SAPIENZA
UNIVERSITÀ DI ROMA

Academic Year 2016/17

Course in

SPACE AND ASTRONAUTICAL ENGINEERING

Class LM 20 – Space and Astronautical Engineering

Academic Regulations

The Academic Regulations for this course are in two sections:

- **Course content**

  This section describes the course and its objectives, and sets out the Prospectus.

- **General Regulations**

  This section sets out the course regulations and general regulations governing the academic career of all students.

Academic Board (CAD) website for Aerospace Engineering

http://www.ingaero.uniroma1.it

Section I – Content of the course

Specific teaching objectives

The Postgraduate Degree Course in Space and Astronautical Engineering equips the student with advanced disciplinary and professional training and specific engineering skills, enabling them to address complex problems that require the use of modern methods of analysis, design, simulation, and optimisation. 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 space 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. These areas of investigation are re-elaborated in relation to a human crew, placing particular emphasis on life support technologies and systems in space.
In terms of methodologies and applications, in the two-year Postgraduate Degree Course these capabilities build on the solid basic preparation previously acquired in the degree course, and take them further.

Course Description

The study pathway consists of four thematic curricula (A: Launch Vehicles; B: Satellites; C: Missions; D: Remote Sensing from Space) plus a fifth (E: Aerospace Engineering), which is taught in English only and is intended mainly for students who hold a non-Italian previous qualification.
Year 1 is the same for the first three curricula (A: Launch Vehicles, B: Satellites, and C: Missions) and consists of 7 modules for a total of 60 CFU credits, during which knowledge is acquired or consolidated in the typical sectors of Space and Astronautical Engineering (gas dynamics, space structures, mechanics of space flight, space propulsion, and space systems) together with basic information in sectors such as electronics and automation. In Year 2 curricula A, B, and C split into groups of subjects that fall within the characterising sectors of those disciplines, from which the student chooses 3 modules worth a total of 18 CFU credits.
Year 1 of curriculum D: Remote Sensing from Space (7 modules, 57 CFU credits) shares some courses with curricula A, B, and C and also introduces the student to the topics of Sensors and Remote Sensing from Space. Year 2 of curriculum D is differently structured from the others and consists of three required subjects worth a total of 21 CFU credits.
Year 1 of curriculum E: Aerospace Engineering consists of 6 modules worth 54 CFU credits in specific Space Engineering subjects (as per the first three pathways) plus Control Systems. In Year 2 of curriculum E the student chooses a course in each of the characterising sectors, from a wide range of topics that includes specific aeronautical engineering subjects.
Additionally, all 5 curricula include 2 modules in related subjects freely chosen by the student, of which 1 is worth 6 CFU credits and the other is worth 12 CFU credits.
At least 60% of the total hours available to the student are intended for personal study or other types of individual learning.
The Postgraduate Degree Course in Space and Astronautical Engineering is part of an Italian-French network that enables a double degree to be acquired at SAE-SUPAERO in Toulouse. For further information see the *Internationali* section of the Aerospace Engineering CAD (www.ingaero.uniroma1.it) website.

Occupational and professional opportunities for graduates

The career prospects for the space and astronautics 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:

- space sector industries
- small and medium manufacturers in the space 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.

PROSPECTUS FOR 2016/17

The study programme consists of five curricula, one of them taught in English.
Teaching takes place at either San Pietro in Vincoli (SPV) or at no. 25 Via Ariosto (ARI).

CURRICULUM A – LAUNCH VEHICLES

This curriculum includes the study of orbital entry trajectory and associated problems relating to guidance, navigation, and control; the design of solid and liquid-fuelled propulsion systems; and the structural problems of launch vehicles. Benefitting from Sapienza's involvement in the VEGA Programmes, the student acquires this knowledge at the systems level, ranging from the conceptualisation and design of a vector to the implementation of a launch campaign. Depending on the freely chosen subjects, the student studies in depth the various different subsystems of a space transport vehicle.

CURRICULUM B – SATELLITES

This curriculum focuses on the general design of a satellite, specifically on energy and thermal balance, structural and technological problems, electrical, electronic and telecommunications subsystems, and satellite control and trim systems.
Students are given access to a very large number of different workshops and can benefit from the experience acquired by the Rome school over many years in designing, constructing, and launching small platforms and operating them in orbit.

