

# STAVBNA FIZIKA IN NOTRANJE OKOLJE

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Stavbna fizika in notranje okolje
<b>Course title:</b>	BUILDING PHYSICS AND INDOOR ENVIRONMENT QUALITY
<b>Članica nosilka/UL Member:</b>	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2023/2024 dalje)	Procesno strojništvo (smer)	2. letnik	2. semester	obvezni

**Univerzitetna koda predmeta/University course code:**

0563384

**Koda učne enote na članici/UL Member course code:**

3037-V

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			40	4

**Nosilec predmeta/Lecturer:**

Ciril Arkar, Uroš Stritih

**Izvajalci predavanj:**

**Izvajalci seminarjev:**

**Izvajalci vaj:**

**Izvajalci kliničnih vaj:**

**Izvajalci drugih oblik:**

**Izvajalci praktičnega usposabljanja:**

--

**Vrsta predmeta/Course type:**

Izbirni strokovni predmet/Elective specialised course

**Jeziki/Languages:**

Predavanja/Lectures:

Slovenščina

Vaje/Tutorial:

Slovenščina

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

**Prerequisites:**

Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.

Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

**Vsebina:**

**Content (Syllabus outline):**

1. Prehod toplote v homogenih netransparentnih in transparentnih gradnikih stavb:  
□ Vpliv konstrukcijskih lastnosti gradnikov stavb na prehod toplote v netransparentnih in transparentnih gradnikih;  
□ Prenos toplote v gradnikih stavb pri nestacionarnih stanjih zunanjega okolja;  
□ Toplotne prehodnosti gradnikov stavb.

2. Prehod toplote v nehomogenih gradnikih stavb in elementih tehničnih stavbnih sistemov:  
□ Vrednotenje toplotnih mostov;  
□ Linijske toplotne in točkovne toplotne prehodnosti;  
□ Izračun toplotnih izgub cevovodov in hranilnikov toplote;  
□ Kazalniki energijske učinkovitosti stavb.

3. Navlaževanje gradnikov stavb:  
□ Prehod vodne pare v gradnikih stavb;  
□ Preverjanje kondenzacije;  
□ Načrtovanje parne ovire;  
□ Kazalniki navlaževanja gradnikov stavb.

4. Naravna osvetlitev stavb:  
□ Modeliranje potenciala naravne

1. Heat transference in homogenous opaque and transparent building structures:  
□ Impact of building material properties on heat transference in homogenous opaque and transparent building structures;  
□ Heat transference in building structures at transient outdoor conditions;  
□ Thermal transmittance of building structures.

2. Heat transference in nonhomogenous building structures and elements of building service systems:  
□ Heat bridges;  
□ 2D and 3D thermal transmittance of heat bridges;  
□ Heat losses of pipelines and heat storages;  
□ Indicators of energy efficiency of buildings.

3. Moistening of building structures:  
□ Vapour vapor transference;  
□ Interstitial condensation;  
□ Design of water vapor barrier;  
□ Evolution of water vapour transference in building structures.

