UNIVERSITÀ DEL SALENTO

CORSO DI LAUREA LM52 –

CdLM Aerospace Engineering

SCHEDE INSEGNAMENTI DIDATTICA PROGRAMMATA
a.a. 2020/2021

# SCHEDA INSEGNAMENTO

# AERODYNAMICS (MOD.1) C.I.

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| Corso di studio di riferimento | LM52 - CdL Magistrale in Aerospace Engineering |
| Dipartimento di riferimento | Dipartimento di Ingegneria dell'Innovazione |
| Settore Scientifico Disciplinare | ING-IND/06 |
| Docente | In attesa di assegnazione |
| Crediti Formativi Universitari | 6 |
| Ore di attività frontale | 54 |
| Ore di studio individuale | 96 |
| Anno di corso | I anno |
| Semestre | II |
| Lingua di erogazione | Inglese |
| Percorso | PERCORSO COMUNE |

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| Prerequisiti | Basic knowledge of Calculus (derivatives and integrals), Applied Thermodynamics and Fluid Dynamics |
| Contenuti | The course provides the fundamentals for the study of gas dynamics and aerodynamics. Starting from the formulation of the fundamental equations of gas dynamics in vector notation, the one-dimensional and quasi-one-dimensional gas dynamics is studied, analyzing the isentropic conditions and the normal shocks, in order to characterize the flow through nozzles. Two-dimensional supersonic flows are then studied taking into account oblique shocks and Prandtl-Meyer expansion waves and finally the flow past airfoils. After recalling the concepts of classical aerodynamics, the approximate solution to several important aerodynamic problems is addressed employing the potential flow assumption. Finally, the study of finite wing theory is carried out. |
| Obiettivi formativi | At the end of the course the student must:<br><br>- Know the fundamental equations of gas dynamics in vector notation and their simplification in the simplified case of: one-dimensional flow; quasi-one-dimensional flow; multi-dimensional irrotational flow;<br>- Know how to characterize and calculate the properties of the flow through a normal shock, an oblique shock, an expansion wave<br>- Know how to evaluate the force coefficients in the case of airfoils in a supersonic flow<br>- Know the fundamental aspects of the flow past an airfoil and past a finite wing, along with the evaluation of the force coefficients. |
| Metodi didattici | Lectures supported by the use of a computer and a projector |
| Modalità d’esame | Written examination for the application part and oral test. |

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| | In the written test (2 hours) the student is requested to solve two/three exercises concerning the arguments of the course; the test aims to verify the capability of the student to select the appropriate solution approach.<br>In the oral test the student has to discuss the theoretical arguments of the course, that the student must demonstrate to know and to be able to explain. |
| Programma | Basic concepts of fluid dynamics. Fluid properties; flow kinematics; Reynolds transport theorem; conservation equations in integral and differential form; Bernoullis equation; Croccos theorem; boundary layer theory (7 hours).<br>Introduction to the basic concepts of aerodynamics (3 hours).<br>One-dimensional gas dynamics. Quesi one-dimensional flow equations: compressibility; speed of sound; quasi one-dimensional steady flow; isentropic flow; stagnation and critical conditions; area-Mach number relation; mass flow rate; normal shocks; convergent nozzle; convergent-divergent nozzle (13 hours).<br>Two-dimensional gas dynamics. Oblique shocks and Prandtl-Meyer expansion waves; Mach angle; oblique shock equations; β - θ - Mach diagram; shock polar; shock reflection from a solid boundary; pressure-deflection diagrams; intersection of shocks of opposite families and of the same family; detached shock in front of a blunt body; isentropic expansions and compressions; Prandtl-Meyer function; reflection from a free boundary; over-expanded and under-expanded nozzle flows; Shock-Expansion Theory, Thin-Airfoil Theory (13 hours).<br>Linearized potential flow. Equations of the velocity potential; linear equation of the perturbed velocity potential; linearized two-dimensional subsonic flow; compressibility correction; critical Mach number (6 hours).<br>Aerodynamics. Kutta condition; Kelvins and Helmholtzs theorems; two-dimensional potential flows. Flow past airfoils of arbitrary shape and evaluation of the force coefficients; finite wing theory and Prandtls Classical Lifting-Line Theory; applications (13 hours). |
| Testi di riferimento | John D. Anderson Jr., Modern compressible flow: With historical perspective , Mc-Graw-Hill, Int. Ed. 1990.<br>John D. Anderson Jr., Fundamental of Aerodynamics , Mc-Graw-Hill, 5th Ed. 2010. |
| Altre informazioni utili | |

