INFORMATION AND COMMUNICATION ENGINEERING CURRICULUM (INTERNATIONAL PROGRAM)

ICE is a new and exciting integration of Computer Engineering, Electrical Engineering, and Industrial Engineering, key subjects at the very core of Chulalongkorn's Engineering School. You will learn the fundamental of computing, become equipped with skills in communication, and complement all this with a solid grounding in management science. Our combination will prepare you for the many stimulating challenges of the IT world.

The ICE program offers students a chance to become hardcore programmers, serving the international community with IT architecture for enterprises, software on mobile devices, satellite communications, game programming, computer networking, and software engineering, to name but a few. The discipline will be strengthened with training in management science that will heighten your competency to an international level. ICE is your future.

Each student is required to accumulate a minimum of 133 credits to graduate for Bachelor of Engineering Program in Information and Communication Engineering (International Program) which has already includes 2 credits of industrial training and 3 credits of senior project.

Curriculum Board

Atiwong	Suchato	Ph.D. (Massachusetts)
Daricha	Sutivong	Ph.D. (Stanford)
David	Banjerdpongchai	Ph.D. (Stanford)
Charnchai	Pluempitiwiriyawej	Ph.D. (USA)
Proadpran	Punyabukkana	Ph.D. (Claremont)
Chate	Patanothai,	M.Eng. (Miami)
Sirin	Nitinawarat	Ph.D. (Maryland)

Professor

PrabhasChongstitvattana,		Ph.D.(Edinburgh)
Parames	Chutima,	Ph.D.(Nottingham

Associate Professors

Computer Engineering

Kultida	Rojviboonchai	Ph.D.(Tokyo)
Vishnu	Kotrajaras	Ph.D.(London)
Chotirat	Ratanamahatana	Ph.D.(California)
Krerk	Piromsopa	Ph.D.(Michigan State)

Electrial Engineering

Chaiyachet	Saivichit,	Ph.D.(London)
Chaodit	Aswakul,	Ph.D.(London)
Charnchai	Pluempitiwiriyawej	Ph.D.(USA)
Lunchakorn	Wuttisittikulkij,	Ph.D.(Essex)

Industrial Engineering

Oran	Kittithreerapronchai	Ph.D.(Georgia)
Wipawee	Thammaphornphilas,	Ph.D.(Pittsburgh)

Assistant Professors

Electrial Engineering

Pasu	Kaewplung,	Ph.D (Tokyo)
Widhyakorn	Asdornwised,	Ph.D.(Chula)

Computer Engineering

Pizzanu	Kanongchaiyos	Ph.D.(Tokyo)
Sukree	Sinthupinyo	Ph.D.(Chula)

ndustrial Engineering

Arisara	Jiamsanguanwong	Ph.D.(Tokyo)

Lecturer

Electrial Engineering

Boonchuay Supmonchai,	M.Eng.(Chula)

Guest lecture

Dechanuchit Katanyutaveetip	Ph.D.(Chula)

ISE Staffs

Yan	Zhao,	Ph.D.(London)
Aung	Pyae	Ph,D. (Finland)

Manufacturing Engineering Operations Management

Natcha	Thaweesaengsakulthai	Ph.D.(Nottingham)

Curriculum

Total number of credits requirement	133	credits	
General Education	30	credits	
Core Courses	97	credits	
Basic Sciences	27	credits	
Compulsory	61	credits	
Approved Electives	9	credits	
Free Electives	6	credits	

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1. General Education   **30**   **credits**

Social Science	3	credits	
Humanity	3	credits	
Science and Mathematics	3	credits	
Interdisciplinary	3	credits	
Foreign Language	12	credits	
5501214	Communication and Presentation Skills	3(3-0-6)	
5501225	Technical Writing	3(3-0-6)	
xxxxxxx	General Education (Foreign Language)	3(3-0-6)	
xxxxxxx	General Education (Foreign Language)	3(3-0-6)	
General Education (Special)	6	credits	
2140111	Exploring Engineering World	3(3-0-6)	
2182205	Probability and Statistics for Data Analysis	3(3-0-6)	

