Memorandum of Understanding
Between
Posts & Telecommunications Institute of Technology
And
College of Staten Island, The City University of NewYork

This Memorandum of Understanding ("MOU") is between Posts & Telecommunications Institute of Technology (" PTIT") located at 122 Hoang Quoc Viet Road, Nghiatan, Caugiays,Hanoi, Vietnam; and the College of Staten Island of The City University of NewYork ("CSI/CUNY"), located at 2800 Victory Boulevard, Staten Island, NY 10314, United States of America ("USA").

WHEREAS, PTIT is one of the top universities in Vietnam specialized in info-communications technology, telecommunications, which enjoys global recognition; and

WHEREAS, CSI/CUNY is a leading research institution in The City University of New York and in the USA with a high academic reputation in the world; and

WHEREAS, PTIT and CSI/CUNY ("Parties") intend to create an Articulation between PTIT and CSI/CUNY for programs of study in Computer Science and Computer Engineering (the "Program") in Hanoi, Vietnam and NewYork, USA in order to recruit, educate and graduate students earning baccalaureate degrees through the Program;

THEREFORE, PTIT and CSI/CUNY will agree as follows:

1. Principles

- The goal of the Program is to meet the demands of Vietnam's economy and promote international academic and educational exchanges between the Parties.
- The purpose of the Program is to introduce international educational standards as well as up-to-date and interdisciplinary subjects and curricula into PTIT's undergraduate programs.
- Students graduating from the Program shall meet the graduation standards of CSI/CUNY and earn baccalaureate degrees from CSI/CUNY upon graduation.
- The Program is based upon the concept of equal partnership and mutual benefits between PTIT and CSI/CUNY.

- The Program will consist of courses taken at PTIT and also at CSI/CUNY based on curriculum as outlined below in item 6 and Appendix A, attached hereto.

2. Responsibilities of PTIT

- Approval of academic programs according to its criteria; provision of teaching staff;
- Use of CSI/CUNY and PTIT curricula, teaching materials and intellectual property in accordance with its requirements;
- Submission of application to the Ministry of Education and Training and subsequently obtain approvals for the Program;
- Provision of and access to academic and associated facilities at Hanoi campus and other campus sites as necessary.

3. Responsibilities of CSI

- Approval of academic programs according to its criteria; provision of teaching staff.
- Use of CSI/CUNY curricula, teaching materials and intellectual property in accordance with its requirements.
- Award of CSI/CUNY degree with rights and privileges accorded to students graduating from CSI/CUNY's own programs;
- Access to library, learning and other resources via the Internet; necessary approvals in the USA;
- Access to CSI/CUNY programs by PTIT students subject to CSI/CUNY admission qualifications; and
- Usage of telecommunication facilities in CSI/CUNY for educational and administrative purposes of this Program.
- The CSI Center for International Service will provide the appropriate visa documents to the students and advise them on preparation for the visa interview.
- CSI and PTIT will keep mutual benefits of this program in the event that CSI sets up a similar program in Computer Science and Computer Engineering with other partners in Vietnam

4. Program Management

a) Administrative Management

A Steering Committee will manage the Program and all associated activities and resources. The Committee will have six members: three appointed by the President of CSI/CUNY and three appointed by the President of PTIT. A Chair of the Committee shall be elected annually alternating between a Chair elected from the members from PTIT and a Chair elected from the members appointed by CSI/CUNY to serve for one year.

b) Academic Aspects

Responsibility for the monitoring and maintenance of academic standards rests with an Academic Committee of six members, three of whom shall be appointed by the President of CSI/CUNY and three of whom shall be appointed by the President of PTIT. A Chair of the Committee shall be elected annually alternating between a Chair elected from the members from PTIT and a Chair elected from the members appointed by CSI/CUNY to serve for one year.

5. Programs of Study

- The initial programs of study shall be the baccalaureate in Computer Science and the baccalaureate in Computer Engineering.
- PTIT and CSI/CUNY will each appoint a senior faculty member as Co-Director for the programs of study who shall be responsible for their management.
- The Academic Committee (and relevant committees at both PTIT and CSI/CUNY when necessary) may recommend teaching staff. The Academic Committee may propose further academic programs in the future.

6. Curriculum

The curricula of the programs of study will be submitted to the Vietnam Ministry of Education and Training, and are annexed hereto as Appendix A.

7. Award of Degree

Students who successfully complete the programs of study at CSI/CUNY will be awarded a CSI/CUNY degree.

8. Assessment

The Academic Committee is responsible for developing an assessment plan for the Program.

9. Students

- The target enrollment for the Program for Year 2009: 20 to 30 students
- PTIT students will apply as transfer students upon successful completion of the PTIT portion of the Program and the following requirements:
  - Completed CUNY Transfer Application with required application fee;
  - TOEFL with minimum passing score of 450 (paper), 133 (computer) or 45-6 (Internet).
  - Submission of an official transcript from PTIT.
  - Academic record with an overall grade equivalent to at least a 2.00 (C) based upon the following grade equivalencies: PTIT 8-10 /Excellent = CSI 4.00/A; PTIT 6-7/Good = CSI 3.00/B; PTIT 5/Pass – CSI 2.00/C; and PTIT 0-4/Fail = CSI 0.00/F
- Students enrolled in the Program will be subject to the rules and regulations of the Program as agreed by the Academic Committee.
- All enrolled students will be accorded equal treatment with other PTIT/CSI/CUNY students as regards PTIT and CSI/CUNY facilities as detailed in items 2 and 3 above.

10. Financial Arrangements

- Tuition and fees for the first two years at PTIT will be set by PTIT under the regulations in Viet Nam.
- The total cost for the last two years at CSI/CUNY, which includes tuition, fees and housing, is set at $10,072/student for the first semester and $8,414/student for each succeeding semester as specific in Appendix B hereto. Tuition and fees are subject to change depending on the CSI/CUNY tuition and fee structure, cost of living in New York, and other financial considerations.

11. Review and Term of an Agreement

An agreement between PTIT and CSI/CUNY incorporating the provisions of this MOU will be submitted by CSI/CUNY to the CUNY Board of Trustees for its approval. The term of such agreement will be for five years with automatic renewal, terminable by either Party by giving notice in writing that the Party is ceasing recruitment and that the agreement shall terminate one year from the date of the notice. Students enrolled in a program of study within the Program at the date of notification will be permitted to complete the Program.

12. Resolution of Disputes

The Parties will use good faith efforts to resolve disputes, consistent with the laws of their respective jurisdictions.

This agreement will be made in two identical English original copies and distributed to each party.