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# SCHEDA INSEGNAMENTO

# AERONAUTIC PROPULSION MOD. 1 C.I.

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| Corso di studio di riferimento | LM52 - CdL Magistrale in Aerospace Engineering |
| Dipartimento di riferimento | Dipartimento di Ingegneria dell'Innovazione |
| Settore Scientifico Disciplinare | ING/IND07 |
| Docente | Maria Grazia De Giorgi |
| Crediti Formativi Universitari | 6 |
| Ore di attività frontale | 54 |
| Ore di studio individuale | 96 |
| Anno di corso | I anno |
| Semestre | II |
| Lingua di erogazione | Inglese |
| Percorso | PERCORSO COMUNE |

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| Prerequisiti | Fluid dynamic and fluid machinery |
| Contenuti | This course presents aerospace propulsive devices with particular focus on air-breathing engine, with focus on: analysis of operating characteristics of turbojet, turbofan, turboshaft, afterburning, and ramjet propulsion systems. Analysis and design of inlet, diffuser, combustor, compressor, turbine, nozzle. Component matching and off-design performance for steady-state and transient operating lines. Piston Engine. |
| Obiettivi formativi | 1 Gain knowledge of different types of aero-engines (turbojets, turbofans, ramjets) and to understand the aerodynamic and thermodynamic characteristics of major engine components.<br>2 Develop the knowledge and skills to analytically and numerically solve problems related to aerospace propulsion systems.<br>3 Develop skills in working independently.<br>4 Develop skills in critical evaluation of scientific literature.<br>5 Develop skills in planning and presentation of scientific talks and reports. |
| Metodi didattici | Theory and practical activities (Tutorials devoted to discussion and problem solving referred to the aeroengine.) |
| Modalità d'esame | The final exam consist of two part:<br>1)Written examination covering all material covered in course<br>2) individual project |
| Programma | 1)Classifications of Aircrafts and Propulsion System: types of Airbreathing Engines. Aircraft Propulsion Requirements.<br>2)A Review of Basic Laws for a Compressible Flow. Quasi-One-Dimensional Flow. Area–Mach Number Relationship; Sonic Throat; Waves in Supersonic Flow<br>3)Performance Parameters of Jet Engines |

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| | 4)Elements of Thermodynamics for Aero Propulsion ; thermodynamic of Ideal Cycle and Real Engine Cycle Analysis. Parametric Cycle Analysis.<br>5) Inlets: Introduction; The Flight Mach Number and Its Impact on Inlet Duct Geometry; Diffusers; Ideal and real Diffuser; Subsonic Diffuser Performance; Supersonic Inlets;<br>6) Axial Flow Compressors:Introduction; The Geometry; Rotor and Stator; The Euler Equation; Axial-Flow Versus Radial-Flow Machines; Axial-Flow Compressors and Fans; Compressor Performance Map; Compressor Instability – Stall and Surge; Multistage Compressors; Compressor Design Parameters and Principles<br>8) Axial Flow Turbines: Aerodynamic Performance Analysis of Axial-Flow Turbines; Preliminary Aerodynamic Design of Axial-Flow Turbine Stages<br>9) Combustors: Introduction; Laws Governing Mixture of Gases; Chemical Reaction and Flame Temperature; Chemical Equilibrium and Chemical Composition; Chemical Kinetics; Combustion Chamber; Combustion-Generated Pollutants; Aviation Fuels<br>10) Exhaust Nozzle: Gross Thrust; Nozzle Adiabatic Efficiency; Nozzle Total Pressure Ratio; Nozzle geometry; Effect of Flow Angularity on Gross Thrust; Nozzle Gross Thrust Coefficient; Overexpanded Nozzle Flow—Shock Losses; Nozzle Cooling; Thrust Reverser and Thrust Vectoring; Noise<br>11) Airbreathing Engine System Considerations.<br>12) Piston Engine: mechanical, thermal, and volumetric efficiencies; operating principles of 2 stroke, 4 stroke, Otto, and diesel; piston displacement and compression ratio.Engine Performance. Principles and purpose of supercharging |
| Testi di riferimento | Aerothermodynamics of Gas Turbine and Rocket Propulsion Gordon C. Oates eISBN: 978-1-60086-134-5 print ISBN: 978-1-56347-241-1 DOI: 10.2514/4.861345<br>Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, Addison-Wesley Publishing Co., 1992,<br>Course notes |
| Altre informazioni utili | |

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# SCHEDA INSEGNAMENTO

# ATMOSPHERIC AND SPACE FLIGHT DYNAMICS (MOD.2)

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| Corso di studio di riferimento | LM52 - CdL Magistrale in Aerospace Engineering |
| Dipartimento di riferimento | Dipartimento di Ingegneria dell'Innovazione |
| Settore Scientifico Disciplinare | ING-IND/03 |
| Docente | In attesa di assegnazione |
| Crediti Formativi Universitari | 6 |
| Ore di attività frontale | 54 |
| Ore di studio individuale | 96 |
| Anno di corso | I anno |
| Semestre | II |
| Lingua di erogazione | Inglese |
| Percorso | PERCORSO COMUNE |

