UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	ENERGETIC AND NUCLEAR ENGINEERING
SUBJECT	NUCLEAR MEASUREMENTS AND DOSIMETRY
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50367-Ingegneria energetica e nucleare
CODE	23142
SCIENTIFIC SECTOR(S)	ING-IND/20
HEAD PROFESSOR(S)	TOMARCHIO ELIO ANGELO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**TOMARCHIO ELIO ANGELO** Tuesday 11:00 13:00 Edificio 6 - II piano - stanza 217 Thursday 11:00 13:00 Edificio 6 - II piano - stanza 217

DOCENTE: Prof. ELIO ANGELO TOMARCHIO

PREREQUISITES	Mathematics and Physics
LEARNING OUTCOMES	knowledge and understanding • At the end of the course, the student will have acquired adequate knowledge on methods and techniques for measuring ionizing radiation and will be able to solve more or less complex radiation protection problems. Capacity to apply knowledge and understanding The student will have acquired adequate knowledge and understanding skills to apply the methods for measuring ionizing radiation and for assessing main dosimetric and radioprotection quantities. It will also be able to experimentally detect the parameters, useful for the evaluation - also in numerical terms - of the radiological risk associated with the various activities involving the use of ionizing radiation. Judgement • At the end of the course, the student will have acquired adequate judgment skills to plan a campaign of measures and to evaluate the interventions to be implemented to ensure the safety of use of ionizing radiation and their control during operation. Communication skills • The student will be able to describe with competence and language skills the specific risk assessments and actions to be taken to reduce the effects related to the activity being investigated. Learning ability • The student will be able to deal autonomously issues related to nuclear measurements and radiation protection and to apply knowledge and calculation techniques in specific cases.
ASSESSMENT METHODS	Oral Exam. The candidate must orally answer at least two / three questions on all issues covered by the course, with reference to the recommended texts. Final assessment aims to evaluate whether the student has knowledge and understanding of the topics, has acquired capability to interpret and independent judge concrete cases. The sufficiency will be reached when the student shows knowledge and understanding of the subjects at least in broad outline, and has minimal application skills in order to solve concrete cases; furthermore, the student must demonstrate argumentative ability to allow the transmission of his knowledge to the examiner. Below this threshold, the exam results insufficient. The evaluation will be positive and will be accompanied by an ever higher rating as the student will be able to interact with the examiner with his argumentative and expositive ability, and how much more his knowledge and applicative ability go into the details of discipline. The evaluation is carried out of thirty (30/30). Description of evaluation methods evaluation : excellent; rating: 30 or 30 cum laude excellent knowledge of the topics, excellent properties of language, good analytic capability and ability to apply acquired knowledge to solve concrete problems and cases evaluation: very good; rating: 26-29 Good knowledge of the topics, full ownership of language, the student is able to apply knowledge to solve problems proposed. evaluation: good; rating : 24-25 Basic knowledge of the main topics, discret property of language, limited ability to independently apply the knowledge to the solution of the proposed problems. evaluation: satisfactory; rating : 21-23 He does not have full command of the main topics but has the knowledge, satisfactory properties of language, poor ability' to independently apply the knowledge gained. evaluation: adequate; rating: 18-20 Minimum basic knowledge of the main teaching and technical language issues, very little or no ability to independently apply the knowledge acquired evaluation: insufficient It does not have an acceptable knowledge of the contents of the topics covered in the course.