FOR CSI/CUNY

Signature:

Name: Dr. Tomas D. Morales
Title: President
Date:

FOR PTIT

Signature:

Name: Dr. Hoang Minh
Title: President
Date:

PTIT/CSI Articulation Agreement in Computer Science BS Degree Proposal

Joint Program between The College of Staten Island City University of New York (CSI/CUNY) and Posts and Telecommunications Institute of Technology (PTIT) and Joining in the project on "advanced education program" of PTIT

Summary

This document describes the course requirements that are necessary to satisfy the BS degree in Computer Science as proposed for the PTIT/CSI Joint Articulation Program. It shows that PTIT students participating in the program will be eligible for approximately 64 CSI credits towards their degree. To fulfill the degree requirements for the Computer Science offered at CSI, the student will need to complete 60 credits of course work at CSI/CUNY. First, we show a table that attempts to map PTIT courses to equivalent CSI courses that PTIT students participating in the program will be exempted from taking. Second, we present a second table that shows the courses that the PTIT students will need to take while they are attending CSI. Finally, a list of course descriptions, as taken from the CSI catalog, that satisfies the requirements of the BS degree in Computer Science, Department of Computer Science at CSI/CUNY is presented.

Exempted Courses (credits earned based on courses taken at PTIT)

The following table shows the mapping of PTIT courses to equivalent CSI courses that under the terms of the Joint Articulation Program PTIT students will be exempted from taking. The mapping between PTIT courses and CSI courses is not one-to-one. Please note the number of CSI credits that the student will be given towards satisfying the CSI degree requirements. The table organizes the data according to the different subject areas. The PTIT courses are numbered using the convention N:M, where N is the course year and M is the course number for corresponding year N.

Subject Areas	PTIT Courses	CSI Courses	Credits
Mathematics (22 CSI credits)	1:11-Analytics 1 1:12-Algebra 1:13-Analytics 2 1:18-Numerical Methods 1:19-Probability Theory and Statistical Mathematics 2:2-Discrete Mathematics 1 2:3-Discrete Mathematics 2	MTH 229-Calculus Computer Laboratory MTH 231-Analytic Geometry and Calculus I MTH 232-Analytic Geometry and Calculus II MTH 233-Analytic Geometry and Calculus III MTH 338-Linear Algebra MTH 311-Probability and an Introduction to Mathematical Statistics CSC/MTH 228 Discrete Mathematics	1 3 3 3 4 4 4

Physics (8 CSI credits)	1:14-Physics 1 1:15-Physics Lab 1 1:16-Physics 2 1:17-Physics Lab 2	PHY 120-General Physics I PHY 121-General Physics I Laboratory PHY 160-General Physics II PHY 161-General Physics II Laboratory	3 1 3 1
Chemistry (4 CSI credits)	1:20-Chemistry	CHM 141-General Chemistry I CHM 121-General Chemistry I Laboratory	3 1
Computer Science (22 CSI credits)	1:21-Introduction to Computer 2:4-Programming Language C++ 2:5-Data Structures and Algorithms 2:1-Digital Electronics 2:7-Computer Architecture	CSC 126-Introdution to Computer Science CSC 211 – Intermediate Programming CSC 326-Information Structures CSC 346 – Switching and Automata Theory I CSC 347-Computer Circuits Laboratory CSC 446-Computer Architecture	4 4 4 4 2 4
Physical Education (1 CSI credit)	1:22-Physical Training	PED 190-Fitness for Life	1
Economics for Engineers (4 CSI credits)	2:17 Technical Economics	ECO 285-Economics for Engineering	4
English (3 CSI credits)	English 1,2,3,4,5	ENG 111-Introduction to College Writing (Student should pass CUNY Proficiency Exam-CPE)	3
Total number of CSI credits			**64**

Courses to be taken at CSI

The following table lists the courses that a PTIT student who will be participating in the Joint Articulation Program will need to take at CSI to satisfy the requirements of the BS degree, in Computer Science in the Department of Computer Science at CSI/CUNY. The TBD (to be determined) entries in the table will be defined at a later date.

CSI Course	Credits
ENG 151-College Writing	4
COR 100-United States: Issues, Ideas, and Institutions	4
(TBD)-The Contemporary World	4

(TBD)-TALA Textual, Aesthetic, and Linguistic Analysis Course	4
CSC 220- Computers and Programming	4
CSC 330- Object-Oriented Software Design	4
CSC 332- Operating Systems I	4
CSC 382- Analysis of Algorithms	4
CSC 430- Software Engineering	4
CSC 490- Seminar in Computer Science	2
CSC Elective 1	4
CSC Elective 2	4
CSC Elective 3	4
General Electives - TBD	10
Total number of CSI credits	**60**

Course Descriptions from CSI Catalog

Exempted Courses

MTH 229 Calculus Computer Laboratory
2 laboratory hours; 1 credit
Computer projects to reinforce calculus concepts from numerical and graphical points of view will be presented. Suitable mathematical software will be utilized. Problem solving techniques using the computer will be discussed. The students will be assigned a number of projects to be completed individually or in small groups.
Corequisite: MTH 230 or MTH 231 or MTH 235

MTH 231 Analytic Geometry and Calculus I
4 hours; 3 credits
The first of a three-semester sequence in calculus. Topics include limits, derivatives, rules of differentiation, trigonometric functions and their derivatives, differentials, graph sketching, maximum and minimum problems, related rates, antiderivatives, areas, exponential and logarithmic functions. (math)
Prerequisite: MTH 123 with a grade of A or MTH 130 or an appropriate score on the CUNY proficiency/placement exam or permission of the Department of Mathematics
Corequisite: MTH 229

MTH 232 Analytic Geometry and Calculus II
4 hours; 3 credits
The second of a three-semester sequence in calculus. Topics include areas between curves, volumes of solids of revolution, techniques of integration, sequences and series, improper integrals, polar coordinates, and parametric representative of curves.
Prerequisite: MTH 230 or MTH 231
Pre- or corequisite: MTH 229

MTH 233 Analytic Geometry and Calculus III

4 hours; 3 credits

The third of a three-semester sequence in calculus. Topics include vectors, solid analytic geometry, partial derivatives, multiple integrals with applications.
Prerequisite: MTH 232
Pre- or corequisite: MTH 229 or permission of the department

MTH 338 Linear Algebra
4 hours; 4 credits
Determinants, matrices, and systems of linear equations; linear dependence; vector spaces; eigenvalues and eigenvectors; matrix equations; linear transformations; convex sets; applications to problems in physics, engineering, economics, and social sciences.
Prerequisite: MTH 232
Pre- or corequisite: MTH 233

MTH 311 Probability Theory and an Introduction to Mathematical Statistics
4 hours; 4 credits

A calculus-based treatment of elementary probability theory, where the notion of sample space, events, and probability is introduced. The basic probability models are discussed. Notion of density and distribution function is introduced. Furthermore, conditioning, independence, and expectation are discussed. Basic concepts of statistics, sample, parameter estimation, confidence interval, hypothesis testing, central limit theorem are treated.
Prerequisite: MTH 233 or MTH 236