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| Prerequisiti | Basic knowledge of fluid-dynamics and a good knowledge of flight mechanics and analytical dynamics are highly recommentded. |
| Contenuti | The course is aimed at introducing the student to the methods for modeling the dynamic behavior of an aircraft as a function of its aerodynamic configuration, propulsion system and inertial characteristics. Based on models derived on first principles, the students will learn the tools necessary for the determination of aircraft characteristics in terms of static and dynamic stability and response to controls. The course is focused on the dyanmics of rigid aircraft. Effects of structural deformation on stability and control are introduced at an elementary level. A few notion on rotorcraft dynamics (helicopter trim and rotor blade flapping dynamics) and satellite attitude dynamics and control are also provided.<br>Tutorials will allow the students to apply the notions learned to representative examples and case studies, maturing the capabilitiy of interpreting aircraft and spacecraft motion as a function of controls. |
| Obiettivi formativi | A the end of the course the student is ecpected to be able to<br>1) determine trim conditions, aircraft stability and response to controls for conventional configurations;<br>2) understand, describe and discuss basic features of rotary wing aircraft dynamics and its response to controls;<br>3) understand, describe and discuss basic features of rigid spacecraft dynamics and how to control it;<br>4) handle mathematical and numerical tools for simulating aircraft and spacecaft dynamic behavior. |
| Metodi didattici | The course is delivered with class and laboratory activities, in three different forms: |

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| | - standard class lectures, where the teacher presents methods and models; students are encouraged to participate by discussing validity of the assumptions at the basis of the models and physical meanings of the results derived from the analysis performed; example: derive the expression of aircraft neutral point;<br>- tutorial classes, during which problems are stated, where the students refine their understanding, by numerically evaluating aircraft performance from geometric, propulsion and aerodynamics characteristics; the teacher supports the class by recalling relevant models and highlighting the procedure; some calculations (e.g. for a different set of parameters) can be proposed to the students as homework; example: evaluate the position of aircraft neutra point from aircraft geometric and aerodynamic data;<br>- computer lab. classes, where students are required to write simple computer programs for performing parametric analysis, and/or use or implement Simulink models for simulation; example: evaluate aircraft response in simulation for differnet control inputs.<br>Results from homework and conputer lab classes will be collected in a report to be delivered and discussed during the oral exam. |
| Modalità d'esame | The exam is oral.<br>The exam starts with a discussion of the projects proposed during the tutorials and lab. classes in order to evaluate the capability of the student in analyzing complex problems, where numerical tools or a large number of calculations are required, using some mathematical programming software and/or simulation tools.<br>The oral exam also includes the discussion of more general aspects regarding aircraft and helicopter dynamics, spacecraft attitude dynamics and control. |
| Programma | - Equations of motion for rigid aircraft (4 hours).<br>- Equilibrium in the longitudinal plane: longitudinal static stability; longitudinal control and trim; directional stability and dihedral effect; lateral-directional control; non-symmetric flight (6 hours).<br>- Tutorials on trim curves and static stability (4 hours)<br>- Dynamic stability: linearization of aircraft equations of motion; stability derivatives; longitudinal dynamics; lateral-directional dyanmics (16 hours)<br>- Tutorials on dynamic stability and response to controls (4 hours)<br>- Nonlinear phenomena: inertial coupling; autorotation; spin (2 hours).<br>- Rotary-wing aircraft: helicoper commands; swashplate; flap dynamics (4 hours).<br>- Project 1: Laboratory on basic facts in aircraft flight simulation (4 hours)<br>- Rigid spacecraft dynamics: free-spinning motion and passive stabilization (4 hours).<br>- Rigid spacecraft active control: sensor and actuators; control tecniques (4 hours).<br>- Project 2: Laboratory on spacecaft attitude dynamics simulation (4 hours) |
| Testi di riferimento | Flight Dynamics<br>B. Etkin. Dynamics of Atmospheric Flight. Dover, 2005 (original hardcover edition: , J. Wiley & Sons, 1972) |

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| | B.L. Stevens, and F.L. Lewis. Aircraft Control and Simulation, 2nd edition, , J. Wiley & Sons, 2003<br>R.F. Stengel. Flight Dynamics, Princeton University Press, 2004<br>G. Guglieri, and C.E.D. Riboldi. Introduction to Flight Dynamics. CELID, 2014<br>M. R. Napolitano. Aircraft Dynamics (from modeling to simulation), J. Wiley & Sons, 2012.<br>In Italiano<br>M. Calcara, Elementi di Dinamica del Velivolo, Edizioni CUEN, Napoli, 1988<br>Suggested readings from…<br>M.J. Abzug and E.E. Larrabee. Airplane Stability and Control: a History of the Technologies that Made Aviation Possible. Cambridge University Press, 1997.<br>Handbooks on spacecraft attitude dynamics and control<br>Bong Wie. Space Vehicle Dynamics and Control, 2nd ed., AIAA Education Series, 2008<br>P.C. Hughes. Spacecraft Attitude Dynamics, Dover, 2004 (original hardcover edition: , J. Wiley & Sons, 1986) |
| Altre informazioni utili | |

