COURSE DESCRIPTION CARD - SYLLABUS

Course name
Reliability theory

Course

Field of study
Mathematics in Technology

Year/Semester
4 / 7

Area of study (specialization)

Profile of study
general academic

Level of study
First-cycle studies

Course offered in

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
15

Other (e.g. online)

Tutorials
0

Projects/seminars
0

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
dr hab. Karol Andrzejczak, prof.PP

Responsible for the course/lecturer:

Prerequisites

The student starting this subject should have basic knowledge in mathematical logic, set theory, differential and integral calculus, special functions, properties and applications of Fourier and Laplace transforms, probability calculus and mathematical statistics. The student should have the skills to express mathematical content in speech and writing, in both theoretical and practical texts. The student should have good skills in using at least one computer package to support numerical and symbolic calculations in the field of probabilistic and statistical methods. As part of social competences, she/he should know the limits of his own knowledge and understand the need for further education. Should formulate precise questions to deepen understanding of the topic or to find missing elements of reasoning. He should be aware of the variety of problems that arise in the various phases of the life cycle of technical objects. She/he should also have the skills to obtain information from the indicated literature in both Polish and English and be open to cooperation within the team.

Course objective

The aim of the course is to familiarize students with the basic issues of modern mathematical theory of reliability and methods of solving selected problems of used technical objects in terms of their reliability, availability, maintenance and safety, taking into account the possibilities of computer-aided. Developing students' ability to solve problems arising when managing non-renewable and renewable operations, both simple and complex technical facilities.

Course-related learning outcomes

Knowledge

A student who completes all forms of education in the theory of reliability has expanded and in-depth knowledge of the problems of reliability theory and detailed knowledge about the possibilities of using mathematical methods and tools in reliability engineering for the needs of technical sciences;

has a systematic knowledge of mathematical terminology and selected issues in the field of engineering and technical sciences related to the theory of reliability;

knows the possibilities and limitations of mathematical modeling;

Skills

As a result of completing all forms of education in the theory of reliability, the student will be able to analyze, model and solve selected elements of supporting the management of the operation of simple and complex technical objects using stochastic methods;

will be able to work individually and in a team and interact with other people; will be able to estimate the time needed to complete the task.

Social competences

As a result of the course the student will gain the following competencies:

the ability to precisely formulate questions to deepen understanding of advanced probabilistic and statistical methods used in reliability theory;

teamwork skills in solving complex research projects.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:

• ongoing assessment of student activity on the basis of self-solved tasks given in e-courses (40% share in the final grade);

• evaluation of the presentation of individually developed sets of tasks (participation in the final evaluation 20%);

• assessment of theoretical knowledge and practical skills demonstrated in the final oral exam (participation in the final grade 40%).

The scale of the final lecture grade: from 45% - 3,0; from 55% - 3,5; from 65% - 4,0; from 75% - 4,5; from 85% - 5,0.

Laboratory exercises:

• the current rating - rewarding new skills have met the practical use of the principles and methods (50% participation in the final assessment);

• assessment of knowledge and the ability to apply it on the basis of a final test (participation in the final grade 50%).

The scale of final grades for laboratory exercises: from 50% - 3,0, from 60% - 3,5, from 70% - 4,0, from 80% - 4,5, from 90% - 5,0.

Programme content

Update 08/23/2022

Issues presented in the lectures:

1. Introduction to the subject. Indication of basic and supplementary literature. Discussion of the maturity and conditions for passing the subject and the form of the final examination (1h).

2. Reliability of non-renewable elements. Uptime time models: Weibull distribution, gamma distribution, Rayleigh distribution, semi-normal distribution (3h).

3. Truncated distributions and mixtures of distributions. Reliability glued function. Positional statistics and their boundary distributions. Expected remaining lifetime. Conditional probability of the component up-state. Lifetime classes - types of component aging. The probability of completing the task (4h).

4. Non-renewable systems. Systems and their reliability structures. System availability. System reliability without structural redundancy. System with structural redundancy (4h).

5. Item Renewal. The stream of renewal. The renewal process. Renewal function. Reneval theorem. Variance of the number of renewals. Time until next failure. Alternative renewal stream. Component replacement strategies - preventive replacement (6h).

6. System reservation and renewal. Renewable types. Renewable systems. Stochastic processes in the assessment of system reliability - Poisson process, Markov process, semi-Markov process (4h).

7. Statistical inference in the theory of reliability. Empirical characteristics of the reliability of objects. Identification of the type of distribution. Evaluation of the parameters of selected distributions. Evaluation of the instantaneous value of the reliability function (4h).

8. Presentations by students of individually developed task sets (2h).

Issues carried out during laboratory exercises:

1. Determination of reliability characteristics with and without computer support. The process of destroying the element by the so-called pitting (2h).

2. Developing ways of increasing the number of mathematical variants of loifetime models and models of component failure (3h).

3. Application of Boolean algebra to determination of reliability structures of binary systems and determination of structures in the form of tables, logical schemas, logical and analytical functions. Modular composition of the system. System paths and cuts. Investigation of monotonicity, irreducibility and coherence of systems. Determining and estimating system availability (2h).

4. Examination of the renewal processes. Kolmogorov equations. Application of Laplace transform. Determining the function creating the renewal process. Determination of reliability characteristics of renewable elements using convolution integrals and Laplace transform (4h).

5. The use of the Markov process to evaluate the reliability of a multi-state system (2h).

6. Final test (2h).

Teaching methods

Lectures: introducing a new topic preceded by reminding the content that should be known to the students already, supporting the lecture with a multimedia presentation, a table presentation of the methodology of solving formulated problems in the theory of reliability.

Laboratory exercises: practical solving of tasks and problems with computer support. Generalization of obtained solutions. Searching for possible applications of theoretical results. Individual or team development of research projects concerning contemporary problems of the theory of reliability and its engineering applications.

Bibliography

Basic

1. Bobrowski Dobiesław, Modele i metody matematyczne teorii niezawodności, Wydawnictwo Naukowo-Techniczne, Warszawa 1985.

2. Macha Ewald, Niezawodność maszyn, Politechnika Opolska, Opole 2001, wersja elektroniczna.

3. Grabski Franciszek, Jaźwiński Jerzy, Funkcje o losowych argumentach w zagadnieniach niezawodności, bezpieczeństwa i logistyki, WKŁ, Warszawa 2008.

Additional

1. Bobrowski D. Probabilistyka w zastosowaniach technicznych, WNT, Warszawa, 1986.

2. Jokiel-Rokita Alicja, Magiera Ryszard, Selected stochastic models in reliability, Wrocław 2011, Politechnika Wrocławska.

3. Aven Terje, Jensen Uwe, Stochastic models in reliability, Springer, 1999.

4. Gertsbakh Ilya, Reliability theory with applications to preventive maintenance, Springer, 2000.

5. Barlow Richard E., Engineering Reliability, ASA and SIAM, 1998.

6. Lawless Jerald F., Statistical Models and Methods for Lifetime Data. A John Wiley & Sons, Inc., Publication, 2003.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies (10h), solving activity tasks (15h), preparation of a presentation (5h), preparation for a colloquium (10h), preparation for an exam (15h)) [1]	55	2,0

[1] delete or add other activities as appropriate