CURRICULUM C– SPACE MISSIONS

This curriculum prepares engineers in the analysis of earth orbit and solar system exploration missions, including orbital design and control with specific reference to the most advanced trajectory analysis techniques. It also includes fields that are currently of particular interest, such as robotic missions and missions that use satellites in constellations and formations.

CURRICULUM D – EARTH OBSERVATION

This curriculum deals with the use of satellites for telecommunications, navigation, and acquiring and processing land, ocean, and atmospheric data using optical, radar, and microwave radiometer systems. The student analyses and tests the complete developmental cycle of missions of this type, from selecting and designing the observational payload to using information extraction to process and make use of the data collected.

CURRICULUM E – AEROSPACE ENGINEERING

All teaching in this curriculum is in English and is intended mainly for students holding a non-Italian qualification which may not have included the all skills required for a first degree in the aerospace sector. The required courses in Year 1 of this curriculum are the same as for Curricula A, B, and C. Year 2 also includes aeronautical subjects to offer a wider range of choices from a broader thematic area than those in curricula A, B, C, and D, which are focused specifically on space engineering fields.

YEAR 1 ANNO (Academic year 2016/17)

ORIENTATION A – LAUNCH VEHICLES, B - SATELLITES, C - MISSION

Subject	L	SSD	CFU credits	Activity type	Sem.	Venue
Control systems	EN	ING-INF/04	9	C	1	SPV
Gasdynamics	IT	ING-IND/06	9	B	1	SPV
Space Flight Mechanics	IT	ING-IND/03	9	B	1	SPV
Space Structures	IT		9	B	2	SPV
Mod. 1 - Analysis and design of space structures		ING-IND/04	(6)			
Mod. 2 - Composite structures		ING-IND/04	(3)			
Electronics	IT	ING-INF/01	6	C	2	SPV
Space missions and systems	EN	ING-IND/05	9	B	2	SPV
Rocket Propulsion	IT	ING-IND/07	9	B	2	SPV

ORIENTATION D – EARTH OBSERVATION

Subject	L	SSD	CFU credits	Activity Type	Sem.	Venue
Control systems	EN	ING-INF/04	9	C	1	SPV
Radio Sensors and Systems	IT	ING-INF/03	6	C	1	SPV
Space Flight Mechanics	IT	ING-IND/03	9	B	1	SPV
Analysis and design of space structures	IT	ING-IND/04	6	B	2	SPV
Electronics and optical sensors Mod 1 – Elettronics Mod 2 – Optical sensors	IT	 ING-INF/01 ING-INF/01	9 (6) (3)	C	2	SPV
Space missions and systems	EN	ING-IND/05	9	B	2	SPV
Microwave Remote Sensing	IT	ING-INF/02	9	C	2	SPV

ORIENTATION E – AEROSPACE ENGINEERING

Subject	L	SSD	CFU credits	Activity Type	Sem.	Venue
Control systems	EN	ING-INF/04	9	C	1	SPV
Spaceflight mechanics Mod 1 – *Orbital mechanics* Mod 2 – *Fundamentals of attitude dynamics*	EN	 ING-IND/03 ING-IND/03	9 (6) (3)	B	1	SPV
Compressible flows Mod 1 – *Theory of compressible flows* Mod 2 – *Numerical methods for compressible flows*	EN	 ING-IND/06 ING-IND/06	9 (6) (3)	B	1	SPV
Aerospace structures Mod 1 – *Fundamentals of aerospace structures* Mod 2 – *Smart composite structures*	EN	 ING-IND/04 ING-IND/04	9 (3) (6)	B	2	SPV
Space missions and systems	EN	ING-IND/05	9	B	2	SPV
Space propulsion Mod 1 – *Fundamentals of aerospace propulsion* Mod 2 – *Rocket propulsion*	EN	 ING-IND/07 ING-IND/07	9 (3) (6)	B	2	SPV

YEAR 2 (academic year 2017/18)

