

DEPARTMENT OF COMPUTER ENGINEERING

Objectives

1. Graduates have knowledge of basic sciences and engineering sciences necessary to engage in further learning.
2. Graduates have knowledge and skills needed for the engineering profession.
3. Graduates are able to use engineering tools appropriately.

The undergraduate program in Computer Engineering is relatively broad-based. The program covers various aspects in computer science and engineering which include the design, analysis, organization, and applications of computer systems. The department offers courses which can be divided into three major areas.

1. Digital System Engineering : Courses cover the design and analysis of digital computer systems which include logic design, microprocessors, microcomputer systems, assembly language, VLSI design, computer architectures, data communications and computer networks.

2. Systems Software Engineering : Courses cover the principles of design and analysis of algorithms, systems software, programming languages, compilers, and operating systems. The students will, in addition, understand the interactions between software and hardware at various interface levels.

3. Information Processing : Courses cover the design and analysis of information processing systems, information technology, software engineering, artificial intelligence, data base management system, computer graphics, and their applications.

A bachelor degree in Computer Engineering will be awarded upon successful completion of the four year curriculum. Being highly competent in the design, analysis, and applications of systems software, digital systems, and information processing, the graduate will be able to work as a systems programmer, a systems analyst or a system engineer.

The department also offers four additional curriculums leading to the Master Degree in Computer Science, Master Degree in Software Engineering, Master Degree in Computer Engineering, and Doctor of Philosophy in Computer Engineering.

HEAD :

Natawut Nupairoj, Ph.D. (Michigan St.)

PROFESSORS :

Boonserm Kijirikul, Ph.D. (Tokyo Institute of Technology)
Prabhas Chongstitvatana, Ph.D. (Edinburgh U.)

ASSOCIATE PROFESSORS :

Atiwong Suchato, Ph.D. (M.I.T.)
Kultida Rojviboonchai, Ph.D. (Tokyo)
Nongluk Covavisaruch, M.S. in E.E. (Missouri Columbia)
M.A. (Languages & International Trade) (Eastern Michigan)
Pornsiri Muenchaisri, Ph.D. (Oregon State)
Sartid Vongpradhip, Ph.D. (U.of Tech. Sydney)
Setha Pan-Ngum, Ph.D. (U. of Warwick)
Somchai Prasitjutrakul, Ph.D. (U. of Illinois)
Wiwat Vatanawood, Ph.D. (Chula)
Taratip Suwannasart, Ph.D. (Illinois Institute of Technology)
Twittie Senivongse, Ph.D. (U. of Kent)
Yachai Limpiyakorn, Ph.D. (Illinois Institute of Technology)

ASSISTANT PROFESSORS :

Arthit Thongtak, D.Eng. (Tokyo Institute of Technology)
Athasit Surarerks, Ph.D. (U.of Pierre et Marie Curie)
Attawith Sudsang, Ph.D. (U. of Illinois)
Boonchai Sowanwanichakul, B.Eng. (Chula)
Chotirat Ratanamahatana, Ph.D. (U. of California)
Krerak Piromsopa, Ph.D. (Michigan St.)
Natawut Nupairoj, Ph.D. (Michigan St.)
Nakornthip Prompoon, M.S. (George Wash.U.)
Nattee Niparnan, Ph.D. (Chula)
Suebskul Phiphobmongkol, Ph.D. (Auburn)
Sukree Sinthupinyo, Ph.D. (Chula)
Proadpran Punyabukkana Pitsatorn, Ph.D. (Claremont)
Pizzanu Kanongchaiyos, Ph.D. (U.of Tokyo)
Thanawan Chantaratanapibul, M.Sc. (Chula)
Thanarat Chalidabhongse, Ph.D. (Maryland)
Veera Muangsin, Ph.D. (U. of Manchester)
Vishnu Kotrajaras, Ph.D. (Imperial College)

LECTURERS :

Chairat Phongphanphanee, Ph.D. (U. of Southampton)
Chate Patanothai, M.Sc. in EE. (U. of Miami)
Duangdao Wichadakul, Ph.D. (U. of Illinois)
Nuttapong Chentanez, Ph.D. (Berkeley)
Peerapon Vateekul, Ph.D. (U. of Miami)
Pitchaya Sitthi-Amorn, Ph.D. (U. of Virginia)
Thit Siriboon, Ph.D. (Oregon State)
Thongchai Rojkangsadan, M.Sc. (Chula)

**COMPUTER ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS**

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
THIRD SEMESTER			SIXTH SEMESTER		
2110200	DISCRETE STRUC	3	2110318	DIS SYS ESSEN	1
2110215	PROG METH I	3	2110332	SYS ANA DESIGN	3
2110221	COMP ENG ESSENTIALS	3	2110422	DB MGT SYS DESIGN	3
2110251	DIG COMP LOGIC	3	2110471	COMP NETWORK I	3
2110253	COMP ELEC INTF	3	2110xxx	APPROVED ELECTIVES	3
2110263	DIG LOGIC LAB I	1	5500308	TECH WRIT ENG	3
xxxxxxx	GENERAL EDUCATION	<u>3</u>	xxxxxxx	GENERAL EDUCATION	<u>3</u>
		19			19
FORTH SEMESTER			SUMMER SEMESTER		
2110201	COMP ENG MATH	3	2100301	ENGINEERING PRACTICE	2
2110211	INTRO DATA STRUCT	3			
2110254	DIG DESIGN VER	3	SEVENTH SEMESTER		
2110265	DIG DESIGN LAB I	1	2110423	SOFTWARE ENG	3
2603284	STAT PHYS SCIENCE	3	2110355	FORM LANG/AUTO	3
5500208	COM PRES SKIL	3	2110490	COMP ENG PRE-PROJ	1
xxxxxxx	GENERAL EDUCATION	<u>3</u>	2110xxx	APPROVED ELECTIVES	6
		19	xxxxxxx	FREE ELECTIVE	<u>3</u>
					16
FIFTH SEMESTER			EIGHTH SEMESTER		
2110313	OS AND SYS PROG	3	2110499	COMP ENG PROJECT	3
2110316	PROG LANG PRIN	3	2110xxx	APPROVED ELECTIVES 9	
2110327	ALGORITHM DESIGN	3	xxxxxxx	FREE ELECTIVE	<u>3</u>
2110352	COMP SYS ARCH	3			
2110363	HW SYN LAB I	1			
xxxxxxx	GENERAL EDUCATION	<u>3</u>			15
		16			

TOTAL CREDITS FOR GRADUATION = 142

**MASTER DEGREE PROGRAMS
COMPUTER SCIENCE**

NAME OF THE DEGREE

: Master of Science
: M.Sc.

ADMISSION

The applicant must have the following qualification:

1. Hold a Bachelor degree in Computer Science, Computer Engineering, Software Engineering, Information Technology, Mathematics, Physics, Statistics, or other Engineering fields.
2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Computer Science Program Committee.

DEGREE REQUIREMENTS

The program requires the total of 36 credits comprising

1. Required Courses: 9 credits (including a non-credit Seminar course)
2. Track Elective Courses: 9 credits chosen from one of the following tracks:
 - a. Intelligent Systems track
 - b. Enterprise Information Systems track
3. General Elective Courses: 6 credits
4. Thesis: 12 credits

COURSE REQUIREMENTS

1) *Required Courses*

2110607	Research Methods in Computer Science	3(3-0-9)
2110636	Performance Analysis and Evaluation	3(3-0-9)
2110681	Computer Algorithm	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-1-3)

Remark: 2110701 Seminar in Computer Engineering I is a non-credit course, with S/U evaluation.

2) *Track Elective Courses*

Each student must choose one of the tracks.

Intelligent Systems Track

Each student chooses 3 courses from the following list. (Remaining courses in the track can be chosen as General Elective Courses.)

2110654	Artificial Intelligence	3(3-0-9)
2110682	Embedded and Real-Time Systems	3(3-0-9)
2110714	Digital Systems	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110773	Data Mining	3(3-0-9)

Enterprise Information Systems Track

Each student chooses 3 courses from the following list. (Remaining courses in the track can be chosen as General Elective Courses.)

2110523	Enterprise Application Architecture	3(3-0-9)
2110637	Large-Scale Information Systems	3(3-0-9)
2110640	Information Security	3(3-0-9)
2110663	Worldwide Network Infrastructure	3(3-0-9)
2110673	Information Storage and Retrieval	3(3-0-9)

3) *General Elective Courses*

Each student chooses 2 courses from the following list.

