he is able to design and evaluate the aerodynamic performance of propellers, rotors and aircraft with the help of appropriate commercial or open source software.

COURSE CONTENT/SYLLABUS

[2 CFU] Unsteady aerodynamics. Navier-Stokes equations in non-inertial reference. Reduced frequency. Incompressible non-dissipative flow. Bernoulli theorem in steady state. The slim profile. Karman & Sears formula. The case of periodic oscillations, Theodorsen theory. Quasi-stationary regime.

[2 CFU] Aerodynamics of the propeller. The actuator disk model. Simple and general momentum theory. Optimal axial and rotational inductions. The vortex system of the propeller. Blade Element Momentum Theory. An approximate optimum condition. Effect of the finite number of blades. Optimal propeller design. Ducted propellers. Momentum theory in compressible regime. A numerical model of actuator disc in compressible regime.

[1 CFU] Aerodynamics of the rotor. Impulsive theory for the hovering rotor. Theory of the blade element for the hovered rotor.

[1 CFU] Ideal and optimal rotor. The real rotor. Figure of merit. Autorotation. Axial climb and descend. Ground effect in hovering. Momentum theory in forward flight. Operating curves. Parasitic power in forward flight.

[1 CFU] Estimate of the required power. Need for the articulated rotor. Cyclical and collective pitch. Dynamics of the blade. Flapping coefficients. Actual speeds and aerodynamic forces. Power in forward flight. Calculation of flapping coefficients. Notes on helicopter configurations. Helicopter performance.

[2 CFU] Aerodynamics of aircraft. Characteristics of turbines. Betz limit. Optimal torque and power for a horizontal axis wind turbine. Blade geometry. Blade airfoils. Characteristic curves and performance of turbines. Wind concentrators. Tip vanes. Vertical axis wind turbines. Differential action turbines. Darreius type turbines.

READINGS/BIBLIOGRAPHY

1) Lezioni di Aerodinamica dell'ala rotante di Renato Tognaccini, available online.

TEACHING METHODS

Lectures, homework written and by computer.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The grade is formulated by the Commission based on the outcome of the written test and the adequacy of the answers provided by the student to the questions asked during the oral test. The student will develop computer projects such as numerical exercises. The final grade is also suitably motivated to the student.

COURSE DETAILS

HYPERSONIC AERODYNAMICS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

None

PREREQUISITES (IF APPLICABLE)

Basic knowledge of aerodynamic physical principles.

LEARNING GOALS

This Course will provide the students with fundamental knowledge on physical effects, classical methods, and recent advancements of hypersonic flows adopted in high enthalpy regimes typical of reentry vehicle, with the aim to fulfill the student knowledge on aerodynamic and space technologies. Specific objectives include: 1) review different hypersonic vehicles and their trajectories; 2) study the environment around hypersonic vehicles created by strong shock waves; 3) introduce students to real gas and nonequilibrium effects caused by high temperature conditions and chemical reactions; 4) study pressure and heat transfer phenomena around hypersonic vehicles in continuum and rarefied flow; 5) educate students on hypersonic experimental test facilities and measurements.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Starting from lessons learned in aerodynamics, the student shall demonstrate an adequate knowledge of high enthalpy flow physics and main problems related to re-entry mission. The course aims to provide the knowledge and the basic methodological tools necessary to analyze typical problems related to the dynamics of atmospheric re-entry. These tools will allow students to analyze the main relationships between the flight of a spacecraft during its re-entry phase, and problems such as aerodynamic heating and decelerations of space vehicles.

Applying knowledge and understanding

The course is aimed to provide students with the methodological-operational aspects necessary to apply the knowledge in the field of flow regimes at high Mach numbers. At the end of the course the student must demonstrate that he/she is able to apply the acquired concepts in the study of relatively simple problems of atmospheric re-entry.

COURSE CONTENT/SYLLABUS

[1 CFU] Fundamentals of hypersonic flight and hypersonic flows.

[1 CFU] Main problems in high enthalpy flows. Aerodynamic heating and aerothermochemistry. Aerothermodynamics of re-entry space vehicles: blunt and lifting bodies. Ballistic parameter and its effect on aerodynamic loads and heat transfer.

[0.5 CFU] Hypersonic shock and expansion waves. Shock angle calculation. Entropy Layer.

[0.5 CFU] Approximate inclination methods for hypersonic flow: Newton theory, tangent-cone method, shock-expansion method.

[1 CFU] Non viscous hypersonic flow methods: method of characteristics; small disturbances theory and principle of Hayes equivalence. Application to flow field around a cone: Taylor and Maccoll equation, other methods.

[0.5 CFU] Small disturbance theory and Hayes principle.

[1 CFU] Aero-thermo-chemistry, chemical and vibrational nonequilibrium. Lighthill and Monti-Napolitano models. Post shock relaxation zone. High temperature viscous flow.

[1 CFU] Hypersonic viscous flow. Equations for chemically reacting flows.

[1 CFU] Hypersonic boundary layer theory. Viscous interaction.

[1 CFU] Introduction to rarefied aerodynamics: Maxwell Theory and Free Molecular Flow, transition regime.

[0.5 CFU] Hypersonic experimental test facilities and measurements. Arc-jet plasma wind tunnels.

READINGS/BIBLIOGRAPHY

1) Elementi di aerodinamica ipersonica, Monti & Zuppardi, Liguori Editore.
2) Hypersonic and High-Temperature Gas Dynamics di John D., Jr. Anderson, Second Edition (AIAA Education)

TEACHING METHODS

Lectures (60% of total hours), numerical (38% of total hours) and laboratory (2% of total hours) sessions.

EXAMINATION/EVALUATION CRITERIA

c) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

d) Evaluation pattern:

COURSE DETAILS

AEROELASTICITY

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

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PREREQUISITES

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LEARNING GOALS

The objective of the course is to introduce the student to the problems of the interaction of aerodynamics, inertia and elastic forces for a flexible structure and the phenomena that can result. The course will be based upon the knowledge of the finite element method and the aerodynamics of lifting surfaces and moves toward the methods of the aeroelasticity from both the numerical and the experimental point of view. The ability of setting up an experimental modal testing will be discussed, and the students will be requested to deal with ground vibration testing and identification methods. The aeroelastic approach will represent furthermore the basis for the design and multidisciplinary optimization of flexible structures.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic aerolastic phenomena and the formulations for representing them in the framework of an optimized design of aircraft.

Applying knowledge and understanding

Students will be able to model a flexible lifting surface under unsteady aerodynamic loads and to verify the criteria for the aeroelastic clearance. Students should be able to assess the results form an experimental and numerical point of view.

COURSE CONTENT/SYLLABUS

[1 CFU] Structural dynamics of single and multi degree of freedom systems. Vibration of continuous systems.

[1 CFU] Static aeroelasticity. Lift distribution, divergence and control effectiveness.

[1 CFU] Experimental modal analysis. Ground vibration tests. Measurements and identification of structural modal parameters. The reduced frequency. The simple aeroelastic wing section. Dynamic aeroelasticity. Unsteady aerodynamics. The Doublet Lattice Method.

[1 CFU] Introduction to unsteady aerodynamics. The flutter phenomenon. The wing section flutter speed. The numerical flutter calculations. The aeroelastic behavior of control surfaces. The V-g and p-k method.

[1 CFU] Effect of non-linearities. Buffeting. Gust and turbulence encounters in time domain and frequency domain. Ground manoeuvres. Flight flutter testing. Aeroelastic wind tunnel testing.

[1 CFU] The aeroelasticity of civil structures. Aeroelastic phenomena of rotating structures.

READINGS/BIBLIOGRAPHY

Course notes.
Bisplinghoff R. L., Ashley H., Halfman R. L., Aeroelasticity, Dover Publications, 1996.
Wright J. R., Cooper J. E., Introduction to Aircraft Aeroelasticity and Loads, John Wiley & Sons, Ltd. 2007.

TEACHING METHODS

Practice with commercial finite element programs.
Implementation of self-coded program, usually using Matlab, for solving simple aeroealstic problems.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	X
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.
The student can develop a report on a specific project topic. This activity is not mandatory.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

AEROSPACE DESIGN PROJECT

SSD ING-IND/04 – 05 - 06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: FIRST AND SECOND
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

This course takes its motivation from the strong interest and growing need of the industrial world in a multidisciplinary approach to engineering problems and design. To answer these requests, this course is aimed to contribute to some specific learning outcomes. The class will be subdivided in group of students. Each group will autonomously select a specific project to be completed by the end of the course. Each student is forced to acquire ability in working in a team environment, improving his/her project management and communication skills, to identify, formulate, and solve engineering problems, to explore and propose solutions, to design a system, or a component, or a process to meet requirements and specifications, managing engineering standards. The students will also learn how to communicate effectively in oral and written form.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should get the team-working, the project management and communication skills.

Applying knowledge and understanding
Students should be able to analyze and to propose the related engineering solutions for an aerospace project paying attention to multidisciplinary objects and requirements as well as design constraints.

COURSE CONTENT/SYLLABUS

[9 CFU] This course provides an opportunity to tackle with complex aerospace system, in a team environment, designing tasks and simulating real working situations, aiming to propose credible and reliable conceptual design solutions. The course is primarily project-based. Student design teams may propose their own project providing a sustainable team working organization. A design brief for an aerospace system is provided, to be used to generate a set of project requirements and specifications to be complied. The student team is asked to provide, to evaluate and to select suitable design concepts to meet the project requirements according to the requested specifications.

READINGS/BIBLIOGRAPHY

Course slides and lecture notes.

TEACHING METHODS

Lectures, tutorials, Seminars with field experts.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the evaluation of the project developed by the student (in team-working) and according to the successive discussion during the oral exam. The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

AEROSPACE REMOTE SENSING SYSTEMS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

-

PREREQUISITES

-

LEARNING GOALS

This course is intended to provide a basic knowledge of scientific and engineering problems related to the aerospace systems for earth observation, with particular reference to airborne and spaceborne high resolution sensors, both in the electro-optical and microwave region of the electromagnetic spectrum, and to space remote sensing mission analysis and design.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic concepts of earth observation by systems based on aerospace remote sensors.

Applying knowledge and understanding
Students should learn the drivers for designing aerospace remote sensing systems with reference to the common engineering problems associated with earth observation.

COURSE CONTENT/SYLLABUS

[2 CFU] Basics of physics of remote sensing. Basics of atmospheric effects on radiation propagation and atmospheric windows. Basics on spectral properties and spectral signatures of natural and man-made targets. Impact on spectral band selection of remote sensors. Examples.

[2 CFU] Passive electro-optical systems, basics of radiometry and optics, telescopes, detectors. Amplitude and Phase Modulation Transfer Functions and geo-radiometric resolution. Multispectral and hyperspectral systems. Data acquisition and basics of digital processing. Radiometric Calibration, Geometric Calibration, Image Registration and Georeferencing.

[2 CFU] Active microwave systems, pulse, Doppler and chirp radar, side-looking radar. Basics on antenna pattern and radar equation for point and extended targets. Synthetic aperture radar (SAR), geometrical issues and range and azimuth resolutions, range-Doppler analogy, Pulse Repetition Frequency, ambiguity. Basics on chirp compression and SAR processing.

[1 CFU] Interferometric and multistatic systems, basics of interferometric processing. Examples of possible solutions and system design.

[2 CFU] Mission analysis of space remote sensing systems, sunsynchronous orbits, repetition factor and coverage patterns, pointing maneuvers, factors affecting orbit and pointing design. Constellations. Examples. Elements on Ground Stations.

READINGS/BIBLIOGRAPHY

T. M. Lillesand et al., “Remote Sensing and Image Interpretation”, J. Wiley & Sons, 2004.
A. V. Oppheneim et al., “Signals and Systems”, Prentice Hall, 1997.
F. T. Ulaby et al., “Microwave Remote Sensing Active and Passive”, Addison-Wesley, 1981.
A. Moccia, “Synthetic Aperture Radar”, Encyclopedia of Aerospace Engineering, J. Wiley & Sons, 2012.
K.I. Duck et al. “Orbital Mechanics for Remote Sensing”, in Manual of Remote Sensing, American Society of Photogrammetry, Virginia, Vol. 1, 1983.

TEACHING METHODS

Lectures and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

RELIABILITY AND RISK IN AEROSPACE ENGINEERING

SSD SECS-S/02

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Basic knowledge in statistics and mathematics

LEARNING GOALS

The objective of the course is providing the students with concepts, methodology, and tools useful for developing reliability and maintainability analyses of components and complex systems as well as for performing risks assessments, including economic ones, associated with use, management, and design thereof.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

On successful completion of the course, the students are expected to be able tackle the following problems: to assess the reliability of simple devices and complex systems, to select maintenance policies.

Applying knowledge and understanding

On successful completion of the course, the students are expected to be able to perform the following tasks: to design a reliability demonstration test; to assess risks; to compute Life Cycle Costs of technological units.

COURSE CONTENT/SYLLABUS

[1,5 CFU] Reliability on non- repairable units

Definition of reliability. Time to failure. Reliability function. Probability density function of time to failure and hazard function. Reliability of used units. Mean time to failure and mean residual life function. Reliability models: negative exponential, Weibull, lognormal, normal and gamma models, Mixed population. Competing risk model, Stress-Strength model. Transformation of Random Variables. Ordered statistics. Delta method. Reliability of non-repairable complex systems. Reliability block diagrams and their solution. Series systems, parallel systems, stand-by systems, r out of n parallel systems, load sharing model, and combinations thereof. Systems with irreducible structure and related solution. Fault Tree Analysis. Reliability allocation.

[1,5 CFU] Reliability on repairable units

Stochastic Point processes. Counting process. Times to failure, times between failures and waiting time to the next failure. Mean function, rate of occurrence of failures, intensity function, and reliability function. Homogeneous Poisson Process, non- homogeneous Poisson process, renewal process.

[1,5 CFU] Inferential procedures

Statistical methods for the analysis of failure data from non-repairable units: complete and censored samples, non-parametric estimators of reliability, maximum likelihood method, and probability Plots. Statistical methods for the analysis of failure/repair data from repairable units: Laplace test and MIL-test. Graphical methods. Maximum likelihood method.

[1 CFU] Economic analysis of failures

Maintenance policies: corrective maintenance, age-based maintenance, time based maintenance, and condition-based maintenance. Life cycle costing. Risk analysis.

[0,5 CFU] RAMS Seminars (Reliability, Maintainability, Safety, FMEA, FMECA).

READINGS/BIBLIOGRAPHY

Course notes prepared by the teacher.
P. Erto, 2008, Probabilità e statistica per le scienze e l'ingegneria, 3a edizione, McGraw-Hill

Other recommended books
P. O'Connor, A. Kleyner, 2012, Practical reliability engineering, 5Th edition, Wiley.
G. Yang, 2007, Life Cycle Reliability Engineering, John Wiley &Sons.

TEACHING METHODS

Lectures and Seminars.

EXAMINATION/EVALUATION CRITERIA

c) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

d) Evaluation pattern:

The grade is formulated by the Examination Commission based on the outcome of the written test and the adequacy of the answers provided by the student to the questions asked during the oral test.
The elements that have been taken into consideration to determine the final grade are illustrated to the student.

COURSE DETAILS

AIRCRAFT DESIGN

SSD ING-IND/03

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Basic knowledge of aerodynamics, aircraft aerodynamics, aircraft stability and control, basic principles on aircraft structural layout and wing and fuselage structural sizing.

