## Subject content

### 1. Program information

| | |
|---|---|
| 1.1 University | West University of Timisoara |
| 1.2 Faculty | Physics |
| 1.3 Department | Physics |
| 1.4 Study direction | Physics |
| 1.5 Study cycle | Master |
| 1.6 Study program | Physics and technology of advanced materials |

### 2. Subject matter information

| 2.1 Subject matter | | | | **PTAM1205** Transport phenomena | | | |
|---|---|---|---|---|---|---|---|
| 2.2 Subject teacher | | | | Prof.dr. Daniel Vizman | | | |
| 2.3 Subject applications teacher | | | | Lect.dr. Alexandra Popescu | | | |
| 2.4 Study year | 1 | 2.5 Semester | 2 | 2.6 Assesment type | Ex | 2.7 Subject type | Ob |

### 3. Study time distribution

| 3.1 Nr. of hours/week | 4 | In which: 3.2 course | 2 | 3.3 seminar/lab | 2 |
|---|---|---|---|---|---|
| 3.4 Total hours in educational plan | 56 | In which: 3.5 curs | 28 | 3.6 seminar/lab | 28 |
| **Time distribution:** | | | | | **hours** |
| Study after lecture notes, bibliography or notes | | | | | 31 |
| Additional documentation in the library, electronic specialty platforms/ field | | | | | 10 |
| Seminar / laboratory preparations, homework, portofolio and essays | | | | | 10 |
| Tutoring | | | | | 4 |
| Exams | | | | | 3 |
| Other activities…………………………………… | | | | | |

| | |
|---|---|
| **3.7 Total number of personal study hour** | **56** |
| **3.8 Total number of hours in semester** | **114** |
| **3.9 Number of credits** | **7** |

### 4. Preconditions (where appropiate)

| | |
|---|---|
| 4.1  curriculum | ● |
| 4.2 skills | ● |

### 5. Conditions (where appropiate)

| | |
|---|---|
| 5.1 for course | ●     Molecular physics; Thermal and statistical physics |
| 5.2 for seminar/lab | ● |

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**6. Objectives of the discipline - expected learning outcomes to the formation of which contribute to the completion and promotion of the discipline**

| | |
|---|---|
| Knowledge | The course study transport phenomena related to the complex method of crystal growth: heat transfer phenomena (conduction, convection and radiation) and mass transport (difusion). The specific objective are: <br> • Description of transport phenomena in crystal growth systems <br> • Understanding the phase transitions in crystal growth processes <br> • Understanding the role of convection and radiation in heat transfer |
| Abilities | -Capacity of analising and description of transport phenomena in complex systems <br> -Capacity of building mental models for crystal growth systems by understanding the related physical phenomena. <br> - Capacity of  understanding the functional relations in a crystal growth system , which describe how one parameter variation imply other parameter variation or the variation of the whole system. <br> - Interpretation of the causal relations between different parts of the crystal growth systems by analyzing of physical phenomena in these systems. |
| Responsibility and autonomy | • Skills in research ethics <br> • Skills in research project management <br> • Team work in a research activity. <br> • Efficient use of informational and communication resources in English language. |

**7. Table of content**

| 7.1 Course | Teaching methods | Observations |
|---|---|---|
| 1. Introduction. Example of complex phenomena which occur in crystal growth processes. | Exposure. Googlemeet platform | Course support in electronic format, Bibliography[1] |
| 2. Principles of heat transfer by conduction. Differential equation of heat transfer. Boundary conditions | Exposure. Googlemeet platform | Course support in electronic format, Bibliography[1] |
| 3. Solving methods: a)Splitting the variables; b)Aproximative analytical methods: integral methods, variational method, Ritz Galerkin method c) numerical methods: finite difference and finite volume | Exposure. Googlemeet platform | Course support in electronic format, Bibliography[1,3] |
| 4. Phase transformations: melting and solidification. Boundary conditions in movement interfaces. | Exposure. Discussions. | Course support in electronic format, Bibliography[1,3] |