2110522	UNIX/LINUX for Enterprise Environment	3(3-0-9)
2110638	Object-Oriented Technology	3(3-0-9)
2110651	Digital Image Processing	3(3-0-9)
2110678	Mobile Computing	3(3-0-9)
2110694	Directed Studies in Computer Science	3(3-0-9)
2110697	Special Topics in Computer Science I	3(3-0-9)
2110698	Special Topics in Computer Science II	3(3-0-9)
2110713	Optimization Methods	3(3-0-9)
2110731	Distributed Systems	3(3-0-9)
2110732	Parallel Computing	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110742	Evolutionary Computation	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110747	Social Network Analysis	3(3-0-9)
2110781	Special Topics in Distributed Systems	3(3-0-9)
2110792	Advanced Topics in Artificial Intelligence	3(3-0-9)
2110795	Advanced Topics in Computer Network	3(3-0-9)

In addition to the list above, students can choose among the following as General Elective Courses:

1. Remaining elective courses of the chosen track which are not part of the 9-credit Track Elective Courses
2. Electives courses of the other track that is not chosen
3. Graduate courses of other programs of the Department (i.e. 21105xx, 21106xx, or 21107xx courses not listed as the General Elective Courses above)
4. Graduate courses of Chulalongkorn University (approval by the Computer Science Program Committee is required).

4) *Thesis*

2110811	Thesis	12	credits
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STUDY PROGRAM

First Semester

2110606	Research Methods in Computer Science	3
2110636	Performance Analysis and Evaluation	3
2110681	Computer Algorithm	3
		9

Second Semester

2110xxx	Track Elective Courses	6
2110xxx	General Elective Courses	3
		9

Third Semester

2110711	Seminar in Computer Engineering I	-
2110xxx	Track Elective Courses	3
2110xxx	General Elective Courses	3
2110811	Thesis	3
		9

Fourth Semester

2110811	Thesis	9
		9

COMPUTER ENGINEERING

NAME OF THE DEGREE

- : Master of Engineering
- : M.Eng.

ADMISSION

The applicant must hold a Bachelor's Degree in Computer Engineering for plan A(1) or a Bachelor's Degree in any Engineering discipline for plan A(2), meet the Graduate School requirements, and also must pass the Interview by the Computer Engineering Department.

DEGREE REQUIREMENTS

Plan A(1) program consists of three non-credit required courses and 36 credits of thesis. Plan A(2) program consists of 3 non-credit required courses, 12 credits of elective courses, and 24 credits of thesis.

COURSE REQUIREMENTS

	1) Required Courses	non-credit
2110606	Research Methods in Computer Engineering	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-3-1)
2110702	Seminar in Computer Engineering II	1(0-3-1)

2) Elective Courses 12 credits

2110502	Formal Verification	3(3-0-9)
2110522	UNIX/LINUX for Enterprise Environment	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110541	Computer Systems Audit	3(3-0-9)
2110605	Computer Programs Structure	3(3-0-9)
2110611	Information Processing and Computer System	3(3-0-9)
2110612	System Programming	3(3-0-9)
2110614	Programming Languages and Compilation	3(3-0-9)
2110621	System Analysis and Design	3(3-0-9)
2110622	Data Management	3(3-0-9)
2110623	Software Requirements Engineering	3(3-0-9)
2110624	Software Engineering	3(3-0-9)
2110629	File Management	3(3-0-9)
2110631	Operating System	3(3-0-9)
2110632	Advanced Topics in Operating Systems	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110636	Performance Analysis and Evaluation	3(3-0-9)
2110637	Large-Scale Information Systems	3(3-0-9)
2110638	Object-Oriented Technology	3(3-0-9)
2110639	Computer System Security	3(3-0-9)
2110640	Information Security	3(3-0-9)
2110642	Object-Oriented Software Engineering	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110651	Digital Image Processing	3(3-0-9)
2110654	Artificial Intelligence	3(3-0-9)
2110657	Computer Simulation	3(3-0-9)
2110661	Computer Network	3(3-0-9)
2110663	Worldwide Network Infrastructure	3(3-0-9)
2110664	Network Management	3(3-0-9)
2110665	Computer Communication System and Standards	3(3-0-9)
2110671	Database Management Systems	3(3-0-9)
2110672	Data Modeling Techniques	3(3-0-9)
2110673	Information Storage and Retrieval	3(3-0-9)
2110674	Information Technology Center Management	3(3-0-9)
2110678	Mobile Computing	3(3-0-9)
2110681	Computer Algorithm	3(3-0-9)
2110682	Embedded and Real-time Systems	3(3-0-9)
2110683	Concurrent Processing	3(3-0-9)
2110684	Information System Architecture	3(3-0-9)
2110685	Computer Application in Enterprises	3(3-0-9)
2110686	Enterprise Computing	3(3-0-9)
2110694	Directed Studies in Computer Science	3(3-0-9)

2110696	Advanced Topics in Computer Application	3(3-0-9)
2110697	Special Topics in Computer Science I	3(3-0-9)
2110698	Special Topics in Computer Science II	3(3-0-9)
2110711	Theory of Computation	3(3-0-9)
2110712	Analysis of Algorithms	3(3-0-9)
2110713	Optimization Methods	3(3-0-9)
2110714	Digital Systems	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110731	Distributed Systems	3(3-0-9)
2110732	Parallel Computing	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110742	Evolutionary Computation	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110744	Machine Vision	3(3-0-9)
2110745	Cryptography	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110747	Social Network Analysis	3(3-0-9)
2110751	Computer Aided Design in Digital Systems	3(3-0-9)
2110752	Design for Testability	3(3-0-9)
2110753	Asynchronous Design	3(3-0-9)
2110771	Advanced Database Design	3(3-0-9)
2110772	Multi-Dimensional Database Systems	3(3-0-9)
2110773	Data Mining	3(3-0-9)
2110781	Special Topics in Distributed Systems	3(3-0-9)
2110791	Advanced Topics in Software Engineering	3(3-0-9)
2110792	Advanced Topics in Artificial Intelligence	3(3-0-9)
2110793	Advanced Topics in Digital Systems	3(3-0-9)
2110794	Advanced Topics in Database Systems	3(3-0-9)
2110795	Advanced Topics in Computer Network	3(3-0-9)

3) *Thesis*

2110814	Thesis (for plan A(2))	24	credits
2110816	Thesis (for plan A(1))	36	credits

STUDY PROGRAMS

Plan A (1)

First Semester

2110606	Research Methods	-
2110816	Thesis	<u>9</u>
		9

Second Semester

2110701	Seminar Computer Eng. I	-
2110816	Thesis	<u>9</u>
		9

Third Semester

2110702	Seminar Computer Eng. II	-
2110816	Thesis	<u>9</u>
		9

Fourth Semester

2110816	Thesis	<u>9</u>
		9

Plan A (2)

First Semester

2110606	Research Methods	-
2110 xxx	Electives	<u>9</u>
		9

Second Semester

2110701	Seminar Computer Eng. I	-
2110 xxx	Electives	3
2110814	Thesis	<u>6</u>
		9

Third Semester

2110702	Seminar Computer Eng. II	-
2110814	Thesis	<u>9</u>
		9

Fourth Semester

2110814	Thesis	<u>9</u>
		9

SOFTWARE ENGINEERING

NAME OF THE DEGREE

: Master of Science
: M.Sc.

ADMISSION

The program has 2 plans.

Plan A(2) is the plan **with thesis**. The applicant must

1. Hold a Bachelor's degree in Engineering, Statistics, Science, or equivalent.
2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Software Engineering Program Committee.

Plan B is the plan with **no thesis**, but students **must do the master project and pass the comprehensive exam**. The applicant must

1. Hold a Bachelor's degree in one of these fields.
 - Engineering
 - Statistics
 - Science
 - Industrial Education with one of these sub-fields
 - Education Technology and Communication
 - Computer and Information Technology
 - Computer Technology or
 - Electronics and Computer
 - Business Administration with one of these sub-fields
 - Business Computer
 - Business Information Technology
 - Computer Information or
 - Computer Information Systems – Software Development
 - or hold other Bachelor's degree but have **at least 1 year** experience working in Information Technology or Computer.
2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Software Engineering Program Committee.

DEGREE REQUIREMENTS

Both Plan A(2) and Plan B require the total of 36 credits.

Plan A(2)

1. Non-credit Courses (2 courses)
2. Required Courses 12 credits
3. Electives 12 credits
4. Thesis 12 credits

Plan B

1. Non-credit Courses (2 courses)
2. Required Courses 18 credits
3. Electives 12 credits
4. Master Project 6 credits
5. Comprehensive Exam

COURSE REQUIREMENTS

Plan A(2)

- 1) *Non-credit Courses*

2110606	Research Methods in Computer Engineering	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-3-1)

Remark: Non-credit courses will be evaluated with S/U.

