Academic Regulations for the Graduate Degree Course in

SPACE AND ASTRONAUTICAL ENGINEERING

Class LM 20 – Aerospace and Astronautical Engineering

Regulations for 2013/14

Specific teaching objectives

The Graduate Degree Course in Aerospace and Astronautical Engineering offers the student advanced disciplinary and professional training, along with specific engineering skills that enable 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 of the classic fields are investigated, such as satellite payload, vehicle, launch base, telemetry, tele-measurement, re-entry, and the landing site in relation to human crew, with particular emphasis on life support technologies and systems in space, where the requirements are reliability and safety, the compatibility of the engineering project for the mission with the physiological needs of the astronauts in ways that take account of their cognitive abilities and of their ability to react, and the limits of human performance in the space environment, included when psychologically stressed. The course also includes learning about the international rules that govern activity in space.

In terms of methodologies and applications, the two years of the Graduate Degree Course build on the solid foundation of previous knowledge acquired in the three-year Degree Course: Year 1 of the Graduate Degree Course 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, which were not addressed 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 the planning of space and interplanetary missions.

Admission requirements and recognition of credits

The Graduate Degree Course accepts applicants holding a first degree who have acquired the equivalent of 72 CFU (Italian) 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>Assessing the student's general educational standard</u>

Admission to the Graduate Degree Course is conditional on passing a written admission test to assess the applicant's general educational standard. However, this requirement does not apply to graduates who meet the condition

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

where "n" is the number of years that were required to complete the three-year Degree Course and "M" is the weighted average of all credits attained in that course, in all examinations.

The admission test is based on the applicant's general understanding of the fundamental required subjects. It takes place each academic year. The date is given 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 Degree Course can nevertheless apply to take the admission test for the Graduate Degree Course.

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

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 whatever ways are specified in such agreements, projects, and/or conventions.
Students are permitted to spend a period of study outside Italy as part of the Erasmus programme, if authorised in advance by the CAD.
If the applicant holds credits attained 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 credits, if these credits are in subject areas that correspond.
If the applicant is transferring from another university, a different faculty of Sapienza, or from another course, the CAD may, if it so decides, recognise any credits they already have. The value of these should normally not exceed the maximum credits that could be attained in the subject areas covered in the Prospectus. 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 attained whilst a student.
For more information on how to transfer CFU credits, obtain recognition for them, or have them taken into account, click on the "PRATICHE STUDENTI" link on the CAD website at (www.ingaero.uniroma1.it)

Attendance

Attendance is not obligatory.

The study pathway: description

Year 1 of the study pathway is shared by all the curricula and consists of 7 modules worth a total of 60 CFU credits. 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 telecommunications, automation, and electronics, which were not addressed in the three-year Degree Course: electronics, automation, and telecommunications.
Year 2 consists of four different thematic study pathways (Launch Vehicles, Satellites, Missions, and Earth Observation) organised within two curricula subdivided into groups. 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 Degree Course in Aerospace and Astronautical Engineering belongs to an Italian-French network that provides for reciprocal recognition with other selected universities and *Grandes Ecoles* in Paris, Grenoble, Toulouse, Nantes, and Nice.
This agreement between Sapienza and its partner institutions in France sets out the procedures and lists the first-level qualifications, licences (or alternatively the second level, *Maitrise*, and qualification awarded by the *Ecole*) that the student can acquire by studying at the partner institutions.

The final examination

The final examination consists of an experimental, design, or written thesis addressing the subjects taken in the Graduate Degree Course 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 field of study.
For development of the thesis the student must first analyse the technical literature on the subject and then propose solutions. They are expected to work on their own initiative in relation to the chosen format of the thesis, 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 prepare an experiment plan that will enable the desired outcomes to be achieved. If the thesis is of the design type, the student is required to determine the characteristics of a space mission, a space vehicle, a satellite, or a re-entry capsule (or part thereof), including the use of calculation codes, to demonstrate the benefits achieved over current solutions.
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 worth 23 CFU credits. At the time of securing approval for an internship proposal 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 university-based tutor will be responsible for asessing the outcome of the internship.

Methods of teaching and for verifying 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 by way of an examination (E) that may consist of oral and/or written tests devised by the tutor. Details of these will be provided together with the course programme.

Part-time study

Matriculants, or enrolled students who have other external commitments, can request to attend on a part-time basis, and therefore plan to attain fewer CFU credits per year than they would 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).

Subjects chosen by the student

The subjects worth 12 credits that are chosen by the student can be other subjects from this course that are 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 degree courses.
This is subject to confirmation, by the CAD, that the chosen subjects are relevant to the study pathway.