LEARNING GOALS

The course will show a complete and organic methodology for the preliminary design of transport aircraft. Starting from the design requirements, all problems concerning design of airplane components and the design of the complete aircraft will be shown. Several applications using software tools for preliminary sizing of aircraft will be performed. Application, methods, and data to enable case studies of subsonic aircraft design are provided and students will develop in group the preliminary design of a transport aircraft also enhancing their soft skill and team-working capabilities.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic methodologies which rule the preliminary design of an aircraft.

Applying knowledge and understanding
Students will be able to develop a multidisciplinary optimization for the preliminary sizing of a transport aircraft.

COURSE CONTENT/SYLLABUS

[3 CFU] Engineering design. Aircraft design process and phases. Design requirements. Certification rules and impact on the design. Basic principles of flight mechanics applied to aircraft design. Aircraft weight and balance. Preliminary aircraft sizing (aircraft weights, wing area and installed thrust), sizing plot.

[3 CFU] Improved flight performance. Stall speed and its effects. Buffet barrier. Jet aircraft cruise grid and best flight conditions. Payload-Range diagram. Block speed. Transport efficiency and productivity. Direct operating cost (DOC) of an aircraft. Optimal range and speed. Wing Design. Flight performances, cruise speed. Drag divergence and buffeting. High-lift system design. Stall speed. Take-off and Landing. Fuselage design. Drag polar estimation. Flight performances calculation

[3 CFU] Longitudinal stability. Stick fixed and stick free stability (neutral point). Longitudinal control issues and horizontal tailplane design. Maneuvering stability. Directional stability and control. Vertical tailplane design. Minimum control speed (VMC) and critical engine definition. Adverse yaw. Lateral stability and dihedral effect. Aileron efficiency and design. Landing gear design. Aircraft cost, safety and environmental issues. Different configurations and arrangements (high-wing vs low-wing, propulsion and engine position, landing gear layout).

READINGS/BIBLIOGRAPHY

Slides and course notes. The students will be also working with a specific software called ADAS and specific applications in Matlab and Excel for aircraft preliminary design.

TEACHING METHODS

Lectures on theory and exercises and applied examples focused on the development of a conceptual/preliminary design of an airplane.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

Examination in average consists of a written essay on two assigned topics (i.e. design of the wing, design of the vertical tail) with open answer. Evaluation of student's capabilities concerning synthesis, link among different topics and design procedures. The development of the group design project gives an additional score (it is not mandatory).

COURSE DETAILS

AIRCRAFT ON-BOARD SYSTEMS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

-

PREREQUISITES

-

LEARNING GOALS

The course discusses all aircraft on-board systems that are needed to develop a professional aircraft. Principle of operation and application examples will be presented. All development phases will be considered, such as design, manufacturing, integration, and maintenance.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the fundamental components of aircraft on-board systems.

Applying knowledge and understanding

Students will be able to design aircraft on-board systems with reference to manufacturing, integration and maintenance issues.

COURSE CONTENT/SYLLABUS

[1 CFU] Air Conditioning and Cabin Pressurisation System.

[1 CFU] Electrical Power System. Equipment and Furnishings. Fire Protection System.

[1 CFU] Flight Controls System. Fuel Systems. Hydraulic Power System.

[1 CFU] Ice and Rain Protection System. Landing Gear. Lights.

[1 CFU] Oxygen System. Pneumatic/Vacuum System. Water/Waste System.

[1 CFU] On Board Maintenance Systems. Emergency Management System.

READINGS/BIBLIOGRAPHY

Course notes and slides.

Reference Textbooks

Currey, N.S., “Aircraft Landing Gear Design: Principles and Practices”, AIAA Press, 1988.
Moir, I., Seabridge A., “Aircraft Systems: Mechanical, Electrical and Avionics Subsystems”, John Wiley and Sons, 2008.
Moir, I., “Aircraft Systems: Mechanical, Electrical, and Avionics Subsystems Integration”, 3rd edition, Wiley, 2008.
Clark C., “Aircraft Fuel Systems”, John Wiley and Sons, 2009.

Tooley M. and Wyatt D., Aircraft Electrical and Electronic Systems – Principles, Maintenance, and Operations, Elsevier, 2009.
Seabridge A. and Morgan S., Air Travel and Health: A Systems Perspective, John Wiley and Sons, 2010.
Eismin, T., "Aircraft Electricity and Electronics", 7th Edition, McGraw Hill, 2019.
Seabridge, A., Moir, I., "Design and Development of Aircraft Systems", 3rd edition, Wiley, 2020.
Hilderman, V., "The Aviation Development Ecosystem", Afuzion Inc., 2021.

TEACHING METHODS

Lectures. Experimental seminars. Tour to manufacturers plants.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

AIR TRAFFIC MANAGEMENT AND CONTROL

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

This course will provide a complete overview about Air Traffic Management and Air Traffic Control systems and procedures. In this framework, the aircraft is considered a component of a global traffic scenario at national, continental, and intercontinental level. The main topic discussed in the course can be summarized as follows: i) Regulations; ii) Surveillance; iii) Navigation; iv) Operations; v) Weather and environmental issues; vi) Advanced topics: UAS integration, PBN, Airport Automation, and modernization. Since Air Traffic Management is developing several innovations in the last few years, a large analysis of future most important changes will be presented at the end of the course. It includes all topics accounted in the main innovation projects worldwide, i.e. Next Gen in the US and SESAR in Europe. Moreover, this course will give students knowledge of Aeronautical Communications System and Air Routes. Theoretical, technological, design, installation and operational issues will be addressed. Course aims at enabling students to manage at system level Voice Communications, Digital Communications, Aircraft Trajectory Prediction, and Mission Path Planning, basics of UAS traffic management and integration.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic elements for air traffic management and for traffic control systems and procedures.

Applying knowledge and understanding
Students will be able to apply the operational issues and design information for the management and control of air traffic.

COURSE CONTENT/SYLLABUS

[3 CFU] ATM fundamentals: System Structure, Basic Procedures; Operational Rules.
ADS-B.
Collision Avoidance, TCAS.
PBN-Performance-Based Navigation: RNAV and RNP.
System Modernization: Next Gen and Sesar.

[3 CFU] Operations: Airport and Terminal Operations; En route Operations; Oceanic Operations;
Weather and environmental issues;
ATM System Modeling;
Aircraft trajectory prediction;
Airport Automation: ASMGCS;

[3 CFU] Basics of radio communications.

Regulations and standards for aeronautical radio communications. Voice radio links; Data radio links.
Air routes: Definition of air routes and flight planning;
Geodesics as paths over the Earth ellipsoid.
Basics of UAS traffic management and integration.

READINGS/BIBLIOGRAPHY

Course slides and lecture notes.

Reference textbooks:

Nolan, M.,S., Fundamentals of Air Traffic Control, Cengage Learning.
Kayton, M. and Fried, W.R., Avionics Navigation Systems, Wiley-Interscience.
Spitzer, C.R., and Ferrell, U., Digital Avionics Handbook, CRC Press.
Helfrick, A., Principles of Avionics, Avionics Communications Inc..
Ashford, N.J., Stanton, H.P.M., and Moore, C.A., Airport Operations, McGraw-Hill Professional Publishing.
Tooley, M. and Wyatt, D., Aircraft Communications and Navigation Systems. Principles, Maintenance and Operation, Routlege.
Stacey, D., Aeronautical Radio Communication Systems and Networks, John Wiley and Sons.

TEACHING METHODS

Oral lectures, laboratory experiences, seminars with field experts, tours to companies and research institutions that are involved in production and integration of ATM related systems.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

AVIONICS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

-

PREREQUISITES

Basic knowledge of system dynamics, maths, general physics, electrical systems.

LEARNING GOALS

The student will acquire knowledge of the operating principles, the design and integration problems of the avionics components on board an aircraft. In particular, the problems relating to air navigation will be investigated. The student will have to acquire understanding of the main engineering aspects related to the use of inertial systems, air data systems, aerial radio navigation systems and satellite navigation systems (GPS, Glonass, Galileo). Reference concepts for aerial surveillance will also be defined. In addition, he / she will have to manage measurement integration techniques such as the Kalman Filter.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students must demonstrate that they have achieved adequate knowledge of the operating principles for the main elements that make up the avionics on board an aircraft.

Applying knowledge and understanding

Students will have to demonstrate that they are able to deal with the design and integration of avionics components on board an aircraft with reference to the problems relating to air navigation.

COURSE CONTENT/SYLLABUS

[1 CFU] On-board avionics subsystems. Display systems.

[3 CFU] Basic concepts of near Earth navigation. Conventional gyroscopes. Unconventional gyroscopes: Coriolis gyroscopes, Dinamically Tuned Gyro, MEMS gyroscopes, Optical gyroscopes. Inertial navigation equations. Inertial navigation error. Stability of the vertical channel of inertial navigation.

[1 CFU] Air data systems.

[2 CFU] Radio assistance: NDB, ADF, VOR, TACAN, DME, RNAV. Instrument Landing System (ILS). Doppler radar. Laser altimeters. Satellite navigation systems: GPS system, Sources of GPS errors. Pseudorange equations, Dilution of Precision. Integrity: RAIM. Dual frequency receivers. Differential GPS. Kalman filter. Integrated navigation.

[2 CFU] Surveillance (primary radar and ground control centers). Identification (secondary radars and transponders). ATCRBS, mode-S. Advanced on-board systems and cockpits: GPWS; TAWS.

READINGS/BIBLIOGRAPHY

Course notes and slides.

Reference Textbooks
Merhav, S., "Aerospace Sensor System and Applications", Springer Verlag, 1996.
Kayton, M., Fried, W.R., "Avionics Navigation Systems", 2nd ed., John Wiley&Sons, 1997.
Savage P.G., “Strapdown Analytics”, Strapdown Associates Inc., 2000.
Rogers R. M., "Applied Mathematics in Itegrated Navigation Instruments", AIAA Press, 2000.
Titterton, D. H., "Strapdown Inertial Navigation Technology", 2nd edition, American Institute of Aeronautics and Astronautics, 2004.
Farrell J. and Barth M., "Aided Navigation: GPS with High Rate Sensors ", McGraw Hill, 2008.
Moir, I., “Aircraft Systems: Mechanical, Electrical, and Avionics Subsystems Integration”, 3rd edition, Wiley, 2008.
Rierson, L., “Developing Safety-Critical Software: A Practical Guide for Aviation Software and DO-178C Compliance”, 1st Edition, CRC Press, 2013.
Kenney, S., “Avionics: Fundamentals of Aircraft Electronics”, Avotek Information Resources, 2013.
Collinson, R.P.G., "Introduction to Avionics Systems”, 3rd edition, Springer Nature, 2014.
Fulton, R., “Airborne Electronic Hardware Design Assurance: A Practitioner's Guide to RTCA/DO-254”, 1st Edition, CRC Press, 2014.
Helfrick, A., “Principles of Avionics”,9th edition, Avionics Communications Inc., 2015.
Spitzer, C., Ferrell, U., Ferrell, T., “Digital Avionics Handbook 3rd Edition“, CRC Press, 2017.
Eismin, T., “Aircraft Electricity and Electronics”, 7th Edition, McGraw Hill, 2019.
Seabridge, A., Moir, I., “Design and Development of Aircraft Systems”, 3rd edition, Wiley, 2020.
Hilderman, V., “The Aviation Development Ecosystem”, Afuzion Inc., 2021.
Dillon, S. (edited by), “Advanced Principles of Avionics”, States Academic Press, 2022.

TEACHING METHODS

Lectures. Experimental seminars. Tour to manufacturers plants.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.

The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

COMBUSTION AND REACTIVE FLUID DYNAMICS

SSD ING-IND/25

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME : II
SEMESTER : I
CFU: 6

REQUIRED PRELIMINARY COURSES:
none

PREREQUISITES :
none

LEARNING GOALS
The course aims to provide the methodological tools and knowledge to frame combustion processes in the context of propulsion, sustainable mobility and power generation applications in order to evaluate their potential development under the constraints related to alternative fuels, pollutant emission limits and performance. Furthermore, the course defines the most relevant prototype configurations and equations describing combustion processes evolving under fixed boundary/initial conditions, analyzing their most significant parameters and most sensitive variations.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student will have to demonstrate an adequate knowledge of combustion systems and their main applications with reference to mobility and power generation.

Applying knowledge and understanding
The student needs to demonstrate to be able to analyze the elementary processes that characterize the modern combustion systems and to guide the design choices also as a function of the environmental impact minimization.

COURSE CONTENT/SYLLABUS

[0.5 CFU] Combustion course introduction. Reactive flow balance equations.

[1 CFU] Adiabatic flame and equilibrium temperatures. Definition and calculation. Fossil and alternative fuels. Biofuels and E-Fuels for mobility and power generation.

[1 CFU] Homogeneous Combustion. Branching reactions. Hydrogen/Oxygen kinetics and explosion diagram. Hydrocarbon oxidation kinetics mechanisms. Steady-state and unsteady oxidation regimes.

[1 CFU] Chemical kinetics modeling. Chemkin software for 0D combustion modeling. Detonation and Deflagration. Rankine-Hugoniot and Rayleigh laws for detonation.

[1 CFU] Laminar Deflagration. Mallard-Le Chatelier theory. Laminar flame speed definition and dependence on system parameters. Turbulent flows and Kolmogorov theory, Borghi Diagram.

[0.5 CFU] Diffusion Ignition processes. 1D stretched diffusion flames modeling.

[1 CFU] Combustion aerodynamics. Atomization and vaporization of liquid fuels. CFD of turbulent reactive flow. Test-case for CFD modeling by means of Fluent.

READINGS/BIBLIOGRAPHY

Lecture notes, online materials and slides.
Video-recording of the lessons reported in https://www.docenti.unina.it/downloadPub.do?tipoFile=md&id=593616
Slides of the course reported in http://www.federica.unina.it/corsi/combustione/
Textbooks: "Lezioni di Combustione" by Antonio Cavaliere, Ed Enzo Albano, 2001 and reported in http://wpage.unina.it/antcaval
Lessons of Combustion published on the site of the Italian section of the Combustion Institute: http://www.combustion-institute.it/

TEACHING METHODS

Lectures notes, Additional lectures, seminars and modeling tutorials

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

b) Evaluation pattern:

The grade is formulated by the Examination Committee on the basis of the consistency of the answers provided by the student to the questions that have been formulated.
The final grade is also suitably motivated to the student.

COURSE DETAILS

AEROSPACE CONSTRUCTIONS II

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION - ACTIVITIES

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

PREREQUISITES

-

LEARNING GOALS

The course aims to deliver theoretical and practical tools for solving structural problems with composite materials for aerospace applications, by calculating the stress state in orthotropic materials, defining the failure theories and the criteria for the structural sizing. The fracture mechanics is then introduced for metallic materials. The crack propagation models are studied and the calculus criteria and sizing procedures analyzed.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student will have to demonstrate that he has achieved an adequate knowledge of the structural design methods of shell structures used in aerospace engineering.

Applying knowledge and understanding

The student will have to demonstrate that he is able to determine and calculate the stress state in composite shell structures and solve fracture mechanics problems.

COURSE CONTENT/SYLLABUS

[0,5 CFU] The effect of structural constraints in shell structures: shear lag and torsion-bending.

[0,5 CFU] Composite materials for aerospace applications. Sizing criteria. Some considerations on the manufacturing process.

[1 CFU] Elastic behavior of layered materials under thermo-mechanical loads. Classical lamination theory. Failure criteria.