2) *Required Courses*

2110623	Software Requirements Engineering	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)

3) *Electives*

Choose 4 courses. Electives will be divided in 2 groups: Software Engineering Electives and General Electives. Student must study at least 2 courses (6 credits) of Software Engineering Electives.

---Software Engineering Electives

2110502	Formal Verification	3(3-0-9)
2110521	Software Architectures	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110725	Software Engineering Process and Improvement	3(3-0-9)
2110726	Software Configuration Management	3(3-0-9)
2110727	Software Evolution and Maintenance	3(3-0-9)
2110728	Special Topics in Software Engineering I	3(3-0-9)
2110729	Special Topics in Software Engineering II	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110791	Advanced Topics in Software Engineering	3(3-0-9)

---General Electives

Student can enroll in any courses open for graduate students. Course must be instructed either by the Department of Computer Engineering or any department in Chulalongkorn University (approval by the Software Engineering Program Committee is required).

4) *Thesis*

2110811	Thesis	12 credits
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Plan B1) *Non-credit Courses*

2110606	Research Methods in Computer Engineering	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-3-1)

Remark: Non-credit courses will be evaluated with S/U.

2) *Required Courses*

2110623	Software Requirements Engineering	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)
2110725	Software Engineering Process and Improvement	3(3-0-9)

3) *Electives*

Choose 4 courses. Electives will be divided in 2 groups: Software Engineering Electives and General Electives. Student must study at least 2 courses (6 credits) of Software Engineering Electives.

---Software Engineering Electives

2110502	Formal Verification	3(3-0-9)
2110521	Software Architectures	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110726	Software Configuration Management	3(3-0-9)
2110727	Software Evolution and Maintenance	3(3-0-9)
2110728	Special Topics in Software Engineering I	3(3-0-9)
2110729	Special Topics in Software Engineering II	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110791	Advanced Topics in Software Engineering	3(3-0-9)

---General Electives

Student can enroll in any courses open for graduate students. Course must be instructed either by the Department of Computer Engineering or any department in Chulalongkorn University (approval by the Software Engineering Program Committee is required).

4) *Master Project*

2110797	Pre-Master Project in Software Engineering	3(0-0-12)
2110798	Master Project in Software Engineering	3(0-0-12)

5) *Comprehensive Exam*

2110896	Comprehensive Examination	
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Remark: Comprehensive examination will be evaluated with S/U. The student can enroll in this course since the semester that all courses in the program are registered.

STUDY PROGRAMS**Plan A(2)****First Semester**

2110623	Software Requirement Eng.	3
2110701	Seminar in Computer Engineering I	-
2110724	Software Testing and Quality Assurance	3
2110xxx	Elective	<u>3</u>
		9

Second Semester

2110634	Software Design and Development	3
2110721	Software Metrics	3
2110xxx	Elective	<u>3</u>
		9

Third Semester

2110606	Research Methods in Computer Engineering	-
2110xxx	Electives	6
2110811	Thesis	<u>3</u>
		9

Fourth Semester

2110811	Thesis	<u>9</u>
		9

Plan B**First Semester**

2110623	Software Requirement Eng.	3
2110701	Seminar in Computer Engineering I	-
2110722	Software Project Management	3
2110724	Software Testing and Quality Assurance	<u>3</u>
		9

Second Semester

2110634	Software Design and Development	3
2110721	Software Metrics	3
2110 725	Software Engineering Process And Improvement	<u>3</u>
		9

Third Semester

2110606	Research Methods in Computer Engineering	-
2110xxx	Electives	6
2110797	Pre-Master Project in Software Engineering	<u>3</u>
		9

Fourth Semester

2110xxx	Electives	6
2110798	Master Project in Software Engineering	3
2110896	Comprehensive Exam	=
		9

PH.D. DEGREE PROGRAM

NAME OF THE DEGREE

- : Doctor of Philosophy
- : Ph.D.

ADMISSION

The applicant must hold one of the following qualification :

A) Bachelor's Degree (Hons-2nd level or equivalent) or grade point not less than 3.25.

B) Master's Degree of Engineering or Science in Computer, Physics or Mathematics.

In addition he/she has to meet the Graduate School requirement.

DEGREE REQUIREMENTS

The program for Bachelor's Degree Holder, plan 2(1), consists of 12 credits of required courses including 4 non - credit seminars , 12 credits of elective courses ,and 48 credits of thesis , for a total of 72 credits.

The program for Master's Degree Holder, plan 2(2), consists of 4 non – credits seminars, 12 credits of elective courses, and 48 credits of Dissertation , for a total of 60 credits.

The student who has fulfilled the requirement of the program and of the Graduate School will be awarded the Degree of Doctor of Philosophy in Computer Engineering.

COURSE REQUIREMENTS

	<i>1) Required Courses</i>	12	credits
2110711	Theory of Computation		3(3-0-9)
2110712	Analysis of Algorithms		3(3-0-9)
2110713	Optimization Methods		3(3-0-9)
2110714	Digital Systems		3(3-0-9)
2110716	Seminar I		1(1-0-3)
2110717	Seminar II		1(1-0-3)
2110718	Seminar III		1(1-0-3)
2110719	Seminar IV		1(1-0-3)
	<i>2) Elective Courses</i>	12	credits
2110694	Directed Studies in Computer Science		3(3-0-9)
2110697	Special Topics in Computer Science I		3(3-0-9)
2110698	Special Topics in Computer Science II		3(3-0-9)
2110721	Software Metrics		3(3-0-9)
2110722	Software Project Management		3(3-0-9)
2110723	Advanced Software Engineering Development		3(3-0-9)
2110724	Software Testing and Quality Assurance		3(3-0-9)
2110730	Software Quality Process and Management		3(3-0-9)
2110731	Distributed Systems		3(3-0-9)
2110732	Parallel Computing		3(3-0-9)
2110741	Robotics		3(3-0-9)
2110742	Evolutionary Computation		3(3-0-9)
2110743	Machine Learning		3(3-0-9)
2110744	Machine Vision		3(3-0-9)
2110746	Big Data Analytics		3(3-0-9)
2110747	Social Network Analysis		3(3-0-9)
2110751	Computer Aided Design in Digital Systems		3(3-0-9)
2110752	Design for Testability		3(3-0-9)
2110753	Asynchronous Design		3(3-0-9)
2110771	Advanced Database Design		3(3-0-9)
2110772	Multi-Dimensional Database Systems		3(3-0-9)
2110773	Data Mining		3(3-0-9)
2110791	Advanced Topics in Software Engineering		3(3-0-9)
2110792	Advanced Topics in Artificial Intelligence		3(3-0-9)
2110793	Advanced Topics in Digital Systems		3(3-0-9)
2110794	Advanced Topics in Database Systems		3(3-0-9)
2110795	Advanced Topics in Computer Network		3(3-0-9)
	<i>1) Dissertation</i>		
2110828	Dissertation		48 credits
2110894	Doctoral Dissertation Seminar		0(0-0-0)
2110897	Qualifying Examination		0(0-0-0)

STUDY PROGRAMS

Plan 2 (1)

First Semester

2110716	Seminar I	-
2110 xxx	Required courses	<u>12</u>

12

Second Semester

2110717	Seminar II	-
2110 xxx	Electives	9
2110828	Thesis	<u>3</u>

12

Third Semester

2110718	Seminar III	-
2110 xxx	Electives	3
2110828	Thesis	<u>9</u>

12

Fourth Semester

2110719	Seminar IV	-
2110828	Thesis	<u>12</u>

12

Fifth Semester

2110828	Thesis	<u>12</u>
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12

Sixth Semester

2110828	Thesis	<u>12</u>
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Plan 2 (2)

First Semester

2110716	Seminar I	-
2110 xxx	Electives	<u>9</u>

Second Semester

2110717	Seminar II	-
2110 xxx	Electives	3
2110828	Thesis	<u>6</u>

Third Semester

2110718	Seminar III	-
2110828	Thesis	<u>9</u>

Fourth Semester

2110719	Seminar IV	-
2110828	Thesis	<u>9</u>

Fifth Semester

2110828	Thesis	<u>12</u>
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Sixth Semester

2110828	Thesis	<u>12</u>
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**COURSE DESCRIPTIONS IN
COMPUTER ENGINEERING (B.ENG.)**

2110101 Computer Programming 3(3-0-6)

Computer concepts, computer system components, hardware and software interaction, electronic information and data processing concepts; programming: data types, operators, statements, control structures; programming tools; programming styles and conventions; debugging; program design and development with applications to engineering problems using a high level language.

2110191 Innovative Thinking 3(3-0-6)

Condition : Free Elective

Definition of innovative thinking ; Types of innovation ; Innovator Role Model; Innovative thinking process; Creative mistakes; Innovation development.

