DIPLOMA SUPPLEMENT ATTACHMENT

POLITECNICO MILANO 1863

Person code: 10482528 | Document ID: 263172/1 | Date of issue: 26/07/2024 | Register number: 0724-0146

1 INFORMATION IDENTIFYING THE HOLDER OF THE QUALIFICATION

1.1 Last name(s)

LARDO

1.2 First name(s)

GIANLUCA

1.3 Date of birth (dd/mm/yyyy)

15/11/1996

1.4 Student identification number or code (if available)

945857

2 INFORMATION IDENTIFYING THE QUALIFICATION

2.1 Name of the qualification and title conferred (in the original language)

Laurea magistrale in SPACE ENGINEERING
Dottore magistrale

2.2 Main field(s) of study for the qualification

Aerospatial and astronautic engineering (LM-20)
ISCED code: 0716

2.3 Name (in original language) and status of the awarding institution

Politecnico di Milano (Istituzione statale), Piazza Leonardo da Vinci 32, 20133 Milano

Description of curriculum

TECHNICAL COMMUNICATION IN ENGLISH

Code: 052776
Credits: 2.00
Grade: --
Date: 24/06/2019

Subject groups

ING-IND/03 FLIGHT MECHANICS

The programme

The course will provide the fundamental information at the basis of scientific/technical communication, by using the English language; they will be focused to their correct use in the preparation of a written text and of an oral presentation.

ADVANCED AEROSPACE CONTROL

Code: 099256
Credits: 6.00
Grade: 30
Date: 04/09/2020

Subject groups

ING-INF/04 SYSTEMS AND CONTROL ENGINEERING

The programme

The course provides advanced competences for the design of aerospace control laws. In particular, the following subjects are presented: stability and performance analysis for linear and nonlinear systems; robust analysis and design for scalar and multivariable systems; nonlinear analysis and synthesis methods; a few case studies on aircraft and rotorcraft control.

SPACE PROPULSION

Code:	099259
Credits:	10.00
Grade:	28
Date:	08/02/2021

Subject groups

ING-IND/07 AEROSPACE PROPULSION

The programme

Introduction to aerospace propulsion: Survey of aerospace propulsion missions. Classification of engines according to applications and operating conditions. Airbreathing propulsion (alternating engines, turbojets, turboprop, turbofan, ramjets, hypersonic engines) with external working fluid and rocket propulsion with internal working fluid. Hybrid configurations, continuous and pulsed operations, jet propulsion. Thrust, power, efficiency. Specific consumption, specific impulses and total impulse, autonomy and range. Energetics of thermochemical propulsion: Conversion of chemical energy in thermal and mechanical energy. Thermochemical energy and gas acceleration. Environmental impact. Governing equations. Thrust theorem. Basic thermodynamic cycles. Nonisentropic compressible flows: effects of stagnation temperature and friction. Thermochemistry and thermodynamics of high-temperature media: Calculation of performance in air or pure oxidizers, combustion chambers and combustion efficiency. Dependency of the available energy on the fuel type, mixture ratio, and operating conditions. Supersonic combustion and post-combustion. Gasdynamic nozzles: Ideal 1D treatment, subsonic and supersonic expansion, optimum conditions, influence of operating conditions. Nonequilibrium phenomena: shock waves, boundary layer separation, chemical reactions, multiphase flows, phase transitions. Real nozzles: 2D geometry, thrust vector control. Fuels: traditional (hydrocarbons) and innovative (synthetic, vegetal, biofuels, hydrogen, nano-metals). Problems in airbreathing propulsion: Generalities on aeronautical propulsion systems, basic architecture, subsonic and supersonic air inlets, turbomachinery, combustor, nozzle, performance and limitations, future developments. Problems in space propulsion: Generalities on space propulsion systems, basic architecture, tanks, feeling techniques, combustor, nozzle, performance and limitations, future developments.