CSC/MTH 228 Discrete Mathematical Structures for Computer Science
3 class hours, 3 laboratory hours; 4 credits
An intermediate-level programming and discrete mathematics course where concepts of discrete structures will be applied to computer science. Topics include elementary set theory, logic, functions, relations, Boolean algebra, elements of graph theory, matrix representation of graphs, and matrix manipulations. Programming projects will be related to mathematical topics. Compound data types, recursive programming and mathematical induction will be introduced.
Prerequisites: CSC 211; MTH 123 or MTH 130 or MTH 230 or MTH 231 or MTH 235

PHY 120 General Physics I
4 hours; 3 credits
Calculus-based physics for Science and Engineering majors. Vectors, forces, kinematics, Newton's laws and applications, particle dynamics, work, energy, conservation laws, collisions, rotational dynamics, ideal gas, thermal properties, heat transfer, thermodynamics. (science)
Pre- or corequisites: MTH 230 or MTH 231 or MTH 235, and PHY 121

PHY 121 General Physics I Laboratory
2 laboratory hours; 1 credit
Measurement, pendulum, gravity, projectiles, force equilibria, acceleration, friction, energy, collisions, centripetal force, calorimetry, Boyle's law. (science)
Corequisite: PHY 120

PHY 160 General Physics II
4 hours; 3 credits
Calculus-based physics for Science and Engineering majors. Electrostatics, potential, Ohm's law, resistance, capacitance, RC circuits, magnetism, induction, waves, and geometric optics. (science)
Prerequisite: PHY 120
Corequisites: MTH 232 or MTH 236, and PHY 161

PHY 161 General Physics II Laboratory
2 laboratory hours; 1 credit
Millikan experiment, electric fields, capacitance, Ohm's law, Wheatstone bridge, DC circuits, meters, RC circuits, electron beams, CRO, AC circuits, standing waves, spectroscope. (science)
Corequisite: PHY 160

CHM 141 General Chemistry I
3 lecture hours, 1 recitation hour; 3 credits
A study of the fundamental principles and laws concerning the structure and behavior of matter. The first semester covers atomic and molecular structure, chemical bonding, reactions, stoichiometry, and the gaseous, liquid, and solid states of matter. (science)
Pre- or corequisite: MTH 123
Corequisite: CHM 121

CHM 121 General Chemistry I Laboratory
3 laboratory hours; 1 credit
Experiments reinforce important chemical concepts discussed in lectures, teach modern lab techniques, and emphasize present day interpretations of lab measurements. (science)
Pre- or corequisite: CHM 141

CSC 126 Introduction to Computer Science
3 class hours, 3 laboratory hours; 4 credits
Computing and information processing. Basic computer structure. Programming methodology: analysis, design, documentation, implementation, and evaluation. Algorithmic approach to problem solving. Computer solutions of several numerical and non-numerical problems.
Pre- or corequisite: MTH 123 or MTH 130 or MTH 230 or MTH 231 or MTH 235

CSC 211 Intermediate Programming
3 hours, 3 laboratory hours; 4 credits
A second course in programming. Programming techniques emphasizing reliability, maintainability, and reusability. Module design and multi-file programs. Abstract data types. Data representation and conversion. Addresses, pointers, and dynamic storage allocation. Recursion and function parameters. User interface design.
Prerequisite: CSC126 with a grade C or better (not open to students who had a C or better in CSC310).

CSC 326 Information Structures
3 class hours, 3 laboratory hours; 4 credits

Organization and processing of various types of information. Storage allocation techniques. Linear list structures including stacks and queues, deques, rings, and linked arrays. Tree structures and multilinked structures. Advanced sorting and searching techniques. Scatter storage techniques. Recursive programming.
Prerequisites: CSC 211 or ENS 336; a knowledge of C programming language

CSC 346 Switching and Automata Theory
4 hours; 4 credits
Codes—error checking and correcting capabilities. Boolean algebra, minimization of combinational circuits. Definition and representation of finite state automata and sequential machines. Equivalence of states and machines, congruence, reduced machines, and analysis and synthesis of machines.
Prerequisite: CSC 220

CSC 347 Computer Circuits Laboratory
4 hours; 2 credits
The design and implementation of circuitry found in modern computers. Physical realizations of minimized switching functions. Design and implementation of finite state machines including synchronous sequential circuits and asynchronous sequential circuits.
Prerequisite: CSC 346

CSC 446 Computer Architecture
(Also ENS 446)
4 hours; 4 credits
Instruction formats and addressing schemes. Arithmetic and logic unit design. Control unit design: hardwired and microprogrammed. Main memory technology. Virtual, high-speed, associative, and read-only memories. Programmable logic arrays. Computer organizations including stack, parallel, and pipeline. System structures: time sharing, multiprocessing, and networking. Digital communications. Input/Output systems; direct memory access.
Prerequisite: CSC 346 or ENS 220

PED 190 Fitness for Life
2 hours; 1 credit
This course is designed to inform students about current issues and practices in fitness and wellness. It combines theory and practice in lectures and physical activities to enable students to plan for a healthy independent future.
Prerequisite: Current medical examination on file with the College Health Center.
Successful completion of PED 190 fulfills the general education requirement in Physical Education.

ECO 285 Economics for Engineers
4 hours; 4 credits

An accelerated calculus-based course. Introduction to contemporary macroeconomic and microeconomic theory. Topics include output, unemployment, inflation, functioning of markets, government policy, and productivity. The course concludes with engineering applications. (social science)
Prerequisites: ENG 111, COR 100; MTH 230 or MTH 231 or MTH 235, CSC 126 or CSC 270 or other evidence of equivalent proficiency with computers

ENG 111 Introduction to College Writing
4 hours; 3 credits
Introduction to and development of critical and analytic writing/reading/thinking skills through class discussion of student work and selected texts. Intensive instruction in techniques for the planning, drafting, revising, and editing of college-level expository essays. Introduction to using the various research options available at the CSI Library.
Prerequisite: Successful completion of the CUNY Assessment Test in Reading and the CUNY Assessment Test in Writing.

