National PhD in Space Science and Technology – 39th cycle

Attachment n.1

COURSES OFFERED

Curriculum 1:

Observation of the Universe

Coordinator: Prof. Carlo Baccigalupi (carlo.baccigalupi@sissa.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd +3rd years (minimum 72 hours total = 9 CFU)					
SISSA	M. Spera	Binary Stars: birth, life and death	3	24	2024/02/26 – 2024/03/19
UNIFI	A. Tiberio	Calorimetric techniques for high energy particles detection	1,5	12	2024/02/01 – 2024/03/31

SISSA	C. Baccigalupi	Cosmic Microwave Background Polarization	1	8	2024/04/08 – 2024/04/30
UNIFE	P. Natoli	Cosmic Microwave Background Statistics and Data Analysis (Theory)	1	8	
SISSA	M. Viel	Cosmological structure formation	3	24	February-March 2024
UNIPA	G. Marsella	Experimental Techniques in Astroparticle Physics	2	16	2024/03/01 – 2024/06/01
UNIFI	S. Salvadori A. Skuladottir	Stellar Archaeology: studying the first stars and galaxies	2	16	January – April 2024
UNITO	M. Crosta	Gravitational metrology for astrophysics and cosmology	4	32	1st semester
SISSA	E. Barausse	Gravitational Waves	3	24	2024/01/10 - 2024/02/01
GSSI	I. De Mitri	High Energy Astroparticle Physics: experiments	4	30	2023/11/06 – 2024/01/31
GSSI	P. Lipari	High Energy Neutrino Astronomy	3	24	2nd semester
GSSI	A. Di Giovanni F. Barbato	High Energy Radiation Measurements (LAB course)	2	24	2024/04/03 – 2024/04/07
SISSA	P. Creminelli	Inflation & Dark Energy	2	16	March-May
UNIFE INAF-BO	A. Gruppuso	Introduction to Theoretical Cosmology and elements of Cosmic Microwave Background Data Analysis (Theory)	2	15	May/June

SISSA	C. Baccigalupi	Linear Cosmological Perturbation Theory	3	24	2024/01/08 – 2024/02/19
UNITN	L. Zaccarian	Nonlinear hybrid dynamical systems	2	16	2025/09/01 – 2025/09/30
UNIFI	M. Romoli	Observations of the sun from space	2	16	2024/05/01 – 2024/06/16
IUSS	A. Tiengo	Observing Space from Space	2	16	2024/02/27 – 2024/03/21
UNIFE	M. Lattanzi	Particle Cosmology	1	9	2024/01/15 – 2024/02/15
GSSI	E. Amato	Plasma physics around astrophysical compact objects	1,5	12	2024/04/15 – 2024/05/31
SISSA	F. Perrotta	Radiative Processes in Astrophysics	2	16	October-November 2024
INAF-BO - SISSA	M. Massardi	Radio Astronomy	1	8	April-May
FBK	G. Paternoster G. Pepponi M. Centis Vignali	Silicon Radiation Sensors (Part 2)	2	16	March-April 2024
UNIFI	S. Landi A. Verdini	Space and Astrophysical plasmas	2	16	May-June 2024
UNITS	M. Messerotti	Space Weather and Space Climate	3	24	2024/09/01 – 2024/09/30

UNIFE	L. Pagano	Statistical Techniques in Cosmology	1	8	2nd semester
IUSS	A. Tiengo	The Many Faces of Neutron Stars	1,5	12	2024/04/16 – 2024/05/09
GSSI	R. Aloisio	Theory and phenomenology of Ultra High Energy Cosmic Rays	2	16	2024/05/01 – 2024/05/31
GSSI	M. Spurio N. Mazziotta	Very High Energy Gamma and Neutrino Astronomy Experiments	1	8	2024/02/26 – 2024/06/21

Example of international schools providing CFU recognition:

Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 2:

Earth and the Sun-Earth system

Coordinator: Prof. Vincenzo Carbone (vincenzo.carbone@fis.unical.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd +3rd years (minimum 72 hours = 9 CFU total)					
INGV	G. Puglisi et al.	Analysis and modelling of geophysical and volcanological data	2	16	2025/04/01 – 2025/07/31
INGV	A. Bonforte S. Scollo M. Sciotto C. Cesaroni	Detection, analysis and modelling of volcanic induced perturbations on the atmosphere	1	8	2024/05/05 – 2024/06/13
INGV	A. Bonforte S. Scollo	Effects of volcanic activity on the atmosphere	1	8	2024/01/15 - 2024/03/14

	M. Sciotto				
INGV	G. Puglisi (Coordinator)	Elements of volcanology	2	16	2024/02/01 – 2024/04/30
INGV	C. Cesaroni	Ionospheric monitoring and modelling	1	8	2023/09/01 – 2023/10/31
UNIFI	R. Avanzinelli M. Casalini	Measurements of isotope ratios through TIMS and MC-ICPMS and applications to Geosciences	0.5	4	2023/12/18 – 2023/12/19
UNITN	R. Iuppa G.A. Prodi M. Cristoforetti	Methods of data analysis: from statistical inference to deep learning	2	18	April-June
UNIFI	M. Romoli	Observations of the sun from space	2	16	2024/05/01 – 2024/06/16
UNITN	L. Bruzzone	Radar and multispectral sensors in Earth observations and planetary exploration	2	16	June – July 2024
INGV	F. Buongiorno (Coordinator)	Remote sensing of geophysical processes	1	8	April May (1st year)
UNIFI	S. Landi A. Verdini	Space and Astrophysical plasmas	2	16	May-June 2024
UNICAL	F. Lepreti F. Valentini	Space plasma physics	2	16	2024/06/10 – 2024/07/05

UNITOV	D. Del Moro	Space science	2	16	2023/10/02 – 2023/12/22
UNITS	M. Messerotti	Space Weather and Space Climate	3	24	2024/09/01 – 2024/09/30
UNITOV	F. Berrilli	Sun and Space weather	1	8	2024/11/04 – 2024/11/20
UNICAL	V. Carbone	Turbulence and nonlinear dynamics	2	16	2023/11/06 – 2023/11/30
INAF-IAPS	C. Carli	VIS-NIR-MIR reflectance spectroscopy of planetary materials	0.5	4	2024/10/01 – 2024/10/31

Example of international schools providing CFU accreditation:

Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 3:
Planetary Sciences

Coordinator: Prof. Giovanni Pratesi (g.pratesi@unifi.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd + 3rd years (minimum 72 hours = 9 CFU total)					
INGV	G. Puglisi et al.	Analysis and modelling of geophysical and volcanological data	2	16	2025/04/01 – 2025/07/31
UNITO	S. Terracini A. Cellina T. Romano	Analytical methods for the space	2	16	November-December 2023
SISSA	L. Silva	Astrobiology	1	8	2024/05/06 – 2024/05/31
UNITN	D. Ascenzi	Astrochemistry	1	8	January-April 2025

INGV	G. Puglisi (Coordinator)	Elements of volcanology	2	16	2024/02/01 – 2024/04/30
UNIPD	G. Piotto	Exoplanetary Astrophysics	2	16	February-March
INAF-UNIPD	G. Cremonese F. Marzari	Exploring the solar system and its environment	2	16	2023/04/15 – 2024/05/24
UNIFI	R. Avanzinelli M. Casalini	Measurements of isotope ratios through TIMS and MC-ICPMS and applications to Geosciences	0.5	4	2023/12/18 – 2023/12/19
UNIFI	G. Pratesi	Mineralogy and petrology of meteorites	1	8	1st semester
UNIFI	G. Pratesi	Optical microscopy analysis of meteoritic material	0,5	4	2nd semester
INAF-OAA	J. Brucato	Principles of Astrobiology	1	8	2024/03/04-2024/03/24
UNITN	L. Bruzzone	Radar and multispectral sensors in Earth observations and planetary exploration	2	16	June – July 2024
UNITO	M.L. Ruggiero D. Gandolfi S. Fineschi	Relativistic mechanics and astrophysics for space sciences	2	16	November – December 2023
UNICAM	G. Giuli	Synthesis and characterization of planetary materials	0.5	4	2024/03/20 – 2024/03/30
INAF-IAPS	C. Carli	VIS-NIR-MIR reflectance spectroscopy of planetary materials	0.5	4	2024/10/01 – 2024/10/31

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Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 4:

Astrobiology, Life Sciences and Space Medicine

Coordinator: Prof. Myrka Zago (myrka.zago@uniroma2.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd + 3rd years (minimum 72 hours total = 9 CFU)					
SISSA	L. Silva	Astrobiology	1	8	2024/05/06 – 2024/05/31
UNITN	D. Ascenzi	Astrochemistry	1	8	January-April 2025
SISSA	F. Perrotta	Astrochemistry and Astrobiology	1	8	2025/03/01 – 2025/05/30
UNIPI	E. Santarcangelo	Cognitive pain control in space	½	4	2024/02/15 – 2024/02/29
UNIMI	A. M. Rizzo	Facilities for space life sciences	1	8	2024/01/29 – 2024/02/29

UNIPD	M. Narici et al.	Human physiological and behavioral alterations in space condition (12 lectures by various specialists).	1,5	12	June or Oct 2024
UNITN-CIMEC	M. Zampini	Multisensory perception in Microgravity	½	4	February-April 2024
UNITN-CIMEC	L. Cattaneo	Physiological Adaptations to Microgravity and High Altitude	1	8	2024/03/01 - 2024/05/31
UNIPI	D. Manzoni E. Santarcangelo	Space Cognitive Processes	½	4	2024/02/19 – 2024/03/04
UNIPI	F. Pratesi L. Caponi	Space Immunology	1	8	2024/02/02 – 2024/05/31
UNIPI	S. Esin A. Salvetti	Space Microbiology and Intestinal Barrier	½	4	2024/02/23 – 2024/03/06
UNITO	R. Ricci	Space Neuropsychology	1	8	May-June 2024
UNITO	F. Di Cunto	Space Neurobiology	½	4	2024/04/01 – 2024/06/30
UNITOV	M. Zago	Space Physiology	1	8	March-July 2024
UNIMI	P. Magni	Use of Nutraceutical products for human health: evidence and critical issues	1	8	2025/05/05 – 21025/05/06

Example of international schools providing CFU accreditation:

Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 5:

Space sensing and instrumentation

Coordinator: Prof. Fabio Gargano (fabio.gargano@ba.infn.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd +3rd years (minimum 72 hours = 9 CFU total)					
UNITN	G. Baldi et al.	Advanced Techniques in Experimental Physics	3	24	2024/02/29 – 2024/05/31
UNITO	M.E. Bertaina R. Bonino L. Latronico	Detectors and Space Equipment	4	32	2023/11/20 – 2023/12/12
UNIBS	M. Lancini	Development of measurement systems	2	12	April-June
UNICA	G. Mura	Diagnostics of electron devices	2	16	2024/10/01 – 2024/12/20

GSSI/INFN	A. Di Giovanni F. Barbato	Front-end and readout electronic systems for High Energy Astroparticle Physics	2	16	2024/03/11 – 2024/03/22
UNIPA	G. Marsella	Experimental Techniques in Astroparticle Physics	2	16	2024/03/01 – 2024/06/01
GSSI	I. De Mitri	High Energy Astroparticle Physics: experiments	4	30	2023/11/06 – 2024/01/31
UNIPI	L. Baldini	High-energy particle and photon detectors in space (Instrumentation)	1	8	
GSSI	A. Di Giovanni F. Barbato	High Energy Radiation Measurements (LAB course)	2	24	2024/04/03 – 2024/04/07
UNITN	L. Pancheri	Image Sensors	2	18	2024/01/22-2024/03/29
SSSA	C. Oton	Laboratory of Optical Fiber Sensing (only in presence)	2	16	2023/11/15 – 2024/02/15
UNIBA	F. Giordano	Laboratory of Space technologies	2	16	
UNIPD	G. Rossi M. Pertile	Measurement techniques fundamentals, PC based, visual and thermal image analysis based	2	16	May
UniTN	D. Bortoluzzi	Mechanical vibrations in Spacecraft design	1,5	12	2023/02/13 -2023/02/23
SSSA	F. Di Pasquale C. Oton	Optical Fiber Sensor Systems	2	16	2nd semester

SSSA	C. Oton	Photonic Integrated Circuits	2	16	2024/04/01 – 2024/06/30
CNR	E.A. Slejko	Polymers and Composites	1	8	2024/03/01-2024/05/31
UNITN	S. Gialanella A. Pegoretti	Properties and selection criteria for materials used in aerospace applications	2	16	2nd semester
UNITN	L. Bruzzone	Radar and multispectral sensors in Earth observations and planetary exploration	2	16	June – July 2024
POLIBA – INFN BA	E. Bissaldi	Scintillators and Silicon Photomultipliers	2	16	2024/05/03 – 2024/06/28
UNITN	G.F. Dalla Betta	Silicon radiation detectors	2	18	2024/01/16-2024/02/15
FBK	G. Paternoster G. Pepponi M. Centis Vignali	Silicon Radiation Sensors (Part 2)	2	16	March-April 2024
UNIPD	M.G. Pelizzo	Optics	3	24	2024/02/01 – 2024/02/29
UNIMI	P. Magni	Use of Nutraceutical products for human health: evidence and critical issues	1	8	2025/05/05 – 21025/05/06

Example of international schools providing CFU accreditation:

Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 6:

Engineering and satellite platform technologies

Coordinator: Prof. Giuseppe Mazzarella (mazzarella@unica.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd +3rd years (minimum 72 hours = 9 CFU total)					
UNITO	M. Bertaina R. Bonino L. Latronico	Detectors and space equipment	4	32	2023/11/20 – 2023/12/12
UNICA	G. Mura	Diagnostics of electron devices	2	16	2024/10/01 – 2024/12/20
SSSA	F. Di Pasquale	Elements of Photonics: from Maxwell to optical fibers	2	16	1st Semester
UNITN	L. Pancheri	Image Sensors	2	18	2024/01/01- 2024/04/30
SSSA	C. Oton	Laboratory of Optical Fiber Sensing (only in presence)	2	16	2023/11/15 – 2024/02/15

UNITN	D. Bortoluzzi	Mechanical vibrations in Spacecraft design	1,5	12	2023/01/08 - 2023/03/31
UNITN	L. Zaccarian	Nonlinear hybrid dynamical systems	2	16	2025/09/01 – 2025/09/30
IUSS	A. Tiengo	Observing Space from Space	2	16	2024/02/27 – 2024/03/21
SSSA	F. di Pasquale C. Oton	Optical Fiber Sensor Systems	2	16	2nd semester
SSSA	C. Oton	Photonic Integrated Circuits	2	16	2024/04/01 – 2024/06/30
CNR	E.A. Slejko	Polymers and Composites	1	8	2024/03/01- 2024/05/31
UNITN	S. Gialanella A. Pegoretti	Properties and selection criteria of materials for aerospace applications	2	16	2nd semester
UNITN	L. Bruzzone	Radar and multispectral sensors in Earth observations and planetary exploration	2	16	June – July 2024
UNITS	S. Seriani	Robotics	2	16	2024/11/04- 2024/11/11
UNITN	L. Zaccarian	Saturated control systems	2	18	2024/04/15- 2024/04/19
UNITN	G.F. Dalla Betta	Silicon radiation detectors	2	18	2024/01/16- 2024/02/15
FBK	G. Paternoster	Silicon Radiation Sensors (Part 2)many faces	2	16	March-April 2024

	G. Pepponi M. Centis Vignali				

Example of international schools providing CFU accreditation:

Updated info available at https://www.unitn.it/phd-sst/749/summer-winter-schools

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

Curriculum 7:

Economics, law and space diplomacy

Coordinator: Prof. David Burigana (david.burigana@unipd.it)

GROUP 1 - MULTI-DISCIPLINARY COURSES

PHD STUDENTS CHOOSE COURSES FOR 32 HOURS = 4 CFU MINIMUM OVER TWO YEARS

SEE COMMON GROUP 1 TABLE

GROUP 2- DISCIPLINARY COURSES

PHD STUDENTS CHOOSE THESE COURSES FOR 72 HOURS = 9 CFU MINIMUM OVER THREE YEARS

Location	**Center / Teacher**	**WEB PAGE / TYPE OF COURSE**	**CFU***	**#Hours**	**Dates**
1st + 2nd +3rd years (minimum 72 hours = 9 CFU total)					
UNIBA	D. Capolongo F. Giordano	Applications for Space activities, and for a more Sustainable space: digital agriculture and green emerging technologies	½	4	2025-26 Second Semester (April 2026)

UNIBA	D. Capolongo	Blockchain applications in Space activities	½	4	2022-23 Second Semester (May 2023)
SSSA	M. Gagliardi	Data Protection and Data Governance in Space activities	½	4	2025/04/02 – 2025/04/30
UNIPD	E. Calandri	European Integration in the last 30 years and EU RelExt	½	4	2023-24 First Semester (November 2023)
SSSA	M. Gagliardi	Introduction to Space and the Law: Space Risks and Insurance Law	½	4	2026/05/04 – 2026/05/29
SSSA	M. Gagliardi	Introduction to Space and the Law 2: specific applications of SST and technology regulation. An example from Earth Observation and agriculture: mapping the regulatory framework	½	4	2023/12/04 – 2024/01/26
UNIPD	D. Burigana	Interdisciplinary approach to the International History of Space Exploration	½	4	2025-26 Second Semester (April 2026)
UNIPD	J. Krige, (Caltech University)	Knowledge Flows in Space	½	4	2024/02/22 – 2024/02/29
SSSA	M. Gagliardi	Legal Issues in AI applications in Space activities	½	4	2025/05/05 – 2025/05/30
SSSA	M. Gagliardi	Legal Issues in Blockchain applications in Space activities	½	4	2024/05/27 – 2024/07/12
SSSA	M. Gagliardi	Legal issues in data processing, in risk management, in liability models 2 (advanced)	1	8	2024/04/15 – 2024/06/28

UNIPD	D. Burigana	Oral History, Video Interviews on Space Diplomacy in cooperation with the Historical Archives of European Union (Firenze)	½	4	2025-26 Second Semester (June 2026)
UNIPD	D. Burigana	Research and learning laboratory on ESA historical Archives (1960s-2005) and on EU Space, Science and Technology with the Historical Archives of European Union (Firenze)	½	4	2025-26 Second Semester (May 2026)
UNIPD	P.-B. Ruffini (Université de Le Havre)	Science Diplomacy: Definition and practice	½	4	2023/12/06
UNIPD	D. Burigana	Space Diplomacy: a long period analysis on Actors, Dynamics and International Arenas	½	4	2025-26 Second Semester (April 2026)
UNIPD	D. Burigana	Space Economy 1	2	16	2023-24 Second Semester (April May and June 2024)
UNIPD	D. Burigana	Space Economy 2	1	8	2024-25 First Semester (October 2024)
UNIBA	N. Carnimeo	Space law regulation at international and domestic level	1	8	2026/04/01 – 2026/05/01
SSSA	M. Gagliardi	SST: Rights on goods and resources	½	4	2025/06/03 – 2025/06/30
UNIMI	M. Elli	Science, Technology and Foreign Policy: an historical reappraisal	½	4	2023/11/27 – 2023/11/29

UNIPD	E. Calandri	The evolution of the international context in the last 40 years: the of the Cold War and the birth of European Union in a "new" Globalization	½	4	2025-26 Second Semester (April/May 2026)
UNIPD	D. Zannoni	The protection of the Space environment, and Laboratory on National Space Laws	½	4	2023-24 Second Semester (May 2024)

Example of international schools providing CFU accreditation:

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GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

SEE COMMON GROUP 3 TABLE

COMMON TABLES

GROUP 1 - MULTI-DISCIPLINARY COURSES

PhD students should choose Courses for minimum 32 hours = 4 CFU over two years

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
1st + 2nd years (minimum 32 hours = 4 CFU total)					
UNITN	G. Baldi et al.	Advanced Techniques In Experimental Physics	3	24	2024/02/01 – 2024/06/30
UNITO	S. Terracini A. Cellina T. Romano	Analytical methods for space	4	32	November/December
UNIFE	A. Drago	Artificial intelligence, Montecarlo techniques and neural networks	1	10	
SISSA	L. Danese	Cosmology	4	32	2024/10/01 – 2024/12/20
UNITO	M. Taoso	Dark Matter and the Physics of the Primordial Universe	2,5	20	2nd semester
UNITO	F. Fenu S. Maldera	Data analysis	3	24	2023/12/14 – 2024/02/29
UNITN	P. Bosetti	Design of Experiments and Statistical Analysis of Experimental Data	4	32	2024/03/11-2024/03/26

UNITO	M. Bertaina R. Bonino L. Latronico	Detectors and space equipment	4	32	2023/11/20 – 2023/12/12
UNIBS	M. Lancini	Development of measurement systems	2	12	April-June
SSSA	F. Di Pasquale	Elements of Photonics: from Maxwell to optical fibers	2	16	1st Semester
GSSI/INFN	A. Di Giovanni F. Barbato	Front-end and readout electronic systems for High Energy Astroparticle Physics	2	16	2024/03/11 – 2024/03/22
GSSI	I. De Mitri	High Energy Astroparticle Physics: experiments	4	30	2023/11/06 – 2024/01/31
GSSI	C. Evoli	High energy Astroparticle Physics: Theory	4	32	2024/01/08 – 2024/02/02
SISSA	A. Celotti	High Energy Astrophysics	1	8	November/December
UNIPI	L. Baldini	High-energy particle and photon detectors in space	1	8	
UNIPI	L. Baldini	High-energy particle and photon detectors in space (Instrumentation)	1	8	
GSSI	A. Di Giovanni F. Barbato	High Energy Radiation Measurements (LAB course)	2	24	2024/04/03 – 2024/04/07
SISSA	A. Lanza	Introduction to General Relativity	2	14	October/November
SISSA	N. Krachmalnicoff	Introduction to Neural Networks: Theory & Practice	1	8	
UNITS	A. Gregorio	Introduction to Satellite Systems	3	24	2024/10/01-2024/12/19

UNIVAQ	P. Francia G. D'Angelo	Introduction to the physics of circumterrestrial space	2	16	2024/05/06 – 2024/06/21
IUSS	A. Taramelli E. Schiavon	Introduction to space economy and law	1,5	12	June 2024
SISSA	N. Krachmalnicoff	Introduction to Statistical Modeling & Inference	3	24	2023/10/01 – 2023/11/0
UNITO	R. Sirovich	Machine learning	4	32	2023/11/20 – 2023/12/22
UNIFI	E. Pace	Management and Engineering of Space Missions	2	16	2024/03/22 – 2024/04/26
UNIPD	G. Rossi M. Pertile	Measurement techniques fundamentals, PC based, visual and thermal image analysis based	2	16	May
UNITN/FBK	R. Iuppa G. A. Prodi M. Cristoforetti	Methods of data analysis: from statistical inference to deep learning	2	18	April-June
UNITO	L. Derosa R. Ricci	Mission Design	3	24	2023/11/27 – 2023/12/19
IUSS	A. Taramelli	New Space Economy in Earth Observations	1	10	March-April
UNIPD	M.G. Pelizzo	Optics	3	24	2024/02/01 – 2024/02/29
UNIFE	M. Lattanzi	Particle Cosmology	1	9	2024/01/15 – 2024/02/15

UNICH	L. Marinangeli	Planetary geology	0.5	4	2024/01/15 – 2024/01/29
UNIBS	S. Federici	Posters and Oral Presentations	1	8	2024/03/01 – 2024/03/15
UNIFI / INAF	F. Belfiore P. Tozzi	Scientific Writing for Physical Sciences	2	16	2024/04/15 – 2024/04/24
INAF-IAPS	F. Capaccioni	Solar system exploration: small bodies, satellites, and planets	0.5	4	2024/05/13 – 2024/05/14
UNIPD	D. Burigana L. Coppolaro	Space Economy 1	2	16	2023-24 2nd Semester
UNIPD	D. Burigana L. Coppolaro	Space Economy 2	1	8	2024-25 First Semester (October 2024)
UNIFE	L. Pagano	Statistical Techniques in Cosmology	1	8	2nd semester
UNICAL	V. Carbone	Turbulence and nonlinear dynamics	2	16	2023/11/06 – 2023/11/30

COMMON TABLES

GROUP 3 – TRANSVERSAL/SOFT SKILLS*

Additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.

