UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

FACOLTÀ DI INGEGNERIA

ACADEMIC YEAR 2012/2013

Laurea Magistrale
Master of Science

STUDY GUIDE

(Pursuant to *D.M. n.270 del 2004*,
to *Regolamento didattico di Ateneo*,
to *Regolamenti didattici dei Corsi di laurea*)

Napoli, July 2012

Laurea Magistrale degree (Master of Science) course in Aerospace Engineering

Class of degrees in Aerospace and Astronautics Engineering, No. L-20

Targets of the Laurea Magistrale Course and job opportunities

The Laurea Magistrale in Aerospace Engineering course can be considered equivalent to a Master of Science degree and aims to provide students with an advanced knowledge of theoretical and scientific aspects of engineering, in order to enable them to identify, formulate and solve complex problems that require interdisciplinary capabilities in the field of industrial engineering in general, and in aerospace industry in particular. Further training goals relate to the ability to conceptualize, plan, design and manage systems, processes and complex and/or innovative design and manage highly complex experiments in the field of Aerospace Engineering.

Specific degree topics are fluid dynamics, flight mechanics, structures, structural design, aerospace technologies, equipments and aerospace systems.

Typical working fields of graduates in Aerospace Engineering are advanced design, research and development, innovation, planning and scheduling of industrial production, management of complex systems. These jobs can be undertaken in aeronautic and space manufacturing companies, in air transport companies, in companies for production and exercise of machines and equipments where fluid dynamics, lightweight structures, advanced modeling, control systems, advanced technologies are relevant, in private and public institutions (such as institutions for air traffic management and control, for certification), Air Force and aviation sectors of other military corps, or as freelance.

In general, the Graduate in Aerospace Engineering, although focused on a particular professional profile, will be able to follow the mobility and variability of the job market and the continuous technological innovation, which are particularly strong in the aerospace arena.

Curriculum of the study course

Course Title	Module Title (if applicable)	Semester	ECTS	SSD	Classification (*)	Disciplinary area	Required prior knowledge
Year 1							
Aircraft Aerodynamics		1st	9	ING-IND/06	2	Aerospace and Astronautics Engineering	
Calculus III		1st	6	MAT/05	4	Basic and Integrative activities	
Advanced Aerospace Structures		1st	9	ING-IND/04	2	Aerospace and Astronautics Engineering	
Applied Mechanics		2nd	9	ING-IND/13	4	Basic and Integrative activities	
Economics and Business Management		2nd	6	ING-IND/35	4	Basic and Integrative activities	
Avionics		2nd	6	ING-IND/05	2	Aerospace Engineering and Astronautics	
Aircraft Flight Dynamics and Flight Simulation		2nd	6	ING-IND/03	2	Aerospace Engineering and Astronautics	
Electives **(see note b)**		1st-2nd	0-15		3		
Year 2							
Electives **(see note a)**		1st-2nd	27		2	Aerospace Engineering and Astronautics	
Futher topics **(see note c)**		1st-2nd	12		6		
Electives **(see note b)**		1st-2nd	0-15		3		
Final examination		2nd	15		5		

Notes:

a) To be chosen in **Table A**
b) To be chosen in **Table B**
c) The 12 ECTS of the Further topics can be achieved, partially or totally, by attending:
- **Stage** (external or intra moenia). To start a stage at least 60 ECTS must be have been acquired.
- **Electives** from Tables A and B.

Table A) Electives to be chosen to form the Laurea Magistrale curriculum

Course Title	Module Title (if applicable)	Semester	ECTS	SSD	Classification (*)	Required prior knowledge
Design of Advanced Aerospace Structures (1)		1st	6	ING-IND/04	2	Advanced Aerospace Structures
Aircraft Design (1)		2nd	9	ING-IND/03	2	Aircraft Aerodynamics Design of Advanced Aerospace Structures
Aeroelasticity (1)		1st-2nd	12	ING-IND/04	2	Advanced Aerospace Structures
Complements of Gasdynamics (2)		1st	9	ING-IND/06	2	Calculus III
Fluid dynamics stability (2)		2nd	6	ING-IND/06	2	
Numerical Fluid Dynamics (2)		1st-2nd	12	ING-IND/06	2	
Space Systems (3)		1st	9	ING-IND/05	2	
Fluid-Structure Interaction (3)		2nd	6	ING-IND/04	2	
Space Fluid Dynamics (3)	Hypersonic Aerodynamics	1st	6	ING-IND/06	2	
	Space experiments (lectures in english)	2nd	6	ING-IND/06	2	

Notes:

(1) The choice of courses marked with (1), ***Aircraft Specialization***, makes the study plan automatically approved
(2) The choice of courses marked with (2), ***Fluid Dynamics Specialization***, makes the study plan automatically approved
(3) The choice of courses marked with (3), ***Space Specialization***, makes the study plan automatically approved

In case of choices from different specializations, the individual study plan needs to be approved by *Consiglio del Corso di Studio*.
The not-overlapping schedule of the lectures will be guaranteed only for the courses of the same specialization.

Table B) Electives

Course Title	Module Title (if applicable)	Semester	ECTS	SSD	Classification (*)	Required prior knowledge
Turbulence		2nd	6	ING-IND/06	3	
Rotary wing Aerodynamics		1st	9	ING-IND/06	3	Aircraft Aerodynamics
Complements of Aeronautical Structures		2nd	6	ING-IND/04	3	Advanced Aerospace Structures
Advanced Aerospace Structures II		1st-2nd	12	ING-IND/04	3	Advanced Aerospace Structures
Technologies Chemical Foundations		1st	9	CHIM/07	3	
Aerospace remote sensing systems (lectures in English)		2nd	6	ING-IND/05	3	
Unmanned Aircraft Systems (lectures in English)		2nd	6	ING-IND/05	3	Avionics
Multimedia Signal Processing		2nd	9	ING-INF/03	3	
Combustion (from Laurea Magistrale degree course in Chemical Engineering)		1st	6	ING-IND/25	3	
Combustion (from Laurea Magistrale degree course in Mechanical Engineering for Energy and Environment)		2nd	12	ING-IND/25	3	
Statistics for Innovation		1st	6	SEC-S/02	3	
Design of Advanced Aerospace Structures		1st	6	ING-IND/04	3	Advanced Aerospace Structures
Aeroelasticity		1st-2nd	12	ING-IND/04	3	Advanced Aerospace Structures
Complements of Gasdynamics		1st	9	ING-IND/06	3	Calculus III
Fluid dynamics stability		2nd	6	ING-IND/06	3	
Numerical Fluid Dynamics		1st	12	ING-IND/06	3	
Space Systems		1st-2nd	9	ING-IND/05	3	
Fluid-Structure Interaction		2°	6	ING-IND/04	3	
Space Fluid Dynamics	Hypersonic Aerodynamics	1st	6	ING-IND/06	3	
	Space experiments (lectures in English)	2°	6	ING-IND/06	3	

Classification of didactical activities according to DM 270/04

Classification	1	2	3	4	5	6	7
ref. DM270/04	Art. 10 comma 1, a)	Art. 10 comma 1, b)	Art. 10 comma 5, a)	Art. 10 comma 5, b)	Art. 10 comma 5, c)	Art. 10 comma 5, d)	Art. 10 comma 5, e)

Teaching activities of the Laurea Magistrale Course

Course title: Advanced Aerospace Structures	
Course module (if applicable):	
ECTS: 9	**SSD: ING-IND/04**
Lectures (hrs): 65	**Tutorials (hrs): 20**
Year: First	

Course objectives:

The course objective is that of making the students familiar with Structural Dynamic problems and to give to the future aerospace engineers the capacity of analyzing , modeling and solving specific practical applications, related to dynamic behavior of typical aerospace structures under the action of time variable loads. Other objective of the course is to give to the students the possibility of a more in dept knowledge of basic concepts and applications of a FEM approach to the structural calculation. In this prospective the problems and methodologies to non-linear analysis of structures, both for static and dynamic analysis cases, through the FEM approach is addressed.

