Kazakh-British Technical University
School of Applied Mathematics

Approved by
Dean of School of Applied Mathematics
_______ Artem V. Sinitsa
On 11.01.2024, protocol № 10

SCHOOL OF APPLIED MATHEMATICS
ҚАЗАҚ-БРИТАН ТЕХНИКАЛЫҚ УНИВЕРСИТЕТІ
КАЗАХСТАНСКО-БРИТАНСКИЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ
KAZAKH-BRITISH TECHNICAL UNIVERSITY
АЛМАТЫ

SYLLABUS
Discipline: **Fundamentals of mathematical and computer modeling of natural-physical processes**
Number of credits: **3 credits (2/1/0)**
Terms: **Spring 2024**
Name/Initials of the teacher: Alibek Issakhov

Information about the teacher	Time and place		Contact information	
	Room	Office hours (TSIS)	Tel.:	e-mail
PhD, professor	Round Hall	314		Alibek.issakhov@gmail.com

Pre-requisition: programming. Operation systems. Information technology.

Goals and Objectives:

Where does the course fit in your curriculum?

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.

Program Objectives

- 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.

1. know

- Differential Equations
- equations of mathematical physics
- Numerical Methods

• programming languages C / C + + or Fortran
• mathematical analysis
• fundamentals of mathematical modeling

2 . be able to
• the choice and use of information technology for applications;
• ability to work with a computer and the use of language programming
• ability to deter a rational solution to the problem
• the ability to use scientific , reference, methodological literature on the subject

3 . skills
• 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

Knowledge Areas that contain topics and learning outcomes covered in the course

Knowledge Area	Hours of Coverage (1h=50min)
Mathematical and computer modelling of physical processes	45=3 h/w * 15 weeks

Body of Knowledge coverage

KA	Knowledge Unit	Topic Covered	Acad. Hours
IPP	Introduction to the subject of mathematical and computer modeling of physical processes.	Introduction to the subject of mathematical and computer modeling of physical processes. Principles of construction of mathematical and computer modeling of physical processes.	**2**
IPP	Tridiagonal matrix method	Tridiagonal matrix method	
IPP	Simple iteration method for the heat equation. Stability analysis.	Simple iteration method for the heat equation. Stability analysis.	**2**

IPP	Five-diagonal matrix method	Five-diagonal matrix method for Poisson equation	2
IPP	Compact scheme. The first scheme against the flow. The second scheme against the flow.	Compact scheme for transport equation. The first scheme against the flow. The second scheme against the flow.	2
IPP	Tridiagonal matrix method. Jacobi, Seidel and over relaxation methods.	Tridiagonal matrix method. Jacobi, Seidel and over relaxation methods for Poisson equation.	2
IPP	The fractional steps method (FSM) for the two-dimensional heat equation. Alternating direction method for the two-dimensional heat equation.	The fractional steps method (FSM) for the two-dimensional heat equation. Alternating direction method for the two-dimensional heat equation.	2
IPP	The fractional steps method (FSM) for the three-dimensional heat equation. Alternating direction method for the three-dimensional heat equation.	The fractional steps method (FSM) for the three-dimensional heat equation. Alternating direction method for the three-dimensional heat equation.	2
IPP	Fourier method for three-dimensional Poisson equation.	Fourier method for three-dimensional Poisson equation.	2
IPP	Mathematical modelling of atmospheric processes	Basic principles of constructing of mathematical and computer modeling of the atmospheric processes. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	2

IPP	Mathematical modelling of ocean pollution	Basic principles of constructing of mathematical and computer modeling of the process. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	**2**
IPP	Mathematical modeling of natural convection processes.	Basic principles of constructing of mathematical and computer modeling of the natural convection processes. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	**2**
IPP	Mathematical modeling of internal flows	Basic principles of constructing of mathematical and computer modeling of the internal flows. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	**2**
IPP	Mathematical modeling of the flow around technogenic obstacles by the wind currents	Basic principles of constructing of mathematical and computer modeling of the flow around technogenic obstacles by the wind currents. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	**2**
IPP	Mathematical modeling of the flow separation in backward-facing step	Basic principles of constructing of mathematical and computer modeling of the flow separation in backward-facing step. Graphical interpretation of physical process. Numerical algorithm. Some simulation results.	**2**
IPP	Turbulent flow. Reynolds equation	Classification of flow. Reynolds equation.	**2**

