

### 4.1 ABOUT THE DEPARTMENT

The Department of Computer Science is one of eight departments in the College of Engineering (COE), University of the Philippines Diliman (UPD). The road to establishing the youngest department in COE started in the mid 1970's with the institution of the Master of Engineering in Computer Science (M. Eng. CS) program, a joint undertaking of the Department of Engineering Sciences (as the lead department), the Department of Electrical Engineering and the Department of Mathematics of the College of Science.

In the early 1980's, the M. Eng. CS program was suspended as the Bachelor in Computer Science (BCS) program was instituted. As with the master's program, the BCS program was also a joint undertaking of the ES, EE and Math departments. An initial batch of 35 shiftees from more than 200 applicants from various colleges in UPD were admitted into the program in the second semester of AY 1982-1983. Of the 35, 32 finished the course, 12 with Latin honors. In this first batch of Computer Science graduates was the 1986 Engineering class valedictorian.

In August 1988, the BOR approved the renaming of the ES department to 'Department of Engineering and Computer Sciences (ECS)' to reflect the expertise available in the department. Three years, later, in August 1991, the ECS department was split into two independent departments – taking ES back to its original name (Department of Engineering Sciences) and bringing to life the Department of Computer Science (DCS). The new department took the full responsibility of offering the BCS program, which was subsequently renamed Bachelor of Science in Computer Science (B.S. CS) program.

As of the end of the second semester of AY 2014-2015, the BCS/B.S. CS program has produced a total of 1164 graduates, 327 with Latin honors: 233 *cum laude*, 85 *magna cum laude* and 9 *summa cum laude*.

As one of the departments under the National Graduate School of Engineering (NGSE), the Department of Computer Science (DCS) offers graduate programs in Computer Science both at the masteral and doctorate levels. These programs aim to produce computer scientists who are adaptable to the fast-paced changes in the state-of-the-art of the discipline by grounding them on solid theoretical foundations, exposing them to current and emerging technologies related to computing, and honing their interpersonal, management and leadership skills.

The programs are crafted to provide the country with a continuous supply of academic researchers that will strengthen the research community in the field of computing and a pool of IT experts who have the leadership and relevant skills to be solution-providers in the industry.

The department maintains an atmosphere of collaborative scholarship among its seven research laboratories. It also provides its student researchers in the undergraduate and graduate level, both the resources and ambiance to pursue their scholarly endeavors, including office spaces and a graduate student lounge.

Its graduate faculty members are all Ph.D. holders in Computer Science and/or its allied fields such as pure and applied Mathematics, and Electrical Engineering, with training from outside of the country. Their research interests are broad with a lot of work done in collaboration with other academic local and international institutions.

Since its establishment in 1991, eight faculty members have served as DCS chair:

Prof. Evangel P. Quiwa  
(October 1991 – October 1995)

Prof. Ma. Veronica M. Tayag  
(November 1995 – April 1996)

Dr. Mark J. Encarnacion  
(May 1996 – March 2000)

Dr. Jaime D.L. Caro  
(April 2000 – September 2002)

Dr. Ronald M. Tungol  
(October 2002 – May 2005)

Dr. Cedric Angelo M. Festin  
(June 2005 – May 2008)

Dr. Jaime D.L. Caro  
(June 2008 – March 2011)

Dr. Adrian Roy L. Valdez  
(March 2011 – March 2013)

Dr. Cedric Angelo M. Festin  
(April 2013 – March 2014)

Dr. Prospero C. Naval, Jr.  
(April 2014 – present)

Initially located in the College of Engineering Building (Melchor Hall), the Department of Computer Science moved to its new home at the Engineering Library and Computer Science Building (UP Alumni Engineers Centennial Hall) on Velasquez Street, University of the Philippines Diliman campus, in January 2007. The UPAECH also houses the library collection of the Department and that of the Electrical and Electronics Engineering Institute.

### 4.2 VISION

The Department of Computer Science will be a world-class teaching and research institution in the field of Computer Science that serves the interests of the country.

### 4.3 MISSION

1. To produce socially-responsible graduates equipped with the knowledge and skills required for professional careers and advanced studies in computer science.
2. To advance the discipline of computing through internationally-recognized research and development.
3. To foster an environment that promotes academic excellence and professionalism.
4. To address the needs of education, government, industry and business through extension projects and continuing education programs.

### 4.4 UNDERGRADUATE PROGRAM

The Bachelor of Science in Computer Science (B.S. CS) program is designed to equip the student with knowledge of the fundamental concepts and a reasonable mastery of the basic tools and techniques in the following computing areas:

- Algorithms and data structures
- Programming languages
- Computer architecture
- Numerical and symbolic computation
- Operating systems
- Software methodology and engineering
- Database and information retrieval
- Artificial Intelligence

Graduates of the program are prepared to engage in the design and development of the following systems:

- Operating systems
- Intelligent systems
- Database systems
- Information systems
- Application systems
- Computer networks and distributed systems

The undergraduate program incorporates the core material which is universally accepted as common to Computer Science undergraduate programs (computer programming, computer organization, computer systems, data structures and algorithms, intelligent systems and programming languages). Underpinning

the software orientation of the program are the subjects on database systems, information system design, software engineering and special problems (primarily, software projects).

In cognizance of the key role of Mathematics in the various areas of Computer Science, the B.S. CS curriculum provides a broad foundation in various files of Mathematics – the Calculus, Statistics, Linear Algebra, Discrete Mathematics, Differential Equations, Numerical Methods and Automata Theory.

