



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
Predmetni učitelj		2	4
The subject teacher			

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
20		20			50	3

Nosilec predmeta / Lecturer:

Milan Svetec

Jeziki /

Predavanja / Lectures:

slovenski/Slovenian

Languages:

Vaje / Tutorial:

slovenski/Slovenian

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

Priporočljivo je predznanje iz klasične mehanike.

Vsaka izmed naštetih obveznosti v načinih ocenjevanja mora biti opravljena s pozitivno oceno

Pozitivna ocena pri pisnem izpitu je pogoj za pristop k ustnemu izpitu.

Prerequisites:

Recommended preknowledge of classical mechanics.

Each of the mentioned commitments must be assessed with a passing grade.

Passing grade of the written exam is required for taking the oral exam.

Vsebina:

Content (Syllabus outline):



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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 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 adiagate, 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)

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 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)

Temeljna literatura in viri / Readings:



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- D. Halliday, R. Resnick, J. Walker: Fundamentals of Physics, 7th ed., extended, Wiley & Sons, cop. 2005.
- V. Savelyev: Physics, A general course I, Mir publications Moscow, 1980
- J. Strnad: Fizika 1. del: Mehanika, Toplota, DMFA - založništvo, 2014.
- Guggenheim, E. A., Thermodynamics : An Advanced Treatment for Chemists and Physicists, North-Holland, 1985.

Dodatna literatura

- C. J. Adkins: Equilibrium Thermodynamics, Cambridge University Press, 2003
- E. Fermi: Thermodynamics, Dover publications, 1956
(<https://gutenberg.net.au/ebooks13/1305021p.pdf>)
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Cilji in kompetence:

Študenti usvojijo temeljna teoretična znanja s področja termodinamike in jih znajo uporabiti pri reševanju ustreznih problemov z rabo usvojenih konceptov in matematičnih orodij

Objectives and competences:

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:

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;
- obravnavati pV diagram poljubne tekočine in določiti kritično točko sistema ter napovedati tipično obnašanje sistema.

Intended learning outcomes:

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



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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 spremenljivkami v odvisnosti od vrednosti parametrov;
- pripravljati fizikalne skice in diagrame prehajanja stanj ter smiselno poročati o izbrani temi;

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;
- prepare physical sketches and diagrams of the state transitions and report in a meaningful manner on the chosen topic;

Metode poučevanja in učenja:

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.

Learning and teaching methods:

- 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.

Delež (v %) /

Weight (in %)

Načini ocenjevanja:

Assessment:

Znanje:

Pisni izpit

Ustni izpit

50

50

Knowledge:

written exam

oral exam



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Za uspešno zaključeno učno enoto mora vsak del posebej biti pozitiven.		For a successfully mastering this course, both oral and written exams have to be positive.
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Opombe:

Pisni izpit se lahko nadomesti s kolokviji v enakem deležu 50%.

Comments:

Written exam can be replaced by written midterm examination in the weight of 50%.

Reference nosilca / Lecturer's references:

SVETEC, Milan, HARKAI, Saša, PAL, Kaushik, KRALJ, Samo. Twist disclinations mediated transformations in confined nematic liquid crystals. Journal of molecular liquids. [Online ed.]. 15 Nov. 2024, part b, [article no.] 126138, 10 str., ilustr. ISSN 1873-3166.
<https://www.sciencedirect.com/science/article/pii/S0167732224021974?via%3Dihub>, DOI: 10.1016/j.molliq.2024.126138. [COBISS.SI-ID 214061315]

JELEN, Žiga, SVETEC, Milan, MAJERIČ, Peter, KAPUN, Stanko, RESMAN, Lara, ČEH, Tatjana, HAJRA, Granit, RUDOLF, Rebeka. Contaminants in the soil and typical crops of the Pannonian region of Slovenia. Sustainability. Oct. 2024, vol. 16, iss. 19, [article no.] 8678, 15 str., ilustr. ISSN 2071-1050. <https://dk.um.si/IzpisGradiva.php?id=91211>, <https://www.mdpi.com/2071-1050/16/19/8678>, dCOBISS, DOI: 10.3390/su16198678. [COBISS.SI-ID 214094851]

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., FRANOVIČ, 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]