UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Letalski motorji 1
Course title:	Aircraft engines 1
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	**Študijska smer**	**Letnik**	**Semestri**
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Prometni pilot letala/helikopterja (smer)	2. letnik	2. semester
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Snovanje in vzdrževanje letal (smer)	2. letnik	2. semester

Univerzitetna koda predmeta/University course code:	0563993
Koda učne enote na članici/UL Member course code:	3079-V

Predavanja	**Seminar**	**Vaje**	**Klinične vaje**	**Druge oblike študija**	**Samostojno delo**	**ECTS**
45		15			40	4

Nosilec predmeta/Lecturer:	Tomaž Katrašnik
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. predavanje: Osnove batnih motorjev z notranjim zgorevanjem (MNZ): - Pretvorbe energije in potek termodinamskega procesa. - Osnove procesov zgorevanja. - Lastnosti realnega delovnega medija 2. predavanje: Analiza procesov 1: - Ključne teoretične osnove (vodilne enačbe) - Sistematizacija toplotnih motorjev z ozirom na različne	1. Lecture: Basic principles of internal combustion engines (ICEs): - Energy conversion and thermodynamic processes, - Basic principles of combustion, - Properties of real working media. 2. Lecture: Process analysis 1: - Theoretical basis (governing equations), - Classification of heat engines with respect to their

kriterije in značilnosti toplotnih motorjev (4 in 2 taktni motorji; prisilni vžig in samovžig; homogena in heterogena zmes…) - Definicija in analiza procesov v realnih toplotnih motorjih 3. predavanje: Analiza procesov 2: - Teoretični procesi v toplotnih motorjih (določitev izkoristka, specifične porabe gorive, delovne sposobnosti, moči…) in njihova primerjava s procesi v realnih toplotnih motorjih - Metode za izboljšanje izkoristka motorjev 4. predavanje: Značilnosti in komponente batnih MNZ - Geometrijske značinosti batnih MNZ - Kinematika bata in uravnoteženje prostih sil in navorov - Komponente batnih MNZ in interakcija z drugimi komponentami 5. predavanje: Motorji s prisilnim vžigom (Ottovi motorji) 1: - Zasnova in komponente - Značilnosti in delovanje sistemov za dobavo in vbrizgavanje goriva - Priprava gorljive zmesi 6. predavanje: Motorji s prisilnim vžigom (Ottovi motorji) 2: - Podrobnejši pregled različnih izvedenk uplinjalnikov - Zaledenitev uplinjalnika - Sistemi za vžig zmesi 7. predavanje: Motorji s prisilnim vžigom (Ottovi motorji) 3: - Vžig zmesi in zgorevanje - Samovžig zmesi - Izpusti onesnažil - Krmiljenje 8. predavanje: Motorji s samovžigom (dizelski motorji): - Zasnova in komponente - Značilnosti in delovanje sistemov za dobavo in vbrizgavanje goriva - Vžig zmesi in zgorevanje - Izpusti onesnažil - Krmiljenje 9. predavanje: Goriva: - Pridobivanje goriv - Sestava goriv - Oktansko število (definicija in metoda določanja) - Cetansko število (definicija in metoda določanja) - Fizikalne in kemijske lastnosti goriv 10. predavanje: Mazanje batnih MNZ in mehanske izgube: - Zasnove mazalnih sistemov batnih MNZ - Lasnosti olj - Režimi mazanja različnih komponent - Obraba - Mahanske izgube	type and characteristics (4 and 2 stroke; spark and compression ignition; homogeneous and heterogeneous mixture…), - Definition and analysis of processes in real engines. 3. Lecture: Process analysis 2: - Theoretical processes in heat engines (evaluation of efficiency and indicated mean effective pressure) and their interrelation to processes in real heat engines, - Methods for increasing efficiency of heat engines. 4. Lecture: Characteristics and components of piston ICEs - Geometrical characteristics of piston ICEs, - Kinematics of the piston motion in piston engines and balancing free forces and moments - Components of piston ICEs and their interaction with other components. 5. Lecture: Spark ignition (SI) engines (Otto engines) 1: - Design and components, - Characteristics and working principles of fuel supply and injection systems, - Mixture preparation. - Rate of heat release, - Self-ignition and knocking, - Modelling approaches. 6. Lecture: Spark ignition (SI) engines (Otto engines) 2: - Detailed analysis of various designs of carburettors, - Carburettor icing, - Ignition systems. 7. Lecture: Spark ignition (SI) engines (Otto engines) 3: - Ignition and combustion, - Self-ignition and knocking, - Exhaust emissions, - Control. 8. Lecture: Compression ignition (CI) engines (Diesel engines) - Design and components, - Characteristics and working principles of fuel supply and injection systems, - Ignition and combustion, - Exhaust emissions, - Control. 9. Lecture: Fuels: - Fuel processing, - Fuel composition, - Octane number (definition and method of determination), - Cetane number (definition and method of determination), - Physical and chemical properties of the fuels. 10. Lecture: Mechanical losses and lubrication systems in piston ICEs: - Designs of lubrication systems in piston ICEs, - Oil properties, - Lubrication regimes,

