

UČNI NAČRT PREDMETA / COURSE SYLLABUS						
<b>Predmet:</b>		Algebraična topologija 1				
<b>Course title:</b>		Algebraic topology 1				
<b>Študijski program in stopnja</b> Study programme and level		<b>Študijska smer</b> Study field		<b>Letnik</b> Academic year	<b>Semester</b> Semester	
Magistrski študijski program Matematika		ni smeri		1 ali 2	prvi ali drugi	
Master's study programme Mathematics		none		1 or 2	first or second	
<b>Vrsta predmeta / Course type</b>				temeljni		
<b>Univerzitetna koda predmeta / University course code:</b>				M2309		
<b>Predavanja</b> Lectures	<b>Seminar</b> Seminar	<b>Vaje</b> Tutorial	<b>Klinične vaje</b> work	<b>Druge oblike študija</b>	<b>Samost. delo</b> Individ. work	<b>ECTS</b>
30	15	30			105	6
<b>Nosilec predmeta / Lecturer:</b>		prof. Dušan Repovš, prof. Janez Mrčun, prof. Petar Pavešić, prof. Sašo Strle				
<b>Jeziki / Languages:</b>		<b>Predavanja / Lectures:</b> slovenski/Slovene, angleški/English				
		<b>Vaje / Tutorial:</b> slovenski/Slovene, angleški/English				
<b>Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:</b>				<b>Prerequisites:</b>		
<b>Vsebina:</b>				<b>Content (Syllabus outline):</b>		
Homotopija, homotopska ekvivalenca, homotopska kategorija, razširitve in dvigi homotopij. Celični kompleksi, celularne				Homotopy, homotopy equivalence, homotopy category, homotopy extensions and liftings. Cell complexes, cellular maps.		

<p>preslikave.</p> <p>Fundamentalna grupa, Seifert - van Kampenov izrek. Krovni prostori, klasifikacija, krovne transformacije. Grupa vozla, proste grupe, prostori <math>K(G,1)</math>.</p> <p>Homološke grupe, homotopska invariantnost, eksaktna zaporedja, izrez. Stopnja preslikave, celularna homologija, Mayer-Vietorisovo zaporedje. Ovojna in spletna števila, indeks vektorskega polja, Lefschetzev izrek, vztrajna homologija, bordizem, homologija Hovanova.</p>	<p>Fundamental group, Seifert - van Kampen theorem. Covering spaces, classification, deck transformations. Group of a knot, free groups, <math>K(G,1)</math> spaces.</p> <p>Homology groups, homotopy invariance, exact sequences, excision. Degree of a map, cellular homology, Mayer-Vietoris sequence. Winding and linking numbers, index of a vector field, Lefschetz fixed point theorem, persistent homology, bordism, Khovanov homology.</p>
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**Temeljni literatura in viri / Readings:**

<p>A. Hatcher: Algebraic Topology, Ch. 0-2.</p> <p>W.Massey: A Basic Course in Algebraic Topology, Ch. I-X.</p> <p>E. Spanier: Algebraic Topology, Ch. 1-4.</p> <p>Dodatna:</p> <p>A. Dold: Lectures on Algebraic Topology, Ch. 1-6.</p> <p>P. May, A Concise Course in Algebraic Topology</p> <p>J. Munkres: Elements of Algebraic Topology, Ch. 1-4.</p>
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**Cilji in kompetence:**

Študent spozna osnovne pojme algebraične topologije kot so homotopija, celični prostori, fundamentalna grupa in homološke grupe.

**Objectives and competences:**

Student learns basic concepts of algebraic topology: homotopy, cellular spaces, fundamental group, homology groups.

**Predvideni študijski rezultati:**

Znanje in razumevanje:  
Poznavanje osnovnih pojmov in tehnik za delo s fundamentalno grupo in homološkimi grupami. Razumevanje homotopske invariance in prijemov za obravnavanje geometrijskih vprašanj s pomočjo algebre.

Uporaba:

V področjih matematike, ki delajo z geometričnimi objekti (kompleksna in globalna analiza, dinamični sistemi, geometrijska in diferencialna topologija, teorija grafov), v računalništvu (grafika, prepoznavanje vzorcev, topološka analiza podatkov, robotika), v teoretični fiziki.

Refleksija:

Razumevanje teorije na podlagi primerov in uporabe.

Prenosljive spretnosti – niso vezane le na en predmet:

Formulacija problemov v primernem jeziku, reševanje in analiza doseženega na primerih, prepoznavanje algebraičnih struktur v geometriji.

**Intended learning outcomes:**

Knowledge and understanding:  
Basic concepts and techniques for the computation of the fundamental group and homology groups. Understanding of the concepts of homotopy invariance and of approaches to geometric problems by algebraic methods.

Application:

Parts of mathematics with strong geometric content (complex and global analysis, geometric and differential topology, graph theory), computer science (computer graphics, pattern recognition, topological data analysis, robotics), theoretical physics.

Reflection:

Understanding of theoretical concepts through examples and applications.