# SCHEDA INSEGNAMENTO

# COMPUTER AIDED DESIGN FOR AEROSPACE APPLICATIONS

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| Corso di studio di riferimento | LM52 - CdL Magistrale in Aerospace Engineering |
| Dipartimento di riferimento | Dipartimento di Ingegneria dell'Innovazione |
| Settore Scientifico Disciplinare | ING-IND/15 |
| Docente | In attesa di assegnazione |
| Crediti Formativi Universitari | 6 |
| Ore di attività frontale | 54 |
| Ore di studio individuale | 96 |
| Anno di corso | I anno |
| Semestre | II |
| Lingua di erogazione | Inglese |
| Percorso | PERCORSO COMUNE |

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| Prerequisiti | Sufficiency in geometry and linear algebra. |
| Contenuti | Computer aided design aims at provide to the students the knowledge regarding the design process and 3d modelling from a theoretical and practical point of view. The course includes the teaching of the 3D modelling software Catia V5, with particular attention to the surface modelling in the Generative Shape Design module. |
| Obiettivi formativi | Overview<br>Computer aided design aims at developing engineering design skills with a particular focus on the proficient use of modern CAD-integrated analysis tools.<br><br>Learning Outcomes<br>After the course the student should be able to<br>* acquire detailed knowledge and understanding of the most recent advances in 3D computer aided design.<br>* know the fundamental building blocks for creating parametric geometry. |
| Metodi didattici | Theoretical and practical lessons |
| Modalità d'esame | The exam consists of two cascaded parts (maximum overall duration: three hours).<br>The first part is closed book (duration: one hour); the student is asked to illustrate some theoretical topics.<br>The second part, that starts when the student has completed the first part (duration: two hours), consists in modelling, using CATIA, a given mechanical/aeronautical component and outputting the detail drawing. |
| Programma | Introduction: CAD/CAM/CAE systems in the industrial product development cycle. |

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| | Geometric modeling methods and techniques.<br>The representation schemes of solid geometry: CSG, B-rep, finite elements, schemes by enumeration of occupied spaces .<br>CATIA V5: Introduction<br>CATIA V5: The sketching<br>CATIA V5: Part Design<br>CATIA V5: Assembly Design<br>CATIA V5: Generative Shape Design<br>CATIA V5: Drawing |
| Testi di riferimento | Lee Kunwoo, Principles of CAD/CAM/CAE Systems , Addison Wesley Longman<br>Mortenson M.E., GeometricModelling ,John Wiley and Sons,1997.<br>Ibrahim Zeid, Mastering CAD/CAM , McGrawHill<br>Michel Michaud,CATIA-Core Tools, McGrawHill<br>slides of the lessons |
| Altre informazioni utili | |

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# SCHEDA INSEGNAMENTO

# SPACE PROPULSION MOD. 2

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| Corso di studio di riferimento | LM52 - CdL Magistrale in Aerospace Engineering |
| Dipartimento di riferimento | Dipartimento di Ingegneria dell'Innovazione |
| Settore Scientifico Disciplinare | ING/IND 07 |
| Docente | Maria Grazia De Giorgi |
| Crediti Formativi Universitari | 6 |
| Ore di attività frontale | 54 |
| Ore di studio individuale | 96 |
| Anno di corso | I anno |
| Semestre | II |
| Lingua di erogazione | Inglese |
| Percorso | PERCORSO COMUNE |

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|---|---|
| Prerequisiti | Fluid dynamic and fluid machinery |
| Contenuti | This course presents aerospace propulsive devices with particular focus on rocket engine |
| Obiettivi formativi | 1 Gain knowledge of different types of rocket engines and to understand the aerodynamic and thermodynamic characteristics of major rocket components.<br>2 Develop the knowledge and skills to analytically and numerically solve problems related to aerospace propulsion systems.<br>3 Develop skills in working independently.<br>4 Develop skills in critical evaluation of scientific literature.<br>5 Develop skills in planning and presentation of scientific talks and reports. |
| Metodi didattici | Theory and practical activities |
| Modalità d'esame | The final exam consist of two part:<br>1)Written or oral examination covering all material covered in course |
| Programma | Rocket Nozzles and Thrust: Performance and nozzle design. Convective Heat Transfer<br>Combustion and Thermochemistry: Perfect gas law and thermodynamics review,equilibrium Thermochemistry, adiabatic flame temperature calculations, non-Equilibrium Flows. Rocket nozzle thermochemistry.<br>Solid Rocket Motors: General description, interior ballistics, component design goals and constraints.<br>Liquid Rocket Motors: General description, engine cycles, power balance calculations, component design fundamentals. Combustion of Liquid |