Course content:

Introduction to the Structural Dynamic. Discreet and continuous dynamic models. Hamilton's principle. Lagrange's equations. Free oscillation equations in generalized and normal coordinates. Solution of the equation trough the Modal Analysis approach. Conservative and dissipative structural systems. Structural damping and different models. Real and complex modal analysis. Structural dynamic response to different type of time dependent loads (periodic, transitory and random). Dynamic analysis economization trough the FEM approach. Superelments and substructuring. General formulation of non-linear structural problem. Introduction to the non linear analysis of structures. Non-linearity of the stress-strain relationship (plasticity, creep, etc.). Non-linearity of the strain-displacement relationship (Geometrical non-linearity). Plates and shell elements in linear and non-linear field. Stability analysis with FEM. Geometric stiffness matrix. Tangent stiffness matrix. Constitutive equations and numerical method of solution for dynamic structural non linear problems. Dynamics of rotating structures.

Teacher: Francesco Franco	
Code:	**Semester:** First

Required/expected prior knowledge:
FEM basic concepts**.** Practice with softwares like Mathcad and/or Matlab.

Education method: classical oral lessons and numerical/experimental laboratory activities

Textbooks and learning aids: Course notes.
Reference Texbook:

1. ZIENKIEWICZ, *The Finite Element Method,* McGraw Hill, 1991 4th Edit., vol. I e II.
2. CESARI F., Comportamento non lineare delle strutture col metodo degli elementi finiti*,* Ed. Pitagora, 1985.
3. CESARI F., Metodi di calcolo nella Dinamica delle Strutture*,* Ed. Pitagora, 1984.

Assessment: written intercourse and final theoretical examination with also a practical numerical problem to be solved and eventually oral examination.

Course title: Advanced Aerospace Structures II	
Course module (if applicable):	
ECTS: 12	**SSD:** ING-IND/04
Lectures (hrs): 90	**Tutorials (hrs):** 30

Year: Second	
Course objectives: The aim of the course is to complete the knowledge on structural dynamics and on the dynamic characterization of complex mechanical systems. The objective is addressed through analytical, numerical and experimental methodologies. The proposed approach has the target to carry out a model update and optimization of the structural systems.	
Course content: Basic descriptive properties of random data (autocorrelation, spectral density functions, etc.). Joint properties of random data. Review of physical system response properties for mechanical systems. Input-Output relationship for physical systems. Statistical errors in random data analysis. Review of analytical and experimental modal analysis: MDOF systems. Modal parameter estimation, identification of systems: MDOF Methods. Model validation & Use of modal parameters. Model updating – Correction methods. Structural optimization: topological refinements and algorithms. Formulation techniques for the Finite Element Method: Review of variational methods and Galerkin – other weighted residual methods. Introduction to nonlinear dynamics. Nonlinear vibrations of rectangular plates. Vibrations of empty and fluid-filled circular cylindrical shells.	
Teacher: F. Franco	
Code:	**Annual Course**
Required/expected prior knowledge: Advanced Aerospace Structures	
Education method: Class lessons, guided tutorials and some seminars on specific topics.	
Textbooks and learning aids: Course notes and view-foils and, in addition, some selected textbooks as: 1. *J.S. Bendat, A. G. Piersol: Random Data: Analysis and Measurement Procedures, John Wiley and Sons, 2010.* 2. *D. J. Ewins: Modal Testing: Theory, Practice and Application, Research Studies Press Ltd., 2001.* 3. *R. D. Cook: Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 2001.* 4. *M. Amabili: Nonlinear Vibrations and Stability of Shells and Plates, Cambridge University Press, 2008.*	
Assessment: Written test - the test is followed by a discussion on the test results.	

Course title: Aeroelasticity	
Course module (if applicable):	
ECTS: 12	**SSD: ING-IND/04**
Lectures (hrs):80	**Tutorials (hrs):30**
Year: Second	
Course objectives: 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 multidisciplinar optimization of flexible structures.	
Course content: Structural dynamics of single and multi degree of freedom systems. Vibration of continous systems. Static aeroelasticity. Lift distribution, divergence and control effectiveness. Introduction to unsteady aerodynamics. Experimental modal analysis. Ground vibration tests. Measurements and identification of strcutural modal parameters. The reduced frequency. The simple aeroelastic wing section. Dynamic aeroelasticity. 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. Effect of non-linearities. Buffeting. Gust and turbulence encounters in time domain and frequency domain. Ground manoeuvres. Flight flutter testing. Aeroelastic wind tunnel testing. The aeroelasticity of civil structures. Aeroelastic phenomena of rotating structures.	
Teacher: Francesco Marulo	

Code:	**Semester: Annual Course**
Required/expected prior knowledge: Advanced Aerospace Structures	
Education method: Class lessons, guided tutorials and seminars on specific topics	
Textbooks and learning aids: *Course notes and Slides. Suggested textbooks:* 1. *Bisplinghoff R. L., Ashley H., Halfman R. L., Aeroelasticity, Dover Publications, 1996* 2. *D.J. Ewins, Modal Testing: Theory and Practice, Research Studies Press, Ltd., Letchworth, Hertfordshire, UK, 1984* 3. *Wright J. R., Cooper J. E., Introduction to Aircraft Aeroelasticity and Loads, John Wiley & Sons, Ltd. 2007*	
Assessment: *Oral discussion, self selected project work (not mandatory)*	

Course title: Aerospace Remote Sensing Systems

Course module (if applicable):

ECTS: 6 CFU	**SSD:ING-IND/05**
Lectures (hrs): 40	**Tutorials (hrs): 12**

Year: II

Course objectives:

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 and to space remote sensing mission analysis.

Course content:

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.
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. Examples of possible solutions and system design.
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. Interferometric and multistatic systems, basics of interferometric processing. Examples of possible solutions and system design.
Mission analysis of space remote sensing systems, sunsynchronous orbits, repetition factor and coverage patterns, pointing maneuvers, factors affecting orbit and pointing design. Constellations and formations. Examples.

Teacher: Antonio Moccia

Code:	**Semester: second**

Required/expected prior knowledge:

Education method: Lectures and exercises

Textbooks and learning aids: Slides, lecture notes, technical papers.

Textbooks:
T.M. Lillesand and R.W. Kiefer, Remote Sensing and Image Interpretation, 4th Ed., John Wiley & Sons, Ltd, 2000.
F.T. Ulaby, R.K. Moore, and A.K. Fung, Microwave remote sensing, Artech House, Inc., 1986.
M. Cherniakov, Editor, Bistatic Radar Emerging Technology, John Wiley & Sons, Ltd, 2008.
K.I. Duck and J.C. King, Orbital Mechanics for Remote Sensing, Chapter 16 in Manual of Remote Sensing, 2nd Ed., vol I, R.N. Colwell, Editor, American Society of Photogrammetry, 1983.

