"Computer modeling of of transfer processes"

The syllabus of the discipline

Details of the discipline	
Level of higher education	**Third (postgraduate)**
Field of expertise	13 - Mechanical engineering
Specialty.	133 - Industrial Machinery Engineering
Educational program	"Industrial Engineering"
Status of the educational component	Selective
Scope of the discipline	150 hours/5 ECTS credits
Year of study, semester	2nd year, spring semester
Form of study	Full-time (daytime)
Class schedule	2 lectures every week, 1 computer workshop every two weeks
Semester control / control measures	Credit
Language of instruction	English
Information about course leader / teachers	phD, Associate Professor, Seminsky Oleksandr Olehovych, forstd@ukr.net , @mahnv_kpi
Placement of the course	http://ci.kpi.ua

Program of the discipline

1. Description of the discipline, its purpose, subject matter and learning outcomes

Computer modeling is a modern approach to the study of processes and their specific features, taking into account the specifics of technological solutions and selected equipment. It is widely used to solve scientific and engineering problems. Therefore, computer modeling methods are actively developing and improving. Computer modeling allows to obtain more complete information about the object of modeling, reduce the cost and labor intensity of experimental research, obtain data on new objects based on similar known objects, reduce the time for the development and improvement of technologies and equipment, and simplify the search for ways to improve their efficiency.

The ***aim*** of the ***discipline*** is to study methods and means of modeling hydromechanical, thermal and mass transfer processes using computer automated systems, principles and approaches to analytical processing of modeling results and their comparison with data obtained from the study of real objects.

The discipline forms the following ***competencies***:

- ability to apply standard analytical methods and computer software tools for scientific research and solving engineering problems of industrial engineering;
- ability to conduct analytical and experimental research activities; organize, plan and predict the results of scientific research;

- the ability to initiate, organize and conduct comprehensive theoretical and experimental research in the field of research and innovation activities that lead to new knowledge.

The ***program learning outcomes*** after studying the discipline include:

-Knowledge of the fundamental principles of the theory of hydrodynamics, heat and mass transfer;

-ability to develop and study conceptual mathematical and computer models of processes taking into account the properties of a continuous environment;

-ability to analyze the state of the continuous environment and substantiate working hypotheses to improve the efficiency of transfer processes;

- ability to develop and analyze conceptual models of processes using computer technology, the results of which can be effectively used to create innovative processes and equipment.

2. Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of study in the relevant educational program)

The study of the discipline is based on professional knowledge within the framework of the study of the normative part of the educational program. The discipline helps to ensure the scientific component of the PhD program.

3. Content of the discipline

Topic 1: Introduction to computer modeling.

Topic 2. Modeling of capacitive equipment.

Topic 3. Modeling of hydromechanical processes.

Topic 4. Modeling of heat transfer processes.

Topic 5. Improving equipment and increasing the efficiency of mass transfer processes.

Topic 6. Practical aspects of applying computer modeling results.

4. Training materials and resources

Basic literature:

1. Vyklyuk Y.I. Modeling of complex systems: a manual / Y.I. Vyklyuk, R.M. Kaminsky, V.V. Pasichnyk. - Lviv: New World-2000, 2017. - 403 c.

2. Kondratov S.O. Mathematical modeling and optimization of chemical technology objects: a textbook / S.O. Kondratov, I.V. Sitak, T.M. Mateiko - Kharkiv: Leader Publishing House, 2019. - 564 c.

3. Kotovskyi V.Y. Computer modeling of physical processes. Creation and study of physical models by the numerical method / V.Y. Kotovskyi, L.Y. Tsybulskyi. - Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2019. 130 p.

4. Sidorenko S.I. Theory of heat and mass transfer in materials: textbook / S.I. Sidorenko, S.M. Voloshko - K.: Igor Sikorsky Kyiv Polytechnic Institute, 2020. - 199 c.

5. Khalatov A.A. Fundamentals of the theory of the boundary layer: a textbook / A.A. Khalatov, E.V. Mochalin, N.F. Dimitrieva - Kyiv: National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", 2019. 191 p.

Additional reading:

1. Amidon G. Transport Processes In Pharmaceutical Systems / G. Amidon. - Taylor and Francis, 2007. - 752 p.

2. Bear J. Modeling Phenomena of Flow and Transport in Porous Media / J. Bear. - Springer, 2018. - 761 p.

3. Bird R. Transport phenomena / R. Bird, W. Stewart, E. Lightfoot. - New York: Wiley, 2007. - 920 p.

4. Blazek J. Computational fluid dynamics. Principles and Applications / J. Blazek. - Amsterdam: Elsevier Ltd., 2015. - 466 p.

