Master Course in Space and Astronautical Engineering
AEROSPACE ENGINEERING PROGRAMME 2019 -20
Welcome to Aerospace Engineering at Sapienza Università di Roma

The long tradition of Sapienza University in the field of Aerospace Education dates back to 1926, with the establishment of the School of Aeronautical Engineering, which provided postgraduate training to a selected group of engineers. The fast growth of the aerospace industry and of the research activity in the sector prompted the need for a more complete and balanced teaching offer. On 1963, the postgraduate education was entrusted to the School of Aerospace Engineering. On 1980, the Faculty of Engineering established a five-year course in Aeronautical Engineering aimed at a wider range of students. On 1990, a five-year course was established in Aerospace Engineering, which also included a curriculum in Space Engineering. On 2012, the Aerospace Education at Sapienza was reorganised in one three-year Bachelor Degree in Aerospace Engineering and two Master of Science Degrees (Aeronautical Engineering, Space and Astronautical Engineering).

After the Master of Science Degree, the training in Aerospace can be continued at Sapienza by joining one of three one-year Professional Master Courses in Civil Aviation, in Satellites and Orbiting Platforms, or in Space Transportation Systems. Finally, the educational offer is completed with a three-year Ph.D. Course in Aeronautical and Space Engineering. Our objective is to offer high quality teaching in aerospace engineering with the goal of developing student knowledge and skills in formulating, analysing, and solving new and challenging problems. We offer study pathways that attract talented young people who are strongly motivated and interested in aerospace engineering, and eager to take positions of responsibility in industry, academia, or state entities and institutions. We also promote internationalisation of the study pathways by favouring the mobility of students within the European university systems, in the most effective way.

We favour a collaborative and interdisciplinary approach on aerospace disciplines that stimulates the creativity of students with a firm background in the basic academic disciplines. Aerospace Engineering offers a complete overview of the prospects and opportunities in the job market, and promotes the creation of study pathways geared up with the expectations of the industrial world where academic knowledge is complemented by the specific skills that industry seeks.

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Chair of the Academic Council of Aerospace Engineering

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SPACE AND ASTRONAUTICAL ENGINEERING IN ROME

The Space and Astronautical Engineering Masters Programme (SAEM) provides students with specific skills related to Space mission planning and the analysis and design of launch vehicles, satellites and remote metering and telemetry systems. The programme emphasizes system-related and interdisciplinary aspects and is closely linked with research and innovation activities in the Italian and European aerospace industries.

The programme in Aerospace Engineering, which is part of the SAEM degree programme, is held entirely in English and provides students with advanced concepts, professional training and specific engineering skills, enabling them to address complex issues requiring analysis, development, simulation and optimization in a wide range of aerospace-related topics. The course also provides an appropriate level of expertise in basic Space access technologies, the utilisation of terrestrial orbits, and Space exploration, with particular reference to the systemic and scientific aspects of launch vehicles, interplanetary missions by astronautical vehicles, and manned Space missions.

The student learns to use the most advanced investigative and design tools for innovation in the aerospace industry, e.g. improving the performance of launch systems to reduce the cost of entry into orbit per unit mass of payload, payload mass reduction (for platforms, sensors, and power units) and increasing the efficiency and utilisation of the available on-board power.

In year one, students acquire knowledge related to major areas of Space engineering such as spacecraft mechanics and altitude dynamics, Systems and control theory, compressible fluid dynamics, propulsion, Structures and Space systems; whereas during the second year, students select follow-up courses from a wide range of topics directly related to Space and Aeronautical Engineering.

CAREER OPPORTUNITIES

The career prospects for the Space and aeronautics engineer are in the advanced design, planning, programming, and management of complex systems in companies, public bodies, or the profession.

The most relevant professional profiles are:
- designer and technical manager
- product and product range manager
- maintenance manager
- specialist in one or more disciplines in the sector: aerodynamics, construction and structures, aerospace equipment and systems, mechanics of flight, propulsion, telecommunications and remote sensing - certification or quality assurance officer.

As professionals, graduates typically practice in the following areas:
- aerospace industries
- small and medium manufacturers in the aerospace sector supply chain
- national and international public and private research centres
- national and international Space agencies
- consulting firms
- service companies and certification bodies.

Holders of a postgraduate degree in Space and Astronautical Engineering are also qualified to work in related sectors that make use of the advanced scientific and technological content of those disciplines.

