Syllabus
Mathematical and computer modelling of physical processes

1. GENERAL INFORMATION	
Faculty	Information Technology
Major code and title	5B070500 Mathematical and Computer Modeling
Year, semester	4th year, 7th semester
Subject category	Basic
Number of Credits	4
Language of Delivery	English
Prerequisites	Programming languages and technologies. Mathematical analysis. Algebra. Differential equations. Equations of mathematical physics. Numerical methods. Mathematical modeling. Physics.
Postrequisites	Computational Fluid Dynamics, Modern methods of MCM
Lecturer	Sultan D. Alpar,lecturer, Master of Engineering Sciences Room 808, e-mail: rapla.natlus@gmail.com Office hours: Tue, Wed, Fri 11.00-13.00
Instructors	Sultan D. Alpar,lecturer, Master of Engineering Sciences Room 808, e-mail: rapla.natlus@gmail.com Office hours: Tue, Wed, Fri 11.00-13.00

2. GOAL AND OBJECTIVES OF THE COURSE

The goal of the course is to provide students with skills in using physical processes with mathematical equations, using of numerical methods as a main tool in solving of thoseequations and their graphic processing for achieving results.

The objectives of the course are to deepen students' understanding of:

- Drafting of mathematical models of complex physical processes.
- Techniques and methods for solving complex problems in mathematical physics.
- Use different numerical methods for physical processes.

Learning outcomes of the course

Students successfully completing the course will be able to:

- Construction of mathematical models of physical processes
- Discretization of differential equations of mathematical physics
- Select the correct numerical method
- Write code to construct mathematical models
- Plotting and animation for the results obtained
- Develop personal qualities self-study, to expand their knowledge of mathematical and computer modeling of physical processes
- Ability to deter a rational solution to the problem
- The ability to use scientific , reference, methodological literature on the subject
- The choice and use of information technology for applications

3. COURSE DESCRIPTION

This discipline is intended for mastering the practical course of mathematical and computer modeling of physical processes. At present, mathematical modeling is one of the most rapidly developing branches of modern applied and computational mathematics. A mathematical model is an approximate description of a physical phenomenon or an object of the real world with the help of a mathematical apparatus. The course includes the study of methods for the numerical solution of problems associated with research of natural-physical and physical-technological processes on the basis of mathematical modeling. It is important to note that modeling is also a

method of cognition of the surrounding world, which makes it possible to study in detail the processes taking place in it, since it is not always possible to carry out a full-scale experiment.

4. COURSE POLICY

Students are forbidden to:

- submit any tasks after the deadline. Late submissions are graded down.
- cheat. Plagiarized papers shall not be graded;
- be late for classes;
- retake any tests, unless there is a valid reason for missing them;
- use mobile phones in class.

Students should always

- be appropriately dressed (formal/semi- formal styles are acceptable);
- show consideration for and mutual support of teachers and other students;
- let the teacher know of any problems arising in connection with their studies.

5. Literature

Basic literature:

1. Жумагулов Б.Т., Абдибеков У.С., Исахов А.А. *Основы математического и компьютерного моделирования естественно- физических процессов*. Алматы, «Қазауниверситеті», 2014.
2.Исахов А.А. *Практикум по математическому и компьютерному моделированию физических процессов*. – Алматы: Қазақуниверситеті, 2015;
3. Chung T. J. *Computational Fluid Dynamics*. Cambridge University Press, 2002

Supplementaryliterature:

1. Ferziger J. H., Peric M. *Computational Methods for Fluid Dynamics*. Springer; 3rd edition, 2013.
2. Mazumder S. *Numerical methods for partial differential equation: Finite Difference and Finite Volume Methods*. – Academic Press, 2015.

6. Course Content

6.1 Lecture, practical/seminar/laboratory session plans

Week No	Course Topic	Reference Materials	Lectures (1 h/w)	Practical classe (1 h/w)	TSIS (1 h/w)	SIS (3 h/w)
1	Introduction to the subject of mathematical and computer modeling of physical processes. Tridiagonal matrix method.	Basic [1]-[3]	L 1	PA 1	TSIS 1	SIS 1
2	Simple iteration method for the heat equation. Stability analysis.	Basic [1]-[3]	L 2	PA 2	TSIS 2	SIS 2
3	Five-diagonal matrix method	Basic [1]-[3]	L 3	PA 3	TSIS 3	SIS 3
4	Compact scheme. The first scheme against the flow. The second scheme against the flow.	Basic [1]-[3]	L 4	PA 4	TSIS 4	SIS 4
5	Tridiagonal matrix method. Jacobi, Seidel and over relaxation methods.	Basic [1]-[3]	L 5	PA 5	TSIS 5	SIS 5

