Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Termodinamika**
Course title:	**Thermodynamics**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika, 1. stopnja		**1**	**2**
Physics, 1st level			

Vrsta predmeta / Course type	obvezni/ Compulsory
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
30		**30**			**90**	**5**

Nosilec predmeta / Lecturer:	Milan Svetec

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Pogojev ni. Priporočljivo je predznanje iz klasične mehanike.	None. Recommended preknowledge of classical mechanics.

Vsebina:	**Content (Syllabus outline):**
Temperatura -merjenje temperature, plinski termometer; ničti zakon termodinamike, temperaturno raztezanje Toplota, specifična toplota in toplotne kapaciteta, fazni prehodi; **Prenos toplote**: a) prevajanje, prevajanje skozi kompozitno ploščo, radialni toplotni tok v cevi; b) konvekcija, c) sevanje, črno telo, sevanje črnega telesa, Newtonov zakon hlajenja; **Idealni plin in kinetična teorija plinov**: enačba stanja idealnega plina, kinetična teorija plinov, povprečna prosta pot molekul, hitrostna	Temperature - temperature measurement, gas thermometer; zeroth law of thermodynamics, temperature expansion Heat, specific heat and heat capacity, phase transitions; **Heat transfer**: a) conduction, conduction through a composite plate, radial heat transfer in the tube; b) convection, c) radiation, black body, black body radiation, Newton's law of cooling; **Ideal gas and kinetic theory of gases:** equation of state of an ideal gas, kinetic theory of gases, mean free path of molecules, velocity

porazdelitev molekul (Maxwell-Boltzmannova porazdelitev), tipične hitrosti molekul; **Prvi zakon termodinamike**: notranja energija, krožna sprememba, kaj je adiabatni proces, sprememba pri konstantnem volumnu, izobarni proces, izotermni proces, specifična toplotna kapaciteta idealnega plina, adiabatni procesi in enačba adiabate, izotermna in adiabatna stisljivost, toplotna kapaciteta plinov, enakomerna porazdelitev energije; **Toplotni stroji in drugi zakon termodinamike**: Carnotov toplotni stroj, hladilni stroj, entropija, drugi zakon termodinamike; **Termodinamski potenciali**: izrek o recipročnosti in izrek o cikličnosti, toplotna kapaciteta, značilnosti funkcij stanja, Clausius-Clapeyronova enačba, Van der Waalsova enačba, termodinamski potenciali (Helmholtzova prosta energija, Gibbsova prosta energija, entalpija) **Odprti sistemi**: Kemijski potencial, ravnovesno pravilo, snovni tok; **Razredčene raztopine**: topljenec, topilo, Helmholtzova prosta energija razredčene raztopine, osmozni tlak, sprememba temperature faznega prehoda za raztopine in sprememba parnega tlaka; **Transportni pojavi**: difuzija v plinih, prevajanje toplote v plinih, viskoznost plinov	distribution of molecules (Maxwell-Boltzmann distribution), typical molecular velocity; **The first law of thermodynamics:** internal energy, cyclical process, what is an adiabatic process, change in constant volume, isobaric process, isothermal process, specific thermal capacity of ideal gas, adiabatic processes and adiabatic equations, isothermal and adiabatic compressibility, thermal capacity of gases, uniform distribution of energy; **Heat engines and second law of thermodynamics**: Carnot heat engine, cooling engine, entropy, second law of thermodynamics; **Thermodynamic potentials**: theorem on reciprocity and the cyclicity theorem, the thermal capacity, the characteristics of the state functions, the Clausius-Clapeyron equation, Van der Waals equation, the thermodynamic potentials (Helmholtz free energy, Gibbs free energy, enthalpy) **Open Systems**: Chemical Potential, Equilibrium Rule, Material Flow; **Diluted solutions**: solute, solvent, Helmholtz free energy of a diluted solution, osmotic pressure, change in phase transition temperature for solutions and change in vapor pressure; **Transport phenomena**: diffusion in gases, heat transfer in gases, viscosity of gases

Temeljni literatura in viri / Readings:

- D. Haliday, R. Resnick, J. Walker: Fundamentals of Physics, extended, with Modern Physics, John Wiley & Sons 1993.
- R. Resnick, D. Halliday, K.S. Krane: Physics, fourth edition, Wiley and Sons, 1992.
- C. J. Adkins: Equilibrium Thermodynamics, Cambridge University Press, 2003.
- M. W. Zemansky, R. H. Dittman: Heat and thermodynamics, McGraw-Hill, 1997.
- E. Fermi: Thermodynamics, Dover publications, 1956.
- V. Savelyev: Physics, A general course I, Mir publications Moscow, 1980.
- J. Strnad: Fizika 1. del: Mehanika, Toplota, Društvo matematikov, fizikov in astronomov Slovenije 1995.
- M. Svetec, Termodinamika: zapiski predavanj, Fakulteta za naravoslovje in matematiko, 2018.