Assessment: Written and/or oral examination

Course title: AIRCRAFT AERODYNAMICS	
Course module (if applicable):	
ECTS: 9	**SSD:** ING-IND/06
Lectures (hrs): 70	**Tutorials (hrs):** 17
Year: FIRST YEAR	
Course objectives. Theoretical approach to the phenomena occurring in each flight condition of an aircraft, related models and solutions. Completion of the knowledge of Applied Aerodynamics to face the study of professional disciplines and a tipical job of an Aerodynamic Design office.	
Course content. Flight mission. Anatomy of an aircraft, numerical description and smoothing of an aerodynamic surface. Non-dimensional numbers to characterize a flight regime, critical Mach numbers. How a lifting or non lifting surface works at every speed. Mathematical models for a continuum flow. Basic aerodynamic solutions: singularities, potential flow around a cylinder, boundary layer on a flat plate, shock waves, expansion waves. Aerodynamic load and relationships with vorticity for airfoils and wings. Conformal mapping: inviscid flow around airfoils. Distributed singularities, supersonic complex singularities. Green's Identities. Theories, methods and solutions for lifting and non lifting surfaces in inviscid and viscous flow: linearized flow, panel methods, approximate empirical methods. Swept and delta wings. Viscous fluid mechanics. Laminar flow, stability and transition, turbulent flows, boundary layer, separation and separated flows, laminar bubbles. Compressibility effects: shock wave/boundary layer interaction. Similar solutions. Von Karman, integral boundary layer parameters, direct and inverse boundary layer methods, estimation of transition and separation. Inviscid/viscous coupling and related methods. An introduction to Computational Aerodynamics, CFD methods applied to Aerodynamics. Solutions for airfoils depending on geometry and its surface conditions and on flight parameters. Low-speed and high-speed stall, buffet. Polar curves. Airfoils for low and high speed. High lift devices. Airfoil design and redesign. Solution for wings and aircraft depending on geometry, configuration, flight conditions. Evaluation of aspect ratio, taper, sweep angle, dihedral angle. Stall of a wing, manoeuver stall. Delta wing at low speed. Polar curves. Area rule. Drag breakdown, aerodynamic interference, empirical methods for polars. Stability derivatives. Sonic Boom. Interference between aircraft in flight. Wall effect. Aerodynamic fundamentals of propulsion: propellers, inlets. Icing effects.	
Teacher: Carlo de NICOLA	
Code:	**Semester:** first semester
Required/expected prior knowledge: none	
Education method: lectures	
Textbooks and learning aids. - 'Aerodinamica degli Aeromobili', Lecture Notes by Carlo de NICOLA, 2010 - V. LOSITO, 'Fondamenti di Aeronautica Generale', Italian Airforce Academy, 1983	
Assessment: oral exam combined with the valuation of an (optional) homework report.	

Course title: Aircraft Design

Course module (if applicable):

ECTS: 9	**SSD:** ING-IND/03
Lectures (hrs): 56	**Tutorials (hrs): 22**

Year: II – 2nd semester

Course objectives:
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 component's and the design of the complete aircraft will be shown.
A software tool for preliminary sizing of aircraft is demonstrated. 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.

Course content:
Aircraft design process and phases. Certification rules and impact on the design. Overall configuration. Design requirements. Preliminary design and optimization. Different configurations and arrangements. Propulsion and engine position. Preliminary sizing (aircraft weights, wing area and installed thrust).
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.
Range(propeller and jet). Block speed. Pay-load Range diagram. Direct Operative Costs (DOC). Optimal range and speed. Transport efficiency.
Aileron efficiency and design. Aircraft weight estimation. Weight and balance.
Landing gear design.
Tail design for stability and control. Longitudinal stability and control. Horizontal plane design. Stick fixed and stick free stability (neutral point). Stick force. Maneuvering stability.
Directional stability and control. Vertical tailplane design. Minimum control speed (V_{MC}). Adverse yaw. Lateral stability and dihedral effect.
Aircraft cost, safety and environmental issues.

Teacher: Fabrizio Nicolosi

Code:	**Semester:** Second

Required/expected prior knowledge:
Aerodinamica degli Aeromobili

Education method: *lessons and exercises*

Textbooks and learning aids: *Course slides and books:*
Perkins "Airplane Performance, Stability and Control"; Torenbeck "Synthesis of Subsonic Airplane Design"; Roskam "Aircraft Design"; Jenkinson "Civil Jet Aircraft Design"

Assessment: *Oral examination and developed project*

Course title: Aircraft Flight Dynamics and Flight Simulation	
Course module (if applicable):	
ECTS:	**SSD: ING-IND/03**
Lectures (hrs): 36	**Tutorials (hrs): 16**
Year: I	
Course objectives: *Main objective of the course is to provide all elements to numerically simulate the aircraft motion. 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 concrete examples. Proposed exercises are solved by making use of Matlab and Simulink.*	
Course content: *Reference coordinate systems. Derivation of the general equations of motion of an airplane in atmospheric flight. Equilibrium flight conditions. Manoeuvring loads on tail planes. Manoeuvred flight. The Spin. Inertial coupling effects. Exercises on the numerical resolution of aircraft equations of motion. 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). 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.*	
Teacher: Domenico Coiro, Agostino De Marco	
Code:	**Semester: II**
Required/expected prior knowledge: *Aircraft performances and static stability.*	
Education method: lessons, practical classes and tutorials, seminars on specific topics	
Textbooks and learning aids: Course slides. Handouts. Textbooks: [1] M. Calcara, *Elementi di dinamica del velivolo*. Edizioni CUEN, Napoli, 1988. [2] W. F. Phillips, *Mechanics of Flight*. John Wiley & Sons, Inc., 2004. [3] B. Stevens, F. Lewis, *Aircraft Control and Simulation*. John Wiley & Sons, Inc., 1992. [4] B. N. Pamadi, *Performance, Stability, Dynamics and Control of Airplanes*. AIAA Education Series, 1998.	
Assessment: *oral exam.*	

Course title: Applied Mechanics	
Course module (if applicable):	
ECTS: 9	**SSD: ING-ING/13**
Lectures (hrs): 60	**Tutorials (hrs): 20**
Year: I	
Course objectives: *The course addresses the problems associated with the movement of material bodies composing the mechanical systems. It regards the kinematic study of mechanisms, the mechanical contact between bodies, the motion transmission systems, dynamic phenomena related to the bodies deformations; a part of the course regards the tire-ground interaction and the vehicle dynamics .*	
Course content: *Review of mathematical physics; reduced systems, equivalent systems.* *Contact between bodies, friction, wear, stick-slip, plain and rolling bearings, mechanical efficiency.* *The motion transmission: friction wheels, gears, belt trasmissions, ordinary and planetary gearbox.* *Study of cam and articulated mechanisms: valve mechanism; four link mechanism; open chain mechanism, slider-crank mechanism.* *Rotating bodies: static and dynamic balancing, bending critical speeds. Periodic torques and torsional critical speeds. Vibration isolation problems.* *Vehicle dynamics: tire-ground interaction; longitudinal dynamics, braking and brakes, steering and vehicle lateral dynamics, suspensions and vertical dynamics, aircraft landing gear, swivel-wheel shimmy.*	

Teacher: Stefano Pagano	
Code:	**Semester: II**
Required/expected prior knowledge: *basic mechanics, technical drawing*	
Education method: *Classroom lectures, computer exercises, laboratory activities*	
Textbooks and learning aids: *A. R. Guido, L. della Pietra – Meccanica delle macchine - CUEN* *L. della Pietra - Lezioni di meccanica applicata alle macchine – EDISES* *Supplementary notes available on the website:* www.docenti.unina.it	
Assessment: *Oral*	

Course title: Avionics	
Course module (if applicable):	
ECTS:6	**SSD:ING-IND/06 Aerospace Systems**
Lectures (hrs):52	**Tutorials (hrs):2**
Year:1st	

Course objectives:
This course will teach students the operating principles of main components of onboard avionics. Furthermore, the most important concepts regarding design and integration issues will be discussed. Airborne Navigation and Air Traffic Management subsystems will be treated in full details. Each student will be able to manage the specific engineering features of the most important issues related to onboard navigation systems, such as:

i) Inertial systems;
ii) Air data systems;
iii) Terrestrial radio navigation systems;
iv) Satellite navigation systems, i.e. GPS, Glonass, and Galileo.