HOW TO APPLY

Applicants for the Graduate Degree Course in Aerospace Engineering must already hold a 3-year degree or an Italian or non-Italian qualification recognised as valid under current legislation, and must also meet specific requirements in relation to the curriculum and their personal background.

The Admissions Board will verify the applicant’s previous educational attainments, curricular needs, motivations, and other factors for assessment as the applicant may submit, such as periods of study outside Italy, internships, and work experience. The Admissions Board may require the applicant to attend for interview. For admission a B2 English language proficiency certificate or equivalent is required.

The general application procedure is composed of three distinct phases, starting with a pre-enrolment phase in which the best candidates are directly enrolled. Other candidates will be considered for the second and third selection phases.

Besides the general documents, the selection process requires the following documents:
- IELTS (International English Language Testing System) or TOEFL (Test of English as a Foreign Language) English Language proficiency certification [certified minimum level B2 or equivalent is required]. The submission of the following documents is strongly recommended and will constitute a positive element in the evaluation for admission to the programme:
  - Cumulative Weighted Grade Point Average (CGPA)
  - GRE (Graduate Record Examinations) General test, or Subject Tests in Mathematics or Physics.

Admission test grades either general or specific for aerospace engineering, as for instance GATE (Graduate Aptitude Test in Engineering) for aerospace engineering (AE), will be also taken into consideration.

Students must apply online at the Sapienza pre-selection application page. Admission procedures are slightly different for foreign students who are EU residents or students who are non-EU residents.

GENERAL REGULATIONS

Teaching methods

Courses are organized into semesters and conventional teaching methods are predominantly adopted. Classes take the form of lectures, classroom exercises, workshop activities, and group work, leaving the student sufficient time for personal study.

Nominally the course lasts for 4 semesters spread over 2 years. Students who have already completed the course but have not been awarded the degree, or did not pass all the required examinations for admission to the Final Examination, are enrolled “fuori corso” (“outside the course”).

Credits

The credits (CFU: Crediti Formativi Universitari) are a measurement of the amount of work completed by a student in
pursuit of an educational objective. The student acquires credits either by passing examinations or by obtaining validation if this is a requirement.

In accordance with the credits system in use by universities in Italy and the other EU Member States, 1 Italian CFU equates to a time commitment of 25 hours on the part of the student, split between the group learning prescribed by the University (e.g. lectures, exercises, workshop activities) and personal study. As prescribed by Art. 23 of the Academic Regulations of the University, 1 Italian CFU in the Aerospace Engineering and Astronautics course equates to 10 hours of lectures, or to 12 hours of workshops or guided exercises.

An information sheet for each subject is available on the CAD (Aerospace Engineering Council) website, giving a breakdown of the CFU and the number of teaching hours for the various activities, along with the admission requirements, teaching objectives, and programmes.

Grading Systems
The Italian university grading system for individual exams is based on a 30-point scale (18 and above is considered passing), while a 110-point grading scale is used for the final dissertation: – 66 is the minimum grade necessary to graduate – “Cum Laude” (Honours) is added to the maximum grade to praise outstanding results.

Teaching calendar
Normally the programme is as follows:
- Semester 1: late September - December
- First Examinations Session: January
- Second Examinations Session: February
- Semester 2: late February - May
- Third Examinations Session: June
- Fourth Examinations Session: July
- Fifth Examinations Session: September.

The start and end dates of each semester or examination session are published online at www.ingaero.uniroma1.it (Calendar Section).

Learning periods must not overlap with examination periods, except for two special examination sessions that normally take place in October-November and March-April and are reserved for repeating students, students who are “outside the course”, and students who had ceased all attendance before the date of the examination session.

Attendance
Attendance is not mandatory except for the courses of Experimental Aerodynamics and Experimental Testing for Aerospace Structures.

Assessment methods
Normally, the student’s progress in any given subject is assessed by an examination which can consist of oral and/or written tests devised by the tutor. Details of these are provided along with the course programme. For certain activities, instead of an examination there is an assessment of eligibility, also devised by the tutor.

Examination programmes and formats
The examination programmes and formats for each course are given on the CAD website (www.ingaero.uniroma1.it).

Personal Study Plan
The CAD must approve the student’s Personal Study Plan before the optional subjects chosen by them can be included on their List of Examinations. The List of Examinations is cancelled otherwise. The CAD will specifically determine that the subjects chosen are appropriate for the student’s Personal Study Plan.

