COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Fundamentals of nuclear energy production by fission reactors*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester - September - December 2024
Credits (CFU/ECTS):	3
SSD	FIS/04
Language	English
Mode of attendance	Recommended, not compulsory

Professor/ Lecturer	
Name and Surname	Mario Mastromarco
E-mail	mario.mastromarco@ba.infn.it
Telephone	+39 3206147555
Department and address	Room R39 – Department of Physics
Virtual room	Microsoft Teams
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Office hours by appointment with the professor

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

Learning Objectives	*Understanding the operating principles of current fission reactors, the related issues, and the R&D status of fourth-generation reactors.*
Course prerequisites	*Basic concepts of Nuclear Physics:* *• Binding energy of the nucleus;* *• Semi-empirical mass formula (Weizsäcker formula);* *• Cross-section;* *• Q-value of the reaction.*

Teaching strategie	*Lectures with a blackboard and image/PPT slide projection by video-projector*
Expected learning outcomes in terms of	
Knowledge and understanding on:	● *Operation principle of thermal reactors (Light Water Reactors) and fast reactors (Fast Breeder Reactors);* ● *Role of nuclear power in the energy transition;* ● *Problems related to the nuclear waste, classification and management;* ● *State of R&D of fourth-generation reactors.*
Applying knowledge and understanding on:	● *Apply concepts of reactor reactivity and kinetics to understand the dynamic behavior of nuclear systems;*

	• *Examination of the environmental impact and ethical implications of nuclear technology, including waste management;* • *Evaluation of the current state of research and development of fourth-generation reactors and discuss future prospects.*
Soft skills	• *Analyze data and information on nuclear reactions, formulating independent and informed judgments;* • *Evaluate the social, environmental, and economic impact of nuclear technologies, with particular attention to waste management;* • *Integrate ethical principles into discussions on the advantages and disadvantages of nuclear applications;* • *Reflect independently on the implications of technological decisions in the context of the global energy transition.* • *Clearly communicate neutron-induced nuclear reactions and their balancing in current fission reactors;* • *Describe the concepts of reactor criticality and dynamics in an understandable way;* • *Clearly and systematically communicate the differences and functioning of various types of nuclear reactors.*
Syllabus	
Content knowledge	***Introduction:*** *The role of nuclear energy in the energy context.* ***Neutron-induced nuclear reactions:*** *Elastic and inelastic scattering, neutron capture, and nuclear fission; Neutron cross sections, mean free path, α-ratio; Neutron energy spectra: thermal neutrons, resolved and unresolved resonance regions, fission threshold; Fissile and fertile isotopes, and "fissionability"; Fission with thermal and fast neutrons; Fission products, total energy balance in fission.* ***Chain reactions in nuclear reactors:*** *Criticality and multiplication factor, neutron yield, chain reactions in uranium; Neutron moderation and thermalization; Reactor kinetics, reactivity, reaction rate; Conversion ratio; Control materials and burnable neutron poisons.* ***Types of nuclear reactors:*** *Overview of reactor types: thermal and fast reactors; Components; First, second, and third-generation reactors; Light water thermal reactors (LWR); Fast breeder reactors (FBR); Fourth-generation reactors: R&D status.*
Texts and readings	*- D. Bodansky, Nuclear energy: principles, practices, and prospects;* *- Lecture notes*
Notes, additional materials	
Repository	

Assessment	
Assessment methods	*The assessment of learning will be exclusively oral*
Assessment criteria	• *Understanding of nuclear reaction concepts and types of nuclear reactors;* • *Application of theoretical knowledge to practical problems in nuclear reactors;* • *Ability to critically analyze and formulate independent judgments on reactor safety and operation;* • *Clear and articulate presentation of knowledge about nuclear reactors;* • *Autonomous integration and updating of knowledge about nuclear reactors.*
Final exam and grading criteria	*Students will be assessed on their ability to understand and clearly explain the fundamental concepts of nuclear fission reactors.*
Further information	