Furthermore, each student will be able to understand the most widely diffused measurement integration techniques such as the Kalman filter. Finally, the course will provide details about the main Air Traffic Control systems and services such as Primary and Secondary Surveillance Radars, Transponder, TCAS, GPWS, and ADS-B.

Course content:

Onboard avionics overview. Symmetrical gyro. Gyroscopic instrumentation for attitude measurements: Vertical Gyro and Horizontal Gyro. Integration of a Vertical Gyro with a Vector Magnetometer. Gyroscopic Compass. Vertical Gyro Erection Mechanism. Single Degree of Freedom Gyro. Stabilized Platform. Non conventional gyros: Coriolis Gyros, Dynamically Tuned Gyros, MEMS Gyros, Optical Gyros. Inertial Navigation Equations. Inertial Navigation Error Equations. Kalman Filter. Integrated Inertial Navigation. Air Data Systems. Radio Navigation Aids: NDB, ADF, VOR, TACAN, DME, RNAV, LORAN-C. Instrument Landing System. Doppler Radar. Laser Altimeter. Air Traffic Surveillance: Trasponder, Primary and Secondary Radars, Interrogation Modes – Mode S. Traffic Alert and Collision Avoidance System (TCAS). Broadcast GPS based surveillance: ADS-B and ADS-C. Ground Proximity Warning System (GPWS). Satellite navigation systems: GPS, Glonass, Galileo. Pseudorange equations. Diluition of Precision. GPS error sources. Dual frequency receivers. Differential GPS. GPS and Galileo Modernization.

Teacher: Domenico Accardo	
Code:	**Semester:2nd**
Required/expected prior knowledge:	
Education method: Oral lectures and laboratory experiences	

Textbooks and learning aids:
Lecture notes and slides

Reference textbooks:
Collinson, R.P.G., "Introduction to Avionics Systems 2nd edition", Kluwer Acaddemic Publishers, Boston MA, USA, 2003
Kayton, M., Fried, W.R., "Avionics Navigation Systems", 2nd ed., John Wiley&Sons, 1997
Farrell J. and Barth M., "The Global Positioning System and Inertial Navigation", McGraw Hill, New York NY, USA, 1999
Savage P.G., Strapdown Analytics, Strapdown Associates Inc., Maple Plain MN, USA, 2000
Rogers R. M., "Applied Mathematics in Integrated Navigation Instruments", AIAA Press, Washington DC, USA, 2000
Merhav, S., "Aerospace Sensor System and Applications", Springer Verlag, Washington DC, USA,1996
Titterton, D. H., "Strapdown Inertial Navigation Technology", Peter Peregrinus, New York NY, USA, 1996

Assessment: Oral exam

Course title: Calculus III	
Course module (if applicable):	
ECTS: 6	**SSD: MAT/05**
Lectures (hrs): 30	**Tutorials (hrs): 22**
Year: First	
Course objectives: This course provides the basic notions and results in view of the main applications to ordinary and partial differential equations, complex analysis and Fourier Analysis.	
Course content: *Taylor series of real functions. Elementary functions in complex field. Power series. Analitic functions. Conformal mappings. Complex integration. Taylor series of complex functions. Laurent series. Residue calculus and applications of contour integration. Elements of Lebesgue measure and integation. Elements of Hilbert spaces. Fourier series; pointwise and quadratic mean convergences. Fourier transform; definition and main properties, inverse Fourier transform. Laplace transform; definition, main examples and properties, inverse Laplace transform. Applications of tansforms to differential equations. Boundary value problems for ordinary differential equations. Partial differential equations: first order partial differential equations and caracteristic method; Laplace equation; heat equation; wave equation. Elements of calculus of variations.*	
Teacher: Anna Mercaldo	
Code:	**Semester: First**
Required/expected prior knowledge:	
Education method: Lectures, exercises	
Textbooks and learning aids: S. Abenda - S. Matarasso, Metodi Matematici, Esculapio. G.C. Barozzi, Matematica per l'Ingegneria dell'Informazione, Zanichelli. G. Di Fazio - M. Frasca, Metodi Matematici per l'Ingegneria, Monduzzi S. Salsa, Equazioni a derivate parziali, Springer	
Assessment: Written and oral examination	

Course title: Combustion	
Course module (if applicable):	
ECTS: 6	**SSD: ING-IND 25**
Lectures (hrs): 42	**Tutorials (hrs): 3**
Year: 1st or 2nd of second level degree	
Course objectives: To acquire knowledge of fundamentals in Combustion Processes in order to evaluate of the potentials for energy-conversion and propulsion application in respect of pollutant limits, of new fossil and synthetic fuels as well as of new improved performances. **Definition and analysis of the model equations describing the main processes in terms of the most relevant parameter and sensitivity analysis.**	
Course content: Definitions and Topics in Combustion/Gaseous and Liquid Fuel/ Solid Fuels and Propellants/ Adiabatic Flame Temperature/ Chemical Kinetics /Explosion /Autoignition/ Rankine-Hugoniot/ Deflagration/Detonation/ Laminar Premixed Flames/ Laminar Diffusion Flames/ Turbulent Premixed and Diffusion Flames/Atomization and Spray/Droplet Vaporization/ Droplet and Spray Combustion/	
Teacher: Antonio Cavaliere	
Code:	**Semester: 1st**
Required/expected prior knowledge: **Fundamentals of momentum and heat transport phenomena.**	
Education method: Oral teaching with aid of web designed tools	
Textbooks and learning aids: **Slides in http://www.federica.unina.it/corsi/combustione/** **Book : "Lezioni di Combustione" by Antonio Cavaliere, Ed Enzo Albano, 2001 (Naples) in http://wpage.unina.it/antcaval/**	
Assessment: oral colloquium	

Course title: Combustion	
Course module (if applicable):	
ECTS: 12	**SSD: ING-IND 25**
Lectures (hrs): 78	**Tutorials (hrs): 10**
Year: 1st or 2nd of second level degree	
Course objectives: To acquire knowledge of fundamentals in Combustion Processes in order to evaluate of the potentials for energy-conversion and propulsion application in respect of pollutant limits, of new fossil and synthetic fuels as well as of new improved performances. **To acquire the ability to recognize in multispecies/multiscale// multiphase reactive flows single sub-process which can be analyzed by means of calculation tools available for class of problem framed in monodisciplinary fields.** **To acquire design procedures and tools in order to evaluate traditional and innovative combustion configuration.**	
Course content: Definitions and Topics in Combustion/Gaseous and Liquid Fuel/ Solid Fuels and Propellants/ Adiabatic Flame Temperature/ Chemical Kinetics /Explosion /Autoignition/ Rankine-Hugoniot/ Deflagration/Detonation/ Laminar Premixed Flames/ Laminar Diffusion Flames/ Turbulent Premixed and Diffusion Flames/Atomization and Spray/Droplet Vaporization/ Droplet and Spray Combustion/ Swirled and Impinging Jets/Mixing of Gas-gas and Gas-liquid Flows/ Flame Stabilizations/ Appliction in Energy Conversion /Aeronautical Gas Turbine/ Applications in Propulsion/ Pollutant Formation and Reduction /Optical and Chemical Diagnostics/ **Use of commercial codes for the analysis of reactor units relevant in the characterization of traditional and innovation combustion configuration/ Analysis of data base exploitable in the implementation of codes and ensembles of codes.**	
Teacher: Antonio Cavaliere	
Code:	**Semester: 2nd**
Required/expected prior knowledge: **Fundamentals of momentum and heat transport phenomena.**	
Education method: Oral teaching with aid of web designed tools. Training on personal computers.	
Textbooks and learning aids: **Slides in http://www.federica.unina.it/corsi/combustione/** **Book : "Lezioni di Combustione" by Antonio Cavaliere, Ed Enzo Albano, 2001 (Naples) in http://wpage.unina.it/antcaval/**	
Assessment: oral colloquium	