Courses to be taken at CSI

ENG 151 College Writing
4 hours; 4 credits
This course builds on the work of ENG 111. It emphasizes expository and analytic writing and longer papers. Attention to reading, library skills, and research methods. Sections may be focused on particular themes, to be announced in the Semester Bulletin.
Prerequisites: ENG 111 and passing the CUNY Assessment Test in Reading

COR 100 United States: Issues, Ideas, and Institutions
4 hours; 4 credits
COR 100 is a required general education course that introduces CSI students to contemporary America's constitutional democracy, multiracial society, and market economy, using the tools of the social sciences. The course seeks historical perspective by examining three formative periods in U.S. history: the American Revolution and debate over the Constitution, the African American freedom struggle from slavery through the civil rights movement, and the evolving relationship between government regulation and the market economy during the 20th century. The course is writing intensive and is intended to develop logical, critical thought and expression.
Pre- or corequisite: ENG 111

CSC 220 Computers and Programming
3 class hours, 3 laboratory hours; 4 credits
Binary and hexadecimal number systems, computer structure, machine language, instruction formats and execution, addressing techniques, and digital representation of data. Computer systems organization, symbolic coding and assembly systems, programming techniques, program segmentation and linkage. Students will complete computer projects in machine language and assembly language.
Prerequisite: A grade of C or above in either CSC 126 or 270

CSC 330 Object-Oriented Software Design
3 class hours, 3 laboratory hours; 4 credits
Large-scale software design issues, object-oriented design paradigms, encapsulation, polymorphism, inheritance, reusability, and specifics of an object-oriented language and associated development tools. Students will be required to implement a substantial and well-engineered project using an object-oriented language.
Prerequisite: CSC 326

CSC 332 Operating Systems I
3 class hours, 3 laboratory hours; 4 credits

Introduction to operating systems. Task management and scheduling. Process and data management. Interrupts. Resource allocation and management. Time sharing. Deadlock mutual exclusion, and synchronization. Case studies of typical operating systems.
Prerequisites: CSC 220 or ENS 362, and CSC 326

CSC 382 Analysis of Algorithms
4 hours; 4 credits
Algorithm development, including running time analysis and correctness arguments. Topics include: asymptotic notation and complexity analysis; use of mathematical techniques to determine the computational complexity of algorithms such as sorting and searching. The course provides an introduction and analysis of elementary graph algorithms and programming techniques such as greedy, backtracking, and dynamic programming. Projects will be assigned to correlate the computational complexity and real-time execution time of the algorithms.
Prerequisites: CSC 326 and CSC/MTH 228
Pre- or corequisite: MTH 311

CSC 430 Software Engineering
3 class hours, 2 laboratory hours; 4 credits
Developing large-scale reliable software systems. Theory and methodology for the design and implementation of software systems from requirements analysis through design and implementation, testing, integration, and maintenance. Tools and techniques for all phases of a software system's life cycle will be discussed. Documentation, testing, and management of large-scale systems. A significant project will be required.
Prerequisite: CSC 330

CSC 490 Seminar in Computer Science
2 hours; 2 credits
Invited speakers will lead discussions on the ethical and societal impact of the computer. Students will write and present papers on current research topics in the computing field.
Prerequisite: Computer Science major with senior standing

The courses fulfilling the advanced CSC electives should be chosen from the following (two may be 200 level 2-credit courses):

CSC 223 Computer Hacking Revealed
1 class hour, 3 laboratory hours; 2 credits
A theoretical and practical survey of computer network and Web security, attack methods, and algorithms for defending computers and computer networks. Students learn about major security threats, methods and technologies used, and how threats affect the development and functioning of computer software and hardware.
Prerequisite: CSC 126 or permission of instructor

CSC 225 Introduction to Web Development and the Internet
1 class hour, 3 laboratory hours; 2 credits
An introduction to the Internet and Web page creation and management, using a markup language, a scripting language, a current editor, and a graphics program. Topics include incorporating graphics, sound, video and proper Web page development concepts. Students will prepare Web pages incorporating text, digitized images, scripts, animations, sound, and video. Not open to students who have completed CSC 114.
Prerequisites: MTH 123

CSC 226 Web Database Applications
1 class hour, 3 laboratory hours; 2 credits
This course offers students a mixture of theoretical and practical information on creating Web database applications. Students will learn open source technologies that are often combined to develop these applications. Student will model and design databases and query remotely located databases on the Web. Searching, browsing, storing user data, validating user input, managing user transactions, and security issues are discussed.
Prerequisites: CSC 126

CSC 227 Introductory Computer Game Programming
1 class hour, 3 laboratory hours; 2 credits
This course covers the process of game development. It also discusses the importance of testing, and how developers use the results of testing to improve their games. Students will be expected to develop simple games, or portions of games, using appropriate game development tools.
Prerequisites: CSC 126 or permission of instructor

CSC 420 Concepts of Programming Languages
4 hours; 4 credits
Definition of programming languages, data types and declaration, storage allocation, statement types, operations, control structures, binding time, procedure, subroutine, function declaration, parameters, string manipulation. Several programming languages will be discussed and problems using these languages will be assigned.
Prerequisites: CSC 220 and CSC 326

CSC 421 Internet Data Communications and Security
3 class hours, 3 laboratory hours; 4 credits
Designed to present a thorough understanding of the Internet structure, its functionality, and the technology. This course covers networks and how they work; Internet protocols; Internet control protocols; Internet and www, Internet clients and servers and their main features; Internet

applications and related protocols; Internet and www security; encryption, public-key cryptography, authentication, and IP security.
Prerequisite: CSC 326

CSC 424 Database Management Systems
4 hours; 4 credits
Introduction to database systems, concepts and architecture; Conceptual data modeling with the Entity-Relationship Model; the Relational database model: concepts, languages, functional dependencies, database normalization and design; programming in SQL; concepts of integrity, security, transactions, concurrency, recovery, distributed and object-oriented databases are introduced. Study of several real-world database management systems. Students are required to implement a database application project in the area of their major interest.
Prerequisite: CSC 326

CSC 427 Advanced Computer Game Programming
4 hours; 4 credits
This course covers advanced principles and practices of computer game programming. The student will be exposed to the different aspects of game development including 2D and 3D asset creation, rendering and animation, sprites, AI for games, programming, and testing. The course emphasizes the hands-on computer programming aspect. Students will work in groups to develop and program games.
Prerequisite: CSC 326

CSC 432 Operating Systems II
4 hours; 4 credits
Concurrent processing. Linear and tree-structured address space. Resource allocation for multiprogramming. Queuing and network control policies. Protection mechanisms. Case studies of various state-of-the-art systems and implementation of a small operating system.
Prerequisite: CSC 332

CSC 434 Compiler Construction
4 hours; 4 credits
Review of assembly techniques of symbol table techniques and macros, and of compilation, loading, and execution. One-pass compilation techniques. Translation of arithmetic expressions from prefix form to machine language. Detailed organization of a simple complete compiler.
Prerequisites: CSC 330 and CSC 326

CSC 435 Advanced Data Communications
4 hours; 4 credits
Concepts of circuit, packet, and message switched networks; local, campus, metropolitan, and wide area networks; concepts of data transmission; the emerging telecommunications industry, private networks, and integrated services digital networks.
Prerequisite: CSC 346