University of Trento (UNITN) provides a rich offer of transversal/soft skills courses which can be followed by the PhD students. The DN SST Secretariat will assist the PhD students in identifying/organizing the courses, which will be accessible starting from January 2023. These courses will provide additional CFU (Units of Education Credits) with respect to the 14 CFU of the Group 1 and Group 2 Courses. The following web addresses could be useful for providing an overview of the UNITN organization in support to: research, PhD courses, thesis, intellectual property and so on.

Also other Universities/Research Centers provide transversal/soft skill courses, as provided in the Table below.

Location	Center / Teacher	WEB PAGE / TYPE OF COURSE	CFU*	#Hours	Dates
UNITN	Directorate of Research Services and Valorization	https://www.unitn.it/en/ricerca/77172/train-your-talent			
UNITN	Research Support Division	Training courses on specific aspects of the research work. Details in the dedicated webpage: https://www.unitn.it/ricerca/109722/formazione-alla-ricerca	TBD	TBD	
UNITN	Language center	Academic Writing for the Sciences and Engineering	3	24	
UNITN	Language center	Academic Writing II for the Sciences and Engineering	3	24	

UNITN	Language center	Presentations for the sciences and engineering	2	16	
UNITN	Library services	Use of electronic resources for bibliographic research	TBD	TBD	
UNITN	Various	Examples of programmes which could be organized/followed: 1. Project writing - (4 hours) *a)Funding opportunities and how to apply* *b)Project design and writing* 2. Boost your administrative skill in research - (2 hours) 3. Research integrity - (3 hours) 4. Crash Course on protection and valorisation of Intellectual Property (6 hours) 5. Research data / scientific publications / doctoral thesis 6. HIT (Trentino innovation): From research to business 7. Use of electronic resources for bibliographic research (6 hours)	TBD	TBD	To be organized through the PhD Course Secretariat. Start date not earlier than January 2024

***additional CFU (Units of Education Credits) with respect to the 14 CFU of Group 1 and Group 2 Courses.**

TEACHING UNITS SYLLABI

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Advanced Techniques in Experimental Physics	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Giacomo Baldi
Contact e-mail	giacomo.baldi@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	This course is organized as a collection of 4 lecture cycles on different topics in advanced experimental physics. Each cycle is given by an invited scientist or by a member of the Physics department of the Univerity of Trento, and consists in about 6 hours of lectures. The topics are selected every year in experimental research areas of interest of the physics department, giving priority to topics not already discussed in other dedicated PhD courses, as for instance: 1) Antimatter experiments, anti-hydrogen, positron beams, atomic physics experiments with positronium, positron and positronium for matter studies; 2) Applications of particle beams in medicine; 3) Biophysics, in particular methods for the conditioning/investigation of single biological molecules and for the

	imaging; 4) Cold gases condensates, atomic interferometry; 5) Instrumentation and methods for observational astrophysics and cosmology; 6) Instrumentation and methods in condensed matter and glasses and in surface science; 7) Instrumentation for synchrotron radiation and free electron laser based experiments; 8) Particle and radiation detectors; 9) Photonic devices; The selection of topics of the course depends also on the availability of lecturers coming from other research institutes. The schedule of the course has to match the agenda of the lecturers and it is provisionally planned.
Prerequisites	The knowledge of a physics graduate is requested.
Bibliography	The bibliography will be provided by the lecturers of the different topics.
Assessment methods	PhD students will give a seminar of 20 minutes on an experimental topic related to the four lectures or to an experimental research presented in the Dialogues, Colloquia and Joint Colloquia. The topic is freely chosen by the PhD student but must be previously agreed with the coordinators of the course and must be different from the field of research of the PhD student.
Activity period	2nd semester
Start date	2024/02/29
End date of activity	2024/05/31
Distance delivery information (if available)	The lectures will be organized in presence at Trento, with the possibility to follow remotely.

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Analysis and modelling of volcanological data	
Academic Year	2024/2025
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 2, Curriculum 3)
Teacher responsible for teaching/training activity	Dr. Giuseppe Puglisi
Contact e-mail	giuseppe.puglisi@ingv.it
Venue of the training/teaching activity	Istituto Nazionale di Geofisica e Vulcanologia - INGV
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	o Knowledge and understanding of the of the analysis of multidisciplinary data and modelling of volcanological phenomena o Applying knowledge and understanding on the specific his/her research activity in the framework of the Space Science and Technology doctoral school; o Making judgements in reading scientific literature and scientific communications through other medias, either specific on the volcanology or on general topics; o Communication skills in presenting his/her research activity, in particular concerning the capability to expose the objectives, methods and results in clear (well-structured and appropriate languages) and synthetic ways. o Learning skills will be evaluated on the base of the capability to appropriately organize and expose the acquired knowledge

Prerequisites	General Physics; General Chemistry; Basic knowledge of Volcanology
Bibliography	Fagen S.A, Gregg T.K.P, Lopes R.M.C. Modelling volcanic Processes; Cambridge University Press. 2013
Assessment methods	Final exam
Activity period	2nd semester
Start date	2025/04/01
End date of activity	2025/07/31
Distance delivery information (if available)	Link on Meet

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Astrobiology	
Academic Year	2023/2024
Year of enrolment	
Didactic Unit Type	Disciplinary (Curriculum 3, Curriculum 4)
Teacher responsible for teaching/training activity	Dr. Laura SIlva
Contact e-mail	laura.silva@inaf.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	1 CFU = 8 hours
Training objectives and	Planet formation and exoplanet detection techniques; characteristics of planets in the solar system and exoplanets;

expected learning outcomes	origin and physical limits of life on Earth; climate and atmospheric patterns; planetary habitability; biosignatures: astrobiology in the solar system and exoplanets.
Prerequisites	-
Bibliography	- Atmospheric Evolution on Inhabited and Lifeless Worlds. D. C. Catling, J. F. Kasting, CUPress. - Planetary Astrobiology. V. S. Meadows, G.N. Arney, B.E. Schmidt, D.J. Des Marais, UAPress.
Assessment methods	Seminar and discussion on a course topic
Activity period	2nd semester
Start date	2024/05/06
End date of activity	2024/05/31
Distance delivery information (if available)	-

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Astrochemistry	
Academic Year	2024/2025
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3, Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Daniela Ascenzi

Contact e-mail	daniela.ascenzi@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Basic molecular processes, detection of molecules in various astronomical objects, chemical processes at different evolution stages of a solar system (early Universe, diffuse clouds, dark clouds and pre-stellar cores, photon dominated regions, shocks, planetary atmospheres), laboratory techniques for molecular astrophysics
Prerequisites	General Chemistry and Physical Chemistry
Bibliography	-
Assessment methods	Written report on course topic, agreed with the lecturer
Activity period	2nd semester
Start date	2025/01/01
End date of activity	2025/04/30
Distance delivery information (if available)	-

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Astrochemistry and Astrobiology	
Academic Year	2023/2024

Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 4)
Teacher responsible for teaching/training activity	Dr. Francesca Perrotta
Contact e-mail	perrotta@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Knowledge and understanding of the main mechanisms of the formation of simple and complex molecules in the interstellar medium, and the chemical, physical and thermodynamic mechanisms that lead to the formation of molecules fundamental to life. Understanding of the main prebiotic complexes and theories of their formation. Knowledge and understanding of astrochemical bases will be tested through written exercises and oral expositions proposed to the student. Autonomy of judgement will be educated through subjective analysis of real observational data or simulations. The programme covered in the course will be as follows: -Aspects of physical chemistry: introduction to Spectroscopy, Atomic and molecular levels, selection rules for transitions, Einstein coefficients, local thermodynamic equilibrium, themodynamics and kinetics of chemical reactions. Derivation of molecular abundances. -The molecular universe. Constituents of the interstellar medium. The structure of the neutral interstellar gas. -Chemical processes in the Interstellar medium: reaction networks, ion-neutral reactions, neutral-neutral reactions, radiative associations, dissociative recombination, surface reactions

	-The importance of water . -The boundaries of life: adaptations to Extremes (high temperatures, low pressure, low water environments), synergies between extremes, water and alternative solvents. -Life, metabolism and energy: self-organization and the nature of matter and energy, emergence and evolution of metabolism, implications for astrobiology. Prebiotic molecules. -Nucleic acides: the physical underpinning of replication.
Prerequisites	Basic knowledge of atomic structure and concepts of thermodynamics and quantum mechanics.
Bibliography	- Astrochemistry and Astrobiology, Smith, Cockell, Leach. - Introduction to Astrochemistry, Yamamoto - Astrochemistry, A. Shaw - Astrobiology, an introduction. A. Longstaff - Biochemistry, Lehninger
Assessment methods	Written exercises during the course . Final oral examination.
Activity period	2nd semester
Start date	2025/03/01
End date of activity	2025/05/30
Distance delivery information (if available)	Lectures delivered in presence and via Zoom

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Binary stars: birth, life and death	
Academic Year	2023/2024
Year of enrolment	1^{st}
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Mario Spera
Contact e-mail	mario.spera@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	- Knowledge and understanding of the main mechanisms of evolution of binary stars (stellar evolution and dynamics) - Knowledge and understanding of the main mechanisms of binary formation of compact objects and implications for their detection by gravitational waves - Knowledge and understanding of the main mechanisms involved in the evolution of binary stars in dense stellar environments (e.g. star clusters) - Ability to discern the main physical properties of binaries of compact objects in relation to their formation environment and ability to recognise these properties independently from detectable gravitational wave signals
Prerequisites	Basic courses in mechanics, astronomy and astrophysics.
Bibliography	The course will mainly use the blackboard (and/or graphics tablets) because it is a pen-and-paper oriented course Useful book: James Binney and Scott Tremaine, Galactic Dynamics: Second Edition

Assessment methods	Final oral examination with discussion of one of the topics covered during the course.
Activity period	2nd semester
Start date	2024/02/26
End date of activity	2024/03/19
Distance delivery information (if available)	The course can be followed remotely. All pen and paper accounts will be made on a graphics tablet if necessary.

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Calorimetric techniques for high energy particles detection	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Alessio Tiberio
Contact e-mail	alessio.tiberio@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	1,5 CFU = 12 hours
Training objectives and expected learning outcomes	The course will provide an overview of the high energy calorimetric techniques used in cosmic-ray and collider experiments. After the course the student will have a good understanding of the operating principles of electromagnetic and hadronic calorimeters. Furthermore, he will know the detector solutions generally adopted

	and the techniques used to optimize the calorimeter performances. Finally, by using several examples from past and present experiments he will get familiarity with the current status and future frontiers of calorimetry.
Prerequisites	A base knowledge of the interaction processes of charged particles and gamma rays with matter is recommended (however, the main properties will be reminded during the course)
Bibliography	M. Livan and R. Wigmans, "Calorimetry for collider physics, an Introduction"
Assessment methods	The student will be requested to have a ~20 minutes seminar about an in-depth study of his choice from the topics of the course. Then some questions will be asked, in particular about the connections of the seminar argument with the course topics.
Activity period	2nd semester
Start date	2024/02/01
End date of activity	2024/03/31
Distance delivery information (if available)	A zoom connection will be provided in order to give the possibility to attend the lectures from remote.

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Cognitive Pain Control in Space	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Enrica Santarcangelo

Contact e-mail	enrica.santarcangelo@unipi.it
Venue of the training/teaching activity	University of Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Cognitive strategies to control pain in space. Prediction of individual efficacy.Role of brain sctructures in pain and interoception.
Prerequisites	General knowledge of pain physiology (which will be summarized)
Bibliography	Santarcangelo EL, Carli G. Individual Traits and Pain Treatment: The Case of Hypnotizability. Front Neurosci. 2021 Jun 2;15:683045; Zelič et al EL. Association of Hypnotizability, Interoception, and Emotion. Int J Clin Exp Hypn. 2023 Jul-Sep;71(3):250-262.
Assessment methods	Interview
Activity period	2nd semester
Start date	2024/02/15
End date of activity	-
Distance delivery information (if available)	-

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Cosmic Microwave Background Polarization	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Carlo Baccigalupi
Contact e-mail	carlo.baccigalupi@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The course aims to provide students with an overview of the observational effort, including space missions, towards mapping the cosmic background radiation in the rotor component of the polarisation (B-mode). The course describes the cosmological components of the signal, i.e. the possible contribution of cosmological gravitational waves and the gravitational lensing effect, and focuses on the main observational challenges, particularly in relation to the contamination of the diffuse Galactic signal. The programme mainly interfaces with the observational context represented by the operating Simons Observatory and future CMB Stage IV observatories, and the LiteBIRD satellite.
Prerequisites	General Cosmology Course on the Theory of Linear Cosmological Perturbations Course on Radiative Processes in Galactic Astrophysics Elements of Linear Inversion.
Bibliography	- Hu, W. et al., 1997, https://arxiv.org/abs/astro-ph/9706147 - Hu, W., White, M.., 1997, https://arxiv.org/abs/astro-ph/9702170

	- Physical Review D (Particles, Fields, Gravitation, and Cosmology), Volume 56, Issue 2, 15 July 1997, pp.596-615, - Krachmalnicoff, N., et al., 2018, https://arxiv.org/abs/1802.01145 - Astronomy & Astrophysics, Volume 618, id.A166, 18 pp.
Assessment methods	The evaluation is based on face-to-face or remote (zoom) interviews.
Activity period	2nd semester
Start date	2024/04/08
End date of activity	2024/04/30
Distance delivery information (if available)	The course will be distance learning on a platform (zoom).

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Cosmological Structure Formation	
Academic Year	2023/2024
Year of enrolment	1st, 2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Matteo Viel
Contact e-mail	viel@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	3 CFU = 24 hours

Training objectives and expected learning outcomes	1. Perturbations in linear theory 2. Inhomogeneities 3,4. Probing the cosmic density field 5. Correlation functions and the power spectrum and bispectrum 6. Non linear evolution 7. LSS probes -galaxies 8. LSS probes -clusters of galaxies and peculiar velocity fields 9. LSS probes -the intergalactic medium 10. Structure formation processes beyond standard models 11. Dark Matter and neutrino impact on structure formation
Prerequisites	Cosmology course on Friedmann equations.
Bibliography	Mo, Van Den Bosch & White "Galaxy Formation and evolution", Daniel Baumann "Cosmology", Peacock "Physical cosmology".
Assessment methods	Seminar
Activity period	2nd semester
Start date	2024/02/01
End date of activity	2024/03/31
Distance delivery information (if available)	Via zoom Platform

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Cosmology	
Academic Year	2024/2025
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Luigi Danese
Contact e-mail	danese@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	The student will acquire knowledge and ability to understand the main physical mechanisms governing Cosmology: Robertson-Walker metric, Einstein equations, scale factor, time, distances, cosmological tests to determine fundamental parameters (Hubble constant, deceleration parameter...), components of the Universe; problems of horizons, flatness, inflation concept, thermal history of the Universe, primordial nucleosynthesis, CMB spectrum, recombination. The ability to apply this knowledge, autonomy of judgement and communication will be tested during the course and in the examination.
Prerequisites	General Relativity
Bibliography	Weinberg 'Cosmology'
Assessment methods	Oral examination and/or seminar. Intermediate assessments during the course
Activity period	1st semester

Start date	2024/10/01
End date of activity	2024/12/20
Distance delivery information (if available)	**Remote delivery not available**

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Dark Matter and the Physics of the Primordial Universe	
Academic Year	2023/2024
Year of enrolment	1^{st}
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Dr. Marco Taoso
Contact e-mail	marco.taoso@to.infn.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	2,5 CFU = 20 hours
Training objectives and expected learning outcomes	Introduction to inflationary cosmology: motivation; classical dynamics; quantum fluctuations; observational tests. Dark Matter: evidences for Dark Matter; production mechanisms in the Early Universe; indirect detection: photons, charged cosmic-rays, neutrinos; direct detection; collider searches; axion Dark Matter; primordial black holes.
Prerequisites	-
Bibliography	Some suggested references:

	- Particle Dark Matter: Observations, Models and Searches, Edited by G. Bertone - TASI Lectures on Inflation, D. Baumann. Additional material will be provided during the lectures.
Assessment methods	The candidate will be asked to prepare a report on topics relevant for the course. An oral presentation will be required.
Activity period	2nd semester
Start date	12/02/2024
End date of activity	08/03/2024
Distance delivery information (if available)	-

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Data Analysis	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Fenu Francesco Priof. Maldera SImone
Contact e-mail	francesco.fenu@asi.it simone.maldera@to.infn.it
Venue of the training/teaching	University of Turin

activity	
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	The objective of the course is to provide an overview of the scientific design of a space experiment and the data analysis process. Concepts such as triggers, exposure, unfolding of a spectrum, event reconstruction, performance estimation of reconstruction algorithms and likelihood analysis for the detection of astrophysical sources will be introduced. Data from both real and simulated space experiments will be analysed.
Prerequisites	It is preferable for the student to have basic knowledge of the physical processes involved in radiation-matter interaction. Basic programming knowledge in C/C++ and/or Python is highly recommended. Due to the presence of practical exercises, students are requested, where possible, to bring their own laptop computer with the basic python libraries and CERN root package installed.
Bibliography	Slides and material provided in class.
Assessment methods	At the end of the course, the student will be asked to do a seminar presenting the results of the exercises proposed in class.
Activity period	1st semester
Start date	2023/12/14
End date of activity	2024/02/29
Distance delivery information (if available)	Lessons will be delivered via teams, webex or zoom platforms. Students will be contacted to provide connection details.

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Data Protection and Data Governance in Space activities

Academic Year	2024/2025
Year of enrolment	2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge about the regulatory framework of data use and data protection in the context of space activities. At the end of the training activity, in addition to basic knowledge, they will develop the personal skills of understanding and also autonomously learning certain legal aspects of space activities.
Prerequisites	-
Bibliography	It will be identified in the run-up to the course and communicated in the run-up to it
Assessment methods	Final briefs
Activity period	2nd semester
Start date	2025/04/02
End date of activity	2025/04/30
Distance delivery information (if available)	-

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Design of Experiments and Statistical Analysis of Experimental Data	
Academic Year	2023/2024
Year of enrolment	1
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Polo Bosetti
Contact e-mail	paolo.bosetti@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	The student is supposed to gain the following skills: • knowledge and understanding of inferential statistics procedures for planning experiments and for analyzing the resulting experimental data. • ability to apply the knowledge above reported on real data, learning to use software tools designed for that purpose (R language, RStudio IDE and libraries). • realization that data analysis requires adaptation and ability to design algorithms that better suit to different applications. • ability to effectively present the data and the results of the analysis. • understanding of the overall design of the framework of tools presented in the course, and ability to

	navigate the technical documentation of the framework to exploit its flexibility.
Prerequisites	Programming experience with at least one programming language (scripted or compiled). A personal laptop with installed the latest version of GNU-R (r-project.org) and RStudio (posit.co).
Bibliography	Douglas C. Montgomery, Design and Analysis of Experiments, Wiley.
Assessment methods	Report on a personal project.
Activity period	2nd semester
Start date	2024/03/11
End date of activity	2024/03/26
Distance delivery information (if available)	Monday 11 March – 2 p.m. to 6 pm. Tuesday 12 March – 2 p.m. to 6 pm. Monday 18 March – 2 p.m. to 6 pm. Tuesday 19 March – 2 p.m. to 6 pm. Monday 25 March – 2 p.m. to 6 pm. Tuesday 26 March – 2 p.m. to 6 pm. Link: https://unitn.zoom.us/j/88052138818?pwd=TVlKWW9uNi84U3RkNmVMdHZOWUlmdz09

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Detection, analysis and modelling of volcanic induced perturbations on the atmosphere

Academic Year	202372024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Dott. A. Bonforte Dott.ssa Simona Scollo Dott.ssa Mariangela Sciotto Dott. Claudio Cesaroni
Contact e-mail	alessandro.bonforte@ingv.it simona.scollo@ingv.it mariangela.sciotto@ingv.it claudio.cesaroni@ingv.it
Venue of the training/teaching activity	Istituto Nazionale di Geofisica e Vulcanologia - INGV
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	- Knowledge and understanding of the eruptive phenomena (e.g. eruptive style, intensity, magnitude) which can create perturbation in the atmosphere - Knowledge and understanding of effects of volcanic activity on geophysical signals, according to the topics of the course, i.e., Signals recorded by volcano monitoring sensors and ground based and spaceborn atmospheric/ionospheric instruments and their analysis - Applying knowledge and understanding on the specific his/her research activity in the framework of the Space Science and Technology doctoral school;

	- Making judgements in reading scientific literature and scientific communications through other medias, either specific on the volcanology or on general topics; - Communication skills in presenting his/her research activity, in particular concerning the capability to expose the objectives, methods and results in clear (well-structured and appropriate languages) and synthetic ways. - Learning skills will be evaluated on the base of the capability to appropriately organize and expose the acquired knowledge
Prerequisites	Basic knowledge of Volcanology and Earth Sciences; General Physics SS&T PhD Course “Ionospheric monitoring and modelling” (C. Cesaroni)
Bibliography	- Astafyeva, E. (2019). Ionospheric detection of natural hazards. Reviews of Geophysics, 57(4), 1265-1288. - Bonforte et al., 2001. Calibration of atmospheric e*ects on SAR interferograms by GPS and local atmosphere models: first results. J. Atmos. Sol.-Terr. Phys., 63, 1343-1357. DOI10.1016/S1364-6826(00)00252-2. - D’Arcangelo et al., 2022. A Multi-Parametric and Multi-Layer Study to Investigate the Largest 2022 Hunga Tonga–Hunga Ha’apai Eruptions. Rem. Sens., 14, 3649, https://doi.org/10.3390/rs14153649. - Madonia et al., 2023. Propagation of Perturbations in the Lower and Upper Atmosphere over the Central Mediterranean, Driven by the 15 January 2022 Hunga Tonga-Hunga Ha’apai Volcano Explosion. Atmos., 14, 65, https://doi.org/10.3390/atmos14010065. - Themens, D. R., Watson, C., Žagar, N., Vasylkevych, S., Elvidge, S., McCaffrey, A., ... & Jayachandran, P. T. (2022). - Global propagation of ionospheric disturbances associated with the 2022 Tonga volcanic eruption. Geophysical Research Letters, 49
Assessment methods	Final Test
Activity period	2nd semester

Start date	2024/05/05
End date of activity	2024/06/13
Distance delivery information (if available)	Google Meet

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Detectors and Space Equipment	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary , Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Mario Edoardo Bertaina
Contact e-mail	marioedoardo.bertaina@unito.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	The objective of teaching Space Detectors and Equipment is to provide an overview and basic knowledge of space detectors and equipment developed for scientific payloads of space missions. The course will illustrate design elements and operational constraints for specific examples of space observatories as determined by specific space mission performance requirements. By the end of the course, the student will have acquired the basic elements required to design a scientific mission.

Prerequisites	It is preferable that the student has basic knowledge of the physical processes involved in radiation-matter interaction. In any case, the course aims to bridge any gaps in the first lesson.
Bibliography	Slides and material provided in class.
Assessment methods	At the end of the course, the student will be asked to take a seminar presenting a scientific mission in order to detail the solutions adopted in terms of detectors and scientific equipment to achieve the scientific requirements imposed by the space mission.
Activity period	1st semester
Start date	2023/11/20
End date of activity	2023/12/22
Distance delivery information (if available)	Lessons will be delivered via webex and zoom platforms. Students will be contacted to provide details of links.

