AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Kinetic theory and transport phenomena

Academic year: 2019/2020 Code: ZSDA-3-0072-s ECTS credits: 3

Faculty of: Szkoła Doktorska AGH

Field of study: Szkoła Doktorska AGH Specialty: —

Study level: Third-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 0

Course homepage: —

Responsible teacher: dr hab. inż. Tkacz-Śmiech Katarzyna (smiech@agh.edu.pl)

Module summary

The course gives a broad view of nonequilibrium statistical mechanics using the kinetic theory approach. The objective is to balance qualitative analysis and detailed description of different phenomena that are explained and quantified by kinetic theory. The students gain knowledge about how the concepts of kinetic theory can be applied to various situations as diverse as light diffusion, bacterial suspensions, granular matter, the expanding universe, and many others.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	Is aware of the importance of basic research in every discipline, including technological sciences.	SDA3A_K01	Participation in a discussion, Activity during classes
Skills: he can			
M_U001	Actively participates in the discussion regarding the fundamental laws of nature.	SDA3A_U04	Activity during classes
M_U002	Can use knowledge of transport phenomena in the description of the properties of matter and technological processes.	SDA3A_U01	Participation in a discussion, Case study, Scientific paper, Activity during classes
Knowledge: he knows and understands			
M_W001	Knows the essence of kinetic theories and their applicability to describe irreversible phenomena.	SDA3A_W01	Scientific paper
M_W002	Understands a universal character of nonequilibrium statistical mechanics.	SDA3A_W05	Activity during classes

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
40	20	0	0	0	0	20	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	Is aware of the importance of basic research in every discipline, including technological sciences.	+	-	-	-	-	-	-	-	-	-	-
Skills: he can												
M_U001	Actively participates in the discussion regarding the fundamental laws of nature.	-	-	-	-	-	+	-	-	-	-	-
M_U002	Can use knowledge of transport phenomena in the description of the properties of matter and technological processes.	-	-	-	-	-	+	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	Knows the essence of kinetic theories and their applicability to describe irreversible phenomena.	+	-	-	-	-	+	-	-	-	-	-
M_W002	Understands a universal character of nonequilibrium statistical mechanics.	+	-	-	-	-	+	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	40 h
Preparation for classes	2 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	3 h
Realization of independently performed tasks	2 h
Summary student workload	47 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

Topics covered in this course include general concepts and tools of kinetic theories as well as various systems described using specific kinetic models
1.A basic presentation of the one-particle distribution and the mean free path approach
2.A formal description of many-body distribution functions
3.Lorentz model for charge transport
4.The Boltzmann equation for classical gases
5.Brownian motion and the Planck equation, diffusion
6.The Vlasov equation for plasmas
7.Systems with long-range interactions, galaxies
8.Quantum gases with the Pauli exclusion principle (fermions, bosons)
9.Electrons in a crystalline solid
10.Band structure, insulators, conductors and semiconductors
11.Chosen numerical methods that can be used to solve the kinetic models

Seminar classes

Presentations covering additional topics selected individually for students according to their research interest.
Solving typical problems related to the kinetic models.
Presentation of the application of the kinetic models in physics, chemistry and materials science.

Teaching methods and techniques:

Lectures: The lecture is presented in the form of a multimedia presentation combined with a classical blackboard lecture.
Seminar classes: In seminar classes, the basis is multimedia and oral presentation by students. Discussion and problem solving are another important element of education.

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

To pass the course, a student has to present at least one presentation, show activity during the

seminars (discussion and solving the problems) and attend at least 6 lectures.

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: Yes
– Participation rules in classes: Lectures present the content in accordance with the syllabus. Some time at the end of the lecture is reserved for questions and discussion. Students receive multimedia materials in advance. In the case of frequent absences from the lecture, the student has to pass a test exam.
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Students present the topic indicated by the teacher. Both the substantive value of the presentation and the so-called soft skills are evaluated. The presentation is followed by a discussion. Activity in the discussion is also evaluated. The acquired knowledge is checked by solving the problems.

Method of calculating the final grade

A final grade is provided a grade for the seminar, calculated in proportion to the number of points scored.
A student can get points for:
- the presentation – max. 20 points
- activity – max 20 points

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

A student can present his/her presentation in another convenient time. He/she can take an additional test of the lectures' content during consultation hours.

Prerequisites and additional requirements

A basis of thermodynamics.
Mathematical skills.

Recommended literature and teaching resources

1.Y. Demirel, V. Gerbaud: Nonequilibrium Thermodynamics: Transport and Rate Processes in Physical, Chemical and Biological Systems, Elsevier 2018.
2.R. Soto: Kinetic Theory and Transport Phenomena, Oxford Univ. Press, 2016.
3.R. W. Balluffi, S. M. Allen, W. C. Carter: Kinetic of materials, Wiley 2005.
4.D. Kondepudi: Introduction to modern thermodynamics, Wiley 2007.
5.Katarzyna Tkacz-Śmiech: Multicomponent Diffusion, Kraków 2018.

Scientific publications of module course instructors related to the topic of the module

1. Katarzyna Tkacz-Śmiech: Multicomponent Diffusion, Kraków 2018.
2. Tkacz-Śmiech K.: Termodynamika dla ceramików, Kraków 2012.
3. K. Tkacz-Śmiech, M. Danielewski, B. Bożek, D. Zientara: Diffusive interaction between Ni−Cr−Al alloys, Metallurgical and Materials Transactions, A, Physical Metallurgy and Materials 48 (2017) 2633.
4. K. Tkacz-Śmiech, B. Bożek, L. Sapa, M. Danielewski: Viscosity controlled interdiffusion in nitriding, Diffusion Foundations 10 (2016) 28.

Additional information

None