Students must submit their Personal Study Plan (see the “Percorso Formativo” function of the Infostud service) at the start of Year 1 [indicatively during December - January on specific dates that will be published from time to time on the CAD website].

Only one Personal Study Plan is permitted per academic year. If the student wishes to make changes to their chosen curriculum or examinations, the Personal Study Plan cannot be resubmitted until November of the following year.

Yearly progression
In order to be able to take exams on Year 2 subjects, students must have acquired at least 27 of the credits for Year 1.

Examinations that can be brought forward
In order to complete the required 60 credits for Year 1, students enrolled on Aerospace Engineering can bring forward one of the subjects for Year 2 or one of their freely chosen optional subjects.

Students repeating Year 1 can apply to bring forward up to 2 of the subjects for Year 2 (respecting the order of the course) whose total worth comes to not more than the value of the credits they already hold.

Credits for examinations brought forward are not considered when calculating the credits required for progressing to the next year. For details of how to bring subjects forward, see the Students procedure section of the CAD website.

Excellence Pathways
For each curriculum the Aerospace Engineering CAD offers an Excellence Pathway, to further enhance the education of outstanding students who wish to deepen their methodological and practical studies of topics that interest them. The additional learning in the Excellence Pathway enhances the experience of students who have performed particularly well in Year 1.

Access to the Excellence Pathway is by application. The requirements are: acquisition of all the credits for Year 1 by 30th November a weighted average mark in any one examination of at least 27.5/30 and not less than 24/30.

Students who take their degree within the time limits for the course and have also successfully completed the Excellence Pathway are awarded a monetary prize for the same amount as the university fees paid during the previous year, together with a special certificate that is added to their academic record.

The conditions and methods for applying to take the Excellence Pathway, along with a downloadable application form, are given on the CAD website (STUDENTS / Excellence Pathways Section).

Final examination
The final examination consists of an experimental or design thesis, or a written dissertation addressing the subjects taken in the Postgraduate Degree Course, prepared under the guidance of a tutor who is a member of the Academic Council, and/or in collaboration with public and private bodies, manufacturing companies, or research centres that operate in the chosen field of study.
For developing the dissertation the students must first review the technical literature on the subject. They are then expected to work on their own initiative in relation to the type of dissertation, and to propose solutions to the problem by developing a suitable mathematical model of the system, as appropriate. The final examination is worth 23 CFU. The final mark is based on the average of all the examination marks, the dissertation, and the final colloquium. The Degree Examining Board awards marks out of a total of 110. Full marks (110/110) with Honours can be awarded by majority vote of the Degree Examining Board.

**Internships**

As an alternative to the final examination, the student can undertake an internship of practical training, which is also worth 23 CFU. At the time of securing approval for an internship the student must nominate two supervising tutors, of whom one must be a university tutor from the relevant CAD, and the other must be active in industry. The academic tutor will be responsible for assessing the outcome of the internship.

**STUDENTS**

Students are expected to acquaint themselves with the regulations governing their university. This information is given on the website www.ingaero.uniroma1.it:

- in the COURSE INFORMATION section of the website: courses on offer (teaching regulations, manifestoes of studies), tutors, course programmes, degree theses, work training, etc.
- in the STUDENTS section: calendars, timetables, study plans, application procedures (transfers/ recognition, changing streams, bringing forward examinations, etc.)

All information published online as set out above constitutes official notification.

**THE SYLLABUS**

The purpose of the Syllabus is to inform new students about the knowledge, skills and abilities required for embarking successfully on the Aerospace Engineering study pathway, enabling them to check their personal educational background and make any adjustments as appropriate.

**Mathematics and numerical methods**

Trigonometry: trigonometric functions, Pythagorean theorem, angle transformation formulas, Euler’s formula.

Analytic geometry: Cartesian coordinate systems, equations and curves, distances, angles, intersections of geometric objects. Tangent line and normal to a curve. Changes of coordinates.

Mathematical Analysis: Limits, Continuity, differential calculus; integral calculus; sequences and series; partial and directional derivatives; vector-valued functions; definite, indefinite, and improper integrals; curved line integrals; multiple integrals; surface integrals; differential operators: gradient, divergence, rotational; vector identities; theorems of Gauss, Green, and Stokes, divergence.

Linear algebra: matrix calculation, systems of linear equations; eigenvalues and eigenvectors.