[1 CFU] Design criteria with composite materials. Low velocity impact damages. Buckling of orthotropic thin plates. Sizing approach of a composite wing box and fuselage. Finite element applications.

[2 CFU] S-N curves and fatigue life. Stress concentration factor and stress intensity factor. Energy approach in fracture mechanics. Crack propagation models. Numerical calculation of crack propagation in shell structures: wing box and fuselage barrels.

[1 CFU] Introduction to nondestructive testing. Lab applications: ultrasounds for delamination detections.

READINGS/BIBLIOGRAPHY

T.H. Megson, Aircraft structures for Engineering Students – Edward Arnold.
R.M. Jones, Mechanics Of Composite Materials, CRC Press.

M.C.-Y. Niu, Composite airframe structures: practical design information and data, Conmlit Press LTD 1992.
Basic Mechanics of Laminated Composite Plates, NASA RP 1351 (Free download from: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19950009349_1995109349. pdf)
Notes of the course.

TEACHING METHODS

Theoretical lessons, numerical exercises with case studies.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) Several options are allowed

b) Evaluation pattern:

The grade is formulated by the Examination Committee on the basis of the adequacy of the answers provided by the student to the questions that have been formulated in the oral test and on the basis of a written test that involves the resolution of some numerical problems.
The final grade is also suitably motivated to the student.

COURSE DETAILS

FLIGHT DYNAMICS AND FLIGHT SIMULATION

SSD ING-IND/03

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: 1
SEMESTER: 1
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Basic knowledge of aerodynamics, aircraft aerodynamics, atmospheric flight performance, aircraft static stability and control.

LEARNING GOALS

The main objective of the course is to provide all elements to numerically simulate the aircraft motion in atmospheric flight. Prediction of loads, spins, inertial coupling and effect of gusts are in the scope of the course. The modern flight simulation techniques are also discussed. The course introduces the use of simulation codes implementing the numerical resolution of 6-degrees-of-freedom airplane equations of motion. Some simulation-related special topics are also presented, such as the graphic representation of flight, and the interactive management of flight control systems in pilot-in-the-loop simulations.

The course introduces to the principles underlying the dynamic stability of the airplane and gives the elements needed to evaluate aircraft flying qualities. Students are guided to the comprehension of the main concepts through practical examples. Proposed exercises are solved by making use of Matlab and Simulink.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic methodologies solve the equations of motion, in their various formulations.

Applying knowledge and understanding

Students will be able to develop a hands-on method to assess aircraft flight qualities thorough the application of simulation codes provided in the course.

COURSE CONTENT/SYLLABUS

[1 CFU] Reference coordinate systems. Derivation of the general equations of motion of an airplane in atmospheric flight. Equilibrium flight conditions.

[3 CFU] Analysis of aircraft longitudinal stability, including nonlinear effects. Manoeuvring loads on tail planes. Manoeuvred flight. Inertial coupling effects. Exercises on the numerical resolution of aircraft equations of motion.

[2 CFU] Some history of flight simulation. Characteristics and design goals of modern flight simulators and flight training devices. Complete representation of aerodynamic and propulsive forces and moments. Graphic representation of flight. Pilot-in-the-loop simulations. Piloting efforts and force feedback on airplane controls. Programming languages and meta-languages commonly used in flight simulation practice (C++, Matlab, XML, VRML).

[3 CFU] Aircraft linearized equations and dynamic stability. Longitudinal and lateral-directional approximated equations. Characteristic modes of airplane response. Gust response. Use of Matlab and Simulink for analysis

of the main characteristic modes: short-period, phugoid, and dutch roll. Definition of flying qualities and estimation criteria.

READINGS/BIBLIOGRAPHY

Slides and course notes. The students will be also working with many Matlab/Simulink examples provided by the instructor.

TEACHING METHODS

Lectures on theory and exercises and applied examples.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

Oral examination aiming at evaluating of student's understanding and assimilation of the course topics. The development of a personal technical report collecting practical exercises gives an additional score (it is not mandatory).

COURSE DETAILS

STRUCTURAL DYNAMICS

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The main goal of the course is to complete the student's knowledge about structural dynamics and identification and dynamic characterization of complex systems. These objectives are pursued both with analytical, numerical, experimental methodologies; mainly by focusing the attention on the possibility of comparing these different approaches to obtain an optimization of the developed models.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should demonstrate the achievement of an adequate knowledge of common methodologies for the dynamic analysis of aerospace structures.

Applying knowledge and understanding

Students should be able to independently carry out a dynamic analysis of the typical structural elements of aerospace vehicles with analytical, semi-analytical, numerical and experimental methodologies.

COURSE CONTENT/SYLLABUS

[1 CFU] Introduction to analytical and/or semi-analytical solution of dynamic problems. The convergency of a modal solution. Review of numerical techniques for modal parameter extraction.

[1 CFU] The Rayleigh-Ritz approach versus the finite element method.

[1 CFU] Review of signal processing for the analysis of the measured data in structural dynamics.

[1 CFU] Identification and characterization of dynamic systems through experimental tests (SDOF and MDOF methods).

[1 CFU] Validation of the synthetized dynamical models derived from experimental data.

[1 CFU] Model updating e structural optimization.

READINGS/BIBLIOGRAPHY

L. Meirovitch: Elements of Vibration Analysis, 2nd Edition, McGraw-Hill, 1986.
D. J. Ewins: Modal Testing: Theory, Practice and Application, Research Studies Press Ltd., 2001.
R. D. Cook: Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 2001.

L. Meirovitch: Computational Methods in Structural Dynamics, Sijthoff & Noordhoff, 1980.

TEACHING METHODS

Lessons on theoretical topics. Introduction to the application of the numerical methods. Seminars and lectures on some specific themes.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee with reference to the level of the student's knowledge of the course topics.

The student can develop a report on a specific project topic. This activity is not mandatory.

The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

ECONOMICS AND ORGANIZATION OF THE AEROSPACE SECTOR

SSD ING-IND/35

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

None

PREREQUISITES, IF ANY

None

LEARNING GOALS

The course aims to:

• Provide fundamental concepts and models relating to the behavior of economic actors with reference to micro and macroeconomic systems.

• Provide basic knowledge for the analysis of operational and strategic business decisions starting from data on business costs and revenues.

• Provide basic knowledge on the management and planning of organizations.

• Address the fundamental elements of the economy and business organization with reference to the aeronautical sector.

• To transfer the concept of complexity of the aeronautical sector in its technological, organizational and economic dimensions.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must demonstrate that they have achieved an adequate knowledge of the principles of microeconomics as well as of business organization, and that they have understood the relationship mechanisms between companies and between them and the reference markets.

Applying knowledge and understanding

At the end of the course, the student will have to demonstrate that they know how to decline the microeconomic dynamics and those of business organization in the context of high-tech sectors such as aerospace.

COURSE CONTENT/SYLLABUS

[1 CFU] The enterprise: definition and modeling - Costs and objectives - Classification criteria - The enterprise, the environment and the market.

[1 CFU] Sector, enterprise and competitiveness - Sector structural analysis - Industry life cycle. Internal analysis and enterprise organization. Business functions and R&D processes. Technology Readiness Level.

[1 CFU] Cost Analysis - Break Even Point - BEP; Industrial investment assessment and evaluation criteria.

[1 CFU] The nature of the innovation process for aerospace product - Stages of the innovative process; Technological innovation and production organization in the aeronautical sector - Stages of the innovation process in the sector.

[1 CFU] Structural features of the sector - Productive organization in aerospace; The network in the aviation industry - Relationships network among the enterprises - Oligopolistic network and vertical relationships among the enterprises.

[1 CFU] Subcontracting relationships in the aviation industry - Technology circulation between contractor and subcontractor - Asymmetric relationship between client and supplier - The selection process of subcontracting enterprises.

READINGS/BIBLIOGRAPHY

Handouts, slides, text "Subcontracting in the aeronautical sector", edited by Massimiliano Bianca, Emilio Esposito - Publisher: McGraw-Hill Education - Year I edition: 2007.

Additional References

TEACHING METHODS

The course involves the active participation of students in lessons, through continuous interaction with the teacher.
There are discussions which encourage critical reflections on case studies of aerospace context both nationally and internationally. The lessons may include the testimony in the courtroom by industry experts.

EXAMINATION/EVALUATION CRITERIA

a) **Exam type:**

Exam type	
written and oral	X
only written	
only oral	
project discussion	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Programming Test	
	Numerical exercises	X

(*) Multiple options allowed

b) **Evaluation modalities:**
The grade is formulated by the Examination Committee based on the adequacy of the answers given by the student to the questions posed to him/her.
In addition, the final grade is appropriately motivated to the student.

COURSE DETAILS

MULTIMEDIA SIGNAL PROCESSING

SSD ING-INF/03 *

DEGREE PROGRAMME: MASTER IN TELECOMMUNICATIONS AND DIGITAL MEDIA ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE (IF APPLICABLE): NO
MODULE (IF APPLICABLE): -
CHANNEL (IF APPLICABLE): -
YEAR OF THE DEGREE PROGRAMME (I, II, III): I-II
SEMESTER (I, II): II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
None

PREREQUISITES (IF APPLICABLE)
None

LEARNING GOALS
The aim of the course is to provide students with basic notions and algorithms for processing digital images and to present the main techniques for encoding still images and video sequences, with particular attention to the most common standards. Beyond providing the mathematical and conceptual tools, the course aims to provide the knowledge needed to develop the main algorithms for image processing in Python.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student needs to show ability to know and understand methodological tools for image analysis and processing. Such tools will allow the student to solve more complex problems both in the space domain and in the frequency domain.

Applying knowledge and understanding
The student needs to show ability to solve problems regarding the image analysis and processing and to choose the most suitable technique for solving a practical problem.

COURSE CONTENT/SYLLABUS
Image enhancement. Enhancement in the spatial domain. Basic intensity transformations: linear and non-linear pixelwise operations. Equalization of the histogram. Bit-plane slicing. Arithmetic operations. Geometric operations. Basics of spatial filtering. Smoothing and sharpening filters. Median filter. Morphological operations. Enhancement in the frequency domain. Two-dimensional Fourier transform. DFT-2D. Examples of low-pass and high-pass filters. Frequency domain filtering: ideal filters, Butterworth and Gaussian filters.
Color representation. Basics on the human visual system. Cones and rods. Relative sensitivity of cones of type S, M and L. Trichromatic theory of colors. Color matching. The color spaces (RGB, HSI). Pigments: subtractive coloring, CMY, CMYK (four-color) printing systems.
Segmentation. Edge based techniques. Point detection and line detection. Roberts, Prewitt and Sobel filters. Gradient thresholding. Zero-crossing of the Laplacian. Canny edge detector. Class-based techniques. K-means algorithm.
Compression of images. Source coding and data compression. Quantization. Uniform and non-uniform quantization. Predictive coding. Diagram of the encoder and decoder. Predictive quantization. Coding by transform. Energy compaction and optimal resource allocation. Linear transforms. Karhunen-Loéve transform and its properties. Discrete cosine transform. The JPEG standard.
Video encoding. Basics of the video signal. Spatial and temporal compression. Conditional replenishment and movement compensation. The hybrid encoder. MPEG-1 and MPEG-2 standard. Scalability in resolution and frame-rate.
Wavelet transform. Time-frequency localization. Continuous Wavelet (CWT). Mother Wavelet. Multi-resolution analysis, scaling function. MRA equations. Extension to the two-dimensional case. Implementation of the discrete wavelet transform (DWT). Analysis and synthesis filter bank. Wavelet encoding. EZW algorithm.

Applications. Examples of advanced applications for image processing: denoising, super-resolution, recognition of faces or objects, classification using local descriptors, semantic segmentation, recognition of manipulations in images and videos also with techniques based on learning (basics of convolutional neural networks).

READINGS/BIBLIOGRAPHY

Recommended books

- R.C.Gonzalez, R.E.Woods: "Digital image processing", 3nd edition, Prentice Hall, 2008.
- A.Bovik: "The essential guide to image processing", Academic Press, 2009.
- K.Sayood: "Introduction to data compression", 2nd edition, Morgan Kaufmann, 2000.

Course notes available at: http://wpage.unina.it/verdoliv/esm/

TEACHING METHODS

Teachers will use: a) lectures for approx.70% of total hours; b) laboratories for approx.30% with guided exercises for the development of software applications in Python to better understand the studied techniques.
The topics of the lectures and exercises are explained with the help of electronic blackboards and/or detailed transparencies, made available to the student in the teaching material via the official website. Recording of the lectures is also provided.

EXAMINATION/EVALUATION CRITERIA

Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

The exam consists of a written and an oral test. The written test, which consists of three algorithms to be developed in Python on the computer, can be replaced by a practical project always in Python on an advanced image processing application. The oral exam consists of two questions on problems/algorithms explained during the course.

COURSE DETAILS

ELASTODYNAMICS AND STRUCTURAL HEALTH MONITORING PRINCIPLES

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

Solve the elasto-dynamics equations for simple structural items made out of isotropic and anisotropic materials.
Build the dispersion curves for simple structural configurations.
Extract waves parameters (Time of Flight, transmission factor, ect..) from numerical and/or experimental waves propagations signals by signal analysis techniques (Short time Fourier Transform, Hilbert Transform, statistical methodologies, etc.) (Numerical and experimental activity).
Build finite elements models for wave propagation simulation into typical aerospace structural configurations (Numerical activity).
Employ state-of-the-art ultrasonic Non-Destructive-Techniques (C-Scan) for structural health analysis in composites structure (Experimental activity).

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic principles for the structural health monitoring of aerospace structure.

Applying knowledge and understanding
Students will be able to model the wave propagation into typical aerospace structural configurations and compare these models versus experimental data.

COURSE CONTENT/SYLLABUS

[2 CFU] Ultrasonic guided waves theory: Field equations of linear elastodynamics; Plane waves in isotropic and anisotropic media; Dispersion and attenuation; Reflection and refraction of waves at a free surfaces and interfaces; Guided waves in metallic and composite plates; Ultrasonic NDE for material and defect characterization (with FEA applications); Structural health monitoring; Signal analysis techniques: ultrasonic signal characterization, Short Time Fourier Transform, Hilbert Transform.

[2 CFU] Numerical simulation of wave propagation into aerospace structures: crack detection, delamination in layered plates, skin-honeycomb disbanding in sandwiches, stringer disbonding in stiffened panels.

[2 CFU] Structural Health Monitoring System Design and Testing Principles: SHM Overview, NDT Techniques, Structural health monitoring technologies, Sensor technology, Signal Parameters (Sampling Frequency, Windowing) and analysis, Damage Index (DI) Approach, Guided waves based SHM methodologies, Tomographic analysis.

READINGS/BIBLIOGRAPHY

Course notes and Slides.

J.D. Achenbach, Wave propagation in solids, North Holland, 1973.
A.C. Eringen, Elastodynamics, Vol. II, Academic Press, 1974.
A.K. Mal and S. Singh, Deformation of elastic solids ,Prentice Hall 1991.
J.L. Rose, Ultrasonic waves in solid media, Cambridge University Press, 1999.
K.F. Graff, Wave motion in elastic solids, republished by Dover Publications (Cambridge University Press, 1975).

TEACHING METHODS

Lectures. Experimental seminars, collaborative working.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	X
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)		
	Multiple choice answers	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in a project work. The project work deals with the numerical modeling of a selected structural test-case; its results are compared to some available measured data.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

EXPERIMENTAL FLUID DYNAMICS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

INFORMAZIONI GENERALI - ATTIVITÀ

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
None.

PREREQUISITES
Basic knowledge of fluid-mechanics.

