

**COURSE OF STUDY** *Physics (LM-17)*
**ACADEMIC YEAR** 2024-2025

**ACADEMIC SUBJECT** *Physics of space electric propulsion*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2024
Credits (CFU/ECTS):	3
SSD	FIS/03
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
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Department and address	CNR-ISTP, Bari CNR research area, via Amendola 122/D, room 410, Bari
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Friday, 10:00-12:00 (on request in person or online)

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
75	24		51
CFU/ECTS			
3	3		

<b>Learning Objectives</b>	Specialized preparation in the electric propulsion concepts and systems, with particular emphasis on the mechanisms of ion production and acceleration Thermodynamics, kinetic gas theory, electromagnetism, atomic and molecular physics, computational physics
<b>Course prerequisites</b>	

<b>Teaching strategie</b>	Class lectures using blackboard and slide presentation
<b>Expected learning outcomes in terms of</b>	
<b>Knowledge and understanding on:</b>	<ul style="list-style-type: none"> <li>o Plasma collective and individual particle behaviours</li> <li>o Kinetic description of plasma out-of-equilibrium</li> <li>o Electromagnetic field configuration for gas ionization and ion acceleration</li> <li>o Computational kinetic and fluid-dynamic approaches for plasma simulation</li> </ul>
<b>Applying knowledge and understanding on:</b>	<ul style="list-style-type: none"> <li>o Gas discharges configurations</li> <li>o Space plasma propulsion for satellite station keeping and deep space missions</li> </ul>
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• <i>Making informed judgments and choices</i> <ul style="list-style-type: none"> <li>o knowledge acquisition, critical understanding and capability of using in a creative and constructive way the information from the course lectures</li> </ul> </li> </ul>

	<p>to develop analytical and numerical models of plasma thruster discharges up to propose original solutions</p> <ul style="list-style-type: none"> <li>● <i>Communicating knowledge and understanding</i> <ul style="list-style-type: none"> <li>○ ability to illustrate the reading matter thoughtfully, clearly, synthetically, effectively and with propriety of expression</li> </ul> </li> <li>● <i>Capacities to continue learning</i> <ul style="list-style-type: none"> <li>○ ability to approach the specialistic literature and develop a critical spirit</li> <li>○ ability to work in a group, and to be inserted quickly and effectively in the workplace.</li> </ul> </li> </ul>
<b>Syllabus</b>	
<b>Content knowledge</b>	<p>1. History and fundamentals of space electric propulsion: rocket equation, power supply penalty, mission analysis.</p> <p>2. Basics of plasma physics:</p> <p>2.a Kinetic and fluid descriptions</p> <p>2.b Individual character of plasma: Collisions in plasmas, Single-particle motion</p> <p>2.c Collective character of plasma: Ideal plasma, Debye length and Langmuir frequency, Transport in plasma (diffusion and mobility), Plasma-wall transition and interaction, Plasma waves.</p> <p>3. Electric propulsion: Electrothermal propulsion (resistojet and arcjet), Electrostatic propulsion (FEEP and Ion thruster), Hall thruster, Electromagnetic propulsion (pulsed plasma, MPD and magnetic nozzle thrusters)</p> <p>4. Numerical models for plasma propulsion with laboratory experience (programming with python)</p>
<b>Texts and readings</b>	<p>- R.G. Jahn, Physics of Electric Propulsion, Dover, 2006.</p> <p>- D.M. Goebels, I. Katz, Fundamentals of Electric Propulsion: Ion and Hall Thrusters, Wiley, 2008.</p> <p>- M. Andrenucci, Electric Propulsion: Concepts and Implementations, AP, 2022.</p>
<b>Notes, additional materials</b>	- Slides and lecture notes provided by teacher
<b>Repository</b>	

<b>Assessment</b>	
<b>Assessment methods</b>	<p>Interview where the student will typically be required to:</p> <ul style="list-style-type: none"> <li>- answer questions on one or more topics of the course;</li> <li>- develop in writing the solution to an original problem addressable by using the information from the course lectures in a creative and constructive way.</li> </ul> <p>Both aspects will be weighted equally (50%).</p>
<b>Assessment criteria</b>	<ul style="list-style-type: none"> <li>● <i>Knowledge and understanding</i> <ul style="list-style-type: none"> <li>○ illustrate the derivation from first principles of his/her solution to the given problem(s) by the introduction of the relevant simplifications and/or approximation;</li> <li>○ justify the introduction of the simplifications and/or approximations used in the derivation;</li> <li>○ assess and discuss the expected level of accuracy and limits of application of the proposed solution.</li> </ul> </li> <li>● <i>Applying knowledge and understanding</i> <ul style="list-style-type: none"> <li>○ Use the acquired knowledge to solve problems of plasma acceleration</li> </ul> </li> <li>● <i>Autonomy of judgment</i> <ul style="list-style-type: none"> <li>○ Developing physical and mathematical tools to properly model physical problems relative to plasma discharges</li> </ul> </li> <li>● <i>Communicating knowledge and understanding</i> <ul style="list-style-type: none"> <li>○ express in a proper way physical and mathematical concepts characterizing plasma space propulsion</li> </ul> </li> <li>● <i>Communication skills</i> <ul style="list-style-type: none"> <li>○ Acquire an appropriate rigorous language to communicate plasma science</li> </ul> </li> <li>● <i>Capacities to continue learning</i> <ul style="list-style-type: none"> <li>○ Develop mathematical and physical tool to model electric thrusters</li> </ul> </li> </ul>



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Final exam and grading criteria	Clarity in the oral exposition of the physical concepts
<b>Further information</b>	