LAUNCH SYSTEMS

Code:	052782
Credits:	8.00
Grade:	28
Date:	01/07/2021

Subject groups

ING-IND/07 AEROSPACE PROPULSION

The programme

Space missions and vehicles: Space propulsion and on-board power systems. Survey of space missions. Classification of engines according to applications and operating conditions. Jet propulsion: gasdynamic or electromagnetic acceleration, continuous or pulsed operations. Analysis of propulsive mission: Engine performance, mission times and costs, mass distribution, Tsiolkovsky equation, velocity balance. Thermal rockets: Chemical rockets with solid, liquid, or hybrid propellants for space launchers or navigation: general architecture, energetic materials, tanks and feeding systems. Electrical thrusters: Electrothermal thrusters: resistojets and arcjets; Ion thrusters and Hall effect; Plasma propulsion. Chemical, nuclear, and radiant power sources. Nuclear rockets: Solid, liquid, and gas core nuclear reactors; fission fragments. Nuclear thermal propulsion (NTP) and/or electric thermal propulsion (NEP). Other propulsion techniques: Natural or artificial radiation (laser, microwaves); propellantless systems (aerodynamic capture, gravitational capture, solar sails, tethers). Micropropulsion. Extraterrestrial resources. On-board power systems: Batteries, fuel cells, solar cells, isotopic decay generators, dual systems. Performance, efficiencies, consumptions, lifetimes. Power system distribution and control.

AEROTHERMODYNAMICS

Code: 083772
Credits: 10.00
Grade: 23
Date: 12/07/2021

Subject groups

ING-IND/06 FLUID DYNAMICS

The programme

One-dimensional compressibile flows. Reminder of classical thermodynamics. Quasi one-dimensional steady nozzle flow. One dimensional flow with friction and heat transfer. Theory of characteristics applied to unsteady flows. Normal shock waves and contact discontinuities. Moving shock waves and shock reflections. Multidimensional compressibile inviscid flows. General form of the governing equations in three dimensions. Homoentropic and irrotational flows. Bernoulli theorem for compressibile flows. Perturbation potential, Prandtl-Glauert equation. Method of characteristics in supersonic flows, Prandtl-Meyer expansion, minimum length nozzles. Compressions, oblique shock waves. Transonic flows Viscous compressibile flows. Compressible Couette flow , adiabatic recovery temperature. Compressible boundary layer equations, solution for the flow over a flat plate and for the stagnation point region. Turbulent boundary layer, reference temperature method. Hypersonic flows. Inviscid hypersonic flows, hypersonic similarity rule. Approximate methods: Newton's method, tangent cone method, thin shock layer method. High temperature flow phenomena. Chemical thermodynamics of the reacting mixtures, thermo-chemical equilibrium. Shock and homoentropic relations at equilibrium conditions. Chemical and vibrational non equilibrium. Heat transfer in hypersonic boundary layers. Kinetic theory of gases: distribution function, Boltzmann's equation, collision integral, equilibrium conditions, Maxwell's distribution. Connection between microscopic and macroscopic description of the gas.

PAYLOAD DESIGN

Code: 099266
Credits: 12.00
Grade: 30
Date: 07/02/2022

Subject groups

ING-IND/03 FLIGHT MECHANICS, ING-IND/05 AEROSPACE EQUIPMENTS AND SYSTEMS

The programme

The course provides the basic knowledge and competences needed to perform the preliminary design of a payload instrument for a space mission. In particular, the following subjects are presented: analysis and definition of requirements, space environment, space sensors, mechanical design, thermal design, electronic design, testing and integration, project management and control.

HUMAN SPACEFLIGHT AND OPERATIONS

Code: 056621
Credits: 6.00
Grade: 29
Date: 15/06/2022

Subject groups

ING-IND/05 AEROSPACE EQUIPMENTS AND SYSTEMS

The programme

The aim of the course is to expose students at aspects of human spaceflight that are not normally discussed or covered during the standard courses, with special attention on the soft skills necessary to be successful in highly completive environments where team work is absolutely a must.

