Program: **ECE** **Faculty/College**: **TGGS**
Degree Level: **Master**

Course 090245343

Parallel Computing

King Mongkut's University of Technology North Bangkok
The Sirindhorn International Thai-German Graduate School of Engineering
Electrical and Computer Engineering Program

Section 1: General Information

1. Course code and course title

090245343 Parallel Computing

2. Total credits

3 credits ☐ (2-2-5) ☑ (3-0-6) ☐ (3-0-9) ☐ (2-3-7)

3. Curriculum and course category:

Curriculum: *Master of Engineering in Electrical and Computer Engineering*

Course category: Required Courses

☐ Core Course ☐ Specific Core Course
☐ Industrial Internship ☐ Master Thesis

Elective Courses

☑ General Elective ☐ Specific Elective ☐ Other Elective

4. Course coordinator/ Instructors

Course Coordinator: _____

Instructor(s): Dr.rer.nat. Ekkapot Charoenwanit

5. Semester/ year of study

☐ Semester 1 (Aug. to Dec.) ☑ Semester 2 (Jan. to May) Academic Year: 2021.

Pre-requisite (if any)

☑ No ☐ Yes, please provide: .....

7. Co-requisites (if any)

☑ No ☐ Yes, please provide: .....

8. Venue of study

Lecture Day/Time: Fridays at 13.00-16.00

☑ On-site: Lecture Room No.:… TBA…… Floor:……TBA… …….
 TGGS, KMUTNB ☐ Faculty of Engineering, CU ☐ RWTH

☑ Online*: Teaching Media: ☑ Microsoft Teams ☐ Google Meet
☐ Zoom ☐ Webex
☐ Other (specify) ……..….

9. Information for quality assurance in education

This course shows evidence of:

- ☐ Development of implementation from previous practices, e.g. the improvement of class teaching, course content, content classification and methods used for learning assessment
- ☐ Involvement from professional bodies/ external agencies in instruction; thus Enhancing student academic and professional experiences
- ☑ Integration of research or creative activities with instruction; use of research-based learning management; knowledge management practices for learning improvement
- ☐ Integration of academic services and course implementation
- ☐ Combination of cultural heritage preservation efforts into instruction or student activities

10. Date of latest revision:

28th July 2021

Section 2: Course Description and Implementation

1. Course Description

Parallel computer architectures. Parallel performance analysis. Shared-memory programming paradigms. Processes and threads. Inter-process communication (IPC). Synchronization primitives. Multithreaded Programming with Pthreads and OpenMP. Distributed-memory programming paradigm. Message-Passing Interface (MPI). Point-to-Point communication. Collective communication. Synchronous and asynchronous operations. Parallel algorithms.

2. Number of hours per semester

Lecture	Practice	Self-study
45 hours/ semester (*3 hours/week**)	*30 hours* (*2 hours/week**)	*75 hours/ semester* (*5 hours/week**)

Remark: * *Based on 15 weeks of lecture*

Course Category: ☑ Lecture ☑ Practice ☑ Laboratory

Course Evaluation: ☑ A-F ☐ S/U ☐P

3. Number of hours per week for academic guidance to individual students

☑ 1. Giving academic advice (minimum number of hours per week) during the office hours

☐1 ☐2 ☑3 ☐ 4 ☐ 5 ☐ .....

Wednesdays at 13.00-16.00
The students can arrange to have office hours at times other than the specified office hours by telephone or email.

☑ 2. Adopting information technology-based academic advising

☑ Email:	ekkapot.c@tggs.kmutnb.ac.th
☑ Phone:	0971179626
	(Do not distribute this mobile number without permission.)
☑ Communication Apps:	Line ID:
	(Please notify the lecturer before adding him/her.)
☑ Meeting Online:	The platform will be informed to students upon request.
☐ Other (specify)	……...……

☐ 3. ……

4. Course Learning Outcomes (CLOs): Students should be able to:

CLO 1. Understand parallel computational models
CLO 2 Design and Analyze the performance of parallel algorithms
CLO 3. Understand the concepts of the two parallel programming paradigms, namely, distributed-memory and shared-memory programming paradigms.
CLO 4. Apply the knowledge of the two parallel programming paradigms, namely, distributed-memory and shared-memory programming paradigms to solve computational problems.

Remark: 1. Guidelines according to Bloom's Taxonomy is available at https://courses.dcs.wisc.edu/design-teaching/PlanDesign_Fall2016/2-Online-Course-Design/2_Learning-Objectives-Alignment/6_objectives_blooms-taxonomy.html

2. For the master level course, CLOs should be "apply" and "analyze" or possibly consider the doctoral CLOs "evaluate" and "create". "Remember" and "Understand" are for the undergraduate level courses, however, they can be implemented only at the beginning of the course.