CSC 462 Microcontrollers (Also ENS 362)
2 class hours, 4 laboratory hours; 4 credits

Introduction to microcontrollers with an overview of the CPU architecture, instruction set, interface with target board, testing and program development using the structured assembly preprocessor. Interrupts and interrupt timing, analog-to-digital conversion and programming of peripheral chips will be some of the concepts covered in this class.
Prerequisite: ENS 221 or CSC 347

CSC 470 Introductory Computer Graphics
4 hours; 4 credits
Introduction to the basic concepts and techniques of interactive computer graphics including the hardware and software components of computer graphics systems and mathematical handling of graphical objects. Algorithms for two-dimensional and three-dimensional graphics: windowing, clipping, and transformations. Viewing with parallel and perspective projections. Possible additional topics include: curves and surface modeling; realistic rendering (shading with illumination and material, shadowing, reflection and surface texturing).
Prerequisite: CSC 326

CSC 475 Image Processing in Computer Science
4 hours; 4 credits
An introduction to the basic computational techniques and algorithms of digital image/video processing. The student will learn modern approaches to image acquisition, image enhancement, image compression, and image analysis.
Prerequisite: CSC 326
Corequisite: MTH 338

CSC 480 Artificial Intelligence
4 hours; 4 credits
General introduction to artificial intelligence. Heuristic versus algorithmic methods. Purpose of heuristic programming, description of cognitive processes. Objective of work in artificial intelligence. Examples from special purpose programs, general problem solver, theorem proving, deductive question answering systems, learning, pattern recognition.
Prerequisite: CSC 326

CSC 482 Discrete Simulation
4 hours; 4 credits
Introduction to simulation. Discrete simulation models. Review of basic probability and statistics. Random number generation. Design of simulation experiments. Analysis of data gathered. Simulation programming and languages. Application of simulation.
Prerequisites: MTH 311 and CSC 326

CSC 484 Theory of Computation
4 hours; 4 credits
The notion of an algorithm. Primitive recursive and partial recursive functions. Turing machines and other models of computation. Markov algorithms. Church thesis. Godel numberings and

unsolvability results. Halting problem. Post correspondence problem. Recursive and recursively enumerable sets. Concepts from formal language theory.
Prerequisites: A grade of C or above in (CSC 126 or CSC 270) and MTH 339 and (MTH 233 or MTH 236)

PTIT/CSI Articulation Agreement in Computer Engineering BS Degree Proposal

On step up Joint Articulation Program between The College of Staten Island City University of New York (CSI/CUNY) and Posts and Telecommunications Institute of Technology (PTIT) and Joining in the project on "advanced education program" of PTIT

Summary

This document describes the course requirements that are necessary to satisfy the BS degree with a Computer Engineering specialization as proposed for the PTIT/CSI Joint Articulation Program. It shows that PTIT students participating in the program will be eligible for approximately 60 CSI credits towards their degree. To fulfill the degree requirements for the Computer Engineering specialization offered at CSI, the student will need to complete approximately 67 credits of course work at CSI/CUNY. First, we show a table that attempts to map PTIT courses to equivalent CSI courses that PTIT students participating in the program will be exempted from taking. Second, we present a second table that shows the courses that the PTIT students will need to take while they are attending CSI. Finally, a list of course descriptions, as taken from the CSI catalog, that satisfies the requirements of the BS degree with a specialization in Computer Engineering in the Department of Engineering Science and Physics at CSI/CUNY is presented.

Exempted Courses (credits earned based on courses taken at PTIT)

The following table shows the mapping of PTIT courses to equivalent CSI courses that under the terms of the Joint Articulation Program PTIT students will be exempted from taking. The mapping between PTIT courses and CSI courses is not one-to-one. Please note the number of CSI credits that the student will be given towards satisfying the CSI degree requirements. The table organizes the data according to the different subject areas. The PTIT courses are numbered using the convention N:M, where N is the course year and M is the course number for corresponding year N.

Subject Areas	PTIT Courses	CSI Courses	Credits
Mathematics (18 CSI credits)	1:11-Analytics 1 1:12-Algebra 1:13-Analytic 2 1:18-Numerical Methods 1:19-Probability Theory and Statistical Mathematics	MTH 229-Calculus Computer Laboratory MTH 231-Analytic Geometry and Calculus I MTH 232-Analytic Geometry and Calculus II MTH 233-Analytic Geometry and Calculus III MTH 330-Applied Mathematical Analysis I MTH 311-Probability and an	1 3 3 3 4

		Introduction to Mathematical Statistics	4
Physics (8 CSI credits)	1:14-Physics 1 1:15-Physics Lab 1 1:16-Physics 2 1:17-Physics Lab 2	PHY 120-General Physics I PHY 121-General Physics I Laboratory PHY 160-General Physics II PHY 161-General Physics II Laboratory	3 1 3 1
Chemistry (4 CSI credits)	1:20-Chemistry	CHM 141-General Chemistry I CHM 121-General Chemistry I Laboratory	3 1
Computer Science (12 CSI credits)	1:21-Introduction to Computer 2:4-Programming Language C++ 2:5-Data Structures and Algorithms 2:9-Operating Systems	CSC 126-Introdution to Computer Science CSC 326-Information Structures CSS 332-Operating Systems I	4 4 4
Physical Education (1 CSI credit)	1:22-Physical Training	PED 190-Fitness for Life	1
Computer Engineering/Digital Electronics (6 CSI credits)	2:1-Digital Electronics 2:7-Computer Architecture	ENS 220-Introduction to Computer Engineering ENS 221-Digital Electronics Laboratory	4 2
English (3 CSI credits)	English 1,2,3,4,5	ENG 111-Introduction to College Writing (Student should pass CUNY Proficiency Exam-CPE)	3
Economics for Engineers (4 CSI credits)	2:17 Technical Economics	ECO 285-Economics for Engineering	4
Microprocessors (4 CSI credits)	2:8 Microprocessors	ENS 362-Microprocessors	4
Total number of CSI credits			**60**

Courses to be taken at CSI

The following table lists the courses that a PTIT student who will be participating in the Joint Articulation Program will need to take at CSI to satisfy the requirements of the BS degree, with a specialization in Computer Engineering in the Department of Engineering Science and Physics at CSI/CUNY. The TBA (to be determined) entries in the table will be defined at a later date.