Course title: Complements of Aeronautical Structures

Course module (if applicable):

ECTS: 6	**SSD:** ING-IND/04
Lectures (hrs): 40	**Tutorials (hrs):** 12

Year: II

Course objectives:

The course covers basically two main topics: an insight on aeronautical structure stability and an analysis of structural problems in aircraft engine design.

Regarding the first topic, the course has the objective to cover the theory and the practice of the elastic and plastic stability of the structures with main emphasis on aerospace applications. After the main definition and theoretical formulation of stability problems, the phenomena of classical stability of column, beam-column, flat and stiffened panels are addressed. Focus on the ultimate load carrying capability of wing and fuselage structures are put. Use of manuals and FEM codes to solve stability of aerospace structures are explained.

Regarding the second topic, the student will learn to distinguish the different types of aircraft engines, based on their architecture and on the aircraft type, on which they are installed. He will learn the gas turbine engine operation principles and will be able to recognize from their geometry the several engine components, of which he will also know the function. He will know which loads are applied on the engine and will be able to determine their amplitude and distribution. He will know all the possible failure modes of the several engine structural components and will be able to perform strength and life analyses. In particular, he will be able to perform a stress analysis on a turbine or compressor blade and to determine its strength and life. At the end he will be able to carry out a turbine or compressor blade structural design

Course content:

Basic of the Stability of the Structures. Simple model with 1 and 2 dof. Equilibrium and effects of some geometrical imperfections. Energy consideration and methods. Shear effect on the critical load. Theory and applications of the beam-column. Flexural-torsional instability of the beam. Lateral instability of the beam. Plates and stiffened panels instabilities. Cylindrical shell instability. Ultimate load for the wing box. Instability of the stiffened and pressurized fuselage. Different types of fuselage collapses. Instability with combine load. Local instability phenomena. Introduction to the instability of composite beam and plates (Equivalent Orthotropic Plate, CFRP e Sandwich).

Architecture and working principles of aircraft gas turbine engines: Mechanical arrangement and working cycle. Origin of loads: assembly loads, operation loads, maneuver loads; Thrust distribution. Failure modes: stress-strain relationship, plastic strain, rupture, failure under cyclic load, stress-cyclic strain relationship, fracture mechanics, fatigue crack growth, cumulative damage, cycle count, rainflow method, creep/stress rupture, Larson-Miller parameter, cumulative creep.

Compressor and turbine blade. Blade geometry, blade fixing, compressor blade, turbine blade, cooled balde, uncooled blade, blades with high curvature and twisting, applied loads, failure modes: HCF, creep/stress rupture, LCF, blade integrity, blade design, blade balancing, blade vibration, Campbell diagram, Goodman diagram, turbine blade creep life analysis, Simon diagram, low cycle fatigue

Teacher:

Code:	**Semester:** 2nd

Required/expected prior knowledge: Advanced Aerospace Structures

Education method: lectures, classroom guided tutorials, major worldwide aircraft engines manufacturers virtual tour, assisted analysis of engine component drawings and hardware, Campania aerospace company guided tour

Textbooks and learning aids: lecture notes: http://www.dias.unina.it/?id=16&sid=0

Assessment: written examination (multiple answer tests) + oral examination

Course title: Complements of Gasdynamics	
Course module (if applicable):	
ECTS: 9	**SSD:** ING-IND/06
Lectures (hrs): 72	**Tutorials (hrs):**
Year:2nd	
Course objectives: In depth study of the gasdynamics and compressible flow. Methodologies for the determination of unsteady and two-dimensional compressible flow fields.	
Course content: Mass addition. Generalized one dimensional flow. Conical supersonic flow. Solution of the Taylor Maccoll equation. Detonation and deflagration. Structure of a shock wave. Potential equation. Partial differential equation, theory of the characteristics. Unsteady flow and theory of the characteristics. Intersection and reflections of waves. Shock tube. Linearized equations for subsonic and supersonic flows and second order corrections.	
Teacher: Tommaso Astarita	
Code:	**Semester:1st**
Required/expected prior knowledge:	
Education method: lectures and laboratory tests.	
Textbooks and learning aids: *Course slides.* *Raffel M., Willert C. E., Wereley S. T. and Kompenhans J., Particle Image Velocimetry 2nd ed., Springer, 2007.* *Tropea C., Yarin A. L., Foss J. F., Springer Handbook of Experimental Fluid Mechanics Springer, 2007.*	
Assessment: Written and oral exam	

Course title: Design of Advanced Aerospace Structures	
Course module (if applicable):	
ECTS: 6	**SSD:**
Lectures (hrs): 44	**Tutorials (hrs): 10**
Year: II	
Course objectives: This course provides the students with engineering knowledge and skill to recognize and analyze specific aircraft structural problems. The course deepens composite materials failures, fatigue and fracture mechanics and the behavior of pressurized vessels.	
Course content: Elastic behavior of multi-directional laminates under thermo-mechanical loads. Failure criteria in laminates. Interlaminar stress and strength in multidirectional laminates. Sizing criteria of composite structures. FE applications. S-N curves and fatigue life. Stress intensity factor. Energy criteria for fracture mechanics. Crack growth models. Crack growth calculation in a typical aircraft components (e.g. pressurized fuselage). Sizing procedures for a pressurized fuselage. FE applications.	
Teacher: Fabrizio Ricci	
Code:	**Semester: I**
Required/expected prior knowledge: Advanced Aerospace Structures	
Education method: Lectures and numerical applications.	
Textbooks and learning aids: **I. M. Daniel and O. Ishai** - *Engineering Mechanics of Composite Materials* – Oxford University Press **S. Abrate** – *Impact on Composite Structures*, Cambridge University Press **M.C.Y. Niu** – *Composite Airframe Structures*, Hong Kong Conmilit Press LTD. **E.F. Bruhn**, *Analysis and Design of Flight Vehicle Structures* - Jacobs Publishing Inc. J. **Schijve** – *Fatigue of Structures and Materials*, Kluwer Academic Publisher **F. Ricci –** *Lecture Notes*	
Assessment: **Mid term written exam, final written exam and optional oral examination**	

