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Faculty of Health, Science and Technology

Materials Engineering

**Syllabus**

**Phase Transformation in Metals and Alloys**

## **Course Code:** 7MTT102**Course Title:** Phase Transformation in Metals and Alloys

##  *Fasomvandling i metaller och legeringar*

## **Subject:** Materials Engineering

## **Credits:** 7.5 ECTS

**Degree Level:** Doctoral

## **Course Approval**

The syllabus was approved by the Faculty of Health, Science and Technology,
28 April 2021 and is valid from the spring semester 2021.

## **Language of instruction**

English

## **Prerequisites**

## Admitted as PhD student at Karlstad University or another university and having a master’s degree, or equivalent, with a profile in materials engineering, or a related field such as materials science, physics or chemistry. Students who have acquired equivalent knowledge in some other way may be deemed eligible.

## **Learning Outcomes**

## The course provides a fundamental understanding of the theoretical background in thermodynamics of metallic systems, kinetics, surface phenomena as well as features of specific transformations like solidification, diffusional and diffusionless transformations in solids. During the course students should:

## -to gain knowledge about the thermodynamic basis for phase transformations, be able to explain binary and tertiary phase diagrams, be able to predict microstructure and heat treatment based on phase diagrams.

## -to explain the atomic mechanisms of diffusion and being able to use this related to relevant and important diffusion problems.

## -to acquire knowledge and classification of the grain/phase boundaries and how these relate to grain boundary mobility.

## -to know diffusional phase transformations taking place by nucleation and growth, including precipitation reactions, recrystallization, and grain growth.

## -to acquire understanding of diffusionless/martensitic transformation, crystallographic relationship between phases, kinetics of phase transformation.

## Important outcome is to be able to show a correlation between a phase diagram, a possible heat treatment and the final mechanical properties with respect to the changes in microstructure.

## **Course Content**

Thermodynamics and Equilibrium Phase Diagrams (Free energy, Entropy, Enthalpy, Equilibrium conditions, Equilibrium in Homogeneous and Heterogeneous systems, Binary Phase Diagrams, Ternary Phase Diagrams)

Diffusion (Fick’s Laws, Solution of Diffusion Equation, Atomic mechanisms of Diffusion, Interstitial and Substitution Mechanisms of Diffusion, Grain-boundaries Diffusion and Diffusion along Dislocations)

Interface and Microstructure (Free Energy of Interface, Coherent and Incoherent interfaces, Precipitates, Migration of Grain Boundaries, Grain Growth)

Solidification (Homogeneous and Heterogeneous Nucleation, Growth of Pure Solids, Alloy Solidification, Eutectic and Peritectic Solidification, Ingot Structures)

Diffusional Transformations in Solids (Homogeneous and Heterogeneous Nucleation in Solids, , Precipitate Growth, Precipitation in Age-Hardening Alloys – System Al-Cu, Eutectoid Transformation in Steels, TTT Diagrams, Tempering of Martensite, Special Cases of Diffusional Transformations, Kinetics of Phase Transformations)

Diffusionless Transformations in Solids (Nucleation and Growth of Martensite)

Recovery, Recrystallization and Grain Growth (Mechanisms, Kinetics, Thermodynamical Approach)

## **Reading List**

See separate document.

## **Examination**

Home assignments and presentations (topics are provided by teacher and can be formulated in relation to the PhD project to gain specific knowledge relevant to the whole research study) relevant to each chapter.

## **Grades**

Text ex: One of the grades Fail (U) or Pass (G) is awarded in the examination of the course.

## **Quality Assurance**

## The course convenor has a duty to encourage a continuous dialogue on learning processes and goal fulfilment. A written evaluation is carried out at the conclusion of the course combined with a joint student-teacher discussion of all aspects commented on. The result of the evaluation is collated and made available in accordance with *The Higher Education* Ordinance, Chapter 1, § 14.

## **Course Certificate**

## Course certificate is issued on request.

## **Goal matrix**

Goals that, after completing the course, are fulfilled for the doctoral or licentiate degree are marked with an X.

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|   | **Doctoral** |  |   |   |   | **Licentiate** |   |
|   | **Knowledge and understanding** |  |   |   |   | **Knowledge and understanding** |   |
| 1a |  - demonstrate broad knowledge and systematic understanding of the research field and |  | x  |   | 1a | demonstrate knowledge and understanding in the field of research including |  x |
| 1b | advanced and up-to-date specialised knowledge in a limited area of this field, and |  |  x |   | 1b | current specialist knowledge in a limited area of this field as well as |  x |
| 1c | familiarity with research methodology in general and the methods of the specific field of research in particular. |  |  x |   | 1c | specialised knowledge of research methodology in general and the methods of the specific field of research in particular |  x |
|   | **Competence and skills** |  |   |   |   | **Competence and skills** |   |
| 2a |  - demonstrate capacity for scholarly analysis and synthesis as well as |  |  x |   | 2a | demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively and to |  x |
| 2b | to review and assess new and complex phenomena, issues and situations autonomously and critically |  |  x |   | 2b | plan and use appropriate methods to undertake a limited piece of research and other qualified tasks within predetermined time frames in order to contribute to the formation of knowledge |  x |
| 3a |  - demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to |  |  x |   | 2c | as well as to evaluate this work |   |
| 3b | plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work |  |   |   | 3a | demonstrate the ability in both national and international contexts to present and discuss research and research findings in speech and writing and in dialogue with the academic community and |   |
| 4 |  - demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research |  | x  |   | 3b | society in general |   |
| 5a |  - demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and |  |   |   | 4 | demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity. |  x |
| 5b | society in general |  |   |   |   |   |   |
| 6 |  - demonstrate the ability to identify the need for further knowledge and |  |   |   |  |   |   |
| 7 |  - demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity. |  |   |   |  |   |   |
|   | **Judgement and approach** |  |   |   |  | **Judgement and approach** |   |
| 8a |  - demonstrate intellectual autonomy and disciplinary rectitude as well as |  |  x |   | 5 | demonstrate the ability to make assessments of ethical aspects of his or her own research |   |
| 8b | the ability to make assessments of research ethics, and |  |   |   | 6 | demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used |   |
| 9 |  - demonstrate specialised insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used. |  |   |   | 7 | demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning. |  x |