UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
BACHELOR'S DEGREE (BSC)	ENERGY ENGINEERING AND RENEWABLE ENERGIES
SUBJECT	PRINCIPLES OF NUCLEAR ENGINEERING
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50304-Ingegneria nucleare
CODE	05771
SCIENTIFIC SECTOR(S)	ING-IND/19
HEAD PROFESSOR(S)	DI MAIO PIETRO ALESSANDRO — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	3
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**DI MAIO PIETRO ALESSANDRO** Monday 10:00 11:00 Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici - Edificio 6 - I Piano - Stanza 115 Wednesday 10:00 11:00 Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici - Edificio 6 - I Piano - Stanza 115 Friday 10:00 11:00 Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici - Edificio 6 - I Piano - Stanza 115

DOCENTE: Prof. PIETRO ALESSANDRO DI MAIO

PREREQUISITES	Knowledge of fundamentals of: - integral and differential calculus - classic physics
LEARNING OUTCOMES	KNOWLEDGE AND UNDERSTANDING At the end of the course, the student will have gained an appropriate level of knowledge and understanding about the following topics: - Atoms, nuclei, nuclear reactions and radioactivity - Interaction of alpha, beta and gamma radiations with matter - Interaction of neutrons with matter - Elements of detection and measurement of ionizing radiations - Fundamentals of neutronics: distribution functions, neutron density, cross section, reaction rate and neutron flux - Fundamentals of the neutron diffusion theory - Criticality equations, critical mass, dimensions and composition of a multiplying system - Fundamentals of 0D neutron kinetics of a uniform fission reactor: reactivity, in-hour equation and stable period - Principle of operation of a nuclear fission reactor - Main components of a nuclear fission reactor The evaluation will be done through oral examination. APPLYING KNOWLEDGE AND UNDERSTANDING The student will accrue the ability to analyze and evaluate: - The main interactions of ionizing radiations with matter - The characteristic features of a neutron population: neutron density, neutron flux and reaction rates - The neutron transport processes in a multiplying system: fission, multiplication, absorption, slowing down and diffusion -The critical, sub-critical or super-critical status of multiplying system with a given mass, composition and size - The neutron dynamics of a uniform multiplying system - The structural and functional characteristics of the main components of a nuclear fission reactor The evaluation will be done through oral examination. MAKING JUDGEMENTS At the end of the course, the student will have gained the ability to independently assess the main ionizing radiation interactions with matter as well as the main processes underling both steady state and dynamic behavior of a nuclear fission reactor. The evaluation will be done through oral examination. COMMUNICATION SKILLS At the end of the course, the student will have gained an appropriate level of familiarity with the technical-scientific language used in the field of nuclear reactor physics and engineering. The evaluation will be done through oral examination. LEARNING SKILLS The student will develop the ability to learn the scientific and technological issues that characterize the operation and design of nuclear fission reactors. The evaluation will be done through oral examination.
ASSESSMENT METHODS	The final evaluation is based on an oral exam evaluated in thirty. The minimum grade to pass the exam is 18/30. The exam lasts 40 to 50 minutes and consists of an interview, divided into at least three open-ended questions concerning the whole program of the course. It is aimed at verifying: - the level of knowledge, understanding and grasp of the course content (50% of final evaluation); - the ability to apply with independent judgment and methodological rigor knowledge and skills acquired to the analysis and solution of typical issues (30% of final evaluation); - the correct use of language and the clarity (10% of final evaluation); - the ability to critically revise the acquired concepts, placing them in the appropriate logical connection with the various issues addressed in the course and in those related to it (10% of final evaluation). EVALUATION METRICS - 30 - 30 cum laude (excellent): excellent knowledge and mastery of the course content illustrated with full language skills and clarity, strong aptitude to apply with independent judgment and methodological rigor skills acquired recasting them critically. - 27 - 29 (distinguished): full knowledge of the course content illustrated with

	language skills and clarity, ability to apply with good independent judgment and methodological rigor skills acquired. - 24 - 26 (good): good knowledge of the course content illustrated with language skills, modest aptitude to apply with a good autonomy skills acquired. - 22 - 24 (satisfactory): satisfactory knowledge of the main contents of the course illustrated with acceptable technical language, poor level of autonomy in the application of acquired skills. - 18 - 21 (sufficient): minimal knowledge of the essential contents of the course and of the relevant technical language, poor quality or no autonomy of application of acquired skills.
EDUCATIONAL OBJECTIVES	The course aims to introduce the basic issues propaedeutic for the analysis and understanding of the pivotal engineering and technological aspects of nuclear fission reactors devoted to electricity production on an industrial scale. The attention will initially be focused on some basics of modern physics concepts related to the atom, the nucleus, nuclear reactions and radioactivity. Later on, the interactions of ionizing radiations (alpha, beta, gamma and neutrons) with matter will be addressed, giving hints on the detection and measurement of such emissions. There will be introduced the fundamentals of neutronics, defining the characteristic functions of a neutron population, such as density, flux and reaction rates. Later on, attention will be put on the processes that determine the neutron transport in a multiplying system such as fission, multiplication, absorption, slowing down and diffusion, introducing the fundamentals of the monoenergetic diffusion theory. It will be analyzed the behavior of a neutron population in a multiplying system under both steady state conditions, by introducing the concepts of critical mass, dimensions and composition, and dynamic conditions, by introducing a 0D neutron kinetic model for a uniform reactor with particular emphasis on the concepts of reactivity, in-hour equation and stable period. Finally, it will be illustrated the principle of operation of a nuclear fission reactor and there will be described the functional architecture and the engineering characteristics of its main components.
TEACHING METHODS	The teaching activity is articulated in frontal lessons and computational exercises, mainly carried out with mathematical software tools.
SUGGESTED BIBLIOGRAPHY	- Lamarsh, Baratta, Introduction to Nuclear Engineering, Addison-Wesley Series in Nuclear Science and Engineering, Prentice Hall College Div, 2001, ISBN: 0201824981 - M. Cumo, Impianti Nucleari, UTET, 1996, ISBN: 8895814630 - C. Lombardi, Impianti Nucleari, CUSL, 2004, ISBN: 8873980554

SYLLABUS

Hrs	Frontal teaching
3	Atoms, nuclei, nuclear reactions and radioactivity
3	Interaction of alpha, beta and gamma radiations with matter
3	Interaction of neutrons with matter
2	Elements of detection and measurement of ionizing radiations
5	Fundamentals of neutronics: distribution functions, neutron density, cross section, reaction rate and neutron flux
8	Fundamentals of the neutron diffusion theory
5	Criticality equations, critical mass, dimensions and composition of a multiplying system
8	Fundamentals of 0D neutron kinetics of a uniform fission reactor: reactivity, in-hour equation and stable period
8	Principle of operation of a nuclear fission reactor
6	Main components of a nuclear fission reactor

Hrs	Practice
3	Radioactivity: radioactive families decay
9	Thermal neutron flux distribution in simple-geometry multiplying systems
6	Assessment of the critical configuration of a multiplying systems
6	Neutron dynamics of a uniform multiplying systems
6	Draft design of a nuclear PWR core