Course title: Fluid dynamics stability	
Course module (if applicable):	
ECTS: 6	**SSD:** ING-IND/06
Lectures (hrs): 44	**Tutorials (hrs):** 10
Year: I/II	
Course objectives: The present course addresses the basic theories and advanced investigation methodologies in order to analyse flows instabilities. The course analyses particularly shear flows. The industrial problem linked to the prediction of the laminar-to-turbulence transition is one of the main applications.	
Course content: Basic concepts and definitions of stability in Fluid mechanics. Linearization of the equations. Normal modes analysis for parallel flows. Some classic cases: Kelvin-Helmholtz instability, capillary instability of a jet. Localized disturbances in space and time. Absolute and convective instability. Landau-Ginzburg equation. Stability of parallel flows: inviscid and viscous theories. Orr-Sommerfeld equation. Stability of non-parallel flows. Global instability. Connections between global instability and absolute/convective instability for locally parallel flows. Theory of the non-modal instability. Laminar-to-turbulent transition in wall bounded flows. Criterions of turbulence prediction .	
Teacher: LUIGI de LUCA	
Code:	**Semester:** second
Required/expected prior knowledge: Some arguments of Analisi matematica III, equations and models of Fluid mechanics, numerical methods in linear Algebra e Fluid mechanics	
Education method: frontal lectures	
Textbooks and learning aids: didactic material issued by the teacher	
Assessment: oral examination	

Course title: Fluid-Structure Interaction	
Course module (if applicable):	
ECTS: 6	**SSD: ING-IND/04**
Lectures (hrs): 44	**Tutorials (hrs): 10**
Year: II	
Course objectives: The background of the students inside the structural aerospace engineering filed 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 hot to manage complex and complete procedures *) will analyse if the available data and tools are enough for getting the required results	
Course content: Generalities about the Aero/Acousto/Elasticity as function of the modal overlap factor. Waves, Modes and Energy (characteristic wavespeed in solids, modal density, mechanical and acoustic impedances, damping). Deterministic Approaches. Energy Methods. Hybrid Methods. From the Modes to the Energy: Energy Distribution Approach. Spectral Finite Element Approach: Dispersion Curves (material characterization). Remarks on simple aeroelastic instability and response. Influence of the excitation/acquisition set-up on the measurements. Stochastic response of linear systems Aeroacoustoelasticity and Thermoelasticity fundamentals.	
Teacher: Sergio De Rosa, Francesco Franco	
Code:	**Semester: Secondo**
Required/expected prior knowledge:	
Education method: classical oral lessons and numerical/experimental laboratory activities	
Textbooks and learning aids: 4. S. De Rosa e F. Franco. Schemi di Interazione Fluido-Struttura (dispense), 2010 5. NASA Technical Handbook, DYNAMIC ENVIRONMENTAL CRITERIA 6. S. De Rosa , F. Franco, F. Ricci. Introduzione alla Tecnica Statistico-Energetica per la Dinamica Strutturale e l'Acustica Interna, Liguori Editore, 1999 7. L. Cremer L., M. Heckl. Structure-Borne Sound (translated by Ungar), Springer, 1972 8. A. E. Thornton. Thermal Structures for Aerospace Applications, AIAA Ed. Series, 1996 Presentations, Mathcad Sheets, VAOne Samples, Nastran models, FastBEM Acoustics models.	
Assessment: exercises, final student project, oral exam.	

Course title: Multimedia Signal Processing	
ECTS: 9	**SSD:** ING-INF/03
Lectures (hrs): 52	**Tutorials (hrs):** 26
Year: II	
Course objectives: Acquiring conceptual and mathematical skills on image and video processing and be able to use such skills to develop algorithms for multimedia signal processing.	
Course content: Introduction to digital image processing. Binary and gray-scale images, multispectral and color images. Image processing in the spatial domain: intensity and geometric transformations, morphological processing, linear filtering, clustering, segmentation, classification. Two-dimensional Fourier transform and basics of filter design in the frequency domain. Principal component analysis. Compression of multimedia signals: quantization and linear prediction, transform coding, image and video compression, audio coding. Overview of standards (JPEG, MPEG, MP3, AVI). Time-frequency analysis and wavelet transform, multiresolution analysis, filter banks. Advanced coding techniques (JPEG2000, video coding based on wavelet). Network transmission problems. Video 3D. Applications: denoising, watermarking, digital forensics, inpainting.	

Teacher:	
Code:	**Semester:** II
Required/expected prior knowledge: Linear time-invariant systems, Fourier transform, fundamentals of probability.	
Education method: Lessons and laboratory.	
Textbooks and learning aids: Course lectures R.C.Gonzalez-R.E.Woods – *Digital Image Processing*, third ed.,Prentice Hall; K.Sayood – *Introduction to Data Compression,* second ed., Morgan Kaufmann.	
Assessment: laboratory test, interview.	

Course title: Numerical Fluid Dynamics	
Course module (if applicable):	
ECTS: 12	**SSD: Ing-Ind 06**
Lectures (hrs): 40	**Tutorials (hrs): 72**
Year: second	
Course objectives: To give the students the rational bases of Numerical Fluid Dynamics founded on mathematical analysis, linear algebra, numerical methods and fluid mechanics as well. In the first part of the course the students will achieve a rather exhaustive knowledge of linear problems associated to Stokes flow and will be tutored in the construction of Finite Differences (FD) and Finite Element Methods (FEM) codes for the numerical resolution of such flows. In a following part of the course those non-linear problems typical of the numerical simulation of the Navier Stokes equations for compressible flows as well as for laminar or turbulent incompressible flows will be considered. The course aims to provide the students the means to comply with the job offer in the Computational Fluid Dynamics (CFD) field, as well as to become a "not fully blind" user of commercial and industrial CFD codes.	
Course content: Basic notions of Linear Algebra, Finite Differences (FD) methods and Finite Elements Method (FEM) through the usage of Matlab: TAYLOR_tool, PDEPE, PDE_tool, fundamentals of Iterative Computing. The Inverse Problem of Vector Calculus (IPVC) and its numerical resolution by means of FD and FEM techniques; test cases against classical analytical methods for 2D specifications of the IPVC in form of the Cauchy-Riemann equations. Connections between the IPVC and the Navier-Stokes (NS) equations. Stokes flow models by means of FD and FEM techniques: associated Galerkin matrices and related numerical resolution problems. Linear transport of passive scalars (advection); the Lagrangian approach for the convective terms for the unsteady incompressible NS eqs. All the above mentioned topics are used for the construction of prototypal numerical codes during the tutoring phase. Problems related to the presence of the non-linear terms (convection and/or stretching) in the corresponding cathegories. The treatment of the convective terms in the unsteady incompressible NS: various analytical forms, and the principal methods in the C.V. methods. Fluid Dynamics instability and the problems for the modeling of convection in turbulent flows: changing the dependent variables and the closure of the convective model. Non-linear convective transport problems and the Burgers' equation: weak solutions, stable solutions, monotony properties, TVD. The Lax-Wendroff theorem, for the FD schemes; Godunov theorem. Basic ideas for the construction of the Euler p.d.e. for the 1D case based on the wave solutions as well as similarity solutions. Classroom construction of codes for non viscous compressible flows.	
Teacher:	
Code:	**Semester: Annual**
Required/expected prior knowledge: Fluid Mechanics	
Education method: Lessons, Computer Tutorials	
Textbooks and learning aids: Meola-de Felice: Fondamenti Lineari per la Fluidodinamica Numerica - L'Ateneo Napoli. Teacher's notes, Computer - code tutorials.	
Assessment: computer home work and oral examination	

Course: Rotary Wing Aerodynamics	
Module:	
ECTS: 9	**SSD:ING-IND/06**
Lectures (hrs): 60	**Tutorials (hrs): 20**
Year: *second*	

Objectives:

To provide the theoretical and practical tools required for the Aerodynamic design of propellers, rotors and wind turbines.

Contents:

Part I. Propeller Aerodynamics
Introduction to the unsteady Aerodynamics. Momentum theories: the actuator disk model, simple momentum theory, optimum load distribution, general momentum theory, optimum axial and rotational induced speeds. Blade element theories: the propeller vortex system, general blade element momentum theory, propeller working conditions, hub loss, optimum propeller, tip losses, propeller design. Ducted propellers, analysis by momentum theory, shroud geometry, airfoil cascades. Compressibility effects: momentum theory in compressible flow, corrections to the blade element momentum theory.