#### 4.4.1 Program Educational Objectives

The Department of Computer Science envisions its graduates to:

1. Actively contribute to the advancement of the field of computing by developing novel ideas to the discipline and/or expanding its applicative value to other knowledge domains, be it in the academic or industrial setting
2. Seek new knowledge thus increasing their stock and expanding their horizons towards improvement of the self and the society at large
3. Be versatile when working in areas where multidisciplinary and interdisciplinary collaboration are expected

#### 4.4.2 Program Outcomes

The UP Diliman Department of Computer Science produces graduates of the Bachelor of Science in Computer Science who possess the following qualities:

1. Fundamentally sound background in the theoretical and practical aspects of computer science
2. Adept in key areas of computing, particularly in algorithmic design and analysis, artificial intelligence, networking, security, modeling, and software engineering
3. Possess the ability to identify key components and processes of a problem and/or a need and produce effective and efficient solutions based on core concepts of computing and software development and engineering
4. Be knowledgeable of general ethical principles and ethical codes of computer science and software engineering, as well as to apply them responsibly in the social context of computing
5. Possess good oral and written communication skills and is able to read and write technical papers and documentation and present results

6. Possess the ability to work within a group environment, both as a leader and as a team member
7. Able to conduct independent research and is driven to update skills and pursue professional growth through continuous learning

**4.5 GRADUATE PROGRAMS**

**Master of Science in Computer Science**

The Master of Science in Computer Science (M.S. CS) program aims to provide both breadth and depth of knowledge in the concepts and techniques related to the theory, design, implementation, and applications of computer systems.

There are two tracks for this program: the thesis option which requires 31 units of courses, seminars and research, and a successful defense of a master's thesis; and the non-thesis option which requires 37 units of courses and seminars, and passing a comprehensive examination.

Both tracks require some 13 units of core courses as follows:

One Theory Course	3 units
One System Course	3 units
One Theory or System Course	3 units
CS 298 Special Problem	3 units
CS 296 Seminar	1 unit

and other courses according to type as follows:

**Thesis Non-Thesis**

Specialization Courses	9 units	12 units
Computer Science Electives	3 units	
Electives	3 units	9 units
CS 300 Thesis	6 units	

**Doctor of Philosophy in Computer Science**

The Ph.D. in Computer Science Program aims to produce computer scientists who are armed with methods, tools and techniques from both theoretical and systems aspects of computing, and who can independently formulate computing problems and develop new and innovative technology as novel solutions to address these problems.

Requirements for the program include finishing 37 units of courses, seminars and research, two publications at least one of which is international, and a successful doctoral dissertation defense.

The 37-unit coursework is divided into 9 units of core courses, namely:

One Theory Course	3 units
One System Course	3 units
One Theory or System Course	3 units

and other courses according to type as follows:

Specialization Courses	9 units
Graduate Electives	6 units
CS 296 Graduate Seminar	1 unit
CS 400 Dissertation	12 units

**4.6 RESEARCH LABORATORIES**

**Algorithms and Complexity Laboratory**

Lab head: Dr. Henry N. Adorna

- Formal Models, Languages and Applications
- Natural Computing with P Systems and Quantum Algorithms
- Hard Combinatorial Problem
- BioInformatics
- Visualization and Implementations

**Computer Security Laboratory**

Lab head: Dr. Susan Pancho-Festin

- Intrusion Detection
- Secure Electronic Commerce
- Risk Analysis
- Security Policy Specification

**Computer Vision and Machine Intelligence Laboratory**

Lab head: Dr. Prospero C. Naval, Jr.

- Probabilistic Machine Learning
- Large Data Mining
- Evolutionary Computation
- Swarm Robotics and Computation
- Intelligent Interfaces for Human Computer Interaction
- Computational Modeling of Biological Systems
- Natural Language Processing for Philippine Languages

**Networks and Distributed Systems Laboratory**

Lab head: Dr. Cedric Angelo M. Festin

- Performance Evaluation of Computer Networks
- Network and Resource Management
- Network Pricing and Economics
- Real-Time and Multimedia Networks
- Distributed and Mobile Computing

**Scientific Computing Laboratory**

Lab head: Dr. Vena Pearl A. Boñolan and  
Dr. Adrian Roy L. Valdez

- Partial Differential Equations and Its Applications
- Stochastic Processes and Analysis
- Stochastic Partial Differential Equations
- Numerical Analysis
- Optimization and Control
- Modeling and Simulation
- Complex and Simulation
- Complex Systems
- Mathematical and Computational Finance
- Mathematical and Computational Biology

**Service Science and Software Engineering Laboratory**

Lab head: Dr. Jaime D.L. Caro

- Database and Software Management Systems and Frameworks
- Service Applications

**Web Science Laboratory**

Lab head: Prof. Rommel P. Feria

- Semantic Web
- Mobile Computing
- Social Computing
- Healthcare Informatics
- Computer Science and Education

**4.7 FACULTY AND STAFF**

**Department Chair**

**Dr. Prospero C. Naval, Jr.**

***Professor Emeritus***

**Evangel P. Quiwa**

M. Eng. Computer Science  
University of the Philippines Diliman, 1978  
*Data Structures, Numerical Methods*

***Professors***

**Henry N. Adorna**

Ph.D. Mathematics  
University of the Philippines Diliman, 2002  
*Automata Theory, Discrete Mathematics*

**Jaime D.L. Caro**

Ph.D. Mathematics  
University of the Philippines Diliman, 1996  
*Complexity Theory, Interconnection Network Theory*

**Cedric Angelo M. Festin**

Ph.D. Computer Science  
University College London, 2002  
*Computer and Communications Networking, Distributed Systems, Mobile Computing*

**Susan B. Pancho-Festin**

Ph.D. Computer Science  
University of Cambridge, 2004  
*Computer Security, Security Protocols Secure Software Engineering, Privacy*