2. Core Courses   **91**   **credits**

Basic Sciences   27   credits

2301107	Calculus I	3(3-0-6)
2301108	Calculus II	3(3-0-6)
2304153	Physics for Engineers	3(3-0-6)
2304154	Physics and Electronics for Engineers	3(3-0-6)
2304193	Physics Lab. For Engineers	1(0-3-0)
2304194	Physics and Electronics Lab For Engineers	1(0-3-0)
2182202	Advanced Mathematics Methods	3(3-0-6)
2182204	Signals and Linear System	3(3-0-6)
2182214	Electrical Circuit for ICE	3(3-0-6)
2182212	Fundamental of Circuit and Digital Electronics Laboratory	1(0-3-0)
2190200	Discrete Structures	3(3-0-6)

Compulsory Courses   61   credits

2140301	Industrial Training	2(0-12-0)
2143101	Introduction to ICE	3(3-0-6)
2143399	ICE Capstone	3(3-0-6)
2143491	ICE Pre-Project	1(0-2-1)
2143499	ICE project	3(0-6-3)
2182371	Principles of Data Communication	3(3-0-6)
2182372	Principle of Telecommunications	3(3-0-6)
2184301	Eng. Economy and Applications	3(3-0-6)
2190101	Computer Programming	3(3-0-6)
2190103	Advanced Computer Programming	3(3-0-6)
2190222	Fundamental Data Structure and Algorithm	4(3-3-6)
2190250	Computer Architecture and Organization	3(3-0-6)
2190413	System Security	3(3-0-6)
2190426	Database Systems	3(3-0-6)

2190423	Software Engineering	3(3-0-6)
2190472	Netcentric Architecture	3(3-0-6)
2190443	User Interface Design	3(3-0-6)
2190512	Application Development	3(3-0-9)
2190513	Data Science	3(3-0-9)
2190514	Artificial Intelligence	3(3-0-9)
2190516	Technology Management	3(3-0-9)

Approved Electives   9   credits

2143423	High Technology Entrepreneurship	3(3-0-6)
2143480	Independent Study I	1(0-3-0)
2143481	Independent Study II	1(0-3-0)
2143482	Independent Study III	1(0-3-0))
2143485	Special Topics in ICE I	2(2-0-4)
2143486	Special Topics in ICE II	2(2-0-4)
2143487	Special Topics in ICE III	2(2-0-4)
2143495	Selected Topics in ICE I	3(3-0-6)
2143497	Selected Topics in ICE II	3(3-0-6)
2143498	Selected Topics in ICE III	3(3-0-6)
2182473	Signal Transmission System	3(3-0-6)
2182475	Tele traffic Engineering and Network Optimization	3(3-0-6)
2184402	Introduction to Stochastic Models	3(3-0-6)
2184403	Theory and Applications of Optimization	3(3-0-6)
2184408	Supply Chain Management	3(3-0-6)
2190479	Graphics Computing	3(3-0-6)
2190517	Software Architecture	3(3-0-9)
2190518	Data Engineering and Big Data	3(3-0-9)
2190519	Natural Language Processing	3(3-0-9)
2190520	Computer Vision	3(3-0-9)
2190521	Cloud Computing	3(3-0-9)
2190523	Game Design	3(3-0-9)
2190524	Embedded Systems Programming	3(3-0-9)

3. Free Electives   **6**   **credits**

Select 6 credits from any courses offered in English by any International Programs in Chulalongkorn University.

INFORMATION AND COMMUNICATION ENGINEERING CURRICULUM (INTERNATIONAL PROGRAM)

OURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER		
2140111	Exploring Engineering World	3
2190101	Computer Programming	3
2301107	Calculus I	3
2304153	Physics for Engineers	3
2304193	Physics Laboratory for Engineers	1
5501112	Communicative English I	3
xxxxxxx	General Education	3
		19
SECOND SEMESTER		
2143101	Introduction to ICE	3
2182205	Probability and Statistics for Data Analysis	3
2190103	Advanced Computer Programming	3
2301108	Calculus II	3
2304154	Physics and Electronics for Engineers	3
2304194	Physics and Electronics Laboratory for Engineers	1
5501123	Communicative English II	3
		19
THIRD SEMESTER		
2182202	Advanced Mathematics Methods	3
2182214	Electrical Circuit for ICE	3
2182212	Fundamental of Circuit and Digital Electronics Lab	1
2190200	Discrete Structure	3
2190222	Fundamental Data Structure and Algorithm	4
2190513	Data Science	3
		17
FOURTH SEMESTER		
2182204	Signals and Linear Systems	3
2190512	Application Development	3
2190514	Artificial Intelligence	3
5501214	Communication and Presentation Skills	3
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		18