ORIENTATION A - LAUNCH VEHICLES

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU credits	Sem.	Venue
Liquid rocket engines	EN	ING-IND/07	6	1	SPV
Solid rocket motors	EN	ING-IND/07	6	2	SPV

12 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU credits	Sem.	Venue
Hypersonics	IT	ING-IND/06	6	2	SPV
Liquid rocket engines	EN	ING-IND/07	6	1	SPV
Flight Mechanics of launchers	IT	ING-IND/03	6	1	SPV
Solid rocket motors	EN	ING-IND/07	6	2	SPV
Space guidance and navigation systems	EN	ING-IND/05	6	2	SPV
Thermal and thermoelastic analysis of aerospace structures	IT	ING-IND/04	6	2	SPV

6 CFU (italian) credits are awarded for any of the following Type C Subjects chosen by the student

Subject	L	SSD	CFU credits	Sem.	Venue
Aerospace materials	EN	ING-IND/22	6	2	SPV
Digital control systems	EN	ING-INF/04	6	1	ARI
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV

ORIENTATION B - SATELLITES

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU credits	Sem.	Venue
Multibody space structures	EN	ING-IND/04	6	2	SPV
Technologies of aerospace materials	IT	ING-IND/04	6	1	SPV

12 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Multibody space structures	EN	ING-IND/04	6	2	SPV
Space Propulsion	IT	ING-IND/07	6	2	SPV
Spacecraft design	EN	ING-IND/05	6	1	SPV
Technologies of aerospace materials	IT	ING-IND/04	6	1	SPV

6 CFU (italian) credits are awarded for any of the following Type C Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Radar Image Processing	IT	ING-INF/03	6	1	SPV
Space Systems Electronics	IT	ING-INF/01	6	1	SPV
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV

ORIENTATION C – MISSIONS

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Space guidance and navigation systems	EN	ING-IND/05	6	2	SPV
Space robotic systems	EN	ING-IND/05	6	1	SPV

12 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Space Propulsion	IT	ING-IND/07	6	2	SPV
Space guidance and navigation systems	EN	ING-IND/05	6	2	SPV
Space robotic systems	EN	ING-IND/05	6	1	SPV
Technologies of aerospace materials	IT	ING-IND/04	6	1	SPV
Trajectories interplenetarie	IT	ING-IND/03	6	1	SPV

6 CFU (italian) credits are awarded for any of the following Type C Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Artificial intelligence I	EN	ING-INF/05	6	1	ARI
Biological effects of space environment and protection methods	IT	MED/08	6	2	SPV
Space Systems Electronics	IT	ING-INF/01	6	1	SPV

ORIENTATION D – EARTH OBSERVATION

Subject	L	SSD	CFU	Activity type	Sem.	Venue
Space Propulsion	IT	ING-IND/07	6	B	2	SPV
Observation and surveillance Systems Mod 1 – Observation systems Mod 2 – Remote sensing trajectories	IT	 ING-IND/05 ING-IND/03	9 (6) (3)	B	1	SPV
Geophysical and Astrophysical Fluid	IT	ING-IND/06	6	B	2	SPV

6 CFU (italian) credits are awarded for any of the following Type C subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Radar Image Processing	IT	ING-INF/03	6	1	SPV
Space Systems Electronics	IT	ING-INF/01	6	1	SPV
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV
Telecommunication Networks	IT	ING-INF/03	6	2	SPV

CURRICULUM E – AEROSPACE ENGINEERING

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Aeroelasticity	EN	ING-IND/04	6	2	SPV
Experimental testing for aerospace structures	EN	ING-IND/04	6	1	SPV
Multibody space structures	EN	ING-IND/04	6	2	SPV

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Space guidance and navigation systems	EN	ING-IND/05	6	2	SPV
Spacecraft design	EN	ING-IND/05	6	1	SPV
Space robotic systems	EN	ING-IND/05	6	1	SPV

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Aircraft aerodynamics and design	EN	ING-IND/06	6	1	SPV
Computational gasdynamics	EN	ING-IND/06	6	2	SPV
Experimental aerodynamics	EN	ING-IND/06	6	1	SPV