**Prospero C. Naval, Jr.**

Ph.D. Electrical Engineering  
University of the Philippines Diliman, 2007  
*Machine Learning, Computer Vision, Data Mining*

***Associate Professor***

**Vena Pearl A. Boñolan**

Ph.D. Applied Mathematics  
Illinois Institute of Technology, 2005  
*Modeling and Simulation*

***Assistant Professors***

**Kelvin C. Buno**

M.S. Computer Science  
University of the Philippines Diliman, 2011  
*Algorithms, Membrane Computing*

**Francis George C. Cabarle**

Ph.D. Computer Science  
University of the Philippines Diliman, 2015  
*Membrane Computing, GPU Computing*

**Roy Vincent L. Canseco**

M.S. Electrical Engineering  
University of the Philippines Diliman, 2009  
*Computational Science, Business Informatics, Databases*

**Mario T. Carreon**

M.S. Computer Science  
University of the Philippines Diliman, 2006  
MPhil CS, University of Cambridge, 2014  
*Networking, Gaming, Computer Systems Human Computer Interaction, Computing for Disabled*

**Joseph Benjamin T. Del Mundo**

M.S. Computer Science  
University of the Philippines Diliman, 2015  
*Computer Security, Data Mining*

**Rommel P. Feria**

M.S. Information Systems  
University of Leeds, 1996  
*Health Informatics, Mobile and Wireless Computing*

## DEPARTMENT OF COMPUTER SCIENCE

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### **Ligaya Leah L. Figueroa**

M.S. Computer Science  
University of the Philippines Diliman, 2007  
*Spatial Information Systems*

### **Nestine Hope S. Hernandez**

M.S. Computer Science  
University of the Philippines Diliman, 2009  
*Algorithms and Complexity*

### **Carlo R. Raquel**

M.S. Computer Science  
University of the Philippines Diliman, 2005  
*Artificial Intelligence, Evolutionary Computation, Machine Learning*

### **Abigail R. Razon**

M.S. Computer Science  
University of the Philippines Diliman, 2010  
*Natural Language Processing*

### **Ma. Rowena C. Solamo**

M.S. Computer Science  
University of the Philippines Diliman, 2006  
*Software Engineering, Computer Security*

### **Jaymar B. Soriano**

M.S. Mathematics  
University of the Philippines Diliman, 2008  
*Complex Systems*

### **Wilson M. Tan**

M.S. Computer Science  
University of the Philippines Diliman, 2009  
*Networks and Distributed Systems*

### **Adrian Roy L. Valdez**

Ph.D. Mathematics  
University of the Philippines Diliman, 2007  
*Applications, Mathematical and Computational Finance, Modeling and Simulations, Optimization and Control*

### **Jan Michael C. Yap**

Ph.D. Computer Science  
University of the Philippines Diliman, 2014  
*Theory, Biological Systems*

### **Philip Christian C. Zuniga**

M.S. Mathematics  
University of the Philippines Diliman, 2007  
*Computer Security, Cryptography, Algorithm, Heuristic Methods*

### **Rose Ann Sale-Zuniga**

M.S. Computer Science  
University of the Philippines Diliman, 2014  
*Software Engineering, Computer Security*

## **Instructors**

### **Ada Angeli D. Cariaga**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Web Science, Game-Based Learning, Learning Analytics*

### **Kristofer E. delas Peñas**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Computer Vision, Artificial Intelligence*

### **Edgardo P. Felizmenio, Jr.**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Computer Security*

### **John Andreau V. Hernandez**

B.S. Computer Science  
University of the Philippines Diliman, 2011  
*Networks and Distributed Systems*

### **Marie Jo-anne M. Mendoza**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Computer Security*

### **Paul Rossener R. Regonia**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Artificial Intelligence*

### **Dustin Edric L. Ricio**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Scientific Computing*

### **Riza Rae A. Pineda**

M.S. Computer Science  
University of the Philippines Diliman (in progress)  
*Computer Vision, Artificial Intelligence*

## **Professorial Lecturer**

### **Pablo C. Manalastas**

Ph.D. Mathematics  
Ateneo De Manila University  
*Graph Theory, Numerical Methods, Operating System*

## **Senior Lecturers**

**Brian Kenneth De Jesus**, M.S. CS

**Roselyn S. Gabud**, M.S. CS

**Elson B. Manahan**, J.D.

**Anne Ivy G. Mirasol**, M.S. CS

## DEPARTMENT OF COMPUTER SCIENCE

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### ***Adjunct Professor***

**Eduardo Mendoza**  
Ph.D. Mathematics  
University of Bonn  
*Systems Biology, Algebra*

### ***Lecturers***

**Juan Felipe Coronel**, B.S. CS  
**Juvy Dela Rosa**, B.S. CS  
**Peter John Francisco**, B.S. CS

### ***Administrative Staff***

Grace T. Dumencel  
Judith G. Martinez  
Maximino A. Santos

## **CONTACT INFORMATION**

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4.8 UNDERGRADUATE PROGRAM CURRICULUM