COURSE NO.	SUBJECT	CREDITS
FIFTH SEMESTER		
2190250	Computer Architecture and Organization	3
2190423	User Interface Design	3
2182372	Principles of Telecommunications	3
2184301	Engineering Economy and Applications	3
2190472	Netcentric Architecture	3
xxxxxxx	Approved Elective	3
		18
SIXTH SEMESTER		
2143399	ICE Capstone	3
2182371	Principles of Data Communication	3
2190426	Database Systems	3
2190423	Software Engineering	3
2190413	System Security	3
5501225	Technical Writing	3
		18
SUMMER SEMESTER		
2140301	Industrial Training	2
		2
SEVENTH SEMESTER		
2143491	ICE Pre-project	1
xxxxxxx	Approved Elective	6
xxxxxxx	Free Elective	3
		10
EIGHTH SEMESTER		
2143499	ICE Project	3
2190516	Technology Management	3
xxxxxxx	General Education	6
		12

TOTAL CREDITS FOR GRADUATION   133

COURSES DESCRIPTIONS IN INFORMATION AND COMMUNICATION ENGINEERING CURRICULUM (B.ENG)

General Education

2140111   Exploring Engineering World   3(3-0-6)
Engineering topics related to daily life: energy, resources, environment manufacturing, process, industry, material, automotive, infrastructure, information system and bio engineering.

**2182205   Probability and Statistics   3(3-0-6)
for Data Analysis**
Basic probability concepts including independent events, conditional probability, and total probability theorem. Discrete and continuous random variables including probability distribution functions, expected value, variance, and moments. Joint distribution functions including covariance, law of large numbers, and central limit theorem. Descriptive statistics and statistical inferences including point and interval estimations, hypothesis testing and regression analysis. Using MATLAB and Excel programs for statistical analysis, which are essential tools for data analysis, problem solving, and decision-making processes for various fields.

**5501214   Communication and Presentation   3(3-0-6)
Skills**
Practice using English for social communication and giving oral presentation on engineering related topics.

5501225   Technical Writing   3(3-0-6)
Practice in writing summaries composing different types and styles of writing in the field of engineering and writing reports of studies and experiments.

Core Course

2301107   Calculus 1   3(3-0-6)
Limit, continuity, differentiation and integration of real variable and their applications; techniques of integration; improper integrals.

**2301108   Calculus 2   3(3-0-6)
CONDITION: PRER 2301107**
Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three-dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

2304153   Physics for Engineers   3(3-0-6)
Mechanics of particles and rigid bodies; properties of matter; fluid mechanics; heat; vibrations and waves; elements of electromagnetism; optics; modern physics.

**2304154   Physics and Electronics for   3(3-0-6)
Engineers**
Electricity DC circuits; AC circuits; basic electronics; electrical actuators.

2304193   Physics Laboratory for Engineers   1(0-3-6)
Measurement and precision; experiments on simple harmonic motion; radius of gyration; dynamics of rotation; velocity of sound; viscosity of fluids.

**2304194   Physics and Electronics   3(3-0-6)
Laboratory for Engineers**
Resistance and electromotive force measurements; experiments on ammeter; voltmeter; oscilloscope; AC circuit; transistor; lenses and mirrors; polarization; interference; diffraction.

2190200   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.

**2182202   Advanced Mathematics Methods   3(3-0-6)
CONDITION: PRER 2301108**
Complex functions, analytic functions, Cauchy integral theorem, Laurent series, Residue theorem, solving linear systems by row reduction of a matrix, inverse matrices and determinants, rowspace and columnspace of a matrix, rank and nullity, change of basis, linear transformations, orthonormal bases and the Gram-Schmidt process, eigenvectors and eigenvalues, diagonalization of a matrix. First-order ODE, Second-order ODE, Higher-order linear ODE.

2182204   Signals and Linear Systems   3(3-0-6))
Basic circuit elements: resistor, capacitor, inductor, diode and transistor; Kirchhoff's laws; node and mesh analysis; DC and AC circuit analysis; Thevenin's and Norton's theorem; logic and digital circuits.

2182214   Electrical Circuit for ICE   3(3-0-6)
Basic circuit elements: resistor, capacitor, inductor, diode and transistor; Kirchhoff's laws; node and mesh analysis; DC and AC circuit analysis; Thevenin's and Norton's theorem; logic and digital circuits.