6 CFU (italian) credits are awarded for any of the following Type B Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Combustion	EN	ING-IND/07	6	1	SPV
Environmental impact of aircraft engines	EN	ING-IND/07	6	2	SPV
Liquid rocket engines	EN	ING-IND/07	6	1	SPV
Solid rocket motors	EN	ING-IND/07	6	2	SPV

6 CFU (italian) credits are awarded for any of the following Type C Subjects chosen by the student

Subject	L	SSD	CFU	Sem.	Venue
Aerospace materials	EN	ING-IND/22	6	2	SPV
Artificial Intelligence I	EN	ING-INF/05	6	1	ARI
Digital Control Systems	EN	ING-INF/04	6	1	ARI
Robust Control	EN	ING-INF/04	6	1	ARI

OTHER SHARED ACTIVITIES

	Valut.	CFU credits	Activity type
Examinations chosen by the student	E	12	D
Other	V	1	AAF
Final examination test		23	E

Key
IT: delivered in Italian; **EN**: delivered in English.
Type of learning activity: A: basic, B: required, C: complementary, for completeness, D: chosen by the student, E: relates to the Final Examination, AAF: other types of learning activity (as per art. 10, paragraph. 1 letter d), E: internship or apprenticeship.
Assessment: E: examination, V: assessment
Venue: SPV via Eudossiana 18, URB via Salaria 851, ARI via Ariosto 25.

Preparatory subjects

Before taking these examinations...	...the student must first pass:
Hypersonics	Gasdynamics or *Compressibile flows*
Multibody space structures	Space Structures or *Aerospace structures*
Liquid rocket engines	Gasdynamics o Compressibile flows, Rocket Propulsion or *Space propulsion*

Tuition

Faculty tutoring support on this Course is provided by Paolo Gaudenzi, Luciano Iess, Francesco Nasuti, Marcello Onofri, and Fabio Santoni in their particular subject areas.

Section II – General Regulations

Admission requirements

Applicants for the Graduate Degree Course in Space and Astronautical 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.

A) Applicants holding an Italian qualification awarded under the old system (DM 270/04 or DM 509/99)

- **Curricular requirements**

a) For applicants whose **weighted average** of all the credits for their first degree, expressed as marks out of 30, **is at least 22/30 but less than 24/30**, the curricular requirements are:
- at least the minimum CFU credits in the following disciplines *(SSDs [subject areas])*:

CFU	SSD
72	MAT/03-/05-/06-/07-/08, FIS/01-/02-/05, CHIM/07 ING-IND/03-/04-/05-/06-/07-/08-/09-/10-/11-/13-/14-/15-/22-/31, ICAR/08, ING-INF/01-/02-/03-/04-/05
27[1]	MAT/05-/07, FIS/01
27[1]	ING-IND/03-/04-/05-/06-/07

(1) out of the 72 for the previous group

NB: applicants who do not meet these requirements must take individual examinations as may be assigned by the Admissions Board.

b) For applicants whose **weighted average is at least 24/30 but less than 26/30**, the curricular requirements are:
- at least the minimum CFU credits in the following disciplines *(SSDs [subject areas]):*

CFU	SSD
72	MAT/03-/05-/06-/07-/08, FIS/01-/02-/05, CHIM/07 ING-IND/03-/04-/05-/06-/07-/08-/09-/10-/11-/13-/14-/15-/22-/31, ICAR/08, ING-INF/01-/02-/03-/04-/05
27[1]	MAT/05-/07, FIS/01
27[1]	ING-IND/03-/04-/05-/06-/07-/08-/09-/14, ING-INF/02-/03-/04

(1) out of the 72 for the previous group

NB: applicants who do not meet these requirements must take individual examinations as may be assigned by the Admissions Board.

c) For applicants whose **weighted average is at least 26/30** the curricular requirements are: - at least the minimum CFU credits in the following disciplines *(SSDs [subject areas]):*

CFU	SSD
72	MAT/03-/05-/06-/07-/08, FIS/01-/02-/05, CHIM/07 any of the following: ING-IND, ICAR/08, ING-INF/01-/02-/03-/04-/05
27[1]	MAT/05-/07, FIS/01

(1) out of the 72 for the previous group

NB: applicants who do not meet these requirements must take individual examinations as may be assigned by the Admissions Board.

