BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
FACULTY OF MECHANICAL ENGINEERING

SUBJECT DATASHEET

I. SUBJECT DESCRIPTION

1. GENERAL DATA

1.1. Subject name (in Hungarian, in English)

Advanced Thermodynamics ● Advanced Thermodynamics

1.2. Neptun code

BMEGEENNWAT

1.3. Type

study unit with contact hours

1.4. Course types and number of hours (weekly / semester)

course type	number of hours (weekly)	nature (connected / stand-alone)
lecture (theory)	2	-
exercise	1	coupled
laboratory exercise	-	-

1.5. Type of assessments (quality evaluation)

exam

1.6. ECTS

4

1.7. Subject coordinator

name:	Dr. Fülöp Tamás Attila
post:	associate professor
contact:	fulop@energia.bme.hu

1.8. Host organization

Department of Energy Engineering (http://www.energia.bme.hu/)

1.9. Course homepage

ftp://ftp.energia.bme.hu/pub/Advanced_Thermodynamics_BMEGEENNWAT

1.10. Course language

english

1.11. Primary curriculum type

mandatory

1.12. Direct prerequisites

Strong prerequisite:	-
Weak prerequisite:	-
Parallel prerequisite:	-
Milestone prerequisite:	-
Excluding condition:	BMEGEENMWAT

(the subject cannot be taken if you have previously completed any of the following subjects or groups of subjects)

2. AIMS AND ACHIEVEMENTS

2.1. Aim

The aim of the course is to acquaint students with the concepts of thermodynamics beyond the introductory level, the analytical and numerical calculation methods of thermodynamics, the levels of thermodynamic modeling, the relationship between entropy and asymptotic stability, the description of thermodynamic phases, the process-centric approach, the connection points between mechanics and thermodynamics, and generally useful skills regarding modeling, identifying distinguished scales, and analytical and computer calculations.

2.2. Learning outcomes

Competences that can be acquired by completing the course:

A. Knowledge

- The student is aware of the levels of thermodynamic modeling, the ways in which time and space dependence are taken into account.
- The student is knowledgeable among van der Waals and more complex fluid models.
- The student masters the transformation relationships among various kinds of information derived from state equations and measurements (variable transformations, Maxwell and Gibbs-Helmholtz relations).
- The student knows the definition of the critical point, and of the spinodal, binodal and phase boundary curves.
- The student can identify the distinguished scales of thermodynamical and other models, and knows how the number of free variables can be reduced, hence, can make the investigation more efficient.
- The student can characterize the behavior of fluids in the metastable, negative-pressure, and supercritical domains.
- The student is familiar with the structure and use of state and phase diagrams.
- The student understands the system of ordinary differential equations describing the processes of discrete thermodynamic systems.
- The student is informed about the role of total entropy as a Lyapunov function in the asymptotic stability study of this system of differential equations.
- The student is familiar with the Lyapunov technique for studying stability in nonlinear problems at the general level as well.
- The student understands the Reitlinger–Chambadal–Novikov–Curzon–Ahlborn heat engine and its importance in thermodynamical modeling.
- The student is aware of the modeling possibilities provided by the thermodynamical internal variables.
- The student is informed about the principles of continuum thermodynamical description.
- The student is aware of the limitations of thermodynamical models, the nature and extent of approximations and simplifications, and their impact on the result obtained from the model.

B. Ability

- The student is able to choose the appropriate mode of modeling for a given thermodynamical problem.
- The student identifies the appropriate (van der Waals or more complex) fluid model for a given situation.

- The student applies the transformation of information derived from state equations and measurements (variable transformations, Maxwell and Gibbs-Helmholtz relations).
- The student determines the critical point, and the spinodal, binodal, and phase boundary curves.
- The student is able to recognize the distinguished scales of thermodynamical and other models, thereby reducing the number of free variables and thus making the investigation more efficient.
- The student identifies behaviors of fluids characteristic of metastable, negative pressure, and supercritical domains.
- The student calculates state and phase diagrams.
- The student applies a system of ordinary differential equations describing the processes of discrete thermodynamic systems.
- The student applies total entropy as a Lyapunov function in the asymptotic stability study of this system of differential equations.
- The student uses the Lyapunov technique to study the stability of nonlinear problems at the general level as well.
- The student operates the Reitlinger–Chambadal–Novikov–Curzon–Ahlborn heat engine model in the framework of thermodynamical modeling.
- The student uses thermodynamical internal variables as modeling options.
- The student operates the principles of continuum thermodynamical description.
- The student identifies the limitations of thermodynamical models, the nature and extent of approximations and simplifications, and their impact on the result obtained from the model.