**2182212   Fundamental of Circuit and Digital   3(3-0-6)
Electronics Laboratory
CONDITION: COREQ 2182214 or consent   from
instructor**
Electronic instruments: multimeter, oscilloscope, DC circuit, voltage regulators, filter circuit, transistor amplifier circuit, digital circuits.

Compulsory Courses

2140301   Industrial Training   2(0-12-0)
Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

2143101   Introduction to ICE   3(3-0-6)
Fundamentals of computer and telecommunication concepts for information systems; technology and trends underlying current and future uses of information and communication technology; Introduction to engineering management including important aspects of management science; real-world experience sharing and tools related to each topic.

2190101   Computer Programming   3(3-0-6)
Introduction to computer systems; problem-solving using computers; programming in high-level languages; program structure, programming style and convention;

control statements, data handling and processing; subprograms; classes and objects.

**2190222   Fundamental Data Structure   4(3-3-6)
and Algorithm
CONDITION: PRER 2190101**

Introduction to computer systems; problem-solving using computers; programming in high-level languages; program structure, programming style and convention; control statements, data handling and processing; subprograms; classes and objects.

**2143399   Information and Communication   3(3-0-6)
Engineering Capstone**

Culminating and applying of knowledge to develop information and communication systems using design thinking; developing a software starting from gathering all the needs of the system to its application under the instructor's supervision; peer collaboration; giving presentations.

**2143491   Information and Communication   1(0-2-1)
Engineering Pre-project**

Specifying topics or problems, scope, problem-solving methodologies and expected benefits from projects on information and communication engineering

**2143499   ICE Project   3(3-0-6)
CONDITION: PRER 2143491**

Group or individual projects on a subject related to information and communication engineering.

2182371   Principles of Data Communication   3(3-0-6)

Introduction to data communication and networking: layer modeling protocols and architectural network (OSI vs. TCP/ IP) ; basic data transmission, physical layer transmission, data link layer protocols, Network layer protocols, standardization, IPbased network protocols; transport layer: Recap on TCP vs UDP, performance analysis, quality of service, congestion management.

2182372   Principles of Telecommunications   3(3-0-6)

Introduction to telecommunications; overview of digital communication systems; signal and noise analysis; PCM encoding: Nyquist's sampling theorem, quantization and companding; digital baseband systems: NRZ, RZ, bi-phase, bipolar RZ, AMI; digital bandpass systems: ASK, PSK, FSK, MSK and QAM; information theory: entropy, source and channel models, channel capacity, Shannon's theorem and introduction to source coding, error detection/correction codes; overviews of cellular mobile phone networks, optical networks, Internet and satellite systems; introduction to radio propagation in wireless communications.

**2184301   Engineering Economy   3(3-0-6)
and Applications**

Interest calculation; time value of money; equivalent value and rate of return; project analysis and evaluation; break-even point; sensitivity analysis; decisions under risk and uncertainty; economic life and replacement analysis.

**2190103   Advanced Computer Programming   3(2-3-6)
CONDITION: PRER 2190101**

Concepts and practice of object-oriented programming; usage of design patterns in object-oriented programming; programming in application development frameworks: graphical user interface and event- driven programming, collection framework, concurrent programming, socket programming, and/or frameworks of contemporary interest; hands- on practice in developing application software through the application of development frameworks.

**2190250   Computer Architecture   3(3-0-6)
and Organization**

Computer evolution and performance; computer structure, function, and interconnection; memory hierarchy; cache memory; virtual memory; storage; input/output; operating system support; process; interrupt; system call; instruction set; processor structure and function; RISC vs CISC; pipelining; superscalar processors; multi-core computers.

2190426   Database Systems   2(2-0-4)

Database management system concepts, terminology, and architecture; entityrelationship modeling; database design and implementation; relational data model; relational algebra and calculus; SQL; functional dependencies and normalization; indexing; non-relational databases

2190423   Software Engineering   3(3-0-6)

Systems development life cycle; systems development methodologies; software project management; requirements determination and analysis; business process and functional modeling; structural modeling; behavioral modeling; verification and validation; human-computer interaction design; software testing.

2190443   User Interface Design   3(3-0-6)

Human-computer interaction concepts; HCI guidelines; HCI theories; design steps; evaluation; future of HCI; HCI for immersive technologies.