Ordinary differential equations: first order linear and non-linear equations; second order linear equations, Euler equations; initial value problems.

Numerical methods: methods for finding the roots of linear and non-linear algebraic equations, quadrature methods; free optimisation.

Programming elements: any programming language (preferred: Matlab, Fortran, Mathematica).

**Chemistry**

Atomic structure of matter; periodic properties of the elements; intermolecular and intramolecular chemical bonds; physical and chemical reactions and the energy content associated with them; chemical, ionic, and solubility equilibria; elements of chemical kinetics and electrochemistry; chemical fundamentals of corrosion.

**Physical and Analytical Mechanics**

Physical quantities, systems of measurement, and scientific method: measure theory, probability elements, errors.

Classical mechanics of particles and rigid bodies: Newton’s laws, cardinal equations and principles of conservation. Macroscopic systems and principles of thermodynamics: temperature, heat, and the first and second laws of thermodynamics.

Force fields: gravitational field and electrostatic field.

Basic laws of electromagnetism: Maxwell’s equations.

Waves and vibrations: oscillations and propagation of elastic and electromagnetic waves.

Analytical Mechanics and Lagrange’s equations.

**Materials Science**


**Electrotechnics**


**Applied Mechanics and Design**

Velocity and acceleration analysis for planar mechanisms. Forces acting in a mechanical system and dynamic analysis. Exchange forces in the main

**Mechanics of solids**

**Aerodynamics**
Basic concepts of fluid dynamics: Flow equations in integral and differential form. Irrotational incompressible flows: Kelvin’s and Helmholtz’s theorems, the Bernoulli Equation, elementary and superimposed solutions. Airfoils: profile classification and characteristics, lift generation; finite wings. Viscous flows: laminar boundary layer over a flat plate, boundary layer separation, notes on turbulence and transition. Compressible flows: compressibility of a fluid, speed of sound. Stationary one-dimensional flows, isentropic flows, normal shock.

**Flight Mechanics**

**Propulsion**

**Structures**

**COURSE DESCRIPTION**
Year 1 of Aerospace Engineering consists of 6 modules worth 54 Academic Credits (CFU) in specific Space Engineering subjects, plus Control Systems.

Year 2 of Aerospace Engineering: the student chooses a course in each of the characterising sectors, from a wide range of topics that also includes specific aeronautical engineering subjects. Additionally, 2 modules in related subjects can be freely chosen by the student for a total of 12 CFU.

**Year 1 Subjects**

<table>
<thead>
<tr>
<th>Subject</th>
<th>CFU</th>
<th>Sem.</th>
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<tbody>
<tr>
<td>Aerospace structures Mod 1 – Fundamentals of aerospace structures</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Mod 2 – Smart composite structures</td>
<td>(6)</td>
<td></td>
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<tr>
<td>Compressible flows Mod 1 – Theory of compressible flows</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Mod 2 – Num, meth, for compressible flows</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>Control systems</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Space missions and systems</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Spaceflight mechanics Mod 1 – Orbital mechanics</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Mod 2 – Attitude dynamics</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>Space propulsion Mod 1 – Fundamentals of aerospace propulsion</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Mod 2 – Rocket propulsion</td>
<td>(6)</td>
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</tbody>
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**Year 2 Subjects**

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<thead>
<tr>
<th>Subject</th>
<th>CFU</th>
<th>Sem.</th>
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<tbody>
<tr>
<td>Aerosoacoustics</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Aeronelasticity</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Aerospace materials</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Aircraft aerodynamics and design</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Artificial Intelligence I</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Combustion</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Control of flying robots and robotic systems</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Digital Control Systems</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Environment impact of aircraft engines</td>
<td>6</td>
<td>2</td>
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<tr>
<td>Experimental aerodynamics</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Experimental testing for aerospace structures</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Gas turbine combustors</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Human Factors</td>
<td>6</td>
<td>2</td>
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<tr>
<td>Liquid rocket engines</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Multibody space structures</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Robust Control</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Space guidance and navigation systems</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Space robotic systems</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Spacecraft design</td>
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Classrooms in Via Ariosto 25
2018/19 COURSE DESCRIPTION

First year

AEROSPACE STRUCTURES 1056174
9 CFU
Professor Giuliano COPPOTELLI
The main learning objective of the course is to give the students the methodologies for the evaluation of the mechanical environment and for the analysis generally required for the synthesis and for the design of structures in the aero-space field (such as wings, launchers, satellites). Analytical methods required for the analysis of thin-walled sections and the semi-mono-cocque structure, both statically and dynamically, will be presented. Fundamental knowledge on the analysis of the structural behavior through the Finite Element Method will be provided.

