

# KLIMATIZACIJA, OGREVANJE, OHLAJEVANJE, PREZRAČEVANJE

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Klimatizacija, ogrevanje, ohlajevanje, prezračevanje
<b>Course title:</b>	AIR-CONDITIONING, HEATING, REFRIGERATION, VENTILATION
<b>Članica nosilka/UL Member:</b>	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Procesno strojništvo (smer)	1. letnik	2. semester	obvezni

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

0566919

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

6017-M

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			65	5

**Nosilec predmeta/Lecturer:**

Uroš Stritih

**Izvajalci predavanj:**

**Izvajalci seminarjev:**

**Izvajalci vaj:**

**Izvajalci kliničnih vaj:**

**Izvajalci drugih oblik:**

**Izvajalci praktičnega usposabljanja:**

**Vrsta predmeta/Course type:**

Obvezni strokovni predmet na smeri Procesno strojništvo, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Process Engineering, which is an elective specialised course in other fields of study.

**Jeziki/Languages:**

Predavanja/Lectures:

Slovenščina

Vaje/Tutorial:

Slovenščina

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

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.

Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

**Vsebina:****Content (Syllabus outline):**

1. Fiziološke, termodinamične in meteorološke osnove:
  - Termoregulacija človeka;
  - Ugodnje v prostoru (PMV-PPD);
  - Meteorološke osnove.
2. Prenos toplote in snovi v stavbah:
  - Prehod toplote v stavbah;
  - Akumulacija toplote v stavbah;
  - Prenos snovi preko stavbnih konstrukcij.
3. Izračun toplotnih izgub (zimsko transmisija):
  - Transmisijske toplotne izgube;
  - Ventilacijske toplotne izgube;
  - Dodatek zaradi prekinitve ogrevanja.
4. Viri in naprave za ogrevanje stavb:
  - Viri energije za ogrevanje stavb;
  - Karakteristike naprav za ogrevanje;
  - Dimenzioniranje naprav za ogrevanje.
5. Razvod in ostala oprema za ogrevanje v stavbah:
  - Izbira in dimenzioniranje cevne mreže;
  - Določevanje tlačnih padcev;
  - Izbira in dimenzioniranje armatur in črpalk.
6. Naprave za oddajo toplote v

1. Physiological, thermodynamic and meteorological basis:
  - Human thermoregulation;
  - Space benefits (PMV-PPD);
  - Meteorological basics.
2. Heat and mass transfer in buildings:
  - Heat transfer in buildings;
  - Heat accumulation in buildings;
  - Mass transfer through building structures.
3. Calculation of heat losses (winter transmission):
  - Transmission heat losses;
  - Ventilation heat losses;
  - Addition for interruption of heating.
4. Building heating sources and installations:
  - Energy sources for heating of buildings;
  - Characteristics of heating devices;
  - Dimensioning of heating appliances.
5. Distribution and other heating equipment:
  - Selection and dimensioning of pipe network