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Diagnostic of Electron Devices	
Academic Year	2024/2025
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Giovanna Mura
Contact e-mail	giovanna.mura@unica.it
Venue of the training/teaching	University of Cagliari

activity	
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Knowledge and understanding in Semiconductor Technology, Reverse Engineering, Failure mechanisms, Principles and fundamental methods in Electron Microscopy, Methodology for the Failure Analysis, The Space environment Applying knowledge and understanding in performing electrical measurements on electron devices, performing selective deprocessing, analyzing the surface of a device by using optical and electronic microscopes Ability to identify and use data to formulate responses, to reading the experimental data in terms of evaluation of a failure analysis report Ability in solving given problems and to report, ability to illustrate and discuss the results of own studies Ability to access complementary sources for studying the theory. Practice with the bibliographic search.
Prerequisites	Knowledge of Solid State Physics, Electronic Devices and Reliability of Electronic Devices is essential.
Bibliography	- S. Sze e K. Ng Kwok. Physics of Semiconductor Devices Third Edition. J. Wiley, 2007, Chapter 12 - SM Sze Dispositivi a semiconduttore capitoli 8 - 12 "Failure Analysis of Integrated circuits - tool and techniques" - L.C.Wagner - Kluwer Academic Publishers, 1999 "Microelectronics Failure Analysis," - T. Gandhi, Desk Reference-ASM International, 2019 Lecture slides will be provided in support. Suggested lectures: - Paolo Ferri, Le sfide di Marte. Storie di esplorazione di un pianeta difficile, Cortina Raffaello 2023 - Paolo Ferri, Il lato oscuro del Sole. L'esplorazione spaziale della nostra stella, Laterza 2022 - Paolo Ferri, Il cacciatore di comete. Diario di un’avventura nello spazio profondo, Laterza 2020

Assessment methods	The final assessment consists of the presentation of a paper of your choice on topics related to the course, which will be used to evaluate: - your knowledge and understanding of the terminology and content of the course, - your ability to elaborate and apply what you have learnt during the course to the specific case under examination, - your communication skills on electronic diagnostic topics, - the competence acquired in researching and analysing the available literature.
Activity period	1st semester
Start date	2024/10/01
End date of activity	2024/12/20
Distance delivery information (if available)	Teams Platform

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Effects of Volcanic Activity on the Atmosphere	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Dr. Alessandro Bonforte Dr. Simona Scollo Dr. Mariangela Sciotto
Contact e-mail	alessandro.bonforte@ingv.it simona.scollo@ingv.it mariangela.sciotto@ingv.it

Venue of the training/teaching activity	Istituto Nazionale di Geofisica e Vulcanologia - INGV
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	- Knowledge and understanding of the impact of volcanic activity in the atmosphere, according to the topics of the course, i.e., Fundamentals of the volcanic processes; Effects on the in the atmosphere; volcano monitoring systems; Volcanic eruptive processes - Applying knowledge and understanding on the specific his/her research activity in the framework of the Space Science and Technology doctoral school; - Making judgements in reading scientific literature and scientific communications through other medias, either specific on the volcanology or on general topics; - Communication skills in presenting his/her research activity, in particular concerning the capability to expose the objectives, methods and results in clear (well-structured and appropriate languages) and synthetic ways. - Learning skills will be evaluated on the base of the capability to appropriately organize and expose the acquired knowledge
Prerequisites	Basic knowledge of Volcanology and Earth Sciences
Bibliography	- D'Arcangelo et al., 2022. A Multi-Parametric and Multi-Layer Study to Investigate the Largest 2022 Hunga Tonga–Hunga Ha'apai Eruptions. Rem. Sens., 14, 3649, https://doi.org/10.3390/rs14153649 - Madonia et al., 2023. Propagation of Perturbations in the Lower and Upper Atmosphere over the Central Mediterranean, Driven by the 15 January 2022 Hunga Tonga-Hunga Ha'apai Volcano Explosion. Atmos., 14, 65, https://doi.org/10.3390/atmos14010065 - Sparks R.S,J., Volcanic Plumes; Wiley, 1997, ISBN: 0471939013, 9780471939016 Volcanoes and the Environment,

	edited by Joan Marti, Cambridge University Press, https://doi.org/10.1017/CBO9780511614767
Assessment methods	Final Test
Activity period	1st semester
Start date	2024/01/15
End date of activity	2024/03/14
Distance delivery information (if available)	Google Meet

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Elements of Photonics: from Maxwell to optical fibers	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multi-disciplinary / Disciplinary (Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Fabrizio Cesare Filippo Di Pasquale
Contact e-mail	f.dipasquale@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	2 CFU = 16 hours

Training objectives and expected learning outcomes	The course provides students with an introduction to the fundamental concepts of electromagnetism and has the ultimate goal of an in-depth understanding of the concepts of guided modes and propagation in optical guides and fibers Application examples of the use of fiber optic devices for telecommunications and sensing will also be described. The course is preparatory to an in-depth understanding of other courses in optical communications and fiber optic sensor systems.
Prerequisites	University courses in physics
Bibliography	1. David M. Pozar, "Microwave Engineering", third editon, John Wiley &Sons. 2. S. Ramo, J.R Whinnery, T. Van Duzer, "Fields and waves in communication electronics", third edition, ISBN: 978-0-471-58551-0, John Wiley &Sons. 3. K. kawano, T. Kitoh, "Introduction to optical waveguide analysis", John Wiley &Sons. 4. G.P. Agrawal, "Fiber-Optic Communication Systems", Wiley-Interscience 2002. 5. Slides fornite dal docente
Assessment methods	Oral Examination
Activity period	1st Semester
Start date	2023/11/09
End date of activity	2024/02/15
Distance delivery information (if available)	Online meetings will be organized for each lesson using the CISCO WebEx system

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Elements of Volcanology

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 2 and Curriculum 3)
Teacher responsible for teaching/training activity	Dr. Giuseppe Puglisi
Contact e-mail	giuseppe.puglisi@ingv.it
Venue of the training/teaching activity	Istituto Nazionale di Geofisica e Vulcanologia - INGV
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	- Knowledge and understanding of the main aspects of the volcanic processes in the Earth's interior, on the surface of the planets and its effects in the atmosphere, according to the topics of the course, i.e., Fundamentals of the volcanic processes; Effects on the Earth surface and in the atmosphere; volcano monitoring; Volcanic hazard - Applying knowledge and understanding on the specific his/her research activity in the framework of the Space Science and Technology doctoral school; - Making judgements in reading scientific literature and scientific communications through other medias, either specific on the volcanology or on general topics; - Communication skills in presenting his/her research activity, in particular concerning the capability to expose the objectives, methods and results in clear (well-structured and appropriate languages) and synthetic ways. - Learning skills will be evaluated on the base of the capability to appropriately organize and expose the acquired knowledge

Prerequisites	General Physics; General Chemistry; Basic knowledge of Earth Dynamics
Bibliography	- Schmincke H-U, Volcanism, Springer, 2004 - Scandone R. & Giacomelli L., Vulcanologia, Liguori Editore, 1998 - pdf file of the presentations used during the course
Assessment methods	Final Test
Activity period	2nd semester
Start date	2024/02/01
End date of activity	2024/04/30
Distance delivery information (if available)	Link on Meet

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Exoplanetary Astrophysics	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3)
Teacher responsible for teaching/training activity	Prof. Giampaolo Piotto
Contact e-mail	giampaolo.piotto@unipd.it
Venue of the training/teaching activity	University of Padua - UNIPD

CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The aim of the course is to present to the students the status of the art of exoplanet search and characterization, as well as provide them with the needed scientific elements to keep updated on future results and perspectives in this Astrophysics research field.
Prerequisites	
Bibliography	
Assessment methods	Final Test
Activity period	2nd semester
Start date	
End date of activity	
Distance delivery information (if available)	

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Experimental techniques in Astroparticle Physics	
Academic Year	2023/2024
Year of enrolment	
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Giovanni Marsella

Contact e-mail	giovanni.marsella@unipa.it
Venue of the training/teaching activity	University of Palermo
CFU / Hours	2CFU = 16 hours
Training objectives and expected learning outcomes	Knowledge and Ability to Understand: Acquisition of basic general knowledge and minimal tools, both theoretical and experimental in nature, for understanding cosmic ray physics. Ability to apply knowledge and understanding: Ability to read and understand the results presented in the field of cosmic ray physics; Autonomy of judgment: To be able to analyze independently, rigorously and critically the fundamental aspects of a paper on cosmic ray physics. Communication skills: Ability to illustrate and communicate the essential elements of a specific problem pertaining to cosmic ray physics. Learning skills: Ability to update independently and to take, using the knowledge acquired, second-level courses within the same discipline.
Prerequisites	Thorough knowledge of general physics, particularly classical mechanics and electromagnetism. Knowledge of statistics for data analysis
Bibliography	Gaisser, Hengel, Resconi “Comic Rays and Particle Physics”, Cambridge University Press T. Stanev, “High Energy Cosmic Rays”, Springer
Assessment methods	The examination consists of an oral test, consisting of an examination-interview concerning the study of a recent

	article chosen by the candidate. This test makes it possible to assess, in addition to the candidate's knowledge and ability to apply it to a recent case study, his or her possession of scientific language properties and clear and direct expository skills.
Activity period	2nd semester
Start date	2024/03/01
End date of activity	2024/06/01
Distance delivery information (if available)	We'll use a dedicated TEAMS channel

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Exploring the Solar System and its Environment	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3)
Teacher responsible for teaching/training activity	Prof. Francesco Marzari Dr. Gabriele Cremonese
Contact e-mail	marzari@pd.infn.it abriele.cremonese@oapd.inaf.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	2 CFU = 16 hours
Training objectives and	The aim of the course is to provide an understanding of the processes that lead to the formation of planetary

expected learning outcomes	systems and in particular the solar system. The physical and dynamic characteristics that characterise the planetary environment are presented and space missions that can acquire important information on the bodies that make up a planetary system such as planets. satellites, asteroids and comets.
Prerequisites	The prerequisites required for the course are acquired during the institutional courses required for degrees in Engineering, Astronomy and Physics and Geology.
Bibliography	Planetary Astrophysics, F. Marzari, Cambridge Scholars Publishing, 2022 Slides available at https://userswww.pd.infn.it/~marzari/ Presentations given by lecturers during lectures
Assessment methods	The assessment consists of an interview in which all students participate (also remotely). During this interview, students may ask for clarification on certain aspects of the material presented during the course or briefly present an in-depth study on a topic of their choice.
Activity period	2nd semester
Start date	2024/04/15
End date of activity	2024/05/24
Distance delivery information (if available)	Lessons are delivered both in-person and via zoom.

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Facilities for Space Life Sciences	
Academic Year	2023/2024
Year of enrolment	2nd

Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Angelo Maria Rizzo
Contact e-mail	angelamaria.rizzo@unimi.it
Venue of the training/teaching activity	University of Milan
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The formative objective of the course is to provide the students an updated view of the available facilities on ground and inflight to simulate the space conditions such as microgravity, radiation and confinement. The course will be focused on the possibilities to exploit experiments in the field of life science and the availability of national or international calls to access platform and facilities and real flight opportunities for students. The expected results are as follows: • Knowledge and understanding of the principal containers and facilities available for ground and flight experiments to asses space effects on molecules, cells and living organisms, including humans • Applying knowledge and understanding: which platform is necessary to answer a specific experimental question and how it is possible to access the facilities. • Making judgements, Communication skills and Learning skills: the students will be request to develop an experiment design using the illustrated facilities and to present the study design to the class.
Prerequisites	-
Bibliography	The presentations and articles used to prepare the course will be made available to students. Most of the information will be retrieved through direct access to the websites of the International Space Agencies.

Assessment methods	The students will be request to develop an experiment design using the illustrated facilities and to present the study design to the class. Evaluation parameters: ability to organise knowledge; critical reasoning skills on the study carried out; quality of presentation, competence in the use of specialist vocabulary. Type of evaluation used: mark out of thirty
Activity period	1st semester
Start date	2024/01/29
End date of activity	2024/02/29
Distance delivery information (if available)	The course will be organised in remote using Teams and can be attended from students of the first and the second year.

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Front-end and readout electronic systems for High Energy Astroparticle Physics	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Felicia Barbato Prof. Adriano Di Giovanni
Contact e-mail	felicia.barbato@gssi.it adriano.digiovanni@gssi.it
Venue of the training/teaching activity	Gran Sasso Science Institute

CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	In questo corso si tratteranno alcuni dei principali circuiti elettronici utilizzati in esperimenti di astroparticelle a terra e nello spazio. Verranno introdotti i principali concetti di trasmissione del segnale su linea, circuiti di amplificazione, comparatori.
Prerequisites	-
Bibliography	Articoli, Libri: "Techniques for nuclear and particle physics experiments - WR Leo"; "Radiation Detection and Measurement - Glenn Knoll". Strumentazione di laboratorio. Modalità di valutazione: Esercizio sui contenuti trattati nel corso e relativa discussione.
Assessment methods	
Activity period	2nd semester
Start date	2024/03/11
End date of activity	2024/03/22
Distance delivery information (if available)	-

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Gravitational Metrology for Astrophysics and Cosmology	
Academic Year	2024/2025
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for	Prof. Mariateresa Crosta

teaching/training activity	
Contact e-mail	mariateresa.crosta@unito.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	The course focuses on the methods of fundamental astronomy and general relativistic metrology in respect to the new advanced generation of space missions operating from within the weak gravitational fields of the Solar System, where the basic requirements are the correct definition of the observation equations and the satellite reference systems in a general relativistic context. The definition of celestial references systems and their application to space-time navigation is also addressed, namely the astrometric relativistic models for a suitable inverse relativistic ray-tracing from the observed object to the observer's location, as well as mathematical/technological/ instrumental issues related to such investigation in space. The lectures will illustrate also the global and differential astrometric techniques in space, their applications in studying satellite systematics and in testing general relativistic effects, including the lensing ones. Therefore connections with cosmology, especially in regard of weak lensings peering strategies and tools, are presented. • **Knowledge and understanding**: role of fundamental astronomy for the calibration of models for stellar astrophysics and in the latest investigations on formation, structure and evolution of the Milky Way, with implications for current cosmological theories; gravitational lensing; Dark matter, Dark Energy • **Applying knowledge and understanding**: methods of gravitational astronomy and relativistic metrology and their applications to astrophysical investigations, especially in respect to the new generation of space mission operating in the weak gravitational field of the Solar System

Prerequisites	
Bibliography	Slides/Notes of the course - Gravity: Newtonian, Post-Newtonian, Relativistic, by Eric Poisson and Clifford Will, Cambridge University Press, 2014 - Classical Measurements in Curved Space-Times, by Fernando de Felice and Donato Bini, Cambridge University Press, 2010 - ESA Gaia Documentation (technical notes) The global sphere reconstruction (GSR). Demonstrating an independent implementation of the astrometric core solution for Gaia, Vecchiato et al., 2018A&A...620A..40V - Application of time transfer functions to Gaia's global astrometry. Validation on DPAC simulated Gaia-like observations, Bertone at al., 2017A&A...608A..83B - Orbiting frames and satellite attitudes in relativistic astrometry, Bini et al., 2003CQGra..20.4695B - General relativistic observable for gravitational astrometry in the context of the Gaia mission and beyond, Crosta et al. 2017PhRvD..96j4030C and references therein - Gaia Collabaration, Lindegren, L., et al., Gaia Data Release 2: The astrometric solution, A&A
Assessment methods	Papers, Reports
Activity period	1st semester
Start date	-
End date of activity	-
Distance delivery information (if available)	-

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Gravitational Waves	
Academic Year	2023/2024
Year of enrolment	1
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Enrico Barausse
Contact e-mail	barausse@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	I. The propagation and generation of gravitational waves *A. Linear perturbations on flat space* *B. Linear perturbations on curved space* *C. Linear perturbations on flat space: a scalar-vector-tensor decomposition* *D. Generation of gravitational waves: a first derivation of the quadrupole formula* *E. Dimensional analysis* II. Post-Newtonian expansion *A. The motion of massive and masseless bodies* *B. The Einstein equations* *C. A more rigorous derivation of the quadrupole formula* III. Local flatness and the equivalence principle

	A. The local flatness theorem and Riemann normal coordinates *B. Fermi Normal Coordinates* IV. The stress energy tensor of gravitational waves *A. The gravitational contribution to the mass of a compact star* V. The inspiral and merger of binary systems of compact objects *A. Geodesics in Schwarzschild and Kerr* *B. A qualitative description of the inspiral and merger* VI. The post-merger signal *A. Scalar perturbations of non-spinning black holes* *B. Tensor perturbations of non-spinning black holes* *C. Tensor perturbations of spinning black holes* VII. The detection of gravitational waves *A. The response of a gravitational wave detector: the low frequency limit* *B. A geometric interpretation of the polarizations* *C. The response of a gravitational wave detector: the transfer function* VIII. Gravitational wave data analysis *A. Gaussian noise and power spectral density* *1. Detection in the presence of noise* *B. The signal-to-noise ratio for inspiraling binaries* *C. Parameter estimation* IX: Gravitational wave astrophysics:

	A. The LVK events and their astrophysical formation channels *B. Sources of gravitational waves for LISA* *C. The pulsar-timing array experiments*
Prerequisites	General Relativity
Bibliography	- M. Maggiore, Gravitational Waves: Volume 1: Theory and Experiments - M. Maggiore, Gravitational Waves: Volume 2: Astrophysics and Cosmology https://arxiv.org/abs/2303.11713
Assessment methods	Oral exam
Activity period	1st semester
Start date	2024/01/10
End date of activity	2024/02/01
Distance delivery information (if available)	Face-to-Face course

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High Energy Astroparticle Physics – Experiments	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Ivan De Mitri

Contact e-mail	ivan.demitri@gssi.it
Venue of the training/teaching activity	Gran Sasso Science Institute – GSSI
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	Experimental techniques used in high energy astroparticle physics experiments, mainly devoted to the study of high energy cosmic radiation (gamma and neutrinos, electrons, positrons and antimatter, protons and nuclei) using balloon and space born detectors, ground based extensive air shower arrays and telescopes, underground / ice / water detectors, space based EAS observatories.
Prerequisites	Previous knowledge of basics of particle physics.
Bibliography	Specific information will be given during the lectures.
Assessment methods	Discussion on the course contents. The discussion will start from one topic chose by the student and the will also extend to other topics covered by the course.
Activity period	1st semester
Start date	2023/11/06
End date of activity	2024/01/31
Distance delivery information (if available)	The lectures could be attended on zoom.

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High Energy Astroparticle Physics – Theory	
Academic Year	2023/2024

Year of enrolment	1^{st}
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Carlo Evoli
Contact e-mail	carmelo.evoli@gssi.it
Venue of the training/teaching activity	Gran Sasso Science Institute
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	High-energy astrophysics 2023/Syllabus A Introduction to Galactic Cosmic Rays - Overview of Cosmic Rays: Nature, Origin, and History - Unsolved Questions in High-Energy Astroparticle Physics B Plasma Physics Fundamentals - Introduction to Plasma: Properties and Characteristics - Plasma Equations and Magnetohydrodynamics (MHD) - Magnetized Plasmas in Astrophysics C Charged Particle Transport in Magnetic Fields - Lorentz Force and Particle Trajectories - Gyro-Motion and Particle Orbits in Magnetic Fields - Pitch-Angle Scattering and Diffusion

	D Diffusive Shock Acceleration - Shock Waves in Cosmic Environments - Fermi Acceleration Mechanisms - Cosmic Ray Spectrum Formation E Energy Loss Processes for High-Energy Particles - Interaction of Cosmic Rays with Matter - Hadronic Interactions and Particle Energy Losses - Leptonic Energy Losses F Cosmic Ray Transport in Galaxies - Transport Equations and Models - Galactic Halo Models and Cosmic Ray Distributions - Cosmic ray transport in Starburst Galaxies G Gamma-Ray and Neutrino Emissions in Cosmic Rays - Gamma-Ray Production Mechanisms - Neutrinos as Messengers of High-Energy Cosmic Processes - Sources of Gamma-Rays and Neutrinos: Supernovae and diffuse emissions H Introduction to UHECRs - Galactic Cosmic Rays vs. Extragalactic Cosmic Rays - Relevant thresholds for UHECRs
Prerequisites	Electromagnetism and Standard Model physics.

Bibliography	- T. Gaisser, R. Engel & E. Resconi, "Cosmic Rays and Particle Physics", Cambridge University Press - M. Vietri, "Foundations of High-Energy Astrophysics", University of Chicago Press - C. Evoli & U. Dupletsa, "Phenomenological models of Cosmic Ray transport in Galaxies", arXiv:2309.00298 - P. Blasi, "The origin of galactic cosmic rays", arXiv:1311.7346 - D. Boncioli, "Cosmic-ray propagation in extragalactic space and secondary messengers", arXiv:2309.12743 - D. Caprioli, "Particle Acceleration at Shocks: An Introduction", arXiv:2307.00284
Assessment methods	Discussion on an individually assigned exercise.
Activity period	1st semester
Start date	2024/01/08
End date of activity	2024/02/02
Distance delivery information (if available)	-

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High Energy Neutrino Astronomy	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Paolo Lipari
Contact e-mail	paolo.lipari@roma1.infn.it

Venue of the training/teaching activity	Gran Sasso Science Institute – GSSI
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	The lectures give an introduction and an overview of high energy gamma ray and neutrino astronomy. The program of the lecture is to introduce the emission mechanisms that generate gamma rays and neutrinos from relativistic charged particles, and will consider some examples of applications to astrophysical sources such as Supernova Remnants, Pulsars (and Pulsar Wind Nebulae) and Active Galactic Nuclei. The lectures will discuss the observations of the IceCube detector that have recently revealed the existence of a flux of astrophysical neutrinos. The lectures on neutrinos will include some discussion on atmospheric neutrinos that are the foreground to the observations of astrophysical signals but are also a powerful instrument for the study of neutrino oscillations. The lectures will be presented in the context of multi–messenger astrophysics, (with neutrinos, cosmic rays, gamma–rays and gravitational waves) for the study of the “High Energy Universe”.
Prerequisites	-
Bibliography	The course is based on the slides presented durig the lectures, and a number of original papers and reviews
Assessment methods	Student are asked to present a topic of their choice among those discussed in the course for a more in depth discussion.
Activity period	2nd semester
Start date	-
End date of activity	-
Distance delivery information	-

(if available)	

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High Energy Radiation Measurements (LAB course)	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Felicia Barbato Prof. Adriano Di Giovanni
Contact e-mail	felicia.barbato@gssi.it adriano.digiovanni@gssi.it
Venue of the training/teaching activity	Gran Sasso Science Institute
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Silicon detectors. Readouts and DAQ systems. Applications for space experiments. Tracking systems: measurements and data analysis. This is a laboratory course. Lectures will be delivered at the Gran Sasso National Laboratories (LNGS).
Prerequisites	The course Front-end and readout electronic systems for High Energy Astroparticle Physics is preparatory to this course. Students must therefore have taken those lectures to access this course.
Bibliography	This is a laboratory course. The theoretical part will be covered in the course Electronic Circuits for High Energy Physics

Assessment methods	Students are expected to prepare a presentation on the activities carried out in the laboratory and the analysis of the data taken. Questions concerning the instrumentation used and measurement techniques will be asked during the presentation.
Activity period	2nd semester
Start date	2024/04/03
End date of activity	2024/04/07
Distance delivery information (if available)	In presence

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Human physiological and behavioral alterations in space condition	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Marco Narici
Contact e-mail	marco.narici@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	1,5 CFU = 12 hours
Training objectives and	This PhD course will deal with the physiological and medical problems of bone loss, kidney stones, motion sickness,

expected learning outcomes	muscle loss, motor function impairment, loss of balance, orthostatic intolerance, cardiovascular deconditioning, weight loss, nutritional alterations, radiation exposure, biological aging, as well as brain health and cognitive function. Specific attention will be given to the mechanisms and pathophysiological relevance of the maladaptations associated with spaceflight, and their impact on human performance, behaviour and health. The course will also cover the different types and effects of countermeasures used to prevent deconditioning of most physiological systems in space and for preserving health and function.
Prerequisites	Bachelor or Master degrees in Life Sciences, Bioengineering, Psychology or Medical/Biomedical degree
Bibliography	- Space Physiology, J.C. Buckely, Oxford University Press; - Fundamentals of Space Medicine, G. Clément, Space Technology Library, Kluver Academic Publisher
Assessment methods	Written project on course-related topic.
Activity period	2nd semester
Start date	June or Oct 2024
End date of activity	June or Oct 2024
Distance delivery information (if available)	Zoom link possible.