COMPRESSIBLE FLOWS 1051403
9 CFU
Professor Fulvio STELLA & Matteo BERNARDINI
The main objective of the course is to introduce the student to fundamental laws governing compressible flows, under subsonic and supersonic conditions. During a first phase the solution of quasi-1D flows will be approached, with application to nozzle, air intake and supersonic wind tunnels. In the following application to subsonic and supersonic wing will be conducted. Basic knowledge of hypersonic flows: Newtonian theory. Numerical tools for simulation of compressible flows will be provided. The main objective is to introduce the student to the modern techniques of numerical analysis applied to gas dynamics. The main focus will be on the definition of general criteria for the development of numerical schemes and on their implementation in numerical codes for the solution of the multi-dimensional Euler equations.

SPACE MISSION AND SYSTEMS 1051386
9 CFU
Professor Luciano IESS
The objective of the course is to provide basic knowledge on the design of Space missions, and on spacecraft navigation and attitude control. Ability to dimension and design simple systems for orbit and attitude determination and control. Knowledge of Space mission phases and operations.

CONTROL SYSTEMS 1044962
9 CFU
Professor Stefano BATTILOTTI

Examples: Examples of application. Design and simulation of control systems via MATLAB/Control System Toolbox and Simulink.

SPACEFLIGHT MECHANICS 10589505
9 CFU
Professor Mauro PONTANI
The course aims at developing the fundamental engineering aspects of orbital and attitude dynamics of rigid spacecraft, starting from ideal conditions (Keplerian motion and free-spinning spacecraft), then including relevant practical aspects, such as the effects of perturbing and control force and torques, up to the determination of control and maneuver strategies in response of mission requirements. At the end of the course, the student is expected to understand the most relevant aspects of spacecraft dynamic behavior, to solve
Second year
AEROACoustics 1055722
6 CFU
Professor Sergio PIROZZOLI
Understanding of the mechanisms of generation and propagation of aeroacoustic noise, with special reference to aeronautical applications. Introduction to modern techniques for the numerical simulation of aeroacoustically generated sound.

AEROSPACE MATERIALS 1041541
6 CFU
Professor Teodoro VALENTE
The main aim is to allow the students to understand the relationships among innovation, technologies, materials, processes and products in the area of structural materials and materials for propulsion. A multidisciplinary approach will be adopted in order to evidence and discuss tools available for materials/product selection and design by an engineering point of view.
Course Topics: Materials for structural applications and form propulsion systems. Materials properties modifications, due to in service conditions, at macroscopic and microstructural level. Superalloys, creep,

**AIRCRAFT AERODYNAMICS AND DESIGN 1041639**
6 CFU
Professor Luca MARINO
The aerodynamic theory is analyzed aimed at the aerodynamic design of a complete aircraft.
Programme: Finite wing theory. Slat and flap devices Jet flap Pressure drag boundary layer theory boundary layer suction wing in the transonic regime aerodynamic and control derivatives Propeller theory.

Blade element theory. The choice of the propeller. Aeroacoustics principles.

**ARTIFICIAL INTELLIGENCE I 1022771**
6 CFU
Professor Daniele NARDI & Luca IACCII
The aim of the course is to give the first elements of artificial intelligence. In particular, we present the techniques for knowledge representation and automatically search for solutions and will introduce the language PROLOG. Topics treated are: Artificial Intelligence and Intelligent Agents; Goals of AI; Short History Intelligent Agents, logical agents, learning agents; Logic and Knowledge Representation, Propositional Logic and Reasoning, First Order Logic, Representation problems (survey); Automated Problem Solving; The algorithm A*; Machine Learning, Classification Algorithms Regression Algorithms, Unsupervised Learning Algorithms.

**COMBUSTION 1041428**
6 CFU
Professor Francesco CRETA
Upon completion of the course, the student is expected to have become acquainted with the most significant processes in the combustion of gaseous mixtures, and with the relevant theoretical and numerical models.