2110200 Discrete Structures 3(3-0-6)

Sets, relations, functions, theorem and proof; combinatorics; counting, principle of inclusion exclusion, recurrent relations, generating functions; graphs and trees; introduction to number theory.

2110201 Computer Engineering Mathematics 3(3-0-6)

Linear algebra, vector, matrix, inverse matrix, solution to system of linear equations, factorization, vector space, subspace, rank, dimension, basis, orthogonality, projection, determinant, determinant computation, eigenvalue, eigenvector, singular value decomposition, computer programming for linear algebra.

2110211 Introduction to Data Structures 3(3-0-6)

Condition : Prerequisite 2110101

Linear allocation: array, stack, queue, dequeues; linked allocation: singly linked lists, and doubly linked lists; string processing and pattern matching; trees: binary tree, traversal, representation, B-tree and AVL-tree; internal searching and sorting: binary, radixes, shell, quicksort and merge sort; heap storage, hash coding and table handling.

2110213 Information Systems Organization 3(3-0-6)

Hardware systems: personal computer, network, Internet, internet protocol, domain name, cable, hub, switch, router, modem, Internet server, corporate server, real-time server, embedded system; application systems: multi-tier system, web server, markup language, application server, database server, query language, multi-vendor database access interface; transaction systems: process abstraction, inter-process communication, synchronization, deadlock, transaction atomicity, checkpoint and rollback, concurrency control.

2110215 Programming Methodology I 3(2-3-4)

Condition : Prerequisite 2110101

Programming methodology: object-oriented programming, event-driven programming, concurrent programming; error and exception handling; application programming interface (API); programming tools; programming styles and practice.

2110221 Computer Engineering Essentials 3(3-0-6)

Overview of computer engineering, information system and information technology; hardware and software; logic circuit and processor; algorithm and program; database; computer network and internet, artificial intelligence and robot; embedded system; data center; security; computer ethics; intellectual property; computer industry.

2110250 Computer Organization 3(3-0-6)

Computer systems organization, hardware components in a computer system, basic computer principles, instruction unit, instruction execution cycle, instruction set architecture, assembly language principles.

2110251 Digital Computer Logic 3(3-0-6)

Number systems; logic gates and logic expressions; Boolean algebra: Karnaugh map and tabulation method; combination logic circuit and applications: adder, subtractor, multiple outputs circuit, decoder, encoder, multiplexer and demultiplexer; gate implementation: tristate; speed and delay in logic circuits; sequential circuits and design; flip-flop, and counter; register.

2110253 Computer Electronics and Interfacing 3(3-0-6)

Principles of design; design of DC and AC circuits using diodes, bipolar junction transistors, field-effect transistors and use of transistors in digital circuits, physical design of simple gates, flip-flops, and memory circuits, interfacing logic families and standard buses.

2110254 Digital Design and Verification 3(3-0-6)

Condition : Prerequisite 2110251 or 2110254

Processor design at instruction set level and register transfer level; hardware description language (HDL); functional verification of HDL models; microprocessors; control unit; memory unit; adders; I/O device interfaces.

2110263 Digital Computer Logic Laboratory I 1(0-2-1)

Hands-on experience in using digital electronics by way of logic gates and integrated circuits; practical construction, testing, and implementation of combinational and sequential logic circuits.

2110265 Digital Design and Verification Laboratory I 1(0-2-1)

Condition : Prerequisite 2110251

Writing hardware description language (HDL) to implement digital designs, adder, arithmetic logic unit, control unit, memory modules, system integration, writing test benches to verify the design.

2110271 Programming Tools 3(2-2-5)

Source-code tools; executable-code tools; user-interface tools; code management tools; deployment tools; documentation tools; testing tools; integrated development environments.

2110291 Individual Study in Computer Engineering I 1(0-0-3)

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110292 Individual Study in Computer Engineering II 1(0-0-3)

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110313 Operating Systems and System Programming 3(3-0-6)

Condition : Prerequisite 2110211, 2110213 or 2110221

OS services: functions, organisation, process, concurrent programming, synchronisation, critical section, semaphore, monitor, deadlock, processor management, memory management, device management, file management, resource protection, and networking; service interfaces: system call, application programming interface (API); service development; tools and utilities: system management tools, development tools, and operation tools.

2110316 Programming Languages Principles 3(3-0-6)

Condition : Prerequisite 2110211

Language definition: grammar, syntax, and semantics; conventional paradigm: data type, control structure, block structure, and recursion; interpretive languages; runtime environment and virtual computer; unconventional paradigm: functional, logic, and markup languages; object-orientation and software components: class, instance, method, message passing, inheritance, method binding, polymorphism, framework, and component-based programming; basic compiling techniques: scanner, parser, code generation, and tools.

2110317 Fundamental of Distributed Systems 3(3-0-6)

Condition : Prerequisite 2110313

Interprocess communication and remote procedure call; Logical clock and ordering; centralised transaction and concurrency control; distributed transaction; two-phase commit protocol; distributed concurrency control; deadlock and distributed deadlock; load distribution; fault tolerance: fault model, recovery; replication: view and vector clock; distributed transaction under failure conditions; security; distributed services.

2110318 Distributed Systems Essentials 1(1-0-2)

Condition : Prerequisite 2110313 or Consent of faculty

Characteristics and system models: client/server, proxy, peer-to-peer; message passing: marshaling, request-reply protocol; distributed objects and remote invocation; time, clock, and ordering; group communication: basic, reliable, and ordered multicast; transaction and concurrency control; distributed transaction: two-phase commit, recovery; advanced topics: consensus, replication, Web services.

2110327 Algorithm Design 3(3-0-6)

Condition : Prerequisite 2110200, 2110211

Algorithm design techniques: divide and conquer, dynamic programming, greedy algorithms, state-space search; asymptotic analysis of algorithms; introduction to computational complexity; algorithm designs for NP-hard problems; backtracking, branch and bound, approximation algorithms.

2110332 System Analysis and Design 3(3-0-6)

Condition : Prerequisite 2110211

Data processing systems and systems life cycle; analysis methodology: tools, cost analysis, problem definition, proposal and feasibility study; design methodology: tools, database approach, systems design, file and form design, program design, documentation; implementation methodology: coding, testing and software maintenance.

2110333 Event-Driven Programming 3(2-2-5)

Condition : Prerequisite 2110101 or Consent of Faculty

Events, event queues, event focus, event handlers, event loop, callbacks, delegation; GUI and distributed environments; event-driven I/Os; windowing system; GUI programming; event-driven program interactions.

2110334 Network Programming 3(2-2-5)

Condition : Prerequisite 2110210 and 2110213 Consent of Faculty

Networking concepts; internet standards; sockets programming; web programming; client-server programming.

2110352 Computer System Architectures 3(3-0-6)

Condition : Prerequisite 2110250 or 2110253

Performance metrics; central processing unit; hardwired and microprogram of control units; instruction level parallelism : pipeline, superscalar; memory system: cache memory, virtual memory, disk array; development and future of architecture.

2110355 Formal Languages and Automata Theory 3(3-0-6)

Studies concepts of grammars, automata, languages, computability and complexity; the relationship between automata and various classes of languages; Turing machine and equivalent models of computation, the Chomsky hierarchy, context-free grammar, push-down automata, etc.; pumping lemmas and variants, closure properties and decision properties; parsing algorithms.

2110361 Hardware Synthesis Laboratory 2(0-4-2)

Condition : Prerequisite 2110264

Synthesis of digital systems on FPGA technology, use of hardware description language to model digital systems and implement the design on a programmable device, design decomposition, testing and debugging the design.

2110363 Hardware Synthesis LaboratoryI 1(0-2-1)

Condition : Prerequisite 2110265

Synthesis of digital systems on FPGA technology, use of hardware description language to model digital systems, testing and debugging the design.

2110388 Database Programming 4(2-4-6)

Condition : Prerequisite 2110210 and 2110213, Consent of Faculty

Structured query language (SQL), database connectivities; database programming tools and components; concurrency control; transactions processing; programming for database-backed site.

2110391 Individual Study in Computer Engineering III 1(0-0-3)

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110392 Individual Study in Computer Engineering IV 1(0-0-3)

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110398 Software Development Pre – Project 1(0-2-1)

Study and specifying topic, scope, methodologies of problem solving and expected benefit of various areas of software development project under project advisor's supervision. Project proposal is examined by a department committee. Written progress reports must be submitted and presented periodically.

2110399 Software Development Project 3(0-6-3)

Continuing of the approved project from Software Development Pre-Project course must be carried out under project advisor's supervision. Written progress report must be submitted periodically. A written final report is required and an oral examination must be taken with a department project committee at the end of the project.