Applicants who match the requirements set out at b) and c) are advised to compare their personal curriculum against the Academic Regulations for the Degree Course in Aerospace Engineering and with the Syllabus (attached to the Academic Regulations for the Course in Aerospace Engineering and Astronautics), and make their own adjustments as appropriate.

Applicants holding one of the following are automatically admitted:
- a Class L-9 (DM 270/04) degree in Aerospace Engineering awarded by Sapienza University
- a Class L-10 (DM 509/99) degree in Aerospace Engineering awarded by Sapienza University.

- **Previous educational attainments**

Applicants with a weighted average mark of at least 22/30 for their first degree are admitted.
Applicants whose weighted average is less than 22/30 can apply to the Head of the Aerospace Engineering CAD for their educational background to be verified[1], following which they may be examined by the Admissions Board.
For admission to Aerospace Engineering curriculum E, a B2 English language proficiency certificate or equivalent is required.

B) Applicants holding a non-Italian qualification or an Italian qualification other than those awarded under the old system (DM 270/04 or DM 509/99)

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 to Aerospace Engineering curriculum E, a B2 English language proficiency certificate or equivalent is required.

Transfers from periods of study outside Italy, and procedures for verification thereof

If the applicant is transferring from another university, a different faculty of Sapienza, or another course, the CAD can recognise any credits already held. These should normally not be worth more than the SSDs (subject areas) given in the Prospectus, or if they are in SSDs not included in the Prospectus, more than 12 CFU credits.
If an applicant holds credits acquired from studies, examinations, or academic qualifications taken outside Italy, in each case the CAD (as per the University Academic Regulations), will examine the programmes thereof and assign equivalent CFU credits in subject areas that correspond.
Courses previously taken at universities in other EU Member States, or non-EU countries, with which the Faculty of Engineering currently has agreements, projects, and/or conventions, are recognised in accordance with those agreements.
Students can spend a period of study outside Italy as part of the LLP Erasmus programme, if authorised in advance by the CAD. For opportunities to spend periods of study outside Italy see the *Internazionale* section of the CAD website (www.ingaero.uniroma1.it)
If the applicant is no longer enrolled as a student the CAD may decide, strictly on the basis of the currently applicable regulations, to wholly or partially recognise the credits previously acquired.

[1] This procedure will not be accepted after the 2017/18 academic year.

For more information on how to transfer credits and have them validated see the *Manifesto degli studi* of the University (University Prospectus) and the *Pratiche studenti* section of the CAD website.

Readmitted students

If the applicant is no longer enrolled as a student the CAD may decide, strictly on the basis of the currently applicable regulations, to approve their reinstatement and wholly or partially recognise any credits previously acquired.
For the readmission procedure see the *Manifesto degli studi* of the University (University Prospectus)

Recognition of credits

Previously acquired professional knowledge and skills that are recognised under current legislation, or were acquired in post-secondary school education courses devised and structured with university input, can be given recognition as credits by the CAD, normally as part of the 12 CFU credits attainable in the optional subjects chosen by the student. No more than 6 credits can be recognised in this way.

Teaching methods

Teaching methods are conventional and are divided into semesters.
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”).

- **Crediti formativi universitari (Italian CFU credits)**

Italian CFU credits (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 credit 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 credit in the Aerospace Engineering and Astronautics course equates to 8 hours of lectures, or to 12 hours of workshops or guided exercises.
An information sheet for each subject is available on the CAD website, giving a breakdown of the CFU credits and the number of teaching hours for the various activities, along with the admission requirements, teaching objectives, and programmes.
The total workload required to successfully take the Degree is 120 CFU credits, equating to a time commitment of 3,000 hours on the part of the student.
At least 60% of the student’s overall time commitment should be for personal study or other types of personal learning.

- **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 (*Calendari* 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 curriculum E - *Experimental Aerodynamics* and *Experimental Testing for Aerospace Structures*.

- **Assessment methods**

Normally, the student's progress in any given subject is assessed by an examination (E), 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 (V), also devised by the tutor.

Examination programmes and formats

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

The 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. If not, the List of Examinations is cancelled. 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 website of the Aerospace Engineering CAD (News section)].

