University of Gdańsk

Subject card

| | | | |
|---|---|---|---|
| Subject name and code | Probability and Information Theory, PG_00158042 | | |
| Field of study | Quantum Information Technology | | |
| Date of commencement of studies | October 2024 | Academic year of realisation of subject | 2024/2025 |
| Education level | postgraduate studies | Subject group | Obligatory subject group in the field of study |
| Mode of study | full-time studies | Mode of delivery | at the university |
| Year of study | 1 | Language of instruction | English<br>English |
| Semester of study | 1 | ECTS credits | 6.0 |
| Learning profile | academic | Assessment form | |
| Conducting unit | | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | dr inż. Marek Winczewski | |
| | Teachers | dr inż. Marek Winczewski<br>Anuradha Tonipe | |

| Lesson types | Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|---|
| | Number of study hours | 30.0 | 30.0 | 0.0 | 0.0 | 0.0 | 60 |
| | E-learning hours included: 0.0 | | | | | | |

| Learning activity and number of study hours | Learning activity | Participation in didactic classes included in study plan | Participation in consultation hours | Self-study | SUM |
|---|---|---|---|---|---|
| | Number of study hours | 60 | 0.0 | 30.0 | 90 |

| | |
|---|---|
| Subject objectives | The aim of this lecture is to provide students with specific knowledge of probability theory and statistics necessary to understand some aspects of quantum mechanics and quantum information theory. The student will also acquire basic knowledge in the field of application of the main concepts of information theory such as entropy, mutual information or relative entropy and their properties. The student will also learn the capacities of communication channels and methods of estimating them. |

Learning outcomes

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| [QITL3_W06] has knowledge of current directions in the development of physics, in particular in the field of quantum information theory | Student is aware about current theoretical and experimenetal challanges of quantum communication, computing and cryptography. | [SW4] test/exam - oral or written |
| [QITL3_K01] knows the limitations of his/hers knowledge and skills; can formulate questions precisely; understands the need for further education of oneself and other people | Student is aware about past challanges in Information Theory, and participates in discussions with his peers about possible ways of overcoming the current ones. | [SK1] oral statement/conversation/ discussion |
| [QITL3_U05] has the ability to synthesize methods and ideas from various areas of physics and other branches of science; is able to notice that distant phenomena are sometimes described by similar models | Student knows examples of application of Information-Teoretic and Statistical Methods in biological, physical and engineering contexts. | [SU4] test/exam - oral or written |
| [QITL3_U06] is able to adapt to related scientific disciplines the knowledge and theoretical methods and methodology of physics | Student can model problems of communication, cryptography, secret sharing, measurement and computing. | [SU4] test/exam - oral or written |
| [QITL3_W02] has in-depth knowledge in the field of advanced mathematics and mathematical and computer methods, necessary to solve physical problems of medium complexity, and advanced knowledge in the area of quantum information and its technological aspects | Student can model and solve problems associated with basic quantum systems using Mathematica software and QuTiP library. | [SW4] test/exam - oral or written |
| [QITL3_U02] has the skills to plan and conduct basic and advanced research and calculations in the area of quantum information theory or its applications | Student can model and solve problems of communication, error correction and cryptography using statistical and Information-Theoretic methods. | [SU4] test/exam - oral or written |
| [QITL3_U01] is able to apply the scientific method in solving physical problems and reasoning in the field of quantum information theory | Student is aware about experimental realizations of communication and cryptographic tasks, and can relate their characteristics to theoretical models. | [SU4] test/exam - oral or written |
| [QITL3_U03] is able to critically analyze observations or theoretical calculations and assess the accuracy of the results | Student knows statistical methods for hyphothesis testing and error estimation. | [SU4] test/exam - oral or written |
| [QITL3_W04] knows advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics | Student knows and can apply structures of Information Theory and Statistics in modeling communication and cryptographic problems. | [SW4] test/exam - oral or written |
| [QITL3_W01] has extended knowledge in the field of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of science, knowledge of the world and social development | Students knows the history of Information Theory, Probability and Statistics. | [SW4] test/exam - oral or written |

<table>
<tr><td>Subject contents</td><td>1. Basic notions of probability: probability space, standard normal distribution, random variable, expected value, variance.2. Density function and the cumulative distribution function, independence of random variables.3. Bayes theorem.4. Law of large numbers and the central limit theorem for indenepent and identically distributed random variables.5. Shannon entropy function, its interpretation and properties.6. Entropy functions of many variables, including conditional entropy, mutual information, relative entropy, conditional mutual information and theirproperties, including data processing inequality and the chain principle for conditional mutual information.7. Asymptotic Equipartition Property theorem, compression codes , error correction codes.8. The concept of typical and total typical sequences, Shannon's theorem on the capacity of a communication channel, random code technique9. Capacities of selected communication channel and Slepian-Wolf theorem on joint coding10. Kraft and Mc Millan inequality</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>None.</td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>lecture part: exam</td><td>51.0%</td><td>50.0%</td></tr>
<tr><td>tutorial part: test</td><td>51.0%</td><td>50.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>E. Shannon, W. Weaver The Mathematical Theory of CommunicationThomas M. Cover, Joy A. Thomas Elements of Information theoryR. W. Yeung A First Course in Information TheoryM. Nielsen, I. Chuang Quantum Information and Computation</td></tr>
<tr><td>Supplementary literature</td><td>None.</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td></td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
</table>

Document generated electronically. Does not require a seal or signature.