11. predavanje: Hlajenje batnih MNZ: - Zasnove hladilnih sistemov batnih MNZ - Lastnosti sistemov zračnega hlajenja - Lastnosti sistemov kapljevinskega hlajenja - Temperature in temperaturna polja komponent motorja in njihov vpliv na življenjsko dobo - Primerjava sistemov zračnega in kapljevinskega hlajenja z ozirom na zasnovo motorja, zmogljivosti in zanesljivost ter trajnost 12. predavanje: Prisilno polnjnje batnih MNZ z mehansko gnanimi polnilniki: - Komponente in način delovanja - Regulacija moči in vpliv parametrov motorja in okolice 13. predavanje: Prisilno polnjnje batnih MNZ s turbopolnilniki: - Komponente in način delovanja - Regulacija moči in vpliv parametrov motorja in okolice 14. Zmogljivosti in upravljanje batnih MNZ in vpliv parametrov leta 1: - Definicija največje, največje vzletne in največje kontinuirane moči. - Potek parametrov motorja med vzletom, letom in pristankom. 15. Zmogljivosti in upravljanje batnih MNZ in vpliv parametrov leta 2: - Vpliv višine leta, vrtilne frekvence in parametrov okolice na moč in izkoristek/sp	- Wear, - Mechanical losses. 11. Lecture: Thermoregulation of piston ICEs: - Designs of thermoregulation systems in piston ICEs, - Characteristics of air cooling, - Characteristics of liquid cooling, - Temperatures and temperature fields of engine components and the impact on durability, - Comparison of air and liquid cooling with respect to engine design, performance and reliability and durability. 12. Lecture: Supercharging of piston ICEs with mechanical superchargers: - Components and working principles, - Power regulation and impact of engine and ambient parameters. 13. Lecture: Supercharging of piston ICEs with turbochargers: - Components and working principles, - Power regulation and impact of engine and ambient parameters. 14. Lecture: Performances and control of piston ICEs and flight parameters 1: - Definition of maximum, maximum take-off and maximum continuous power, - Engine parameters during take-off, flight and landing. 15. Lecture: Performances and control of piston ICEs and flight parameters 2: - Impact of altitude, engine speed and ambient parameters on engine power and efficiency/specific fuel consumption, - Control systems.

Temeljna literatura in viri/Readings:

1. S. Jeppesen. Joint aviation authorities ATPL Powerplant manual, Book 4. 2007
2. TRENC, Ferdinand, KATRAŠNIK, Tomaž. Letalski motorji. Ljubljana: Fakulteta za strojništvo, 2015. VI, 266 str., ilustr. ISBN 978-961-6536-86-8
3. Heywood, J.B.: Internal combustion engine fundamentals, McGraw-Hill, N.York,1988,ISBN 0-07-028637-X

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Razumeti teoretične osnove in procese v batnih letalskih motorjih 2. Spoznati in razumeti komponente in procese v komponentah batnih letalskih motorjev 3. Spoznati in razumeti interakcije in soodvisnosti procesov v batnih letalskih motorjih 4. Spoznati različne zasnove batnih letalskih motorjev in razumeti njihove značilnosti in prednosti 5. Razumeti in znati aplicirati metode za zvišanje moči in izkoristka batnih letalskih motorjev	Objectives: 1. Understand the theoretical foundations of processes in piston aircraft engines 2. To know and to understand components and processes in components of piston aircraft engines 3. To know and to understand interactions in interdependencies of process in piston aircraft engines 4. To know different designs of piston aircraft engines and to understand their characteristics and