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

To progress to Year 2, the student must have acquired at least 27 of the credits for Year 1. These credits must have been acquired before January 31 of the calendar year after the academic year in which the student first enrolled. Students who do not meet the requirements for progressing to the next year are enrolled as "repeating students".

Examinations that can be brought forward

In order to complete the required 60 credits for Year 1, students enrolled on curriculum E – 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 *Pratiche studenti* section of the CAD website.

Part-time study

Matriculants or enrolled students can request to attend on a part-time basis, attaining fewer credits per year than if attending full-time.
Students who already know at the time of enrolling that they will have limited time to devote to study, or who are "outside the course", are advised to opt for part-time study. The terms, procedures, and regulations for applying for part-time study are set out in the General University Regulations at (http://www.uniroma1.it/didattica/regolamenti/part-time).

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 30 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 (*STUDENTI / Percorsi di eccellenza* Section).

The 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 relevant Teaching 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 student 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. If the dissertation is of the experimental type, the student is required to prepare an experiment plan that will enable the desired outcomes to be attained. A dissertation of the design type is dedicated to studying the characteristics of launch vehicles or space vehicles and their subsystems, including payloads, and the analysis and planning of space missions. The final examination is worth 23 CFU credits.

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 credits. 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.

Quality assessment

In collaboration with the University, this Postgraduate Degree Course participates in collecting student feedback about all courses. The method for collecting feedback is integrated with a quality pathway and is entrusted to a self-assessment group consisting of tutors, students, and course teaching staff. The results of the feedback, and the analyses made by the self-assessment group, are used to improve teaching quality.

Attachment

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 and Astronautics 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.

Science of materials
Main classes of materials, properties, analytical reports selecting/dimensioning/treating materials in relation to the stress conditions and basic operating conditions. Crystalline and amorphous materials; deformability, viscoelasticity, recovery and recrystallisation, binary phase diagrams, Solid state diffusion. Mechanical and physical properties, metallic materials (steels, aluminium alloys, superalloys, notes on titanium and magnesium alloys), correlations between microstructure, properties and processes. Ceramics: mechanical testing and Weibull statistics. Thermal shock. Polymer and composite polymer matrix materials. Chemical degradation of materials: causes and prevention. Degradation due to wear, finishes. merit indices for the choice of materials.

Electrotechnics
Analysis of electric circuits and networks: steady-state operating, sinusoidal periodic regime, voltage and current sources, single phase systems, three-phase systems.
Electromechanical energy conversion. Principles of operation of electrical machines: transformers, motors, generators.
Notes on the production, distribution, and use of electricity.

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 devices for transmission and transformation of motion (mechanisms, flexible, gears, gearing). Single degree of freedom vibrating systems. Multiple degree of freedom vibrating systems.
Understanding technical design and the related ISO regulations. Basic concepts of solid modelling.

Mechanics of solids
Kinematics and statics of deformable continua: descriptors of motion and deformation, descriptors of internal forces (stress), conservation laws, constitutive relations and linear elastic solids. The Saint-Venant problem. Structural analysis of beam systems: loading diagrams (shear force, bending moment and deflection).

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.

Mechanics of flight
Physical properties of the atmosphere, reference atmosphere. Fundamentals of physics of atmospheric flight.
Basics of orbital mechanics, in particular the analytical solution of the two-body problem in the trajectory plane.

Propulsion
Fundamentals of thermochemistry. Fundamentals of heat transmission. Thermodynamic cycles: Carnot, Brayton, Diesel, Otto. Basic concepts of thrust generation and cost in jet engines.

Structures
Stress and strain: equilibrium equations, constitutive relations for linear elastic solids, kinematic bond deformation deflection, compatibility equations, state of stress and plane deformation(the Airy function).
Aircraft structures: aircraft load scenarios and manouvre diagrams. General characteristics of aeronautical structures and materials: primary structural elements (axial members, shear panels, bending and torsion elements), load transfer in fuselage and wing structures, metallic and composite materials. Shear flow in thin-walled structures. Buckling of beams. Breaking criteria. Structural dynamics: free and forced vibration of discrete systems. Damping and resonance.