4. Daylight:

<p>svetlobe;</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Načrtovanje naravne osvetlitve;</li> <li><input type="checkbox"/> Tehnike preprečevanja bleščanja;</li> <li><input type="checkbox"/> Vpliv kakovosti naravne osvetlitve na kazniške energetske učinkovitosti stavb.</li> </ul> <p>5. Širjenje zvoka v gradnikih stavb in stavbah:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Zvok v zraku;</li> <li><input type="checkbox"/> Udarni zvok;</li> <li><input type="checkbox"/> Sprejemljive ravni zvočnega tlaka v bivalnem okolju.</li> </ul> <p>6. Zvočna izolirnost gradnikov stavb:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Zvočna izolirnost;</li> <li><input type="checkbox"/> Raven udarnega zvoka;</li> <li><input type="checkbox"/> Akustika prostorov.</li> </ul> <p>7. Razvoj požara v stavbah in odziv gradnikov pri požaru:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Faze razvoja požara;</li> <li><input type="checkbox"/> Požarna obremenitev;</li> <li><input type="checkbox"/> Klasifikacija materialov in gradnikov stavb glede na odziv ob požaru.</li> </ul> <p>8. Širjenje in odvod dimnih plinov pri požaru:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Načrtovanje odprtin za odvod dima;</li> <li><input type="checkbox"/> Tehnični protipožarni ukrepi;</li> <li><input type="checkbox"/> Šprinkler sistem.</li> </ul> <p>9. Človek in notranje okolje ter toplotna oddaja človeka:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Toplotno okolje;</li> <li><input type="checkbox"/> Toplotni model človeka;</li> <li><input type="checkbox"/> Termoregulacija človeka.</li> </ul> <p>10. Ugodje v prostoru ter vplivni parametri:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperatura zraka in srednja sevalna temperatura;</li> <li><input type="checkbox"/> Vlažnost zraka in hitrost gibanja zraka;</li> <li><input type="checkbox"/> Vpliv oblečenosti in aktivnosti.</li> </ul> <p>11. Bivalno ugodje v notranjem okolju:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Določitev ugodja (PMV vrednost);</li> <li><input type="checkbox"/> Določitev odstotka nezadovoljnih ljudi (PPD);</li> <li><input type="checkbox"/> Kriteriji presoje.</li> </ul> <p>12. Kakovost zraka v stavbah:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Viri onesnažil;</li> <li><input type="checkbox"/> Viri onesnažil v prostoru;</li> <li><input type="checkbox"/> Olfaktometrija;</li> <li><input type="checkbox"/> Fizikalni mehanizem transporta primesi.</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Daylight potential models;</li> <li><input type="checkbox"/> Design of daylight in indoor environment;</li> <li><input type="checkbox"/> Glare evaluation and protection;</li> <li><input type="checkbox"/> Daylight and energy efficiency of the buildings.</li> </ul> <p>5. Sound propagation in building structures:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Airborne sound;</li> <li><input type="checkbox"/> Impact sound;</li> <li><input type="checkbox"/> Noise level evaluation and exposure in indoor environment.</li> </ul> <p>6. Sound insulation of building structures:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Level of airborne sound and noise protection measures;</li> <li><input type="checkbox"/> Level of impact sound;</li> <li><input type="checkbox"/> Room acoustic.</li> </ul> <p>7. Development of fire in buildings and response of building structures to the fire:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Development of the fire in indoor environment;</li> <li><input type="checkbox"/> Fire load;</li> <li><input type="checkbox"/> Classification of materials according to their response to the fire.</li> </ul> <p>8. Propagation and extraction of gasses during the duration of fire:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Design of ventilation openings;</li> <li><input type="checkbox"/> Technical fire protection measures;</li> <li><input type="checkbox"/> Active fire fighting systems.</li> </ul> <p>9. Human, internal environment and human heat emission:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Thermal environment;</li> <li><input type="checkbox"/> Human thermal model;</li> <li><input type="checkbox"/> Human thermoregulation.</li> </ul> <p>10. Space comfort and influence parameters:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Air mean radiant temperatures;</li> <li><input type="checkbox"/> Humidity and air velocity;</li> <li><input type="checkbox"/> The impact of clothes and activity.</li> </ul> <p>11. Living comfort in the indoor environment:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Determination of comfort (PMV value);</li> <li><input type="checkbox"/> Determination of percentage of dissatisfied people (PPD);</li> <li><input type="checkbox"/> Criteria for assessment.</li> </ul> <p>12. Air quality in buildings:</p>
---	---

<p>13. Kakovost zraka v stavbah:</p> <ul style="list-style-type: none"> <li>□ Prezračevanje;</li> <li>□ Potrebne količine zraka;</li> <li>□ Učinkovitost prezračevanja;</li> <li>□ Gibanje zraka v prostoru.</li> </ul> <p>14. Problemi modernih stavb:</p> <ul style="list-style-type: none"> <li>□ Sindrom bolne stavbe (Sick Building Syndrome);</li> <li>□ Sindrom tesnih stavb (Tight Building Syndrome).</li> </ul> <p>15. Ukrepi za izboljšanje kvalitete notranjega okolja:</p> <ul style="list-style-type: none"> <li>□ Odstranjevanje škodljivih primesi;</li> <li>□ Filtri in ostali elementi prezračevanja;</li> <li>□ Čisti prostori.</li> </ul>	<ul style="list-style-type: none"> <li>□ Sources of pollutants;</li> <li>□ Sources of pollutants in the room;</li> <li>□ Olfactometry;</li> <li>□ Physical mechanism of impurity transport.</li> </ul> <p>13. Air quality in buildings:</p> <ul style="list-style-type: none"> <li>□ Ventilation;</li> <li>□ Required air volumes;</li> <li>□ Efficiency of ventilation;</li> <li>□ Movement of air in space.</li> </ul> <p>14. Problems of modern buildings:</p> <ul style="list-style-type: none"> <li>□ Sick Building Syndrome;</li> <li>□ Tight Building Syndrome.</li> </ul> <p>15: Measures to improve the quality of the indoor environment:</p> <ul style="list-style-type: none"> <li>□ Removal of harmful impurities;</li> <li>□ Filters and other ventilation elements;</li> <li>Clean spaces.</li> </ul>
---	--

### Temeljna literatura in viri/Readings:

Medved, Sašo. Gradbena fizika II : toplota, vlaga, svetloba, zvok, požar, mikroklima v mestih. Ljubljana: Fakulteta za arhitekturo, 2014.

Hagentoft, C.-E. Introduction to Building Physics. Studentlitteratur, Lund, 2001.

