COURSE SPECIFICATION FORM,
approved by the Academic Council 17.06.2015 (#39)

SECTION A: DEFINITIVE

1.	**General course information**		
1.1	School: Science and Technology	1.6	Credits (ECTS): 6
1.2	Course Title: Parallel Systems and GPU Programming	1.7	Course Code: CSCI 523
1.3	Pre-requisites: *CSCI 332 Operating Systems (C and above)*	1.8	Effective from: *Fall 2018*
1.4	Co-requisites: none		
1.5	<u>Computer Science</u> ☐ Core ☒ Elective Programs: *MSc Data Science* *MSc Computer Science*		

2.	**Course description (max.150 words)**

This course is intended for master's students interested in the efficient use of modern parallel systems. Topics such as parallel computer architecture, programming models, memory hierarchy, parallel program design and parallel programming tools for multi-core systems and general-purpose graphics processing units (GPGPUs) will be covered. This comprehensive overview will equip students with a broad understanding of the key approaches in heterogeneous programming. Students will engage in practical, hands-on projects utilizing real-world scientific models to tackle contemporary challenges and applications, including physics, chemistry, biology and trustworthy machine learning. In the second part, the course covers the most common and current GPU parallel programming techniques with lab-based programming assignments using CUDA API with C/C++ and Python.

3.	**Summative assessment methods** (tick if applicable)**:**				
3.1	Examination	☐	3.5	Presentation	☐
3.2	Term paper	☐	3.6	Peer-assessment	☐
3.3	Project	☒	3.7	Essay	☐
3.4	Laboratory Practicum	☒	3.8	Other *(specify)*	____________

4.	**Course aims**

The aims of the course are:
1) to introduce students to concepts, hardware architectures and software programming models of parallel systems
2) to develop knowledge and understanding of parallel programming technologies
3) to develop hands-on experience skills in designing and implementing simple parallel programs
4) to develop knowledge and understanding of running programs on GPU
5) to ensure students can apply the learned methodologies to tackle contemporary challenges in science fields

6) to promote teamwork and collaborative problem solving, preparing students for interdisciplinary work in professional or research settings.

5. Course learning outcomes (CLOs)

By the end of the course the student will be expected to be able:
1) Define concepts related to CPU and GPU hardware architectures from mobile multi-core to server/cluster many-core parallel systems.
2) Articulate the differences of diverse parallel systems with the connection of parallel programming tools/APIs
3) Critically assess the performance of various CUDA applications, utilizing both quantitative metrics and qualitative insights, to identify the bottlenecks;
4) Design and implement parallel programs using the parallel programming techniques and CUDA
5) Integrate current research findings, methodologies, and advancements into heterogeneous computing
6) Solve parallel programming problems using C++ multithreading

CLO ref #	Program Learning Outcome(s) to which CLO is linked
1, 2	1, 2
3, 4	1, 2, 6

Program Learning Outcomes (PLOs) – ABET Student Outcomes for CS Programs

Upon the completion of the BSc in Computer Science program, students should be able to:

PLO 1: Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.

PLO 2: Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.

PLO 3: Communicate effectively in a variety of professional contexts.

PLO 4: Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.

PLO 5: Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

PLO 6: Apply computer science theory and software development fundamentals to produce computing-based solutions.

PLO 7: Demonstrate the ability to explain scientific concepts and research findings, using various modalities of communication, with particular emphasis on tertiary education instruction.

Mapping of the eight NU graduate attributes to the Program Learning Outcomes (PLOs)

NU Graduate Attributes	**Program Learning Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
1. Possess an in-depth and sophisticated understanding of their domain of study.	X	X				X
2. Be intellectually agile, curious, creative and open-minded	X	X				X
3. Be thoughtful decision makers who know how to involve others	X			X	X	
4. Be entrepreneurial, self-propelling and able to create new opportunities.	X		X	X		X
5. Be fluent and nuanced communicator across languages and cultures			X		X	
6. Be cultured and tolerant citizen of the world			X	X		
7. Demonstrate personal integrity				X		
8. Be prepared to take a leading role in the development of their country	X		X	X		X

SECTION B: NON-DEFINITIVE
Course Syllabus
Details of teaching, learning and assessment

6.	**Detailed course information**		
6.1	Academic Year: 2025-26	6.3	Schedule (class days, time): Tu, Th 15:00 ~ 16:15 pm
6.2	Semester: Spring 2026	6.4	Location (building, room): 7.522