Part II. Rotorcraft Aerodynamics
Hovering: momentum theory and blade element theory, ideal, optimum and real rotor, figure of merit, climb speed, autorotation, working charts in axial climb and descend flight, ground effects. Rigid rotor in forward flight: momentum theory in forward flight, parasite power, calculation of necessary power for forward flight, fuselage parasite power, inverse flow region, ground effects in forward flight. Articulated rotor: need of the articulated rotor, cyclic and collective pitch, blade dynamics, flapping coefficients, oscillating airfoil, Theodorsen's theory, effective speed on the blade element, the aerodynamic forces, power in forward flight, calculation of the flapping coefficients, climb rate, rotorcraft performance, the stall of the rotor, dynamic stall, aerodynamics of the helicopter fuselage.

Part III. Wind turbine Aerodynamics
Horizontal axis wind turbines: performance, classification, Betz's limit, optimum torque and power for a horizontal axis wind turbine, optimum torque at start-up, optimum geometry of the blade, wind concentrators, tip vane. Vertical axis wind turbines: drag-type devices, Darrieus turbine, single-stream tube theory.

Part IV. Numerical methods for the rotary wing
Inviscid methods. Viscous methods. A numerical model of the actuator disk in compressible flow. Wake simulation.

Teachers: R. Tognaccini (6 ECTS), C. de Nicola (6 CFU)	
Code:	**Semester: first**

Propedeutic courses:

Aircraft Aerodynamics

Instruction modalities: *lectures*

Didactic material: *lectures available online*

Assessment: *oral discussion*

Course title: Space fluid dynamics	
Course module: Hypersonic Aerodynamics	
ECTS: 6	**SSD: Ing-Ind-06**
Lectures (hrs): 40	**Tutorials (hrs): 20**
Year: 2nd	

Course objectives:
The course objective is providing the student with a view of the problems in high energy flow fields and with the tools for their solution. The student will be able, at the end of the course, to analyze the flow field past a lifting or non-lifting space vehicle (capsule) along the re-entry path at high altitudes, therefore from the free molecule flow to continuum. Some problems, already studied by the student in base courses in Aerodynamics and Gasdynamics are reviewed and applied to hypersonic flow field such as: 1) thermo-dynamics with chemical reactions, 2) method of characteristics in non-omo-entropic flow fields, 3) hypersonic boundary layer. In this way the range of applicability of these methods will be extended and made of more general application.

Course content:
The course deals with high velocity flow fields, characterized by Mach numbers higher than 5. These flow fields are experienced by space vehicles during the re-entry to Earth. The course is made up of seven parts:

1) Problems of re-entry: flight corridor and re-entry path.

2) Shock wave and computation of the shock wave angle.

3) Thermodynamics of air in high energy flow fields, the presence of vibration and of chemical reactions (dissociation, recombination) is considered: models of Lighthill and of Monti-Napolitano. Computation of the relaxation zone downstream a shock wave.

4) Computing non-diffusive, non-omoentropic, two-dimensional, hypersonic flow fields (method of characteristics) and two-dimentional, axisymmetric, omo-entropic flow fields (equations of Taylor-Maccoll).

5) Small disturbance and approximate theories.
6) Viscous hypersonic flow fields: Navier-Stokes equations, boundary layer (similar solutions), viscous interaction, influence of chemical reactions on heat transfer, effective thermal conductivity.

7) Rarefied flow fields: free molecule flow and Maxwell theory, transitional regime and DSMC (Direct Simulation Monte Carlo) method.

Computer exercises, on the above topics, are required

Teacher: Gennaro Zuppardi	
Code:	**Semester: 1st**
Required/expected prior knowledge:	
Education method: lectures, laboratory, film show	
Learning aids: books and notes	
Assessment: oral examination	

Course title: Space Fluid Dynamics	
Course module (if applicable): Space Experiments	
ECTS: 6 CFU	**SSD:ING-IND/06**
Lectures (hrs): 35	**Tutorials (hrs): 25**
Year: II	
Course objectives: This course is intended to provide an overview of the scientific and engineering problems related to the execution of experiments onboard space platforms, with particular reference to the current microgravity research.	
Course content: Part A: Introduction to space utilization and overview of main scientific space programmes. Role of principal investigators, space industries and agencies. Space platforms. Microgravity environments. Motivations for research in microgravity. Overview of main research fields in Fluid, Material, Life Sciences and related applications. Short-duration microgravity opportunities: drop towers and drop tubes, parabolic flights on aircrafts, sounding rockets, orbital platforms. Microgravity Fluid dynamics: capillarity, balance equations, order of magnitude analysis and examples. Part B: International Space Station (ISS) overview. Principal pressurized and unpressurized elements. Accomodation and utilisation resources for payloads. Columbus laboratory. Microgravity facilities. Scientific operations. Ground Segment. Role of User Support Operation Centers (USOC's). Telescience. Optical diagnostics for microgravity fluid dynamics.	
Teacher: Raffaele Savino (3 ECTS)	
Code:	**Semester: second**
Required/expected prior knowledge: Fundamental knowledge of Fluid Dynamics and Aerospace Systems	
Education method: Lectures, laboratory, seminars	
Textbooks and learning aids: Slides, chapters of books related to Microgravity Sciences and International Space Station facilities and operations	
Assessment: Oral examination	

Course title: Space Systems	
Course module (if applicable):	
ECTS: 9	**SSD: ING-IND/05**
Lectures (hrs): 66	**Tutorials (hrs): 12**
Year: Second	

Course objectives:

The course provides the basic elements for the design of a space system 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

Course content:

Elements of space system design and engineering: space project phases, space mission architecture, system and subsystem mass and power budgets from mission objectives, design margins, examples of different missions.
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, the thermal environment, the main perturbations acting on a satellite
Elements for the design of the satellite subsystems: main subsystems and components of a satellite, architectures, operating principles, derivation of the design requirements from mission objectives. Simplified mathematical models for subsystem and component design: guidance, navigation and control subsystem (attitude and orbital control), electrical power subsystem, thermal control subsystem, telemetry and telecommunication subsystem. Design examples.
Introductory elements on space qualification and ground testing.

Teacher: Michele Grassi	
Code:	**Semester: 1st**
Required/expected prior knowledge:	
Education method: Lessons and exercises	

Textbooks and learning aids: course viewgraphs and the following suggested textbooks:
Charles D. Brown, Elements of Spacecraft Design, AIAA education series, American Institute of Aeronautics and Astronautics, Inc., 2002, ISBN 1563475243
James Richard Wertz, Wiley J. Larson, Space mission analysis and design, Space Technology Library, Volume 8, Springer, 1999, ISBN 0792359011
James Richard Wertz, Spacecraft attitude determination and control, Astrophysics and space science library, Springer, 1978, ISBN 9027709599
Vincent L. Pisacane, Fundamentals of space systems, Johns Hopkins University/Applied Physics Laboratory series in science and engineering, Oxford University Press US, 2005, ISBN 0195162056