BACHELOR OF SCIENCE IN COMPUTER SCIENCE, 2015 <sup>†</sup>

First Year							
First Semester	Lect hrs/wk	Lab (hrs/wk)	Units	Second Semester	Lect hrs/wk	Lab (hrs/wk)	Units
GE (AH 1) <sup>2</sup>	3	0	3	GE (SSP 2) Philo 1 (Philo Analysis)	3	0	3
GE (SSP 1)	3	0	3	GE (AH 2) <sup>2</sup>	3	0	3
GE (MST 1) <sup>3</sup>	3	0	3	GE (MST 2) <sup>3</sup>	3	0	3
Math 17 (Algebra & Trigonometry)	5	0	5	Math 53 (Elementary Analysis I)	5	0	5
CS 11 (Computer Programming I)	2	3	3	CS 12 (Computer Programming II)	2	3	3
PE <sup>4</sup> (Physical Education)			(2)	PE <sup>4</sup> (Physical Education)			(2)
	16	3	17		16	3	17
Second Year							
First Semester	Lect hrs/wk	Lab (hrs/wk)	Units	Second Semester	Lect hrs/wk	Lab (hrs/wk)	Units
GE (AH 3) Eng 10 (College English)	3	0	3	GE (AH 4) Fil 40 <sup>1</sup> (Wika, Kultura at Lip)	3	0	3
Math 54 (Elementary Analysis II)	5	0	5	GE (MST 3) <sup>3</sup>	3	0	3
CS 32 (Data Structures)	3	0	3	Math 55 (Elementary Analysis III)	3	0	3
CS 30 (Discrete Math for CS)	3	0	3	Physics 71 (Elementary Physics I)	4	0	4
CS 21 (Comp Org & Asm Lang Prog)	3	3	4	CS 140 (Operating Systems)	2	3	3
				CS 150 (Programming Languages)	2	3	3
PE <sup>4</sup> (Physical Education)			(2)	PE <sup>4</sup> (Physical Education)			(2)
NSTP <sup>5</sup> (National Service Training Program)			(3)	NSTP <sup>5</sup> (National Service Training Program)			(3)
	17	3	18		17	6	19
Third Year							
First Semester	Lect hrs/wk	Lab (hrs/wk)	Units	Second Semester	Lect hrs/wk	Lab (hrs/wk)	Units
GE (AH 5) Comm 3 (Pract Speech Fund)	3	0	3	GE (SSP 3) Kas 1 <sup>1</sup> (Kasaysayan ng Pil)	3	0	3
Physics 72 (Elementary Physics II)	4	0	4	CS 130 (Mathematical Methods in CS)	3	0	3
Stat 130 (Intro to Math Stat for CS)	3	0	3	CS 145 (Computer Networks)	2	3	3
CS 135 (Algorithm Design & Analysis)	3	0	3	CS 180 (Artificial Intelligence)	3	0	3
CS 165 (Database Systems)	2	3	3	CS 192 (Software Engineering II)	2	3	3
CS 191 (Software Engineering I)	3	0	3	CS 153 (Intro to Computer Security)	3	0	3
				CS 194 (Undergraduate Seminar)	1	0	1
	18	3	19		17	3	19
MidYear							
CS 195 (Practicum)	3	0	3				
Fourth Year							
First Semester	Lect hrs/wk	Lab (hrs/wk)	Units	Second Semester	Lect hrs/wk	Lab (hrs/wk)	Units
Math, Science or Engg Elective	3	0	3	PI 100 (The Life & Works of Jose Rizal)	3	0	3
GE (MST 4) STS (Science, Tech & Society)	3	0	3	CS 196 (Seminar on EPIC)	1	0	1
CS 133 (Automata Theory & Comp)	3	0	3	CS 199 (Special Problems II)	1	6	3
CS 198 (Special Problems I)	1	6	3	CS 200 (Undergraduate Thesis)			
CS 131 (Numerical Methods)	3	0	3	Computer Science Elective	3	0	3
GE (SSP 4)	3	0	3	Free Elective	3	0	3
				GE (SSP 5)	3	0	3
	16	6	18		14	6	16
Total Number of Units = 146							

Notes

<sup>†</sup> Effective AY 2011-2012 (with minor revisions in 2012). Total number of units = 146

<sup>1</sup> Fil 40 and Kas 1 satisfy the 6-unit Philippine Studies requirement

<sup>2</sup> Nine (9) units of GE (AH) courses must be in Communication in English

<sup>3</sup> A GE (MST) course whose content is substantially covered in the required courses in the B.S. CS curriculum may not be taken for credits as a GE course

<sup>4</sup> For physical education (PE), the student is required to complete any 4 physical education (PE) courses

<sup>5</sup> As a requirement for graduation, all students must take six (6) units of the National Service Training Program (NSTP) components: Civic Welfare Training Service (CWTS), Literacy Training Service (LTS), and Reserved Officer's Training Corps Military Science (ROTC Mil Sci)

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### 4.9 GRADUATE PROGRAMS CURRICULA

#### MASTER OF SCIENCE IN COMPUTER SCIENCE (M.S. CS)

	Thesis Option	Non-Thesis Option
Core Courses		
Theory Course	3 units	3 units
Systems Course	3 units	3 units
Theory or Systems Course	3 units	3 units
CS 298 Special Problem	3 units	3 units
Seminar	1 unit	1 unit
Specialization Courses	9 units	12 units
Computer Science Elective	-	3 units
Elective	3 units	9 units
CS 300 Thesis	6 units	-
<b>Total</b>	<b>31 units</b>	<b>37 units</b>

#### DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE (Ph.D. CS)

	Thesis
Core Courses	
Theory Course	3-6 units
Systems Course	3-6 units
Seminar	1 unit
Specialization Courses	9 units
Elective	6 units
CS 400 Thesis	12 units
<b>Total</b>	<b>37 units</b>

\* Ph.D. CS Course

#### The Theory Core Courses should be taken from among the following:

CS 204	Theory of Computation
CS 210	Advanced Algorithms and Data Structures
CS 214*	Parallel Algorithms
CS 231*	Numerical Computing
CS 360*	Formal Methods

