Министерство науки и высшего образования Российской Федерации
НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ (НИ ТГУ)

Механико-математический факультет

УТВЕРЖДАЮ:
Декан
_____Л. В.Гензе
«30» 06 20 22 г.

Рабочая программа дисциплины

Методы параллельных вычислений

по направлению подготовки

01.04.01 Математика

Направленность (профиль) подготовки :
Математический анализ и моделирование (Mathematical Analysis and Modelling)

Форма обучения
Очная

Квалификация
Магистр

Год приема
2022

Код дисциплины в учебном плане: Б1.В.3.ДВ.03.02

СОГЛАСОВАНО:
Руководитель ОП
_____А.В.Старченко

Председатель УМК
_____Е.А.Тарасов

Томск – 2022

Authors:
Professor, Doctor, Alexander Starchenko
Assistant professor, PhD, Eugeni Danilkin

Reviewer:
Bertsun Vladimir Ncholaevich, Assistant Professor, PhD, FMM TSU

Course curriculum « Parallel Computing Methods» create in accord with ES (Educational Standard) NR TSU:

Educational Standard NR TSU majoring in 01.04.01 Mathematics (Approved by Academic Council NR TSU, record of proceedings 29.12.2021 №10)

Course curriculum approved by academic and methodological commission FMM
Record of proceedings 30.01.2020 №1

1. Course Aims

The main goal of the discipline "Methods of parallel computations" is to get an idea of the parallel implementation of algorithms for the numerical solution of the Cauchy problem and boundary value problems on modern multiprocessing computers with distributed memory.

2. Course place and impact in the curriculum

The discipline belongs to the variable disciplines of the professional cycle of Block 1 "Disciplines/modules".

Prerequisites of the discipline: Mathematical analysis, Differential equations, Numerical methods, Computer Science, Programming in C++.

Post-requirements of the discipline: research work, execution and defense of the final qualifying work

3. Competencies and learning outcomes.

Table 1

Competence	Competence indicator	Learning outcomes
PC 1: - Is able to independently solve research tasks within the framework of the implementation of a scientific (scientific-technical, innovative) project	IPC 1.1: - Conducts research aimed at solving individual research tasks	LO-1: Has the skills to work with professional literature. Is able to collect, process, analyze and systematize scientific and methodological information on the topic. He is able to solve computational and theoretical problems in the field of parallel computing methods.

4. Course structure and content

4.1. Course structure and types of learning activities

The total labor intensity of the discipline is 6 credits, 216 hours.

Table 2

Type of learning activities	Hours	
Total labor intensity	2 semester	total
Contact work:	71,5	67,2
Lectures (L):	32	32
Practical exercises (PE)	32	32
Group consultations	3,2	3,2
Interim certification	4,3	4,3
Independent work of the student:	121,8	121,8
- study of educational material, publications on the subject of the discipline	56	56
- performing individual tasks	56	56
- writing a report on completed tasks	9,8	9,8
- preparation for the exam	22,7	22,7
Type of intermediate certification	**Total exam**	

4.2. Course content

Таблица 3

N	Chapters and topics	Type of learning activities	Semester	Hours	Learning outcomes
	Section 1. Solution of ODE systems	L, PE, IW	2	L-16, PE-16, IW-60,9	
1.1	Parallel algorithms for solving the Cauchy problem for a system of ordinary differential equations	L	2	4	LO-1
1.2	The method of successive Picard approximations	L	2	4	LO-1
1.3	Параллельная реализация метода Рунге-Кутты	L	2	4	LO-1
1.4	Multistep Adams methods. Predictor-corrector scheme	L	2	4	LO-1
1.5	Implementation of Picard and Adams methods for solving a system of ordinary differential equations (laboratory 1)	PE	2	16	LO-1
1.6	Preparation of a report on the first laboratory work.	IW	2	4,9	LO -1
1.7	Solution of the ODE problem (laboratory 1)	IW	2	56	LO-1
	Section 2. Solving boundary value problems for partial differential equations	L, PE, IW	2	L-16, PE-16, IW-60,9	
2.1	Solving boundary value problems for partial differential equations	L	2	4	LO-1
2.2	Parallel implementation of iterative methods for solving system of linear equations: Jacobi, Seidel, upper relaxation	L	2	4	LO-1
2.3	Parallel algorithms for solving problems of non-stationary thermal conductivity using explicit and non-explicit difference schemes	L	2	8	LO-1
2.4	Solution of the Dirichlet problem (laboratory 2)	PE	2	8	LO-1
2.5	Solution of the Dirichle problem (laboratory 2)	IW	2	28	LO-1
2.5	Solution of the heat equation problem (laboratory 3)	PE	2	8	LO-1
2.5	Solution of the heat equation problem (laboratory 3)	IW	2	28	LO-1
2.5	Preparation of a report on the second and the third laboratory work.	IW	2	4,9	LO -1
	Section 3. Consultation				
4.1	Consultations		2	3,2	LO-1