**CONTROL OF FLYING ROBOTS AND ROBOTIC SYSTEMS 10589446**
6 CFU
Professor Leonardo LANARI
The course presents a selection of advanced topics in Robotics and is intended as an introduction to research. At the end of the course the student will be able to:
- fully develop a problem in Robotics, from its analysis to the proposal of solution methods and their implementation
- understand major aspects in mathematical modeling and control of Unmanned Aerial Vehicles (UAVs) with main emphasis on quadrotors
- recognize major features of the Hummingbird quadrotor
- understand and design attitude and position controllers
- analyze and manage algorithms for trajectory generation and tracking, and sensor-based control
- understand and solve problems related to modelling and control of locomotion and haptic interfaces for VR exploration..

**DIGITAL CONTROL SYSTEMS 1041428**
6 CFU
Professor Claudia CALIFANO
The course provides methodologies for the analysis of linear and nonlinear discrete time and sampled dynamics, the design of digital controllers with a major focus on linear systems, and implementation on embedded microcontrollers. The student will be able to compute digital models of given discrete time systems as well as digital discrete time equivalent models of continuous dynamics, to design digital control laws both for discrete and for continuous systems and to use standard microcontrollers for their implementation.
Programme: mathematical representation of linear discrete time systems and sampled ones. Methodologies for their analysis in the time domain and in the z-transformed one. Effects of the sampling and reconstruction actions on the signals are discussed. Concepts of transfer function, frequency response, and stability (with associated criteria) for discrete time systems. Design requirements for a digital controller. Design approaches (of indirect or direct type) such as discretization of continuous time control laws, root locus methods, frequency design in the complex domain, analytical design techniques (pole/zero assignment, finite time response, deadbeat). The synthesis of digital PID regulators. Mathematical representations of nonlinear discrete and sampled time systems. Commercial microcontrollers and embedded systems for the implementation of the digital control laws. Application examples in simulation using Matlab and with implementation on PIC and Arduino-based systems.
ENVIRONMENTAL IMPACT OF AIRCRAFT ENGINES 1041540
6 CFU
Professor Marco LUCERTINI
The course aims to introduce the causes of chemical and noise emissions from aircraft engines, and the factors which can be exploited to contain them. Chemical emissions are dealt with in the more general frame of man-induced emissions of pollutants and contaminants, and ensuing effects are detailed. Sources of noise emissions are identified, including non-propulsive ones, together with the relevant abatement techniques.

EXPERIMENTAL AERODYNAMICS 1041535
6 CFU
Professor Giovanni Paolo ROMANO
Theoretical knowledge and practice of methods and instruments employed in experimental fluid mechanics and aerodynamics.
Programme: Visualizations in fluid flows with examples. Effects of dyes and tracer particles. Laser Induced Fluorescence (LIF). Measurements of density and temperature fields: Shadowgraph, Schlieren and Interferometry. Velocity field measurements: Hot Wire and Hot Film Anemometry (HWA and HFA), Laser Doppler Anemometry (LDA), Image Analysis Techniques, Particle Image Velocimetry and Particle Tracking Velocimetry (PIV and PTV). Advanced image analysis in PIV Signal analysis in fluid mechanics and relations with turbulent scales.

EXPERIMENTAL TESTING FOR AEROSPACE STRUCTURES 1041575
6 CFU
Professor Giuliano COPPOTELLI
Knowledge of the working principles and application of the main transducers used in the aerospace field. Application of the main methodologies for static and dynamic experimental investigation of aerospace structures aimed to support the civil aviation authority in structural verification and flight qualification.
Programme: Backgrounds in the theory of measurements: fundamental measuring quantities, measuring system, metrological characteristics of the measuring systems, measurement blocks (range, accuracy, dynamic response, precision). Error propagation and "3-sigma" analysis. Working principles of strain gauges, accelerometers, load cells, excitation systems such as hammers and shakers. Static measurements: experimental set up for transmissibility matrix and correlation with numerical models. Dynamic measurements with deterministic inputs: wide frequency band input (hammer) and narrow frequency band input (shaker with periodic input). Static model updating. Problems in signal analysis: discrete Fourier Transform, aliasing, leakage, windowing. Auto-Cross correlation functions: Wiener Theorem. Estimates of the modal parameters: a) from FRF's data using single- and multi-degree of freedom methods; b) direct modal appropriation; c) time domain methods. Dynamic measurements with random inputs: Correlation functions and power spectral densities PSD. Correlation between experimental and F.E. numerical models. Fundamentals on structural F.E. updating. Dynamic measurement techniques for flying aircrafts; free-free structure model simulations. Techniques for the measurements of the dynamic response of satellites during environmental testing. Launch qualification, sine, random and shock testing.

