TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School

____________ / Oleg Yu. Dolmatov

"25" 06 2020

Course Name: Lab Practicum

Field of Study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear Power Engineering

Level of Study: Master Degree Programme

Year of admission: 2020

ECTS: 3

Total Hours: 108

Contact Hours: 32

- **Labs:** 32

Self-study: 76

Assessment: Credit-test

Division: Nuclear Fuel Cycle

Director of Programme ____________ / Vera V. Verkhoturova

Instructor ____________ / Artem G. Naymushin

Course name: Lab Practicum

Course Overview

Course Objectives	The objective of the course is to develop practical knowledge and skills among learners to prepare them for conducting their professional activity closely connected with the determination of physical parameters of the research reactor operation.
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** – the features of professional etiquette of foreign and domestic cultures; – the basics of structuring a report and preparing presentations in a foreign language, accepted in the international environment; – modern methods of research, evaluation and presentation of the results of work performed; – the main types, classes and groups of materials, their compositions and properties (nuclear fuel, coolants, moderators, construction materials, shielding materials); – the features of the application of the basic calculation methods used in the maintenance of operation, conducting experiments and designing nuclear installations; – basic methods of conducting experiments on measuring the parameters of breeding systems and controls of a nuclear reactor; – the techniques for the development of design and working technical documentation, the design of completed design work; – basic types and design solutions of existing and planned nuclear facilities; – the main characteristics of the control and protection system of a nuclear reactor, power control and distribution of energy release, automated control and management systems. **Upon completion of the course, a graduate will be able to:** – compile and present technical and scientific information used in professional activities in the form of a presentation; – perceive authentic audio and video materials related to training; – apply modern research methods, evaluate and present the results of work performed; – simulate the geometric and material composition of the reactor core, experimental volumes and biological shielding of nuclear reactors; – use computational tools for modeling neutronic and thermohydraulic processes in nuclear reactors; – apply the correct methodology for analyzing the state of breeding systems, describe the data obtained and interpret the results, make recommendations based on the data received; – collect and analyze scientific and technical information for processing nuclear physics research data using computer technologies and information resources; – analyze design decisions of developed and created nuclear facilities;

	– perform calculations, design parts and assemblies of nuclear facilities in accordance with the terms of reference using CAD-software. **Upon completion of the course, a graduate will have experience in:** – communicating professional ideas and texts using a foreign language (tables, graphs, charts, etc.); – application of modern research methods, evaluating and presenting the results of work performed; – making calculations of the reactor core and experimental volumes of nuclear reactors in all operating conditions; – creating and verifying numerical models of reactor cores of nuclear reactors; – conducting experiments to measure the neutron-physical parameters of the reactor core of nuclear reactors and results interpretation; – collecting and analyzing initial data for the design of devices and installations; – design of reactor cores, regulators and biological shielding of nuclear facilities for multi purposes; – performing engineering calculations for the main types of professional tasks (control and protection systems for a nuclear reactor, instrumentations of power control and distribution of energy release).
Course Outline	The course consists of two sections. **Section 1. Operating of the nuclear reactor IRT-T (22 hours)** This section consists of 11 labs: 1. Constructive and technological features of the reactor IRT-T (2 hours) 2. Study of the reactor control and protection system IRT-T (2 hours) 3. Study of the instrumentation and control system (2 hours) 4. Pre-start preparation (2 hours) 5. Manual start-up of a nuclear reactor (2 hours) 6. Automatic start-up of a nuclear reactor (2 hours) 7. Calibration of automatic control rod (2 hours) 8. Calibration of shim rod (2 hours) 9. Monitoring of operational parameters of the reactor IRT-T (2 hours) 10. Study of the water-chemical regime of the operation of the IRT-T reactor primary cooling loop (2 hours) 11. Investigation of water activity of the primary cooling loop of the reactor IRT-T (2 hours) **Section 2. Scientific equipment of a nuclear reactor (10 hours)** This section consists of 5 labs: 12. Measurement of the neutron flux density in the experimental channels of the IRT-T reactor (2 hours) 13. Measurement of neutron flux distribution along the vertical and horizontal cross-section of the reactor core (2 hours) 14. Irradiation of ingots of semiconductor materials in the tangential experimental channel of the research reactor (2 hours) 15. Calibrations of semiconductor gamma spectrometer characteristics for energy, efficiency and resolution (2 hours) 16. Neutron-activation analysis of hafnium impurity content in a zirconium sample (2 hours) Within the framework of the course, students perform 16 labs using the equipment of the IRT-T research reactor. Reports on each of the labs should be