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Image Sensors	
Academic Year	2023/2024
Year of enrolment	1st, 2nd

Didactic Unit Type	Disciplinary (Curriculum 5, curriculum 6)
Teacher responsible for teaching/training activity	Prof. Lucio Pancheri
Contact e-mail	lucio.pancheri@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	2 CFU = 18 hours
Training objectives and expected learning outcomes	This course offers an introduction to the fundamentals of image sensing, from the basic principles of light detection in semiconductors to the most up-to-date imaging technologies. Although the lectures are mainly focused on image sensor IC operation and characteristics, the course is also intended to convey a general view of related system and application issues. The following topics are covered: • Fundamentals of radiation detection • Image sensors characteristics and measurement • CCD image sensors • CMOS image sensors • Color detection and color imaging • X-ray image sensors • Thermal and Thz imaging • Range image sensors At the end of the course, the student is expected to understand the operation principles and the characteristics of image sensors operating in the different regions of the electromagnetic spectrum, and to have gained the required

	background for an effective use of image sensors and their application in scientific and industrial contexts.
Prerequisites	The student should have a basic understanding of analog and digital electronics.
Bibliography	The classes will be based on slides made available by the teacher. References suggested for more in-depth study: **Books** • J. P. Theuwissen: "Solid-State Imaging with Charge-Coupled Devices", Springer, 1995 • J. R. Janescik, "Scientific charge-coupled devices", Bellingham, Wash., SPIE, 2001 • J. Ohta, "Smart CMOS image sensors and applications", CRC press, 2nd edition, 2020 • Rogalski, "Infrared detectors", CRC press, 2011 • J. Nakamura, "Image Sensors and Signal Processing for Digital Still Cameras", Taylor & Francis, 2017. **Review papers** • El Gamal and H. Eltoukhy, "CMOS Image Sensors" IEEE Circuits and Devices Magazine, Vol. 21. Iss. 3, May-June 2005 • E. R. Fossum and D. B. Hondongwa, "A Review of the Pinned Photodiode for CCD and CMOS Image Sensors," in IEEE Journal of the Electron Devices Society, vol. 2, no. 3, pp. 33-43, May 2014.
Assessment methods	Oral presentation on a theme of choice related to image sensors characteristics and applications and discussion
Activity period	2nd semester
Start date	2024/01/22
End date of activity	2024/03/24
Distance delivery information (if available)	Lectures will last 2 hours and will be conducted on the zoom platform.

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Interdisciplinary approach to the International History of Space Exploration	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: The history of space exploration is presented from the point of view of a country obliged to international cooperation because it lacks the economic and techno-scientific capabilities to proceed independently, first of all in the construction of a launcher: Italy. It thus becomes relevant to point out the stages of the international evolution of space activities in the various sectors from the observation of space from the Earth to space to satellites, from human flight to interplanetary probes up to the development of launchers and the various national space agencies. Italy thus becomes an opportunity to present how important and inevitable it is for most countries to resort to cooperation to participate in the Space Race. Some case studies will be presented starting from the 60s up to the 90s with the end of the Cold War and the start of Globalization. **Applying knowledge and understanding**: raise awareness of the opportunity to trace, thanks to historical analysis, some elements characterizing the dynamics of cooperation between States in their respective fields of application

	of space exploration. **Making judgements**: The attention to Italy, a country that emerged from poverty, to be rebuilt at the end of the War, helps a comparison with current countries in a position of inferiority in terms of development and geopolitics. Communication skills: students are invited to find some of the elements characterizing Italian spatial development presented in the lessons in some proposed documents.
Prerequisites	-
Bibliography	Some texts indicated and commented in Space Diplomacy Lab (https://www.spacediplomacy.it/) and selected from: G. Caprara, *A History of the Italian Space Adventure: Pioneers and Achievements from the XIVth Century to the Present*, Springer, 2020; J. Krige, A. Maharaj, A. Long Callahan (eds.), *NASA in the World: Fifty Years of International Collaboration in Space*, Palgrave, 2013; D. Burigana, «Air, space and techno-scientific innovation in Italian foreign policy during the 1970s and 1980s», in A. Varsori, B. Zaccaria (eds.,) *Italy in the International System from Détente to the End of the Cold War. The Underrated Ally*, Palgrave MacMillan, 2017, p. 227-251
Assessment methods	
Activity period	2nd semester (April 2026)
Start date	-
End date of activity	--
Distance delivery information (if available)	-

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Introduction to Satellite Systems

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Anna Gregorio
Contact e-mail	anna.gregorio@ts.infn.it
Venue of the training/teaching activity	University of Trieste
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: to know and master the different systems of a space mission. **Applying knowledge and understanding**: use the acquired knowledge to design a space mission. Autonomy of judgement: evaluate a choice between different solutions and manage the complexity of a space mission. **Making Judgements**: evaluating a choice between different solutions and managing the complexity of a space mission. **Communication skills**: organising space mission analysis in a proposal. **Learning skills**: collaborating in a group and knowing how to orientate oneself in new conditions.
Prerequisites	Physics and mathematics teaching in first-level science degree courses.
Bibliography	Reference text: 'Space Mission Analysis and Design' (SMAD), J.R. Wertz and W.J. Larson, 3rd edition, Space Technology Library Lecturer's notes available.
Assessment methods	In-depth seminar on a topic related to the course, to be agreed with the lecturer.

Activity period	2nd semester
Start date	2024/10/01
End date of activity	2024/12/19
Distance delivery information (if available)	Course Registered on the MS TEAMS System of the University of Trieste

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Introduction to Space and the Law: Space Risks and Insurance Law	
Academic Year	2025/2026
Year of enrolment	2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge on the discipline of risk management, also in the insurance and reinsurance field, with particular reference to space activities. At the end of the training activity, in addition to basic knowledge, they will develop personal skills in understanding, analysing and also autonomously learning certain legal profiles of space activities.

Prerequisites	-
Bibliography	To be selected close to the beginning of the course
Assessment methods	Final briefs
Activity period	2nd semester
Start date	2026/05/04
End date of activity	2026/05/29
Distance delivery information (if available)	-

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Introduction to Space and the Law 2: specific applications of SST and technology regulation. An example from Earth Observation and agriculture: mapping the regulatory framework	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant’Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours

Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge on the regulatory framework of the application of certain technologies to sustainable development objectives, thus developing personal skills in understanding the legal profiles of space activities.
Prerequisites	-
Bibliography	It will be provided during the course
Assessment methods	Collective discussion
Activity period	1st semester
Start date	2023/12/04
End date of activity	2024/01/26
Distance delivery information (if available)	-

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Introduction to Space Economy and the Law	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Andrea Taramelli Prof. Emma Schiavon
Contact e-mail	andrea.taramelli@iusspavia.it emma.schiavon@iusspavia.it
Venue of the training/teaching activity	IUSS University School for Advanced Studies of Pavia
CFU / Hours	1,5 CFU = 12 hours
Training objectives and expected learning outcomes	The course aims to provide students with an introduction to the fundamental concepts that make up the national and international space economy which is defined as the full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and using space. Students will also learn about national and international space economy business models, their evolution along the history and their effect on the national economy as well as exploring the principal factors influencing decision making and learn how to perform cost and benefit analysis of space investment. Moreover, the course will provide students with methods and tool to systematically define and measure the space economy and its constituent economic activities and valuate the economic impacts resulting from public investment in the space sector, considering effects on employment, economic growth, innovation, and competitiveness. assess the impact and sustainability of long-term investment initiatives in relation to the private sector. The course will

	also introduce students to the principles and rules of space law, including: main principles of space law, international cooperation and space governance and liability regimes. The course will deal with theories and principles of space politics and explores current political issues that Italy and the European Union must face. The course will also address the debates and challenges present in the space sector, including the dichotomy between use commercial and military space and risks and responsibilities related to space activities. The course will conclude with a focus on the main methodologies and logic for identifying user needs connected to the development of future trade missions and public spaces. The course includes lectures, group work, discussion of case studies, oral presentations, reading of articles, and the simulation of moments of management and management of projects in the space sector through role playing. At the end of the course students will be able to critically analyze national space economy dynamics and identify business models for the development of successful space economy objectives. In addition, students will be equipped with substantial knowledge to analyze current regional and global trends in relation to the evolution space law and transnational and international co-operation and competition, across both the public and private sectors. The innovative character of the course is to stimulate, the formation of innovative ideas in space policies through knowledge of legal-institutional, technical-scientific and socio-economic factors for the training of transversal skills that must interface in the different backgrounds necessary for the management of these projects.
Prerequisites	-
Bibliography	- Xiong, Xiaoxiong, Comprehensive remote sensing Shunlin Liang Volume 1: Missions and sensors / Xiaoxiong Xiong, James. J. Butler

	OECD (2022), OECD Handbook on Measuring the Space Economy, 2nd Edition, OECD Publishing, Paris, https://doi.org/10.1787/8bfef437-en **-** Gil Denis, Alain Claverie, Xavier Pasco, Jean-Pierre Darnis, Benoît de Maupeou, Murielle Lafaye, Eric Morel, Towards disruptions in Earth observation? New Earth Observation systems and markets evolution: Possible scenarios and impacts, Acta Astronautica, Volume 137, 2017, Pages 415-433, ISSN 0094-5765, https://doi.org/10.1016/j.actaastro.2017.04.034 - Tresca, Giulia, Andrea Taramelli, Riccardo De Lauretis, and Roberta Vigni. "La nuova politica spaziale europea: la missione operativa CO2." (2018): 114-119. - Harris, R., & Baumann, I. (2015). Open data policies and satellite Earth observation. *Space Policy*, *32*, 44-
Assessment methods	Students will be assigned a course project to be presented at the end of the lessons. The project will be elaborated in small groups and the presentations should be accompanied by a group thesis of around 5 pages demonstrating the understanding of the concepts and theories introduced in the course.
Activity period	2nd semester
Start date	11th June 2024
End date of activity	18th June 2024
Distance delivery information (if available)	11th June → h 14-17 12th June → h 9-12 17th June → h 14-17 18th June → h 9-12

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Introduction to statistical modeling and inference

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Dr. Nicoletta Krachmalnicoff
Contact e-mail	nkrach@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	Knowledge of the basics of Bayesian and frequentist statistics.
Prerequisites	Basic knowledge of python
Bibliography	-
Assessment methods	Oral Exam
Activity period	1st semester
Start date	2023/10/01
End date of activity	2023/11/20
Distance delivery information (if available)	-

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Introduction to the Physics of Circumterrestrial Space	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Dr. Patrizia Francia Dr. Giulia D'Angelo
Contact e-mail	patrizia.francia@univaq.it giulia.dangelo@inaf.it
Venue of the training/teaching activity	University of L'Aquila
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Knowledge of the structure and dynamics of the Earth's magnetosphere and ionosphere and ability to understand the processes underlying Space Weather phenomena. After passing the exam the student should: - have a good knowledge of the characteristics of different magnetospheric regions and understanding of the processes of solar wind-magnetosphere-ionosphere interaction; - have the ability to apply this knowledge to the identification of different magnetospheric phenomena and their origin; - have the ability to expose of the topics studied; - demonstrate ability to understand articles and texts on course topics.
Prerequisites	Knowledge of the fundamentals of general physics, particularly electromagnetism and fluid dynamics and preferably magnetohydrodynamics.

Bibliography	Slides - Gombosi, Physics of the Space Environment, Cambridge University Press (1998) - Kivelson and Russell, Introduction to Space Physics, Cambridge University Press (1992).
Assessment methods	Oral examination, during which the degree of understanding of the various topics covered in the course and the ability to expound them in a logical and coherent manner will be tested.
Activity period	2nd semester
Start date	2024/05/06
End date of activity	2024/06/21
Distance delivery information (if available)	Webex platform.

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Introduction to Theoretical Cosmology and elements of Cosmic Microwave Background Data Analysis (Theory)	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Dr. Alessandro Gruppuso
Contact e-mail	alessandro.gruppuso@inaf.it
Venue of the training/teaching activity	Italian National Institute for Astrophysics - INAF

CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The first half of the course is an introduction to theoretical cosmology, and the second half is related to data analysis. Both parts are presented with a theoretical/analytical approach. More specifically, we start from the cosmological principle and Einstein's equations and derive and solve the Friedmann-Lemaitre-Robertson-Walker equations. The standard problems of cosmology (causality and fine-tuning problems) are presented and solved by considering an inflationary phase of the expansion of the universe. Afterword the frequency spectrum of the cosmic background radiation (CMB) and its role in the development of the cosmological model are discussed. Then the anisotropies of the CMB are considered, first from a theoretical point of view and then from a data analysis point of view. The concept of the angular power spectrum is introduced and it is shown why it is the most important observable for extracting the cosmological information contained by the CMB. We then go on constructing estimators of the CMB spectrum under both ideal and realistic conditions
Prerequisites	
Bibliography	e.g. Cosmology (Daniel Baumann);
Assessment methods	Short essay or short seminar (to be agreed with the PhD students)
Activity period	-
Start date	-
End date of activity	-
Distance delivery information (if available)	-

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Ionospheric monitoring and modelling	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Claudio Cesaroni
Contact e-mail	claudio.cesaroni@ingv.it
Venue of the training/teaching activity	Istituto Nazionale di Geofisica e Vulcanologia - INGV
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	**Knowledge and understanding** Students should know: • the fundamentals equations ruling the propacarligation of EM waves through the ionosphere (Hartree-Appleton equation); • the main parameters useful to describe the morphology of the ionosphere (Total Electron Content, critical frequencies of the ionospheric layers, etc.); • the main instruments used to monitor the ionosphere (GNSS, ionosondes, in-situ instruments); • the main ionospheric models (NeQuick2, IRI). **Applying Knowledge and understanding** Students should be able to: • Infer the main ionospheric characteristics from the GNSS and ionosonde measurements

	• Discuss the status of the ionosphere looking at the data; • Infer the cause-effect relationship between the external forcing and the ionospheric perturbations **Making judgments** Students should be able to evaluate the quality of the data retrieved form the measurements **Communication skills** Students should be able to report on a topic among the ones discussed during the lessons in a 15 minutes oral presentation **Learning skills** Students should be able to learn about topics related to the ones presented during the lessons in a independent way
Prerequisites	Students should know in advance the fundamentals of Space Weather
Bibliography	Kelley, M. C. (2009). The Earth's ionosphere: Plasma physics and electrodynamics. Academic press. Mendillo, M. (2006). Storms in the ionosphere: Patterns and processes for total electron content. Reviews of Geophysics, 44(4). Nava, B., Coisson, P., & Radicella, S. M. (2008). A new version of the NeQuick ionosphere electron density model. Journal of atmospheric and solar-terrestrial physics, 70(15), 1856-1862. Bilitza, D., Pezzopane, M., Truhlik, V., Altadill, D., Reinisch, B. W., & Pignalberi, A. (2022). The International Reference Ionosphere model: A review and description of an ionospheric benchmark. Reviews of Geophysics, 60(4), e2022RG000792.
Assessment methods	Oral exam

Activity period	2nd semester
Start date	2023/09/01
End date of activity	2023/10/31
Distance delivery information (if available)	-

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Knowledge Flows in Space	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. John Krige
Contact e-mail	johnkrige@gmail.com
Venue of the training/teaching activity	Georgia Institute of Technology
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: By studying several concrete examples of international collaboration in space, the students will learn about the debates over technology transfer between the U.S and Western Europe and the U.S. and China, in space science, in the Shuttle and in launchers. This will provide them with deep insight into the geopolitical stakes involved in space collaboration, into the key actors that share or deny transnational knowledge

	flows, and into the articulation of knowledge with power in scientific and technological cooperation. **Making judgements**: students will be equipped to critically assess claims made for international collaboration in science and technology, and be able to question the costs and benefits of such programs, and of their use for science diplomacy **Communication skills**: students will be encouraged to interact verbally with the teacher, gaining confidence in learning both the technical language required to grasp technology transfer, and the ability to pose questions and discuss the stakes involved in negotiations over technology transfer, notably its scientific, industrial political and foreign policy dimensions. **Learning skills**: students will be required to grasp and comment on a number of academic texts, and to reflect critically on their structure and argument.
Prerequisites	-
Bibliography	Suggested readings: – J. Krige, “Embedding the National in the Global: U.S. – French Relationships in Space Science and Rocketry in the 1960s,” in Naomi Oreskes and John Krige, eds. Science and Technology in the Global Cold War (Cambridge: MIT Press, 2014), 237-250. – J. Krige, “A Victory for Clean Interfaces. European Participation in the Space Shuttle Program,” in Roger Launius, John Krige, and Jim Craig, eds, The Space Shuttle Legacy. How We Did It and What We Learned (Reston VA: AIAA Press, 2013), 265-282. – John Krige, ‘Regulating the Transnational Flow of Intangible Knowledge and Space Launchers between the United States and China in the Clinton era,’ in J. Krige, ed., Knowledge Flows in a Global Age (University of Chicago Press, 2022), pp. 173-200.

Assessment methods	Students will be asked to respond to 20 multiple-choice questions that will probe their understanding of the readings and their attention during the lectures.
Activity period	1st semester
Start date	2024/02/22, 10:00 a.m. – 12:00 p.m.
End date of activity	2024/02/29, 10:00 a.m. – 12:00 p.m.
Distance delivery information (if available)	-

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Laboratory of Optical Fiber Sensing	
Academic Year	2023/2024
Year of enrolment	1
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Claudio Oton
Contact e-mail	c.oton@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	2 CFU = 16 hours
Training objectives and	The course will introduce the student to different fiber-optic components and devices used for photonic sensing.

expected learning outcomes	The student will first learn how to use the most common components, such as lasers, photo-receivers and passive devices, while during the rest of the course the student will learn how to independently build an experimental set-up and how to practically perform most significant measurements of photonic sensing components, and their sensing response. The class will be sub-divided into smaller laboratory groups in order to allow significant individual work with instrumentation and components. Topics include characterization of optical fibers, light sources, passive components, spectral analysis, optical time-domain reflectometry, fiber Bragg grating sensors (FBGs), Raman/Brillouin scattering phenomena, optical gyroscopes, etc.
Prerequisites	Basic knowledge of Optics and Electromagnetism (at level of a graduate in Engineering or Physics).
Bibliography	D. Derickson, Fiber Optic Test and Measurement, Ed. Prentice Hall. Fiber Optic Sensors, Edited by S. Yin, P. B. Ruffin, F. T. S. Yu, CRC Press, 2nd Edition (2008). B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics, Ed. Wiley, 3rd Edition (2001).
Assessment methods	Lab reports
Activity period	1st semester
Start date	2023/11/15
End date of activity	2024/02/15
Distance delivery information (if available)	The course combines lab work and data analysis/report writing. The lab sessions will only be in presence. The data analysis sessions can be followed online.

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Legal Issues in AI applications in Space activities	
Academic Year	2024/2025
Year of enrolment	2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge of the regulatory framework of Artificial Intelligence and of the main legal issues related to its applications in the context of space activities. At the end of the training activity, in addition to basic knowledge, they will develop personal skills in understanding and learning, also autonomously, certain legal aspects of space activities.
Prerequisites	-
Bibliography	It will be indicated close to the course
Assessment methods	Final briefs
Activity period	2nd semester
Start date	2025/05/05
End date of activity	2025/05/30
Distance delivery information	-

(if available)	

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Legal Issues in Blockchain applications in Space activities	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant’Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge on the regulatory framework of the application of specific technologies. Basic knowledge related to the individual technology will be complemented by more mature understanding and analysis of the legal profiles of space activities.
Prerequisites	-
Bibliography	It will be identified and signposted close to the course
Assessment methods	Final briefs
Activity period	2nd semester

Start date	2024/05/27
End date of activity	2024/07/12
Distance delivery information (if available)	-

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Legal issues in data processing, in risk management, in liability models 2 (advanced)	
Academic Year	2023/2024
Year of enrolment	1^{st}, 2^{nd}
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, both through the transfer of basic and advanced knowledge and through training in individual research on certain legal profiles of space activities
Prerequisites	-
Bibliography	It will be identified during the course on the basis of the laboratory activities of the individual PhD students involved

Assessment methods	Final briefs
Activity period	2nd semester
Start date	2024/04/15
End date of activity	2024/06/28
Distance delivery information (if available)	-

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Linear Cosmological Perturbation Theory	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Carlo Baccigalupi
Contact e-mail	carlo.baccigalupi@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	The course describes the classification of cosmological perturbations in the linear regime, in general relativistic cosmology. We then move on to a discussion of their dynamics in the cosmological epochs predicted by the Standard Model.

	The first part of the course is concluded by an understanding of the statistics and shape of the power spectrum of matter, and its main quantities and associated cosmological parameters are defined. The analysis of linear cosmological perturbations is specialised to the case of a blackbody of photons, representing the cosmic background of electromagnetic radiation. One derives the Boltzmann equation governing such a system, and develops it in spherical harmonics to analyse its behaviour, with particular regard to the variables in polarisation. An integral solution of the Boltzmann equation is derived and its main properties are analysed, in terms of photon-matter decoupling, anisotropies of primary origin of cosmic radiation, and secondary anisotropies. Finally, the angular power spectrum of the anisotropies of the cosmic background radiation is derived, and its main characteristics are analysed.
Prerequisites	Notions of General Relativity, General Cosmology. Statistical Mechanics.
Bibliography	- Scott Dodelson, Modern Cosmology Kodama & Sasaki, Linear Cosmological Perturbation Theory http://ui.adsabs.harvard.edu/abs/1984PThPS..78....1K/abstract - Hu & White, CMB anisotropies, https://ui.adsabs.harvard.edu/abs/1997PhRvD..56..596H/abstract - Baccigalupi, CMB Anisotropies from Symmetric Structures https://ui.adsabs.harvard.edu/abs/1999PhRvD..59l3004B/abstract
Assessment methods	Oral Examination
Activity period	1st semester
Start date	2024/01/08
End date of activity	2024/02/19

Distance delivery information (if available)	Zoom platform

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Machine Learning	
Academic Year	2023/2024
Year of enrolment	1^{st}
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Roberta Sirovich
Contact e-mail	roberta.sirovich@unito.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	4 CFU = 32 hours
Training objectives and expected learning outcomes	Knowledge and understanding: knowledge and understanding of the learning paradigm and of the main methodologies for both regression and classification problems will be acquired. Autonomy of judgement: the ability to place a real problem in the context of the presented methodologies, to choose and critically compare the results obtained by different methods applied to the same problem will be developed. Communication skills: the ability to illustrate methodologies present in the literature and the results that can be obtained by applying them will be stimulated.

	Ability to learn: the ability to learn and rework material proposed during lectures and independently in textbooks will be stimulated.
Prerequisites	-
Bibliography	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning - with Applications in R. Second Edition. Springer 2021.
Assessment methods	The learning assessment involves the reworking of a topic not covered in the lecture with critical discussion of the performance of the methodology through a seminar.
Activity period	1st semester
Start date	2023/11/20
End date of activity	2023/12/22
Distance delivery information (if available)	The link to participate in the lectures will be made available by the individual lecturers. For the first lessons it will be https://unito.webex.com/meet/roberta.sirovich

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Management and Engineering of Space Missions	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Emanuele Pace
Contact e-mail	emanuele.pace@unifi.it

Venue of the training/teaching activity	University of Florence
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	**Level 1: Knowledge and understanding** *Learning objectives:* - Acquire a thorough knowledge of the fundamentals of space mission mnagement and engineering with particular reference to scientific payloads. - Understand theories and concepts of management as applied to the space industry. *Expected learning outcomes:* - Demonstrate a thorough understanding of space engineering and management principles. - Apply theoretical concepts to solve complex problems in the context of space missions. **Level 2: Application of knowledge and understanding** *Learning objectives:* - Apply acquired knowledge to design and manage space projects and missions. - Critically analyse challenges and opportunities in the space industry. *Expected learning outcomes:* - Demonstrate competence in applying engineering and management principles based on scientific requirements to design space mission payloads. - Critically evaluate solutions and strategies in the context of the space industry. of space missions and projects. **Level 3: Evaluation skills**

	Learning objectives: - To develop research and innovation skills in the field of space engineering and management. - Integrate multidisciplinary knowledge to address emerging challenges in the development of innovative instrumentation. *Expected learning outcomes:* - Conduct original and innovative research in the space sector. - Integrate multidisciplinary approaches to address emerging challenges in the space sector. **Level 4: Knowledge management and transfer skills** *Learning objectives:* - Develop project management and communication skills. - Transfer acquired knowledge and skills to other contexts or sectors. *Expected learning outcomes:* - Effectively manage projects and resources in the context of space missions. - Communicate clearly and transfer acquired knowledge to other contexts or sectors. **Level 5: Autonomy and responsibility** *Learning objectives:* - Promote self-learning and the assumption of professional responsibility. - Demonstrate leadership skills in the space sector. *Expected learning outcomes:* - Demonstrate autonomy in learning and deepening knowledge in the space sector. - Demonstrate leadership and responsibility in space missions and projects.