#### The Theory Core Courses should be taken from among the following:

CS 250	Advanced Operating Systems
CS 253*	Computer Security
CS 255*	Advanced Computer Networks
CS 260	Advanced Software Engineering
CS 268*	Web Science
CS 270	Advanced Database Systems
CS 280	Intelligent Systems
CS 351*	Pervasive Computing and Communication
CS 369*	Semantic Web



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The following are the courses in the two (2) specialization areas:

### Theory:

CS 204	Theory of Computation
CS 208	Complexity Theory
CS 210	Advanced Algorithms and Data Structures
CS 211	Combinatorial Optimization
CS 213	Communication Theory
CS 214	Parallel Algorithms
CS 216	Randomized Algorithms
CS 222	Programming Language Theory
CS 236	Scientific Computing
CS 237	Biomedical Informatics
CS 239	Parallel Computing
CS 240	Computer Graphics
CS 242	Visualization
CS 247	Cryptography
CS 271	Database Theory
CS 290	Advanced Topics in Theoretical Computer Science
CS 294	Advanced Topics in Computational Science
CS 301	Communication Complexity
CS 315	Algorithms in Bioinformatics
CS 318	Approximation Algorithms
CS 334	Computational Systems Biology
CS 338	Computational Methods of Biological Processes
CS 360	Formal Methods
CS 390	Independent Study
CS 397	Special Topics
ES 201	Advanced Mathematical Methods in Engineering I
ES 202	Advanced Mathematical Methods in Engineering II

### Systems:

CS 220	Survey of Programming Languages
CS 250	Advanced Operating Systems
CS 253	Computer Security
CS 255	Advanced Computer Networks
CS 256	Computer Systems Performance Analysis
CS 257	Distributed Systems
CS 258	Mobile Computing
CS 259	Network Performance, Modeling and Monitoring
CS 260	Advanced Software Engineering
CS 262	Methods of Software Development
CS 265	Software Quality Assurance
CS 266	IT Project Management
CS 267	Software Engineering for the Web
CS 268	Web Science
CS 270	Advanced Database Systems
CS 280	Intelligent Systems
CS 281	Robotic Systems
CS 282	Computer Vision
CS 283	Data Mining
CS 284	Machine Learning
CS 286	Natural Language Understanding

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CS 291	Advanced Topics in Net-Centric Computing
CS 292	Advanced Topics in Software Systems
CS 293	Advanced Topics in Computer Systems
CS 295	Advanced Topics in Intelligent Systems
CS 341	Knowledge Engineering
CS 351	Pervasive Computing and Communication
CS 369	Semantic Web
CS 371	Security Engineering
CS 381	Computational Intelligence II
CS 385	Artificial Neural networks
CS 389	Digital Image Processing
CS 390	Independent Study
CS 397	Special Topics

#### 4.10 UNDERGRADUATE PROGRAM RETENTION RULES

1. Any B.S. Computer Science student who fails to obtain a passing grade in two takes of any of the following Math or CS courses shall be dismissed from the Department of Computer Science: Math 17, Math 53, Math 54, Math 55, CS 11, CS 12, CS 21, CS 30, CS 32.
2. Any B.S. Computer Science student who fails to obtain a passing grade in any three of the following CS courses shall be dismissed from the Department of Computer Science: CS 11, CS 12, CS 21, CS 30, CS 32.
3. Any B.S. Computer Science student who fails to obtain a passing grade in more than a half of the total number of units of CS and Math courses taken in three successive semesters shall be dismissed from the Department of Computer Science.
4. For interpretation purposes, the phrase 'fails to obtain a passing grade' is understood to mean any of the following:
  - (a) the student obtains a grade of 5.00
  - (b) the student obtains a grade of 4.00, takes and fails the removal exam and gets a grade of 5.00
  - (c) the student obtains a grade of 4.00, does not remove the 4.00 and retakes the course
  - (d) the student obtains a grade of 4.00 and does not remove the 4.00 by the last day for late registration of the succeeding semester
  - (e) the student obtains a grade of 'DRP' either because he or she officially dropped the course or because he or she 'abandoned' the course and is given a grade of 'DRP', provided that grade(s) of 'DRP' obtained when the student filed a leave of absence (LOA) shall not be counted
  - (f) the student obtains a grade of 'Inc', does not complete the 'Inc' and retakes the course
  - (g) the student obtains a grade of 'Inc' and does not complete the 'Inc' by the last day for late registration of the succeeding semester

#### 4.11 UNDERGRADUATE PROGRAM COURSE DESCRIPTIONS

##### **Computer Science (CS)**

**CS 11 Computer Programming I.** Introduction to Computer Science. Problem-solving strategies. Algorithm development. Coding conventions. Debugging. Fundamental programming constructs: types, control structures, functions, I/O. Basic data structures. Coreq: Math 17/equiv. 5 h (2 lec, 3 lab) 3 u.

**CS 12 Computer Programming II.** Advanced programming techniques. Recursion. Abstract data types: stacks, queues, linked structures. Programming interfaces. Introduction to object-oriented programming: classes, inheritance, polymorphism. Event-handling. Exception handling. API programming. Prereq: CS 11. 5 h (2 lec, 3 lab) 3 u.

**CS 21 Computer Organization and Assembly Language Programming.** Digital Logic and data representation. Computer architecture and organization. Interfacing and I/O strategies. Memory architecture. Functional organization. Multiprocessing. Graphics System. Assembly language programming. Prereq: CS 12/ ES 26/equiv. 6 h (3 lec, 3 lab) 4 u.

**CS 30 Discrete Mathematics for Computer Science.** Combinatorial structures and their applications in Computer Science. Prereq: Math 17. Coreq: Math 53. 3 u.