7. Course leader and teaching staff

Position	**Name**	**Office #**	**Contact information**	**Office hours**
Course Leader(s)	Talgat Manglayev	7e428	talgat.manglayev@nu.edu.kz	TBD
Course Instructor(s)	Talgat Manglayev	7e428	talgat.manglayev@nu.edu.kz	TBD
Teaching Assistant(s)				TBD

8. Course Outline

Session	**Date** (tentative)	**Topics and Assignments**	**Course Aims** (ref. # only, see item 4)	**CLOs**
Week 1		Course Overview. Introduction to parallel systems. Introduction to parallel algorithms and concurrency using C++. Fork join Algorithm.	1, 2	1, 2

Week 2		Introduction to parallel algorithms and concurrency using C++. Thread states. Mutex. Atomicity. Producer Consumer Relationship.	1, 2, 3	2, 3, 5
Week 3	Quiz 1 Lab 1	Introduction to parallel algorithms and concurrency using C++. Liveness problems: deadlock, livelock and starvation.	2, 3	2, 3, 5
Week 4		Fundamentals of accelerated computing with CUDA C/C++.	2, 3, 4	2, 3, 4
Week 5		Optimize CUDA programs using Nsight profiling tools.	2, 3, 4	2, 3, 4, 5
Week 6	Lab 2	Accelerate CUDA C++ applications using concurrent streams.	2, 3, 4	1, 2, 3, 4
Week 7	Midterm 1 Quiz 2	CUDA C++ features.	2, 3, 4	1, 2, 3, 4, 5
Week 9		Fundamentals of accelerated computing with CUDA python. Introduction to CUDA with Numba.	2, 3, 4	1, 2, 3, 4
Week 10		Fundamentals of accelerated computing with CUDA python. Custom CUDA Kernels in Python with Numba. . Effective Use of the Memory Subsystem.	2, 3, 4	1, 2, 3, 4
Week 11	Quiz 3, Lab 3	Fundamentals of Accelerated Data Science.	2, 3, 4	1, 2, 3, 4
Week 12		Fundamentals of Accelerated Data Science.	2, 3, 4	1, 2, 3, 4
Week 13	Lab 4	Getting Started with Deep Learning with Python calling CUDA functions.	2, 3, 4	1, 2, 3, 4
Week 14		Reduction algorithm implementation variations using CUDA C/C++.	2, 3, 4	1, 2, 3, 4
Week 15	Quiz 4, Midterm 2	Research issues on recent parallel systems. Summary and Course Review.	1, 2, 3, 4	1, 2, 3, 4

9.	**Learning and Teaching Methods**
1	Lecture-demonstration by teacher
2	Formal face-to-face lectures and office hours
3	Group/pair problem solving in class and in labs
4	Students presenting solutions to the class
5	Lab-based programming assignments to support lecture sections and provide practical hands-on experience with parallel programming techniques

10. Summative Assessments (tentative)

#	**Activity**	**Date** (tentative)	**Weighting (%)**	**CLOs**
	Homework and Classwork		30 %	1, 2, 3, 4, 5, 6
	Midterm 1 and Midterm 2		40 %	1, 2, 3, 4, 5, 6
	Quiz x4		30 %	1, 2, 3, 4, 5, 6

11. Grading

Letter Grade	Percent range	Grade description (where applicable)
A	95-100	See Section 6 of "Academic Policies and Procedures for Undergraduate Programs" (available at https://registrar.nu.edu.kz/policies-and-procedures)
A-	90-94.9	
B+	85-89.9	
B	80-84.9	
B-	75-79.9	
C+	70-74.9	
C	65-69.9	
C-	60-64.9	
D+	55-59.9	
D	50-54.9	
F	0-49.9	

12. Learning resources (use a full citation and where the texts/materials can be accessed)

E-resources, including, but not limited to: databases, animations, simulations, professional blogs, websites, other e-reference materials (e.g. video, audio, digests)	CUDA C Programming Guide (web and pdf versions available): https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html
E-textbooks	N/A
Laboratory physical resources	Labs will be conducted in appropriate computer labs (e.g., 7-422, 7-522) with required software installed
Special software programs	C++ STD17, and Nvidia CUDA SDK on Linux, Text editors
Journals (inc. e-journals)	Blelloch, G.E., 1996. Programming parallel algorithms. *Communications of the ACM*, *39*(3), pp.85-97. Other publications.
Textbooks	Computer Organization and Design 4th Edition (Ch. 7) by John L. Hennessy and David A. Patterson, MK Publications; Computer Architecture: A Quantitative Approach 5th Edition (Ch. 3 and Ch. 4) by John L. Hennessy and David A. Patterson, MK; Sanders, Jason, Edward Kandrot, and Jack Dongarra. *CUDA by Example*. Upper Saddle River, N.J: Addison-Wesley, 2011. Print.; Harvey Deitel, and Paul J. Deitel. C++20 for Programmers: An Object's-Natural Approach, 3rd Edition, 2022; Paul J. Deitel. C++20 Fundamentals, 3rd Edition. 2024; Programming Massively Parallel Processors: A Hands-on Approach, 3rd Edition, Kirk, DB ; Hwu, WMW, 3rd Edition