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| | Propellants ; Injection and Mixing ; Stability; Pressurization and Pump Cycles; Turbomachinery Performance<br>Trajectory Analysis and staging: The rocket equation, vertical trajectories, multistage rockets.<br>Electric Propulsion: General description and classification of electric propulsion systems, performance analysis.<br>Hybrid rockets: Classification, Challenges, and Advantages of Hybrids |
| Testi di riferimento | Aerothermodynamics of Gas Turbine and Rocket Propulsion Gordon C. Oates eISBN: 978-1-60086-134-5 print ISBN: 978-1-56347-241-1 DOI: 10.2514/4.861345<br>Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, Addison-Wesley Publishing Co., 1992,<br>George P. Sutton, Oscar Biblarz, Rocket Propulsion Elements, 7th Edition John-Wiley & Sons, Ltd.<br>Course note |
| Altre informazioni utili | |

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno

ADVANCED TECHNOLOGIES AND ADDITIVE MANUFACTURING FOR AEROSPACE

Obiettivi formativi

- The course aims is to deepen the aspects related to production technologies applied in aeronautical constructions with particular reference to the choice and function performed by the construction materials and the transformation technologies connected to them.
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Programma di massima

- The study and classification of light alloys for aeronautical application as well as superalloys for airframe and engine applications will be addressed. In particular, for the nickel and titanium superalloys, the main aspects that characterize their metallurgy and workability will be studied by comparison with the applications. In the field of plastic deformation technologies, the fundamental principles of super plastic forming and its applicability to the aeronautical sector will be illustrated.

At the same time, the aspects relating to assembly processes and in particular those relating to the welding of metallic materials and riveting of the components will be treated. Lastly non-destructive testing for verification of product quality will be tackled.

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OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

## LM52 - CdL Magistrale in Aerospace Engineering - II anno

### Aerospace Structures

#### Obiettivi formativi

At the end of the course the student is expected to:
1) understand the criteria of choosing aerospace architecture and materials;
2) understand the design rules for aircraft of different size;
3) elaborate a lumped parameters structural equivalent model for preliminary computations;
4) understand the numbers coming out from the computation;
5) have a global view on the overall structural issues of a typical flying vehicle.

#### Programma di massima

Architectural elements of the aircraft. The primary structures. The secondary structures. Wings: the wing box, the spars, the stiffeners, the ribs. The frames. The tail. Solutions used for the different categories of aircraft. (3 hours).
The loads. The regulatory framework. Load factors. Speed characteristics. Symmetrical maneuvers. Diagram of maneuver. Diagram of load balancing. Gust loads. Diagram of gust loads. Not symmetrical maneuvers. Controlled and uncontrolled maneuvers. Ground handling. Landing loads. The pressurization. (8 hours).
Mechanical behavior of materials. Fatigue problems in aircraft structures. Allowable mechanical stress. Criterion for the selection of materials for aerospace structures. Stress-strain relations for linear elastic materials. (4 hours).
Principles of construction of aircraft structures. The materials commonly used in the construction of the aircraft. The materials associated with the various parts of the airplane. The function of the structural elements. The implementation of structural elements. Bending, shear and torsion of thin-walled beams with open and closed sections. Structural analysis of combined open and closed sections. Structural idealization of wing box and typical aircraft structures to lumped parameters. Effect of idealization on the analysis of beam sections, open and closed. Analysis of the displacements of open and closed beam sections. Stress analysis on the elements of an aircraft. Effect of taper on lumped parameters idealized beams. Analysis of the wings. Fuselage frames and wing ribs. Effects of the openings in wings and fuselages. (38 hours). Solution of assigned problems (10 hours).
Structural instability. Euler buckling load for the beams under axial compression. Inelastic buckling. Buckling of thin plates. Inelastic buckling of plates. Experimental determination of the critical load for a plate. Local buckling of the plates. Instability of stiffened panels. Evaluation of failure loads for thin plates and stiffened panels. Lateral torsional buckling of thin-walled columns. Tension field, complete and incomplete. (7 hours)
Elements of Aeroelasticity. The Aeroelasticity: background and principles. Static and dynamic aeroelastic phenomena. The divergence. Control effectiveness and reversal. Methods for the prevention of static aeroelastic phenomena. The flutter. Methods for the prevention of flutter in typical aircraft structures. (7 hours)
Elements of fatigue in aircraft structures. S-N curves. The fatigue design in the field of aerospace structures: safe-life, fail-safe structures. GAG cycle. Procedure for calculating the fatigue life of an aeronautical structural component (4 hours).

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
AIRCRAFT DESIGN
Obiettivi formativi

At the end of the course the student is expected to
- understand the relation between aircraft mission and its configuration, in qualitative as well as quantitative terms;
- use this knowledge to perform, at a conceptual level, the preliminary sizing of a fixed wing aircraft as a function of a set of mission and regulatory requirements; draw a sketch by means of some Computer Aided Design tool; estimate performance and update the design, if necessary;
- autonomously perform choices with respect to possible alternatives (e.g. type of engines, cabin layout, wing planform shape and position, etc.);
- present and discuss the resulting design in a report and in oral form, providing adequate motivation for all the choices performed;
- become aware of sources of information related to aircraft design, airworthiness, certification procedures, etc. deriving useful and reliable information for the design process.