**CS 32 Data Structures.** Concepts, algorithms and applications of complex data structures: tables, trees, graphs, heaps, generalized lists, multilinked structures. Basic algorithmic techniques and analysis: sorting algorithms, hash tables, binary search trees, balanced trees. Prereq: CS 12/ES 26/equiv. 3 u.

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**CS 120 Internet Technologies.** Programmer-oriented survey of contemporary authoring, distributing, browsing, client-server and other technologies; role, use and implementation of current Internet tools; security and privacy issues. Prereq: CS 32/COI. 3 u.

**CS 130 Mathematical Methods in Computer Science.** Vector spaces. Linear transformations. Matrices and determinants. Ordinary differential equations and systems of ordinary differential equations; Fourier series; Laplace transforms. Prereq: Math 55. 3 u.

**CS 131 Numerical Methods.** Interpolations, numerical differentiation and integration. Numerical solutions of algebraic and transcendental equations, systems of equations, ordinary and partial differential equations. Prereq: CS 12, CS 130. 3 u.

**CS 133 Automata Theory and Computability.** Alphabet, words, languages and algorithmic problems. Finite automata and hierarchy of languages. Turing machines. Tractable and intractable problems. Uncomputable functions. The halting problem. Prereq: CS 30. 3u.

**CS 134 Computational Complexity.** Time complexity; the classes P and NP; NP-completeness; the polynomial hierarchy; space complexity; intractability. Prereq: CS 133. 3 u.

**CS 135 Algorithm Design and Analysis.** Algorithm analysis: asymptotic analysis, time and space tradeoffs, recurrence relations. Greedy, divide and conquer, heuristics and other algorithm design strategies. Fundamental computing algorithms for sorting, selection, trees and graphs. Intractability and approximation. Prereq: CS 32, CS 30. 3 u.

**CS 137 Computer Algebra.** Arithmetic in basic algebraic domains; the Euclidean algorithm; polynomial greatest common divisors and resultants; polynomial factorization. Prereq: CS 135/COI. 3 u.

**CS 140 Operating Systems.** Survey of operating systems. Memory management: virtual memory, segmentation, paging, fetch and replacement policies. Processor and process management: scheduling, concurrency, synchronization and mutual exclusion, deadlock. Device management. Security. File systems: sequential, direct access, and indexed sequential files. Implementation of file organization. Prereq: CS 21. 5 h (2 lec, 3 lab) 3 u.

**CS 145 Computer Networks.** Network models and layers; terminal and file transfer protocols; message handling protocols; concurrency; network interconnection; distributed computation; overview of networking and communication software. Prereq: CS 140. 5 h (2 lec, 3 lab) 3 u.

**CS 150 Programming Languages.** History and overview of programming languages. Programming paradigms: imperative, functional, object-oriented, logical. Type systems. Data and execution control. Declaration and modularity. Introduction to syntax and semantics. Introduction to language translation. Prereq: CS 32. 5 h (2 lec, 3 lab) 3 u.

**CS 153 Introduction to Computer Security.** Computer security models and protocols. Security issues. Cryptographic algorithms and digital signatures. Risk Assessment. Prereq: CS 140. Coreq: CS 145, CS 192. 3 u.

**CS 155 Compiler Construction.** Grammar specification, lexical analysis, parsing techniques, semantic analysis, code generation and optimization, runtime storage administration, error detection and recovery. Prereq: CS 133, CS 150. 3 u.

**CS 160 File Processing. Logical and Physical File Structures.** Secondary storage devices. Sequential, direct and indexed files. Single-key and multiple-key retrieval. Data compaction. Implementation of file organizations. Prereq: CS 32. 3 u.

**CS 165 Database Systems.** Database concepts: data independence, architecture, models, administration, relational algebra and calculus, normalization, structured query language, query optimization, transactions, concurrency, recovery, security. Survey of database management systems. Prereq: CS 32. 5 h (2 lec, 3 lab) 3 u.

**CS 171 Topics in Theoretical Computer Science.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 172 Topics in Net-Centric Computing.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

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**CS 173 Topics in Software Technology.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 174 Topics in Computer Systems.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 175 Topics in Computational Science.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 176 Topics in Intelligent Systems.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 180 Artificial Intelligence.** Fundamental principles of artificial intelligence. Search methods. Knowledge representation and reasoning. Agents. Machine learning and neural networks. Current research applications. Prereq: CS 32, COI. 3 u.

**CS 191 Software Engineering I.** Principles of software engineering. Software project management, requirements engineering, system analysis and design. Prereq: CS 32, Junior standing; Coreq: CS 165. 3 u.

**CS 192 Software Engineering II.** Software architecture and design patterns, software quality assurance; software implementation and maintenance. Prereq: CS 191. 5 h (2 lec, 3 lab) 3 u.

**CS 194 Undergraduate Research Seminar.** Prereq: Junior standing. 1 u.

**CS 195 Practicum.** Prereq: CS 192. 180 h. 3 u.

**CS 196 Seminar on Ethical and Professional Issues in Computing.** Prereq: Senior standing. 1 u.

**CS 197 Special Topics.** Prereq: Senior standing. 3 u.; may be taken twice, topic to be indicated for record purposes.

**CS 198 Special Problems I.** Prereq: CS 192, Senior standing. 7 h (1 lec, 6 lab) 3 u.

**CS 199 Special Problems II.** Prereq: CS 198. 7 h (1 lec, 6 lab) 3 u.

**CS 200 Undergraduate Thesis.** Prereq: CS 198. 3 u.

### *Information Technology (IT)*

**IT 100 Introduction to Information Technology.** Overview of computer hardware and software. Using the World Wide Web and the Internet, problem solving, applications. Social and ethical issues in computing. 5 h (2 lec, 3 lab) 3 u.