13. Course expectations

ATTENDANCE

As per university policy, all students are expected to attend class, and are required to be present at the beginning of the semester, and to remain until the semester is completed. Students who do not attend the first two weeks of class can be dropped from the course. If your overall attendance starting from week 8 is lower than 50% you will be dropped from the course. Though attendance is not listed as a separate component of your final grade, you cannot get credit for lab exercises if you are not physically there. You also must be physically present to take the quizzes during the scheduled times.

ELECTRONIC RESOURCES

Students will have access to our hybrid computer labs, which are designed to accommodate the full range of course activities. However, for convenience, we generally encourage students to bring and use their own laptops, with the proper software installed. Text editors, web browsers, and Excel will be used during the course. You are expected to check your Nazarbayev University e-mail and course Moodle page on a daily basis for updates and announcements about the course. Not checking your e-mail or Moodle is not an excuse for missing an announcement.

LAB SUBMISSION POLICY

You will also be required to use Moodle to submit your exercises and assignments when directed. These need to be submitted at the time and date specified by your instructors. If you are having problems with Moodle, and you need to submit your lab, you must e-mail your submission to both your lab instructor and primary TA for your section before the given deadline. Any solutions submitted after the deadline are subject to a 100% penalty.

CLASSROOM BEHAVIOR

You are expected to act respectfully towards your fellow classmates, TAs, and instructors inside and outside of the classroom. We have a limited amount of space and computers, and so be mindful about not disrupting/annoying others. Talking on your phone, texting, chatting online, browsing VK or other social media sites, and talking excessively with your neighbors about non-class related stuff in the classroom or lab are just a few examples of behavior that is not acceptable. Acts of harassment or intimidation towards classmates, TAs, instructors, other students, staff, or anybody else will not be tolerated, and will result in a meeting with the Dean.

If you disagree with a grade, you may bring up the issue politely with your instructor. However, persistent pestering and arguing about a grade once the matter is deemed settled by the instructor constitutes harassment, and will be reported. The proper approach to dispute a grade is to bring the matter to the attention of the Vice-Dean of Academic Affairs instead.

14. Academic Integrity Statement

Nazarbayev University and The School of Science and Technology have established high standards for academic integrity, using an approach in which students are trained to produce original work according to professional standards, and to properly cite and reference the work of others when it is appropriate to do so.

The specific guidelines are published in the NU Student Handbook. In particular,

- The assignments in this class are designed to introduce important concepts and techniques, and enable you to explore the material independently so as to gain insight and comprehension of the subject. Doing the work is much more important than getting the right answer.
- The course is designed such that the new material presented each lesson builds on the skills developed in the preceding days; thus, any action that interferes with this process (e.g., skipping lesson exercises, copying) will seriously impede your progress.
- You are welcome—and encouraged—to talk through concepts and ideas with your fellow students and to study with them, but do not give or receive direct help from your classmates on graded exercises.
- Assignments should be completed individually. If you distribute or allow others to look at your work, even if you are not intending them to copy it, this is still considered academic misconduct.
- Even the appearance of cheating or inappropriate copying should be avoided.

- Students should be aware that the code submission process incorporates an automated plagiarism detector.
- You may only get help on graded work from designated people—the instructors, TAs, or lecturers for the course. If you are struggling with something, by all means, please seek help from them.

In the event that academic misconduct such as plagiarism or cheating is discovered, the student will receive no credit for the work, and the event reported to the Dean of your school. Egregious cases, or a second offense, can result in failure of the course and potential suspension or expulsion from the university. When a student suspects that another student has violated the academic honesty policy, a report should be made to the appropriate faculty member.

15. E-Learning

If the content of the course and instruction will be delivered (or partially delivered) via digital and online media, consult with the Head of Instructional Technology to complete this section and/or provide a separate document complementary to this Template.

16. Approval and review

Date of Approval:	**Minutes #:**	**Committee:**
Date(s) of Approved Change:	**Minutes #:**	**Committee:**