6. Razumeti pristope za zmanjšanje izpustov onesnažil batnih letalskih motorjev Kompetence: 1. Sposobnost upravljanja in vzdrževanja batnih letalskih motorjev (S1-PAP, S7-PAP) 2. Razumevanje fizikalnih pojavov in procesov v batnih letalskih motorji (P1-PAP) 3. Obvlada temeljna strokovna znanja na področju komponent in sistemov batnih letalskih motorjev (P3-PAP) 4. Obvlada specifična znanja na področju komponent in sistemov batnih letalskih motorjev, ki omogočajo aplikativna, inženirska in strokovno organizacijska dela (P8-PAP, P9-PAP)	advantages 5. To understand and to be skilled to apply methods for increasing power and efficiency of piston aircraft engines 6. Understand approaches for reduction of pollutant emissions in piston aircraft engines Competencies: 1. The ability to operate and maintain piston aircraft engines (S1-PAP, S7-PAP) 2. Understanding the laws of physics and the phenomena and processes in piston aircraft engines (P1-PAP) 3. Mastering the fundamental specialised knowledge in the field of components and systems related to piston aircraft engines (P3-PAP) 4. Mastering specific knowledge in the field of components and systems of piston aircraft engines, which enable executing applied, engineering and organisational tasks (P8-PAP, P9-PAP)

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Poglobljeno strokovno teoretično in praktično znanje na področju batnih letalskih motorjev, podprto s širšo teoretično in metodološko osnovo Spretnosti: 1. S1 Sposobnost upravljanja in vzdrževanja batnih letalskih motorjev. 2. S1.2 Samostojna uporaba pridobljenega znanja pri analizi in diagnostiki batnih letalskih motorjev. 3. S1.3 Sposobnost uvajanja metod za zvišanje moči in izkoristka ter zmanjšanje izpustov onesnažil batnih letalskih motorjev. 4. S1.4 Sposobnost nadaljnjega, samostojnega študija.	Knowledge: Z1: In depth professional theoretical and applied knowledge in the area of piston engines, supported by comprehensive theoretical and methodological basis. Skills: 1. S1.1 Mastering the operation and maintenance of piston aircraft engines. 2. S1.2 Independent use of knowledge for analysis and diagnostics of piston aircraft engines. 3. S1.3 Ability to apply methods for increasing power output and increasing efficiency as well as reducing pollutant emissions of piston aircraft engines. 4. S1.4 Capability of further independent self-learning in the area of piston aircraft engines.

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri. P4 Laboratorijske vaje. P5 Uporaba študijskega gradiva v obliki (e-verzija	P1: Classroom lectures with inclusion of solving selected typical and practical examples. P2: Presenting of the learning content in an orderly and pre-interpreted systematics P3: Tutorials where theoretical knowledge of lectures is supported by computational examples. P4: Laboratory work. P5: Use of study materials in format (e-version of lecture

predstavitve predavanj). P8 Izdelava in predstavitev aplikativnih seminarskih nalog P10 Uporaba anket v realnem času P14 Virtualni eksperimenti P15 Uporaba video vsebin kot priprava na predavanja in vaje	presentation). P8: Design and presentation of applied seminar work P10: Use of real-time surveys P14: Virtual Experiments P15: Using video content to prepare for lectures and exercises

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
- Teoretične vsebine (predavanja)	50,00 %	- Theory (lectures)
- Samostojno delo na vajah:	50,00 %	- Practical coursework

Reference nosilca/Lecturer's references:

Tomaž Katrašnik:

1. **KATRAŠNIK, Tomaž**, TRENC, Ferdinand. Innovative approach to air management strategy for turbocharged diesel aircraft engines. Proceedings of the Institution of Mechanical Engineers. Part G, Journal of aerospace engineering, ISSN 0954-4100, 2012, vol. 226, no. 8, str. 966-979
2. TAVČAR, Gregor, BIZJAN, Frančišek, **KATRAŠNIK, Tomaž**. Methods for improving transient response of diesel engines - influences of different electrically assisted turbocharging topologies. Proceedings of the Institution of Mechanical Engineers. Part D, Journal of automobile engineering, ISSN 0954-4070, Sep. 2011, vol. 225, iss. 9, str. 1167-1-1167-16
3. ŽVAR BAŠKOVIČ, Urban, VIHAR, Rok, MELE, Igor, **KATRAŠNIK, Tomaž**. A new method for simultaneous determination of the TDC offset and the pressure offset in fired cylinders of an internal combustion engine. Energies, ISSN 1996-1073, Jan. 2017, vol. 10, iss. 1, f. 1-22
4. RAŠIĆ, Davor, VIHAR, Rok, ŽVAR BAŠKOVIČ, Urban, **KATRAŠNIK, Tomaž**. Methodology for processing pressure traces used as inputs for combustion analyses in diesel engines. Measurement science & technology, ISSN 0957-0233. [Print ed.], Apr. 2017, vol. 28, iss. 5, str. 1-22
5. BANJAC, Titina, WURZENBERGER, Johann C., **KATRAŠNIK, Tomaž**. Assessment of engine thermal management through advanced system engineering modeling. Advances in engineering software, ISSN 0965-9978. [Print ed.], May 2014, vol. 71, str. 19-33