Academic Regulations for the Graduate Degree Course in

SPACE AND ASTRONAUTICAL ENGINEERING

Class LM 20 – Aerospace and Astronautical Engineering

Regulations for 2015/16

Specific teaching objectives

The Graduate Course in Space and Astronautical Engineering offers the student advanced disciplinary and professional training and specific engineering skills, enabling them to address complex problems requiring analysis, development, simulation, and optimisation. They also learn the fundamentals of manned and interplanetary space missions that use astronautical vehicles and re-entry capsules, with particular reference to systems and scientific aspects.

The student learns how to use the most advanced investigative and design tools for innovation in the space industry, such as improving efficiency and reducing weight. Some classic fields are investigated such as satellite payload, vehicle, launch base, telemetry, tele-measurement, and re-entry, as well as the characteristics of a landing site in relation to a human crew, with particular emphasis on life support technologies and systems in space, and where the requirements are reliability and safety; the compatibility of a mission engineering project with the physiological needs of the astronauts in relation to their cognitive abilities and their ability to react; and the limits of human performance in the space environment, including when psychologically stressed. The course also includes learning the international regulations that govern activity in space.

In terms of methodologies and applications, these capabilities build on the solid foundation of knowledge previously acquired in the three-year Degree Course. Year 1 consolidates the student's understanding of the typical sectors of space engineering (Gas Dynamics, Space Construction, Mechanics Of Space Flight, Space Propulsion, and Space Systems) and addresses the fundamentals of Telecommunications, Automation, and Electronics, not covered in the three-year Degree Course. Year 2 offers a choice of different curricula that provide deeper knowledge of the structures and propulsion systems of launch vehicles; space platforms; Earth observation; and planning space and interplanetary missions.

Admission requirements and recognition of credits

The Graduate Course accepts applicants holding a first degree who have acquired the equivalent of 72 Italian CFU credits in the following disciplines (SSDs - *Settori Scientifici e Disciplinari*):
ING-IND/03, ING-IND/04, ING-IND/05, ING-IND/06, ING-IND/07, ING-IND/08, ING-IND/13, ING-INF/01, ING-INF/02, ING-INF/03, ING-INF/04, ING-INF/05, ICAR/08, INF/01, MAT/02, MAT/03, MAT/05, MAT/07, FIS/01, FIS/02, FIS/05, and CHIM/07, of which at least 27 credits must be in disciplines MAT/05, MAT/07, and FIS/01.

<u>Assessment of the applicant's general educational standard</u>

Admission to the Graduate Course is conditional on passing a written admission test to assess the applicant's general educational standard. However, this requirement does not apply to applicants whose previous qualifications satisfy the condition

$$M \geq 21 + (n-4) \text{ with } n \geq 4$$

where "n" is the number of years they took to complete the three-year Undergraduate Course and "M" is the weighted average of all the credits they acquired in that course, in all examinations.

The admission test is based on the applicant's general understanding of the required basic subjects. This takes place each academic year, on a date that is announced on the website of the CAD (*Consiglio d'Area Didattica* - Teaching Council) for Aerospace Engineering at www.ingaero.uniroma1.it. Students who have not yet completed the three-year Undergraduate Course can apply for the Graduate Course, provided that they are in the position to ask for the requirements check

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

Courses previously taken by the applicant at universities in other EU Member States, or non-EU countries, with which the Faculty of Engineering currently has agreements, projects, and/or conventions in place, are recognised in accordance with these agreements, etc..
Students are permitted to spend a period of study outside Italy as part of the LLP Erasmus programme, if authorised in advance by the CAD.
If an applicant holds credits acquired as a result of studies, examinations, or academic qualifications taken outside Italy, in each case the CAD (to comply with the Academic Regulations of the University) will examine the programmes thereof in order to assign equivalent Italian CFU credits in subject areas that correspond.
If the applicant is transferring from another university, from a different faculty of Sapienza, or from another course, the CAD may, if it so decides, recognise any credits they already hold. The value of these should normally not exceed the maximum Italian CFU credits that could be acquired in the subject areas covered in the Prospectus for this Course. If they are in subject areas not included in the Prospectus, they cannot add up to more than the equivalent of 12 (Italian) CFU credits.
If the applicant is no longer a student the CAD may, if it so decides, and exclusively on the basis of the currently applicable regulations, approve their reinstatement and may wholly or partially recognise any credits they previously acquired.
For more information on how to transfer credits and how to have them validated or taken into account, see the "PRATICHE STUDENTI" link on the CAD website at (www.ingaero.uniroma1.it)

Attendance

Attendance is not obligatory.