5. Das M.K. Modeling Transport Phenomena in Porous Media with Applications / M.K. Das, P.P. Mukherjee, K. Muralidhar. - Springer International Publishing AG, 2018. - 250 p.

6. De Souza-Santos M.L. Analytical and Approximate Methods in Transport Phenomena / M.L. De Souza-Santos. - CRC Press Taylor & Francis Group, 2008. - 577 p.

7. Luyben W.L. Process modelling, simulation for chemical engineers / W.L. Luyben. - McGraw-Hill Publishing Company, 1996. - 752 p.

8. Saatdjian E Transport Phenomena: Equations and Numerical Solutions / E. Saatdjian. - Willey, 2000. - 426 p.

9. Nikitenko N.I. Study of heat and mass exchange processes by the method of grids / N.I. Nikitenko - K.: Naukova Dumka, 1978. - 212 p.

Educational content

5. Methods of mastering the discipline (educational component)

Calendar and thematic plan

Week	*The content of the training work*	*SRS (96 hours according to the curriculum)*
Topic 1: Introduction to computer modeling.		
1, I week	**Lecture 1.** Features of computer modeling as a method of studying transfer processes in industrial engineering. Computer modeling tools. Tools for building geometric objects.	Working out the topic of the lesson.
2, II week	**Lecture 2:** Basic equations describing heat and mass transfer processes and methods for solving them. Grid methods for solving equations: the finite element method (beginning). **Workshop 1:** Building geometric objects. Bringing real objects to a model form: virtual interpretation of boundary conditions.	Working out the topics of the classes. Practice the geometric construction of objects.
3, I week	**Lecture 3**: Mesh methods for solving equations: finite element method (finite element), finite volume method.	Working out the topic of the lesson.
4, II week	**Lecture 4.** Peculiarities of building calculation grids for solving equations: automatic and "manual" methods. Optimization of grids. **Workshop 2:** Building and optimizing grids.	Working out the topics of the classes. Practice building and optimizing meshes on arbitrary objects.
Topic 2. Modeling of capacitive equipment.		
5, I week	**Lecture 5.** Modeling of capacitive equipment and its elements.	Working out the topic of the lesson. Practice of models.

Week	*The content of the training work*	*SRS (96 hours according to the curriculum)*
6, II week	**Lecture 6.** Calculation of pipeline structures. Modeling the flow of the fluid in the flowing parts of pipelines and their elements. **Practical lesson 3.** Modeling of capacitive equipment and pipelines. Analysis of the results.	Working out the topics of the classes. Practice making calculations and analyzing the results.
Topic 3. Modeling of hydromechanical processes.		
7, I week	**Lecture 7.** Determination of hydraulic losses and energy losses of objects due to overcoming the resistance to movement in a fluid medium.	Working out the topic of the lesson.
8, II week	**Lecture 8.** Peculiarities of modeling the flow of fluid through porous layers. **Practical training 4.** Development of motion models using fluid environments. Presentation and analysis of calculation results.	Working out the topics of the classes. Practice making calculations and analyzing the results.
9, I week	**Lecture 9.** Consideration of the peculiarities of the mechanics of non-Newtonian media. Non-Newtonian models and their choice. Examples of calculations.	Working out the topic of the lesson.
10, II week	**Lecture 10.** Modeling of hydrodynamic machines. Features of the construction and definition of rotation regions. Taking into account the phenomenon of cavitation. **Practical training 5.** Determination of operating modes of hydrodynamic machines.	Working out the topic of the lesson. Practice making calculations and analyzing the results.
11, I week	**Lecture 11.** Modeling of apparatus for mixing. Models of mixing methods. Features of modeling mechanical mixing devices.	Working out the topic of the lesson.
12, II week	**Lecture 12.** Modeling the operation of a filtering plant. Modeling the operation of the fluidized bed apparatus. **Practical lesson 6.** Modeling of hydrodynamic processes in technological equipment.	Working out the topics of the classes. Practice making calculations and analyzing the results.
Topic 4. Modeling of heat transfer processes.		
13, I week	**Lecture 13.** Features of heat transfer modeling. Heating and cooling.	Working out the topic of the lesson.
14, II week	**Lecture 14.** Radiation heat transfer and its modeling. **Practical lesson 7.** Applied aspects of heat transfer modeling.	Working out the topics of the classes. Practicing calculations and analyzing the results.
15, I week	**Lecture 15.** Non-stationary heat transfer. Boundary and coupled problems of heat transfer.	Working out the topic of the lesson.