CSI Course	**Credits**

ENG 151-College Writing	4
COR 100-United States: Issues, Ideas, and Institutions	4
(TBD)-The Contemporary World	4
(TBD)-TALA Textual, Aesthetic, and Linguistic Analysis Course	4
PHY 240-Waves and Modern Physics	3
ENS 100-Introduction to Engineering	2
ENS 110-Engineering Graphics	2
ENS 241-Electrical and Electronic Circuits	4
ENS 249-Basic Measurement Laboratory	2
ENS 250-Engineering Mechanics	3
ENS 310-Thermodynamics	4
ENS 331-Digital Signal Processing	4
ENS 336-Computer-Aided Engineering	4
ENS 439-Systems Laboratory	2
ENS 471-Control Systems	4
ENS 485-Properties of Material	4
ENS 491-Advanced Engineering Design I	2
ENS 492-Advanced Engineering Design II	2
(TBD) Four credits of technical electives approved by an engineering science advisor	4
(TBD) At least eight credits of advanced ENS electives	8
Total number of CSI credits	**70**

Course Descriptions from CSI Catalog

Exempted Courses

MTH 229 Calculus Computer Laboratory

2 laboratory hours; 1 credit

Computer projects to reinforce calculus concepts from numerical and graphical points of view will be presented. Suitable mathematical software will be utilized. Problem solving techniques using the computer will be discussed. The students will be assigned a number of projects to be completed individually or in small groups.

Corequisite: MTH 230 or MTH 231 or MTH 235

MTH 231 Analytic Geometry and Calculus I

4 hours; 3 credits

The first of a three-semester sequence in calculus. Topics include limits, derivatives, rules of differentiation, trigonometric functions and their derivatives, differentials, graph sketching, maximum and minimum problems, related rates, antiderivatives, areas, exponential and logarithmic functions. (math)

Prerequisite: MTH 123 with a grade of A or MTH 130 or an appropriate score on the CUNY proficiency/placement exam or permission of the Department of Mathematics

Corequisite: MTH 229

MTH 232 Analytic Geometry and Calculus II
4 hours; 3 credits
The second of a three-semester sequence in calculus. Topics include areas between curves, volumes of solids of revolution, techniques of integration, sequences and series, improper integrals, polar coordinates, and parametric representative of curves.
Prerequisite: MTH 230 or MTH 231
Pre- or corequisite: MTH 229

MTH 233 Analytic Geometry and Calculus III
4 hours; 3 credits

The third of a three-semester sequence in calculus. Topics include vectors, solid analytic geometry, partial derivatives, multiple integrals with applications.
Prerequisite: MTH 232
Pre- or corequisite: MTH 229 or permission of the department

MTH 330 Applied Mathematical Analysis I
6 hours; 4 credits
Advanced mathematics for engineering and science students. Ordinary differential equations, linear algebra, eigenvalue problems, systems of ordinary linear differential equations, Laplace transforms. Credit will not be given for both MTH 330 and MTH 334.
Prerequisite: MTH 233 or MTH 236

MTH 311 Probability Theory and an Introduction to Mathematical Statistics
4 hours; 4 credits
A calculus-based treatment of elementary probability theory, where the notion of sample space, events, and probability is introduced. The basic probability models are discussed. Notion of density and distribution function is introduced. Furthermore, conditioning, independence, and expectation are discussed. Basic concepts of statistics, sample, parameter estimation, confidence interval, hypothesis testing, central limit theorem are treated.
Prerequisite: MTH 233 or MTH 236

PHY 120 General Physics I
4 hours; 3 credits
Calculus-based physics for Science and Engineering majors. Vectors, forces, kinematics, Newton's laws and applications, particle dynamics, work, energy, conservation laws, collisions, rotational dynamics, ideal gas, thermal properties, heat transfer, thermodynamics. (science)
Pre- or corequisites: MTH 230 or MTH 231 or MTH 235, and PHY 121

PHY 121 General Physics I Laboratory
2 laboratory hours; 1 credit
Measurement, pendulum, gravity, projectiles, force equilibria, acceleration, friction, energy, collisions, centripetal force, calorimetry, Boyle's law. (science)
Corequisite: PHY 120

PHY 160 General Physics II
4 hours; 3 credits
Calculus-based physics for Science and Engineering majors. Electrostatics, potential, Ohm's law, resistance, capacitance, RC circuits, magnetism, induction, waves, and geometric optics. (science)
Prerequisite: PHY 120
Corequisites: MTH 232 or MTH 236, and PHY 161

PHY 161 General Physics II Laboratory
2 laboratory hours; 1 credit
Millikan experiment, electric fields, capacitance, Ohm's law, Wheatstone bridge, DC circuits, meters, RC circuits, electron beams, CRO, AC circuits, standing waves, spectroscope. (science)
Corequisite: PHY 160

CHM 141 General Chemistry I
3 lecture hours, 1 recitation hour; 3 credits
A study of the fundamental principles and laws concerning the structure and behavior of matter. The first semester covers atomic and molecular structure, chemical bonding, reactions, stoichiometry, and the gaseous, liquid, and solid states of matter. (science)
Pre- or corequisite: MTH 123
Corequisite: CHM 121

CHM 121 General Chemistry I Laboratory
3 laboratory hours; 1 credit
Experiments reinforce important chemical concepts discussed in lectures, teach modern lab techniques, and emphasize present day interpretations of lab measurements. (science)
Pre- or corequisite: CHM 141

CSC 126 Introduction to Computer Science
3 class hours, 3 laboratory hours; 4 credits
Computing and information processing. Basic computer structure. Programming methodology: analysis, design, documentation, implementation, and evaluation. Algorithmic approach to problem solving. Computer solutions of several numerical and non-numerical problems.
Pre- or corequisite: MTH 123 or MTH 130 or MTH 230 or MTH 231 or MTH 235

CSC 326 Information Structures
3 class hours, 3 laboratory hours; 4 credits
Organization and processing of various types of information. Storage allocation techniques. Linear list structures including stacks and queues, deques, rings, and linked arrays. Tree structures and multilinked structures. Advanced sorting and searching techniques. Scatter storage techniques. Recursive programming.
Prerequisites: CSC 211 or ENS 336; a knowledge of C programming language

CSC 332 Operating Systems I
3 class hours, 3 laboratory hours; 4 credits

Introduction to operating systems. Task management and scheduling. Process and data management. Interrupts. Resource allocation and management. Time sharing. Deadlock mutual exclusion, and synchronization. Case studies of typical operating systems.
Prerequisites: CSC 220 or ENS 362, and CSC 326

PED 190 Fitness for Life
2 hours; 1 credit
This course is designed to inform students about current issues and practices in fitness and wellness. It combines theory and practice in lectures and physical activities to enable students to plan for a healthy independent future.
Prerequisite: Current medical examination on file with the College Health Center.
Successful completion of PED 190 fulfills the general education requirement in Physical Education.