LEARNING GOALS
The course aims at providing both the theoretical background and the practical technicalities of the most used Experimental Fluid Dynamics methods. Each measurement technique is explained highlighting: the potential advantages and drawbacks; the principles of operation; the application limits and uncertainties; the implementation and integration in a real experiment.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should achieve adequate knowledge of the theoretical formulations that describe the techniques used in the Experimental Fluid Dynamics.

Applying knowledge and understanding
Students should demonstrate that they are able to apply the concepts/techniques, learned in the study of the Experimental Fluid Dynamics.

COURSE CONTENT/SYLLABUS

[1 CFU] Measurement theory. Measurement uncertainties: random and bias. Propagation of uncertainty. Signal Theory. Sampling Theory. Fundamentals of continuous and discrete Fourier transforms.

[1 CFU] Pressure measurements. Liquid manometers. Bourdon manometers. Pressure transducers. Pitot tube. Laboratory exercises: pressure measurements.

[2 CFU] Temperature measurements. Liquid thermometers. Thermocouples. Radiation Theory. Infrared thermography. Heat flux sensors: heated thin foil, thin-film and this-skin sensors. Laboratory exercises: temperature measurements.

[3 CFU] Velocity measurements: hot-wire anemometry, laser Doppler anemometry Particle Image Velocimetry. Evaluation of a pressure field from velocity measurements. Determination of aerodynamic forces form velocity measurements. Laboratory exercises: velocity measurements.

[2 CFU] Fundamentals of optics. Density measurements: Shadowgraph, Schlieren and Interferometry. Laboratory exercises: density measurements. Wind tunnels: subsonic and hypersonic. Force measurements. Load cells. Laboratory exercises: force measurements.

READINGS/BIBLIOGRAPHY

Notes and slides of the course.

Main Textbooks
Discetti Ianiro Experimental Aerodynamics CRC Press (2017).
Tavoularis Measurements in fluid mechanics CUP 2009.
Astarita Carlomagno Infrared Thermography for Thermo-Fluid-Dynamics Springer 2013.
Raffel et al Particle Image Velocimetry springer 2018.
Tropea et al Springer handbook of experimental fluid mechanics Springer 2007.
Barlow et al Low-Speed Wind Tunnel Testing Wiley (1999).

TEACHING METHODS

About 2/3 of the total hours of the course are used for lectures and the remaining part will be dedicated to practical applications.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) More options are allowed

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the oral exam and/or in the oral discussion of a project.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

EXPERIMENTAL VIBROACOUSTICS

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I-II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The student knowledge regarding the management of dynamic phenomena where interaction of vibrating structure with confined of open-air fluid emerge, will be deeply studied under the experimental point of view.
The course will introduce the student to the several instrumentation and techniques to measure and evaluate both the acoustic and the vibrational parameters and relative correlation; also, the methods for the verification and updating of the related numerical model will be widely studied.
At the end of the course, the student:
- will be introduced to the specific themes through the study of a large variety of examples very close to the common engineering practice;
- will acquire knowledge, tools and methods for experimental measurement in the field of the course;
- will learn how to manage complex and complete experimental set-up;
- will be able to organize a test report;
- will be able to manage the verification and updating process of numerical models.

All the topics will be introduced by the use of a large variety of real applicative cases and student will be involved in many laboratory sessions where he will be able to experiment the theoretical knowledge self-performing real test.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic methods and the complex procedures for analyzing dynamic phenomena in an experimental facility.

Applying knowledge and understanding

Students will be able to use or set-up experimental activities for the study of vibroacoustic phenomena. Moreover, they will be able to assess critically the measured data.

COURSE CONTENT/SYLLABUS

[2 CFU] Fundamentals of acoustic and vibration phenomena, experimental measurement sensors and actuators (accelerometers, laser vibrometer, microphones, intensity probes, beam forming antennas, force and acoustic actuators).

[2 CFU] Measurement errors and relative management, acoustic measurement techniques of different sound field indicators (pressure, intensity and power) and relative reference normative, measurement of acoustic absorption properties of materials (laboratory and in-situ techniques), evaluation of transmission loss and insertion loss properties of structural and acoustic systems.

[2 CFU] Vibration measurement, evaluation of structural insertion loss and damping loss factor of damping systems, operational deflection shape and experimental modal analysis test of complex structures, near field acoustic measurement and correlation with vibrational field, vibro-acoustic response of complex structures (eigenmodes and odf), data analysis techniques, processes and tools for numerical model updating.

READINGS/BIBLIOGRAPHY

Textbooks and learning aids:

E. Monaco, M. Viscardi. Experimental Vibroacoustics handouts.
C.M. Harrys. Handbook of Noise Control. McGraw-Hill Higher Education; 2nd edition.
B&K Technical Review Collection.
D. J. Ewins, Modal testing theory and practice, Research Studies Pr Ltd.
SIEMENS/LMS Reference manuals.
UNI-EN and ISO reference normative.

TEACHING METHODS

Oral lessons and numerical/experimental laboratory activities.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

FLIGHT TEST

SSD ING-IND/03

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

None

PREREQUISITES (IF APPLICABLE)

Basic knowledge of mathematics and general physics.

LEARNING GOALS

The student will acquire the fundamental concepts concerning the scientific and engineering problems related to the flight tests, with reference to the fixed-wing aircraft certification. Topics include the study of flight tests instrumentation and calibration, aircraft performance estimation, stability and control flight tests and system identification technique. The student will acquire the capacity plan, design, perform and process flight test data acquired.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must have achieved an adequate knowledge of the scientific and engineering problems related to the execution of flight tests of fixed wing atmospheric aircraft.

Applying knowledge and understanding

The student must demonstrate to be able to apply the concepts acquired in the study of the phenomena that characterize the experimentation in flight, must be able to understand the physical principles, the technological solutions and the theoretical, numerical, and experimental methodologies used for such applications.

COURSE CONTENT/SYLLABUS

[1cfu] Introduction on flight tests. Flight tests environment. Flight tests instrumentation, International standard atmosphere. Aircraft regulations.

[1 cfu] Flight tests program. Air data system calibration. Weight and balance. Stall flight tests. Flight tests data reduction.

[1 cfu] Level Flight tests. Available characteristics. Drag estimation from flight tests. Climb flight tests.

[1 cfu] Take-off and landing flight tests. Aircraft flight manual production.

[1 cfu] Static stability flight tests. Aircraft controllability flight tests. Stick force estimation.

[1 cfu] Dynamic stability fight tests. Flight qualities. System identification from flight tests. Methods and applications.

READINGS/BIBLIOGRAPHY

Slides and course notes.
Ralph D. Kimberlin, "Flight testing of fixed-wing aircraft", AIAA Education Series.
Donald, T., Ward, Thomas, W. Straganac, "Introduction to Flight Test Engineering", second edition, Kendall/Hunt Publishing company.

Ravindra V., Jategaonkar, "Flight Vehicle System Identification", AIAA series.

TEACHING METHODS

Lectures on theory and practical examples with spreadsheet and Matlab applications. Video demo. Flight experiences on the airfield with a light airplane.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

Final evaluation is based on the oral examination scores and on the project discussion.
The final score will be clearly motivated to the student.

COURSE DETAILS

FLUID-DYNAMIC STABILITY

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course addresses basic theories and advanced investigation methodologies to analyze flows instabilities. Inner and open shear flows are particularly investigated. Industrial problems such as the prediction of laminar-to-turbulence transition and the break-up of two-phase interface leading to atomization phenomena are some of the major application fields.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic theories and methodologies for analyzing flow instabilities.

Applying knowledge and understanding

Students should learn how to analyze an industrial problem with reference to some optimization criteria.

COURSE CONTENT/SYLLABUS

[2 CFU] Basic concepts and definitions of stability in Fluid mechanics. Lyapunov and asymptotic stability. Bifurcation and instability. Basic elements of function spaces, inner product and norm. Linearized equations of disturbances. Temporal normal modes analysis for parallel flows. Sturm-Liouville eigenvalues problem.

[2 CFU] Some classic models: Kelvin-Helmholtz instability, capillary instability of a jet. Localized disturbances in space and time, spatio-temporal theory. Absolute and convective instability. Spatial normal modes. Landau-Ginzburg equation. Stability of parallel flows: inviscid and viscous theories. Rayleigh inflection point theorem. Squire theorem. Orr-Sommerfeld equation. Stability of non-parallel flows. Global instability. Modal decomposition techniques: POD, SPOD, DMD.

[2 CFU] Connections between global instability and absolute/convective instability for locally parallel flows. Theory of non-modal instability. Growth function and pseudospectrum. Comparison of modal and non-modal theories for industrial flows: Poiseuille flow, Blasius flow, jet, wake, mixing layer. Laminar-to-turbulent transition in wall bounded flows. Criteria of turbulence prediction. e^N *method.*

READINGS/BIBLIOGRAPHY

Notes on lectures delivered by the teacher and available on web site https://www.docenti.unina.it.

Some suggested textbooks:

P.G. Drazin, Introduction to Hydrodynamic Stability, Cambridge University Press, 2002.

P. Huerre and P.A. Monkewitz, Ann. Rev. Fluid Mech., 32, 473-537, 1990.

P.J. Schmid and D. S. Henningson, Stability and Transition in Shear Flows, Springer, 2001.

TEACHING METHODS

Lectures, numerical exercises, application seminars.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the numerical exercise and in the successive discussion on the analytical and methodological topics.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

COMPUTATIONAL FLUID-DYNAMICS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The purpose of the course is to provide the student with the means to respond to the job demand in the field of Computational Fluid Dynamics (CFD). The student will acquire the tools to evaluate the potential and limits of the commercial codes used in Computational Fluid Dynamics, in order to use them consciously. The course provides the rational foundations of numerical fluid dynamics founded on basic knowledge of mathematical analysis, linear algebra, numerical methods, and fluid mechanics.
The student will have the opportunity to understand the linear and non-linear problems typical of the numerical treatment of the Navier-Stokes equations, practicing both in the construction of Finite Differences (DF) codes and in the use of open-source software.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student should achieve adequate knowledge of the structures of common numerical algorithms in Computational Fluid Dynamics.

Applying knowledge and understanding
The student should demonstrate the ability to independently conduct a fluid dynamics analysis with numerical simulation software and to critically analyze the related results.

COURSE CONTENT/SYLLABUS

[3 CFU] Review of linear algebra: finite-dimensional vector spaces, matrices as linear operators, matrix decompositions, eigenvectors and eigenvalues, matrix norms, and induced norms. Fundamentals of iterative methods for the solution of linear systems: applications to the numerical solution of elliptic equations. Review of the Finite Differences (DF) method for elliptic, parabolic, and hyperbolic problems.

[3 CFU] Numerical solution of the Navier-Stokes (NS) equations for incompressible flows: projection methods and Inverse Problem of Vector Calculus. Numerical treatment of convective terms in incompressible NS equations using finite-difference and finite-volume methods. Analysis of the conservation properties of the discretizations. Vorticity-streamfunction and Harlow-Welch methods and their generalizations. Outline of high order and spectral methods.

[3 CFU] Numerical simulation of low-Mach compressible flows: kinetic-energy preserving schemes. Problems related to the simulation of flows with discontinuities. Non-linear hyperbolic conservation laws. Weak solutions and shock-capturing numerical discretizations. Monotone and TVD schemes, the Lax-Wendroff theorem. Principles of construction of numerical fluxes for the Euler equations in 1D.

READINGS/BIBLIOGRAPHY

C. Meola, G. de Felice, Fondamenti Lineari per la Fluidodinamica Numerica. L'Ateneo, Napoli. (1996).
H. Lomax, T. H. Pulliam, D. W. Zingg, Fundamentals of Computational Fluid Dynamics, Springer (2013).
C. Hirsch, Numerical Computation of Internal and External Flows. Butterworth-Heinemann (2007).
R. J. Leveque, Finite volume methods for hyperbolic problems. Cambridge University Press (2002).
Notes from the lectures. Numerical codes written during the exercise lessons.

TEACHING METHODS

Theoretical lectures, computer applications illustrated by the teacher and practical exercises carried out by the students in the laboratories.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)		
	Multiple choice answers	
	Open answers	
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the practical exercise and to the answers to the theoretical exam. The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

FLUID-STRUCTURE INTERACTION

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II

SEMESTER: I

CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

-

PREREQUISITES

Fluid-structure interaction is a discipline which faces with the analysis of the exchange of waves between fluids and structures. In some cases, it becomes aero-elasticity or hydro-elasticity that is the study of the lifting forces self-generated by the vibrating elastic bodies. In general sense, it concerns the problems of interactions between fluids (gas and liquids) and elastic structures. A good background in matrix algebra, coding capability and some fundamentals on mechanics of a structure and/or a fluid are prerequisites.

LEARNING GOALS

The background of the students inside the structural aerospace engineering field will be completed by correlating several arguments. They are interpreted in a modern sense as fluid-structure interaction. The student:
- will be introduced to the specific themes by using examples very close to the common engineering practice;
- will acquire lexicon, tools and methods;
- will learn how to manage complex and complete procedures;
- will analyse if the available data and tools are suitable and enough for getting the required results.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic methods and the complex procedures for analyzing the fluid-structure interaction problems.

Applying knowledge and understanding
Students will be able to use or design numerical tools or arrange experimental activities for the study of fluid-structure interaction problems. Moreover, they will be able to assess critically numerical and experimental results.

COURSE CONTENT/SYLLABUS

[0,5 CFU] Generalities about the Fluid-Structure Interaction (Aero/Acousto/Elasticity).

[0,5 CFU] The piston-pipe system: the simplest coupled system.

[0,5 CFU] Summary of the Deterministic Approaches (modal methods) in continuous and discrete coordinates schemes.

[0,5 CFU] Non-Lifting Aeroelasticity: remarks on instability and response for simplified scheme.

[0,5 CFU] Influence of the excitation/acquisition set-up on the measurements.

[1,0 CFU] Fundamentals of Waves, Modes and Energy (characteristic wave speed in solids, modal density, mechanical and acoustic impedances, damping).

[0,5 CFU] Energy Methods and Energy Distribution Approach.

[0,5 CFU] Notes on Similitude and Scaling Approaches.

[0,5 CFU] Spectral Finite Element Approach: Dispersion Curves (material characterization).

[0,5 CFU] Stochastic response of linear systems.

[0,5 CFU] Fundamentals of aero-acousto-elastic problems.

READINGS/BIBLIOGRAPHY

- Course Notes.
- Cremer, Heckl and Petersson, Structure-Borne Sound, Springer (Required).
- Hambric, Nefske, and Sung (editors), (Optional) Engineering Vibroacoustic Analysis: Methods and Applications, Wiley, 2016.
- Nilsson and Liu, Vibro-Acoustics, Springer (Optional).

TEACHING METHODS

Classical oral lessons and numerical/experimental laboratory activities. It will be asked to the students a high level of participation to the lessons and related homework. This course should be actively lived in order to get the best results. For this reason, each course, year by year, will offer and develop different contents.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	x
project discussion	x
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the project development and according to the oral exam. Nevertheless, the project activity is not mandatory but highly recommended.

COURSE DETAILS

CHEMICAL FUNDAMENTALS OF TECHNOLOGIES

SSD CHIM/07

DENOMINAZIONE DEL CORSO DI STUDIO: INGEGNERIA AEROSPAZIALE

ANNO ACCADEMICO 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course offers a deep knowledge of the structure of matter, matter/radiation interactions, origin and applications of nuclear energy and radioactivity, chemical kinetics and electrochemistry, with particular focus on engineering topics, such as: main analytical techniques of materials, interpretation of their properties (electrical, mechanical, magnetic), nanostructured materials, combustion and oxidation processes at low and high temperatures.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student will have to prove an adequate knowledge of chemical and electrochemical phenomena in the field of engineering applications.