EDUCATIONAL OBJECTIVES	The aim of this course is to study the methods and techniques for measuring ionizing radiations to evaluate the risk for their use and to identify the protective devices suitable for reducing the radiological risk to acceptable values. (See also Educational objectives listed in the Academic Regulations).
TEACHING METHODS	Lectures, numerical exercises and laboratory applications
SUGGESTED BIBLIOGRAPHY	Testi consigliati e di consultazione: - Laitano R.F., Fondamenti di dosimetria delle radiazioni ionizzanti, 4.a edizione, ENEA, 2015 (disponibile in rete). - Tsoulfanidis N., Landsberger S., Measurement and Detection of Radiation, CRC Press, 5th Edition, 2021. ISBN 9781003009849 (e-book) - Turner J.E., Atoms, Radiation, and Radiation Protection, 2007, Wiley-VCH. ISBN 9783527406067 - Knoll G., Radiation Detection and Measurements, 4th edition, 2010, Wiley, ISBN 978-0470131480 Materiale didattico: - Presentazioni delle Lezioni - Dispense e Documentazione messa a disposizione dal docente

SYLLABUS

Hrs	Frontal teaching
6	INTRODUCTION TO THE COURSE - Review of Physics of Ionizing radiations - Radioactive decay - Interaction of heavy particles, electrons and photons with matter - Neutrons, classification and their interaction. Introduction to radiation measurement.
10	RADIATION DETECTORS - Interactions of radiation with matter. Detectors based on the ionization measurements. Gas detectors. Ionization chamber. Proportional and Geiger-Muller counters. Organic and inorganic scintillators. The lanthanum bromide scintillator. Photomultiplier tubes. Semiconductor detectors. Diode detectors. Hyperpure Germanium (HPGe) detectors. Gamma spectrometry with scintillators. High resolution gamma spectrometry with HPGe. Individual dosimeters. Slow and fast neutron measurement instruments. The rem-counter. Instrumentation based on neutron activation. Contamination detectors.
4	COUNTING STATISTICS AND ERROR PREDICTION. Characterization of measurement data. Statistical models. Gaussian and Poisson dsitribution. Calculation of measurement uncertainties. Variance and standard deviation. Error propagation. Optimization of counting times. Application of the principle of least squares.Statistical tests.
10	RADIATION DOSIMETRY: Dosimetric quantities. Absorbed dose. Kerma, Exposure. Relationship between dosimetric quantities. Specific constant of kerma in air. Equilibrium of charged particles. Measurement of exposure and absorbed dose: free air chamber and cavity chamber. The Bragg-Gray law. Biological effects of radiation. Mechanism of damage to cellular tissues. Cellular and molecular effects of radiation. Elements of Radiobiology. - Radiosensitivity and individual susceptibility. Fundamental principles of radiation protection. Radioprotection quantities. Equivalent Dose and Effective Dose. ICRU Operational quantities: environmental and personal dose equivalent. Calculation of the attenuation of gamma and neutron radiations. The build-up factor and the removal cross section. Calculation of flux density from external sources. Calculation of shielding thickness for sources of different geometry and use. Internal dosimetry. Internal dose calculations: metabolic and physical-geometric aspects.
8	RADIOPROTECTION: Reference legislation. Shield design. Physical security surveillance. Dose limits. Radiation protection of workers, population and the environment. Notes on patient radiation protection. Operational radiation protection. Methods for evaluating the equivalent dose and effective dose in exposure to external sources, natural sources, internal sources, in the measurement of effluents. Measurement of contamination with direct measurements or with the use of smear tests. Evaluation of potential dose: in the case of nuclear emergencies, for the dispersion of pollutants, etc.

Hrs	Practice
8	1) Calculation of the fundamental parameters of a radiation field: Flux, Kerma, Dose. 2) Computation of neutron-induced activity by activation. 3) Calculation of the concentration in the air following an incidental emission. 4) Design of a shield for gamma sources. 5) Design of a shield for neutron sources. 6) Calculation of the internal dose following an administration of radioactive substances (Nuclear Medicine). 7) Risk assessment and mitigation interventions for a complex plant based on use of radioactive sources.

Hrs	Workshops
8	1) Effective dose rate measurement with portable instrumentation. 2) Measurement of radionuclide activity in a sample through gamma spectrometry with HPGe detector. 3) Measurement of neutron dose from Am-Be sources with rem counter. 4) Search for radioactive sources using a specific tool (Isotope Finder). 5) Detection of surface contamination with a contaminameter and/or use of smear tests.