ENS 220 Introduction to Computer Engineering
4 hours; 4 credits
Number systems and codes. Logic functions, gates and assertion levels. Combinational circuit design and minimization. MSI and LSI circuits and their applications. Sequential machine fundamentals, analysis, and design.
Prerequisite: ENS 100
Pre- or corequisite: CSC 126

ENS 221 Digital Electronics Laboratory
4 laboratory hours; 2 credits
Design, construction, testing, and evaluation of digital systems. Counters, registers, and multiplexers are used to build combinational circuits and sequential machines, including programmable system controllers.
Prerequisite: ENS 220

ENG 111 Introduction to College Writing
4 hours; 3 credits
Introduction to and development of critical and analytic writing/reading/thinking skills through class discussion of student work and selected texts. Intensive instruction in techniques for the planning, drafting, revising, and editing of college-level expository essays. Introduction to using the various research options available at the CSI Library.
Prerequisite: Successful completion of the CUNY Assessment Test in Reading and the CUNY Assessment Test in Writing.

ECO 285 Economics for Engineers
4 hours; 4 credits
An accelerated calculus-based course. Introduction to contemporary macroeconomic and microeconomic theory. Topics include output, unemployment, inflation, functioning of markets, government policy, and productivity. The course concludes with engineering applications. (social science)
Prerequisites: ENG 111, COR 100; MTH 230 or MTH 231 or MTH 235, CSC 126 or CSC 270 or other evidence of equivalent proficiency with computers

ENS 362 Microcontrollers (Also CSC 462)
2 class hours, 4 laboratory hours; 4 credits
Introduction to microcontrollers with an overview of the CPU architecture, instruction set, interface with target board, testing and program development using the structured assembly preprocessor. Interrupts and interrupt timing, analog-to-digital conversion and programming of peripheral chips will be some of the concepts covered in this class.
Prerequisite: ENS 221 or CSC 347

Courses to be taken at CSI

ENG 151 College Writing
4 hours; 4 credits
This course builds on the work of ENG 111. It emphasizes expository and analytic writing and longer papers. Attention to reading, library skills, and research methods. Sections may be focused on particular themes, to be announced in the Semester Bulletin.
Prerequisites: ENG 111 and passing the CUNY Assessment Test in Reading

COR 100 United States: Issues, Ideas, and Institutions
4 hours; 4 credits
COR 100 is a required general education course that introduces CSI students to contemporary America's constitutional democracy, multiracial society, and market economy, using the tools of the social sciences. The course seeks historical perspective by examining three formative periods in U.S. history: the American Revolution and debate over the Constitution, the African American freedom struggle from slavery through the civil rights movement, and the evolving relationship between government regulation and the market economy during the 20th century. The course is writing intensive and is intended to develop logical, critical thought and expression.
Pre- or corequisite: ENG 111

PHY 240 Waves and Modern Physics
4 hours; 3 credits
Calculus-based physics for Engineering and Physical Science majors. Wave mechanics, electromagnetic spectrum, radiation, photoelectric and Compton effects, spectra. Introductory quantum mechanics, harmonic oscillator, hydrogen atom, many-electron atoms, binding and energy bands in solids.
Prerequisite: PHY 160 or 230
Pre- or corequisite: MTH 330

ENS 100 Introduction to Engineering
4 hours; 2 credits
Introduction to engineering disciplines, organizations, and ethics; basic engineering parameters; engineering standards and codes, principles for engineering data acquisition and presentations, and effective experimentation; engineering statistics and data analysis; problem solving and case studies illustrating engineering solutions.
Prerequisites: Passing the CUNY Assessment Test in Reading, passing the CUNY Assessment Test in Writing, and passing the CUNY COMPASS Mathematics Test

ENS 110 Engineering Graphics
5 hours; 2 credits
CAD (computer-aided drafting) is used throughout the course. Othographic projections, and drawings, dimensioning, working drawings, graphs, laboratory sketches, vectors, 3D space, spatial analysis, isometric drawings.
Prerequisites: Passing the CUNY Assessment Test in Reading, passing the CUNY Assessment Test in Writing, and passing the CUNY COMPASS Mathematics Test

ENS 241 Electrical and Electronic Circuits
2 lecture hours, 4 laboratory hours; 4 credits
Analysis of linear time invariant passive and active circuits. Kirchoff's laws, Thevenin and Norton equivalents, node and mesh analysis. Analogy to mechanical, fluid, and thermal system. Signal waveforms, diodes, bipolar, and MOS transistors. Transistor-level digital circuit analysis and design. Analysis and design of single-stage amplifiers. Operational amplifiers and their applications.
Prerequisites: PHY 160 and MTH 232

ENS 249 Basic Measurements Laboratory (Also PHY 309)
4 laboratory hours; 2 credits
Basic instrumentation and precise measurements in engineering applications. Design, construction, testing, and analysis of simple analog systems using the circuit design tools and simulation software. Comparison of measured data to simulated data and reconciliation of discrepancies are emphasized.
Prerequisite: ENS 241

ENS 250 Engineering Mechanics
3 hours; 3 credits
Three-dimensional vector algebra. Equivalence of force-coupled systems and equilibrium of rigid bodies. Engineering application of statics. Analysis of trusses, frames, and machines. Friction and moment of inertia. Introduction to stress and strain.
Prerequisites: ENS 100, and PHY 120 and PHY 121, or PHY 230
Pre- or corequisite: MTH 233

ENS 310 Thermodynamics (Also PHY 310)
4 hours; 4 credits
Basic concepts: systems, temperature, work, and heat. First and second laws of thermodynamics. Entropy, vapor, and gas power systems. Refrigeration and heat pump systems. Nonreacting gas mixtures and psychrometrics.
Prerequisite: PHY 160 or PHY 230
Pre- or corequisite: MTH 233 or MTH 236

ENS 331 Digital Signal Processing
4 hours; 4 credits
Representation and analysis of systems. Sampling and discrete systems. Solution of difference equations. Discrete Fourier series and transforms. Convolution. Z transforms and stability.