Prerequisites	-
Bibliography	1. Course slides (required) 2. ECSS - ESA (required)
Assessment methods	The doctoral student's actual acquisition of the training objectives and learning outcomes will be ascertained through an interview with the lecturer. The doctoral student will present a topic chosen from those of the course to illustrate the contents and discuss the insights gained. The discussion may range over the various topics explained during the course from the topics presented by the doctoral student.
Activity period	2^{nd} semester
Start date	2024/03/21
End date of activity	2024/04/19
Distance delivery information (if available)	21/03 Struttura di un progetto spaziale: dall'idea scientifica alla realizzazione 22/03 Fasi di sviluppo, filosofia dei modelli e qualifiche 28/03 Project management: WBS, Product tree, Risks, Schedule, Configuration, etc. 29/03 System engineering: requirements, optical, mechanical, electrical, thermal, software 11/04 Assembly, Integration & Verification management 12/04 Product and Quality Assurance 18/04 Science Ground Segment 19/04 European Cooperation for Space Standardization (ECSS-ESA) e tools di management 14.30-16.30 https://www.google.com/url?q=https://unifirenze.webex.com/unifirenze/j.php?MTID%3Dm5f1b6

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Measurements of Isotope ratios through TIMS and MC-ICPMS and applications to Geosciences	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 2, Curriculum 3)
Teacher responsible for teaching/training activity	Prof. Riccardo Avanzinelli
Contact e-mail	riccardo.avanzinelli@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	This short course aims to highlight the potential of isotope geochemistry applied to extra-terrestrial materials and terrestrial analogues, also describing the basic principles for the measurements of isotope ratios through TIMS or MC-ICPMS. Different isotopic tools can be used to understand the processes involved in the genesis and the evolution of planetary objects (e.g., geochronology, differentiation, cosmochemistry). In this context, their determination and application to scientific problems, requires the knowledge not only of their systematics, but also of the analytical procedures and methods. The students will acquire the main tools to perform and apply isotopic measurements to a multitude of scientific topics. This knowledge will be useful for the development of their scientific independence even in contexts not

	necessarily related to their specific research topics, and of their capability to conduct research activities in multi-disciplinary context in collaboration with researchers from other scientific disciplines.
Prerequisites	The students should have basic knowledge of (geo)chemistry, but no specific prerequisite are require
Bibliography	Slides and scientific papers provided by the teachers
Assessment methods	Short test at the end of the course based on multiple choice questions
Activity period	1st semester
Start date	2023/12/18
End date of activity	2023/12/19
Distance delivery information (if available)	The course will be held remotely through GoogleMeet or equivalent platform. The course consists in 2 lectures (2h each) held in two different days.

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Mechanical vibration in spacecraft design	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Daniele Bortoluzzi
Contact e-mail	daniele.bortoluzzi@unitn.it

Venue of the training/teaching activity	University of Trento
CFU / Hours	1,5 CFU = 12 hours
Training objectives and expected learning outcomes	The course collects typical topics of mechanical vibrations which are used in the design of spacecraft structures and are usually addressed in different references. Placing spacecraft or satellites into an orbit constitutes a severe test for the launch vehicle – payload system since propulsion, aerodynamics, acoustic and shock loads interact with their overall dynamic characteristics and introduce mechanical vibrations which can affect their functionality or even integrity. The design of spacecraft, payloads and their interfaces must consider their structural response under the action of forces of different nature. Knowledge and understanding. The student will be able to understand the phenomena ruling the dynamic response of a spacecraft structure subjected to the typical launch environment Applying knowledge and understanding. The student will be able to build models to predict the critical behavior of spacecraft, subsystems and equipment in the launch environment. The students will be able to define design requirements in order to limit the criticalities of the dynamic response of the system. Making judgements. The student will be able to make critical assessments on the potential risks involved in a given launch configuration and propose design guidelines to limit them. The same considerations may apply in general to a mechanical system subjected to a dynamic environment which may significantly affect its integrity. Communication skills. The student will be able to present and discuss a project where the dynamic response of a complex mechanical system is investigated. Learning skills. The student will have the knowledge to understand and apply typical methods of mechanical system design and verification (e.g. ECSS).

Prerequisites	Fundamentals of mechanics and mechanical vibration. Fundamentals of Fourier and Laplace transforms.
Bibliography	S. Rao, Mechanical vibration, Prentice Hall L. Meirovitch, ELEMENTS OF VIBRATION ANALYSIS, McGRAW-HILL INTERNATIONAL EDITION Mechanical Engineering Series Mechanical Vibrations in Spacecraft Design, Jaap Wijker, Springer-Verlag Berlin Heidelberg GmbH Space engineering Spacecraft mechanical loads analysis handbook, ECSS-E-HB-32-26A, ECSS Secretariat ESA-ESTEC Requirements & Standards Division, Noordwijk, The Netherlands
Assessment methods	Evaluation of a project work, possibly related to the PhD research topic, presented and discussed as an oral presentation.
Activity period	1st semester
Start date	2024/02/13
End date of activity	2024/02/23
Distance delivery information (if available)	By means of Zoom platform

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Mineralogy and Petrology of Meteorites	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3)

Teacher responsible for teaching/training activity	Prof. Giovanni Pratesi
Contact e-mail	giovanni.pratesi@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The course aims to illustrate the main mineralogical-petrographic characteristics of meteorites and provide an overview of their classification. Educational objectives include educating students about the importance of mineralogy and petrology for the study of planetary bodies and for understanding the processes that have occurred in the Solar System since its earliest stages. At the end of this course, students will be able to recognize the mineralogical and petrographic characteristics of the different meteorite classes and apply this knowledge, for example, to the characterization of extraterrestrial environments through the analysis of meteorite specimens.
Prerequisites	-
Bibliography	Monica Grady, Giovanni Pratesi, Vanni Moggi Cecchi (2014). Atlas of meteorites. Cambridge University Press.
Assessment methods	Students will prepare a brief report on an article of their choice illustrating the classification of a meteorite.
Activity period	1st semester
Start date	07/10/2024
End date of activity	14/10/2024
Distance delivery information (if available)	Google Meet 07/10/2024 – 9am to 1pm 14/10/2024 – 9am to 1pm

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Mission Design	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Luca De Rosa
Contact e-mail	luca.derosa@imexa.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	**Knowledge and Understanding**. Introduction to space engineering and mission and spacecraft design. Introduction to the space environment. Introduction to human factors and space medicine. Thermal control. Environmental control system and life support. Orbit design and astrodynamics. Structures and mechanisms. Attitude and orbital control system. Propulsion system. Electrical power system. Ground segment. Communication system. On-board computer. Payload and experiments. **Applying knowledge and understanding**. Ability to define the preliminary characteristics of space missions and to preliminarily design spacecraft. **Making judgements**. At the end of the course, the doctoral student must acquire autonomy in defining the preliminary characteristics of a mission and a spacecraft.

	Communication skills. At the end of the course, the doctoral student should be able to communicate ideas, definitions, information, data, results, problems and solutions in written and oral form to specialists as well as non-specialists. **Learning skills.** The PhD student will develop the method necessary to optimally acquire information useful for the course of study and subsequent work activities.
Prerequisites	A knowledge of physics and mathematics at university level is necessary.
Bibliography	**Essential bibliography:** 1) Slides provided by the lecturer; 2) J. R. Wertz, W. J. Larson, Space Mission Analysis and Design **Recommended bibliography:** 1) C. D. Brown, Elements of Spacecraft Design; 2) P. Fortescue, J. Stark, Spacecraft Systems Engineering; 3) A. C. Tribble, The Space Environment - Implications for Spacecraft Design
Assessment methods	After the end of the course, the PhD student will be required to carry out the preliminary design of a spacecraft potentially suitable for a specific mission defined by the lecturer.
Activity period	1st semester
Start date	2023/11/27
End date of activity	2023/12/19
Distance delivery information (if available)	It will be possible to follow the course remotely via Zoom or similar platform

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Multisensory perception in Microgravity	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Massimiliano Zampini
Contact e-mail	massimiliano.zampini@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	The goal of this advanced course is to introduce the students to the current research topics in the field of multisensory perception in microgravity condition. The course purports to promote active learning and participation. At the end of the course, the students should be able to: • analyze critically the scientific literature on the topic.
Prerequisites	-
Bibliography	Handouts of the lectures and a list of readings will be made available online on the website of the course.
Assessment methods	Oral interview
Activity period	2nd semester
Start date	Thursday, March 14th, from 2 pm to 4 pm

End date of activity	Thursday, March 21st, from 2 pm to 4 pm
Distance delivery information (if available)	-

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Nonlinear Hybrid Dynamical Systems	
Academic Year	2025/2026
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Luca Zaccarian
Contact e-mail	luca.zaccarian@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	This course will provide the student with the fundamental tools behind the recent framework developed by Goebel, Teel and Sanfelice for the description of hybrid dynamical systems. The course will begin with a brief overview of the essential results behind Lyapunov-based nonlinear continuous-time dynamical systems analysis (a good reference for this may be Hassan Khalil's "Nonlinear Systems" book by Prentice Hall). The continuous-time results will be used as a track to follow when introducing the corresponding generalized notions for hybrid dynamical systems: solution concepts, asymptotic stability, Lyapunov functions and invariance principles. Several examples

	will be given during the course to motivate the mathematical tools that will be progressively introduced. The majority of the course will be based on the recently published book: "Hybrid Dynamical Systems: Modeling, Stability, and Robustness, Princeton University Press", which will also serve as a reference for the course material. During the course we will also illustrate how the simulation of hybrid systems can be performed in a Matlab environment with suitable tools. The last lectures will address some recent research activity on two control-related topics where the hybrid tools introduced in the course will be useful.
Prerequisites	Basics of control theory. Linear Algebra, Calculus. Some basic understanding of nonlinear dynamics (differential equations, difference equations).
Bibliography	Goebel, R., Sanfelice, R. G., & Teel, A. R. (2009). Hybrid dynamical systems. IEEE control systems magazine, 29(2), 28-93. Goebel, R., Sanfelice, R. G., & Teel, A. R. (2012). Hybrid Dynamical Systems: Modelling, Stability, and Robustness. Princeton University Press
Assessment methods	The final evaluation will be carried out based on the preparation of an individual project.
Activity period	1st semester
Start date	2025/09/01
End date of activity	2025/09/30
Distance delivery information (if available)	-

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Observations of the sun from space

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Marco Romoli
Contact e-mail	marco.romoli@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: Have demonstrated a systematic understanding of The Sun (intro). The physics of the solar corona and the heliosphere. Space instruments for the Sun's observation: remote sensing instruments: doppler-magnetographs, disk imagers, coronagraphs, heliospheric imagers. In situ instrumentation: solar wind analysers, high energy particle analysers, Magnetic and electric field measurements. **Applying knowledge and understanding**: demonstrated through devising and sustaining arguments and solving problems within the field of the course **Making judgements:** have the ability to gather and interpret relevant data within the field of the course **Communication skills**: can communicate with their peers, the larger scholarly community and with society in general about there areas of expertise, obtained by means of the final evaluation **Learning skills**: have developed those learning skills that are necessary for them to continue to undertake further study in the field of the course with a high degree of autonomy
Prerequisites	Basic courses in physics and astrophysics. Basic knowledge of radiative processes and radiative transfer.

Bibliography	E. Landi Degl'Innocenti, Fisica solare, Springer Verlag, 2007 D. J. Mullan, Physics of the Sun: A First Course, 2nd Edition, CRC Press, 2022 Lectures' slides Suggested papers
Assessment methods	20 minutes seminar on a subject chosen by the student based on one or more papers suggested by the teacher
Activity period	2nd semester
Start date	2024/05/01
End date of activity	2024/06/16
Distance delivery information (if available)	The course will be delivered using the google meet platform and sharing slides and a blackboard.

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Observing Space from Space	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1 and Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Andrea Tiengo
Contact e-mail	andrea.tiengo@iusspavia.it
Venue of the training/teaching activity	University School for Advanced Studies Pavia - IUSS

CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Students enrolled in this course will: - Understand the fundamental reasons behind the construction of astrophysics space missions. - Analyze various examples of such missions, focusing on onboard instrumentation and significant scientific results. - Assess the scientific implications and potential discoveries associated with past, ongoing or planned space missions. - Engage in a simplified role-playing exercise simulating the ideation, construction, and selection process of space missions. Specifically, they will design a "virtual" X-ray astrophysics mission within predefined budget constraints, assembling components from real satellites to achieve specific scientific objectives. Upon completion of this course, students are expected to demonstrate: *1. Knowledge and Understanding:* - A comprehensive understanding of the motivations driving astrophysics space missions and of the main characteristics of the onboard instrumentation. - In-depth knowledge of various real-world space missions and their scientific contributions. *2. Applying Knowledge and Understanding:* - Apply their knowledge to analyze and solve problems related to the design and execution of astrophysics space missions. - Propose creative solutions within budget constraints to achieve specific scientific objectives. *3. Making Judgments:* - The capacity to assess the feasibility and scientific relevance of proposed mission designs within budget

	constraints. - Making informed judgments about the potential success of a space mission based on scientific objectives and available technology. *4. Communication Skills:* - Effective communication of complex ideas related to space missions in oral presentations. - Demonstrating proficiency in articulating scientific concepts and mission proposals to a diverse audience. *5. Learning Skills:* - Developing problem-solving skills by engaging in a simulated mission planning exercise. - Enhancing learning skills through collaborative and creative thinking, adapting to changing mission requirements and constraints.
Prerequisites	-
Bibliography	Scientific papers, documents, websites and the teacher's slides will be made available at the end of each lecture.
Assessment methods	The exam will consist in the oral presentation of the designed virtual mission, articulating the scientific rationale, technical aspects, and budget considerations. The students will present the various aspects of their space mission, as if in front of a selection committee from a space agency. Each of them will be evaluated based on the originality and coherence of the mission they have developed and the knowledge they demonstrate to have learned and critically processed during the course.
Activity period	2nd semester
Start date	2024/02/27
End date of activity	2024/03/21
Distance delivery information	Zoom link: https://iusspavia.zoom.us/my/andrea.tiengo

(if available)	

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Optical Fiber Sensor Systems	
Academic Year	2023/2024
Year of enrolment	1
Didactic Unit Type	Multi-disciplinary / Disciplinary (Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Fabrizio Cesare Filippo Di Pasquale
Contact e-mail	f.dipasquale@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The course, after providing the basic concepts of optical components, will focus on the main fiber optic sensing technologies This area attracts considerable interest as fiber optic photonic sensing technologies, capable of measuring.
Prerequisites	University courses in physics
Bibliography	1. G.P. Agrawal, "Fiber-Optic Communication Systems", Wiley-Interscience 2002.
Assessment methods	Oral Examination
Activity period	2nd Semester
Start date	2024/03/05

End date of activity	2025/05/31
Distance delivery information (if available)	In the event of mutualisation with other educational initiatives, online meetings will be organised using the CISCO webex system or other

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Optical microscopy analysis of meteoritic material	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3)
Teacher responsible for teaching/training activity	Prof. Giovanni Pratesi
Contact e-mail	giovanni.pratesi@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	The course consists in lesson with observation and discussion on the mineralogical and textural features of not equilibrated, equilibrated, and differentiated meteorites. At the end of the course, students will acquire a detailed knowledge of the mineralogical and textural characteristics of meteorites that they can successfully apply in the study of planetary geology and mineralogy.
Prerequisites	Basic knowledge of mineralogy and petrology.
Bibliography	Grady Monica, Pratesi Giovanni, Moggi Cecchi Vanni (2014). Atlas of meteorites. Cambridge University Press.

Assessment methods	A brief report on an article of students' choice illustrating the textural and mineralogical features of a meteorite.
Activity period	2nd semester
Start date	21/10/2024
End date of activity	21/10/2024
Distance delivery information (if available)	The course will be held **in person** at the Italian Museum of Planetary Science (Prato) on Oct. 21 from 9 a.m. to 1 p.m.

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Optics	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Maria Grazia Pelizzo
Contact e-mail	pelizzo@dei.unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	Basic knowledge in geometric and wave optics. Theory of aberrations. Sizing of an optical system. Performance verification through ray-tracing simulations and figures of merit. Imaging systems and telescopes, with examples of applications in space missions. Spectrographs and examples of applications in space missions. The theoretical

	part is followed by 10 hours of activities involving the design and simulation of simple imaging systems, reflectors and catadioptrics, using ray-tracing software.
Prerequisites	Elements of general physics, such as electromagnetism and possibly optics.
Bibliography	Materials provided by teachers.
Assessment methods	Written test with open questions.
Activity period	1st semester
Start date	2024/02/01
End date of activity	2024/02/29
Distance delivery information (if available)	Zoom platform

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Oral History, Video Interviews on Space Diplomacy in cooperation with the Historical Archives of European Union (Firenze)	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it
Venue of the training/teaching	University of Padua

activity	
CFU / Hours	0.5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: The interview technique will be presented, also online, as a tool for historical reconstruction. **Applying knowledge and understanding**: The treatment of the video interview, its cataloguing, and its use for historical-internationalist research will also be presented. *Making judgements*: The identification of critical points, of important elements in the CV of a witness and the consequent organization of a structure of questions, of a path for the interview. **Communication skills**: How to communicate to colleagues the importance of leaving their testimony to allow them to fill the gaps in the archive documentation, to reconstruct relational dynamics and practices that cannot result from documents alone.
Prerequisites	-
Bibliography	Some examples of interviews (videos and audio) provided by the Padua University Research Unity (PIN 2022) to be stocked at Historical Archives of EU commented in Space Diplomacy Lab (https://www.spacediplomacy.it/), and which can be downloaded from.
Assessment methods	On the basis of a list of some witnesses, each PhD student will be assigned one for which to reconstruct the Curriculum and carry out the video interview which will be deposited in the Historical Archives of the EU.
Activity period	2nd semester (June 2026)
Start date	-
End date of activity	-
Distance delivery information	-

(if available)	

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Photonic Integrated Circuits	
Academic Year	2023/2024
Year of enrolment	1
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Claudio Oton
Contact e-mail	c.oton@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advances studies - Pisa
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	This course will introduce integrated optical devices and circuits. Emphasis will be on the simulation and design of Silicon-based passive integrated devices (e. g., directional couplers, multimode interference couplers, ring resonators, Mach-Zehnder interferometers, edge and grating couplers), exploiting both analytic and numerical techniques. Front lectures will be complemented with exercises using Lumerical and Matlab/Python software. In detail the course will include the following topics: Introduction to integrated photonics; waveguide design: Slab waveguide and Rectangular waveguide; Numerical tools for photonic integrated circuits; Mode solver Propagator / FDTD; Circuit solver; Optical I/O; Grating coupler; Edge coupler; Couplers and splitters; Directional coupler; Y branch; Multimode interference coupler; Ring resonators; Mach-Zehnder interferometers.

Prerequisites	-
Bibliography	• C. Pollock, M. Lipson, "Integrated Photonics," Springer • Amnon Yariv, Pochi Yeh, "Photonics: Optical Electronics in Modern Communications", Oxford University Press 2007 • Ginés Lifante, Integrated Photonics: Fundamentals, Wiley, 2003 • L. Chrostowski, "Silicon Photonics Design", Cambridge University Press
Assessment methods	Assignments and oral exam
Activity period	2nd semester
Start date	2024/04/01
End date of activity	2024/06/30
Distance delivery information (if available)	The course can be taken online.

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Physiological Adaptations to Microgravity and High Altitude	
Academic Year	2023/2024
Year of enrolment	1st, 2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Luigi Cattaneo
Contact e-mail	luigi.cattaneo@unitn.it
Venue of the training/teaching	University of Trento

activity	
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The general educational objective is to provide the student with a conceptual framework on normal human physiology and the consequences of microgravity on it.Particularly, the teaching will be but conceptually-oriented rather than notion-oriented. At the end of the course, the student must possess the fundamental notions of cardiovascular physiology, the physiology of gas exchange, the physiology of the sense of balance and the physiology of the musculoskeletal system. Students will have to know which pathological changes occur in these systems in conditions of microgravity, hypoxia and the return to Earth's gravity and what the physiological adaptations to these alterations are.
Prerequisites	-
Bibliography	No text is necessary for the course, but the following text is advised for in-depth follow-up studying: Vander's Human Physiology: The Mechanisms of Body Function 12th Edition
Assessment methods	Students will be asked to write a short essay (300-500 words) on one of the topics of the course. The work will be due in 15 days from the assignment.
Activity period	2nd semester
Start date	2024/03/01
End date of activity	2024/05/31
Distance delivery information (if available)	The course will be entirely held in synchronous remote modality on a videoconferencing platform.

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Planetary Geology	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Lucia Marinangeli
Contact e-mail	lucia.marinangeli@unich.it
Venue of the training/teaching activity	“Gabriele d’Annunzio” University – Chieti-Pescara
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	The course aims to provide basic information on the geology of terrestrial planets and the techniques used to recostruct the geological evolution. (descriptor 1) The students will understand the comparative approach in analysing the different geological characteristics of planetary bodies which can help to better focus the research objectives of their thesis developed likely under curriculum 3. (descriptor 2) Furthermore, the students will acquire specific geological terminology which can help in comunicating science research in interdisciplinary teams as common practise in planetary exploration as well as in scientific conferences. (descriptors 3-5)
Prerequisites	-
Bibliography	The lectures material with specific bibliographic references will be provided to the students during the course.

Assessment methods	On-line test
Activity period	1st semester
Start date	2024/01/19
End date of activity	2024/01/29
Distance delivery information (if available)	-

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Plasma physics around astrophysical compact objects	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Dr. Elena Amato
Contact e-mail	elena.amato@inaf.it
Venue of the training/teaching activity	Gran Sasso Science Institute - GSSI
CFU / Hours	1,5 CFU = 12 hours
Training objectives and expected learning outcomes	At the end of the course the student will be familiar with the electrodynamics of compact objects, with the equations of relativistic magnetohydrodynamics, with the main mechanisms of particle acceleration in astrophysics, and with the modelling of the evolution of astrophysical sources of non-thermal radiation. The

	student will be able to apply the knowledge acquired to sources other than those directly treated in the course, exporting, for example, the mechanism of unipolar induction from the magnetospheres of neutron stars to the description of the electrodynamics of black holes, and relativistic magnetohydrodynamics from the field of pulsar wind nebulae to sources such as gamma-ray bursts or jets of active galaxies. The knowledge provided by the course offers useful tools for dealing with the vast majority of high-energy astrophysical sources.
Prerequisites	The background provided by a degree course in physics or astronomy is sufficient. It is useful to have taken courses in plasma physics and to be familiar with non-thermal emission processes.
Bibliography	- Varenna Proceedings - Course 208 "Foundations of Cosmic Ray Astrophysics": Particle Acceleration in Pulsars and Pulsar Wind Nebulae - Astrofisica delle Alte Energie by Mario Vietri, 2006, Bollati Boringhieri, ISBN 9788833957739 - Theory of Neutron Star Magnetospheres, 1990, Chicago University Press, IDSBN 9780226523316
Assessment methods	Oral examination. The student prepares a presentation on a topic of his/her choice that demonstrates mastery of the knowledge acquired during the course, and possibly the ability to export it to physical sources/processes not directly covered; the examination committee reserves the right to interrupt the presentation at any time with follow-up questions.
Activity period	2ns semester
Start date	2024/04/15
End date of activity	2024/05/31
Distance delivery information (if available)	A zoom connection (by GSSI) will be available to follow the course remotely

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Polymers and Composites	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Dr. Emanuele Alberto Slejko
Contact e-mail	emanuelealberto.slejko@cnr.it
Venue of the training/teaching activity	National Research Council - CNR
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Knowledge on common and advanced polymers for aerospace applications Comprehension of the limits in the use of polymer materials in space Understanding the properties and characteristics of composite materials Knowledge on the basic principles of multi-objective materials selection
Prerequisites	Basic knowledge on materials properties and mechanics of solids
Bibliography	Introduction to aerospace materials, ed Mouritz (chapters 13 and 15) Materials selection in mechanical design by Ashby (chapter 5) Slides of the course

Assessment methods	Oral evaluation on a simple materials selection problem regarding polymers or composites
Activity period	2^{nd} semester
Start date	2024/03/01
End date of activity	2024/05/31
Distance delivery information (if available)	-

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Posters and Oral Presentations	
Academic Year	2023/2024
Year of enrolment	1^{st}
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Prof. Stefania Federici
Contact e-mail	stefania.federici@unibs.it
Venue of the training/teaching activity	University of Brescia
CFU / Hours	1 CFU = 8 hours
Training objectives and	**Knowledge and Understanding**

expected learning outcomes	- Acquire an understanding of oral and poster presentation techniques in scientific disciplines - Deepen your knowledge of the fundamentals of visual and verbal communication for engaging presentations **Applying Knowledge and Understanding** - Develop practical skills in organising and designing oral and poster presentations - Applying effective communication strategies to convey complex ideas clearly and persuasively during presentations **Making Judgements** - Critically evaluate oral and poster presentations, identifying strengths and areas for improvement in both own and colleagues' work - Developing the ability to make informed decisions on the choice of presentation tools best suited to specific academic contexts **Communication Skills** - Improve oral communication, including effective time management, clarity of presentation and the ability to respond to questions in an articulate manner - Refine skills in designing eye-catching posters, with a focus on visual organisation and effective use of graphic elements **Learning Skills** - Promoting the ability to learn continuously, encouraging self-assessment and critical reflection on one's presentation performance - Developing self-improvement strategies and awareness of the importance of feedback in the growth of presentation skills

	The expected learning outcomes can be summarised as: - Design and deliver effective oral and poster presentations, - Critically evaluate presentations and integrate constructive feedback, - Apply advanced communication skills, demonstrating clarity, persuasiveness and adaptability in academic contexts, - Use self-assessment strategies to identify and improve one's presentation skills over time, - Demonstrate independent judgement in choosing the most appropriate presentation methods for specific needs.
Prerequisites	Demonstrate genuine interest and commitment to actively participate in course activities, as active participation is crucial for success.
Bibliography	-
Assessment methods	During the examination phase, you will be asked to prepare a poster presentation on a topic of interest, or give an oral presentation on a topic of interest.
Activity period	2nd semester
Start date	2024/03/01
End date of activity	2024/03/15
Distance delivery information (if available)	The course is delivered **exclusively in presence**.