2110401 Computer Engineering Professional Ethics 3(3-0-6)

Ethical theory; privacy; intellectual properties: patents, copyrights; computer crimes; professional codes of ethics; social issues; case studies.

2110412 Parallel Computer Architecture 3(3-0-6)

Condition : Prerequisite 2110211

Parallel architectures; parallel computation models; parallel algorithms; parallel programming and languages.

2110413 Computer Security 3(3-0-6)

Computer security principle; symmetric key cryptography; public key cryptography; message digest; authentication: access control; enterprise security; network security.

2110414 Large Scale Computing Systems 3(3-0-6)

High-performance and large-scale computing infrastructure: cluster, peer-to-peer, Grid, Cloud; virtualization; software architecture and middleware; HPC applications and algorithms; HPC software development.

2110420 Compiler Construction 3(3-0-6)

Grammar, syntax, and semantics; lexical analysis; parsing methods; symbol table construction; intermediate representation; code generation; basic and advanced code optimization techniques.

2110421 Theory of Programming Languages 3(3-0-6)

Data and control abstractions; binding; type checking; advanced control constructs, backtracking and nondeterminism; formal methods for program description, formal syntax and formal semantics; methods for proving programs correctness.

2110422 Database Management Systems Design 3(3-0-6)

Condition : Prerequisite 2110200, 2110211

Database concepts: goals, data independence, relationships, logical and physical organizations, schema and subschema; data models: hierarchical, network, and relational models; data normalization: first, second, and third normal forms of data relations; canonical schema, data independence; data description languages; query facilities: relational algebra, relational calculus, data structures for establishing relations, query functions, design and translation strategies; file organization, file security; data integrity and reliability.

2110423 Software Engineering 3(3-0-6)

Design tools and techniques; top-down design, modular design, software tools, debugging and test

data; software reliability, theory and concepts, errors, faults and estimation, reliability models, availability models; management techniques, cost estimation, software maintenance.

2110424 Software Process Improvement 3(3-0-6)

Condition : Consent of Faculty

Software process improvement premise; software process modeling; foundation and infrastructure of software process improvement; approach for transitioning to process improvement program; quality assurance components in software project life cycle; software engineering process group; software process and product measurement.

2110428 Introduction to Data Mining 3(3-0-6)

Fundamental concepts of data mining; data mining methodologies, decision trees, classification, association, clustering; data mining algorithms.

2110429 Information Retrieval Systems 3(3-0-6)

Condition : Prerequisite 2110211

Information structures; dictionary systems; statistical systems; vector matching and searching strategies; input specifications and systems organization; output systems; evaluation; automatic question answering.

2110430 Time Series Mining and Knowledge Discovery 3(3-0-6)

Time series mining: classification, clustering (shape-based/model-based), association rules, summarization/visualization, anomaly detection, motif discovery; similarity measurement: dynamic time warping; distance measure; data preprocessing; time series indexing; time series representation and dimensionality reduction.

2110431 Introduction to Digital Imaging 3(3-0-6)

Overview of theory of digital image processing and analysis: definition of terms, basic principles of human visual perception, image representation, preprocessing, image enhancement, image segmentation, feature extraction and analysis, image compression; survey of applications.

2110432 Automatic Speech Recognition 3(3-0-6)

Condition : Consent of Faculty

Overview of speech and language technology; human speech production models; spectrogram; speech sounds in languages and spectrogram reading; speech representation; template matching using dynamic time warping; acoustic modeling; frame-based speech recognition using Hidden Markov models; language modeling; examples of other approaches to automatic speech recognition.

2110433 Computer Vision 3(3-0-6)

Image formation; feature detection; color; texture; region segmentation and representation; object recognition; dynamic vision; 3D vision; vision applications.

2110435 Introduction to Robotics 3(3-0-6)

An overview of robotics technology; introduction to the configuration space concept, rigid transformation and manipulator kinematics; sensing and control; robot programming; robot motion planning and application; robot manipulation.

2110441 Software Design and Development 3(3-0-6)

Design techniques : models of structured programming, code reading and correctness, stepwise refinement and reorganization, top-down design and development, structured design, strength, and coupling measures; organization and management: milestones and estimation, chief programmer teams, program libraries, walk through, and documentation; team project: organization, management and development of large scale software.

2110442 Object-Oriented Analysis and Programming 3(3-0-6)

Object-oriented design and object-oriented software construction; design and construct : classes, methods, messages, instances, inheritance, static and dynamic binding, replacement and refinement and polymorphism analyze : frameworks and design patterns, and object-oriented software engineering.

2110443 Human-Computer Interaction 3(3-0-6)

Condition : Prerequisite 2110101

HCI design, implementation and evaluation; graphical user interface programming; prototyping tools and toolkits; window-based systems; usability engineering.

2110444 Introduction to Formal Verification 3(3-0-6)

Condition : Prerequisite 2110200

Fundamental concepts of mathematical logic; formal specification language definition : syntax, semantics; formal specification language: Z, Object Z, CafeOBJ; mathematical models of software and hardware; formal verification methods.

2110445 Enterprise information Systems 3(3-0-6)

Condition : Consent of Faculty

Enterprise information systems; information technology infrastructure and integration; impact of information systems on organizations; information technology and business strategies; e-business and e-commerce; ethical and social issues related to technology; technology decisions; business value of information systems.

2110451 Digital Computer Hardware Design 3(3-0-6)

The principles of design of modern digital computers; especially in the simple and advanced microprogrammed control unit; ALU design, carry look-ahead and multiplication and division algorithms.

2110455 Testing Digital Circuits 3(3-0-6)

Testing techniques for digital logic circuits; fault modelling; test generation; test evaluation; testability analysis; design for greater testability; automatic test

equipment; IDDQ testing; writing simulation programs, current research issues on testing.

2110471 Computer Networks I 3(2-3-4)

Condition : Prerequisite 2110221

History and Overview of Computer Networks, Network Architecture and Protocol, LAN and WAN, Client-Server and Peer-to-Peer Computing, Data Security and Integrity, Wireless and Mobile Computing.

2110473 Fault Tolerant Computing 3(3-0-6)

Fault model; test generation of combinational and sequential circuits: Boolean difference, path sensitization and algorithm; digital simulation technique; design of self checking circuit; error detection and correction codes redundancy techniques; diagnosis of digital system and design of simplified testing.

2110475 VLSI Design 3(3-0-6)

Integrated circuit technology; design and implementation of very large scale integrated circuits including design methodology: design using stick diagram; the use of CAD tools including layout generators, simulators, and plot utilities; I/O pads; study of some digital subsystem, digital architecture and design styles; Fabrication processes; criterion for foundries; case study of some custom design integrated circuits.

2110476 Artificial Intelligence I 3(3-0-6)

Philosophy of mind, knowledge and reasoning, agent-based systems, planning perception, robotics: sensing, navigation & control, introduction to evolutionary computation.

2110477 Artificial Intelligence II 3(3-0-6)

Definition of Artificial Intelligence problem solving by search, knowledge representation, natural language processing, Prolog programming, machine learning, neural networks.

2110478 Computer and Communication 3(3-0-6)

Introduction: computer and communication technology; Communication and network model: Shannon and Weaver model, ISO-OSI model, LAN, and Inter/Intranet; System component: modem, multiplexer, interface, and repeater/bridge/router/switch; Resource management and error control; Data security: natural disaster and vandalism.

2110479 Computer Graphics 3(3-0-6)

The fundamentals of computer imagery; modeling ; curve, surface, geometric primitives 2D and 3D geometric transformations, rendering: clipping and windowing, scene, algorithms for visible surface determination, introduction to local and global shading models, color, and real-time rendering methods; presentation of projects in computer graphics engineering.

2110481 Wireless Computer Networks 3(3-0-6)

Condition : Prerequisite 2110478

Digital transmission; queueing theory, mobile IP internetworking, IPv6, DHCP, proxy service.

2110482 High Technology Entrepreneurship 3(3-0-6)

This is a course focused on the student participating in the building business plan for new venture that create or use a new technology to create significant new value.

2110490 Computer Engineering Pre-Project 1(0-2-1)

Determination of topics or problems; scope, methodologies of problem solving and expected benefit from various areas of computer engineering projects under the supervision of a project advisor; examination of project proposal; periodical writing of progress reports and report presentation.

2110491 Topics in Systems and Languages 3(3-0-6)

Condition : Prerequisite 2110421

Current interest and new developments in the areas of software systems, theory of programming languages and translations.

2110492 Topics in Operations Systems 3(3-0-6)

Condition : Prerequisite 2110411

Topics of current interest and new developments in the areas of operating systems, modeling, performance analysis, utility systems.

2110493 Topic in Database Management Systems 3(3-0-6)

Condition : Prerequisite 2110422

Topics of current interest and new developments in the areas of database management systems, information systems and data dictionary.