C. Attitude

- The student constantly monitors his/her work, results and conclusions.
- The student expands his/her knowledge of thermodynamical modeling through continuous acquisition of knowledge.
- The student is open to the use of information technology tools.
- The student aspires to learn about and routinely use the tools needed to solve thermodynamical problems.
- The student develops his/her ability for accurate and error-free problem solving, engineering precision and accuracy.
- The student is open to systematic thinking and scrutiny, to focusing on the essence, and to intellectual tightness.

D. Independence and responsibility

- The student collaborates with teachers and fellow students to expand knowledge.
- The student accepts substantiated critical remarks and suggestions for improvement.
- The student independently performs the analysis of thermodynamic tasks and problems and their solving based on specific sources.
- The student is committed to methodical and rigorous thinking.
- The student is committed to the model-based and levels-of-knowledge based approach.

2.3. Teaching methodology

During the teaching of the subject, the lectures and practices both motivate the students to take their own notes, understand the activity in class, to consult, to communicate bravely in English, to use their own notes, and to follow the online notes. In addition to the general principles, the lecture also presents illustrative examples. The practice promotes the application and skill-level acquisition of knowledge by going into technical details.

2.4. Support materials

a) Textbooks

Herbert B. Callen, Thermodynamics and an introduction to thermostatistics, Wiley, 1995, New York, ISBN 978-0-471-86256-7

S. R. De Groot and P. Mazur, Non-equilibrium thermodynamics, Dover, 2011, New York, ISBN 978-0486647418

T. Matolcsi, Ordinary thermodynamics, Society for the Unity of Science and Technology, 2017, Budapest, ISBN 978-615-80157-2-1

b) Lecture notes

T. Fülöp, Chapters in thermodynamics, 2020,

ftp://ftp.energia.bme.hu/pub/Advanced_Thermodynamics_BMEGEENNWAT

c) Online materials

ftp://ftp.energia.bme.hu/pub/Advanced_Thermodynamics_BMEGEENNWAT

2.5. Validity of the course description

Start of validity:	2019. September 1.
End of validity:	2025. July 15.

II. SUBJECT REQUIREMENT

3. ACHIEVEMENT CONTROL AND EVALUATION

3.1 General rules

During the term time, the students write a 90-minutes long Midterm is written, which counts with 35% weight in the grade. A Retake is available for the Midterm, and the better result counts. Then, during the exam period, a 90-minutes long written exam is to be written, which counts with 65% weight in the grade. Thirdly, based on their work on lectures, practices and consultations (comments, remarks, questions), students receive a maximally 10%. The signature requires at least 70% attendance at lecture and an at least 40% Midterm result.

3.2 Assessment methods

A. Detailed description of mid-term assessments

1. Mid-term assessment

type: summative assessment

count: 1

purpose, description: The summative performance evaluation is a complex, written way of evaluating knowledge and ability type competence elements in the form of a 90-minutes long Midterm, which basically focuses on the application of the acquired knowledge. Students are given a list of example problems to help their preparation for the practical (calculational) tasks.

2. Mid-term assessment

type: formative assessment, simple

count: 1

purpose, description: The evaluation of term-time activity is a simplified way of assessing knowledge, ability, attitude, and competency elements of the autonomy and responsibility type. It judges prepared appearance and active participation during lectures, practices, and consultations. Extra points are awarded based on the total number of good comments, remarks and questions made during the semester.

B. Detailed description of assessments performed during the examination period (if relevant)

Elements of the exam:

1. written partial exam

obligation: mandatory (partial) exam unit, but failing the unit does not results in fail (1) exam result

description: The exam is a complex, written way of assessing the knowledge and ability type competence elements of the subject. It basically focuses on the application of the acquired knowledge, thus focusing on problem recognition and solution, i.e., primarily practical (calculational) problems must be solved, in 90 minutes. Students are given a list of example problems to help their preparation for the practical (calculational) tasks.