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Principles of Astrobiology	
Academic Year	2023/2024

Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 3)
Teacher responsible for teaching/training activity	Dr. John Brucato
Contact e-mail	john.brucato@inaf.it
Venue of the training/teaching activity	Istituto Nazionale di Astrofisica - INAF
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Astrobiology deals with the study of the origin, evolution and distribution of life in the Universe, a scientific topic that in recent years has been attracting increasing interest from the international scientific community. Astrobiology is a multidisciplinary science that benefits from the knowledge and skills that come from disciplines until now considered to belong to distinct areas such as biology, chemistry, astronomy, geology, planetology, and genetics. The study of the birth of life on Earth and the search for signs of life in space are topics which, in addition to exercising great fascination, above all represent an important direction that current science wants to undertake to seek answers to questions that have always accompanied the man. The goals that astrobiology aims to achieve will allow us to open up new horizons of research and technological development in the biological, genetic, chemical and astrophysics fields in the coming years. Life on Earth is directly linked both to the origin and evolution of the Solar System and to the initial conditions present in the molecular cloud from which our Solar System originated. Life, as it is known on Earth, is governed by complex reactions based on carbon chemistry, likely the result of the interaction of organic molecules and inert

	material from space. It is therefore important to have knowledge both on the chemical-physical mechanisms of synthesis and evolution of organic matter in space environments and knowledge of the nature of extraterrestrial material (meteorites, interplanetary dust particles or samples brought back to earth by space missions). Another important aspect is being able to identify the chemical paths that organic material follows in the interstellar medium, its evolution in protoplanetary disks and, finally, how this material was incorporated into the formation of Solar System objects. Once formed, a planetary system will have characteristics such that it can contain regions of habitability in which life can originate and proliferate. Therefore, the study of extrasolar planets and detection methods will be addressed. Today it is possible to have a detailed chronology of the extraordinary and complex evolutionary history of life, punctuated by violent catastrophes. What factors caused the appearance of only three domains of life? What conditions on planet Earth led to the appearance of eukaryotes? How can we detect signs of life in other environments of space? This course aims to provide a basic understanding of the central problems of astrobiology, allowing you to integrate knowledge of astrophysics with that of chemistry and biology.
Prerequisites	Basic knowledge of physics, chemistry and biology is required
Bibliography	- I. Gilmour and M. Sephton: An Introduction to Astrobiology - C. Cockell Astrobiology: Understanding Life in the Universe J. Lunine: Astrobiology - G. Horneck and P. Rettberg: Complete Course in Astrobiology - D.C.B. Whittet: Dust in the Galactic Environment - F. Dyson: Origin of Life

Assessment methods	The evaluation will take place through an oral exam aimed at ascertaining the knowledge acquired by the student on the topics covered during the course
Activity period	2nd semester
Start date	2024/03/04
End date of activity	2024/03/24
Distance delivery information (if available)	-

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Properties and selection criteria for materials used in aerospace applications	
Academic Year	2023/2024
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Alessandro Pegoretti Prof. Stefano Gialanella
Contact e-mail	alessandro.pegoretti@unitn.it stefano.gialanella@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	2 CFU = 16 hours
Training objectives and	The Course provides the main tools for the selection of materials and relevant processing routes, for aerospace

expected learning outcomes	applications, referring to specific case studies. The design driven process is based on the identification of those materials properties which better satisfy specified service requirements and that will be discussed during the Course lectures. At the end of the Course, students will be able to select the best material candidates for designing aerospace structures and systems.The background of the Students accessing the Space Science and Technology Doctoral School is adequate to follow this Course.
Prerequisites	The background of the Students accessing the Space Science and Technology Doctoral School is adequate to follow this Course.
Bibliography	- M.F. Ashby, H. Shercliff, D. Cebon – Materials. Engineering, Science, Processing and Design - M.F. Ashby, Materials Selection in Mechanical Design, Fifth Edition, Butterworth-Heinemann (2017)
Assessment methods	Oral exam in the form of a seminar on a topic of the Course program.
Activity period	2nd semester
Start date	-
End date of activity	-
Distance delivery information (if available)	The Course is going to be given on site and online, using the Zoom platform.

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Radar and Multispectral Sensors in Earth Observation and Planetary Exploration	
Academic Year	2023/2024

Year of enrolment	1^{st}, 2^{nd}, 3^{rd}
Didactic Unit Type	Disciplinary (Curriculum 2, Curriculum 3, Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Lorenzo Bruzzone
Contact e-mail	lorenzo.bruzzone@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Overview on planetary and Earth observation missions. Basics of passive remote sensing: EM spectrum; elements of radiation theory; radiation properties of Earth, Sun and celestial bodies; transmittance and diffusion in the atmosphere. Spectral signature. Spectral regions used in passive and active remote sensing. Taxonomy of instruments. Multispectral scanners: principles; scanning modes; geometrical, spectral and radiometric resolutions; A/D conversion and digital multispectral images. Hyperspectral scanners: principles; spectral resolution. Basics of radar theory: principles; radar equation; radar cross section and backscattering coefficient. Radar for imaging: ambiguity; acquisition geometry; side-looking radar; geometric distortions. Geometric resolution: slant-range, ground range and azimuth resolution. Image construction and speckle. Overview of satellite missions with multispectral, hyperspectral and radar systems for Earth observation. Ground penetrating radar (GPR) and radar sounders: definitions and basic principles. Acquisition process. Propagation in dielectric media and attenuation. Reflection, transmission and velocity of propagation in the media. Clutter. Geometrical resolutions and penetration. Examples of real systems: MARSIS (Mars Express), SHARAD (MRO), RIME (JUICE) and SRS (EnVision).

Prerequisites	-
Bibliography	Course slides
Assessment methods	Presentation on in-depth course content
Activity period	2nd semester
Start date	2024/06/01
End date of activity	2024/07/31
Distance delivery information (if available)	Via Zoom platform

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Radiative Processes in Astrophysics	
Academic Year	2024/2025
Year of enrolment	1
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Dr. Francesca Perrotta
Contact e-mail	perrotta@sissa.it
Venue of the training/teaching activity	SISSA – Scuola Internazionale Superiore di Studi Avanzati
CFU / Hours	2 CFU = 16 hours
Training objectives and	At the end of the course, the student should be able to know the physical mechanisms of the main radiative

expected learning outcomes	processes in astrophysics, both in terms of continuous emission signals and emission of lines
Prerequisites	General Physics. Restricted Relativity. Thermodynamics. Quantum mechanics. Elements of statistical physics.
Bibliography	1. G.R. Rybicki, A.P. Lightman, "Radiative Processes in Astrophysics" Additional teaching materials will be provided to students following the course.
Assessment methods	Preparation will be assessed through a written examination with numerical problems and theoretical and interpretative questions
Activity period	1st semester
Start date	October 2024
End date of activity	November/December 2024
Distance delivery information (if available)	-

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Research and learning laboratory on ESA historical Archives (1960s-2005) and on EU Space, Science and Technology with the Historical Archives of European Union (Firenze)	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it

Venue of the training/teaching activity	University of Padua
CFU / Hours	0.5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: Starting from their research, the students will choose a "historical" case study to analyze through the documents of the ESA Archives. In addition to the teacher, they will be followed by the archivists of the HAEU who will present the research tools and the funds of the documents preserved in the HAEU. The richness of the archives makes it possible to carry out cross-research concerning space activities using the funds of the European institutions - Commission, Council, Parliament, Court, Agencies - and private papers, as well as oral history series. **Applying knowledge and understanding**: Know and use a historical archive as a source for the present. Making judgements: how to analyze an archival source (document, photo, video, audio) and how to classify it for preservation and communication; Students will be asked to propose mission data as an archive source starting from the ESA historical data portal. **Communication skills**: The importance of memory, preservation of documents and reconstruction of the past; how to communicate it to the younger generations and the scientific community.
Prerequisites	-
Bibliography	Some examples of archival sources (documents, photos, videos, audio) provided by the EU Historical Archives and briefly commented in Space Diplomacy Lab (https://www.spacediplomacy.it/), and which can be downloaded from.
Assessment methods	Students will be asked to produce a PowerPoint presentation of of an archive source (document, foo, video, audio and mission data)

Activity period	2nd semester (May 2026)
Start date	-
End date of activity	-
Distance delivery information (if available)	-

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Robotics	
Academic Year	2024/2025
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Stefano Seriani
Contact e-mail	sseriani@units.it
Venue of the training/teaching activity	University of Trieste
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The course will give students knowledge about the field of robotics, including manipulation and mobile robotics. The main areas of the state-of-the-art will be described and implementation aspects will be discussed together with examples and use-cases. Kinematic analysis and models for industrial robots and mobile robots will be covered in detail.

	Knowledge and understanding: The student will have to know the basic principles of operation of robots, their functionalities and the mechanical components that are part of them. Students shall demonstrate knowledge and the ability to comprehend new concepts in the field of robotics. **Applying knowledge and understanding**: The student shall be able to apply their knowledge in order to demonstrate the ability to discuss and to cope with problems in the field of robotics at large. **Making judgements**: The student should be able to assess what automation strategies to adopt in order to perform a given function. The student shall be able to collect and interpret information in the field of robotics and mechatronics and employ them with the goal of making reasoned decisions in other fields. **Communication**: The student shall demonstrate their ability to constructively discuss topics related to the field of robotics and to propose meaningful arguments. **Lifelong learning skills**: The student must be able to interpret and use technical manuals to program a robot. The student shall have acquired learning and deductive skills that will enable them to perform well both in the area of research and development and in the industry.
Prerequisites	Geometry, Matematical analysis
Bibliography	- Robotica - Modellistica, pianificazione e controllo. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo - Robotics Authors: Mihelj, M., Bajd, T., Ude, A., Lenarčič, J., Stanovnik, A., Munih, M., Rejc, J., Šlajpah, S. Springer

	edition - Introduction to Autonomous Mobile Robots. R. Siegwart, I.R. Nourbakhsh
Assessment methods	The candidate will deliver a short presentation regarding on a topic related to the field of robotics. The topic shall be approved by the teacher.
Activity period	1st semester
Start date	2024/11/04
End date of activity	2024/11/11
Distance delivery information (if available)	Microsoft Teams Students will receive a link to the lectures.

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Saturated Control Systems	
Academic Year	2024/2025
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Luca Zaccarian
Contact e-mail	luca.zaccarian@unitn.it
Venue of the training/teaching activity	University of Trento

CFU / Hours	2 CFU = 18 hours
Training objectives and expected learning outcomes	The magnitude of the signal that an actuator can deliver is usually limited by physical or safety constraints. This limitation can be easily identified in most common devices used in the process industry, such as proportional valves, heating actuators, power amplifiers, and electromechanical actuators. Common examples of such limits are the deflection limits in aircraft actuators, the voltage limits in electrical actuators and the limits on flow volume or rate in hydraulic actuators. While such limits obviously restrict the achievable performance, if these limits are not treated carefully and if the relevant controllers do not account for them appropriately, peculiar and pernicious behaviors may be observed (aircraft crashes, Chernobyl nuclear power station meltdown). This course addresses stability analysis and stabilization of linear systems subject to control saturation. We will discuss a first approach consists in designing a (possibly nonlinear) controller directly accounting for the saturation constraints. Then we will present the so called anti-windup approach, where an anti-windup augmentation is inserted on an existing control system which "winds up" (performs undesirably) due to actuator saturation. The anti-windup feature is then to preserve the predesigned controller before saturation is activated and to recover stability for larger saturated responses. Anti-windup solutions differ in architecture and performance achievements. We will discuss several architectures suited for different saturation problems. Simulations and a few applications will be used to illustrate the presented techniques.
Prerequisites	Basics of Linear Algebra, Calculus, Basics of Control Theory.
Bibliography	Tarbouriech, S., Garcia, G., da Silva Jr, J. M. G., & Queinnec, I. (2011). Stability and stabilization of linear systems with saturating actuators. Springer Science & Business Media. L. Zaccarian and A.R. Teel. Modern anti-windup synthesis: control augmentation for actuator saturation. Princeton University Press, Princeton (NJ), 2011.

Assessment methods	The final evaluation will be carried out based on the preparation of an individual project.
Activity period	1st semester
Start date	2024/04/15
End date of activity	2024/04/19
Distance delivery information (if available)	-

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Science Diplomacy: Definition and Practice	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Pierre-Bruno Ruffini
Contact e-mail	pierre-bruno.ruffini@univ-lehavre.fr
Venue of the training/teaching activity	University of Milan
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	As a first approach, science diplomacy refers to a large array of professional practices at the intersection of diplomacy (the implementation of a state's foreign policy through privileged ways of mediation and negotiation) and science (understood as the activity of research, all disciplines taken together, and the incorporation of its

	results into technology). The rationale of science diplomacy is twofold: from a state's perspective, science diplomacy is a subset of the State's foreign policy and a strategy for advancing its interests and needs; from a global perspective, science diplomacy is perceived as a potential solution for tackling science-intensive global challenges. Interest in science diplomacy is recent. It is not as such an academic subject, although its study draws much on two disciplinary fields: international relations, due to the emphasis put on foreign policy, and science studies, which seek to situate science in the broader context of society. The purpose of this course is to give an introduction to science diplomacy, by presenting and discussing the state of the art and the most significant practices on this emerging topic.
Prerequisites	-
Bibliography	- Flink, Tim and Rüffin, Nicolas (2019): "The Current State of the Art of Science Diplomacy". In: Dagmar Simon, Stefan Kuhlmann, Julia Stamm, Weert Canzler (Eds.), Handbook on Science and Public Policy. Handbooks of Research on Public Policy Series. Cheltenham/Northampton, MA: Edward Elgar, S. 104–121. . Pierre-Bruno Ruffini (2020): "Collaboration and competition: The twofold logic of science diplomacy", The Hague Journal of Diplomacy, 15(3):371-382.
Assessment methods	TBD
Activity period	1st semester
Start date	2023/12/06, 9:30-11:30 a.m. and 2:30-4:30 p.m.
End date of activity	2023/12/06, 9:30-11:30 a.m. and 2:30-4:30 p.m.
Distance delivery information (if available)	-

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Science, Technology and Foreign Policy: an historical reappraisal	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Mauro Elli
Contact e-mail	mauro.elli@unimi.it
Venue of the training/teaching activity	University of Milan
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Knowledge and understanding: by offering first-hand examples of historical investigations, students will be prodded to a critical understanding of the interrelation of science and technology, on the one hand, and political, economic, social, cultural and religious themes in post-1945 history Applying knowledge and understanding: students will be able to question the role and meaning of science and technology in a given historical context, defined by political-institutional configurations, socio-economic expectations and cultural influences in a glocally connected world Making judgements: students will perceive the opportunity of a history-based, critical approach to the disciplinary content of science & technology Communication skills: students will be introduced at the use of disciplinary language tools (language properties,

	correct specific lexicon) in order to start to express, in a clear and effective form, concepts of political, institutional, economic and social nature. Learning skills: students will be introduced to the use of documentary sources as an essential moment of critical reflection and methodological learning.
Prerequisites	-
Bibliography	Suggested readings: - ELLI, M.: Elli, "'Nuclear Power is not just Economics': Atomic Energy and Economic Development in the Karachi Nuclear Power Plant Project (Kanupp), 1955–1965." Cold War History 22:4 (2022): 1 – 23. DOI: https://doi.org/10.1080/14682745.2022.2059071 - HAMBLIN, J.D.: The Wretched Atom. America's Global Gamble with Peaceful Nuclear Technology - ROEHRLICH, E.: Inspectors for Peace. A History of the International Atomic Energy Agency
Assessment methods	Students will be asked to produce a short report (max. 1500 words), which should offer a critical contextualisation of a theme arising from a one or more documents made available to them.
Activity period	1st semester
Start date	2023/11/27, 2:30 – 4:30 p.m.
End date of activity	2023/11/29, 2:30 – 4:30 p.m.
Distance delivery information (if available)	Online, Zoom platform

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Scientific Writing for Physical Sciences

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Dr. Francesco Belfiore
Contact e-mail	francesco.belfiore@inaf.it
Venue of the training/teaching activity	INAF - Arcetri Astrophysical Observatory
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	Course summary: Writing is a vital component of a scientist's skill set. In this course we present an overview of how to write scientific papers. We will address how to structure ideas, produce outlines, build paragraphs, and adapt your style and grammar to the conventions of scientific journals. Throughout the course we will draw on example texts from the field of astrophysics. Finally, we will touch on other text genres, including funding and observing proposals, and popular science articles. Course outline: Macrostructure (outlining, sectioning) Microstructure (paragraphs, transitions) Stylistics (syntax, tenses, commas) Publishing (how to give feedback, the refereeing process, ethical aspects) Pearls from the ArXiv (detailed study of example papers, reverse outlining) Tricks of the trade (time management, overcoming writer's block, visual thinking, software)

	Other genres (Proposals, science communication)
Prerequisites	-
Bibliography	There is no required reading for the course, but the following textbook and articles may be of interest: - Cargill and O'Connor, Writing Scientific Research Articles, Wiley Blackwell, 2009 - Alley, The Craft of Scientific Writing, Fourth Edition, Springer, 2018 - Knapen, Chamba & Black, How to write and develop your astronomy research paper, NatAst, 2022, 6, 1021
Assessment methods	Students will be required to hand in a piece of original writing which will be assessed and further discussed during an oral exam.
Activity period	2nd semester
Start date	2024/04/15
End date of activity	2024/04/22
Distance delivery information (if available)	The course will be delivered via zoom.

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Scintillators and Silicon Photomultipliers	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Elisabetta Bissaldi

Contact e-mail	elisabetta.bissaldi@poliba.it
Venue of the training/teaching activity	Polytechnic University of Bari National Institute for Nuclear Physics - INFN
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	This course aims to provide the student with advanced knowledge of radiation measurements and detection techniques, from classic scintillation detectors to modern Silicon Photomultiplier devices. The program includes Photon-matter interactions; Organic and Inorganic scintillators; Optical coupling; Solid-state photodetectors: The pn junction, the Photodiode, the SPAD, the SiPM. Different SiPM technologies. SiPM properties: single photoelectron resolution, gain, signal to noise ratio, photo-detection efficiency. Temperature dependence. The equivalent circuit of a SiPM. Optimal front-end: current feedback, pole zero cancellation network. SiPM arrays. SiPM coupled to scintillators. SiPM applications. Part of the course will be devoted to laboratory sessions.
Prerequisites	It requires an elementary background in radiation measurements, radiation-matter interactions and basic electronics.
Bibliography	1. G. Knoll – "Radiation Detection and Measurement" 2. Sedra and Smith – "Microelectronic Circuits" 3. Sze - "Physics of Semiconductor Devices" 4. Recent Publications
Assessment methods	Final laboratory report
Activity period	2nd semester
Start date	2024/05/03

End date of activity	2024/06/28
Distance delivery information (if available)	It is delivered in hybrid mode (both in-person and distance) including workshop activities

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Silicon Radiation Detectors	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 5, Curriculum 6)
Teacher responsible for teaching/training activity	Prof. Gian-Franco Dalla Betta
Contact e-mail	gianfranco.dallabetta@unitn.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	2 CFU =18 hours
Training objectives and expected learning outcomes	Silicon radiation detectors are widely employed in several fields of fundamental and applied research, as well as for medical imaging and industrial diagnostics. This course offers a general, broad introduction to silicon radiation detectors, covering operation principles, related fabrication technologies and application fields. At the end of the course, the students are expected to become familiar with the terminology and the problems commonly found in the field of radiation detectors. They should be able to describe the operation principle and the figures of merit of a silicon detector, and understand the main design and technological aspects of detectors

	required in different applications. The following topics are covered: - Introduction. Application fields. - Interaction between radiation and silicon. - Operation principle of silicon detectors, Signal formation, Ramo's theorem. - Signal processing: spectroscopic chain, noise considerations. - Figures of merit: responsivity, quantum efficiency, detection efficiency, response speed, spatial resolution, energy resolution, radiation hardness. - Categories and variants of silicon sensors: Photodetectors: photoresistors, photodiodes, phototransistors, colour sensors. Detectors for spectroscopy: PIN diodes, drift detectors. Position sensitive detectors: strip detectors, pixel detectors. - Fabrication technologies: general aspects. Detailed description of 2 case studies. - Simulation and design methodologies for silicon detectors - Radiation damage: Bulk and surface radiation damage in silicon detectors. Radiation hardening by design and technological solutions. - Detectors with three-dimensional electrodes (3D detectors). Operation principle, simulations, technology, selected results, radiation hardness. Active edge detectors. Applications other than high energy physics: neutron detection, FELs, dosimetry. - Avalanche based detectors: impact ionization effects, different detector types (APD, LGAD, SPAD). - The Silicon PhotoMultiplier (SiPM). - Monolithic Active Pixel Sensors: The CMOS MAPS approach: general features, pros and cons, examples of

	implementations. Monolithic integration of transistors and detectors on high resistivity silicon: pioneering works, the DEPFET, other relevant results. - Introduction. Application fields. - Interaction between radiation and silicon. - Operation principle of silicon detectors, Signal formation, Ramo's theorem. - Signal processing: spectroscopic chain, noise considerations. - Figures of merit: responsivity, quantum efficiency, detection efficiency, response speed, spatial resolution, energy resolution, radiation hardness. - Categories and variants of silicon sensors: Photodetectors: photoresistors, photodiodes, phototransistors, colour sensors. Detectors for spectroscopy: PIN diodes, drift detectors. Position sensitive detectors: strip detectors, pixel detectors. - Fabrication technologies: general aspects. Detailed description of 2 case studies. - Simulation and design methodologies for silicon detectors - Radiation damage: Bulk and surface radiation damage in silicon detectors. Radiation hardening by design and technological solutions. - Detectors with three-dimensional electrodes (3D detectors). Operation principle, simulations, technology, selected results, radiation hardness. Active edge detectors. Applications other than high energy physics: neutron detection, FELs, dosimetry. - Avalanche based detectors: impact ionization effects, different detector types (APD, LGAD, SPAD). - The Silicon PhotoMultiplier (SiPM). - Monolithic Active Pixel Sensors: The CMOS MAPS approach: general features, pros and cons, examples of

	implementations. Monolithic integration of transistors and detectors on high resistivity silicon: pioneering works, the DEPFET, other relevant results.
Prerequisites	Basic knowledge of semiconductor device physics and electronics.
Bibliography	Slides provided by the Instructor. Reference books: - G. Lutz, "Semiconductor Radiation Detectors: Device Physics", Springer, 1999 - H. Spieler, "Semiconductor Detector Systems", Oxford University Press, 2005 - L. Rossi, P. Fischer, T. Rohe, N. Wermes, "Pixel detectors - From fundamentals to applications", Springer, 2006
Assessment methods	Oral presentation on a topic of choice and discussion.
Activity period	1st semester
Start date	2024/01/16
End date of activity	2024/02/15
Distance delivery information (if available)	The link to Zoom will be provided to registered attendees in due time.