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Cilji in kompetence:	**Objectives and competences:**
Študenti usvojijo temeljna teoretična znanja s področja termodinamike in jih znajo uporabiti pri reševanju ustreznih problemov z rabo usvojenih konceptov in matematičnih orodij.	Students acquire basic theoretical knowledge in the field of thermodynamics and can use them to solve relevant problems using the adopted concepts and mathematical tools.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Po uspešno zaključeni učni enoti bodo študenti sposobni: • definirati fizikalni sistem, opredeliti dejavnike v okolici, ki vplivajo na stanje sistema, in kvalitativno ter kvantitativno napovedati spreminjanje stanja izbranega fizikalnega sistema v odvisnosti od parametrov in spremenljivk v sistemu in okolici; • uporabiti zakonitosti termodinamike za analiziranje pojavov, povezanih s prenosom toplote, za analiziranje različnih stanj idealnega plina v odvisnosti od dejavnikov v okolici, za opis in razločevanje prehodov med različnimi stanji opazovanega sistema (predvsem idealnega plina) na pV diagramu, za matematični opis krožnih procesov in izračun izkoristka naprave, za opis sistema s primernim termodinamskim potencialom, za analiziranje sistema, sestavljenega iz več komponent ter ustrezno izbiro termodinamskega potenciala za opis; • obravnavati pV diagram poljubne tekočine in določiti kritično točko sistema ter napovedati tipično obnašanje sistema. **Prenesljive/ključne spretnosti in drugi atributi:** Po uspešno zaključeni učni enoti bodo študenti zmožni: • uporabljati sodobno računalniško programsko opremo kot pomoč pri kvantitativnem računanju ter za izrisovanje odvisnosti med	**Knowledge and understanding:** After successful completion of the learning unit students will be able to: • define the physical system, define the environmental factors that influence the state of the system, and predict qualitatively and quantitatively the change in the state of the selected physical system depending on the parameters and variables in the system and environment; • apply the principles of thermodynamics to analyze the phenomena associated with heat transfer, to analyze the various states of ideal gas depending on the surrounding factors, to describe and distinguish the transitions between the various states of the observed system (especially the ideal gas) on the pV diagram, for the mathematical description of the cyclical processes and calculation of the efficiency of the engine, for describing the system with a suitable thermodynamic potential, for analyzing a system consisting of several components and an appropriate choice of the thermodynamic potential for the description; • Consider the pV diagram of any liquid and determine the critical point of the system and predict the typical behavior of the system. **Transferable/Key Skills and other attributes:** After successful completion of the learning unit students will be able to: • use modern computer software for quantitative calculations and for plotting dependencies among variables at different values of parameters;

spremenljivkami v odvisnosti od vrednosti parametrov; • pripravljati fizikalne skice in diagrame prehajanja stanj ter smiselno poročati o izbrani temi; • uporabiti osnovno znanje linearne algebre in analize za obravnavo fizikalnih problemov.	• prepare physical sketches and diagrams of the state transitions and report in a meaningful manner on the chosen topic; • use the basic knowledge of linear algebra and analysis to deal with physical problems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
eksperimentalna predavanja teoretične vaje razlaga razgovor demonstracija delo s tekstom metoda pisnih in grafičnih del uporaba simulacij elementi obrnjenega poučevanja Poučevanje in učenje potekata z didaktično uporabo informacijsko-komunikacijske tehnologije.	- lectures with experiments - theoretical exercises explanation discussion demonstration work with text work with graphic elements use of simulations elements of flipped learning Teaching and learning are performed through the didactic use of ICT.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): Pisni izpit (lahko se nadomesti z dvema vmesnima kolokvijema) Ustni izpit Za uspešno zaključeno učno enoto mora vsak del posebej biti pozitiven.	 **50** **50**	Type (examination, oral, coursework, project): written exam (can be replaced by two written tests) oral exam For a successfully mastering this course, both oral and written exams have to be positive.

Reference nosilca / Lecturer's references:

SHAHRIARI, Zahra, NAZARIMEHR, Fahimeh, RAJAGOPAL, Karthikeyan, JAFARI, Sajad, PERC, Matjaž, SVETEC, Milan. Cryptocurrency price analysis with ordinal partition networks. *Applied mathematics and computation*. [Print ed.]. Oct. 2022, vol. 430, str. 1-14. ISSN 0096-3003. DOI: 10.1016/j.amc.2022.127237. [COBISS.SI-ID 110070019]

KLINSHOV, Vladimir, KOVALCHUK, Andrey V., FRANOVIĆ, Igor, PERC, Matjaž, SVETEC, Milan. Rate chaos and memory lifetime in spiking neural networks. *Chaos, solitons and fractals*. [Print ed.]. May 2022, vol. 158, str. 1-7. DOI: 10.1016/j.chaos.2022.112011. [COBISS.SI-ID 102476291]

KLEMENČIČ, Eva, SLAVINEC, Mitja, SVETEC, Milan. Phase change materials for the thermal stability of buildings. V: CELEC, Robert (ur.). *Transfer of studies regarding environmental problems to the field of economy through education*. Hamburg: Dr. Kovač, 2018. Str. 55-65, graf. prikazi. Schriftenreihe Erziehung - Unterricht - Bildung, Band 188. ISBN 978-3-339-10272-0. ISSN 0945-487X. [COBISS.SI-ID 24324872]

SVETEC, Milan. Hawkingova temperatura črne luknje. V: SLAVINEC, Mitja (ur.). *Astronomi v Kmici : štiriindvajsetič*. Murska Sobota: AD Kmica: ZOTKS, 2021. Str. 16-19. ISBN 978-961-95235-1-3. [COBISS.SI-ID 103919363]