Assessment: Written and Oral Examination

Course title: Statistics for Innovation	
Course module (if applicable):	
ECTS: 6	**SSD:** SECS–S02
Lectures (hrs): 40	**Tutorials (hrs): 12**
Year: I or II	
Course objectives: *Statistics for Innovation is a methodological – applicative course whose aim is to train students on statistical tools used to promote and manage the innovation of engineering systems taking into account the specific applicative context.* *Applications and study cases refer to several strategic activities like: design of experiments to study main effects as well as interactions of several environmental or design factors; optimization of processes and/or industrial products; predictive evaluation of the performance of engineering systems under uncertain conditions about the relative environmental context.*	
Course content: *Advances on random variables and extremes theory. Monte Carlo Method. design of experiments and Analysis of Variance. Robust Design and Innovation. Analysis of Linear Regression. Statistical experiments carried out in the classroom to test the effectiveness of the proposed methodologies.*	
Teacher: Pasquale Erto	
Code:	**Semester: I**
Required/expected prior knowledge:	
Education method: *Lectures, tutorials and seminars*	
Textbooks and learning aids: *P. Erto, 2008, Probabilità e statistica per le scienze e l'ingegneria 3/ed, McGraw-Hill* *P. Erto, 2002, La Qualità Totale... in cui credo, CUEN*	
Assessment: *Individual written test and its oral discussion*	

Course title: Technologies Chemical Foundations	
Course module (if applicable):	
ECTS: 9	**SSD: CHIM/07**
Lectures (hrs): 64	**Laboratory (hrs): 6**
Year: I or II	
Course objectives: **Full knowledge of matter structure and transformations thermodynamic and kinetics with special reference to engineering problems and technologies (materials, environment, energy…). Wide place is reserved to materials and environment investigation techniques.**	
Course content: **Origins of quantum mechanics: classic theory of radiation and photon theory. Interaction between matter and radiant energy. Spectroscopic techniques. X-ray diffraction.** **Atom electronic structure and chemical bond from quantum mechanics. Valence bond and molecular orbitals theory. Crystalline and amorphous solids. The Condon-Morse curves; elastic and anelastic properties. Origin of valence and conduction bands in conductors and, intrinsic and doped, semiconductors; band structure and photovoltaic effect. Crystal defects (point, line and surface) and their effect on electrical and mechanical properties. Nuclear chemistry, radioactivity and their applications.** **Chemical kinetics. Rate laws and reaction mechanisms. Arrhenius equation and activation energy. Catalysis. Some concepts of flame chemistry, flammability limits, auto-ignition curves. Oxidation.** **Galvanic cells. Electrode potential. Nernst equation. Electrolytic cells and electrolytic deposition methods. Electrochemical sensors. Measure of equilibrium constants. Ion selective electrodes in water analysis. Galvanic corrosion and metal passivation. Electrochemical methods in metallurgy. Iron, aluminium and copper and their alloys. Technologies for the production and storage of energy. Batteries and storage batteries. Fuel cells.** **Organic chemistry. Hydrocarbons, functional groups and classes of reactions.** **General concepts about combustion: higher and lower heating value, combustion theoretical air, adiabatic flame temperature, chimney loss, exhaust gases analysis.** **Petroleum distillation. Fuels and lubricants. Synthetic polymers and polymerization reaction mechanisms. Nanostructured composites: perspectives and problems**	
Teacher: Francesco Branda	
Code:	**Semester:**
Required/expected prior knowledge:	
Education method: Lessons, laboratory	
Textbooks and learning aids: - **B.H.Mahan, University Chemistry, Addison-Wesley Publishing company.** - **Notes on specific applied topics**	
Assessment: Oral examination	

Course title: Turbulence	
ECTS: 6	**SSD:** ING-IND/06
Lectures (hrs): 46	**Tutorials (hrs):** 8
Year: *First or Second*	
Course objectives: After introducing basics on turbulent flows and semi-empirical models for internal or external flows, the target of the course is to lead the students – through some theoretical deepening - to comprehend and to use in a conscious way the most recent theoretical and numerical turbulence models.	
Course content: Origin and main features of turbulent flows. Basics on the probabilistic approach. Averaged balance equations for mass, momentum and scalars. The Reynolds Stress tensor, its evolution equation and the closure problem. Kinetic Energy equation for Averaged and Turbulent quantities. Eddy (or turbulent) viscosity. Semi-empirical models for wall flows: the wall law. Effects of wall roughness. Similarity and Semi-empirical models for jets and some free shear flow. Charts for Turbulent flows around arbitrarily shaped bodies. The structure of turbulence for homogeneous and isotropic flows: space and time correlations. Turbulence scales: transfer and dissipation mechanisms in real as well as spectral space; Kolmogorov's Universal Equilibrium theory. General features of the Direct Numerical Simulation (DNS) and its limitations. Turbulence differential Modelling for the numerical simulation (K-eps, RSM). Large Eddy Simulations (LES): filtering and filtered equations. The residual-stress tensor and its decompositions; the Smagorinsky model. Navier-Stokes Equations in the wave number space. Dynamic and Mixed models for the residual-stress tensor. Near wall difficulties for the Numerical Simulation. Sensitivity to Initial Conditions and long time unpredictability for LES. Elementary notions about compressible turbulent flows.	
Teacher: Giuseppe de Felice	
Code:	**Semester:** First
Required/expected prior knowledge: *Navier-Stokes Equations*	
Education method: *Lectures, tutorials*	
Textbooks and learning aids: *International textbooks such as:* S. B. Pope, *TURBULENT FLOWS*, Cambridge University Press, 2003 *plus some teacher's slides*	
Assessment: *Oral*	

Course title: Unmanned Aircraft Systems	
Course module (if applicable):	
ECTS: 6 CFU	**SSD:ING-IND/05**
Lectures (hrs): 52	**Tutorials (hrs): 2**
Year: I or II	

Course objectives:

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 will be given to enabling technologies for integrating UAS in the civil airspace such as ground-based and airborne sense and avoid systems.

Course content:

Introduction. Definitions and principles.
UAS Configurations and Applications: Military & Civilian Roles. Evolution, current and future systems.
UAS Onboard Systems:

- Basics of airborne sensors: atmospheric transmission, radar, electro-optical (visible/IR), lidar, other sensors. Estimation and data fusion techniques: basics of stochastic filtering, Kalman filter, Extended Kalman filter, nonlinear filtering techniques, taxonomy of data fusion algorithms. Basics of airborne tracking systems;
- UAS guidance, navigation and control systems. Architectures and basic algorithms of UAS autopilots.

UAS communications and data links.
UAS ground stations and human factors, levels of automation, mission planning systems.
Regulations and airspace integration: airspace categories and current UAS operations, cooperative and non cooperative collision avoidance systems, ground-based and airborne sense and avoid systems and algorithms. Practical anti-collision system design examples.
MicroUAS and vision-based techniques.

Teacher: Giancarmine Fasano	
Code:	**Semester: second**
Required/expected prior knowledge: Avionica	
Education method: Lectures and exercises	

Textbooks and learning aids: Slides, lecture notes, technical papers.

Textbooks:
J. Gundlach, Designing Unmanned Aircraft Systems: A Comprehensive Approach, AIAA Education Series, 2012
R.K. Barnhart, S. B. Hottman, D.M. Marshall J.D., E. Shappee (Editors), Introduction to Unmanned aircraft systems, CRC press, 2011
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
S. Blackman, R. Popoli, Design and analysis of modern tracking systems, Artech House, 1999.
R.C. Nelson, Flight Stability and Automatic Control, McGraw Hill, 1998

Assessment: Written and/or oral examination

Academic Year 2011/2012 Calendar

	Start	**End**
1st Semester	September 24, 2012	December 21, 2012
1st Exam session	December 22, 2012	March 02, 2013
2nd Semester	March 04, 2013	June 07, 2013
2nd Exam session	June 08, 2013	August 03, 2013
3rd Exam session	August 26, 2013	September 28, 2013

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