Applying knowledge and understanding
The student will have to prove knowledge and ability to analyze the basic parameters that control the fundamental chemical phenomena involved in the industrial technologies.

COURSE CONTENT/SYLLABUS

[1 CFU] Origins of quantum mechanics: classical theory of radiation and photons. Interactions between matter and radiant energy. Spectroscopic techniques. X-ray diffraction theory. Explanation of the electronic structure of atoms and of the chemical bond according to quantum mechanics. Chemical bond: valence bond and molecular orbital theories.

[2 CFU] Crystalline and amorphous solids. Condon-Morse curves; elasticity and anelasticity. The establishment of valence and conduction bands in conductors and semiconductors, intrinsic and doped; band structure and photovoltaic effect. Defects in the crystal structure (point, line and plane defects) and their influence on electrical and mechanical properties. Nuclear chemistry and radioactivity and their applications.

[2 CFU] Chemical kinetics. Kinetic equations and reaction mechanisms. Activation energy. Catalysis. Fundamentals of flame chemistry, flammability, autoignition curves. Oxidation and reduction. Galvanic cells. Electrochemical potential. Nernst equation. Electrolysis and electrodeposition: electroplating and electroforming. Electrochemical sensors. Measurement of equilibrium constants by electrochemical methods.

[1 CFU] Corrosion and passivation of metals. Electrochemical methods used in metallurgy. Iron, aluminium, copper and their alloys.

[1 CFU] Technologies for the production and storage of energy. Batteries and accumulators. Fuel cells.

[2 CFU] Organic chemistry: hydrocarbons, functional groups, classes of reactions. Stoichiometry and thermochemistry of combustion reactions: higher and lower calorific values, theoretical air of combustion, theoretical combustion temperature, flue gasses, thermal potential, smoke analysis. Crude oil distillation. Liquid and solid fuels, lubricants. Synthetic polymers and polymerization mechanisms. Nanostructured composites: opportunities and issues.

READINGS/BIBLIOGRAPHY

Didactic materials provided by the Professor.
Martin S. Silberberg, Chimica, McGraw-Hill.
Oxtoby, Gillis, Campion, Chimica Moderna Edises.

TEACHING METHODS

Lectures and training classes.

EXAMINATION/EVALUATION CRITERIA

a) Examination procedure:

The exam comprises	
writing and oral test	
only writing test	
only oral test	X
discussion of a project report	
others	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Modalità di valutazione:

The grade is formulated by the Examination Commission on the basis of the adequacy of the answers provided by the student to the questions that have been formulated.
The final grade is also suitably motivated to the student.

COURSE DETAILS

ELECTRICAL FUNDAMENTALS FOR AERONAUTICS

SSD ING-IND/32

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES (IF APPLICABLE)

-

LEARNING GOALS

The performance of a modern aircraft depends to a large extent on the configurations, characteristics and continuous reliability of electrical and electronic systems and subsystems, on which it is, therefore, essential to acquire knowledge. The course aims to provide the basic notions and appropriate insights on electrical and electronic systems with particular reference to those of power on board aircraft and other aeronautical systems. These include alternators, static power converters, on-board storage, distribution and use of electricity, also with reference to interrupting and protective devices, and electromechanical actuators. The main architectures envisaged for the electric and hybrid propulsion of aircraft are also described.
A part of the course is dedicated to covering the contents of modules 4 and 5 of the regulatory program (EASA Part 66/ EMAR 66), for the benefit of those who wish to pursue a career in the field of aircraft maintenance and obtain an Aircraft Maintenance License (LMA)/Military Aircraft Maintenance License (MAML).

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student must demonstrate that he has achieved an adequate knowledge of electrical and electronic systems and subsystems of an aircraft.

Ability to apply knowledge and understanding
The student must demonstrate to be able to analyse the power systems on board an aircraft and the main problems of its maintenance according to the EASA Part 66 / EMAR 66 standard.

COURSE CONTENT/SYLLABUS

[0,5 CFU] CONTINUOUS AND ALTERNATING ELECTRIC POWER LINES. Analysis of possible distribution schemes on board aircraft. Switches, contactors and manoeuvring devices. Protection against overcurrents and surges. TRANSFORMERS – Principle of operation, models, operational characteristics and construction of single-phase and three-phase transformers. Symbology. Magnetic configurations and connection of three-phase transformer windings. Parallel connection of transformers. Autotransformer. Measuring transformers. Laboratory tests on transformers.

[0,5 CFU] AC ELECTRIC MOTORS AND GENERATORS - Electromechanical energy conversion. Magnetic circuits and electrical windings. Three-phase asynchronous motors: models, operating characteristics, starting, speed regulation, voltage-frequency law for variable frequency regulation. Single-phase asynchronous motors: operation, starting problem, condenser-start motors. Three-phase synchronous PM and reluctance motors: features of operation, speed regulation. Three-phase synchronous generators with excitation winding and permanent magnets: features of operation and regulation of frequency and voltage. Stand-alone and grid

connected operation. Symbology. Laboratory tests for the determination of the electrical parameters of rotating machines.

[1 CFU] SEMICONDUCTOR ELECTRONIC DEVICES (M4. Part-66) – Diode: Symbology, characteristics, and properties. Connection in series and in parallel. Light emitting diode, Schottky, photoconductor, Zener. Varistors. Thyristor: Symbolism. Features of operation. Waveform of voltage and current on the load. Tests on diodes and thyristors. Transistor: Symbology. Features and properties. Basic configurations. Multistage configurations. Other switching devices: GTO, IGBT, MOSFET.
Electronic circuits - Integrated circuits: description and operation of logic circuits and linear circuits; regulators and comparators. Printed circuit boards: description and method of realization and use.
Other transistor applications: amplifiers; polarization, decoupling, stabilization circuits; cascade circuits, push-pull, oscillators, multivibrators, flip-flops. Logic circuits, operational amplifiers.

[0,5 CFU] POWER ELECTRONIC CONVERTERS - Single-stage ac-dc conversion: single and double half-wave rectifiers; semi- and total-controlled, single-phase and three-phase rectifiers; 1, 2 and 4 quadrant configurations. Dc-dc conversion: Step-up and step-down chopper; 1, 2 and 4 quadrant configurations. Ac-dc conversion: single-phase and three-phase Voltage Source Inverter; rectangular wave inverter; sinusoidal PWM. Dual-stage ac-dc conversion: configurations; dc-link. Grid-side filtering systems and power quality.

[0,5 CFU] ELECTRIC ENERGY STORAGE SYSTEMS – Electrochemical storage: main characteristics of batteries; analysis of different types of batteries; battery charging systems. Notes on electrostatic accumulators (supercapacitors) and electromechanical accumulators (high-speed flywheels).
Notes on Fuel Cells: functionality, types of hydrogen supply.

[1 CFU] ELECTRIC DRIVES - Motor+converter; open- and closed-loop control; cascade control; use of voltage, current, speed, position (encoder, resolver) sensors/transducers; standard regulators; hysteresis regulators; scalar and vector control of induction motor drives; AC and DC brushless drives with permanent magnet synchronous motors. Reversible operation. Analog or microcontroller control systems. Examples of electric drives for aircraft propulsion.

[0,5 CFU] SERVOMECHANISMS - Basic concepts, functionalities and fundamental aspects.
ELECTROMECHANICAL ACTUATORS – Definitions and classification; analysis of different types of actuators with reference to the aeronautical field.

[1 CFU] PART 2 - DIGITAL TECHNIQUES AND ELECTRONIC INSTRUMENTATION SYSTEMS (M5 Part-66)
ELECTRONIC INSTRUMENTATION SYSTEMS: Typical arrangement of systems and cabin layout of electronic instrumentation systems. Data conversion: analog/digital (A/D) and D/A conversion. Data bus: Operation in aeronautical systems, including knowledge of the ARINC standard. Logic circuits: Identification of common symbols related to logic circuits, tables and equivalent circuits. Applications for aeronautical systems. Microcontrollers: typical functions, lay-outs and characteristics of microprocessors. Integrated circuits: Functions and use of encoders and decoders. Multiplexing: Functions and applications of multiplexers and demultiplexers. Fiber optics: Advantages and disadvantages of data transmission using optical fibers. Fiber optic data bus. Terminology. Endings. Applications in aeronautical systems. Electronic displays: Mode of operation of the most common types of displays used in modern aircraft. Devices sensitive to electrostatic electricity: Specific treatment of components sensitive to electrostatic discharge; awareness of risks and possible damages, personal and component antistatic protection devices. Software management control: awareness of restrictions, airworthiness requirements and possible catastrophic effects of unapproved changes to software programs. Electromagnetic environment: influence on the maintenance practices of the electronic system of:

EMC - Electromagnetic compatibility; EMI – Electromagnetic interference; HIRF - High intensity radiation fields. Lightning and lightning protection.

[0,5 CFU] TYPICAL AERONAUTICAL ELECTRONIC/DIGITAL SYSTEMS: General layout of typical aeronautical electronic/digital systems and related BITE (Built In Test Equipment) tests, such as: ACARS — ARINC Communication and Addressing and Reporting System; ECAM - Electronic Centralised Aircraft Monitoring; EFIS - Electronic Flight Instrument System; EICAS - Engine Indication and Crew Alerting System; FBW - Fly by Wire; FMS - Flight Management System; GPS - Global Positioning System; IRS - Inertial Reference System; TCAS - Traffic Alert Collision Avoidance System.

READINGS/BIBLIOGRAPHY

Lecture Notes.
Bibliographic material provided by the professor.

TEACHING METHODS

Lectures and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)		
	Multiple choice answers	
	Open answers	X
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The grade is formulated by the Examination Commission on the basis of the outcome of the written test and the adequacy of the answers provided by the student to the questions that were formulated during the oral exam.
The final grade is also appropriately motivated to the student.

COURSE DETAILS

ELECTROMAGNETIC FUNDAMENTALS FOR SPACE APPLICATIONS

SSD ING-INF/02

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I/II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

None

PREREQUISITES (IF APPLICABLE)

Basic knowledge of mathematical analysis and general physics.

LEARNING GOALS

The student will acquire the fundamental concepts of electromagnetism, with particular reference to space applications. The course will be accompanied by numerical / experimental laboratory exercises using commercial measurement instrumentation and design software.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must have achieved an adequate knowledge of the basic elements of electromagnetism for space applications.

Applying knowledge and understanding

The student must demonstrate that he/she is able to apply the concepts acquired in the study of transmission and reception phenomena and of free-space and guided propagation, orienting himself in identifying the salient characteristics of the involved devices, depending on the application of interest, and in the dimensioning of a link.

COURSE CONTENT/SYLLABUS

Review of electromagnetism. Maxwell's equations. The general electromagnetic properties of material media. The time domain and the frequency domain. The sinusoidal regime and the phasor domain. The concept of the band of an electromagnetic signal. The energy associated with the electromagnetic field. Setting up the electromagnetic problem. The concept of polarization of an electromagnetic field in a sinusoidal regime. Elementary solutions of Maxwell's equations: plane waves. Propagation, attenuation and dispersion. Electromagnetic reflection, refraction and diffusion. The concept of Radar Cross Section. The Doppler effect. [3 CFU]
Plasma, and its declinations. [1 CFU]
Free-space and guided propagation. Structures for guided propagation: cables, metal guides, printed guides, and dielectric guides. Elements of free propagation: transmitting antenna and receiving antenna. [1 CFU]
The communication channel and the connection formula. The multi-path phenomenon. The radar. The atmospheric radar. Elements of atmospheric propagation. Radio, microwave and millimeter wave propagation. Surface waves. Attenuation for fog, rain, snow, ice and atmospheric gases. Diffusion from rain and depolarization. Tropospheric and ionospheric propagation. [2 CFU]
The main components of a guided propagation network: dividers, attenuators, phase shifters, hybrid junctions, isolators, circulators, filters, generators and amplifiers. Antennas for space applications: antennas for ground stations, for satellites, for microsatellites, for interplanetary probes and for Rovers. Antennas for aerospace applications. Antennas for drones. Radar antennas. Antennas for radiolocation and radio navigation. The Antenna Placement problem. [1 CFU]
The electromagnetic blackout and possible countermeasures. Electric propulsion.
Elements of electromagnetic compatibility with reference to space applications.
Numerical / experimental laboratory, in which some relevant examples are discussed using laboratory equipment and commercial software adopted for professional design. [1 CFU]

READINGS/BIBLIOGRAPHY

SEE WEBSITE OF THE REGULAR TEACHER

TEACHING METHODS

Lectures and laboratory sessions.

EXAMINATION/EVALUATION CRITERIA

e) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

f) Evaluation pattern:

COURSE DETAILS

IMPACT DYNAMICS

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
-

PREREQUISITES
-

LEARNING GOALS
The course aims to provide an in-depth description of all aspects related to the design of vehicles with respect to their crashworthiness. Here within are included technical aspects, which are finally placed in the context of the total product development processes of current industries. This course introduces students to different computational techniques used for modelling engineering problems in solids and structures.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic crashworthiness criteria for the design of aerospace vehicles.

Applying knowledge and understanding
Students will be able to model the typical phenomena of impact dynamics with specific reference to typical aerospace structural lay-out.

COURSE CONTENT/SYLLABUS

[2 CFU] Basic physical principles of impact; Structural aspects and material selection for airworthiness; Introduction to Low Velocity Impact (LVI) phenomena.

[2 CFU] Damages involving composite laminates; FEM explicit approach; Numerical models for the prediction of both first failure and delamination area involving composite laminate under LVI phenomena; Finite element (FE) method for the simulation of LVI phenomenon; Damage modelling techniques according to FE method.

[2 CFU] Global-Local approach for the modelling of both intra and inter-laminar damages; Practice exercise; Compression After Impact (CAI) test for the residual strength assessment; CAI test simulation by means of quasi-static analysis; Biomechanics and multibody approach; Design of experiments DOE.

READINGS/BIBLIOGRAPHY
Course notes and Slides.
Serge Abrate - Impact Engineering of Composite Structures. Cambridge University Press, 2005. ISBN: 0521018323, 9780521018326.
Matthew Huang - Vehicle crash mechanics. CRC press, 2002.
F. Marulo, M. Guida, L. Maio, F. Ricci, "Numerical simulations and experimental experiences of impact on composite structures". Dynamic Response and Failure of Composite Materials. Springer, The Netherlands 2017. ISBN 9780081008874.

TEACHING METHODS

It enables students to develop skills in utilizing modern modelling and analysis techniques in the context of relevance to practical engineering problems thanks to the use of explicit codes.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the written exam and according to the successive discussion during the oral exam.

The student can develop a self-selected project work. This activity is not mandatory.

The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

MACHINE LEARNING AND BIG DATA

SSD ING-INF/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

-

PREREQUISITES

-

LEARNING GOALS

The aim of the course is to present the main machine learning techniques, covering all aspects from data preparation to performance evaluation, through practical exercises carried out with commercial and/or open-source tools. An introduction to Big Data and Data Analytics lifecycle is also provided, with reference to the design of large and complex databases, and to the process of modeling, acquiring, sharing, analyzing and visualizing the information embedded into Big Data.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic machine learning techniques.

Applying knowledge and understanding

Students should learn how to analyze large and complex databases using commercial and/or open-source tools.