2. oral partial exam

-

3. practical partial exam

-

4. inclusion of mid-term results

obligation: (partial) exam unit chosen by the student, the exam result assessed by other partial exam unit can be changed restrictedly description: The result of the Midterm is added to the result of the written exam: the written exam counts with 65% weight, the Midterm with 35% weight, and the activity points with 10% weight. Accordingly, the result of the Midterm is added to the result of the written exam: the written exam counts with 65% weight, the Midterm with 35% weight, and the activity points with 10% weight. Consequently, result of the Midterm is added to the result of the written exam: the written exam counts with 65% weight, the Midterm with 35% weight, and the activity points with 10% weight.

3.3 The weight of mid-term assessments in signing or in final grading

identifier	**weight**
1 . Mid-term assessment	77 %
2 . Mid-term assessment	23 %

The condition for signing is that the score obtained in the mid-year assessments is at least **40%**.

3.4 The weight of partial exams in grade (if relevant)

type	**weight**
written partial exam	65 %
oral partial exam	0 %
practical partial exam	0 %
inclusion of mid-term results	45 %

3.5 Determination of the grade

grade ● [ECTS]	**the grade expressed in percents**
very good(5) ● Excellent [A]	above 90%
very good(5) ● Very Good [B]	85% .. 90%
good(4) ● Good [C]	70% .. 85%
satisfactory(3) ● Satisfactory [D]	55% .. 70%
sufficient(2) ● Pass [E]	40% .. 55%
insufficient(1) ● Fail [F]	below 40%

The lower limit specified for each grade already belongs to that grade.

3.6 Attendance and participation requirements

Must be present at at least **70%** (rounded down) of lectures.

At least **70%** the exercises (rounded down) must be actively attended.

3.7 Special rules for improving, retaken and replacement

The special rules for improving, retaken and replacement shall be interpreted and applied in conjunction with the general rules of the CoS (TVSZ).

Need mid-term assessment to individually complete?

NO

Can the submitted and accepted partial performance assessments be resubmitted until the end of the replacement period in order to achieve better results?

NO

The way of retaking or improving a summary assessment for the first time:

each summative assessment can be retaken or improved

Is the retaking-improving of a summary assessment allowed, and if so, than which form:

retake or grade-improving exam not possible

Taking into account the previous result in case of improvement, retaken-improvement:

out of multiple results, the best one is to be taken into account

The way of retaking or improving a partial assessment for the first time:

partial assesment(s) in this group cannot be improved or repeated, the final result is assessed in accordance with Code of Studied 122. § (6)

3.8 Study work required to complete the course

Activity	**hours / semester**
participation in contact classes	42
mid-term preparation for practices	7
preparation for summary assessments	16
elaboration of a partial assessment task	4
exam preparation	28
additional time required to complete the subject	27
summary	**124**

3.9. Validity of subject requirements

Start of validity: 2019. September 1.

End of validity: 2025. July 15.

4. ADDITIONAL INFORMATION

4.1 Primary course

The primary (main) course of the subject in which it is advertised and to which the competencies are related:

Mechanical modelling

4.2 Link to the purpose and (special) compensations of the Regulation KKK

This course aims to improve the following competencies defined in the Regulation KKK>

a) knowledge

- Student has the knowledge of modelling and analysis of time-varying processes in machines and mechanical systems.
- Student has the knowledge of the scientific theories (mathematical, mechanical, fluid mechanics, thermal and electronic) and computational methods relevant to mechanical engineering research and development.
- Student has the knowledge of modern experimental and numerical modelling techniques.

b) ability

- Student has the ability to apply and put into practice the knowledge acquired, using problem-solving techniques.
- Student has the ability to learn, develop and improve own knowledge.
- Student has the ability to solve problems creatively and flexibly, and to engage in lifelong learning.

c) attitude

- Student strives to carry out their work in a complex approach based on a systems and process-oriented thinking.
- Student is committed to high quality work and strives to communicate this approach to his staff.
- Student is open to professional training for self-learning and self-development.

d) independence and responsibility

- Student is able to carry out activities in the field of mechanical engineering modelling with a high degree of autonomy and responsibility.
- Student acts independently and proactively in solving technical problems.
- Student independently selects and applies relevant problem-solving methods when solving professional tasks.

4.3 Prerequisites for completing the course

Knowledge type competencies

(a set of prior knowledge, the existence of which is not obligatory, but greatly facilitates the successful completion of the subject)	Addition, subtraction, multiplication, division, differentiation, integration.

Ability type competencies

(a set of prior abilities and skills, the existence of which is not obligatory, but greatly contributes to the successful completion of the subject)	The student is able to take notes, and to ask and comment.