GAS TURBINE COMBUSTORS 10592716
6 CFU
The educational objective of the course is to provide the student with the theoretical skills to achieve an advanced design of gas turbine combustors. To this end, the course is organized as follows: fundamentals of combustion theory; role and design of the diffuser; aerodynamics of gas turbine combustor; performance of gas turbine combustor (efficiency, flame stabilization, ignition); the process of fuel injection; heat exchange in gas turbine combustors; noise and pollutant emissions of the combustion process; traditional and alternative aviation fuels.

LIQUID ROCKET ENGINES 1044024
6 CFU
Professor Francesco NASUTI
The main objective is to convey basic knowledge for the study of most parts of liquid rocket engines and of the LRE system.
Course Topics: Reasons for a high chamber pressure and system designs to achieve this goal; Cooling systems in liquid rocket engines. Propellant tanks; Pressure-fed systems; Basic characteristics of pump-fed systems and comparison with pressure-fed systems; Turbomachines: the macroscopic balances of mass, momentum, energy, and moment of momentum; moments with respect to the axis of rotation; Euler's equation for turbomachinery; methods for the analysis of flows in turbomachines; Pumps: nondimensional parameters and characteristic curves, real flow effects; cavitation. Axial turbines: nondimensional parameters, classification, performance. Impulse turbine: single rotor, pressure compounded and velocity compounded. Turbopump assembly. Gas generators: open and closed cycle architectures. Jet expansion systems: advanced nozzles. Introduction to combustion instabilities in liquid rocket engines.

HUMAN FACTORS 10557721
6 CFU
Professor Marco LUCERTINI
Analysis of the flight related effects on human beings, both for atmospheric and extra-atmospheric flight, emphasizing some specific aspects as those related to the behavior of neurovegetative and sensorial/cognitive systems, including flight related diseases. Human-machine interface will also be a topic to be covered, as many forms of ground-based simulation of the human flight environment, with the different effects that such exposures can generate, both in normals as in individuals affected with different diseases.
MULTIBODY SPACE STRUCTURES
1041548
6 CFU
Professor Paolo GASBARRI

Main objectives of the Course are:

ROBUST CONTROL 1041453
6 CFU
Professor Alberto ISIDORI

The course is addressed to students willing to expand their knowledge on the design of control systems in presence of model uncertainties. The course covers, in a systematic manner, various fundamental methods of analysis based on the use of linear matrix inequalities and various design methods, to be used in the case of parameter uncertainties as well as in the case of modeling uncertainties.


SOLID ROCKET MOTORS 1044027
6 CFU
Professor Francesco CRETA

The course will focus on the basic design of solid rocket motors (SRM) and on the wide spectrum of phenomena that characterize them. The introductory part of the course will address the main theoretical tools and mathematical models which describe the quasi-steady regime of operation. The central part of the course will focus on the multi-faceted aspect of solid propellant combustion, its description and tentative modeling. The third and last part will concentrate on SRM-specific aspects such as ablation of nozzle surfaces, two-phase flows, grain geometry and ignition transient. An outline of hybrid rocket motors will also be given. Exercises will be integrated within each part of the course.


SPACE GUIDANCE AND NAVIGATION SYSTEMS 1051389
6 CFU
Professor Fabrizio PIERGENTILI

SPACE ROBOTIC SYSTEMS 1051406
6 CFU
Professor Fabio SANTONI
The course provides the required knowledge to cope with the design of robotic Space systems. The main objective is the study of the guidance, navigation and control systems for missions of on-orbit-servicing, rendezvous and docking, and planetary exploration.
Programme: Spatial Description and Transformations. Control Systems of a Space Vehicle. Space Dynamical Environment. Active control systems using momentum exchange systems (reaction wheels and Control Moment Gyros). Active control system using propulsion. Bang-bang control technique and Pulse-Width-Modulation. Large Angle Attitude Maneuvers. Space Manipulators. Manipulator kinematics. Inverse Manipulator Kinematics. Jacobians: Velocities and Static Forces. Manipulator Dynamics. Trajectory generation. Linear Control of Space Manipulators. Nonlinear Control of Space Manipulators. Attitude Control of the spacecraft-manipulator system. Space robotics applications: On orbit Servicing, Active Debris removal, Planetary robotics.