Study Plans

Each student must submit a personal Study Plan (see the **Percorso formativo** [i.e. Study Plan] function of the Infostud service), adding up to at least 96 CFU credits, **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 can be resubmitted in November of the following year. Only one Study Plan is permitted per academic year.

Rules for progressing to the next year, or preparing to do so

To proceed to Year 2 the student must have attained at least 27 credits during Year 1. These must have been attained before January 31 of the calendar year that follows the academic year in which they first enrolled.
Students who need to re-enrol to repeat Year 1 can also apply to bring forward up to 2 examinations from Year 2. For details of how to do this, see the PRATICHE STUDENTI section of the CAD website.

Course programmes and examination texts

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

Tutoring services

Faculty of Engineering support tutoring, for the students taking this course, is provided by Paolo Gaudenzi, Luciano Iess, Marcello Onofri, and Giovanni Palmerini in their particular disciplines.

Quality assessment

In collaboration with the University, the CAD gathers student feedback for all the courses. This is integrated with a quality assessment process that is carried out by a self-assessment group consisting of tutors, students, and course staff. The results of the feedback, and the analyses by 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 the following prospects:
- 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

Those who attain our Graduate Degree are also qualified to work in related sectors that benefit from the high scientific and technological content that it offers.

PROSPECTUS 2013/14

The four study pathways fall into two "Orientations" that share the same subjects in Year 1. Teaching takes place at either S. Pietro in Vincoli (SPV) or at no. 851 Via Salaria, near Roma-Urbe Airport (URB). All the Year 1 courses take place at SPV.

ORIENTATION A - LAUNCH VEHICLES, SATELLITES, AND MISSIONS

1. Study pathway: Launch vehicles (LAN)

This pathway includes the guidance, navigation, and control of launch vehicles, designing an orbital entry trajectory, and the structural and design aspects of solid and liquid-fuelled propulsion systems. 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 in the detail of the various subsystems of a space transport vehicle.
Before taking the LAN orientation it is advisable in Year 1 to have taken Principles of Automation.

All Year 2 courses in this orientation take place at San Pietro in Vincoli.

2. Study pathway: Satellites (SAT)

This pathway focusses on the general design of a satellite, specifically on energy balance and thermal balance, structural and technological problems, electrical, electronic and telecommunications subsystems, and satellite control and trim systems.
The student can avail themselves of a very large number of different workshops and will benefit from the experience gained over many years by the Rome school in designing, constructing, and launching small platforms and operating them in orbit.
Before taking the SAT orientation it is advisable in Year 1 to have taken Principles of Automation.

In this orientation the first semester of Year 2 takes place at Roma-Urbe (except for Telecommunications and Remote Sensing) and the second semester takes place at San Pietro in Vincoli.

3. Study pathway: Missions (MIS)

This pathway prepares engineers who specialise in mission analysis for Earth orbit and space exploration. 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.
Before taking the MIS orientation it is advisable in Year 1 to have taken Principles of Automation.

In this orientation the first semester of Year 2 takes place at Roma-Urbe and the second semester takes place at San Pietro in Vincoli.

ORIENTATION B - EARTH OBSERVATION

4. Study pathway: Earth Observation (OST)

This pathway 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.
Before taking the OST orientation it is advisable in Year 1 to have taken Telecommunications, Remote Sensing, and Satellite Telecommunications Systems.

For the first semester and the second semester the courses In this orientation take place on alternate days at Roma-Urbe and San Pietro in Vincoli.

YEAR 1 (2013/14 academic year)

SUBJECTS SHARED BY BOTH ORIENTATIONS

Subject	L	SSD	CFU credits	Activity type	Sem.	Venue
Gasdynamics	IT	ING-IND/06	9	B	1	SPV
Space Flight Mechanics	IT	ING-IND/03	9	B	1	SPV
Optional group (9 CFU credits)						
Automatic Control	IT	ING-INF/04	9	C	1	SPV
System Identification and Optimal Control(1)	EN	ING-INF/04	9	C	2	SPV[3]
Telecommunications, Remote Sensing, and Satellite Telecommunications Systems Mod. 1: Fundamentals of Telecommunications and Remote Sensing Mod. 2: Satellite Telecommunications Systems	IT	 ING-INF/03 ING-INF/03	9 (6) (3)	C	1	SPV
Optional group (6 CFU credits)						
Electronics	IT	ING-INF/01	6	C	2	SPV
Satellite Electronics(2)	IT	ING-INF/01	6	C	2	SPV
Space Structures and Systems	IT	ING-IND/04	9	B	2	SPV
Space Missions and Systems	IT	ING-IND/05	9	B	2	SPV
Rocket Propulsion	IT	ING-IND/07	9	B	2	SPV

Note:
(1) This subject is **obligatory for students** coming from the INSA Orientation of the 3-year course. **No other students** can include this subject in Year 1 of their Study Plan.
(2) This subject is **obligatory for students** a) coming from the INSA Orientation of the 3-year course, b) coming from the SAIN Orientation who had enrolled for the 3-year course during the 2009/10 academic year (as was required by the Academic Regulations for that academic year) and who have passed the examination in **Electronics**. **No other students** can include this subject in Year 1 of their Study Plan.
(3) This course takes place at the Department of Computerised and Automated Management Engineering at 25 Via Ariosto.

