

## School of Computing and Information Sciences

**Course Title:**  
Introduction to Parallel Computing

**Date:** 9/26/2019

**Course Number:** COP-4520

**Number of Credits:** 3

<b>Subject Area:</b> Programming	<b>Subject Area Coordinator:</b> Tim Downey  <b>email:</b> downeyt@cis.fiu.edu
<b>Catalog Description:</b> This course introduces the field of parallel computing. The students will be taught how to design efficient parallel programs and how to use parallel computing techniques to solve scientific problems.	
<b>Textbook:</b> Parallel Programming in C with MPI and OpenMP Michael J. Quinn McGraw Hill, 2004. ISBN: 0-07-282256-2	
<b>References:</b> An Intro to Parallel Computing, Design and Analysis of Algorithms, 2/e Ananth Grama, Vipin Kumar, Anshul Gupta, and George Karypis Addison-Wesley, 2003. ISBN 0-201-64865-2	
<b>Prerequisites Courses:</b> COP-3530 and (CDA-3102 or CDA-4101 or EEL-4709)	

Type: CS Elective (Systems group)

Prerequisites Topics:

- Programming experience in C or C++
- Basic knowledge of undergraduate level algorithms, data structures, and computer organization

Course Outcomes:

1. Be familiar with parallel algorithm design.
2. Be familiar with parallel performance analysis.
3. Master the MPI programming paradigm.
4. Be familiar with POSIX multi-threaded programming.
5. Be familiar with OpenMP programming.
6. Be exposed to parallel applications.

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## Introduction to Parallel Computing

### Outline

<b>Topic</b>	<b>Number of Lecture Hours</b>	<b>Outcome</b>
<ul style="list-style-type: none"><li>• Introduction to parallel computing<ul style="list-style-type: none"><li>○ Parallel computers</li><li>○ Parallel programming paradigms</li><li>○ Parallel applications</li></ul></li></ul>	7	1,6
<ul style="list-style-type: none"><li>• Principles of parallel algorithm design<ul style="list-style-type: none"><li>○ Task/channel model</li><li>○ Foster's design methodology</li></ul></li></ul>	3	1,3
<ul style="list-style-type: none"><li>• Analytical modeling of parallel algorithms<ul style="list-style-type: none"><li>○ Speedup and efficiency</li><li>○ Amdahl's Law</li><li>○ Gustafson-Barsis's Law</li><li>○ Karp-Flatt Metric</li><li>○ Isoefficiency metric</li></ul></li></ul>	5	1,2
<ul style="list-style-type: none"><li>• Parallel programming<ul style="list-style-type: none"><li>○ Basic communication operations</li><li>○ Message-Passing Interface (MPI)</li><li>○ Multi-threading</li><li>○ OpenMP</li></ul></li></ul>	6	3,4,5
<ul style="list-style-type: none"><li>• Parallel computing applications<ul style="list-style-type: none"><li>○ Floyd shortest-path algorithm</li><li>○ Dense matrix algorithms</li><li>○ System of linear equations</li><li>○ Documentation classification</li><li>○ Monte Carlo methods</li><li>○ Sorting</li><li>○ Finite difference methods</li><li>○ Fast Fourier Transformation</li></ul></li></ul>	15	3,6

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**Course Outcomes Emphasized in Laboratory Projects / Assignments**

	<b>Outcome</b>	<b>Number of Weeks</b>
1	Fundamentals of parallel computing Outcomes: 1	2
2	Collective operations in MPI Outcomes: 2,3,4	2
3	Parallel algorithm design and performance analysis Outcomes: 2,3	2
4	Implementation of Cannon's matrix multiplication algorithm in MPI Outcomes: 2,3,4	3
5	Parallel application: solving linear equations Outcomes: 2,6	2

**Oral and Written Communication**

No significant coverage

**Social and Ethical Implications of Computing Topics**

No significant coverage

**Approximate number of credit hours devoted to fundamental CS topics**

<b>Topic</b>	<b>Core Hours</b>	<b>Advanced Hours</b>
<b>Algorithms:</b>		<b>1.0</b>
<b>Software Design:</b>		<b>1.0</b>
<b>Computer Organization and Architecture:</b>		<b>0.25</b>
<b>Data Structures:</b>		<b>0.25</b>
<b>Concepts of Programming Languages</b>		<b>0.25</b>
<b>Other CS Topics:</b>		<b>0.25</b>

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**Theoretical Contents**

Topic	Class time
Performance analysis of parallel algorithms	5

**Problem Analysis Experiences**

1. 

Parallel computing applications and performance analysis of parallel solutions
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**Solution Design Experiences**

1. 

Parallel computing applications, including parallel shortest-path algorithm, sorting, matrix multiplication, linear equations, finite difference methods, FFT, etc.
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**The Coverage of Knowledge Units within Computer Science Body of Knowledge<sup>1</sup>**

Knowledge Unit	Topic	Lecture Hours
AL8	Advanced algorithm analysis; parallel algorithm performance analysis, including speedup, efficiency, Amdahl's law, Gustafson-Basis' Law, Karp-Flatt, and Isoefficiency metrics	5
AL11	Parallel algorithm design; parallel programming paradigms	3
OS3	Concurrency; mutual exclusion, process synchronization, parallel programming	3
SE3	Software tools and environments; MPI, OpenMP, and POSIX threads	6
CN4	High-performance computing; parallel applications.	19

<sup>1</sup>See <http://www.computer.org/education/cc2001/final/chapter05.htm> for a description of Computer Science Knowledge units