2110495 Advanced Topics in Computer Engineering I 3(3-0-6)

Condition : Senior Standing or Consent of instructor

Topics of current interest and new developments in various fields of computer engineering.

2110496 Advanced Topics in Computer Engineering II 3(3-0-6)

Condition : Senior Standing or Consent of instructor

Topics of current interest and new developments in various fields of computer engineering.

2110497 Special Problems in Computer Engineering I 3(2-3-4)

Condition : Senior Standing or Consent of instructor

A study of investigation of special problems assigned by the instructor with the consent of the head of department. The work must be completed within one semester. A written report, a copy of which is to be kept by the department, is required and an oral examination must be taken.

2110498 Special Problems in Computer Engineering II 3(2-3-4)

Condition : Senior Standing or Consent of instructor

A study of investigation of special problems assigned by the instructor with the consent of the head of department. The work must be completed within one semester. A written report, a copy of which is to be kept by the department, is required and an oral examination must be taken.

2110499 Computer Engineering Project 3(0-6-3)

Condition : Prerequisite 2110490

Continuing of approved project from course 2110490 must be carried out under project advisor's supervision. Written progress reports must be submitted periodically. A written final report is required and an oral examination must be taken with a department project committee at the end of project.

COURSE DESCRIPTIONS IN COMPUTER ENGINEERING (M.ENG., M.SC., PH.D.)

2110501 Automata Computability and Formal Languages 3(3-0-9)

Finite states concepts: regular expressions, closure properties, sequential machines and finite state transducers. state minimization; formal grammars: chomsky hierarchy grammars, pushdown acceptors and linear bounded automata, closure properties and algorithms on grammars; computability and Turing machines as acceptor and transducer, universal machine, computable and noncomputable functions, and halting problem.

2110502 Formal Verification 3(3-0-9)

Mathematical logic and temporal logic; formal models: identifying problem domain and building the formal models of concurrent system and/or asynchronous system; verification of the formal models: model checking; verification modeling language and tools: Petri Nets, signal transition graph, Promela and SPIN.

2110505 Distributed Systems 3(3-0-9)

Definition; interprocess communication; logical clock; concurrency control: two-phase locking, optimistic, timestamp ordering; distributed transaction, atomic commit protocol; deadlock: detection, prevention, avoidance, distributed detection; scheduling; reliability; fault tolerance, replication, recovery; security; distributed services: name, file, distributed management; standards and cases.

2110511 Game Programming 3(3-0-9)

Condition : Consent of Faculty

Theory of game design; graphics programming; computer graphics model; data structure for game programming; online game.

2110512 Computer Animation 3(3-0-9)

Condition : Consent of Faculty

Techniques and algorithms in computer-generated animation; vector algebra; numerical techniques; 2D and 3D animation programming; motion specification : shape interpolation algorithms and models for rule-and constraint-based motion generations.

2110513 Assistive Technology 3(3-0-9)

Background, issues, and research in assistive technology, application of IT in designing and developing software application; tools, or programs to the need of disabled or the elderly to increase their independence and improve their quality of life.

2110521 Software Architectures 3(3-0-9)

Condition : Consent of Faculty

Principles of software architectures; practical methods in software architectures using scenario-based analysis, heuristic, and formal approaches; architectural styles; architectural description language; software architectural analysis and design; software architectures specification tools; software architecture-based testing; use of software architectures in the software development process.

2110522 UNIX/Linux for Enterprise Environment 3(3-0-9)

Historical perspectives; branches and distributions; main characteristics and components; subsystems and supports; advancements; server: performance considerations, monitoring, and tuning; desktop: distros, usability, and compatibility; administration and installation practices.

2110523 Enterprise Application Architecture 3(3-0-9)

Foundation concepts of enterprise architecture; analysis and design of enterprise application; UML profile specification, design quality metrics; patterns of enterprise application architecture: structure, constraints and limitation of the patterns; enterprise applications integration techniques and implementation: presentation, data, application level integration approach and their implementations; best practices and enterprise architecture modelling standards and tools.

2110541 Computer Systems Audit 3(3-0-9)

Design of information system; internal control and auditing of data; validity; reliability; security and protection.

2110579 Computer Graphics Systems 3(3-0-9)

Architectural aspects of modern GPUs, programming on GPU: high level languages for GPU programming, GPU applications for graphics and general purposes : geometry modelling, physical simulation scientific computing and games.

2110605 Computer Programs Structure 3(3-0-9)

High-level structured programming languages; data types and operations; control structures; subprograms; records, sets, pointers and dynamic memory allocations; recursive programming; non-numerical

problem solving techniques; problem analysis and program design; introduction to software engineering.

2110606 Research Methods in Computer Engineering 3(3-0-9)

Research methods in Computer Engineering; Research techniques and tools; Project and time management; Technical paper writing; Oral presentation; Current research topics.

2110607 Research Methods in Computer Science 3(3-0-9)

Research methods in Computer Science; research techniques and tools in Computer Science; project and time management; academic writing; oral presentation; code of conduct for researchers; current Computer Science research topics.

2110611 Information Processing and Computer System 3(3-0-9)

Introduction to information processing concepts, processing methods, computer development and applications; classification and architecture; data communications and computer networks; computer center management.

2110612 System Programming 3(3-0-9)

Components of a programming system; evolution of operating systems; design of assembler, macro language, macro processor, loader schemes; types of loaders; design of loaders.

2110614 Programming Languages and Compilation 3(3-0-9)

Language structures data, operation, control structures; software-simulated computer; language translation lexical analysis, and parsing, and code generation; other language methodologies list processing, logic programming, object-oriented programming.

2110621 System Analysis and Design 3(3-0-9)

Basic analysis steps, determining system alternatives, determining system economics, defining logical system requirements, basic design tools and objectives; hardware and software: selection and evaluation; design and engineering of software; database development, program development, system implementation, post implementation analysis.

2110622 Data Management 3(3-0-9)

List structures: lists, stacks, queues; table and hash in tree structures: binary search trees, AVL trees, B- trees, heaps; searching and sorting; fundamental of file structures

2110623 Software Requirements Engineering 3(3-0-9)

Methods, tools, notations, and validation techniques for the elicitation, analysis and specification of software requirements; investigating the project or applying approaches to software requirements engineering.

2110624 Software Engineering 3(3-0-9)
Fundamental areas of software engineering: life cycle, paradigms, metrics, and tools; management techniques; cost estimation; software maintenance methodologies; incremental programming; very high level languages.

2110629 File Management 3(3-0-9)
Introduction to data management, files, and applications; an overview of input/output system architecture; logical file organizations; mapping logical organization onto physical storage; operating systems; file system interface; higher level languages; data management facilities.

2110631 Operating System 3(3-0-9)
Evolution, types, goals, functions and organization: concepts of process; process synchronization; process management; memory management; device management; file management;

2110632 Advanced Topics in Operating Systems 3(3-0-9)
Condition: Consent of Faculty
Advanced and current topics in Operating Systems.

2110634 Software Design and Development 3(3-0-9)
Techniques of software design and development: project management, structured programming, verification and validation, security and privacy, and project documentation; students are required to apply these techniques to large software projects.

2110636 Performance Analysis and Evaluation 3(3-0-9)
Performance metrics; performance measurements; benchmarking; workload characterization; summarizing measured data; introduction to queuing theory; single queue analysis; introduction to simulation; analysis of simulation results.

2110637 Large-Scale Information Systems 3(3-0-9)
System framework; middleware; service-oriented architecture; large-scale services; scalable data services; cloud computing; cluster architecture and system; management distributed algorithms; map-reduce architecture; volunteer computing.

2110638 Object-Oriented Technology 3(3-0-9)
Object orientation concepts and software development; object-oriented programming language implementation; software development frameworks; design patterns; design heuristics; design flaws; aspect-oriented programming; case studies; current topics in object-oriented technology.

2110639 Computer System Security 3(3-0-9)
Security system planning and administration; access control; data encryption; computer crime protection; disaster recovery planning; security models; including Orange book, and RACF

2110640 Information Security 3(3-0-9)
Information security models: confidentiality; integrity; authentication software security; network security; privacy; security management security; related laws and regulations.

2110642 Object-Oriented Software Engineering 3(3-0-9)
An overview of object-oriented technology concepts on objects, classes, inheritance, polymorphism, and relationship between classes; software development process, software configuration management, software quality assurance, object-oriented project planning and management, object-oriented analysis and design methodologies, object-oriented programming and object-oriented software testing and maintenance, use of CASE tools.