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Solar system exploration: small bodies, satellites, and planets	
Academic Year	2023/2024
Year of enrolment	1st

Didactic Unit Type	Multidisciplinary
Teacher responsible for teaching/training activity	Dr. Fabrizio Capaccioni
Contact e-mail	fabrizio.capaccioni@inaf.it
Venue of the training/teaching activity	Italian National Institute for Astrophysics - INAF
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	The objective of this course is to provide state of the art knowledge of minor bodies, satellites and planets as derived from direct observations by means of interplanetary probes. The course will describe the observational data, along with the instruments required to derive it, and the knowledge gained concerning Solar System formation, composition and evolution.
Prerequisites	-
Bibliography	Reference articles will be proposed by the lecturer during the lessons
Assessment methods	Assessment through oral examination
Activity period	2nd semester
Start date	2024/05/13
End date of activity	2024/05/14
Distance delivery information (if available)	Modalities of links will be indicated close to the course delivery

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Space and Astrophysical Plasmas	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1 ; Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Simone Landi Prof. Andrea Verdini
Contact e-mail	simone.landi@unifi.it andrea.verdini@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The course aims to provide students interested in studying astrophysical, heliophysical and geophysical processes with the fundamental concepts of plasma physics: characteristic quantities, fluid and kinetic models, waves, instability, dissipation. The course also provides various concepts useful for non-linear physics processes and is also suited to a theoretical profile. Course Content: Definition of plasma and fundamental quantities. Orbit theory. Kinetic theory: Vlasov and Boltzmann equations. From kinetic theory to fluid description. One-fluid model and magnetohydrodynamic (MHD) equations. Equilibria and instability in the MHD regime. Waves in the MHD regime and waves of plasmas. Waves in kinetic regime and particle wave interactions. Shock waves. Magnetic reconnection and resistive instabilities. Turbulence in plasmas (outline).

	Accretion and ejection in radial symmetry, Parker's solar wind, shock solutions and connection with the interstellar medium. Structure of the heliosphere and properties of the solar wind. Turbulence in the solar wind. Correlations between observed properties. Solar wind heating. Notes on observed temperature anisotropies.
Prerequisites	-
Bibliography	Bibliographic references and notes will be provided during the course
Assessment methods	Oral test involving an in-depth examination of a topic agreed with the student.
Activity period	2^{nd} semester
Start date	07/05/2024
End date of activity	29/05/2024
Distance delivery information (if available)	7/05 10:00-12:00 9/05 10:00-12:00 14/05 10:00-12:00 16/05 10:00-12:00 20/05 10:00-12:00 22/05 10:00–12:00 27/05 10:00–12:00 29/05 10:00—12:00

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Space Cognitive Processes	
Academic Year	2023/2024
Year of enrolment	1^{st}, 2^{nd}
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Diego Manzoni Prof. Enrica Santarcangelo
Contact e-mail	enrica.santarcangelo@unipi.it diego.manzoni@unipi.it
Venue of the training/teaching activity	University of Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Sensory control of cognitive functions: the challenge of space flight; coping strategies to buffer sensory information reduction: mental imagery.
Prerequisites	General knowledge of modulatory systems and cortical function (that will be summarized); general knowledge of the physiology of voluntary movement (which will be summarized).
Bibliography	- Spina et al., L. High Motor Cortex Excitability in Highly Hypnotizable Individuals: A Favourable Factor for Neuroplasticity? Neuroscience. 2020 Mar 15; 430:125-130 - Ibáñez-Marcelo et al. Topology highlights mesoscopic functional equivalence between imagery and perception: The case of hypnotizability. Neuroimage. 2019 Oct 15;200: 437-449 - Trigeminal, Visceral and Vestibular Inputs May Improve Cognitive Functions by Acting through the Locus Coeruleus and the Ascending Reticular Activating System: A New Hypothesis. De Cicco et al., Front Neuroanat. 2018 Jan 8; 11:130.

Assessment methods	Interview
Activity period	2nd semester
Start date	2024/02/19
End date of activity	2024/03/04
Distance delivery information (if available)	-

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Space Diplomacy: a long period analysis on Actors, Dynamics and International Arenas	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	0.5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: Dynamics and actors of Space Diplomacy are presented through a few episodes: San Marco (1960-82) and Piano Fanfani (1996), the Giotto Probe in Halley's Armada (1978-86), the Italian National

	Space Plan (1974-78) and the birth of ASI (1988), the creation of the European Space Agency (1975), the SpaceLab (1971-83), the International Space Station (1983-98), the Italian membership of ESO (1976-78), the long march of Franco-Soviet space relations (1964-89), the role of France in Earth Observation. **Applying knowledge and understanding**: Particular attention will be paid to the interplay between experts/advisers and policy makers, and between scientists and diplomats as well as to the difference between Science, Techno-Science and Innovation Diplomacy. **Making judgements**: the analysis of diplomatic languages and practices. **Communication skills**: The communication, the image of diplomatic languages and practices.
Prerequisites	-
Bibliography	Some texts indicated and commented in Space Diplomacy Lab (https://www.spacediplomacy.it/) and selected from: D. Burigana, «Air, space and techno-scientific innovation in Italian foreign policy during the 1970s and 1980s», in A. Varsori, B. Zaccaria (eds.) *Italy in the International System from Détente to the End of the Cold War. The Underrated Ally*, Palgrave MacMillan, 2017, p. 227-251; D. A. Epstein, *Though the Space Age is not new, space diplomacy remains an esoteric specialty at State. Here's why it's important to start changing this now. The Foreign Service Journal*, May 2022; Mai'a K. Davis Cross and Saadia M. Pekkanen, *Introduction. Space Diplomacy: The Final Frontier of Theory and Practice*, The Hague Journal of Diplomacy, Vol. 18, Issue 2-3 (May 2023), pp. 193–217
Assessment methods	Students will be asked to produce a PowerPoint presentation on a case study of a Space negotiations (bi- or multilateral)
Activity period	2nd Semester (April 2026)
Start date	-
End date of activity	-

Distance delivery information (if available)	-

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Space Economy 1	
Academic Year	2023/2024
Year of enrolment	3rd
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: Framing it in the evolution of international diplomacy that has characterized space cooperation since the beginning of the Space Race, the Space Economy is presented with a long-term analysis from the central role of the State to the start of the commercialization of space activities. The constituent elements of the Space Economy will be presented with particular reference to the Italian experience in the European and international framework. The new spaces for private companies. How has the role of the state changed? **Applying knowledge and understanding**: students will receive some notes on the origins and functioning of the arenas of international negotiation. The relationship between research and industry. National and international

	Investments, lenders. Geopolitics and economics. **Making judgements**: students will be presented with an analytical grid on actors, dynamics, objectives of economic subjects, which will then be useful in various other economic analysis scenarios Communication skills: the opportunity to experiment with the use of a language and an analysis process typical of the economic and social science.
Prerequisites	-
Bibliography	Some texts indicated and commented in Space Diplomacy Lab (https://www.spacediplomacy.it/) and selected from: J. L. Bromberg, *NASA and the Space Industry*, John Hopkins University Press, 1999; G-Petroni, B. Bigliardi (eds,), *The space economy : from science to market*, Cambridge Scholars Publishing, 2019; P. Di Tullo, *The New Space Economy*, Franco Angeli, 2023; S. Di Pippo, *Space economy: the new frontier for development*, Bocconi University Press, 2023.
Assessment methods	Students will be asked to produce a PowerPoint presentation as a kind of policy briefing on a subject chosen in agreement with the teacher among projects, companies, and international negotiation arenas
Activity period	2nd semester
Start date	2024/04/15
End date of activity	2024/06/07
Distance delivery information (if available)	- Tue 16.04 1° Lesson 15.30-18.30 [0.45 x 3 + 15 minutes break = 15.30-18.00] - Tue 23.04 2° Lesson 15.30-18.30 [0.45 x 3 + 15 minutes break = 15.30-18.00] - Thu 16.05 3° Lesson 15.30-18.30 [0.45 x 3 + 15 minutes break = 15.30-18.00] - Thu 23.05 4° Lesson 15.30-18.30 [0.45 x 3 + 15 minutes break = 15.30-18.00] - Mon 10.06 5° Lesson 15.30-18.30 [0.45 x 3 + 15 minutes break = 15.30-18.00]

	- Tue 11.06 6° Lesson 15.30-17.30 [0.45 x 2 = 15.30-17.00]

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Space Economy 2	
Academic Year	2024/2025
Year of enrolment	3rd
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. David Burigana
Contact e-mail	david.burigana@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: The aim of the module is to provide practical knowledge to understand concepts and dynamics of Space economy and diplomacy trough the theoretical approaches and the historical evolution, enabling factors and challenges of Space economy development, international trade, Foreign Direct Investment and Official Development Assistance (ODA). A case study of a particular industrial fields will be developed as well as the Italian example. The material describing the specific country will be provided in class. **Applying knowledge and understanding**: Students will be asked to develop a strategy and operational plan for the development of a specific field of Space economy or of a specific country.

	Making judgements: As a team analysis exercise, we will use the report The Space Economy by the Numbers: How Space Contributes to the Global Economy, OECD, 2019 *Communication skills*: Students will be asked to interact in class as a basis for a discussion and 'food for thought' for future learning and practice.
Prerequisites	-
Bibliography	Some texts indicated and commented in Space Diplomacy Lab (https://www.spacediplomacy.it/) and selected from: J. L. Bromberg, *NASA and the Space Industry*, John Hopkins University Press, 1999; G-Petroni, B. Bigliardi (eds,), *The space economy : from science to market*, Cambridge Scholars Publishing, 2019; P. Di Tullo, *The New Space Economy*, Franco Angeli, 2023; S. Di Pippo, *Space economy: the new frontier for development*, Bocconi University Press, 2023
Assessment methods	Students will be asked to produce a PowerPoint presentation as a kind of policy briefing on a subject chosen in agreement with the teacher, with particular attention to measuring the impact of the Space Economy at a national, European or regional level (Africa, Latin America, Asia)
Activity period	2nd semester
Start date	2024/11/25
End date of activity	2024/11/29
Distance delivery information (if available)	- Mon 04.11 1° Lesson 17.30-19.30 [0.45 x 2 = 17.30-19.00] - Tue 05.11 2° Lesson 17.30-19.30 [0.45 x 2 = 17.30-19.00] - Mon 11.11 3° Lesson 17.30-19.30 [0.45 x 2 = 17.30-19.00] - Tue 12.11 4° Lesson 17.30-19.30 [0.45 x 2 = 17.30-19.00]

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Space Immunology	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Laura Caponi Prof. Federico Pratesi
Contact e-mail	laura.caponi@unipi.it federico.pratesi@unipi.it
Venue of the training/teaching activity	University of Pisa
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	To understand the biology of immune modulation under spaceflight conditions and its role in the pathogenesis of space-related pathologies. To understand the changes that microgravity causes to major organs and systems, with particular reference to the musculoskeletal and cardiovascular systems
Prerequisites	General knowledge of immunology and general pathology. Knowledge of basic anatomy and physiology.
Bibliography	Bharindwal S, Goswami N, Jha P, Pandey S, Jobby R. Prospective Use of Probiotics to Maintain Astronaut Health during Spaceflight. Life (Basel). 2023 Mar 8;13(3):727.
Assessment methods	Written exam or interview

Activity period	2nd semester
Start date	2024/03/01
End date of activity	2024/05/31
Distance delivery information (if available)	-

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Space law regulation at international and domestic level	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Nicolò Giovanni Carnimeo
Contact e-mail	nicologiovanni.carnimeo@uniba.it
Venue of the training/teaching activity	University of Trento
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The teaching of Space law regulation at international and domestic level aims to provide students with basic notions about the legal regulation of space sector in the public and private sphere. A good knowledge of international and internal sources is provided, as well as of the main public and private institutions and the necessary stimuli to approach this sector in which specialized knowledge and an interdisciplinary approach are

	required.
Prerequisites	-
Bibliography	- G.Catalano Sgrosso, Diritto internazionale dello Spazio, Firenze, 2011 - Lefebvre D'Ovidio Pescatore Tullio, Manuale di diritto della Navigazione, Milano, 2019
Assessment methods	Oral Exam
Activity period	2nd semester
Start date	2024/04/01
End date of activity	2024/05/01
Distance delivery information (if available)	-

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Space Microbiology and Intestinal Barrier	
Academic Year	2023/2024
Year of enrolment	1st, 2nd
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Semih Esin Prof. Alessandra Salvetti
Contact e-mail	semih.esin@unipi.it alessandra.salvetti@unipi.it
Venue of the training/teaching activity	University of Pisa

CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Influence of extreme conditions on microorganisms and host-microbe interactions in the space environment. Mechanisms regulating intestinal barrier integrity and countermeasures to mitigate its dysfunction in altered gravity.
Prerequisites	General knowledge of microbiology, cell biology and molecular genetics
Bibliography	- Swati Bijlani, et. Al. Advances in space microbiology. iScience, 2021, https://doi.org/10.1016/j.isci.2021.102395 - Salvetti et al. Artificially altered gravity elicits cell homeostasis imbalance in planarian worms, and cerium oxide nanoparticles counteract this effect - J Biomed Mater Res A. 2021 Nov;109(11):2322-2333. doi: 10.1002/jbm.a.37215 - Alvarez et al. Simulated Microgravity Environment Causes a Sustained Defect in Epithelial Barrier Function. Sci Rep. 2019 Nov 26;9(1):17531.
Assessment methods	Interview
Activity period	2^{nd} semester
Start date	23/02/2024
End date of activity	06/03/2024
Distance delivery information (if available)	23/02/2024 Prof. Salvetti 10-12 06/03/2024 Prof. Esin 9.30-11.15

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Space Neurobiology

Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for teaching/training activity	Prof. Ferdinando Di Cunto
Contact e-mail	ferdinando.dicunto@unito.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	The objective of this module will be to address the molecular and epigenetic bases of the physiological and pathological phenomena induced in neural and muscular cells by the challenging environment that characterizes human space missions. In particular, lessons will concentrate on the molecular effects of microgravity, of space radiations, of confined environment, as well as the interaction between these factors and the possible countermeasures. Moreover, the module aims at discussing the main experimental models for studying the impact of space-related conditions. At the end of the course, the students should be familiar with the main biological and neurobiological problems related to working in space for prolonged times, as well as with their potential impact on astronauts' health. Moreover, they should be capable of coping with the most recent scientific literature on these topics. In particular, the course will analyze in depth the following topics: - General biological effects of space radiation and microgravity on cells - Specific effect of radiation and microgravity on neural tissue - Alterations of gene expression and epigenetics in space

	- Milestone biological experiments on animal models in space - The problem of simulating the space environment on Earth for the execution of biological experiments
Prerequisites	The course presupposes a good knowledge of basic biology, in particular of the fundamental mechanisms of duplication and expression of genetic information.
Bibliography	The reference teaching material for the course will consist of recent reviews that specifically analyze the topics covered.
Assessment methods	Multiple choice evaluation questionnaire, possibly supplemented by a short interview
Activity period	2nd semester
Start date	2024/04/01
End date of activity	2024/06/30
Distance delivery information (if available)	https://unito.webex.com/meet/ferdinando.dicunto Although the course is proposed to the first year students, during the 2023/2024 year it can be also followed by second year students, who did not have the possibility to take it last year.

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Space Neuropsychology	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 4)

Teacher responsible for teaching/training activity	Prof. Raffaella Giovanna Nella Ricci
Contact e-mail	raffaella.ricci@unito.it
Venue of the training/teaching activity	University of Turin
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The objective of the course is to provide advanced knowledge of the humans' response to the conditions and hazards encountered in space. Behavioral, cognitive, and brain changes induced by the altered gravity and psychological stressors associated with living in an isolated, confined, and extreme (ICE) environment will be presented. Ground-based models of space conditions and possible countermeasures to counteract or mitigate the adverse effects of living in space are also discussed. By the end of the course, students will have acquired knowledge of the major space factors that affect human neuro-psychological functions, as well as relative ground-based analogs, and countermeasures. Specifically, they are expected to demonstrate the following: I) knowledge and understanding of the major brain, cognitive, and behavioral changes induced in humans by space conditions, II) applying knowledge and undestarding on the topics covered in the course and their use also in relation to the study of cognitive processes in the healthy brain and the rehabilitation of brain functions on Earth; III) conceptual and analytical ability in analyzing the topics covered in the course, in making judgments on them, and in establishing relationships between factors and conditions encountered in space and psychological, cognitive/behavioral and neural changes; IV) skills in communicating clearly and exhaustively the theoretical framework, method and findings of a scientific study and the ability to

	independently formulate interpretations, ideas, and conclusions about the topics covered in the course; V) learning skills as demonstrated by discussion of contents and papers on the topics treated in the course.
Prerequisites	-
Bibliography	The slides and the papers discussed during the course
Assessment methods	The learning outcomes will be assessed during the interaction and discussion of the topics covered by the course with the students and during the students' presentation of a scientific paper on one of the topics treated by the course.
Activity period	Second Semester
Start date	11/06/2024
End date of activity	18/06/2024
Distance delivery information (if available)	11/06/2024 – 10am to 1pm 13/06/2024 – 10am to 1pm 18/06/2024 – 10am to 12pm The course will be held remotely on the webex link: https://unito.webex.com/meet/raffaella.ricci

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Space Physiology	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 4)
Teacher responsible for	Prof. Myrka Zago

teaching/training activity	
Contact e-mail	myrka.zago@uniroma2.it
Venue of the training/teaching activity	University of Rome Tor Vergata
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The course will address fundamentals of physiological effects of the space environment on humans and the methods employed to mitigate such effects At the end of the course students should have an enhanced knowledge of physiological, medical and operational issues relating to prolonged stays in Space. On the successful completion of this course, the student should - have a clear understanding of the physiological effects of the space environment on humans - have an enhanced knowledge of physiological, medical and operational issues related to prolonged stays in Space and of the methods employed to mitigate adverse effects - be able to apply their knowledge of human physiology in extreme conditions to the engineering design and development of simple protocols to facilitate space adaptation and manage adverse events in space missions (International Space Station, Moon or Mars missions) - have acquired sufficient background to allow them to independently evaluate the contents of scientific texts and to appraise experimental data related to space physiology - have effective communication on the topics of the course and will be able to discuss them critically - be able to explore and understand the scientific literature, and to use this knowledge for translational purposes, research and development

Prerequisites	Basic knowledge of mathematics, physics, biology
Bibliography	Selected articles
Assessment methods	Oral examination
Activity period	2nd semester
Start date	-
End date of activity	-
Distance delivery information (if available)	-

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Space plasma physics	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Fabio Lepreti Prof. Francesco Valentini
Contact e-mail	fabio.lepreti@unical.it francesco.valentini@unical.it
Venue of the training/teaching	University of Calabria

activity	
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The "Space plasma physics" training unit aims to provide the student with advanced knowledge of kinetic theory of plasmas, as well its main applications to space physics, and of energetic particles in interplanetary space. At the end of the course the student will be able to determine the properties of waves and instability in the kinetic regime of plasmas and to understand the main characteristics of the Solar Energetic Particle (SEP) and Energetic Storm Particle (ESP) events. EXPECTED LEARNING RESULTS Knowledge and understanding: basic principles and methodology of kinetic theory of plasma and of energetic particle events in the interplanetary space. Ability to apply knowledge and understanding: apply the basic principles of kinetic theory of plasmas to obtain an analytical solution of selected problems and ability to determine the properties of energetic particles in the interplanetary space. Autonomy of judgment: ability to independently extract fundamental information on the distribution function of plasmas in phase space, to analyze the properties of waves in plasmas, and to recognize and characterize the phenomena associated with SEP and ESP events. Communication skills: ability to describe the phenomenology that underlies the dynamics of a plasma, even outside the thermodynamic equilibrium, and the occurrence of energetic particles in the interplanetary space. Learning skills: ability to understand the importance of selecting the most appropriate description for interplanetary space plasmas.
Prerequisites	-

Bibliography	Compulsory readings: - N. A. Krall and A. W. Trivelpiece, Principles of plasma physics, McGraw-Hill Inc., US, 1973; - D. V. Reames, Solar Energetic Particles, Springer, 2021. Further readings: - L. D. Landau, On the vibration of the electronic plasma, J. Phys. Moscow 10, 25 (1946); - T. M. O'Neil, Collisionless damping of nonlinear plasma oscillations, Phys. Fluids 8, 2255 (1965); - R. W. Gould, T. M. O'Neil, and J. H. Malmberg, Plasma wave echo, Phys. Rev. Lett. 19, 219 (1967); - I. B. Bernstein, J. M. Green, and M. D. Kruskal, Exact nonlinear plasma oscillations, Phys. Rev. 108, 546 (1957); - F. Valentini, T. M. O'Neil and D. H. Dubin, Excitation of nonlinear electron acoustic waves, Phys. Plasmas, 13, 052303 (2006); - F. Valentini et al., Undamped electrostatic plasma waves, Phys. Plasmas, 19, 092103 (2012). Suggested readings: - R. C. Davidson, Methods in nonlinear plasma theory, Academic Press, New York, 1972; F. F. Chen, Introduction to plasma physics, Springer.
Assessment methods	Oral test on a topic agreed with the student(s)
Activity period	2nd semester
Start date	2024/06/10
End date of activity	2024/07/25
Distance delivery information (if available)	-

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Space Science	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Space Science
Teacher responsible for teaching/training activity	Disciplinary (Curriculum 2)
Contact e-mail	delmoro@roma2.infn.it
Venue of the training/teaching activity	University of Rome – Tor Vergata
CFU / Hours	2 CFU = 6 hours
Training objectives and expected learning outcomes	The course focuses on the near-Earth space environment. • Knowledge: Fundamental knowledge of circumterrestrial environment physics. • Competencies: To be able to read and understand recent scientific articles about space physics. • Skills: To be able to present an in-depth study of space physics. - Good English language to enable efficient interaction with researchers from other countries.
Prerequisites	Physics of the Earth's space environment: Ionosphere (Structure, generation, simple model and anomalies, perturbations); Magnetosphere (Geomagnetic field, the interaction of the solar wind with the Earth's magnetic field, magnetosphere formation, magnetopause, geomagnetic tail, solar activity and magnetic perturbations on the ground, sub-storm, magnetic storm.); Motion of charged particles in a magnetic field; Van Allen Belts; Basics of low-density magnetized plasma physics; Thermosphere
Bibliography	Physics of the Earth Space Environment by G.W. Prols

Assessment methods	Written report on course topic, agreed with the lecturer
Activity period	1st semester
Start date	2023/10/02
End date of activity	2023/12/22
Distance delivery information (if available)	-

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Space Weather and Space Climate	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1, Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Mauro Messerotti
Contact e-mail	mauro.messerotti@ts.infn.it
Venue of the training/teaching activity	University of Trieste
CFU / Hours	3 CFU = 24 hours
Training objectives and expected learning outcomes	1. Knowledge and understanding. The students will learn the phenomenology of Extragalactic to Geospheric Weather by analysing the high-energy astrophysical phenomena that occur from cosmological to planetary spatial scales. They will understand how high-energy processes at large can trigger perturbative phenomena and impact

	biological and technological systems on the Earth and planetary environments. 2. Applying knowledge and understanding. The acquired knowledge of high-energy processes occurring in galactic and extragalactic astrophysical systems and their impacts will provide a key interpretation tool of the observed phenomenology. In turn, the understanding of the physics underpinning the phenomenology will allow the students to identify adequate countermeasures to mitigate the impacts. 3. Making judgements. The acquired knowledge will allow the students to correctly discriminate between natural and man-made phenomena that affect technological systems. 4. Communication skills. The students will be able to provide targeted, effective, and customised communication on the Space Weather phenomena to a wide audience that spans from the scientist to the layman. 5. Learning skills: As the class covers multiple branches of Space Weather and Climate, the student will improve his/her learning skills by necessarily adopting an interdisciplinary approach in using multi-messenger data.
Prerequisites	The student is expected to have a basic knowledge of the Sun and the Solar System, the Galaxy, and the Universe. Furthermore, the knowledge of basic plasma physics is useful but not necessary.
Bibliography	All the material of the class will be provided as presentation files (lectures) and electronic documents (papers, reference documents, etc.) that will be downloadable from the repository of the MS Teams channel of the class. References are listed in the presentation files. References - C.J. Owen, An introduction to Space Plasma Physics, in Space Science, L.K. Harra (eds.), Imperial College Press, 111, 2004. - Messerotti, M., Defining and Characterising Heliospheric Weather and Climate, in Proc. IAU, Vol. 13, Symposium: S335 Space Weather of the Heliospheric Processes and Forecasts, pp. 226-231, 2018. (DOI:

	https://doi.org/10.1017/S1743921317008857) - Messerotti, M., et Al., Solar Weather Event Modelling and Prediction, Space Science Reviews, Volume 147, Issue 3-4, pp. 121-185, 2009. (DOI: 10.1007/s11214-009-9574-x)
Assessment methods	The candidate is expected to give a seminar on a topic of his/her interest. The seminar must be relevant to a topic that was elaborated during the lectures or just related to the class programme, and it must be an in-depth analysis of it. The duration of the seminar must not exceed 30 minutes. A discussion with the examination board will follow and will be focussed on the core topic of the seminar as well as on specific aspects of the class programme. The evaluation will be based on a set of criteria as follows: a. quality of the presentation as arguments' structuring (outline, introduction, core, conclusions); b. correctness of the presentation as English language, scientific terminology, and formulae; c. clarity of presentation as the level of understanding for a specialised and non-specialised scientific audience; d. comprehensiveness of the presentation as in-depth analysis; e. quality of the presentation speech as understandability and completeness; f. quality of the discussion.
Activity period	2nd semester
Start date	2024/09/01
End date of activity	2024/09/30
Distance delivery information (if available)	The class will be given online. The Microsoft Teams software platform will be used. The class material will be made available on the repository of the relevant Teams channel devoted to the class. The lectures will be recorded to allow students to see offline classes again.