COURSE CONTENT/SYLLABUS

[2 CFU] Data Mining and Machine Learning. Knowledge representation: Trees, Rules, Clusters.
Basic Machine Learning methods: Statistical Modeling, Linear Models, Instance based learning, Clustering.
Performance Evaluation: Cross-Validation, Cost-sensitive classification, ROC curves.

[2 CFU] Advanced Machine Learning: Decision Trees, Support Vector Machines, MLP, Bayesian Network, Hierarchical Clustering, EM, Semi-supervised Learning.
Data transformation: attribute selection, PCA, Sampling, Cleansing.
Deep Learning: training and performance evaluation of Deep Networks, Convolutional Neural Networks. Introduction to database systems. Definition of a Big Data system. Data model for Big Data. The Hadoop ecosystem. Yarn. Pig. Hive. Giraph. Spark. NoSQL database: Key-value - Column-family, Graph database systems.

[2 CFU] Introduction to Big Data Analytics (BDA): BDA Lifecycle: knowledge discovery in database, data preparation, model planning, model building, data visualization.
Examples of commercial and open source Tools: Oracle, IBM Business Analytics, Microsoft Power BI, Microsoft Azure. AWS. SAP Hana.

READINGS/BIBLIOGRAPHY

Data mining: practical machine learning tools and techniques - 4th ed., Ian H. Witten, Frank Eibe, Mark A. Hall, Christopher J. Pal —The Morgan Kaufmann, 2017.
Mining of Massive Datasets, J. Leskovec, A. Rajarman, J.D.Ullman, 2014 (online book).

TEACHING METHODS

Lectures and laboratory activities.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to:	**Multiple choice answers**	
	Open answers	
	Numerical exercises	X

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the student's knowledge of analytical and methodological topics.

The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

APPLIED MECHANICS TO AEROSPACE ENGINEERING

SSD ING-IND/13

MASTER'S DEGREE NAME: AEROSPACE ENGINEERING
ACADEMIC YEAR 2022-23

GENERAL INFORMATION - TEACHER

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION - ACTIVITIES

YEAR OF STUDY: I
SEMESTER: I
CFU: 9

PROPEDEUTICAL COURSES

None

PREREQUISITES

Basic knowledge of mathematics and physics

EDUCATIONAL OBJECTIVES

The course aims to resume and develop some topics of analytical mechanics to provide the basic knowledge for the understanding and analysis of the problems that arise in the functioning of the "dynamic machines" characterized by mechanical elements in relative motion. The most common mechanical systems, adopted in the industrial and aerospace fields, are described and studied.

EXPECTED LEARNING RESULTS (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student will achieve an adequate knowledge of analytical mechanics that will be applied to the most widespread mechanical systems also used in the aerospace field.

Ability to apply knowledge and understanding

The student will be able to conduct the analysis of the most common mechanical systems adopted in the industrial field.

PROGRAMMA-SYLLABUS

[1,5 CFU] Machines and mechanisms, kinematic pairs, degrees of freedom, classification of forces, equivalent systems, reduced systems, passive resistances, mechanical efficiency.

[2 CFU] Study of mechanisms: cam mechanism, crank mechanism, qfour-bar linkage, glyph mechanism, open kinematic chains; examples of mechanisms adopted for the retractable landing gear and for the articulated suspension of space rovers.

[1,5 CFU] Balancing of rotating parts. Critical bending and torsional speeds.

[1,5 CFU] Elements of vehicle mechanics: wheel for prepared and unprepared soil; longitudinal, lateral and vertical dynamics of the vehicle; wheel travel during the landing phase of the aircraft; castor wheel, shimmy phenomenon; vehicles adopted for space exploration.

[1,5 CFU] Machine elements: friction wheels, toothed wheels, ordinary and epicyclic gears, belt drives, bearings, brakes.

[1 CFU] Mechanical characteristic curve; regulation and stability of the operating conditions of a group of machines.

TEACHING MATERIALS

The teaching material consists of notes available on the department's website. Recommended refeference books are:

A.R. Guido, L. Della Pietra - Lezioni di meccanica delle macchine – CUEN.

L. Della Pietra – Meccanica Applicata alle Macchine – EdiSES.
M. Callegari, P. Fanghella, F. Pellicano - Meccanica Applicata alle Macchine – Citta Studi Ed.

CONDUCT OF THE COURSE

The course includes a) laboratory visits to watch mechanical components, mechanisms and some dynamic phenomena; b) the use of a commercial multibody program to solve some exercises; c) seminars held by speakers coming from mechanical industries.

VERIFICATION AND ASSESSMENT OF LEARNING

a) Examination method:

Examination method:	
written and oral test	
written test only	
oral test only	X
project discussion	
other	

In case of written test, the questions are (*)	Multiple choice
	A free answer
	Numerical exercises

b) Assessment methods:

The exam commission defines the final grade by judging the adequacy of the answers to the exam test.

COURSE DETAILS

MATHEMATICAL METHODS FOR ENGINEERING

SSD MAT/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Conoscenze di base di analisi matematica.

LEARNING GOALS

The course aims to provide basic knowledge of Mathematical Analysis required to formulate mathematical models of engineering and scientific problems.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student must show his good knowledge of advanced mathematical tools for solving engineering problems.

Applying knowledge and understanding
The student will show to be able to develop a mathematical modeling of typical engineering problems.

COURSE CONTENT/SYLLABUS

[1 CFU] Complex numbers. Elementary functions in complex field.

[1 CFU] Power series in complex field. Analytic functions. Conformal mappings. Integral of complex functions. Taylor series. Laurent series.

[2 CFU] Residues and applications to integral calculus. Lebesgue Measure and Lebesgue integration. Fourier series; pointwise convergence and quadratic mean convergence, Bessel inequality. Fourier transform: definition and main properties; antitransform.

[2 CFU] Laplace tranform: definiton; main examples of Laplace transform; main properties; application of Laplace transform to linear differential models.

[1 CFU] Homogeneous and non homogeneous Sturm-Louville problems. Green identity.

[1 CFU] Mathematical models: classical examples. Laplace equation; heat equation; waves equation. First order partial differential equations. Classification of linear second order partial differential equation. Characteristic curves.

[1 CFU] Basic notion of Calculus of Variations.

READINGS/BIBLIOGRAPHY

Notes on website.
A. Ferreo, F. Gazzola, M.Zanotti, Elements of Advanced Mathematical Analysis for Physics and Engineering, Esculapio
G.C. Barozzi, Matematica per l'Ingegneria dell'Informazione, Zanichelli.
S. Salsa, Equazioni a derivate parziali, Springer.

TEACHING METHODS

Lessons and training in presence

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to:	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

b) Evaluation pattern:

The grade is formulated by the Examination Commission depending on the answers provided by the student to the questions that have been formulated.
The final grade is also motivated to the student.

COURSE DETAILS

GEOMETRIC MODELING AND AEROSPACE VIRTUAL PROTOTYPING

SSD ING-IND/15

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR: 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES (IF APPLICABLE)

-

LEARNING GOALS

Study and use of the most advanced methodologies for the design, modeling and management of complex systems of aeronautical and aerospace interest by means of 3D CAD software. Ability to import information and manage mathematics in CAD environment and export models useful for FEM and multi-physical analyzes. Ability to interpret complex designs and analyze design problems with an interdisciplinary approach. Solution of geometric dimensioning problems and drafting of the related project documentation according to ISO-GPS and ASME-GD&T.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must present adequate knowledge of advanced CAD modeling techniques for virtual prototyping and successive FEM analyses.

Applying knowledge and understanding

The student will have to demonstrate to be able to interpret complex designs and analyze design problems by means of an interdisciplinary approach.

COURSE CONTENT/SYLLABUS

[3 CFU] Advanced geometric modeling techniques: Feature Based Modeling, Surface Modeling, Hybrid Modeling, Knowledge Based Engineering, Direct Modeling. Curves and surfaces (Hermite, Spline, Bézier, B-Spline, NURBS). Data exchange between CAx systems. Reverse Engineering techniques. Algorithms and software for the reconstruction of curves and surfaces from point clouds (Curve and Surface Fitting). Study, design and modeling of mechanical and aeronautical assemblies and recognition of technological characteristics.

[3 CFU] Geometric tolerances, classification and designation. ISO-GPS and ASME-GDT standards and applications in the aeronautical field. Assembly modeling with Bottom-Up and Top-Down approaches. Advanced CAD modeling for detailed virtual prototyping of the main aircraft assemblies: Fuselage (Nose, Cabin, Tail Cone), Wing, Tailgate, Carriages. CAD analysis and realization of structures with Longerons, Stringers, Formers, and Ribs.

[3 CFU] Analysis and simulation of kinematics by means of 3D CAD software. Principles of Design for Assembly. Use of virtual mannequins for ergonomic analysis of design and assembly. Management of complex CAD models by means of PDM (Product Data Management). Notes on the Pre-Processing and Post-Processing phases of FEM analysis. Examples and applications in the structural and fluid dynamics field. Outlines on multi-physical analyzes. Photorealistic rendering techniques. Rendering equation. Ray-Tracing and Radiosity algorithms.

READINGS/BIBLIOGRAPHY

UNI, ISO, EN standards.
Assignments and tutorials available on the teacher's website.
Mortenson M.E., "Modelli geometrici in Computer Graphics", McGraw-Hill Companies 1989.
Course notes.

TEACHING METHODS

The course is based on the balance between frontal classroom teaching and computer lab exercises. In particular, thanks to the use of specific 3D CAD software for the aeronautical world, students are enabled to develop complex and detailed parametric CAD models of aircraft or parts of them, then managed by means of PDM tools. The 3D CAD models developed then make it possible to carry out multidisciplinary activities based on the skills acquired during the course through ergonomic, structural, fluid-dynamic and multi-physical analyzes.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

The final mark is formulated by the Examination Commission on the basis of the adequacy of the solution of a graphic test and of the answers provided by the student to the questions of the oral exam. Furthermore, the student will present the CAD exercises carried out during the course. The final mark is also suitably motivated to the student.

COURSE DETAILS

NUMERICAL AND EXPERIMENTAL METHODS FOR AIRCRAFT DESIGN

SSD ING-IND/03

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course has the objective to show the numerical and experimental procedures for an accurate analysis of aircraft aerodynamics, stability, and control and to provide information on aircraft MDA(Multi-Disciplinary-Analysis)/MDO(Multi-Disciplinary-Optimization) frameworks. The numerical section provides details on the application of tools for aircraft aerodynamic analysis, load estimations and aircraft stability and control. The second part will deal with the detailed presentation of multi-disciplinary frameworks for aircraft MDA/MDO. The third part will cover experimental section and will present the procedures and the typical issues of aircraft wind tunnel testing. The course will provide about 10-16 hours of laboratory activities in the department main subsonic, closed-circuit, closed test-section wind tunnel.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the basic methodologies for an accurate analysis of aircraft aerodynamics, stability and control. Students should learn also MDO theory and practice and state-of-the-art applications.

Applying knowledge and understanding

Students will be able to develop a multidisciplinary analysis and optimization for the preliminary sizing of an aircraft. Students will also learn fundamental for wind-tunnel experiments applied to aircraft stability and control.

COURSE CONTENT/SYLLABUS

[1 CFU] Motivational aspects of aircraft aerodynamic analysis and optimization for design and certification. Possible software for aircraft aerodynamic analysis, from simple 2-D cases to 3-D analysis. Limits and possible use of each tool.
[1CFU] Real applications. Aircraft drag polar, longitudinal, and lateral-directional stability and control, effects of Reynolds and Mach number.
[1 CFU] High lift devices, aerodynamic design, and analysis. Aero-propulsive interaction.

[1 CFU] General aspects on optimization problems and strategies (including pareto-front, scalarization).
[1 CFU] MDA/MDO frameworks for aircraft multi-disciplinary design, critical aspects.
[1CFU] Collaborative framework. Aircraft application and tools' integration. Practical applications.

[1 CFU] Aircraft wind tunnel testing. Different wind-tunnel for Reynolds and Mach envelope, measuring instrumentation, sensors, and processing of acquired data.
[1 CFU] Type of test, aircraft and airfoil model design and manufacturing. Uncertainty of measurements, correction of the experimental data and industrial use of results.

[1 CFU]. Real practical applications on aircraft model or components with measurements of drag polar, longitudinal, and lateral-directional stability and control, high lift. Possible applications on propulsive effects with small electric engines.

READINGS/BIBLIOGRAPHY

Slides and course notes. Academic or free-license software tools.
Martins, J, Ning, A, Engineering Design Optimization.
Low-speed wind-tunnel testing – Barlow, Rae, Pope.

TEACHING METHODS

Lectures on theory and practical examples with software application. Laboratory activities in the department main subsonic, closed-circuit, closed test-section wind tunnel(10-16 hours)..

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

Examination includes a written report that the student will develop in group throughout the course, focused on both numerical and experimental activities.
This report is discussed during the oral exam.

COURSE DETAILS

DESIGN PRINCIPLES FOR WIND AND OCEAN RENEWABLE ENERGY SYSTEMS

SSD ING-IND/03

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: 1 AND 2
SEMESTER: 1
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The main objective of the course is to provide all elements to allow the student to understand basic working principles of both wind turbines and systems for producing renewable energy from ocean (tidal currents and waves).

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should demonstrate to have reached an adequate knowledge of both technologies and working principles of renewable energy systems from wind and ocean.

Applying knowledge and understanding

Students should demonstrate to know the technologies and to be able to assess the performances of wind and ocean energy converters thorough the use of open source simulation codes and/or through the development of their own software.

COURSE CONTENT/SYLLABUS

[1 CFU] Methods for resource assessment for wind, tidal currents and waves

[2 CFU] Principles of energy conversion from the primary energy source to electricity.
Principles of design or choice of the various elements that make up the transformation chain.
Power control principles for limiting the maximum power.

[2 CFU] Existing regulations for the determination of design load cases and their effects on system components
Methods for estimating the costs of the complete system and the energy produced

[1 CFU] Application examples of systems for the generation of renewable energy from: onshore and offshore wind, tidal currents and waves

READINGS/BIBLIOGRAPHY

Slides and course notes. The students will be also working with open-source codes.

TEACHING METHODS

Lectures on theory and exercises and applied examples.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

Oral examination aiming at evaluating of student's understanding and assimilation of the course topics. The development of a personal technical report containing performance prediction software or results obtained using open-source software (it is not mandatory).

COURSE DETAILS

SPACE PROPULSION

SSD ING-IND/07

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Basic knowledge of thermo-fluid-dynamics, gas-dynamics and chemistry. Basic knowledge of electro-magnetism.

LEARNING GOALS

The course presents the fundamentals of rocket propulsion and discusses advanced concepts in space propulsion, involving chemical and electrical rocket engines. Topics, starting from mission and system requirements for space transportation systems, orbital and interplanetary flight, include the description of the physics and technology of different kinds of thrusters. These include chemical-type rocket engines (solid propellant, liquid or hybrid bi-propellant, monopropellant) and electric thrusters. The latter include electrothermal, electrostatic and electromagnetic devices.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The students should demonstrate that they have achieved adequate knowledge of the scientific and technological aspects underlying the functioning of space propulsion systems.

Applying knowledge and understanding

The students will have to demonstrate knowledge of the essential elements for the preliminary sizing of thermal and electric propulsion systems, and for the analysis of their performance, also through numerical simulation tools.