Week	*The content of the training work*	*SRS (96 hours according to the curriculum)*
16, II week	**Lecture 16.** Features of modeling heat exchangers of various designs. **Practical lesson 8.** Determination of the efficiency of the heat exchanger.	Working out the topics of the classes. Practicing calculations and analyzing the results.
Topic 5. Improving equipment and increasing the efficiency of mass transfer processes.		
17, I week	**Lecture 17:** Improving equipment and increasing the efficiency of mass transfer processes.	Working out the topic of the lesson.
Topic 6. Practical aspects of applying computer modeling results.		
18, II week	**Lecture 18.** Data verification. Accuracy of calculations and selection of a rational number of calculations. Practical use of modeling results. **Practical training 9.** Presentation by graduate students of the possibilities of computer modeling of processes on the topics of dissertation research. Credit class.	Study the topic of the lecture. Preparation for the test lesson.

6. Independent work of a student/graduate student

The types of independent work are listed in the table in paragraph 5, according to the academic weeks and scheduled classes.

During the course of studying the discipline, postgraduate students work through the material presented, taking into account the specifics of their dissertation research topics and develop options for applying the acquired competencies.

Policy and control

7. Policy of the academic discipline (educational component)

A system of requirements for students:

- **rules for attending classes** - attendance at all types of classes (lectures, practical classes) is mandatory both in classrooms and in distance learning. In the latter case, classes are held in Zoom conferences and graduate students "attend" them by connecting to the links provided by teachers;
- **rules of behavior in the classroom** - not to interfere with other graduate students' listening to lectures or working in practical classes by unnecessary activities, conversations (including by phone). In the classroom and during distance learning at home, follow safety rules;
- **rules for crediting practical classes and awarding points for their completion** - the teacher evaluates the work of the graduate student during the class, the quality and timeliness of the presentation of the results of the task;
- **rules for the defense of individual assignments** - projects on research topics are presented at the last lecture session and a discussion of the presented results is mandatory;
- **rules for awarding incentive and penalty points** - no incentive points are provided; 4 penalty points are awarded for absence from class without a valid reason, late completion of practical assignments or late submission of a project on the research topic;
- **policy of deadlines and retakes**:
  1) all assignments are submitted and evaluated exclusively during classroom sessions;

2) retakes are carried out according to the schedule established at the university level within the timeframe determined by the instructor and communicated to graduate students when the rating scores are announced;

- **policy on academic integrity** - graduate students are required to comply with the provisions of the Honor Code and the requirements of academic integrity during the educational process.

8. Types of control and rating system for assessing learning outcomes (RSO)

Current control: evaluation of work in practical classes (completion of tasks in each class is evaluated up to 8 points, the maximum for all practical classes is 64 points), preparation and presentation of a project on the research topic is evaluated with a maximum of 36 points.

Calendar control: is carried out twice a semester on weeks 7-8 and 14-15 as a monitoring of the current state of fulfillment of the requirements of the silaBus - a student receives "satisfactory" during the first and second calendar control if his/her current rating is at least 0.5 of the maximum number of points possible at the time of control.

Semester control: credit.

Conditions of admission to semester control:

- admission to the test is possible only in case of successful completion of all practical classes and presentation of the project on the research topic;
- graduate students who received a total rating score of < 25 during the semester are not allowed to take the test;
- if at the beginning of practical training 9 a postgraduate student has a total rating score < 60, he/she cannot receive a positive result of the test.

Table of correspondence between rating points and grades on the university scale:

Number of points	*Assessment.*
100-95	Excellent
94-85	Very good
84-75	Okay.
74-65	Satisfactory
64-60	Enough
Less than 60	Unsatisfactory
The conditions for admission are not met	Not allowed

9. Additional information on the discipline (educational component)

Lectures are held in the form of master classes supplemented by explanations of theoretical material and lectures-discussions.

The retake is conducted according to a "hard" scheme (with the cancellation of previous points) and consists of a test task consisting of one theoretical question (based on the lecture material), which is assessed with a maximum of 40 points, and one practical question (applied task), which is assessed with a maximum of 60 points.

The assessment of the test task is carried out as follows. For answering a question, points are awarded in accordance with the completeness and validity of the answer in proportion to the corresponding maximum number of points. If the answer contains less than 30% of the required information, it is considered unsatisfactory and 0 points are awarded. The final score is determined as the sum of the points for both questions.

The syllabus of the discipline:

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