The study pathway: description

The Couse pathway is organized four thematic curricula (Launch Vehicles, Satellites, Missions, and Space Remote Sensing).
Three curricula (Launchers Vehicles, Satellites, Missions) have in common the first year, organized into 7 modules for a total of 60. It consolidates the student's understanding of the typical sectors of space engineering and astronautics (Gas Dynamics, Space Construction, Mechanics Of Space Flight, Space Propulsion, and Space Systems) and addresses the fundamentals of Electronics and Automation, which are not covered in the three-year Undergraduate Course. Year 1 of curriculum Space Remote Sensing (7 modules, 60 CFU) shares the first semester with the other pathways, while the second semester introduces the issues concerning the spatial remote sensing basis along with the electronics and control theory.

Year 2 consists of four thematic curricula (Launch Vehicles, Satellites, Missions, and Earth Observation) organised into groups, from which the student can choose any 4 modules that add up to 24 CFU credits. At least 68% of the total hours available to the student are intended for personal study or other types of individual learning.

The Graduate Course in Space and Astronautical Engineering is part of a French-Italian network for the acquisition of the double - title at ISAE - SUPAERO Toulouse. The agreement between La Sapienza and the French defines the operational arrangements to achieve the title. Information can be gathered at International section of the CAD website at (www.ingaero.uniroma1.it)

The final examination

The final examination consists of an experimental, design, or written thesis addressing the subjects taken in the Graduate Course and that has been developed under the guidance of a tutor belonging to 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 development of the thesis 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 thesis, and to propose solutions to the problema proposed, using models to analyse the response of a system with variable characteristics. If the thesis is of the experimental type, the student is required to plan
the experiment to achieve the desired results. A design type thesis is aimed at the analysis of the characteristics of launchers or space vehicle and the corresponding subsystems, payload included. These thesis concern also the study and planning of space missions.

The final examination is worth 23 CFU credits.

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 asessing the outcome of the internship.

Teaching formats and methods for assessing student progress

The format for teaching individual subjects may be classes, practical exercises, workshops, group work, or any other format which the tutor may consider appropriate.
Normally, the student's progress in any given subject is assessed by an examination (E) which may consist of oral and/or written tests devised by the tutor. Details of these will be provided along with the course programme.

Part-time study

Matriculants, or enrolled students who have non-university commitments, can request to attend on a part-time basis and plan to attain fewer CFU credits per year than if attending full-time.
The regulations and methods for part-time attendance are given in the University Regulations. For the rights and obligations of part-time students, see the General University Regulations at (http://www.uniroma1.it/didattica/regolamenti/part-time).

Optional subjects chosen by the student

The optional subjects chosen by the student (worth 12 credits) can either be subjects from this Course not already included in their personal Study Plan, subjects from the courses included in the Graduate Degree in Aeronautical Engineering, or subjects in related sectors that are delivered by other graduate courses.
This is subject to confirmation by the CAD that the chosen subjects are pertinent to the student's study pathway.

The Personal Study Plan

Each student must submit a personal Study Plan (see the **Percorso formativo** [i.e. Study Plan] function of the Infostud service) **at the start of Year 1** (indicatively in December - January) on specific dates that are published from time to time in the "News" section of the website (www.ingaero.uniroma1.it) of the Aerospace Engineering CAD.
If the student wishes to make changes to their chosen orientation or their examinations, the Study Plan cannot be resubmitted until November of the following year. Only one Study Plan is permitted per academic year.

Rules for progressing, or for preparing to progress, to the next year

To proceed to Year 2 the student must have acquired at least 27 credits during Year 1. These must have been acquired before January 31 of the calendar year after the academic year in which they first enrolled.
Students re-enrolled to repeat Year 1 can apply to bring forward up to 2 examinations from Year 2 (provided the prerequisites is fullfilled), with a maximum CFU equal to those acquired. The CFU brought forward are not computed among the CFU required to proceed to the next year.
For details of how to do this, see the PRATICHE STUDENTI section of the CAD website.

Course programmes and texts of examinations

The Course programmes and texts of examinations can be consulted at the website of the Aerospace Engineering CAD (www.ingaero.uniroma1.it).