Transferable skills:

Recognition of algebraic structures in geometry, appropriate formulation of problems.

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**Metode poučevanja in učenja:**

predavanja, vaje, domače naloge, konzultacije

**Learning and teaching methods:**

Lectures, exercises, homeworks, consultations

**Načini ocenjevanja:**

izpit iz vaj / pisni izpit  
izpit iz teorije / ustni izpit

Ocene: 5 (negativno), 6-10 (pozitivno)  
(po Statutu UL)

Delež (v %) /  
Weight (in %)

**Assessment:**

Exercise-based exam / written exam  
Theoretical knowledge exam / oral exam

Grading: 5 (fail), 6-10 (pass) (according  
to the Statute of UL)

**Reference nosilca / Lecturer's references:**

Janez Mrčun:

- MOERDIJK, Ieke, MRČUN, Janez. Introduction to foliations and Lie groupoids, (Cambridge studies in advanced mathematics, 91). Cambridge, UK: Cambridge University Press, 2003. IX, 173 str., ilustr. ISBN 0-521-83197-0 [COBISS.SI-ID 12683097]
- MOERDIJK, Ieke, MRČUN, Janez. Lie groupoids, sheaves and cohomology. V: EuroSchool PQR2003 on Poisson geometry, deformation quantisation and group representations, Université Libre de Bruxelles, June 13-17, 2003. GUTT, Simone (ur.), RAWNSLEY, John Howard (ur.), STERNHEIMER, Daniel (ur.). Poisson geometry, deformation quantisation and group representations, (London Mathematical Society lecture note series, ISSN 0076-0552, 323). Cambridge [etc.]: Cambridge University Press, cop. 2005, str. 147-272 [COBISS.SI-ID 13657689]
- MRČUN, Janez. Topologija, (Izbrana poglavja iz matematike in računalništva, 44). Ljubljana: DMFA - založništvo, 2008. VI, 147 str., ilustr. ISBN 978-961-212-207-2 [COBISS.SI-ID 243021824]

Petar Pavešič:

- PAVEŠIĆ, Petar CONNER, Gregory R., HERFORT, Wolfgang, PAVEŠIĆ, Petar. Some anomalous

examples of lifting spaces. *Topology and its Applications*, ISSN 0166-8641. [Print ed.], April 2018, vol. 239, str. 234-243.

– PAVEŠIĆ, Petar, A topologist's view of kinematic maps and manipulation complexity. V: GRANT, Mark (ur.). *Topological complexity and related topics : Mini-Workshop Topological Complexity and Related Topics*, February 28 - March 5, 2016, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, (Contemporary mathematics, ISSN 0271-4132, 702). Providence: American Mathematical Society.

– PAVEŠIĆ, Petar. *Splošna topologija*, (Izbrana poglavja iz matematike in računalništva, 43). Ljubljana: DMFA - založništvo, 2008. VI, 89 str., ilustr. ISBN 978-961-212-205-8 [COBISS.SI-ID 240425984]

Dušan Repovš:

– BANAKH, Taras, REPOVŠ, Dušan. Direct limit topologies in the categories of topological groups and of uniform spaces. *Tohoku mathematical journal*, ISSN 0040-8735, 2012, vol. 64, no. 1, str. 1-24 [COBISS.SI-ID 16215897]

– CÁRDENAS, Manuel, LASHERAS, Francisco F., QUINTERO, Antonio, REPOVŠ, Dušan. On manifolds with nonhomogeneous factors. *Central European Journal of Mathematics*, ISSN 1895-1074, 2012, vol. 10, no. 3, str. 857-862 [COBISS.SI-ID 16241753]

– KARIMOV, Umed H., REPOVŠ, Dušan. On generalized 3-manifolds which are not homologically locally connected. *Topology and its Applications*, ISSN 0166-8641. [Print ed.], 2013, vol. 160, iss. 3, str. 445-449 [COBISS.SI-ID 16558681]

– CENCELJ, Matija, REPOVŠ, Dušan. *Topologija*, (Zbirka Pitagora). 1. ponatis. Ljubljana: Pedagoška fakulteta, 2011. XVI, 169 str., ilustr. ISBN 978-86-7735-051-2 [COBISS.SI-ID 254230528]

Sašo Strle:

– STRLE, Sašo. Bounds on genus and geometric intersections from cylindrical end moduli spaces. *Journal of differential geometry*, ISSN 0022-040X, 2003, vol. 65, no. 3, str. 469-511 [COBISS.SI-ID 13135193]

– OWENS, Brendan, STRLE, Sašo. A characterisation of the  $n < 1 > [oplus] < 3 >$  form and applications to rational homology spheres. *Mathematical research letters*, ISSN 1073-2780, 2006, vol. 13, iss. 2, str. 259-271 [COBISS.SI-ID 13873241]

– OWENS, Brendan, STRLE, Sašo. Rational homology spheres and the four-ball genus of knots. *Advances in mathematics*, ISSN 0001-8708, 2006, vol. 200, iss. 1, str. 196-216 [COBISS.SI-ID

13875033]