SPACECRAFT STRUCTURES

Code: 099260
Credits: 10.00
Grade: 25
Date: 29/08/2022

Subject groups

ING-IND/04 AEROSPACE STRUCTURES AND DESIGN

The programme

The course consists of a first part, which is focused on the theoretical aspects of continuum mechanics. The general Eulerian and Lagrangian forms of stress and strain tensors and of balance equations are presented and the forms that are valid under the assumptions of small strains and displacements will be derived. A second part of the course presents and applies the force and the displacement approaches for the analyses of typical aerospace structures, starting from the types that can be modelled as systems of beams. In particular, the methods for the evaluation of the stress states in thin-walled beams, with inner diaphragms, are presented, basing on semi-monocoque schemes. Subsequently, plate theory is described and applied to orthotropic laminates and sandwich structures. The final part of the course includes a presentation of the methods for approximate solutions, such as Ritz and Galerkin methods. Such approaches are employed to introduce the finite element method, which is formalised for structural and thermal problems in the linear field. The theoretical and computational aspects of the method are presented, including the application of the main modelling techniques. Some applications to non-linear problems are considered.

ORBITAL MECHANICS

Code: 083794
Credits: 10.00
Grade: 24
Date: 05/09/2022

Subject groups

ING-IND/03 FLIGHT MECHANICS

The programme

The course provides a comprehensive presentation of orbital mechanics theory, for a detailed analysis of problems related to space missions. The student will acquire familiarity with methods and tools useful to analyse and solve a variety of space mission trajectory problems, related to near Earth and interplanetary missions. In detail, the following subjects are taught: elements of astronomy, the Solar system, the basic problem of the celestial mechanics, perturbations and keplerian co-ordinates, two and three bodies problems, elements of impulsive dynamics, launchers, multistage optimisation, gravity motion, escape velocity, orbital motion, orbit transfer, interplanetary motion, re-entry, rendez-vous, orbit perturbations.

SPACECRAFT ATTITUDE DYNAMICS AND CONTROL

Code: 091357
Credits: 8.00
Grade: 27
Date: 08/02/2023

Subject groups

ING-IND/05 AEROSPACE EQUIPMENTS AND SYSTEMS

The programme

The course provides the basic knowledge on the angular motion of a rigid satellite, on sensors and algorithms for attitude determination, on actuators and attitude control laws.

SPACE PHYSICS

Code: 097486
Credits: 8.00
Grade: 30
Date: 07/07/2023

Subject groups

FIS/01 EXPERIMENTAL PHYSICS

The programme

The course gives an introduction to space physics, with reference to the Earth's magnetosphere as well as its interactions with charged particles. The main topics concern: introductory concepts of astronomy (stellar spectra, stellar evolution, Hertsprung-Russell diagram, compact stars), physics of the Sun and the solar wind; the physics of plasmas in the solar system (only outlined); the Earth's ionosphere and magnetosphere and related phenomena; space effects (radiations and microgravity) on biological systems and on instrumentation; physical principles of some classes of instruments (mainly telescopes, detectors and spectrometers) used for space exploration.

DYNAMICS AND CONTROL OF SPACE STRUCTURES

Code: 099262
Credits: 10.00
Grade: 25
Date: 05/09/2023

Subject groups

ING-IND/04 AEROSPACE STRUCTURES AND DESIGN

The programme

The course aims at providing a unified vision of the dynamic modeling of aerospace structures and their active control, coupling the description of multiple degrees of freedom discrete systems with that of continuous systems. A fundamental content is represented by the integration of dynamic model of the structure with other, thermo-aerodynamic, systems and their use in the design of active controlers to improve thei performances.

THESIS AND FINAL EXAM

Code:	056077
Credits:	20.00
Grade:	--
Date:	02/07/2024

Subject groups

Unavailable

The programme

Unavailable