2110644 Formal Software Specification 3(3-0-9)
Mathematical Logic: Set, Relation, Function, Predicate Calculus, Algebraic system; Formal software specification language: Z, CafeOBJ; Identifying problem domain; Design and software modeling; Formal software specification method; Consistency verification of formal specification and its proof; Utilization of formal software specification in software process.

2110645 Software Engineering Methodology 3(3-0-9)
Software engineering process concepts; context for personal software process; planning and measurement concepts; software size measurement; general size estimating methods; resource and schedule estimation; process measurement; design and code reviews; software quality management.

2110646 User Interface Design 3(3-0-9)
Foundations of user-interface; human-centered software evaluation; software development; graphic user-interface design; graphic user-interface programming; multimedia systems.

2110651 Digital Image Processing 3(3-0-9)
Visual perception, digitization and coding of images, converting pictures to discrete(digital) forms; image enhancement; image restoration including improving degraded low-contrast, blurred, or noisy pictures; image compression : data compression used in image processing; image segmentation referred to as first step in image analysis.

2110654 Artificial Intelligence 3(3-0-9)
Definitions and application of artificial intelligence; knowledge representation; Prolog programming; natural language processing; machine learning techniques.

2110657 Computer Simulation 3(3-0-9)
Monte Carlo simulation; discrete event simulation and implementation techniques, queueing theory; equilibrium and steady state; input/output analysis; random numbers; output measurement; simulation accuracy; trace and execution-driven simulation;

computer system simulation; continuous system simulation; combining continuous and discrete-event simulation

2110661 Computer Network 3(3-0-9)

Introduction to network and network components; transmission links and protocols; design and analysis of networks; WAN; IMP; topology; network protocols; flow control and routing techniques.

2110662 Communication and Computer Network 3(3-0-9)

Network components; transmission links and protocols; design and analysis of networks; WAN; IMP; topology; network protocols; flow control and routing techniques.

2110663 Worldwide Network Infrastructure 3(3-0-9)

Background and history of networks and the internet; principles of network applications, protocols, services, socket programming; client/server and peer-to-peer paradigms; reliable data transfer; congestion control; the Internet Protocol (IP); routing in the internet; multimedia networking; wireless and mobile networks; large-scale and global networks; next generation networks.

2110664 Network Management 3(3-0-9)

Condition: Consent of Faculty

Information systems environment, business, and networks; network management data integrity, data security, network availability, network service, network adaptability.

2110665 Computer Communication System and Standards 3(3-0-9)

Introduction to computer and communication systems: on-line system, computer networks, distributed processing; communication model: OSI Standard; networks and standards: ISDN, X.25.

2110671 Database Management Systems 3(3-0-9)

Definition, objectives, and basic concepts information storage and retrieval system; data management system; data management functions and components of database management system: database interrogation, update; data model; security policy; major trade-offs in database management; introduction to object oriented database.

2110672 Data Modeling Techniques 3(3-0-9)

Data modelling concepts; conceptual objects used on simple and complex abstraction level: entity and entity set, entity attributes, relationship and relationship sets, relationship attributes, domain; normalization of relation: 1NF, 2NF,3NF,4NF and 5NF; conceptual data modeling: entity-relationship,data flow,logical and physical model, transformation of the logical model into a physical model,and functional design; object-oriented design concept.

2110673 Information Storage and Retrieval 3(3-0-9)

Models and methods for storage and retrieval of information; Topics include information retrieval

techniques, text analysis and automatic indexing, document clustering, search techniques, retrieval performance measurement, and search mechanisms for retrieval from the World Wide Web.

2110674 Information Technology Center Management 3(3-0-9)

Organization of the Information-Technology Center, computer personnel; nature of the users; software development tools; computer site operation; personnel management; systems software tuning; hardware evaluation; problems facing the director of the center.

2110678 Mobile Computing 3(3-0-9)

Principles, technologies and applications of mobile computing and wireless networks; mobile and wireless environment; protocols and architecture of mobile computing; mobile device technology; mobile computing security; application of distributed system in mobile computing; mobile middleware; mobile information and database access; mobile computing platforms; Web-based mobile application development.

2110681 Computer Algorithm 3(3-0-9)

Analysis and design of efficient algorithms; divide and conquer, recursion, dynamic programming and greedy algorithm; selection of appropriate data abstraction; analysis and correctness of algorithms; algebraic algorithms; combination problems; proving techniques for complexity analysis.

2110682 Embedded and Real-time Systems 3(3-0-9)

Microcontroller architecture (RAM, ROM, CPU), I/O, and peripheral devices, I/O interfacing, real-time operating systems, real-time constraints, scheduling theory, real-time system design methodology, case studies.

2110683 Concurrent Processing 3(3-0-9)

Principles of distributed, parallel and concurrent systems, parallel architecture and concurrent computing models; concepts of networks protocols for concurrent processing, operating systems and hardware support for distribution of codes, concurrent processing, parallel processing and networking.

2110684 Information System Architecture 3(3-0-9)

Hardware systems: personal computers, network equipment, servers, clusters and super servers, embedded system; application systems: multi-tier systems, markup language, query language; transaction systems: process abstraction, inter-process communication, synchronization, deadlock, transactions, concurrency control; Web-based applications; global systems.

2110685 Computer Application in Enterprises 3(3-0-9)

Business transaction; processes and organisation; information and business decision; human resources and knowledge management; data warehousing.

2110686 Enterprise Computing	3(3-0-9)	2110716 Seminar I	1(1-0-3)
IT infrastructure; management; stability, efficiency and responsiveness; theoretical and practical aspects of systems management; discipline in data centres; development, integration, and management of IT processes; business-support functions; enterprise services; information systems services.		Seminar in the assigned topics on current experiment and / or research on computer engineering.	
2110694 Directed Studies in Computer Science	3(3-0-9)	2110717 Seminar II	1(1-0-3)
Study of current interest and new developments in various fields of computer science.		Seminar on current experiment and / or research on computer engineering concerning theses.	
2110696 Advanced Topics in Computer Application	3(3-0-9)	2110718 Seminar III	1(1-0-3)
Current advanced topics and technologies in computer applications.		Seminar on current experiment and / or research on computer engineering concerning theses.	
2110697 Special Topics in Computer Science I	3(3-0-9)	2110719 Seminar IV	1(1-0-3)
Current special topics and new technologies in computer science.		Seminar on current experiment and / or research on computer engineering concerning theses.	
2110698 Special Topics in Computer Science II	3(3-0-9)	2110721 Software Metrics	3(3-0-9)
Current special topics and new technologies in computer science.		Theoretical foundations of software metrics; data collection; experimental design and analysis; software metric validation; measuring the software development and maintenance process; measuring software systems; support for metrics; statistical tools; applications of software measurement.	
2110701 Seminar in Computer Engineering I	1(0-3-1)	2110722 Software Project Management	3(3-0-9)
Seminar in Computer Engineering about the thesis and assignments.		Concepts of software product and process quality; roles of Total Quality Management (TQM); use of metrics, feasibility studies; cost and effort estimates; discussion of project planning and scheduling; the Capability Maturity Model; basis tenets and application of process validation.	
2110702 Seminar in Computer Engineering II	1(0-3-1)	2110723 Advanced Software Engineering Development	3(3-0-9)
Seminar in Computer Engineering about the thesis and assignments.		Software development process improvement; a series of individual programming and process projects; project planning measurement size estimation task scheduling and defect clarification.	
2110711 Theory of Computation	3(3-0-9)	2110724 Software Testing and Quality Assurance	3(3-0-9)
Computable functions decidable predicates and solvable problems; computational complexity; NP-complete problems; automata theory; formal language; lambda calculus.		Technical and management views of software testing and SQA; quality concepts; black and white box testing techniques; test coverage; levels of testing; the formation of a testing organization; testing-in-the-large; documentation for testing; inspections and walkthroughs.	
2110712 Analysis of Algorithms	3(3-0-9)	2110725 Software Engineering Process and Improvement	3(3-0-9)
Algorithm complexity and problem complexity; discrete mathematics real analysis, and combinatorics; algorithms and data structures; average-case worst-case and amortized analysis.		<i>Condition : Consent of Faculty</i> Process definition; software engineering process model; process implementation and change; process quality assessment; process and product measurement; software engineering process standards such as IEEE and ISO Standards.	
2110713 Optimization Methods	3(3-0-9)	2110726 Software Configuration Management	3(3-0-9)
Dynamic optimization; mathematical programming; least square methods; gradient methods; Newton's method; linear programming; nonlinear programming; discrete optimizations.		<i>Condition : Consent of Faculty</i> Software configuration management (SCM) process; SCM planning; configuration management plan; SCM measures; software configuration identification; software change request process; software configuration status	
2110714 Digital Systems	3(3-0-9)		
Digital system architecture; logic elements, processor, compilers, operating systems; digital abstraction, synthesis of digital systems; performance measures; interpretation; micro architecture; memory architecture; processes; multiplexing; synchronization; interrupts; real time systems.			

reporting; software configuration auditing; software release management and delivery.