	submitted by students within the course study. Lab reports should be presented in paper and formatted according to the TPU guidelines. The number of pages for the report (except for the title page and the list of references) should be at least 5 and not more than 10. The maximum score for a lab report is 5. Scoring each lab report is performed according to the system of knowledge assessment. Final assessment is performed orally using an exam paper. Each exam paper includes three questions or tasks. Preparation time is 20 minutes. The maximum score is 20 points; the minimum required score is 12. Total score is formed in accordance with three criteria: – Knowledge of professional subject (0-4 scores), – Logical and well-structured answers (0-6 scores), – Correctness and completeness of answers (0-10 scores).
Prerequisites (if available)	1. Dosimetry and Protection from Ionizing Radiation. 2. Control and Safety of Nuclear Reactor. 3. Reactor Physics. 4. Nuclear and Radiation Safety. 5. Reactor Kinetics and Control.
Course Structure	Within the framework of the course, students study the following sections: *Section 1. Operating of the nuclear reactor IRT-T.* Labs referring to this section are aimed at developing learners' practical skills on the following topics: 1. The main decisions in the design and construction of a research reactor 2. Formation of control and protection system and technological parameters control system and their features in the operation of a research reactor. 3. Ensuring safety during manual and automatic start-up. 4. Control of the main technological parameters during the research reactor operation. *Section 2. Scientific equipment of a nuclear reactor.* Labs referring to this section are aimed at developing learners' practical skills on the following topics: 1. Experimental methods for measuring the distribution and absolute values of the neutron flux density in the core and the experimental channels of a nuclear reactor. 2. Studying the technology of neutron-transmutation doping. 3. Fundamentals of work with a semiconductor gamma spectrometer. 4. Fundamentals of neutron activation analysis.
Facilities and Equipment	1. IRT-T Research Nuclear Reactor. 2. Control and protection system on the basis of security modules "Mirage MB". 3. Instrumentation and control system. 4. Activation foils and wires detectors. 5. The complex of neutron-transmutation doping of silicon. 6. Gamma-spectrometer Canberra with germanium detector.
Grading Policy	In accordance with TPU rating system we use: – Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities (lab completing, problem solving). Max score for current assessment is 80, min – 56.

	– Course final assessment (credit test) is performed at the end of the semester. Max score for course final assessment is 20, min – 12. The final score is determined by summing the scores of the current assessment during the semester and credit test scores at the end of the semester. Maximum overall score corresponds to 100, min pass score is 62.
Course Policy	Current assessment is performed in a form of lab reports defense. Lab reports must be presented in paper and formatted according to the TPU guidelines. The number of pages in the report (except for the title page and the list of references) should be at least 5 and not more than 10. The maximum score for a report is 5. The number of scores received by a student for each lab is determined according to the system of knowledge assessment. Final assessment is carried out orally using exam paper. Each exam paper includes three questions or tasks. Preparation time is 20 minutes. The maximum score is 20 points; the minimum required score is 12. Total score is formed in accordance with three criteria: – Knowledge of professional subject (0-4 scores), – Logical and well-structured answers (0-6 scores), – Correctness and completeness of answers (0-10 scores).
Teaching Aids and Resources	**Compulsory reading:** 1. Oka Y. Nuclear Reactor Design / Y. Oka. – Tokyo : Springer, 2014. – 327 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-54898-0 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Shimjith, S. R. Modeling and control of a large nuclear reactor / S. R. Shimjith, A. P. Tiwari, B. Bandyopadhyay. – New York : Springer, 2010. – 327 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-30589-4 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 3. Takigawa N. Fundamentals of Nuclear Physics / N. Takigawa K. Washiyama. — Tokyo : Springer, 2017. — 269 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-55378-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Additional reading**: 1. Hoffelner W. Materials for Nuclear Plants. From Safe Design to Residual Life Assessments / W. Hoffelner. – New York : Springer, 2013. – 502 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-1-4471-2915-8 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ 2. Nuclear Thermal Hydraulics / H. Akimoto, Y. Anoda, T. Kazuyuki [and others] – Tokyo : Springer. 2016. – 464 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-55603-9 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.
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