SPACECRAFT DESIGN 1041550
6 CFU
Professor Fabio SANTONI
The course describes the methodologies for the detailed design of satellites and satellite systems, including technical and project planning methods, following the international Space mission standards.
Programme: The course provides the technical skills for the design of a spacecraft, including integrated design methodologies and international standard. All the phases of spacecraft design are analysed, from mission conceptual design to the spacecraft architecture definition and detailed subsystems preliminary design, realization procedures, ground testing and qualification for launch.
CONTACTS

FOR GENERAL INFORMATION ON STUDYING AT SAPIENZA
Hello – International Student Help
Desk. Rectorate Building Colonnade
Piazzale Aldo Moro, 5 helio@uniroma1.it
Open: Monday – Friday 9:30 am to 5:00 pm

FOR INFORMATION ON ENROLLING AT SAPIENZA:
International Admissions Office
Palazzo Servizi Generali
Stairwell C - Second Floor
Piazzale Aldo Moro, 5 settorettolosstraniero@uniroma1.it
Open: Monday, Wednesday, Thursday 8.30 -12.00

STUDY PLAN PREPARATION ASSISTANCE
Prof. Francesco NASUTI
francesco.nasuti@uniroma1.it

FOREIGN STUDENTS HELPDESK
Dr. Benedetta Ermini
aerospaceengineering@uniroma1.it
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Open: Monday-Friday 9.00 - 12.00

STUDENT FORMALITIES
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Piazzale Aldo Moro 5, Palazzo delle Segreterie, Stairwell A, 4th floor
Open: Mon/Wed/Fri - 8:30 to 12:00 am; Tue/Thurs 2:30 – 4:30 pm
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Tel. (+39) 06 4970 7507
Fax. (+39) 06 497 0367
www.jobsoul.it mailto:info@jobsoul.it

Further information
TUITION AND SCHOLARSHIPS
Tuition fees at Sapienza University are amongst the lowest in Europe. Moreover, Sapienza offers lower tuition costs to students from developing countries. Sapienza also helps hundreds of students to reduce the cost of their education. The university provides a variety of scholarships to both Italian and foreign students based on merit and need. Moreover, other scholarships are provided by EU authorities and programmes
https://www.uniroma1.it/en/pagina/scholarships-0

SAPIENZA STUDENT CARD
The Sapienza International Office provides all students with a student card that will enable you to take advantage of special discounts, etc.

STUDENT SERVICES
Sapienza offers students a wide range of services and opportunities that makes studying here enjoyable.

CAMPUS WI-FI
You can use the campus Wi-Fi by selecting “Sapienza” from the available wireless networks. International students can access the network by using their enrolment identification number (matricola) as a username and their Infostud password.

UNIVERSITY CANTEENS
To eat at the university canteens, you have to apply for a canteen card. The canteen of Faculty of Engineering is at walking distance from the campus (Via delle Sette Sale 29)

https://www.uniroma1.it/en/pagina/housing-and-canteens
INFOSTUD
The Student Information System
Infostud, which is accessible from the student section of the Sapienza website, is the main tool to manage administrative procedures for students, including: registration, booking exams, viewing completed exams, printing forms and certificates such as the university fee paying slip, degree records with completed exams, enrollment certificates, etc. Infostud allows students to print certificates and documents with the University digital stamp of certification.

ACCOMMODATION
It is possible to take advantage of a special housing programme reserved for exchange students.
http://www.student.it/

LIBRARIES
International students have access to all Sapienza libraries upon presentation of a photo ID and their student card. Each library has different regulations, so please consult the library staff for details on how to borrow books; in general, however, a photo ID and a student card or number are required. The on-line library catalogue is available at: http://opac.uniroma1.it/
If you have been a resident of Rome for more than three months, you can become a member of Rome’s public library network: Biblioteche di Roma. Membership allows you to access all of Rome’s public libraries from which you can borrow books, DVDs, use the Internet and enjoy the vast private study areas. In order to apply for membership, you must show your proof of residence in Rome, proof of enrolment and photo ID.

LIFE IN ROME
Sapienza students not only study in a world class university, they also live in a world renowned city. Rome is the ideal environment to learn about and enjoy an infinite amount of history, art and culture. It is a city full of surprises that never fails to delight the senses. Living here is an integral part of the university experience and will greatly enrich your stay at Sapienza.
https://www.uniroma1.it/sites/default/files/allegati/International%20Student%20Guide.pdf