## 4.12 GRADUATE PROGRAMS COURSE DESCRIPTIONS

### *Computer Science (CS)*

**CS 204 Theory of Computation.** Formal models of computation; recursive function theory; undecidability. Resource-bounded computational complexity, non-determinism, NP-completeness. Prereq: CS 133 or COI. 3 u.

**CS 208 Complexity Theory.** Computational models, measures of complexity, complexity classes: nondeterministic, alternating, probabilistic, parallel. Boolean circuits. Complete problems. Prereq: CS 204. 3 u.

**CS 210 Advanced Algorithms and Data Structures.** Advanced data structures: algorithm design techniques; mathematical techniques in the analysis of algorithms. Prereq: CS 135. 3 u.

**CS 211 Combinatorial Optimization.** Design and analysis of algorithms for combinatorial optimization problems, worst-case complexity, NP-Completeness proofs, heuristics. Open problems. Prereq: COI. 3 u.

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**CS 213 Communications Theory.** Mathematical theory of communication. Information Theory. Communication Channels. Coding. Cryptography. Prereq: COI. 3 u.

**CS 214 Parallel Algorithms.** Models of parallel computation. Performance measures, scalability, pipelining, techniques for analyzing parallel algorithms. Interconnection network topologies. Applications. Prereq: CS 210. 3 u.

**CS 216 Randomized Algorithms.** Construction and analysis of randomized algorithms. Expected performance of randomized algorithms, fundamental limitations on probabilistic computations, complexity issues, applications. Prereq: CS 135 and Stat 112 or COI. 3 u.

**CS 220 Survey of Programming Languages.** Comparative study of different types of modern programming languages: imperative, functional, logic-based and object-oriented. Syntax, semantics and implementation of programming languages. Prereq: CS 150 or equivalent. 3 u.

**CS 222 Programming Language Theory.** Fundamental concepts underlying all programming languages. Semantic aspects including binding times, visibility, retention, storage management, abstraction mechanisms and extensibility. Operational and denotational semantic specifications. Prereq: CS 150 or equivalent. 3 u.

**CS 225 Compiler Design and Construction.** Theory of compiler design and construction; techniques in error correction and recovery; code generation and optimization. Prereq: CS 220. 3 u.

**CS 231 Numerical Computing.** Algorithm design for numerical computation. Error analysis. Performance evaluation of numerical software. Prereq: CS 131 or COI. 3 u.

**CS 236 Scientific Computing.** Problems and methods in scientific computing. Applications from science and engineering. Prereq: COI. 3 u.

**CS 237 Biomedical Informatics.** Computational methods for managing and analyzing information about biomedical systems. Standards and tools in Biomedical Informatics. Prereq: COI. 3 u.

**CS 239 Parallel Computing.** Parallel computer architectures, Programming for parallel architectures. Representation, program dependence, control structures. Prereq: COI. 3 u.

**CS 240 Computer Graphics.** Solid modelling: Euler operators, finite element methods. Rendering: filling, shading, ray tracing. Natural modeling: L-systems, fractals. Image processing: filtering, antialiasing, enhancement. Prereq: COI. 3 u.

**CS 242 Data Visualization.** Visualization techniques for data from science, business, social science, demographics, and information management. Prereq: COI. 3 u.

**CS 247 Cryptography.** Primality testing, finite fields, elliptic curves. Protocols: public key cryptography, digital signatures, zero-knowledge proofs, and other cryptographic protocols. Prereq: COI. 3 u.

**CS 250 Advanced Operating Systems.** Synchronization and communication mechanisms; virtual memory management, file systems, deadlock control, resource allocation, protection and access control. Case study of specialized systems. Prereq: CS 140 or equiv. 3 u.

**CS 253 Computer Security.** Encryption, digital signatures, authentication, key management. Secure electronic commerce. Network Security. File security. Prereq: COI. 3 u.

**CS 255 Advanced Computer Networks.** The OSI Reference Mode and layers. Distributed computing. Networked multimedia systems. Client-server computing. Communication and internetworking. Prereq: CS 250. 3 u.

**CS 256 Computer Systems Performance Analysis.** Overview of performance evaluation. Measurement techniques and tools. Applications of probability theory and techniques. Experimental design and analysis. Simulation and queuing models. Prereq: COI. 3 u.

**CS 257 Distributed Systems.** Computer communications networks and their protocols. Event ordering and synchronization. Deadlocks. Network operating systems and languages for distributed computing. Distributed databases. Fault tolerance and recovery strategies. Applications. Prereq: CS 140 or equiv. 3 u.

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**CS 258 Mobile Computing.** Mobile computing systems. Data management, packet transmission, mobile IP, routing protocols, reliability and issues in mobile wireless networks. Prereq: COI. 3 u.

**CS 259 Network Performance, Modeling and Monitoring.** Network Performance Evaluation. Measurement Techniques and Tools. Simulation, queuing models, case studies, practicals. Prereq: CS 255 and CS 256 or COI. 3 u.

**CS 260 Advanced Software Engineering.** Structured approach to requirements analysis, system design, implementation and maintenance of software systems. Formal description and documentation techniques. Prereq: CS 192 or equiv. 3 u.

**CS 262 Methods of Software Development.** Modern approaches to software development. Prototyping and automated tools. Computer Aided Systems Engineering (CASE) methods and tools. Object-oriented Programming Systems (OOPS). Prereq: CS 260. 3 u.

**CS 265 Software Quality Assurance.** Quality Management, Quality Assurance, Quality Control. Measurement and Analysis. Maturity Models. Prereq: CS 260 or COI. 3 u.