YEAR 2 (2014/15 academic year)

ORIENTATION A - LAUNCH VEHICLES, SATELLITES, AND MISSIONS

Pathway 1 LAUNCH VEHICLES

18 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	1	SPV
Flight Mechanics of Launcher	IT	ING-IND/03	6	1	SPV
Solid Propulsion Modelling	IT	ING-IND/06	6	2	SPV
Liquid Propellant Engines	EN	ING-IND/07	6	1	SPV
Turbopump Systems for Liquid Roket Engines	IT	ING-IND/07	6	2	SPV
Navigation Systems	IT	ING-IND/05	6	1	SPV

Smart Structures and Thermoelasticity	EN	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
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV
Spacecraft Control	EN	ING-INF/04	6	1	SPV

Pathway 2 SATELLITES

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

SUBJECT	L	SSD	CFU credits	Sem.	Venue
Space Environment and instrumentation	EN	ING-IND/05	6	2	SPV
Space Vehicles Thermal Control Systems	IT	ING-IND/05	6	1	URB
Multibody Space Structures	EN	ING-IND/04	6	2	SPV
Space Propulsion	IT	ING-IND/07	6	2	SPV
Space Vehicle Design	EN	ING-IND/05	6	1	URB
Technology of Aerospace Materials	EN	ING-IND/04	6	1	URB

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
Space Systems Electronics	IT	ING-INF/01	6	1	URB
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV
Telecommunication and Remote Sensing	IT	ING-INF/03	6	1	SPV

Pathway 3 MISSIONS

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

SUBJECT	L	SSD	CFU credits	Sem.	Venue
Space Environment and Instrumentation	IT	ING-IND/05	6	2	SPV
Space Propulsion	IT	ING-IND/07	6	2	SPV
Space Guidance Systems	IT	ING-IND/05	6	1	URB
Robotic Space Systems	IT	ING-IND/05	6	1	URB
Interplanetary Trajectories	IT	ING-IND/03	6	1	URB

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
Biological Effects of the Space Environment, and Protection Systems	IT	MED/08	6	1	URB
Space Systems Electronics	IT	ING-INF/01	6	1	URB
Artificial intelligence I	EN	ING-INF/05	6	1	SPV[3]

ORIENTATION B - EARTH OBSERVATION

Pathway 4 EARTH OBSERVATION

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
Space Vehicles Thermal Control Systems	IT	ING-IND/05	6	1	URB
Laboratory of Images Acquisition and Processing	IT	ING IND/05	6	2	URB
Observation and Surveillance Systems	IT	ING-IND/05	6	2	URB
Spacecraft Vehicle Design	EN	ING-IND/05	6	1	URB
Space Structure Technologies	IT	ING-IND/04	6	2	URB

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

SUBJECT	L	SSD	CFU credits	Sem.	Venue
Satellite Electrical Systems	IT	ING-IND/33	6	2	SPV
Space Systems Electronics	IT	ING-INF/01	6	1	URB
Radar Image Processing	IT	ING-INF/03	6	1	SPV
Satellite Navigation and Radiolocation	IT	ING-INF/03	6	2	SPV
Telecommunications Networks	IT	ING-INF/03	6	1	SPV
Spacecraft Control	EN	ING-INF/04	6	1	SPV
Microwave Remote Sensing	IT	ING-INF/02	6	2	SPV

OTHER SHARED ACTIVITIES

	Assessment	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

If only non-Italian students sign up for "Instrumentation in the Space Environment", it will be delivered entirely in English. If only non-Italian students sign up, it will nevertheless be partly delivered in English.

Preparatory subjects

Before taking these examinations...	...the student must first pass:
Spacecraft Control	Automatic Control
Radar Image Processing	Telecommunications, Remote Sensing, and Satellite Telecommunications Systems
Hypersonics	Gasdynamics
Solid Propulsion Modelling	Gasdynamics, Roket Propulsion
Liquid Propellant Engines	Gadynamics, Roket Propulsion
Satellite Navigation and Radiolocation	Telecommunications, Remote Sensing, and Satellite Telecommunications Systems

Telecommunications Networks	Telecommunications, Remote Sensing, and Satellite Telecommunications Systems
Turbopump Systems for Liquid Roket Engines	Gasdynamics, Roket Propulsion
Multibody Space Structures	Space Structures