Programma di massima

Aircraft design is on one side a separate discipline in the framework of aeronautical engineering, where specific methods and analysis tools are introduced to size a new aircraft with the objective of developing a vehicle which outperforms existing ones in the same market segment. At the same time, an aircraft designer needs to be well skilled in all the fundamental aeronautical engineering disciplines (aerodynamics, propulsion, structures, systems and – last but not least - flight mechanics), in order to understand and handle all the available options for performing a given set of mission tasks. The course is aimed at introducing the student to this unique mix of specific expertize and multidisciplinary knowledge, challenging him/her with the development of a realistic design for a given set of (possibly competing) mission requirements.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
AIRCRAFT POWERPLANT DESIGN CONTROL AND MAINTENANCE
Obiettivi formativi
(knowledge and understanding)
- Specialist knowledge of propulsion, advanced elements of mechanical design of aircraft engines.
- Knowledge of the internal fluid dynamics.
- Insights on design and technological features and performance of different types of engines.
- Insights into automatic controls and system design aimed at providing an integrated view of the aerospace product.
- Knowledge of advanced propulsion systems.
- Knowledge of specific technical terms in English.
(applying knowledge and understanding)
- Understanding of the main features of a project of the engine.
- Ability to perform sketches and preliminary dimensioning of the components of an aircraft engine.
- Ability to take action in the main stages the project of an aircraft engine.
- Advanced capabilities for the analysis of systems and control techniques.
- Ability to see the product in the form of system integrated complex.
(making judgements)
- Ability to analyze the mission requirements of the aircraft and to evaluate the necessary engine performance.
- Ability to understand the technological issues and system integration for the engine.
- Ability to understand the problems of research and development of an aircraft engine or of an aviation system.
(communication skills)
- Ability to communicate with experts in other fields of engineering for the integrated design of the engine.
(learning skills)
- Development of learning skills that enable to continue to study for the most part autonomously.
- Availability update the acquired knowledge.
Programma di massima
FLUID MECHANICAL DESIGN OF AIRCRAFT ENGINE TURBOMACHINERY
COMBUSTION
DESIGN AND PRODUCTION OF INNOVATIVE TURBOMACHINERY
ENGINE CONTROL
AIRWORTHINESS AND ENGINE HEALTH MANAGEMENT
ADVANCED PROPULSION CONCEPTS

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
ELECTRICAL ENERGY STORAGE FOR AERONAUTICS
Obiettivi formativi
Conoscenze e comprensione: Lo studente acquisirà le conoscenze per la selezione e scelta dei diversi tipi di batterie in funzione delle diverse densità di energia e Potenza richieste dell'utenza finale.
Capacità di applicare conoscenze e comprensione: Lo studente conoscerà i modelli di funzionamento delle celle e delle batterie. Questo consentirà di utilizzare tali modelli per la progettazione di sistemi applicabili in campo aerospaziale.
Autonomia di giudizio: Al termine del corso lo studente sarà capace di operare in autonomia all'interno dell'ambito specifico.
Abilità di comunicative: Lo studio comune per lo svolgimento di un breve lavoro di gruppo consentirà una migliore è maggiore interazione tra gli studenti consentendo la messa in condivisione dei metodi di approfondimento e dei contenuti acquisiti.
Capacità di apprendimento: La capacità di apprendimento sarà favorita dell'interazione continua col docente e tra i vari gruppi di studenti.
Programma di massima
Il corso mostrerà le basi di funzionamento dei sistemi di stoccaggio di energia elettrica. Particolare attenzione verrà rivolta ai sistemi applicati e/o applicabili in campo aerospaziale.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

## LM52 - CdL Magistrale in Aerospace Engineering - II anno

## EMBEDDED AND CERTIFIED SOFTWARE

### Obiettivi formativi

- **Conoscenze e comprensione**

Concetti principali inerenti alla progettazione, allo sviluppo, al test e alla certificazione di software embedded per applicazioni specifiche in sistemi mobili, robotici e di controllo.

- **Capacità di applicare conoscenze e comprensione**

Capacità di progettare, sviluppare, testare, verificare e validare software embedded in conformità a requisiti esterni (requisiti utente e di sistema) ed interni (requisiti imposti dalle normative vigenti e dai processi di certificazione).

- **Autonomia di giudizio**

Abilità di comprendere i problemi ed individuare soluzioni adeguate.

- **Abilità comunicative**

Abilità di comunicare con linguaggio tecnico appropriato.

- **Capacità di apprendimento**

Abilità di estendere capacità e conoscenza in autonomia.