**CS 266 IT Project Management.** Detailed discussions of project management knowledge areas and processes. Case studies. Simulations and walkthrough of real-world IT projects from initiation and planning to evaluation and closing. Prereq: COI. 3 u.

**CS 267 Software Engineering for the Web.** Software process and requirements analysis, design, development and testing for web-based systems, software development tools, configuration management systems, case studies. Prereq: CS 260 and CS 270 or COI. 3 u.

**CS 268 Web Science.** The Web as a full communications medium that foster full collaboration, social interaction and commerce. Case studies. Prereq: CS 267. 3 u.

**CS 270 Advanced Database Systems.** Data models and their underlying mathematical foundations; database manipulation and query languages; functional dependencies; physical data organization and indexing methods; concurrency control; crash recovery; database security; distributed databases. Prereq: CS 250. 3 u.

**CS 271 Database Theory.** Relational database model, query languages, domain independence, relational calculus, query optimization, constraints. Prereq: CS 165 or equivalent. 3 u.

**CS 280 Intelligent Systems.** Fundamental issues in Intelligent Systems. Intelligent search and optimization methods. Knowledge representation and reasoning. Learning, natural language understanding, pattern recognition, knowledge-based systems and other methods in intelligent systems. Prereq: COI. 3 u.

**CS 281 Robotic Systems.** Biologically-motivated robotic systems. Reactive, deliberative, and hybrid architectures. Knowledge representation for robotics systems. Sensor fusion and perceptual strategies. Adaptation and social behavior. Prereq: CS 280 or equiv. 3 u.

**CS 282 Computer Vision.** Image formation. Early vision. Segmentation from texture and motion. Object representation. Matching and inference. Knowledge-based vision. Prereq: COI. 3 u.

**CS 283 Data Mining.** Decision trees, association rules, clustering. Intrusion detection. Design and use of serial, distributed and parallel data mining algorithms. Prereq: CS 165 and CS 280 or COI. 3 u.

**CS 284 Machine Learning.** Pattern recognition, parametric and non-parametric learning, decision trees, Bayesian and neural networks, reinforcement learning, genetic algorithms, computational learning theory. Prereq: CS 280 or COI. 3 u.

**CS 286 Natural Language Understanding.** Computational properties of natural languages. Morphological, syntactic and semantic processing from an algorithmic perspective. Models of acquisition and parsing. Prereq: CS 280 or COI. 3 u.

**CS 290 Advanced Topics in Theoretical Computer Science.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

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**CS 291 Advanced Topics in Net-Centric Computing.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

**CS 292 Advanced Topics in Software Technology.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

**CS 293 Advanced Topics in Computer Systems.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

**CS 294 Advanced Topics in Computational Science.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

**CS 295 Advanced Topics in Intelligent Systems.** Prereq: COI. 3 u.; may be repeated for a maximum of 6 u.; topic should be indicated for record purposes.

**CS 296 Seminar.** Prereq: COI. 1 u.; may be repeated for a maximum of 3 u.

**CS 297 Special Topics.** Prereq: COI. 3 u.; may be repeated if topics are different; topic to be indicated for record purposes.

**CS 298 Special Problem.** Prereq: Completion of 12 u. including 6 u. of specialization courses. 3 u.; may be taken twice; problem to be indicated for record purposes.

**CS 300 Thesis.** 6 u.

**CS 301 Communication Complexity.** Communication complexity and its applications to parallel computing. Communication complexity measures, lower bound techniques. Prereq: CS 210 or COI. 3 u.

**CS 315 Algorithms in Bioinformatics.** Algorithm design techniques applied to Bioinformatics Problems, DNA Sequencing, Gene Expression Analysis, and Protein Folding. Prereq: CS 135 or COI. 3 u.

**CS 318 Approximation Algorithms.** Approximate methods for solving a wide range of intractable or hard problems. Prereq: CS 210 or COI. 3 u.

**CS 334 Computational Systems Biology.** Analysis of molecular interaction networks and pathways. Qualitative and quantitative methods and tools applied to biochemical systems. Prereq: COI. 3 u.

**CS 338 Computational Models of Biological Processes.** Formal models and heuristic approaches for biological processes. Prereq: COI. 3 u.

**CS 351 Pervasive Computing and Communication.** Technologies for ubiquitous computing. Prereq: CS 255, CS 267 and CS 280 or COI. 3 u.

**CS 360 Formal Methods.** Program specification, verification, and refinement. Prereq: COI. 3 u.

**CS 369 The Semantic Web.** Web technologies, ontology engineering, social network analysis and web standards. Prereq: CS 267. 3 u.

**CS 371 Security Engineering.** Security issues in the design and engineering of software-based systems for different platforms. Prereq: CS 253 or COI. 3 u.

**CS 380 Computational Intelligence 1.** Metaheuristic algorithms and their utility in solving engineering and scientific problems. Prereq: CS 280 or COI. 3 u.

**CS 381 Computational Intelligence 2.** Agent-based systems and their applications to real-world problems. Prereq: CS 280 or COI. 3 u.

**CS 385 Artificial Neural Networks.** Computational models inspired by the structural and functional aspects of the brain. Prereq: CS 280 or COI. 3 u.



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**CS 389 Digital Image Processing.** Tools and techniques for transformation of images for subsequent human or machine interpretation. Prereq: COI. 3 u.

**CS 390 Independent Study.** Prereq: Completion of 18 units of CS graduate courses including 6 units of Specialization courses. 3 u.; may be taken twice.

**CS 397 Special Topics.** Prereq: COI. 3 u.; may be taken twice provided that topics are different.

**CS 400 Dissertation.** Prereq: completion of all coursework requirements for the program. 12 u.; may be spread over 2 semesters.