Karlsson, B., Quintiere, J. G. Enclosure Fire Dynamics. CRC Press, Boca Raton, 2000.

P.M. Bluyssen: The Indoor Environment Handbook, 2009

P.Wargorcki at al.: Indoor Climate and Productivity in Offices, REHVA Guidebook 6, Brussels, 2006

E. Mundt et al.: Ventilation Effectiveness, REHVA Guidebook 2, Brussels, 2004

ASHRAE Handbook: Fundamentals (izbrana poglavja), Atlanta, 2017

### Cilji in kompetence:

Cilji:

Spoznati vodila in tehnične rešitve na področju prenosa toplote in vodne pare v gradnikih stavb, naravne osvetlitve, zaščite pred hrupom in požarne varnosti.

Spoznati osnove vrednotenja in načrtovanja notranjega okolja v stavbah.

Kompetence:

S1-PAP, P8-PAP: Sposobnost ocenjevanja, vrednotenja in načrtovanja stavbe fizike in notranjega okolja v

### Objectives and competences:

Education goals:

Get to know the guides and technical solutions in the field of heat and water vapour transfer in building structures, natural lighting, noise protection and fire safety.

To learn the basics of the evaluation and planning of the internal environment in buildings.

Student competence:

S1-PAP, P8-PAP: The ability to use the

stavbah. S2-PAP, P3-PAP: Sposobnost samostojnega dela v okviru znanj s področja načrtovanja notranjega okolja v bivalnih in delovnih stavbah.	attained knowledge in the practice in study field of building physics and design indoor environments in buildings. Mastering the basic and required specific knowledge in study field.  S2-PAP, P3-PAP: The ability to work autonomously in the framework of knowledge of interior design in residential and office buildings. Mastering the fundamental specialised knowledge in the field of study.
--	---

<b>Predvideni študijski rezultati:</b>	<b>Intended learning outcomes:</b>
<p>Znanja:</p> <p>Z1: Poglobljeno strokovno teoretično in praktično znanje na področju načrtovanja gradnikov stavb in stavbnih sistemov ter zdravega bivanja v stavbah.</p> <p>Spretnosti:</p> <p>S1.2: Obvladovanje zahtevnih, kompleksnih procesov načrtovanja prenosa toplote in snovi v gradnikih stavb in stavbnih sistemih in kompleksnih procesov načrtovanja kakovostnega notranjega okolja v stavbah.</p> <p>S1.3. Diagnosticiranje in reševanje problemov v delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja.</p>	<p>Knowledge:</p> <p>Z1: In-depth professional theoretical and practical knowledge in the design of building structures and building service systems and wellbeing in buildings that is supported with a broad theoretical and methodological basis.</p> <p>Skills:</p> <p>S1.2 Mastering demanding and complex design processes of heat and mass transfer in building structures and building service systems in processes of design of indoor living comfort.</p> <p>S1.3 Problem diagnostics and solving in different and specific working environments that are linked to the teaching and training content of the course.</p>

<b>Metode poučevanja in učenja:</b>	<b>Learning and teaching methods:</b>
<p>Klasične oblike poučevanja:</p> <p>P1: Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P3: Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.</p> <p>P4: Laboratorijske vaje z namenski didaktičnimi multimedijскими pripomočki z dostopom na daljavo.</p>	<p>Conventional teaching methods:</p> <p>P1: Auditorial lectures with solving selected field-specific theoretical and applied use cases.</p> <p>P3: Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples.</p> <p>P4. Laboratory exercises with special-purpose didactic multimedia tools with remote access.</p> <p>Contemporary and flexible teaching</p>

Moderne oblike poučevanja: P6: Interaktivna predavanja. P8: Izdelava in predstavitev aplikativnih seminarских nalog. P15: Uporaba video vsebin kot priprava na predavanja in vaje.	methods: P6: Interactive lectures. P8. Making and presenting applied seminar exercises. P15. Application of multimedia presentations for preparations to the lectures and exercises.
---	---

Načini ocenjevanja:	Delež/ Weight	Assessment:
Teoretične vsebine (predavanja)	50,00 %	Theory
Samostojno delo na vajah	30,00 %	Tutorials
Delo na laboratorijskih vajah (vključno s poročili)	20,00 %	Individual lab work (with written reports)