Computer-aided design and analysis of digital filters. Hardware demonstrations using the Texas Instruments TMS 320C30 single-board DSP computer.
Prerequisites: ENS 221 or CSC 347, and MTH 232

ENS 336 Computer-Aided Engineering
2 hours lecture, 4 hours laboratory; 4 credits
Application of numerical analysis and computer simulation to the solution of engineering design problems. Topics include optimization and error analysis; solution of nonlinear equations; systems of algebraic equations; data analysis; regression and interpolation; numerical differentiation and integration; solution of ordinary and partial differential equations; finite difference and finite element methods; and introduction to programming for parallel processing and multimode machine. Theory will be implemented with several projects emphasizing design applications.
Prerequisite: CSC 126
Pre- or corequisite: MTH 330

ENS 439 Systems Laboratory
4 laboratory hours; 2 credits
Students will undertake projects illustrating the principles, operation, and characteristics of electrical and electromechanical systems, operational amplifiers, digital filters, and transducers. Additional projects will involve modulation, transmission, and detection in analog and digital communication systems, and signal and image processing techniques. Projects will be designed and simulated using the appropriate hardware and software tools. Measured data will be compared to simulated results. These projects fulfill the course objective of translation of systems theory into operating circuitry and systems.
Prerequisite: ENS 309

ENS 471 Control Systems
4 hours; 4 credits
Concepts of feedback control system. State space and transfer function models of dynamic systems. System reduction and response analysis. Sensitivity, stability, and steady-state error analysis. Root locus and frequency response (Bode and Nyquist) design methods, compensator design. Computer-aided analysis/design.
Prerequisites: ENS 241, ENS 310, ENS 336, and MTH 330

ENS 485 Properties of Materials (Also PHY 485)
4 hours; 4 credits
Structure of crystalline and noncrystalline solids. Defects in solids. Phase equilibrium and transformations, thermodynamics of multicomponent systems, surfaces, diffusions, and structural changes. Mechanical properties, plasticity, strengthening. Heat treatment. Electrical properties, conductivity, energy bands, semiconductors, superconductors, and devices. Optical and dielectric properties, optical fibers, and lasers. Magnetic and thermal properties. Material consideration in the engineering design process.
Prerequisite: PHY 240 or permission of the instructor

ENS 491 Advanced Engineering Design I

4 laboratory hours; 2 credits
This is the first course of a two-semester sequence dealing with the major design experience, which provides an integration of the analytical techniques of engineering science and mathematics, and their application to engineering design. Topics covered: problem identification, formulation of the problem, proposed solution(s), theoretical foundation and simulation of the proposed solution.
Prerequisites: ENS 336 and ENS 362
Pre- or corequisite: ENS 439

ENS 492 Advanced Engineering Design II
4 laboratory hours; 2 credits
This is the second course of a two-semester sequence dealing with the major design experience. Topics covered: engineering standards; realistic constraints including but not limited to economic, environmental, social, ethical, and political considerations, manufacturability, health and safety, and sustainability; system design adaptation under realistic constraints; and design implementation and demonstration of functionality.
Prerequisites: ECO 285, ENS 471, ENS 491

The courses fulfilling the advanced ENS electives should be chosen from the following:

ENS 441 Electrical Network Analysis
2 lecture hours, 4 laboratory hours; 4 credits, 6 hours
Power and three-phase circuits, power transmission, and transformers. Real and reactive power, power flow and power handling capacity of parallel lines. Long haul high-voltage power transmission. Applications of Convolution. Complete response of first, second, and higher-order circuits. Sinusoidal steady-state and transient analysis. The application of Laplace transform in circuit analysis. Frequency response. Analog filter design.
Prerequisite: ENS 241
Corequisite: MTH 330

ENS 420 Analog and Digital Systems Design
4 hours; 4 credits
Systematic design of integrated digital systems, using combinational, sequential, and MSI/LSI circuit chips. Transistor and FET circuit analysis and design. Operational amplifiers. Design of linear and nonlinear analog systems based on op-amps.
Prerequisites: ENS 220 and ENS 241

ENS 422 Signals and Noise
4 hours; 4 credits
Application of probability theory to engineering problems. Topics include random signal models and their uses, linear prediction and signal modeling, filtering of stationary random signals, parameter identification by the maximum likelihood methods, noise reduction and signal enhancement filters, quantization noise, linear estimation and detection of signals.
Prerequisites: ENS 241 and senior-level status or permission of instructor

ENS 432 Digital and Analog Communication Systems

4 hours; 4 credits
Bandwidth limitations on communication system capacity. Review of Fourier transforms. Sampling theorems. Digital systems: PAM, PCM. Analog systems: AM, FM. Modulator and demodulator circuits. Introduction to probability theory and detection of signals in noise, information theory, and coding.
Prerequisites: ENS 241 and senior-level status or permission of instructor

ENS 446 Computer Architecture (Also CSC 446)
4 hours; 4 credits
Instruction formats and addressing schemes. Arithmetic and logic unit design. Control unit design: hardwired and microprogrammed. Main memory technology. Virtual, high-speed, associative, and read-only memories. Programmable logic arrays. Computer organizations including stack, parallel, and pipeline. System structures: time sharing, multiprocessing, and networking. Digital communications. Input/output systems; direct memory access.
Prerequisite: CSC 346 or ENS 220

ENS 463 Introduction to Nanotechnology (also PHY 463)
2 hours lecture, 4 hours laboratory; 4 credits
This is an introductory course on nanotechnology. It covers the physical basics of submicron- and nano-size structures, methods and materials of nanotechnology, characterization of nanostructures and their industrial applications. The course covers (i) mechanical, electronic, and optical properties of nanoscopic systems; (ii) engineering approaches in nano-electro-mechanics; nanoelectronics, and nanophotonics; (iii) practical computer simulation and design of nanodevices; (iv) practical nanofabrication of rudimentary nanodevices with focused ion beams.
Prerequisite: ENS /PHY 485

The courses fulfilling the technical electives should be chosen from the following:

CSC 330 Object-Oriented Software Design
3 class hours, 3 laboratory hours; 4 credits
Large-scale software design issues, object-oriented design paradigms, encapsulation, polymorphism, inheritance, reusability, and specifics of an object-oriented language and associated development tools. Students will be required to implement a substantial and well-engineered project using an object-oriented language.
Prerequisite: CSC 326

CSC 430 Software Engineering
3 class hours, 2 laboratory hours; 4 credits
Developing large-scale reliable software systems. Theory and methodology for the design and implementation of software systems from requirements analysis through design and implementation, testing, integration, and maintenance. Tools and techniques for all phases of a software system's life cycle will be discussed. Documentation, testing, and management of large-scale systems. A significant project will be required.
Prerequisite: CSC 330

CSC 435 Advanced Data Communications

4 hours; 4 credits
Concepts of circuit, packet, and message switched networks; local, campus, metropolitan, and wide area networks; concepts of data transmission; the emerging telecommunications industry, private networks, and integrated services digital networks.
Prerequisite: CSC 346

CSC 480 Artificial Intelligence
4 hours; 4 credits
General introduction to artificial intelligence. Heuristic versus algorithmic methods. Purpose of heuristic programming, description of cognitive processes. Objective of work in artificial intelligence. Examples from special purpose programs, general problem solver, theorem proving, deductive question answering systems, learning, pattern recognition.
Prerequisite: CSC 326

CSC 482 Discrete Simulation
4 hours; 4 credits
Introduction to simulation. Discrete simulation models. Review of basic probability and statistics. Random number generation. Design of simulation experiments. Analysis of data gathered. Simulation programming and languages. Application of simulation.
Prerequisites: MTH 311 and CSC 326