<p>stavbah:</p> <ul style="list-style-type: none"> <li>- Vrste naprav za ogrevanje prostorov;</li> <li>- Izračuni toplotne oddaje naprav za ogrevanje;</li> <li>- Dimenzioniranje naprav za ogrevanje.</li> </ul> <p>7. Prezračevanje prostorov:</p> <ul style="list-style-type: none"> <li>- Pomen prezračevanja (sindrom bolnih stavb);</li> <li>- Lokalni in centralni sistemi prezračevanja;</li> <li>- Tehnologije za izrabo odpadnega zraka (rekuperacija, regeneracija).</li> </ul> <p>8. Izračun toplotnih dobitkov (letna transmisija):</p> <ul style="list-style-type: none"> <li>- Notranji toplotni dobitki;</li> <li>- Zunanji toplotni dobitki;</li> <li>- Dobitki zaradi prezračevanja.</li> </ul> <p>9. Naprave za hlajenje v stavbah:</p> <ul style="list-style-type: none"> <li>- Vrste naprav za hlajenje;</li> <li>- Izračun oddaje hladu naprav;</li> <li>- Dimenzioniranje naprav za hlajenje.</li> </ul> <p>10. Klimatizacija ter elementi klimatskih naprav:</p> <ul style="list-style-type: none"> <li>- Lastnosti klimatizacije zraka v prostorih;</li> <li>- Elementi klimatske naprave;</li> <li>- Dimenzioniranje klimatske naprave.</li> </ul> <p>11. Priprava in razvod zraka za klimatizacijo:</p> <ul style="list-style-type: none"> <li>- Čiščenje zraka;</li> <li>- Preračun kanalske mreže;</li> <li>- Dimenzioniranje ventilatorjev.</li> </ul> <p>12. Vpihovanje zraka v prostor:</p> <ul style="list-style-type: none"> <li>- Določevanje gibanja zraka v prostoru;</li> <li>- Koanda efekt;</li> <li>- Dometna razdalja.</li> </ul> <p>13. Regulacija notranjih sistemov ogrevanja, hlajenja in klimatizacije:</p> <ul style="list-style-type: none"> <li>- Osnovne zračnosti regulacije;</li> <li>- Vrste regulatorjev;</li> <li>- Uporaba in primeri regulacije sistemov.</li> </ul> <p>14. Raba in znižanje rabe energije v sistemih:</p> <ul style="list-style-type: none"> <li>- Definicija učinkovite rabe energije (URE);</li> <li>- Računske metode in metode merjenja;</li> <li>- Ukrepi za znižanje rabe energije v stavbah.</li> </ul> <p>15. Prikaz delovanja sistema v praksi:</p>	<ul style="list-style-type: none"> <li>- Determination of pressure drops;</li> <li>- Selection and dimensioning of fittings and pumps.</li> </ul> <p>6. Heat emission devices in buildings:</p> <ul style="list-style-type: none"> <li>- Types of space heating appliances;</li> <li>- Calculations of the heat power of heating appliances;</li> <li>- Dimensioning of heating appliances.</li> </ul> <p>7. Room ventilation:</p> <ul style="list-style-type: none"> <li>- The importance of ventilation (sick building syndrome);</li> <li>- Local and central ventilation systems;</li> <li>- Technologies for the utilization of waste air heat (requperation, regeneration).</li> </ul> <p>8. Calculation of heat gains (summer transmission):</p> <ul style="list-style-type: none"> <li>- Internal heat gains;</li> <li>- External heat gains;</li> <li>- Ventilation gains.</li> </ul> <p>9. Cooling units in buildings:</p> <ul style="list-style-type: none"> <li>- Types of cooling devices;</li> <li>- Calculation of the heat emission of cooling devices;</li> <li>- Dimensioning of cooling devices.</li> </ul> <p>10. Air conditioning and elements:</p> <ul style="list-style-type: none"> <li>- Air-conditioning properties;</li> <li>- Elements of air-conditioning;</li> <li>- Dimensioning of Air-conditioning device.</li> </ul> <p>11. Preparation and distribution of air:</p> <ul style="list-style-type: none"> <li>- Air purification;</li> <li>- Calculation of the air ducts;</li> <li>- Sizing of fans.</li> </ul> <p>12. Blowing air into a room of buildings:</p> <ul style="list-style-type: none"> <li>- Determination of air movement;</li> <li>- Coanda effect;</li> <li>- Range distance.</li> </ul> <p>13. Regulation of internal heating, cooling and air-conditioning systems:</p> <ul style="list-style-type: none"> <li>- Basic properties of regulation;</li> <li>- Types of regulators;</li> <li>- Use and examples of system regulation.</li> </ul> <p>14. Energy use and reduction in systems:</p> <ul style="list-style-type: none"> <li>- Definition of energy efficiency (EEU);</li> <li>- Calculation and measurement</li> </ul>
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<ul style="list-style-type: none"> <li>- Prikaz glavnih sestavnih delov sistema;</li> <li>- Predstavitev dimenzioniranja sistema;</li> <li>- Prikaz delovanja sistema v različnih obdobjih.</li> </ul>	<p>methods;</p> <ul style="list-style-type: none"> <li>- Energy use reduction in buildings.</li> </ul> <p>15. Demonstration of system operation in practice:</p> <ul style="list-style-type: none"> <li>- Presentation of the main components of the system;</li> <li>- System dimensioning presentation;</li> <li>- Demonstration of system operation at different periods.</li> </ul>
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### Temeljna literatura in viri/Readings:

1. Recknagel, H. ; Sprenger, E. ; Hönnmann, W. Recknagel: Taschenbuch für Heizung und Klimatechnik : einschließlich Warmwasser- und Kältetechnik, München ; Wien : R. Oldenbourg, 1995, [COBISS.SI-ID [1518107](#)]
2. B. Labudović: Priročnik za ogrevanje, Energetika Marketing, 2006 [COBISS.SI-ID [229592832](#)]
3. B. Labudović: Priručnik za ventilacijo i klimatizacijo, Energetika Marketing, 2000, [COBISS.SI-ID [5391894](#)]
4. ASHRAE Pocket Guide for heating, refrigeration, ventilation, air-conditioning, 1993, [COBISS.SI-ID [12926235](#)]
5. ASHRAE Handbook — HVAC Applications, 2011 [COBISS.SI-ID [15736091](#)]
6. ASHRAE Handbook — Refrigeration, 2010 [COBISS.SI-ID [15736347](#)]
7. ASHRAE Handbook — Fundamentals, 2009 [COBISS.SI-ID [11003675](#)]
8. ASHRAE Handbook — HVAC Systems and Equipment, 2008 [COBISS.SI-ID [15736603](#)]

### Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> <li>1. Spoznati vsebine in delovanje ogrevalnih naprav in sistemov.</li> <li>2. Spoznati vsebine in delovanje hladilnih naprav in sistemov.</li> <li>3. Spoznati vsebine in delovanje prezračevalnih naprav in sistemov.</li> <li>4. Spoznati vsebine in delovanje klimatizacijskih naprav in sistemov.</li> </ol> <p>Kompetence:</p> <ol style="list-style-type: none"> <li>1. S6-RRP, P4-RRP: Sposobnost ocenjevanja, vrednotenja in načrtovanja ogrevalnih in hladilnih naprav in sistemov.</li> <li>2. S6-RRP, P4-RRP: Sposobnost ocenjevanja in načrtovanja prezračevalnih in klimatizacijskih naprav in sistemov.</li> </ol>
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### Objectives and competences:

<p>Education goals:</p> <ol style="list-style-type: none"> <li>1. To get know the contents and functioning of heating devices and systems.</li> <li>2. To get know the contents and operation of refrigeration systems and systems.</li> <li>3. To get know the contents and operation of ventilation devices and systems.</li> <li>4. To get know the contents and operation of air conditioning systems and systems.</li> </ol> <p>Student competence:</p> <ol style="list-style-type: none"> <li>1. S6-RRP, P4-RRP: Ability to evaluate and design heating and cooling systems and systems.</li> <li>2. S6-RRP, P4-RRP: Ability to evaluate and design ventilation and</li> </ol>
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	air-conditioning systems and systems.
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<b>Predvideni študijski rezultati:</b>	<b>Intended learning outcomes:</b>
<p>Znanja:</p> <p>Z2: Poglobljeno teoretično, metodološko in analitično znanje na področju ogrevanja, ohlajevanja, prezračevanja in klimatizacije.</p> <p>Spretnosti:</p> <p>S2.1: Obvladovanje zelo zahtevnih kompleksnih delovnih procesov na področju ogrevanja, ohlajevanja, prezračevanja in klimatizacije.</p> <p>S2.3: Diagnosticiranje in reševanje problemov na področju ogrevanja, ohlajevanja, prezračevanja in klimatizacije.</p>	<p>Knowledge:</p> <p>Z2: Advanced theoretical, methodological and analytical knowledge in the fields of heating, cooling, ventilation and air conditioning.</p> <p>Skills:</p> <p>S2.1: Dealing with very complex challenges in the areas of heating, cooling, ventilation and air conditioning.</p> <p>S2.3: Diagnosis and problem solving in the fields of heating, cooling, ventilation and air conditioning.</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 predavanjem podkrepi z računskimi primeri.</p> <p>P4: Laboratorijske vaje z namenskim didaktičnim pripomočki (tudi z dostopom na daljavo).</p> <p>Moderne oblike poučevanja:</p> <p>P6: Interaktivna predavanja.</p> <p>P8: Izdelava in predstavitev aplikativnih seminarskih nalog.</p> <p>P9: Skupinsko delo (razprave za-proti, strukturirana diskusija, projektno delo...).</p> <p>P10: Uporaba anket v realnem času.</p> <p>P12: Individualizirane domače naloge v spletni učilnici.</p>	<p>Classic forms of teaching:</p> <p>P1: Classroom lectures by solving selected - typical and practical examples.</p> <p>P3: Tutorials where theoretical knowledge of lectures is supported by calculation examples.</p> <p>P4: Laboratory exercises with dedicated didactic aids (also with remote access).</p> <p>Advance forms of teaching:</p> <p>P6: Interactive Lectures.</p> <p>P8: Design and presentation of applied seminar work.</p> <p>P9: Group work (discussions for and against, structured discussion, project work...).</p> <p>P10: Use of real-time surveys.</p> <p>P12: Individualized homework in an online classroom.</p> <p>P13: Individualized self-correcting tests.</p>