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

##### Uroš Stritih:

1. STROPNIK, Rok, KOŽELJ, Rok, ZAVRL, Eva, **STRITIH, Uroš**. Improved thermal energy storage for nearly zero energy buildings with PCM integration. *Solar energy*. [Print ed.]. Sep. 2019, vol. 190, str. 420-426, ilustr. ISSN 0038-092X. <https://www.sciencedirect.com/science/article/pii/S0038092X19308229>, DOI: 10.1016/j.solener.2019.08.041. [COBISS.SI-ID [16754715](#)]
2. **STRITIH, Uroš**, TYAGI, V. V., STROPNIK, Rok, PAKSOY, Halime, HAGHIGHAT, Fariborz, JOYBARI, Mahmood Mastani. Integration of passive PCM technologies for net-zero energy buildings. *Sustainable cities and society*. [Spletna izd.]. Aug. 2018, vol. 41, str. 286-295, ilustr. ISSN 2210-6715. <http://onlinelibrary.wiley.com/doi/10.1111/ffe.12804/epdf>, DOI: 10.1016/j.scs.2018.04.036. [COBISS.SI-ID [16096539](#)]
3. OSTERMAN, Eneja, BUTALA, Vincenc, **STRITIH, Uroš**. PCM thermal storage system for free heating and cooling of buildings. *Energy and buildings*. [Print ed.]. Nov. 2015, vol. 106, str. 125-133, ilustr. ISSN 0378-7788. DOI: 10.1016/j.enbuild.2015.04.012. [COBISS.SI-ID [14117659](#)]
4. **STRITIH, Uroš**, OSTERMAN, Eneja, BUTALA, Vincenc. Energy conservation in building with innovative PCM room ventilation storage system. V: IAQVEC 2016 : healthy & smart environment. 9th International Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings, October 23-26, 2016, Songdo, Incheon, Republic of Korea. [S. l.: s. n., 2016]. Datoteka 1499 (8 f.), ilustr. [COBISS.SI-ID [15055643](#)]
5. **STRITIH, Uroš**, GRUM, Stane, BUTALA, Vincenc. *Strokovno mnenje o vgradnji delilnikov na objektu Puhova 3 v Ljubljani*. Ljubljana: Fakulteta za strojništvo, Laboratorij za ogrevalno, sanitarno in solarno tehniko ter klimatizacijo, 2016. 9 f., ilustr. [COBISS.SI-ID [15026971](#)]

##### Ciril Arkar:

1. **ARKAR, Ciril**, ŽIŽAK, Tej, MEDVED, Sašo. *Nadgradnja programa Trimo Expert*

*Building Physics*. Ljubljana: Fakulteta za strojništvo, 2022. 7 f., graf. prikazi. [COBISS.SI-ID [127764227](#)]

2. ŽIŽAK, Tej, DOMJAN, Suzana, MEDVED, Sašo, **ARKAR, Ciril**. Efficiency and sustainability assessment of evaporative cooling of photovoltaics. *Energy*. Sep. 2022, vol. 254, pt. a, str. 1-12, ilustr. ISSN 0360-5442. <https://www.sciencedirect.com/science/article/pii/S036054422201163X>, DOI: [10.1016/j.energy.2022.124260](#). [COBISS.SI-ID [108992259](#)]
3. **ARKAR, Ciril**, ŽIŽAK, Tej, DOMJAN, Suzana, MEDVED, Sašo. Dynamic parametric models for the holistic evaluation of semi-transparent photovoltaic/thermal façade with latent storage inserts. *Applied energy*. Dec. 2020, vol. 280, str. 1-16, ilustr. ISSN 0306-2619. <https://www.sciencedirect.com/science/article/abs/pii/S0306261920314392?via%3Dihub>, DOI: [10.1016/j.apenergy.2020.115994](#). [COBISS.SI-ID [34825731](#)]
4. **ARKAR, Ciril**, DOMJAN, Suzana, MEDVED, Sašo. Heat transfer in a lightweight extensive green roof under water-freezing conditions. *Energy and buildings*. [Print ed.]. 2018, vol. 167, str. 187-199, ilustr. ISSN 0378-7788. <https://www.sciencedirect.com/science/article/pii/S037877881733325X>, DOI: [10.1016/j.enbuild.2018.02.056](#). [COBISS.SI-ID [15947035](#)]
5. **ARKAR, Ciril**, DOMJAN, Suzana, MEDVED, Sašo. Lightweight composite timber façade wall with improved thermal response. *Sustainable cities and society*. [Spletna izd.]. Apr. 2018, vol. 38, f. 325-332, ilustr. ISSN 2210-6715. [https://ac.els-cdn.com/S2210670717313161/1-s2.0-S2210670717313161-main.pdf?\\_tid=08af99dc-0b23-11e8-bb7c-00000aabb0f6c&acdnat=1517910753\\_7f15ca1894a6cf3aab75032c71714584](https://ac.els-cdn.com/S2210670717313161/1-s2.0-S2210670717313161-main.pdf?_tid=08af99dc-0b23-11e8-bb7c-00000aabb0f6c&acdnat=1517910753_7f15ca1894a6cf3aab75032c71714584), DOI: [10.1016/j.scs.2018.01.011](#). [COBISS.SI-ID [15863579](#)]