Course Structure:

Total: 30 hours (lect) +15 hours (pract) = 45 hours

References

Basic:

1. Жумагулов Б.Т., Абдибеков У.С., Исахов А.А. Основы математического и компьютерного моделирования естественно-физических процессов. Алматы, «Қаза университеті», 2014. –208 с.
2. Исахов А.А. Практикум по математическому и компьютерному моделированию физических процессов. – Алматы: Қазақ университеті, 2015;

3. Марчук Г.И. Математическое моделирование в проблеме окружающей среды. –М.: Наука, 1982. –320 с.

4. Яненко Н.Н. Метод дробных шагов решения многомерных задач математической физики. –Новосибирск: Наука, 1967. – 196 с.

5. Флетчер К. Вычислительные методы в динамике жидкости. - М.: Мир, 991. – Т. 2 – 552 с.

6. Роуч П. Вычислительная гидродинамика. М.: Мир, 1980. - 616 с.

7. Пейре Р., Тейлор Т.Д. Вычислительные методы в задачах механики жидкости. –Л.: Гидрометеоиздат, 1986. - 352 с.

8. Самарский А.А. Теория разностных схем. –М.: Наука, 1989. – 616 с.

9. Иевлев В.М. Численное моделирование турбулентных течений. М.:Наука, 1990. - 273 с.

10. Lumley J.L. Computational modeling of turbulent flows // Adv. Appl. Mech. -1978. - Vol 18. -P.123-176.

11. Hanjalic K., Launder B.E. A Reynolds stress model of turbulence and its application to thin shear flows // J. Fluid Mech. -1972.-Vol. 52, № 4. P.609 - 638.

12. Курбацкий А.Ф. Моделирование нелокального турбулентного переноса импульса и тепла. - Новосибирск: Наука, 1988. - 240 с.

13. Монин А.С., Яглом А.М. Статистическая гидромеханика. – М.:Наука,1965. - Ч. 2 - 686 с.

14. Хинце И.О. Турбулентность. М.:Физматгиз, 1963. - 680 с.

15. Турбулентность. Принципы и применения. - М.: Мир, 1980. - 535 с.

Бэтчелор Дж. Теория однородной турбулентности. - М.: ИЛ., 1955. - 245с.

The form the schedule of performance and delivery of works

№	Type of evaluation	Week																Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-17	
1	Quizzes								*							*		20
2	SIS: homework	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		40
3	Final exam																*	40
	Total																	100

V. Evaluation System:

Grade in Letter	Grade in Number (GPA)	Grade in percentage %	Grade in traditional system
A	4	95-100	"Excellent"
A-	3,67	91-94	
B+	3,33	86-90	"Good"
B	3	81-85	
B-	2,67	76-80	
C+	2,33	71-75	"Satisfactory"

C	2	66-70	
C-	1,67	61-65	
D+	1,33	56-60	
D	1	51-55	
F	0	< 50	"Fail" (no-go grade)
I	0	0	"Incomplete Discipline"
W	0	0	"Withdraw"
AW	0	0	"Academic Withdraw"
AU	0	0	"Attend Discipline"
P/NP Pass / No Pass	-	65-100	"Pass/ No Pass"

Grading Policy:
During semester percentage – 60.
Final examination percentage – 40.
If a student has during semester percentage <30 or final examination percentage <20, then the final result is "F" even if the summer percentage is ≥ 50.

Additional remarks:
- Attendance (always be in time on lectures)
- Read main and additional materials
- Do home work

Grading Policy:
KBTU Standard grading policy is used.

*PhD, Professor, Alibek A.Issakhov*________