	Section 4. Interim attestation				
5.1	Exam preparation	IW	2	22,7	LO-1
5.2	The examination in the discipline	Final exam	2	4,3	LO-1

5. Education technologies, methodical, resource and information support for course realization

During the implementation of the discipline, classical educational technologies are used – practical exercises; independent study of recommended literature and gradual completion of individual tasks; intermediate certification in the form of verification of individual tasks. Independent work includes: theoretical mastering of the lecture course, practical performance of tasks and laboratory work, preparation for the test. To perform independent work, access to information resources of the course is provided:
- lecture materials;
- textbook "Methods of parallel computing";
- textbook "Workshop on parallel computing methods";
- a massive open online course "Introduction to parallel programming using OpenMP and MPI";
- a list of questions for self-examination of knowledge and preparation for the exam.
- a list of references, including textbooks and books on the subjects studied in the course.

All laboratory work and individual tasks are selected in such a way as to maximally stimulate the psychological attitude of mathematics students to form a connection between mathematical theory and its practical application. The report on each laboratory work includes a theoretical part, a complete practical task and an analysis of the results obtained.

5.1. Course literature

a) Primary course literature.

1. Starchenko A.V., Bertzun V.N. Parallel computing methods; Tomsk:Tomsk university, 2013. – 224 p. http://math.tsu.ru/sites/default/files/mmf2/e-resources/parallel%20comp%20meth.pdf
2. Pactice in parallel computing methods: [textbook] / A.V. Starchenko, E.A. Danilkin, V.I. Laeva, S.A. Prokhanov – M. : Moscow state university, 2010. – 199 p. – URL: http://vital.lib.tsu.ru/vital/access/manager/Repository/vtls:000421177
3. Gergel V.P. High performance computations on multiprocessor multicore computers. Nizhni Novgorod – M. : Fizmatlit, 2010. – 539 p.
4. Linev A.V. Parallel programming technologies for processors of new architectures – M. : Moscow State University, 2010. – 148 p.
5. High performance computing on custers. – Tomsk: Tomsk University, 2008. – 198 p. http://math.tsu.ru/sites/default/files/mmf2/e-resources/parallel.pdf

б) Additional course literature.

1. Hockney, Jesshope. Parallel computers. M.: Radio and Communications, 1986.
2. Ortega J. Introduction to parallel and vector methods for solving linear systems. Moscow: Mir, 1991.
3. Voevodin V.V., Voevodin V. V. Parallel computing. -St. Petersburg: BHV -Petersburg, 2002. - 608 p.

5.2. Databases and information and reference systems

- http://parallel.ru/
- http://www.netlib.org/blas/
- https://software.intel.com/en-us/intel-mkl

- Massive open online course "Introduction to parallel programming using OpenMP and MPI" https://www.coursera.org/learn/parallelnoye-programmirovaniye
- https://github.com/OpenACC/openacc-training-materials

5.3. Software list

1) operational system Windows 10 https://www.microsoft.com/ru-ru/software-download/windows10
2) putty (distributive putty) https://www.putty.org/
3) winscp (distributive winscp) https://winscp.net/eng/download.php

5.4. Education and technical equipment

For practical exercises work and independent work, the classrooms of the FMM educational and computing laboratory and the Cyberia computing cluster of TSU are used. When performing individual tasks, independent work and practical exercises, free and licensed software is used:

- Microsoft Office 2010 office suite (reporting);
- putty (a program for work on a computing cluster).

6. Course guideline for students

For the successful development of the material, students need to attend classes, and during independent work, use the main and additional literature, databases and information and reference systems that are presented in the list of references. Independent work of students consists of: repeating the material from practical classes and self-study of additional questions, a deeper analysis of the topic with the help of literature; in performing individual tasks.

Independent work, depending on the topic, may consist of one or more parts: work with literary sources, which is checked during testing; the software part is writing programs implementing parallel algorithms for solving tasks in the C/C++ programming language. When performing tasks of independent work, students will have to: collect and study information; analyze, systematize and transform information; display information in the necessary form; consult a teacher.

7. Teaching staff

Starchenko Alexander Vasilievich, professor, doctor of physical and mathematical sciences.
Danilkin Evgeni Alexandrovich, PhD, assistant professor.

8. Language of instruction

English