2110727 Software Evolution and Maintenance 3(3-0-9)

Condition : Consent of Faculty

Basic knowledge on software evolution; software comprehension and software maintenance; definition of software evolution and maintenance; laws of software evolution; maintenance categories; maintenance process and process models; maintenance metrics and testing; impact analysis; software rejuvenation; software maintainability.

2110728 Special Topics in Software Engineering I 3(3-0-9)

Condition : Consent of Faculty

Current advanced topics and new technologies in software engineering.

2110729 Special Topics in Software Engineering II 3(3-0-9)

Condition : Consent of Faculty

Current advanced topics and new technologies in software engineering.

2110730 Software Quality and Process Management 3(3-0-9)

Software quality basics; quality tools; software life cycle processes and process assets establishment; process management premise; process improvement models; improvement paradigms; quality management in process improvement context; configuration management; measurement information model.

2110731 Distributed Systems 3(3-0-9)

Characterization and models of distributed systems; remote communication between system components; distributed applications; transactional applications; concurrency control of transactions; coordination between system components: global system state, time synchronization, access to shared resources, ordering of exchanged messages, agreement; fault tolerance; data replication; system recovery; current distributed systems and related issues; current research topics.

2110732 Parallel Computing 3(3-0-9)

Architectures in parallel computing : shared/distributed memory, SIMD/MIMD architecture, interconnection networks, granularity of the machines, dataflow and systolic arrays computers; parallel processing : pipelining and parallelism, software for parallel computers.

2110741 Robotics 3(3-0-9)

A broad view of robotics : robot control, sensors and interfacing, robot intelligence and programming; a broad spectrum of disciplines : mechanical, electrical, industrial, and computer engineering; current topics : planning, subsumption architecture, reactive systems.

2110742 Evolutionary Computation 3(3-0-9)

Computer algorithms gleaned from the model of biology; algorithms inspired by organic evolution : genetic algorithms, classifier systems, genetic programming and evolution strategies; theoretical basis of these algorithms.

2110743 Machine Learning 3(3-0-9)

Computing with logic; using logic set theory, number theory, algebras graph theory, automata; language of first order logic, model theory and logic programming; problems of inductive inference in the framework of first-order predicate calculus and the probability calculus; introduction of computational learning theory.

2110744 Machine Vision 3(3-0-9)

Low-level vision and higher-level techniques : binary machine vision, morphology, neighborhood operators, labeling, texture, region segmentation, feature extraction, motion, image matching, model matching and knowledge-based vision systems.

2110745 Cryptography 3(3-0-9)

Introduction; symmetric encryption; block ciphers; pseudorandom permutations and pseudorandom functions; one-way functions; pseudorandom generators; hash functions; message authentication; authenticated encryption; asymmetric encryption; digital signatures; authenticated key exchange; interactive proofs and zero knowledge.

2110746 Big Data Analytics 3(3-0-9)

Introduction to Big Data Analytics, Hadoop, MapReduce, Spark, Programming Languages for Big Data Analytics, Search and Indexing, Recommendation System, Regression, Classification, Clustering and Feature Selection.

2110747 Social Network Analysis 3(3-0-9)

Social networks definition; types of social networks; Social Network Representation by Computational Models; Random Network Models; Network Centrality; Clusters in Social Networks; Small World Models; Data Retrieval from Social Networks Data Analysis and Classification from Social Networks; Application examples, such as an analysis for enterprises.

2110751 Computer Aided Design in Digital Systems 3(3-0-9)

Layout editing; schematic datacapture; simulation; design rule checking; automatic placement and routing; logic synthesis for combination and sequential circuits; logic synthesis for architectural design; formal method for specifications.

2110752 Design for Testability 3(3-0-9)

Methods of design for testability; digital chip design for automatic testing equipment; ad hoc rules and structured method called scan design; fault analysis; controllability; observability; Scan-In Scan-Out (SISO) principle; Level Sensitive Scan Design (LSSD); built-in testing and other current techniques.

2110753 Asynchronous Design 3(3-0-9)
 Design of digital systems not using global clock; limitation to synchronous processor; hazard analysis; Fundamental of asynchronous logic design; delay assumption; signaling protocol; asynchronous communication; Petri net; signal transition graph; completion detection; data and control paths implementations.

2110771 Advanced Database Design 3(3-0-9)
 Fundamental of database design : data modeling, relational theory, query language, dependency theory; query optimization, computing with logic and universal relation.

2110772 Multi-Dimensional Database Systems 3(3-0-9)
 Modern multi-dimensional database systems : spatial databases, temporal databases, multimedia databases; algorithms and data structures : R-tree, R+ tree, R* tree, quad-tree, spatial and temporal reasoning, disk clustering and declustering.

2110773 Data Mining 3(3-0-9)
 Overview of data mining; process of knowledge discovery in large databases; applications of data mining to real-world problems; data preprocessing; data warehousing and OLAP; data mining methods: association, classification, clustering

2110779 Advanced Topics in Computer Graphics 3(3-0-9)
 In-depth study of selected current and interesting topics in computer graphics; hardware architecture, graphics systems, picture/image generation, graphics utilities, computational geometry and object modeling, methodology and techniques, three-dimensional graphics and realism and current applications.

2110781 Special Topics in Distributed Systems 3(3-0-9)
 Current topics, related researches, and technology trends in distributed systems.

2110791 Advanced Topics in Software Engineering 3(3-0-9)
 State of the art and current interest in software engineering.

2110792 Advanced Topics in Artificial Intelligence 3(3-0-9)
 In-depth study of the current and interesting topics in artificial intelligence : problem solving, search, heuristic methods, machine learning, knowledge representation, natural language processing, computer vision, expert systems, theorem proving and current applications.

2110793 Advanced Topics in Digital Systems 3(3-0-9)
 State of the art and current interest in digital systems.

2110794 Advanced Topics in Database Systems 3(3-0-9)
 State of the art and current interest in database systems.

2110795 Advanced Topics in Computer Network 3(3-0-9)
 State of the art and current interest in computer network.

2110797 Per-Master Project in Software Engineering 3(0-0-12)
Condition : Consent of Faculty
 Integration of software engineering principles to prepare for software engineering project to get the output which in the project proposal.

2110798 Per-Master Project in Software Engineering 3(0-0-12)
Condition : Prerequisite 2110797
 Integration of software engineering principles for software engineering project.

2110799 Master Project 6(0-0-24)

2110811 Thesis 12 Credits

2110814 Thesis 24 Credits

2110816 Thesis 36 Credits

2110828 Dissertation 48 Credits

2110894 Doctoral Dissertation Seminar 0(0-0-0)

2110896 Comprehensive Examination 0(0-0-0)

2110897 Qualifying Examination 0(0-0-0)

COURSES OFFERED TO STUDENTS OUTSIDE FACULTY OF ENGINEERING ONLY :

2110102 Computer Programming – Fortran
 Computer systems, problem-solving procedures, algorithms, control structures, data types, vector, array and record, string manipulation. Coding, compiling and linking Fortran programs, constants and variables, operators and expressions, assignment statements, control statements, functions and subprograms, numeric and character applications.

2110103 Computer Programming-Pascal
 Computer systems, problem-solving procedures, algorithms, control structures, data types, vector, array and record, string manipulation. Pascal data types, variables, operators, expression, assignment statement, identifiers, program structure, input, output and control statements, procedures and functions composited data types, files.

2110104 Computer Programming – C

Computer system, problem-solving procedures, algorithms, control structures, data types, vector, array and record, string manipulation. C programming concepts, constants, variables, operators and expressions, statements, functions, array and pointer, structure, preprocessor.

2110172 Information Technology 3(2-2-5)

Application software packages: word processing, spreadsheet, presentation and database software; utility software; basic computer system management: backup and restore, software installation and uninstallation.

2110182 Introduction to computer and data Processing 2(2-0-4)

An overview of computer components, hardware and software interaction: basic data processing concepts, data transformation, method of data processing, data communication and programming concepts.

2110183 Introduction to Computer and Programming 3(3-0-6)

An overview of computer components, hardware and software interaction, EDP concepts: programming concepts and introduction to FORTRAN programming.

2110206 Assembly Language Programming 3(2-2-4)

This course will emphasize hand-on experience with Assembly language programming, loader, assembler and I/O devices.

2110281 Basic Programming 2(1-2-3)

Overview of elements of Basic Language, including BASIC statements: arithmetic, input and output, flow of control, subprogram; file processing; sequential access, and random access; application programs in various fields.