### Programma di massima

- Sviluppo di software per sistemi embedded: concetti generali, compilazione del software, cross-compilazione, ambiente di sviluppo, build system. Caso di studio: compilatore GCC e debugger GDB.
- Software per dispositivi mobili: concetti generali, casi di studio iOS e Android. Architettura dei sistemi operativi iOS e Android: kernel, strati, ambienti di runtime. Caratteristiche di sicurezza e gestione energetica. Introduzione allo sviluppo di applicazioni per sistemi mobili: ciclo di vita di un'applicazione, pattern architetturali ed API fondamentali. Requisiti di certificazione per la distribuzione delle applicazioni su App Store.
- Software per dispositivi robotici: caso di studio ROS (Robot Operating System). Requisiti generali, architettura, framework publish/subscribe, servizi, package. Sviluppo di un nodo ROS. Introduzione ai problemi tipici in robot autonomi: mapping, path planning, path following, motion control. Simulatore Gazebo e visualizzatore RViz.
- Software per sistemi operativi real-time embedded. Caso di studio OSEK-OS: modello di sviluppo di task, linguaggio OIL di specifica della configurazione del sistema, ciclo di vita di un task, caratteristiche del sistema operativo. Piattaforme AUTOSAR Classic e Adaptive (cenni).

Model-based embedded software design: concetti generali, verifica e validazione, modello a V. Concetti generali del model checking: automi e strutture di Kripke, logiche proposizionali temporali LTL e CTL, tipi di proprietà verificabili. Model checking statistico. Caso di studio: Uppaal SMC.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
FUNDAMENTALS OF AEROSPACE TECHNOLOGIES C.I.
Obiettivi formativi
- Knowledge of materials for aeronautical application and processes for their transformation
- Basic knowledge for the characterization of Nichel and Titanium superalloys
- Basic knowledge for characterization and use of Forging Manufacturing technologies
- Basic knowledge for characterization and use of Additive Manufacturing technologies
- Basic knowledge for finite element simulation of chip removal, forging and additive processes.

Programma di massima
The course aims to deepen the aspects related to production technologies applied in aeronautical constructions with particular reference to the choice and function performed by the construction materials and the transformation technologies connected to them.
The materials/technologies solutions mainly used for realization of airframe and structures engine will be discussed. The aspects related to the "Workability of materials, for aeronautical application, by chip removal technologies" will be treated. The processes by plastic deformation will be analyzed. The main elements that characterize the Additive Manufacturing technologies will be provided.
The study and classification of light alloys for aeronautical application as well as superalloys for airframe and engine applications will be addressed. In particular, for the nickel and titanium superalloys, the main aspects that characterize their metallurgy and workability will be studied by comparison with the applications. In the field of plastic deformation technologies, the fundamental principles of super plastic forming and its applicability to the aeronautical sector will be illustrated.
At the same time, the aspects relating to assembly processes and in particular those relating to the welding of metallic materials and riveting of the components will be treated. Lastly non-destructive testing for verification of product quality will be tackled.
Numerical exercises will be carried out on some aspects covered in the theory part to familiarize with the physical quantities that characterize them, in addition to laboratory exercises that will be focused on tools for the finite element simulation of: chip removal, forging and additive processes.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
Metallic Materials for aeronautics
Obiettivi formativi
Gli studenti acquisiranno conoscenze e competenze sulle leghe metalliche impiegate nel settore aeronautico e sapranno giustificarne l'utilizzo in relazione alle rispettive proprietà meccaniche (resistenza a trazione, rigidezza, resistenza a fatica) e fisico chimiche come densità e resistenza alla corrosione a basse e alte Temperature. Conosceranno i processi per l'ottenimento dei vari componenti (sia per impieghi strutturali a freddo che per impieghi nei sistemi di propulsione) e i trattamenti termici per garantire la microstruttura più idonea all'esercizio. Sapranno individuare i rivestimenti per la protezione dalla corrosione e ossidazione, i processi di giunzione più idonei e le possibilità di ottimizzazione topologica dei componenti mediante additive manufacturing.
Programma di massima
1)Introduzione sulle leghe per applicazioni aeronautiche: leghe di alluminio, leghe di Magnesio, leghe di Titanio, Acciai ad alta resistenza, Superleghe di Nichel e Cobalto.
2)Richiami sulla cristallografia, difetti, meccanismi di rafforzamento
3)Principi di solidificazione: microstruttura, trattamenti termici, difetti
4)Deformazione plastica, evoluzione microstrutturale e trasformazioni di fase allo stato solido: Recupero e ricristallizzazione statici e dinamici
5)Indurimento per precipitazione
6) Leghe di Alluminio:
Designazione, microstruttura, proprietà e applicazioni aeronautiche
Leghe da getto e da deformazione plastica
Ruolo degli alliganti e trattamenti termici: metallurgia, evoluzione microstrutturale e meccanica
Processabilità e Saldabilità
7) Leghe di Magnesio
Designazione, microstruttura, proprietà e applicazioni aeronautiche
Ruolo degli alliganti e trattamenti termici: metallurgia, evoluzione microstrutturale e meccanica
Leghe da getto e da deformazione Plastica
Processabilità e Saldabilità
8) Acciai ad alta resistenza: acciai a medio contenuto di carbonio basso legati ( es 41XX, 43XX), acciai a migliorata tenacità (es HP-9-4-30), acciai maraging, acciai inossidabili induribili per precipitazioni (PH 17-4 stainless stees).
Designazione, microstruttura, proprietà, applicazioni aeronautiche
Ruolo degli alliganti e trattamenti termici: metallurgia, evoluzione microstrutturale e meccanica
Processabilità e Saldabilità
9) Superleghe: di Nichel, Cobalto, Ferro-Nichel
Designazione, microstruttura, proprietà, applicazioni aeronautiche
Ruolo degli alliganti e trattamenti termici: metallurgia, evoluzione microstrutturale e meccanica
Leghe da getto e da deformazione plastica
Processabilità e Saldabilità
10) Leghe di Titanio:
Designazione, microstruttura, proprietà e applicazioni aeronautiche
Titanio commercialmente puro, Leghe alfa, Leghe near alfa, Leghe Alpha / Beta, Leghe beta
Ruolo degli alliganti e trattamenti termici: metallurgia, evoluzione microstrutturale e meccanica
Processabilità e Saldabilità