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SST: Rights on goods and resources

Academic Year	2024/2025
Year of enrolment	2nd, 3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Maria Gagliardi
Contact e-mail	maria.gagliardi@santannapisa.it
Venue of the training/teaching activity	Sant'Anna School of Advanced Studies - Pisa
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Students will be guided in learning the basics of legal reasoning on space activities, and will acquire knowledge on the discipline of the appropriation and circulation of goods and utilities, with particular reference to space activities. At the end of the training activity, in addition to basic knowledge, they will develop personal skills in understanding, analysing and also autonomously learning certain legal aspects of space activities.
Prerequisites	-
Bibliography	It will be selected close to the course
Assessment methods	Final briefs
Activity period	2nd semester
Start date	2025/06/03
End date of activity	2025/06/30
Distance delivery information (if available)	-

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Statistical Techniques in Cosmology	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Multidisciplinary; Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Luca Pagano
Contact e-mail	pgnlcu@unife.it
Venue of the training/teaching activity	University of Ferrara
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The course covers the following topics: • general theory of map-making tecniques for CMB observations • de-noising tecnquiques • power spectrum estimation methods • practical applications The acquired knowledge will enable the student to understand the general methods for building CMB maps, and to acquire the rudiments for computing auto- and cross-power spectra of maps of astrophisical observables.
Prerequisites	Rudiments of bayesian statistics and signal processing theory.
Bibliography	Slides are made available. Papers published in peer-review journals.

Assessment methods	The final exam is a colloquium. The exam will be aimed at verifying the competence level and the knowledge acquired, by means of discussions concerning the course material as well as specific examples of application of the theory.
Activity period	2nd semester
Start date	-
End date of activity	-
Distance delivery information (if available)	-

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Stellar Archaeology: studying the first stars and galaxies	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Stefania Salvadori Dr. Asa Skuladottir
Contact e-mail	stefania.salvadori@uniifi.it asa.skuladottir@unifi.it
Venue of the training/teaching activity	University of Florence
CFU / Hours	2 CFU = 16 hours
Training objectives and	This PhD course aims to give students a comprehensive view of one of the most active and wide-ranging branches

expected learning outcomes	of research in astrophysics and danese: stellar archaeology or near-field cosmology. Students will learn how spectroscopic studies of today's ancient, heavy-chemical-poor stars can provide indirect information on the properties of the first stars, which were born over 13 billion years ago. The course will therefore provide varied knowledge, both theoretical and observational, including: the formation of the first stars and their impact on the Universe, models of galaxy formation including stellar evolution and feedback processes, spectroscopic studies of single stars of the Local Group for the determination of chemical abundances, the new spectroscopic surveys (WEAVE, 4MOST) that will provide key knowledge on the subject over the next 5 years.
Prerequisites	A general knowledge of basic astrophysical concepts is necessary: what is a star, a galaxy. A basic knowledge of cosmology is recommended but not necessary.
Bibliography	Since the subject of the course is actively researched, there are no reference books but reviews or scientific articles that include (among others) sections of the following theoretical (i) and observational(ii) reviews: (i) Klessen & Glove 2023 "The First Stars: Formation, Properties, and Impact", ARA&A (ii) Frebel & Norris 2015 "Near-Field Cosmology with Extremely Metal-Poor Stars", ARA&A
Assessment methods	Oral examination (online or face-to-face) involving an oral presentation (~20/30 min) of a scientific paper chosen from a list provided by the lecturer + general questions about the course.
Activity period	2nd semester
Start date	09/02/2024
End date of activity	22/03/2024
Distance delivery information (if available)	The course can only be delivered during this period due to the lecturer's other teaching commitments. Interested students should contact the lecturer by 31 January 2024 at the latest in order to be able to plan their lessons

	appropriately. Dates and times: Friday, February 9, 14-16: **S. Salvadori** *First stars: formation* Friday, February 16, 14-16: **S. Salvadori** *First stars: evolution and observational signatures* Friday, March 1, 14-16: **A. Skuladottir** *Observations of metal-poor stars* Tuesday, March 5, 14-16: **R. Lucchesi** *Metal-poor stars' spectra and chemical abundances* Friday, March 7, 14-16: **A. Skuladottir** *The evolution of the Milky Way* Friday, March 8, 14-16: **I. Koutsouridou** *First stars' limits with Galactic halo stars* Tuesday, March 12, 14-16: **V. Gelli** *Connecting near- and far-field cosmology* Friday, March 15, 14-16: **A. Skuladottir** *The future: ongoing and upcoming surveys* Friday, March 22, 14-16: **S. Salvadori** *Overview on the inferred first stars' properties*

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Sun and Space Weather	
Academic Year	2024/2025
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Francesco Berrilli
Contact e-mail	francesco.berrilli@roma2.infn.it
Venue of the training/teaching activity	Tor Vergata University of Rome

CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	Module 1: Solar magnetic field: basics and dynamos Module 2: The solar cycle and global dynamo Module 3: Magnetic field rearrangement in the photosphere Module 4: Space Weather sources
Prerequisites	-
Bibliography	An Introduction to Space Weather, Mark Moldwin
Assessment methods	Presentation of a report on an agreed topic of the course and related questions
Activity period	1st semester
Start date	2024/11/04
End date of activity	2024/11/23
Distance delivery information (if available)	-

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Synthesis and characterization of planetary materials	
Academic Year	2023/2024
Year of enrolment	1st

Didactic Unit Type	Disciplinary (Curriculum 3)
Teacher responsible for teaching/training activity	Prof. Gabriele Giuli
Contact e-mail	gabriele.giuli@unicam.it
Venue of the training/teaching activity	University of Camerino
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	Elements of crystal nucleation and accretion; synthesis of geo-materials useful for planetary sciences (using various techniques: air or controlled fugacity furnaces; hydrothermal bombs; piston cylinders; sol-gel synthesis) with examples of synthesis of crystals, polycrystalline materials, nanocrystalline materials, amorphous materials
Prerequisites	Elements of Mineralogy
Bibliography	All optional - Shaw (2018) Geoscience Canada, v. 45, pages 67–84 https://doi.org/10.12789/geocanj.2018.45.134 - De Yoreo and Vekilov, Principles of crystal nucleation and growth https://doi.org/10.2113/0540057 - Holloway, J.R., and Wood, B.J., 1988, Simulating the Earth : experimental geochemistry:Unwin Hyman Inc., Winchester, MA, 196 p., https://doi.org/10.1007/978-94-011-6496-2
Assessment methods	Evaluation of a paper
Activity period	2nd semester
Start date	2024/03/20
End date of activity	2024/03/30
Distance delivery information	-

(if available)	

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The evolution of the international context in the last 40 years: the of the Cold War and the birth of European Union in a “new” Globalization	
Academic Year	2025/2026
Year of enrolment	3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Elena Calandri
Contact e-mail	elena.calandri@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding**: by offering first-hand examples of historical investigations, students will be prodded to a critical understanding of the main trends of post-1980 international history and of how EC/EU institutions, policies and concepts have evolved to make the EU a global player. This will involve **Applying knowledge and understanding**: students will be able to question international political trends in the context of the new globalization and the issues concerning EU international actorness **Making judgements**: students will perceive the opportunity of a history-based, critical approach to the international political context in which science diplomacy acts and impacts.

	Communication skills: students will be introduced at the use of disciplinary language tools (language properties, correct specific lexicon) in order to start to express, in a clear and effective form, concepts of political, institutional, geopolitical nature. **Learning skills**: students will be introduced to the use of documentary sources as an essential moment of critical reflection and methodological learning.
Prerequisites	-
Bibliography	https://www.cvce.eu/en
Assessment methods	Students will be asked to produce a short report (max. 1500 words), which should offer a critical contextualisation of a theme arising from a one or more documents made available to them.
Activity period	2nd semester
Start date	2026/04/01
End date of activity	2026/05/31
Distance delivery information (if available)	-

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The Many faces of Neutron Stars	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for	Prof. Andrea Tiengo

teaching/training activity	
Contact e-mail	andrea.tiengo@iusspavia.it
Venue of the training/teaching activity	IUSS University School for Advanced Studies of Pavia
CFU / Hours	1,5 CFU = 12 hours
Training objectives and expected learning outcomes	The educational objectives of this course are designed to equip students with a comprehensive understanding of neutron stars, their various classes, and the observational phenomena associated with them. The overarching objective is to foster the development of a unifying physical theory that can explain the diverse properties and manifestations of neutron stars. Students will also develop critical thinking skills, research abilities, and scientific communication skills. Expected Learning Outcomes (Dublin Descriptors): 1. Knowledge and Understanding By the end of the course, students are expected to possess a deep and comprehensive knowledge of neutron stars, their various classes (including accretion-powered neutron stars, rotation-powered pulsars, magnetars, and cooling neutron stars), and their associated properties. They will understand the current state of research in the field. 2. Applying Knowledge and Understanding Students should be able to conduct independent research related to neutron stars. They will learn how to formulate research questions, propose for observational studies, gather and analyze archival data, and draw conclusions from their findings. 3. Making Judgments Students will have the ability to critically assess existing theories and models related to neutron stars, as well as

	identify and address observational challenges. They will develop problem-solving skills to tackle complex issues in the field. 4. Communication Skills Students will be able to effectively communicate and critically discuss the content of scientific papers about the phenomenology and modelling of neutron stars. 5. Learning Skills Students will be prepared to collaborate with experts from diverse backgrounds, such as theory and observations at different wavelengths. They will understand the value of collaborative efforts in advancing our understanding of neutron stars and related phenomena.
Prerequisites	-
Bibliography	Scientific papers and the teacher's slides will be made available at the end of each lecture.
Assessment methods	The exam will consist in the oral presentation of a scientific paper reporting the observations of a specific neutron star. After briefly introducing the main observational properties of the object and the state of the art of its interpretation, the student will critically discuss the observations, analysis methods, results and interpretations reported in the selected paper. They will be evaluated based on: the knowledge of the main properties of the different classes of neutron stars, the methods used to study them at different wavelengths and the models adopted to interpret their phenomenology; their capacity to deeply understand and critically process the content of a scientific paper; their ability to summarize and present effectively the relevant information.
Activity period	2^{nd} semester
Start date	2024/04/16
End date of activity	2024/05/09

Distance delivery information (if available)	Zoom link: https://iusspavia.zoom.us/my/andrea.tiengo

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The protection of the Space environment, and Laboratory on National Space Laws	
Academic Year	2023/2024
Year of enrolment	1st. 2nd and 3rd
Didactic Unit Type	Disciplinary (Curriculum 7)
Teacher responsible for teaching/training activity	Prof. Diego Zannoni
Contact e-mail	diego.zannoni@unipd.it
Venue of the training/teaching activity	University of Padua
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	**1. Knowledge and understanding**. The course aims to provide students with knowledge of the legal regime applicable to space activities, with particular attention to the protection of the space environment. **2. Applying knowledge and understanding**. Students will be asked to solve some practical cases in the light of the knowledge acquired legal knowledge. **3. Making judgements**. The course aims to develop the ability of students to develop coherent legal reasoning. **4. Communication skills**. The course aims at developing students' ability to students to express themselves using correct legal-technical language.

	5. Learning skills. The course aims to provide students with the tools to adequately understand the legal regime relevant to space activities.
Prerequisites	-
Bibliography	We recommend reading the 'Space Law' section of the Yearbook of International Disaster Law, 2019 to 2022. These sections are freely accessible online.
Assessment methods	Oral interview
Activity period	1st semester
Start date	2024/01/15
End date of activity	2024/01/19
Distance delivery information (if available)	Zoom Platform

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Theory and phenomenology of Ultra High Energy Cosmic Rays	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Roberto Aloisio

Contact e-mail	roberto.aloisio@gssi.it
Venue of the training/teaching activity	Gran Sasso Science Institute - GSSI
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	1. UHECR Phenomenology and principal experimental results 2. Energy losses and secondary particles 2.a Proton-photon interactions 2.b Nucleus-photon interaction 2.c Adiabatic energy losses 2.d Secondary emissions gamma rays and neutrinos 2.e Electromagnetic cascades and γ/ν phenomenology 3. UHECR Propagation 3.a A bit of cosmology 3.b Transport in the rectilinear regime 3.c Transport in the diffusive regime: static universe 3.d Transport in the diffusive regime: expanding universe 3.e Expected secondary emissions γ/ν 4. Astrophysical sources 4.a Hillas plot, luminosity bounds and emissivity 4.b Acceleration by non-relativistic shock (LSS) 4.c Acceleration by relativistic shock (AGN, GRB)

	4.d Unipolar induction 4.e Injection and maximum energy (recap)
Prerequisites	Basics of the cosmic rays standard model. Basics of production and propagation of cosmic rays. Basics of particles interaction with magnetic fields and plasmas.
Bibliography	- V. S. Berezinsky, S. V. Bulanov, V. A. Dogiel and V. S. Ptuskin, ‘Astrophysics of cosmic rays’, Elsevier Science Publisher (1990), ISBN: 0444886419. - T.K. Gaisser, “Cosmic Rays and Particle Physics”, Cambridge University Press, Cambridge (UK), 1990, ISBN: 0521326672. - A. Coleman, J. Eser, E. Mayotte, F. Sarazin, F.G. Schröder, et al, ’ Ultra high energy cosmic rays The intersection of the Cosmic and Energy Frontiers’, Astropart.Phys. 149 (2023) 102819 - R. Aloisio, P. Blasi, I. De Mitri and S. Petrera, ‘Selected Topics in Cosmic Rays Physics’, in ‘Multiple Messengers and Challenges in Astroparticle Physics’, Springer (2018) ISBN: 9783319654256
Assessment methods	The examination consists in a discussion at the blackboard touching the most relevant calculations and results presented during the course.
Activity period	2nd semester
Start date	2024/05/01
End date of activity	2024/05/31
Distance delivery information (if available)	-

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Turbulence and non-linear dynamics	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 2)
Teacher responsible for teaching/training activity	Prof. Vincenzo Carbone
Contact e-mail	vincenzo.carbone@fis.unical.it
Venue of the training/teaching activity	University of Calabria
CFU / Hours	2 CFU = 16 hours
Training objectives and expected learning outcomes	The course aims to train PhD students in the specific knowledge of non linear processes, mainly related to the Sun-Earth connections and observations of the Earth from Space, i.e. the science of the extreme variability of the Sun and of the interplanetary space. The student must have in-depth knowledge of the dynamics of turbulent processes observed in interplanetary space. They must also possess the ability to understand the dynamics of non-linear systems and the ways of obtaining information on them. They must be able to apply the knowledge acquired, through the development or the use of numerical codes for data analysis and for the numerical solution of systems of differential equations. He/she must possess the ability to form an autonomous and critical judgment in the evaluation of scientific works on the topic of the course, and on the significance of the numerical results, and he/she will have to communicate the results of the data analysis, or of the numerical solution of differential equations, during the final seminar of

	the course. This ability is essential to facilitate teamwork and collaborate effectively and professionally. Finally, the student must have the ability to learn new developments and trends in scientific research in the field of turbulence, mainly applied to the interplanetary space, making use of the skills acquired and knowledge of bibliographic means.
Prerequisites	The PhD student must have knowledge of programming, or the use of data analysis software and numerical solution of differential equations.
Bibliography	- R. Bruno & V. Carbone, Turbulence in the Solar Wind, 2016 - Lecture Notes in Physics 928 (Springer) - U. Frisch, Turbulence: the legacy of A.N. Kolmogorov, 1995 - Cambridge University Press - E. Ott, Chaos in dynamical systems, 1993 - Cambridge University Press
Assessment methods	The learning verification will take place through a short in-depth seminar on a topic chosen by the student, among those covered during the course.
Activity period	1st semester
Start date	2023/11/06
End date of activity	2023/11/30
Distance delivery information (if available)	The course will be delivered remotely on a platform to be defined, whose access information will be communicated at the time of delivery of the course.

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Use of Nutraceutical products for human health: evidence and critical issues	
Academic Year	2024/2025
Year of enrolment	1st

Didactic Unit Type	Disciplinary (Curriculum 4, Curriculum 5)
Teacher responsible for teaching/training activity	Prof. Paolo Magni
Contact e-mail	paolo.magni@unimi.it
Venue of the training/teaching activity	University of Milan
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The learning objectives include knowledge of the main nutraceuticals used in human health, with specific information on the strengths and weaknesses of these products. These aspects will cover the 5 index items (Dublin descriptors), including knowledge and understanding in the field of nutraceutics applied to human health; ability to apply this knowledge and understanding in specific health and disease conditions; autonomy of judgement with respect to critical issues related to nutraceutical products; communication skills in this area; ability to actively learn in the area of nutraceutics applied to human health.
Prerequisites	The course requires basic knowledge of human nutrition, knowledge of the mechanisms of human diseases, particularly those related to neuroscience, metabolism and the cardiovascular system.
Bibliography	The course requires basic knowledge of human nutrition, knowledge of the mechanisms of human diseases, particularly those related to neuroscience, metabolism and the cardiovascular system
Assessment methods	The actual acquisition of knowledge and skills will be verified by means of an oral test.
Activity period	2nd semester
Start date	2024705/05
End date of activity	2024/05/06

Distance delivery information (if available)	Teams

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Very High Energy Gamma and Neutrino Astronomy Experiments	
Academic Year	2023/2024
Year of enrolment	1st
Didactic Unit Type	Disciplinary (Curriculum 1)
Teacher responsible for teaching/training activity	Prof. Maurizio Spurio Dott. Nicola Mazziotta
Contact e-mail	maurizio.spurio@unibo.it Marionicola.Mazziotta@ba.infn.it
Venue of the training/teaching activity	Gran Sasso Science Institute - GSSI
CFU / Hours	1 CFU = 8 hours
Training objectives and expected learning outcomes	The term "multi-messenger" is quite new and increasingly used in astronomy and astroparticle physics. It refers to combining information from different cosmic messengers (i.e. photons, cosmic rays, neutrinos and gravitational waves) to gain a deeper understanding of the phenomena responsible for high energy emission in the Universe. This course will focus on information gained using high-energy gamma-ray and neutrino data. Experimental techniques using space and ground based gamma-ray telescopes and neutrino telescopes will be presented. Students will learn the working principles of the presented instruments and understand their limitations. A review

	of the latest results and future perspecttives will be given. Basic theoretical ideas to aid the interpretation of experimetal results will be discussed. For their examination, students will select a few research articles covering recents results on multi messenger astrophysics with high-energy gamma-rays and neutrinos and the connections between the different research areas. They will apply the acquired compentence to identify and understand the challenges faced in the selected articles and the solutions implemented and summarize them in a short seminar. They will learn extracting key aspects of the results reported in the arcticles and discuss them in relation to the starte of the art of the research field.
Prerequisites	This course is addressed to students with basic knowledge of elementary particles and their interactions, nuclear physics and physics of detectors of particles and radiation.
Bibliography	Spurio, Maurizio, The Probes of Multimessenger Astrophysics: Springer, 2019. Perkins, Donald H., Particle astrophysicsD.H. Perkins. Oxford: Oxford University Press, 2009. De_Angelis, Alessandro; Pimenta, Mário João Martins, Introduction to particle and astroparticle physicsmultimessenger astronomy and its particle physics foundationsAlessandro De Angelis, Mario Pimenta. Cham: Springer, 2018. Longair, Malcolm S., High energy astrophysicsMalcolm S. Longair. Cambridge: Cambridge University Press, 2011.
Assessment methods	Oral examination. Once the choice of research articles is agreed with the lecturer, students will present a short review seminar. Students are expected to prove the ability to identify key aspects of the methodologies employed in the research work presented. They will elaborate on the state of the art of the research field, open issues and their view on possible future advancements. Students are expected to demonstrate abilities to apply the competences acquired during the course and making own judgements of challenges and possible solutions.
Activity period	2nd semester

Start date	2024/02/26
End date of activity	2024/06/21
Distance delivery information (if available)	Lectures will used the ZOOM platform. The link will be shared to registered students prior to the programmed start date.

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VIS-NIR-MIR reflectance spectroscopy of planetary materials	
Academic Year	2023/2024
Year of enrolment	2nd
Didactic Unit Type	Disciplinary (Curriculum 2, Curriculum 3)
Teacher responsible for teaching/training activity	Dr. Cristian Carli
Contact e-mail	cristian.carli@inaf.it
Venue of the training/teaching activity	Italian National Institute for Astrophysics - INAF
CFU / Hours	0,5 CFU = 4 hours
Training objectives and expected learning outcomes	**Knowledge and understanding** --> The student is expected to acquire the concepts of reflectance and emissivity spectroscopy and their relevance to the study of the Solar System. Understand how these techniques are applied in the laboratory and the connection with the interpretation of absorption processes on the surfaces of other bodies in the Solar System. Also understand how and what, from a spectral point of view, differentiates certain meteorites from others.

	Ability to apply knowledge and understanding/ Applying knowledge and understanding --> The student is expected to be able to point out and connect the differences in spectral properties with the different mineralogies of meteorites and Solar System objects. **Autonomy of judgement/ Making judgements** --> The student is expected to be able to develop a critical argument considering the material studied in the course. **Communication skills** --> The student is expected to be able to develop the scientific topic under study without having to be supported by the lecturer. Learning skills --> The student is expected to be able to expand on a course topic at will.
Prerequisites	-
Bibliography	The course material will be self-supported and shared with the students, the interested student may find useful hints in: - Reviews in Mineralogy and Geochemistry: o Planetary Materials, vol. 36 o Spectroscopic Methods in Mineralogy and Geology, vol. 18 o Spectroscopic Methods in Mineralogy and Materials Sciences, vol. 78 - EMU Notes in Mineralogy: o Spectroscopic methods in mineralogy, vol. 6
Assessment methods	The examination will be oral, and may rest on a presentation of a topic of the candidate's choice given the course material and which the candidate may expand upon.
Activity period	1^{st} semester
Start date	2024/10/01
End date of activity	2024/10/31

Distance delivery information (if available)	-