COURSE CONTENT/SYLLABUS

[1 CFU] Definitions and fundamentals of Space Propulsion. Thrust and specific impulse, characteristic velocity and thrust coefficient, efficiencies. Classification of space thrusters. Space missions. Tsiolkowskij equation. Structural coefficient and payload ratio for conventional and non-conventional rockets. Multi-stage rockets in series and in parallel. Estimation of the ΔV required for different types of missions.

[2 CFU] Scientific and technological fundamentals of conventional rockets. Combustion process and chemical equilibrium. Calculation of the adiabatic combustion temperature. Rocket nozzles and thrust coefficient. Sizing of a converging-diverging nozzle. Non-conventional nozzles. Heat exchange in rockets, effect on performance and cooling techniques (regenerative cooling, heat sink cooling, film cooling, ablative cooling, radiation).

[4 CFU] Architectures of conventional rockets. Liquid propellant rockets: characteristics of the propellants; propellant feed systems and turbopump cycles. Thrust chambers: injectors, combustion chambers, cooling systems, ignition. Sizing examples. Combustion instability in liquid rockets. Solid propellant rockets: types of propellants; basic definitions; regression rate and combustion stability; propellant grain shape; ignition systems and ignition delay; sizing of a solid propellant rocket. Design trade-off between solid and liquid propellant rockets. Hybrid propellant rockets: architectures and characteristics; typical propellants; regression rate; sizing;

experimental characterization activities. Monopropellant rockets: hydrazine engines; hydrogen peroxide and nitrous oxide engines; catalysts. Space launchers.

[2 CFU] Review of electromagnetism and basics of plasma physics. Electrothermal rockets: resistojets, arc-jet thrusters. Electrostatic thrusters: ion thrusters and other configurations. Electromagnetic thrusters. Hall-effect thrusters: architectures, sizing and performance analysis.

READINGS/BIBLIOGRAPHY

Course slides, available on the degree programme website.
Sutton G.P., Biblarz O., Rocket Propulsion Elements, John Wiley & Sons Inc
Hill P., Peterson C., Mechanics and Thermodynamics of Propulsion, Ed. Pearson
Ward T.A., Aerospace Propulsion Systems, John Wiley & Sons Inc
Goebel D.M., Katz I., Fundamentals of Electric Propulsion: Ion and Hall Thrusters, John Wiley & Sons Inc

TEACHING METHODS

Lectures and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the student's knowledge of analytical and methodological topics.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

AUTOMOTIVE PROPULSION SYSTEMS

SSD ING-IND/08

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

TEACHER:
PHONE:
EMAIL:

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course aims to deepen the study of Internal Combustion Engines (ICE) and more generally of the latest generation of automotive propulsion systems, for a sustainable mobility from an energy and environmental point of view. With reference to propulsion systems for urban and extra-urban vehicle traction, the most recent methodologies available for the reduction of consumption, emissions and noise impact will be studied in detail. With reference instead to high-performance engines, the aim is to analyze in detail the techniques for maximizing the power output. The study of innovative combustion systems (such as HCCI, lean combustion, pre-chamber engines, etc.) will be addressed and their impact on CO2 production on homologation cycles currently in force in Europe (WLTP) and in real operating conditions, (Real Driving Emission, RDE) will be quantified. The course will highlight the complex interactions among the different subsystems that constitute a modern propulsion system, in order to achieve specific objectives in terms of performance and fuel consumption. The guidelines for the identification of control strategies for energy management in hybrid propulsion systems (series, parallel and their various combinations) will be defined. Problems related to the experimental calibration of an ICE and the use of non-conventional fuels (hydrogen, methanol, natural gas, etc.) will be mentioned. Additional seminars will be held by staff from leading companies in the automotive sector (Stellantis, Ferrari, Lamborghini), or from other research centers (CNR STEMS Institute).

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must exhibit the achievement of an adequate knowledge of modern propulsion systems with reference to overall performance and fuel consumption.

Applying knowledge and understanding

The student must be able to analyze the interaction among the various subsystems that constitute a modern propulsion system and guide their design choices.

COURSE CONTENT/SYLLABUS

[0.5 CFU] Current situation and prospects for internal combustion engine (ICE) application in automotive propulsion systems: design objectives of the latest generation ICEs compatible with a sustainable mobility from energy and environmental point of views

[1 CFU] Traditional and high-performance engines. Quoted plans and techniques for maximizing power. Importance of the volumetric efficiency

[1 CFU] Laminar flame speed analysis. Combustion / turbulence interaction, definition of the different combustion "regimes". Design of the intake and exhaust ducts, and their impact on the in-cylinder flow motion for engines with 2 or 4 valves per cylinder.

[1 CFU] Abnormal combustion phenomena. Auto-ignition maps. Techniques to increase knock resistance: EGR, water injection. Experimental analysis and test-bench calibration: definition of ECU calibration maps. Electronic control, management of the signals supplied by the on-board sensors and optimal control logics.

[1 CFU] Traditional propulsion systems for urban and extra-urban mobility: techniques for reducing fuel consumption and CO2 emission on recent homologation cycles (WLTP, RDE): variable valve timing systems (VVT, VVA), downsizing, exhaust gas recirculation (EGR), variable compression ratio engines, integrated use of the above methods. Quantification of the advantages on specific fuel consumption in predetermined operating points and on the entire engine operating plane.

[1 CFU] Unconventional combustion systems: Homogeneous Charge Compression Ignition (HCCI), Spark-Assisted Compression Ignition (SACI), Stratified Lean Combustion, prechamber engines.

[0.5 CFU] Acoustic impact: aerodynamic, gasdynamic, combustion noise and techniques for reducing acoustic emissions

[1 CFU] Advanced turbocharging systems: two-stage boosting, e-boosting. Steady state and transient operation. Turbo-Lag problems. Turbocharger selection. Variable geometry turbines. Measurement of characteristic maps on experimental flow benches and critical analysis of the internal performance of the fluid machines.

[2 CFU] Hybrid propulsion systems (series / parallel / advanced schemes): definition of the main architectures of the propulsion system and management of energy flows between thermal and electric units, gear shift management, battery recharging.

READINGS/BIBLIOGRAPHY
Lecture notes and slides of the course.

TEACHING METHODS
Additional lectures and seminars.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to:	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

b) Evaluation pattern:

The grade is formulated by the Examination Commission on the basis of the consistency of the answers provided by the student to the questions that have been formulated.

The final grade is also suitably motivated to the student.

COURSE DETAILS

RADAR SYSTEMS

SSD ING-INF/03

DEGREE PROGRAMME:

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE (IF APPLICABLE): NO
MODULE (IF APPLICABLE):
CHANNEL (IF APPLICABLE):
YEAR OF THE DEGREE PROGRAMME (I, II, III): I-II
SEMESTER (I, II): I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE “REGOLAMENTO”)

None

PREREQUISITES (IF APPLICABLE)

None

LEARNING GOALS

The main goals of the course are to provide advanced concepts for the design and the analysis of radar systems in diverse operative contexts, complemented by detailed elements to model channel, interference, and radar target phenomenology. A further aim is the introduction of the fundamental techniques for radar signal processing in time and Doppler domain.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must demonstrate the knowledge of the main radar typologies, configurations, and operative modes; must be capable of applying correctly the radar equation to specific system functions (as for instance search and tracking). Besides, he/she must be able to characterizing the radar performance in terms of false alarm and detection probabilities for different models of the useful target (fluctuating and non-fluctuating) and for different integration logics of the radar returns (as for instance coherent and non-coherent). Finally, the student must understand the fundamental radar signal processing techniques for clutter rejection (both in time and Doppler domain), for false alarm control, and for the estimation of the useful target parameters.

Applying knowledge and understanding

The student must demonstrate the ability to set the main parameters of the radar transmitter and receiver in diverse operative contexts via the exploitation of suitable analytic models for their description and optimization. Moreover, the he/she must be capable of characterizing the diverse radar functions and modes. Finally, the student must show abilities toward the selection of suitable schemes for radar signal processing with emphasis on clutter filtering, target detection, estimation of the target parameters, and false alarm control.

COURSE CONTENT/SYLLABUS

Main principles of pulsed and continuous wave radar systems. Fundamental radar parameters, functions, and applications. Radar equation and its diverse forms. Search and tracking processes. Atmospheric effects and their correction. Characterization of clutter. Characterization of radar target. Acquisition and digitization of the radar signal. Radar detection and computation of the false alarm and detection probability. Techniques for false alarm control. Doppler processing. Radar signals and codes. Techniques for target parameters estimation and tracking.

READINGS/BIBLIOGRAPHY

Books:

M. A. Richards, J. A. Scheer, and W. A. Holmes: "Principles of Modern Radar: Basic Principles", Scitech, 2010.
M. Skolnik: "Radar Handbook", Third Edition, Mc Graw Hill, 2008.
G. Stimson: "Introduction to Airborne Radar", Third Edition, IET, 2014.

Other:

“Slides of the course”, distributed annually.

TEACHING METHODS

Teaching is 100% based on lectures, which include both theory and computer exercises.

EXAMINATION/EVALUATION CRITERIA

Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

COURSE DETAILS

SPACECRAFT DYNAMICS AND CONTROL

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

This course covers basic and advanced topics in spacecraft dynamics and control. Classic examples of control systems components, operation and design are presented and detailed to provide the basic knowledge essential to tackle more complex problems.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The course aims at providing students with the knowledge and methodological tools necessary to analyze spacecraft dynamics and control. These tools will allow students to understand the causal connections between mission requirements and spacecraft dynamics and control, as well as the functional relationships among the various components of a control system. Students must demonstrate knowledge and understanding of the main problems related to the design of spacecraft dynamics control systems

Applying knowledge and understanding

Students must be able to apply the methodological tools learned in the course to the design, simulation and operation of spacecraft dynamics control systems. The course is therefore aimed at transmitting the ability to apply and concretely use the knowledge and methodological tools acquired for the design of spacecraft dynamics control systems.

COURSE CONTENT/SYLLABUS

[1 CFU] Environmental Torques, Stabilization and Control techniques, Momentum Exchange Systems, Mass Movement Systems, Selection of actuators and control strategies for different missions and applications. Representative examples of attitude control.

[2 CFU] Design of a momentum-bias system, pitch loop and the roll/yaw stabilization. Design of a Control Moment Gyro, pitch loop and roll/yaw loop. Design of a reaction-wheel control system. Structural Dynamics and liquid sloshing effects. Practical Examples

[2 CFU] Design of an all-thruster system, duty-cycle analysis, attitude manoeuvres. Design of a Magnetic Control System, Magnetic Torquers, Three-axis attitude control, De-tumbling. Practical Examples

[1 CFU] Tethered satellite system dynamics and control. Practical Examples

READINGS/BIBLIOGRAPHY

Course notes distributed by the teacher.
Agrawal, Design of Geosynchronous Spacecraft, Prentice-Hall, 1986, ISBN-13: 978-0132001144.

Chobotov, V.A., Spacecraft attitude dynamics and control, 1991, Krieger, ISBN 0-89464-031-3.
Kaplan, M.H., Modern spacecraft dynamics & control, 1976, John Wiley & Sons, ISBN 0-471-45703-5.
Wertz, J.R., ed., Spacecraft attitude determination and control, 1980, D. Reidel, ISBN 9-027-71204-2.
MICHAEL J. RYCROFT & ROBERT F. STENGEL (ed.), Spacecraft Dynamics and Control, CAMBRIDGE AEROSPACE SERIES 7, 1998

TEACHING METHODS

Lectures, tutorials and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	x
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the score achieved by the student in the oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

SPACE EXPERIMENTS

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
None

PREREQUISITES (IF APPLICABLE)
Basic knowledge of mathematics and general physics.

LEARNING GOALS
The student will acquire the fundamental concepts concerning the scientific and engineering problems related to the execution of experiments on board space platforms, with particular reference to the aspects concerning research in microgravity. Topics include the study of the behavior of fluids in conditions of reduced gravity, their modeling and the study of experimental techniques available on board space platforms.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student must have achieved an adequate knowledge of the scientific and engineering problems related to the execution of experiments on board space platforms.

Applying knowledge and understanding
The student must demonstrate that he/she is able to apply the concepts acquired in the study of the phenomena that characterize the experimentation on board of space platforms, must be able to understand the physical principles, the technological solutions and the theoretical, numerical and experimental methodologies used for such applications.

COURSE CONTENT/SYLLABUS

[1cfu] Introduction to space utilization and overview of main scientific space programmes. Role of principal investigators, space industries and agencies. Historical perspectives of human space flight. Lessons learned.

[0.5 cfu] Space Agencies organization and activities. Current governative and commercial space programs. Motivations for research in microgravity.

[0.5 cfu] Overview of main research fields in Fluid, Material, Life Sciences and related applications.

[1cfu] Short and long-duration microgravity opportunities: drop towers and drop tubes, parabolic flights on aircrafts, sounding rockets, orbital platforms.

[1cfu] Fluid science fundamentals. Fluids and materials behaviour in space. Microgravity Fluid dynamics: capillarity, balance equations, order of magnitude analysis and examples. Buoyancy and surface tension-driven convection. Technological issues: containerless processing.

[1cfu] The International Space Station (ISS). Pressurized and unpressurized elements. Accomodation and utilisation resources for payloads. Columbus laboratory. Microgravity facilities.

[1cfu] Scientific operations. Ground Segment. Optical diagnostics for microgravity fluid dynamics.

READINGS/BIBLIOGRAPHY

SEE WEBSITE OF THE REGULAR TEACHER

TEACHING METHODS

Lectures, numerical and laboratory sessions.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

COURSE DETAILS

SPACE FLIGHT DYNAMICS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES (IF APPLICABLE)

-

LEARNING GOALS

The course is aimed at introducing the methods of space flight dynamics that are applied to real space systems. Starting from the basic knowledge linked to two-body mechanics, several topics will be covered in depth, including orbit perturbations analysis and propagation methods, orbital maneuvers, orbit maintenance approaches, and interplanetary trajectories.

Special emphasis will also be given to the study of relative dynamics in space and its application to distributed space systems, and to autonomous rendezvous and docking in missions such as on orbit servicing and active debris removal.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student should achieve an adequate knowledge of methods and phenomena related to space flight dynamics

Applying knowledge and understanding
The student must demonstrate that he/she is able to apply the concepts acquired in the study of the space flight dynamics with specific reference to orbital maneuvers, orbit maintenance, relative dynamics in space, orbit design

COURSE CONTENT/SYLLABUS

[1 CFU] Orbital maneuvers and launch constraints

[1 CFU] Fundamentals of orbit determination and estimation, introduction to space surveillance

[3 CFU] Orbit perturbations analysis:
- *General and special perturbation techniques. Orbit propagation methods and tools.*
- *Perturbation effects on different classes of Earth orbits.*

[1 CFU] Orbit maintenance for LEO and GEO satellites

[2 CFU] Relative motion in space:
- *Hill's equations and advanced mathematical models.*
- *Formation flying, on orbit monitoring, rendezvous and docking.*
- *Spaceborne collision avoidance strategies.*

[1 CFU] Fundamentals of interplanetary trajectories.

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.

Main textbooks:

D.A. Vallado, Fundamentals of Astrodynamics and Applications, 4th ed., Springer Space Technology Library, 2013.
R. R. Bate, Fundamentals of Astrodynamics, Dover Publications, 1972.
V.A. Chobotov, Orbital Mechanics, AIAA Education Series, 2002.

TEACHING METHODS

Lectures, tutorials, exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The final grade is formulated by the Examination Committee with reference to the level of the student's knowledge of the course topics.