Tuition

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

Quality assessment

In collaboration with the University, the CAD gathers student feedback for all the courses as part of a quality assessment process. This is carried out by a self-assessment group consisting of tutors, students, and staff teaching the Course. The results of the feedback, and the analyses of the self-assessment group, are used to improve teaching quality.

Work and professional opportunities for graduates

Thanks to the in-depth skills offered by this course, which cover a very wide range of manufacturing and managerial activities, the career openings for the graduate Space and Astronautical Engineer include, for example, the following:
- in public and private research centres as R&D coordinators or team members
- in industry as designers or project managers
- in national and international space agencies working on the planning, implementation, and management of space missions

Our Graduates in Space and Astronautical Engineering are also qualified to work in related sectors that benefit from the high scientific and technological content that the Course offers.

PROSPECTUS FOR 2015/16

The four study curricula fall into two "Orientations" that share the same subjects in Year 1. 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 related problems of 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 knowledge at the systems level, ranging from the concept and design of a vector to implementing a launch campaign. Depending on which subjects the student chooses, their studies go into the detail of the various subsystems of a space transport vehicle.

CURRICULUM B – SATELLITES

This curriculum focusses 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 can avail themselves of a very large number of different workshops and 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 trains engineers specialised in mission analysis for Earth orbit and exploration of the solar system. It includes 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 satellite constellations and formations.

CURRICULUM D – SPACE REMOTE SENSING

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

YEAR 1 (academic year 2015/16)

CURRICULA A - LAUNCH VEHICLES, B - SATELLITES, C - MISSION

SUBJECT	L	SSD	CFU	Activity type	Sem.	Venue
Spacecraft control	IT	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 Mod.1-Analysis and design of space structures Mod.2-Composite structures	IT	 ING-IND/04 ING-IND/04	9 (6) (3)	B	2	SPV
Electronics	IT	ING-INF/01	6	C	2	SPV
Space missions and systems	IT	ING-IND/05	9	B	2	SPV
Rocket propulsion	IT	ING-IND/07	9	B	2	SPV

CURRICULUM D – SPACE REMOTE SENSING

SUBJECT	L	SSD	CFU	Activity type	Sem.	Venue
Spacecraft control	IT	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– Electronics Mod.2– Optical sensors	IT	 ING-INF/01 ING-INF/01	9 (6) (3)	C	2	SPV
Space missions and systems	IT	ING-IND/05	9	B	2	SPV
Electromagnetic fields and waves	IT	ING-INF/02	9	C	2	SPV

YEAR 2 (academic year 2016/17)

CURRICULUM 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	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	Sem.	Venue
Hypersonics	IT	ING-IND/06	6	2	SPV
Liquid rocket engines	EN	ING-IND/07	6	1	SPV
Launch systems flight mechanics	IT	ING-IND/03	6	1	SPV
Guidance systems and rocket propulsion	IT	ING-IND/05	6	2	SPV
Smart composite structures	EN	ING-IND/04	6	2	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
Satellite electrical systems	IT	ING-IND/33	6	2	SPV
Digital control systems	EN	ING-INF/04	6	1	ARI

CURRICULUM B - SATELLITES

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

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

CURRICULUM C – MISSION

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

SUBJECT	L	SSD	CFU	Sem.	Venue
Guidance systems and rocket propulsion	IT	ING-IND/05	6	2	SPV
Robotic space systems	IT	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
Guidance systems and rocket propulsion	IT	ING-IND/05	6	2	SPV
Robotic space systems	IT	ING-IND/05	6	1	SPV
Technologies of aerospace materials	IT	ING-IND/04	6	1	SPV
Interplanetary mission design	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 the space environment and protection systems	IT	MED/08	6	2	SPV
Space Systems electronics	IT	ING-INF/01	6	1	SPV

CURRICULUM D – SPACE REMOTE SENSING

SUBJECT	L	SSD	CFU	Activity type	Sem.	Venue
Geophysical and astrophysical fluid dynamics	IT	ING-IND/06	6	B	2	SPV
Space propulsion	IT	ING-IND/07	6	B	2	SPV
Observation and surveillance systems	IT	ING-IND/05	9	B	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
Telecommunication networks	IT	ING-INF/03	6	2	SPV
Satellite electrical systems	IT	ING-IND/33	6	2	SPV

OTHER SHARED ACTIVITIES

	Valut.	CFU	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
Multibody space structures	Space structures
Liquid rocket engines	Gasdynamics, Rocket propulsion