6	The fractional steps method (FSM) for the two-dimensional heat equation. Alternating direction method for the two-dimensional heat equation.	Basic [1]-[3]	L 6	PA 6	TSIS 6	SIS 6
7	The fractional steps method (FSM) for the three-dimensional heat equation. Alternating direction method for the three-dimensional heat equation.	Basic [1]-[3]	L 7	PA 7	TSIS 7	SIS 7
8	Fourier method for three-dimensional Poisson equation.	Basic [1]-[3]	L 8	PA 8	Mid-term	
9	Mathematical modelling of atmospheric processes	Basic [1]-[3]	L 9	PA 7	TSIS 8	SIS 8
10	Mathematical modelling of ocean pollution	Basic [1]-[3]	L 10	PA 10	TSIS 9	SIS 9
11	Mathematical modeling of natural convection processes.	Basic [1]-[3]	L 11	PA 11	TSIS 10	SIS 10
12	Mathematical modeling of internal flows	Basic [1]-[3]	L 12	PA 12	TSIS 11	SIS 11
13	Mathematical modeling of the flow around technogenic obstacles by the wind currents	Basic [1]-[3]	L 13	PA 13	TSIS 12	SIS 12
14	Mathematical modeling of the flow separation in backward-facing step	Basic [1]-[3]	L 14	PA 14	TSIS 13	SIS 13
15	Reynolds equation	Basic [1]-[3]	L 15	PA 15	End of term	
	Total hours	**90**	**15**	**15**	**15**	**45**

Abbreviation	Meaning
TSIS	Teachersupervised independent work (СРСП)
SIS	Students' independent work (СРС)
IHW	Individual homework
PA	Practical assignment

6.2 List of assignments for Student Independent Study

№	Assignments (topics) for Independent study	Hours	Recommended literature and other sources (links)	Form of submission
1	Tridiagonal matrix method for Poisson equation . Tridiagonal matrix method for heat equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
2	Simple iteration method for heat equation.	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
3	Tridiagonal matrix method for Burger's equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
4	Simple iteration method for two-dimensional heat equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
5	Simple iteration method for two-dimensional Burger's equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
6	Fractional step method for two-dimensional heat equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW

7	Jacobi method for two-dimensional Poisson equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
8	Gauss-Seidel method for two-dimensional Poisson equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
9	The method of upper relaxation for two-dimensional Poisson equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
10	Tridiagonal matrix method for two-dimensional Poisson equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
11	Fractional step method for two-dimensional Burgers equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
12	Fractional step method for three-dimensional heat equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW
13	Numerical solution of the Navier-Stokes equation	6	Basic [1]-[3] Supplementary [1][2]	Submission of IHW

7. Student performance evaluation system for the course

Period	Assignments	Number of points	Total
1st attestation	**Class work:** Regular attendance\Active participation **Student Independent Study:** Individual Home Work # 1 Individual Home Work # 2 Individual Home Work # 3 Individual Home Work # 4 Individual Home Work # 5 Individual Home Work # 6 Individual Home Work # 7 **Mid term**	**14** 14 **70** 10 10 10 10 10 10 10 **16**	100
2nd attestation	**Class work:** Regular attendance\Active participation **Student Independent Study:** Individual Home Work # 8 Individual Home Work # 9 Individual Home Work # 10 Individual Home Work # 11 Individual Home Work # 12 Individual Home Work # 13 **End of term**	**12** 12 **70** 5 5 20 5 5 30 **18**	100
Final exam	**Exam**	**100**	100
Total	**0,3*1stAtt+0,3*2ndAtt+0,4*Final**		**100**

*If the number of absences exceeds 20%, student will be automatically scheduled for a Retake (summer semester)

Achievement level as per course curriculum shall be assessed according to the evaluation chart adopted by the academic credit system:

Letter Grade	Numerical	Percentage	Grade according to the

	equivalent		traditional system
A	4,0	95-100	Excellent
A-	3,67	90-94	
B+	3,33	85-89	Good
B	3,0	80-84	
B-	2,67	75-79	
C+	2,33	70-74	Satisfactory
C	2,0	65-69	
C-	1,67	60-64	
D+	1,33	55-59	
D	1,0	50-54	
F	0	0-49	Fail

8. METHODOLOGICAL GUIDELINES

Assessment is administered continuously throughout the course. The students are rated against their performance in **continuous rating** administered throughout the semester (credited 60%) and **summative rating** done during the examination session(credited 40%), total **100%.Continuous rating** is students' on-going performance in class and independent work. Class work is assessed for attendance and active participation (problem solving).

Teaching methodology

Theory classes:

- lectures developing the theoretical aspects of the subject
- practical classes aimed at applying theory to problems.

Workshop classes:

- practical classes in which students solve problems in groups or individually.

SIS (Student Independent Study) comprises topics related problems to be done by students independently and checked in class.

TSIS (Teacher Supervised Student Independent Study) comprises individual homework assignments to be done by students independently and checked by teacher.

Mid-term examination is held in the 8th week of the semester and includes topics 1-7 of the course. **End-of-term** examination is held in the last week of the semester and includes topics 8-15 of the course.

Final examinationis a paper-basedexam thatconsists of multiple questions covering all topics of the course.