UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Verjetnostne metode za kompleksna omrežja
Course title:	Probabilistic methods for complex networks

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Informacijske znanosti, doktorski študijski program tretje stopnje	Matematika kompleksnih omrežij	Drugi	Tretji ali četrti
Information Sciences, third cycle Doctoral Study Programme	Mathematics of complex networks	Second	Third or fourth

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: 1-IZ-DR-MKO-IP-VMKO-2024-04-24

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	-	-	-	-	270	10

Nosilec predmeta / Lecturer: prof. dr. Janez Povh

Jeziki / Languages:	
Predavanja / Lectures:	Slovenski, angleški / Slovene, English
Vaje / Tutorial:	Slovenski, angleški / Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Predhodno znanje iz teorije verjetnosti.

Prerequisites:

Prior knowledge of probability theory.

Vsebina:

- Verjetnostne metode v kompleksnih omrežjih: slučajne spremenljivke, pomembni konvergenčni izreki, sklapljanje slučajnih spremenljivk, stohastična urejenost, verjetnostne meje, martingali.
- Pregled glavnih modelov omrežij.
- Slučajni procesi in sprehodi, markovske verige v diskretnem času, v zveznem času in njihova uporaba.
- Gručenje v omrežjih: definicija problema, pregled metod in mer za ocenjevanje kvalitete gručenja.

Content (Syllabus outline):

- Probabilistic methods in complex networks: random variables, important convergence theorems, coupling of random variables, stochastic order, probability bounds, martingales.
- Review of key network models.
- Random processes and walks, Markov chains in discrete and continuous time and their applications.
- Clustering in networks: definition of the problem, review of methods and measures for evaluating clustering quality.

• Asortativnost in disasortativnost v realnih omrežjih ter njihov pomen. • Procesi razvejanja: preživetje ali izumrtje, obravnava preko slučajnih sprehodov, superkritični procesi razvejanja, binomski in Poissonov proces razvejanja. • Fazni prehodi v slučajnih omrežjih: uvod, primerjava s procesi razvejanja, fazni prehodi Erdos-Renyi-jevih slučajnih grafov.	• Assortativity and disassortativity in real networks and its relevance. • Branching processes: survival or extinction, random walk prospective, supercritical branching processes, binomial and Poisson branching processes. • Phase transitions in random networks: introduction, comparison with branching processes, phase transitions of Erdos-Renyi random graphs.

Temeljni literatura in viri / Readings:

- Van Der Hofstad, R. (2017). *Random graphs and complex networks* (Vol. 43). Cambridge university press.
- Grimmett, G. R., & Stirzaker, D. R. (2020). *Probability and Random Processes,* 4th Edition. New York: Oxford University Press.
- Rice, J.A. (2021). *Mathematical Statistics and Data Analysis,* 3rd Revised Edition. California: Cengage Learning.

Cilji in kompetence:	**Objectives and competences:**
Učna enota prispeva k razvoju naslednjih splošnih in predmetno specifičnih kompetenc: *Splošne kompetence:* • Prizadevanje za kakovost znanstveno-raziskovalnega dela skozi avtonomnost, (samo)kritičnost, (samo)refleksivnost in (samo)evalviranje. • Ustvarjanje novega znanja, ki pomeni relevanten prispevek k razvoju znanosti. • Sposobnost identificiranja danega raziskovalnega problema, njegove analize, ovrednotenja ter oblikovanja možnih rešitev. • Zavezanost profesionalni etiki. *Predmetno-specifične kompetence:* • Analiziranje zahtevnejših vsebin iz verjetnosti in teorije grafov. • Sposobnost aplikacije nekaterih slučajnih procesov v diskretnem in zveznem času. • Sposobnost izbire in uporabe ustreznih metod in primerne programske opreme za reševanje verjetnostnih problemov na kompleksnih omrežjih.	*The instructional unit contributes to the development of the following general and subject-specific competences:* *General competences:* • Striving for quality in scientific research through autonomy, (self-)criticism, (self)reflexivity and (self-)evaluation. • Ability to create new knowledge, which represents a contribution to science. • Ability to identify a given research problem, analyse it, evaluate it and formulate possible solutions. • Commitment to professional ethics. *Subject-specific competences:* • Analysis of advanced aspects of probability and graph theory. • Ability to apply some of the principles of random processes in discrete and continuous time. • Ability to choose and use appropriate methods and suitable software to solve probability problems on complex networks.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: *Študent/študentka:* • analizira nekatere najpomembnejše aplikacije verjetnosti, • raziskuje pomembne lastnosti slučajnih grafov ter verjetnostne metode na grafih (omrežjih), • aplicira slučajne procese, procese razvejanja in koncepte Markovskih verig, • je sposoben/a izbire in uporabe napredne programske opreme za aplikacijo usvojenega znanja, • je sposoben/ refleksije in kritičnega vrednotenja primernosti določene raziskovalne metode za analizo konkretnega problema.	Knowledge and understanding: *The student:* • analyses some of the most important applications of probability, • explores the important properties of random graphs and probabilistic methods on graphs (networks), • applies the random processes, the branching processes, and the concepts of Markov chains, • is able to choose and use advanced software to apply the knowledge acquired, • is able to reflect and critically evaluate the appropriateness of certain research methods for the analysis of concrete problems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• *predavanja* z aktivno udeležbo študentov (razlaga, diskusija, vprašanja, primeri, reševanje problemov, predstavitve), • *individualne in skupinske konzultacije* (diskusija, dodatna razlaga, obravnava specifičnih vprašanj).	• *lectures* (explanation with discussions, questions, case-studies, and presentations). • *individual and group consultations* (debate, additional explanations, considering specific issues).

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): • projektna raziskovalna naloga • ustni izpit	 50 % 50 %	Type (examination, oral, coursework, project): • project research paper • oral exam

Reference nosilca / Lecturer's references:

- Ikica, B., Gabrovšek, B., Povh, J., & Žerovnik, J. (2022). Clustering as a dual problem to colouring. *Computational and Applied Mathematics, 41*(4), 147.
- Mihelač, L., & Povh, J. (2020). AI based algorithms for the detection of (ir)regularity in musical structure. *International Journal of Applied Mathematics and Computer Science, 30*(4), 761–772.
- Benedik, B., Rihtaršič, J., Povh, J., & Tavčar, J. (2021). Failure modes and life prediction model for high-speed bearings in a through-flow universal motor. *Engineering Failure Analysis,* 128, 105535.
- Asadi, S., & Povh, J. (2021). A block coordinate descent-based projected gradient algorithm for orthogonal non-negative matrix factorization. *Mathematics,* 9(5), 540.

- Crnkić, A., Povh, J., Jaćimović, V., & Levnajić, Z. (2020). Collective dynamics of phase-repulsive oscillators solves graph coloring problem. *Chaos: An Interdisciplinary Journal of Nonlinear Science, 30*(3).