The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

SPACE MISSION DESIGN

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES (IF APPLICABLE)

-

LEARNING GOALS

This course will provide students with the competences needed to perform the preliminary design of a space mission starting from assigned broad mission objectives. The aim is the preliminary design/selection of the main elements of the space mission architecture (e.g. space, launch and ground segment), and of the satellite (bus and payload) performing the assigned mission. To this end, the technological solutions and sizing procedures typical of space mission elements and satellite sub-systems are taken as reference, and the impact of different solutions and alternatives at system and sub-system level are evaluated. The course aims to familiarize students with the distinctive teamwork of space systems projects, with the organization in phases of the projects and with relevant concepts, such as: project review, critical path analysis, concurrent engineering, reliability and risk analysis, cost analysis, market analysis, design trade-off, etc.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students should learn the common procedures for designing a space mission.

Applying knowledge and understanding

Students will be able to define and select the main elements of the space mission architecture versus the mission objectives and constraints.

COURSE CONTENT/SYLLABUS

[9 CFU] The course starts with introductory lessons in which the space mission design overall process is presented, using also practical examples, and a set of space mission design assignments (or project works) is proposed to the students divided into teams. The assignments may concern the design of different space missions, the design of the elements of a given space mission or the concurrent design of the same space mission. Then, interactive problem-solving lessons are started in which the students, organized in teams, present the identified solutions and the advancement status of the various project works for group discussion. For each assignment, at least two formal reviews are foreseen in which each team has to perform a power point presentation of the project work status: the MDR (Mission Definition Review) and the PRR (Preliminary Requirements Review). The PRR will take place at the end of the course.

READINGS/BIBLIOGRAPHY

J. R. Wertz , D.F. Everett, J.J. Puschell, Space Mission Engineering: The New SMAD, Space Technology Series, Space Technology Library Vol.28, Springer, 2011.

W. Ley, K. Wittmann, W. Hallmann, Handbook of Space Technology, John Wiley & Sons, 2009.

NASA Space Systems Engineering Handbook, NASA/SP-2007-6105 Rev1. ECSS Standards (http://www.ecss.nl).

C. D. Brown, Elements of Spacecraft Design, AIAA education series, American Institute of Aeronautics and Astronautics, Inc., 2002, ISBN 1563475243.
J. R. Wertz, W. J. Larson, Space mission analysis and design, Space Technology Library, Volume 8, Springer, 1999, ISBN 0792359011.
V. L. Pisacane, Fundamentals of space systems, Johns Hopkins University/Applied Physics Laboratory series in science and engineering, Oxford University Press US, 2005, ISBN 0195162056.

TEACHING METHODS

Oral lectures, tutorials, interactive lectures, use of open-source software for space mission analysis, cost analysis, etc., internet-based analysis.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) multiple options are possible

b) Evaluation pattern:

The oral exam will concern the content of the project work and will be like a review conducted according to international standards. Each student of a given team shall be able to defend the content and design choices of the related project work, also by making use of computer presentations and multimedia files. The discussion will be managed by the teachers who will act as a customer.

COURSE DETAILS

SPACE SYSTEMS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course provides the basic elements for the design of a space system in response to space mission requirements and objectives, with particular concern to the subsystems on board a satellite, in terms of mathematical and physical modeling of the subsystem behavior, technologies and development examples and solutions.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The course aims at providing students with the knowledge and methodological tools necessary to analyze space systems. These tools will allow students to understand the causal connections between mission requirements and space system design, the functional relationships among the various subsystems of a satellite, and to grasp the implications on the design of a space system or subsystem deriving from the interaction with the space environment. Students must demonstrate knowledge and understanding of the problems related to the design of a space system and its components and subsystems.

Applying knowledge and understanding

Students must be able to use a set of technical information concerning space systems and related components and subsystems to solve problems concerning their design and operation; to apply the methodological tools learned in the course to the design of a space system and its components. The course is therefore aimed at transmitting the ability to apply and concretely use the knowledge and methodological tools acquired for the design of a space system.

COURSE CONTENT/SYLLABUS

[1.5 CFU] Elements of space systems design and engineering: space program life-cycle, space mission architecture (mission objective and payload, space segment, ground segment, launcher), system and subsystem mass and power budgets, design margins. Exercise and practical design examples. Introductory elements on space qualification and ground testing

[1.5 CFU] The Space Environment and its interaction with the satellite and its subsystems: the atmosphere, the ionosphere, the magnetosphere, the radiation environment and its main effects on satellite units and subsystems, the thermal environment, the main perturbations acting on a satellite and their effects.

[6 CFU] Elements for the design of satellite subsystems: main subsystems/units and components of a satellite, architectures and technological solutions, operating principles, derivation of the design requirements from mission objectives. Simplified mathematical models for subsystem and component design: attitude and orbit control subsystem, electrical power subsystem, thermal control subsystem, telemetry and telecommunication subsystem, propulsion subsystem. Exercises and practical design examples. A set of design assignments (or project works) is also proposed to students divided in teams to be developed during the course.

READINGS/BIBLIOGRAPHY

Course viewgraphs and the following suggested textbooks:
Charles D. Brown, Elements of Spacecraft Design, AIAA education series 2002, ISBN 1563475243;
James Richard Wertz, Wiley J. Larson, Space mission analysis and design, Volume 8, Springer, 1999, ISBN 0792359011; James Richard Wertz, Spacecraft attitude determination and control, Springer, 1978, ISBN 9027709599;
Vincent L. Pisacane, Fundamentals of space systems, Oxford University Press US, 2005, ISBN 0195162056.

TEACHING METHODS

Lessons and exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	
only written	
only oral	x
project discussion	x
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the project presentation and successive oral exam.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

STATISTICAL LAB FOR INDUSTRIAL DATA ANALYSIS

SSD SEC-S/02

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")
-

PREREQUISITES
-

LEARNING GOALS
Statistical Lab for Industrial Data Analysis is a problem-based learning course whose aim is to train students on the application (illustrated through open-source statistical software environment R) of interpretable statistical techniques for decision-making, possibly scalable also up to big data frameworks. Every student must choose a data analysis project gathered along the course by experts in industrial engineering fields and develop it by working in team. The industrial engineering experts may want to take part to initial, intermediate and final workshops, where student groups shall show their project work in progress. In this way, students will have the opportunity to improve the ability of recognizing and implementing the most suitable statistical techniques to the problem at hand as well as of communicating relevant results and impact of their analysis also to non-statisticians.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students should learn the basic statistical techniques for the data analysis in an industrial framework.

Applying knowledge and understanding
Students will be able to work in a team, to get the skills for the decision-making in a data analysis project.

COURSE CONTENT/SYLLABUS

[3 CFU] Overview and course objectives. Description of multivariate data and inference about mean vectors. Elements of unsupervised learning: principal component analysis and clustering methods.

[3 CFU] Elements of supervised learning: problems in multivariate linear regression models; linear model selection and regularization (ridge regression, the lasso); reduction methods (principal components regression, partial least squares). Overview of classification methods.

[2 CFU] Statistical process monitoring and control: control charts for variables and attributes; the Hotelling control chart; regression adjustment; interpretation of out-of-control signals.

[1 CFU] Beyond multivariate data analysis: introduction to functional data analysis; statistical monitoring of functional data. Engineering examples through software environment.

READINGS/BIBLIOGRAPHY
Johnson, R.A., Wichern, D.W. (2007) Applied Multivariate Statistical Analysis (6th edition), Prentice Hall, Upper Saddle River.
Montgomery, D. C. (2014) Introduction to Statistical Quality Control. 7th edition. John Wiley & Sons.

James, G., Witten, D., Hastie, T., Tibshirani, R. (2013) An introduction to statistical learning. New York: Springer.
MOOC Industry 4.0 Big Data e Data Analytics III - a cura di B. Palumbo e M. L. Chiusano (2019) https://landing.federica.eu/industria40/.

TEACHING METHODS

Problem-based learning. Flipped classroom. Lectures. Lab Sessions and Seminars. Peer-grading. Team work. Interactive and anonymous quiz games.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	X
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee according to the scores achieved by the student in the peer-graded project discussion, the written exam and the successive discussion during the oral exam. The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

ADVANCED AEROSPACE STRUCTURES

SSD ING-IND/04

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: I
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

Basic knowledge of calculus and aerospace structures.

LEARNING GOALS

The course aims to provide the essential concepts for numerical structural calculation with finite elements, both for statics and for structural dynamics. The basic elements for the discretization and modeling of the structural behavior of typical aerospace structures are presented to allow future aerospace engineers to analyze and to solve complete structural components with examples of specific practical applications. Problems related to the evaluation of the non-linear behavior of structures, both from a static and dynamic point of view, are also addressed, taking into account both geometric non-linearities and those related to the non-linear behavior of materials.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student should demonstrate that he/she has achieved an adequate knowledge of common methodologies for linear or non-linear static and dynamic analysis of aerospace structures.

Applying knowledge and understanding

The student should be able to independently conduct a static and dynamic analysis of the typical structural elements of aerospace engineering and, therefore, to address the development of a correct design.

COURSE CONTENT/SYLLABUS

[1 CFU] The static behavior of structures with the finite element method. Modeling and discretization. The calculation and assembly of the stiffness matrix. The calculation of the stress and the stress analysis.

[1 CFU] The one-dimensional, two- and three-dimensional elements. The isoparametric elements.

[2 CFU] Introduction to the Dynamics of Structures. Models with lumped and consistent characteristics. Simple continuous dynamic structures. Hamilton's principle. Lagrange equations. Equations of motion of free vibrations in generalized and modal coordinates and their solution with the Modal Analysis approach. The orthogonality's principle. Damping in structures. Damping models. Real and complex modal analysis.

[2 CFU] Dynamic response of structures to various types of forcing functions (periodic, transient and random). The solution of the equations of motion with a direct approach.

[1 CFU] General formulation of a non-linear problem. Introduction to non-linear analysis methods. Non-linearity in the stress-strain relationship (plasticity, creep, etc.). Non-linearity in the deformation-displacement relationship (Geometric non-linearity problems) for thin plates with mixed behavior. The model of the non-linearities of the materials. Geometric matrix. Tangent stiffness matrix. Analysis and comparisons with cases of linear behavior.

[1 CFU] Constitutive relations and setting up of numerical calculus for a non-linear dynamic problem. The characterization of the non-linear finite element. Other types of non-linear models.

[1 CFU] Dynamics of rotating structures.

READINGS/BIBLIOGRAPHY

Course notes.
Cook R.D., Malkus D.S., Plesha M.E., Witt R.J., "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley & Sons, Inc., 2002.

TEACHING METHODS

Lessons on theoretical topics. Examples of programming for finite elements and use of commercial available software. Seminars and lectures on some specific themes.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee with reference to the level of the student's knowledge of the course topics.
The student can develop a report on a specific project topic. This activity is not mandatory.
The final evaluation is discussed and highlighted to each student.

COURSE DETAILS

TURBULENCE

SSD ING-IND/06

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-23

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: II
CFU: 6

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES (IF APPLICABLE)

-

LEARNING GOALS

The aim of the course is to introduce the student to turbulence in fluid dynamics. In addition to the theoretical study, the theoretical-numerical analysis methods will be introduced which, at the current state of the art, allow the fluid dynamic design in problems in which turbulence is dominant. The course will also feature some computational labs.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
The student will have to demonstrate that he achieved an adequate understanding and knowledge of the modeling methodologies of turbulent fluid dynamics phenomena.

Applying knowledge and understanding
The student must demonstrate to be able to carry out the study of turbulent phenomena using the theoretical-numerical models introduced during the lectures.

COURSE CONTENT/SYLLABUS

[3 CFU] Fundamentals, Examples and Applications. Mean-flow equations. Wall bounded flows: channel, boundary layers. Statistical description of turbulent motion. Scales of motion, spectra.

[3 CFU] Introduction to computational turbulence. DNS methods. LES methods. RANS–modeling. One-equation/two-equation closures. RANS models for heat transfer predictions. The V2F model. Algebraic models and RSMs. Ideas behind hybrid RANS/LES modeling.

READINGS/BIBLIOGRAPHY

S.Pope, Turbulent flows, Cambridge University Press, 2000.
Slides of the lectures.

TEACHING METHODS

Lectures and computational labs.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam type	
written and oral	
only written	
only oral	X
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

COURSE DETAILS

UNMANNED AIRCRAFT SYSTEMS

SSD ING-IND/05

DEGREE PROGRAMME: AEROSPACE ENGINEERING

ACADEMIC YEAR 2022-2023

GENERAL INFORMATION – TEACHER REFERENCES

SEE DEGREE PROGRAMME WEBSITE

GENERAL INFORMATION ABOUT THE COURSE

YEAR OF THE DEGREE PROGRAMME: II
SEMESTER: I
CFU: 9

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

-

PREREQUISITES

-

LEARNING GOALS

The course is intended to provide a basic knowledge about architecture and operation of Unmanned Aircraft Systems (UAS), dealing in particular with UAS classification, regulations, sensors and data fusion algorithms, autonomous guidance, navigation and control, communication and data links, ground stations.
Special emphasis is given to enabling technologies for autonomous flight and UAS integration in the civil airspace, such as ground-based and airborne sense and avoid systems.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding
Students will learn basic information about architecture and operations of Unmanned Aircraft Systems, with emphasis on autonomous flight and communications, navigation and surveillance technologies.

Applying knowledge and understanding
Students will be able to apply their knowledge on Unmanned Aircraft Systems to design, develop, or select architectures and technologies that fulfill specific mission objectives, also accounting for airspace integration.

COURSE CONTENT/SYLLABUS

[1 CFU] Introduction. Definitions and principles.
UAS Configurations and Applications: Military & Civilian Roles. Evolution, current and future systems.

[5 CFU] UAS Onboard Systems:
- Overview of UAS payloads
- Onboard navigation systems and landing aids
- Vision-based applications and techniques, vision-aided navigation
- Basics of data fusion and airborne tracking systems
- UAS planning, guidance, and control
o fixed wing - architecture and algorithms of UAS autopilots: path planning, path management, guidance (trajectory tracking, path following), autopilot control loops
o rotary wing - dynamics and control of multirotor systems, planning and guidance approaches
o exercises and practical examples of small UAS guidance navigation and control with ad hoc software tools.

[1 CFU] UAS communications and ground control systems
UAS ground stations and human factors, levels of automation, mission planning systems.

[2 CFU] Regulations and airspace integration

Current UAS operations, cooperative and non-cooperative separation assurance and collision avoidance systems, ground-based and airborne sense and avoid systems and algorithms. Practical anti-collision system design examples.

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.

Textbooks:

J. Gundlach, Designing Unmanned Aircraft Systems: A Comprehensive Approach, AIAA Education Series, 2012.
R. Austin, Unmanned Aircraft Systems: UAVs Design, Development and Deployment, Wiley, 2010.
R.W. Beard, T.W. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012.
R.W. Beard, Quadrotor dynamics and control, lecture notes, 2008.
S. Blackman, R. Popoli, Design and analysis of modern tracking systems, Artech House, 1999.

TEACHING METHODS

Lectures, tutorials, exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type:

Exam Type	
written and oral	X
only written	
only oral	
project discussion	
other	

In case of a written exam, questions refer to: (*)	**Multiple choice answers**	
	Open answers	X
	Numerical exercises	X

(*) È possibile rispondere a più opzioni

b) Evaluation pattern:

The final grade is formulated by the Examination Committee with reference to the level of the student's knowledge of the course topics.

The final evaluation is discussed and highlighted to each student.