3. CLOs can be defined as many as appropriate for the course.

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5. The mapping between Expected Learning Outcomes (ELOs) from the curriculum and Course Learning Outcomes (CLOs)

Table 5.1 ELOs-CLOs Consistency *(for a subject-specific course/ a specific curriculum)*

Remark: All ELOs and ELOs for the course (highlighted row) are as written in the Official Approved Curriculum.

ELOs/CLOs consistency	CLO 1	CLO 2	CLO 3	CLO 4
ELO1	✓	✓	✓	✓
ELO2	✓	✓	✓	✓
ELO3	✓	✓		
ELO4	✓	✓		
ELO5				
ELO6				
ELO7				
ELO8				
ELO9				
ELO10				

Table 5.2 Mapping desirable characteristics of KMUTNB graduates and CLOs *(for non-specific courses designed for various curriculums)*

Consistency between desirable characteristics of KMUTNB Graduates- CLOs	CLO 1	CLO 2	CLO 3	CLO 4
1. **Professional credentials with critical thinking skills**	✓	✓	✓	✓
2. **Integrity and social responsibility**				
3. **Innovative and technopreneur mindset**			✓	✓
4. **Global Competence**	✓	✓	✓	✓

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Section 3: Student Improvement in relation to Course Learning Outcomes (CLOs)

Organizing learning to develop skills/ knowledge; evaluation of CLOs in accordance with the ones identified in Section 2.4

Course Learning Outcomes (CLOs)	Teaching Methods compliant with CLOs	Evaluation Methods compliant with CLOs
CLO 1	• Lectures • Examples • In-class exercises • Individual assignments • Supervision Sessions	• Assignment evaluation • Assessment of assigned exercises • Exams****
CLO 2	• Lectures • Examples • In-class exercises • Individual assignments • Supervision Sessions	• Assignment evaluation • Assessment of assigned exercises • Exams****
CLO 3	• Lectures • Examples • In-class exercises • Individual assignments • Supervision Sessions	• Assignment evaluation • Assessment of assigned exercises • Exams ****
CLO 4	• Lectures • Examples • In-class exercises • Individual assignments • Supervision Sessions	• Assignment evaluation • Assessment of assigned exercises • Exams****

*Remark: * Lecture on the concept of the topic is introduced with basic or fundamental definitions, visualization, and correlations. For the complicated equation, the derivation from the basic laws can be shown to students. So, the students do not memorize the equations but understand the basic concept and basic equation. The lecturer will introduce the advanced and new concepts, technologies, and findings to students from publications such as journals and websites and from the research and industrial experiences.*

*** Active learning by asking questions related to the topic in the lecture and encouraging the students to respond to the questions. If the students cannot respond with answers, then the lecturer will give some guidance until the students can respond.*

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**** Quiz in the closed-book format on the basic concepts and equations with simple problem solving to evaluate their learning. The solution will be given to students after grading, so they can identify their mistakes and weakness.*

***** Exam on the basic concepts and equations with simple problem-solving in the closed-book format as a review, whereas the complicated/integrated problem solving will be worked in the open-book format.*

Section 4: Lesson Plan and Evaluation

1. **Lesson Plan**

Week	Topics/Details	CLOs	Hours	Learning and teaching activities; teaching media (if any)	Lecturer
1	Chapter 1: Parallel Computer Architectures and Performance Analysis	CLO 1 CLO 2	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 1	Ekkapot
2	Chapter 2: Processes and Threads, Synchronization Primitives: Spinlock, Mutex, Semaphore, Monitor, etc.	CLO 3	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 2	Ekkapot
3	Chapter 3: Parallel Programming with Pthreads: Thread Creation, Thread Join, Thread Destruction, Mutex, Condition Variable	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 3	Ekkapot
4	Chapter 4: Parallel Programming with Pthreads:	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples	Ekkapot

	Advanced Features: Thread-Local Storage (TLS), Thread Attributes, Mutex Attributes, Thread Cancellation, Cancellation Point, Thread Stack, Scheduling Policy, etc., Design Models for Multithreaded Programs			• In-class exercise • Assignment 4	
5	Chapter 5: Parallel Programming with OpenMP: Fork-Join Model, Parallel Region, Work-sharing Constructs, Loop Parallelization	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 5	Ekkapot
6	Chapter 6: Parallel Programming with OpenMP: Runtime, Synchronization Primitives, Critical Sections, Nested Parallelism	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 6	Ekkapot
7	Chapter 7: Parallel Programming with OpenMP: Tasked-Based Programming with OpenMP Tasking	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 7	Ekkapot
8	Chapter 8: Parallel Programming with OpenMP: Memory Consistency Issues in	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise	Ekkapot