P13: Individualizirani kolokviji s samodejnim popravljanjem.	P15: Using video content to prepare for lectures and tutorials.
P15: Uporaba video vsebin kot priprava na predavanja in vaje.	

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).

Ocenjevalna lestvica:	Grading system:

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

##### Uroš Stritih:

1. ZAVRL, Eva, ZUPANC, Gašper, **STRITIH, Uroš**, DOVJAK, Mateja. Overheating reduction in lightweight framed buildings with application of phase change materials. *Strojniški vestnik*. Jan. 2020, vol. 66, no. 1, str. 3-14, ilustr. ISSN 0039-2480. <https://www.sv-jme.eu/article/overheating-reduction-in-lightweight-framed-buildings-with-application-of-phase-change-materials/>, DOI: [10.5545/sv-jme.2019.6244](https://doi.org/10.5545/sv-jme.2019.6244). [COBISS.SI-ID [17015835](https://cobiss.si/17015835)]
2. ZAVRL, Eva, EL MANKIBI, Mohamed, DOVJAK, Mateja, **STRITIH, Uroš**. Experimental investigation of air-based active-passive system for cooling application in buildings. *Sustainable cities and society*. [Spletna izd.]. Oct. 2022, vol. 85, str. 1-13, ilustr. ISSN 2210-6715. <https://www.sciencedirect.com/science/article/pii/S2210670722003511>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=140154>, DOI: [10.1016/j.scs.202104031](https://doi.org/10.1016/j.scs.202104031). [COBISS.SI-ID [117204483](https://cobiss.si/117204483)]
3. MLAKAR, Urška, STROPNIK, Rok, KOŽELJ, Rok, MEDVED, Sašo, **STRITIH, Uroš**. Experimental and numerical analysis of seasonal solar-energy storage in buildings. *International journal of energy research*. 2019, vol. 43, iss. 12, str. 6409-6418, ilustr. ISSN 0363-907X. <https://onlinelibrary.wiley.com/doi/abs/10.1002/er.4449>, DOI: [10.1002/er.4449](https://doi.org/10.1002/er.4449). [COBISS.SI-ID [16558619](https://cobiss.si/16558619)],
4. **STRITIH, Uroš**, OSTERMAN, Eneja, BUTALA, Vincenc. Annual operation of LHT storage system for offices. V: HEISELBERG, Per Kvols (ur.). *CLIMA 2016 : proceedings of the 12th REHVA World Congress, 22-25 May 2016, Aalborg, Denmark*. Vol. 4. 12th REHVA World Congress, 22-25 May 2016, Aalborg, Denmark. [Aalborg: University, 2016]. F. 2-11, ilustr. ISBN 87-91606-29-2, ISBN 87-91606-36-5. [http://vbn.aau.dk/files/233718256/paper\\_738.pdf](http://vbn.aau.dk/files/233718256/paper_738.pdf). [COBISS.SI-ID [14672923](https://cobiss.si/14672923)]
5. OSTERMAN, Eneja, HAGEL, K., RATHGEBER, C., BUTALA, Vincenc, **STRITIH, Uroš**. Parametrical analysis of latent heat and cold storage for heating and

cooling of rooms. *Applied thermal engineering*. [Print ed.]. Jun. 2015, vol. 84, str. 138-149, ilustr. ISSN 1359-4311. DOI: 10.1016/j.applthermaleng.2015.02.081. [COBISS.SI-ID [13978139](#)]