11) Microstruttura ed evoluzione delle proprietà meccaniche in seguito a cicli termici di saldatura
12) Nuove tecniche di giunzione: microstruttura e proprietà
13) Rivestimenti: microstruttura e proprietà
14) Additive manufacturing: microstruttura e proprietà
15) Casi di studio e applicazione degli argomenti teorici.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
PROCESSING AND PROPERTIES OF COMPOSITE MATERIALS FOR AERONAUTICS
Obiettivi formativi
Knowledge and understanding:
The course provides the basis of knowledge to understand and solve complex new problems in design and processing of composite materials accounting for anisotropy and reactive processing
Applying knowledge and understanding
The student will be able to apply the basic knowledge on mechanics of anisotropic materials to the design of simple structural elements. A multidisciplinary approach is presented accounting for chemical, materials and mechanical engineering aspects.
Making judgements
Simplification and synthesis of complex problems is presented in order to promote the judgement and evaluation capabilities of the students
Communication
The course promotes the development of the following skills of the student: ability to expose in precise and formal terms an abstract model of concrete problems, identifying the salient characteristics of them and discarding the inessential characteristics; ability to describe and analyze an efficient solution for the problem under consideration. A seminar on composite properties is assigned to students
Learning skills
Autonomous learning is promoted thanks to the use of: different books and slides, numerical methods, homework exercise to be solved in groups of two.
Programma di massima
This course provides a strong interdisciplinary approach to composite materials in view of their application in aeronautic structure. Competences on polymer matrices and reinforcements, mechanics of anisotropic materials, fabrication technologies of thermoplastic and thermosetting matrix composites are provided.

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
Space Economy
Obiettivi formativi
Fornire agli studenti i principali elementi e strumenti metodologici per comprendere e analizzare le caratteristiche e dinamiche di sviluppo della space economy, con particolare riferimento alle nuove opportunità di business ad essa correlate, all’evoluzione tecnologica, di mercato e istituzionale.
Programma di massima
Space Economy: origini ed evoluzione
- La Space Economy nelle economie nazionali
- Le opportunità di business della Space Economy: dallo spazio alla terra e dalla terra allo spazio
- La Space Economy e il contesto istituzionale

OBIETTIVI FORMATIVI E PROGRAMMI DI MASSIMA DEGLI INSEGNAMENTI DI II E III ANNO

LM52 - CdL Magistrale in Aerospace Engineering - II anno
SYSTEMS AND DEVICES FOR SATELLITES
Obiettivi formativi
The training objectives of the course are as follows.
1) KNOWLEDGE AND UNDERSTANDING of the fundamentals of the electronic devices/systems for space at the state-of-the-art.
2) APPLYING KNOWLEDGE AND UNDERSTANDING, by designing innovative electronic systems for space.
3) MAKING JUDGEMENT, by choosing independently the most appropriate approach to implement a specific functionality.
4) COMMUNICATION, by writing proper technical reports on different topic relevant to electronic devices/systems for space, and by discussing their contents.
5) LIFELONG LEARNING SKILLS, as ability of studying and understanding autonomously new electronic devices/systems for space.
Programma di massima
The course aims at presenting the basic concepts and the recent advances in the field of electronic devices and systems for space. After a brief introduction on the space missions and the space environment, the fundamental building blocks and sub-systems of a satellite are discussed. The electronic systems for the satellite platform and payloads are the main topics of the course. Finally, main degradation phenomena of electronic system due to the space environment are shown.