	OpenMP, Flush Construct			• Assignment 8 •	
9	Midterm Exam	All CLOs	3.0	• Written Exam	Ekkapot
10	Chapter 9: Memory Consistency Models: Sequential Consistency, Relaxed Memory Models, Acquire and Release Semantics	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 9	Ekkapot
11	Chapter 10: C++ 11 Memory Model and Introduction to Lock-Free Programming	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 10	Ekkapot
12	Chapter 11: Parallel Programming with MPI: Message Passing Paradigm, Rank, Blocking and Non-Blocking Operations	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 11	Ekkapot
13	Chapter 12: Parallel Programming with MPI: Distributed-Memory Programming Model, Single Program Multiple Data (SPMD), Initialization and Finalization of an MPI Environment, General Structure of an MPI Program, Rank, Data Type Handle, Local and	All CLOs	3.0	• Lecture presentation slides • Q&A • Examples • In-class exercise • Assignment 12	Ekkapot

	Non-local Operations, Synchronous and Asynchronous Operations				
14	Chapter 13: Parallel Programming with MPI: Point-to-Point Communication, Send-Receive Operations, Message Matching Mechanism, Different Modes of Send and Receive Operations, Deadlock, Blocking and Non-Blocking Operations	All CLOs 5	3.0	• Lecture presentation slides • Discussion • Q&A • In-class exercise • Assignment 13	Ekkapot
15	Chapter 14: Parallel Programming with MPI: Type Signature and Type Map, Basic and Compound Datatypes	All CLOs	3.0	• Lecture presentation slides • Discussion • Q&A • In-class exercise • Assignment 14	Ekkapot
16	Chapter 15: Parallel Programming with MPI: Collective Communication: Reduction, Broadcast, Scatter, Gather, etc.,	All CLOs	3.0	• Lecture presentation slides • Discussion • Q&A • In-class exercise • Assignment 15	Ekkapot
17	Final Exam	All CLOs	3.0	• Written Exam	Ekkapot
		Total	51.0		

2. **Evaluation Plan** (**in accordance with OBE** 2 **mapping framework**)

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Course Learning Outcomes (CLOs)	Evaluation Methods	Week of Evaluation	Percentage of Evaluation
All CLOs	15 Assignments	1-8, 10-16	70%
All CLOs	2 Exams (Midterm: 15%, Final:15%)	9,17	30%

Section 5 Teaching/Learning Resources

Textbooks and materials

1. E. Charoenwanit. Parallel Computing (Presentation Slides)

2. Vipin Kumar, Ananth Grama, Anshul Gupta, and George Karypis. 1994. Introduction to parallel computing: design and analysis of algorithms. Benjamin-Cummings Publishing Co., Inc., USA.

3. Barbara Chapman, Gabriele Jost, and Ruud van der Pas. 2007. Using OpenMP: Portable Shared Memory Parallel Programming (Scientific and Engineering Computation). The MIT Press.

4. Peter S. Pacheco. 1996. Parallel programming with MPI. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.

5. Michael J. Quinn. 2003. Parallel Programming in C with MPI and OpenMP. McGraw-Hill Education Group.

6. Scott Meyers. 2014. Effective Modern C++: 42 Specific Ways to Improve Your Use of C++11 and C++14 (1st. ed.). O'Reilly Media, Inc.

7. Ken A. Berman and Jerome Paul. 1996. Fundamentals of Sequential and Parallel Algorithms (1st. ed.). PWS Publishing Co., USA.

Section 6 Course Evaluation and Improvement

1. **Course evaluation by students**

The students will have an opportunity to evaluate the effectiveness of the course in the form of paper-based surveys and group interviews at the end of each semester. The results of the survey and the interview including the grading will be reviewed by the curriculum committee to evaluate the course's effectiveness.

2. Strategies for assessing learning management

The students will have an opportunity to evaluate the teaching in the form of paper-based surveys and group interviews at the end of each semester. The results of the survey and the interview including the grading will be reviewed by the curriculum committee to evaluate the teaching. The lecturer will be informed of the evaluation for future improvements.

3. **Improvement schemes of course implementation**

The evaluation from the students including the grading will be submitted to the curriculum committee for reviewing and brainstorming to improve the teaching of each course. Comments and suggestions given by the curriculum committee will be informed to the responsible lecturer of each course.

4. **Verification of students' learning outcomes, referred to OBE 2 and 3**

The grading of this course will be evaluated and reviewed by the Department meeting and the TGGS executive board meeting in order to verify its appropriateness before the final approval.

5. Course review and improvement plans

The results of the grading evaluation and student evaluation will be submitted to the curriculum committee for reviewing and brainstorming to improve the effectiveness of the offered courses. Comments and suggestions will be informed to the responsible lecturer of each course.