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| | | |
|---|---|---|
| 5. Convective heat transfer. | Exposure. Discussions. | Course support in electronic format, Bibliography[1,3,4] |
| 6. Equations of ideal and real fluid flow (Navier-Stokes). | Exposure. Discussions. | Course support in electronic format, Bibliography[1,3] |
| 7. Introduction in magnetohydrodynamics | Exposure. Discussions. | Course support in electronic format, Bibliography[4] |
| 8. Equation of heat transfer by convection | Exposure. Discussions. | Course support in electronic format, Bibliography[1,3] |
| 9. Radiative heat transfer. Fundamentals. | Exposure. Discussions. | Course support in electronic format, Bibliography[2] |
| 10. Mass transfer. Molecular and convective diffusion. | Exposure. Discussions. | Course support in electronic format, Bibliography[2] |
| 11. Numerical methods | Exposure. Discussions. | Course support in electronic format, Bibliography[4] |
| 12. Simulation code Crysmas | Exposure. Discussions. | Course support in electronic format, Bibliography[1,3] |
| 13. Simulation code STHAMAS | Exposure. Discussions. | Course support in electronic format, Bibliography[4] |
| 14. Heat transfer analysis in Bridgman, Czochralski and EFG crystal growth methods. | Exposure. Discussions. | Course support in electronic format, Bibliography[4] |

**Bibliography**

1. *W.Carslaw, R.Jaeger, Heat conduction in solid,* Clarendon Press, Oxford (1986)
2. *M. Necati Ozisik, Radiative Transfer and interaction with conduction and convection, Wiley-Interscience Publication, 1972*
3. *I.Nicoara, Transfer de caldura si substanta in procesele de cristalizare din topitura, Tipografia Univ. de Vest Timisoara, 1996*
4. *Daniel Vizman, PhD thesis, 1996*
5. *R. Moreau, Magnetohydrodynamics, Kluwer Academic Publischers, London,1990*
6. *Crysmas, user manual*

| 7.2 Seminar / labs | Teaching methods | Observations |
|---|---|---|
| 1. Introduction. Presentation of differential eqautions for transport phenomena. | Dialogue, Googlemeet platform | **Students will gain skills to solve complex problems of heat transfer with practical applications, Bibliography [1,2]** |
| 2. Applications at the heat transfer by conduction: solving practical problems with Diriclet boundary conditions. | Dialogue, Googlemeet platform | |
| 3. Applications at the heat transfer by conduction: solving practical problems with convective boundary conditions. | Dialogue, Googlemeet platform | |
| 4. Applications at the heat transfer by conduction: solving practical problems with radiative boundary conditions. | Dialogue, Googlemeet platform | |
| 5. Solving heat conduction equation by splitting the variables method | Dialogue, Googlemeet platform | |
| 6. Solving heat conduction equation by splitting the aproximative methods | Dialogue, Googlemeet platform | |
| 7. General overview on Crysvun software. | Interactive method using modelling software | The students will learn practically to use a modelling software for modelling crystal growth |
| 8. Applications at the heat transfer simulation in a Czochralski process | Interactive method using modelling software | |

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| 9. Applications at the heat transfer simulation in a Bridgman process | Interactive method using modelling software | equipment and related physical phenomena. |
|---|---|---|
| 10. Applications to the phase transitions | Interactive method using modelling software | Bibliography [3,4] |

**Bibliography**
1. *W.Carslaw, R.Jaeger, Heat conduction in solid,* Clarendon Press, Oxford (1986)
2. *I.Nicoara, Transfer de caldura si substanta in procesele de cristalizare din topitura, Tipografia Univ. de Vest Timisoara, 1996*
3. *Crysmas, user manual*
4. *D. Vizman, B. Faina, Modelarea fenomenelor de transport, Indrumator de laborator, Editura Universitatii de Vest, 2008, Timisoara*

## 8. Relation between subject content and the expectations of employers

Transport phenomena gives work skills in almost all domains in which the future graduate can work. Mainly related with crystal growth processes, metalurgy, etc.

## 9. Assesment

| Activity type | 9.1 Assesment criteria | 9.2 Assesment method | 9.3 Percent in final mark |
|---|---|---|---|
| 9.4 Course | The assimilation level of knowledge gained | Oral examination | 60% |
| | | | |
| 9.5 Seminar / labs | Capacity of solving specific problem | Written test | 40% |

**9.6 Minimum performance standards**
1. Correct recognition of physical parameters in diferential equations of transport phenomena.
2. Statement of possible boundary conditions.
3. Explanation of the difference between heat transport by conduction, convection and radiation.
4. Explanation of the difference between difusive and convective regimes of mass transport.

Data completării

18.01.2022

Semnătura titularului de curs

Semnătura directorului de departament

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