**2190472   Netcentric Architecture   3(3-0-6)
CONDITION: PRER 2190101**

TCP/IP architecture; application layer: principles of network applications, File Transfer Protocol (FTP), electronic mail, Domain Name Systems (DNS), web caching, Content Distribution Networks (CDN) through multimedia, peer-to-peer applications, socket programming, client- server model, peer- to- peer model; transport layer: User Datagram Protocol (UDP) , reliable data transfer protocols, Transmission Control Protocol (TCP) , principles of congestion control; network layer: virtual circuit and datagram networks, internet Protocol (IP) , routing in the Internet; multimedia networking: streaming stored audio and video, protocols for real-time interactive applications; security in computer networks.

**2190513   Data Science   3(3-0-9)
CONDITION: PRER 2190101, 2182205**

Data science definition; data science pipeline; data preparation; exploratory data analysis; statistical analysis; model development; model evaluation; data visualization.

2190512   Application Development   3(3-0-9)

Full-stack development from backend to frontend. Modern backend development tools; data analysis. Current database tools. Well-known frontend development framework for web and mobile applications. Hands-on practice in all levels of software application development.

2190413   System Security   3(3-0-6)
Principles of security and privacy, authentication, authorization, auditing, confidentiality, integrity, availability, fundamental of cryptography, network security, secure software design, penetration test, interdisciplinary in cybersecurity.

2190514   Artificial Intelligence   3(3-0-9)
Search; evolutionary algorithms; K-mean clustering; regression analysis; naïve Bayes; Gaussian mixture models; expectation maximization; dimensionality reduction; support vector machines; deep neural networks.

2190516   Technology Management   3(3-0-9)
Classification of technology; Investment in technology; technology strategy; technology adoption; technology management framework: identification, selection, acquisition, exploitation, protection; concept proof tool; technology roadmap.

Approved Elective

2143423   High Technology   3(3-0-6)
           Entrepreneurship
Establishing technological or new businesses based on knowledge in technology and innovation, starting from basic ideas to ideas that can be implemented in terms of business; project analysis in terms of technical and business readiness, setting up business plan to prepare to investors who are interested; use of problem-based teaching to achieve results and exchange knowledge among all segments involved.

2143480   Independent Study I   1(0-3-0)
Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143481   Independent Study II   1(0-3-0)
Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143482   Independent Study III   1(0-3-0)
Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143485   Special Topics in ICE I   2(2-0-4)
Review and discussion of special topics in information and communication engineering

2143486   Special Topics in ICE II   2(2-0-4)
Review and discussion of special topics in information and communication engineering.

2143487   Special Topics in ICE III   2(2-0-4)
Review and discussion of special topics in information and communication engineering.

2143495   Selected Topics in ICE I   3(3-0-6)
Topics of current interest and in new developments in information and communication engineering

2143497   Selected Topics in ICE II   3(3-0-6)
Topics of current interest and in new developments in information and communication engineering

2143498   Selected Topics in ICE III   3(3-0-6)
Topics of current interest and in new developments in information and communication engineering

2182475   Teletraffic Engineering and   3(3-0-6)
           Network Optimization
Teletraffic engineering overview; quality of service and network performance optimization; classification of teletraffic engineering systems and teletraffic parameters; teletraffic data collection techniques and statistics; modeling of non-queuing/loss-type system and queuing/delay-type system; modeling of system with mobile users; fundamentals of modeling network of by computer program ; simulation program; real-time network management and long-term network planning; application of optimization techniques in network controls; case studies in network design.

2184402   Introduction to Stochastic Models 3(3-0-6)
Unconditional and conditional probability; discrete and continuous random variables; moments; Poisson processes; discrete time Markov chain and applications; stochastic analysis and modeling.distributed transaction under failure conditions; security; distributed services.

2184403   Theory and Applications of   3(3-0-6)
           Optimization
Introduction to theory, algorithms, and applications of optimization; optimization methodologies: linear programming, network optimization, and integer programming.

2184408   Supply Chain Management   3(3-0-6)
Definition of supply chain; coordination difficulties; pitfalls and opportunities in supply chain management; inventory/ service level tradeoffs; performance measurement and incentive; extensive supply chain management; mass customization; supplier management; design and redesign of products and process for supply chain management; analytical tools; industrial applications; current industry initiatives.

2190473   Ubiquitous Computing and   3(3-0-6)
           Networking
Introduction to ubiquitous computing, overview and basic terminologies; visions and fundamental challenges; wireless MACs; mobile IP; wirelessad hoc networks; wireless sensor networks; programming wireless networks of embedded systems; adaptive topology; time synchronization; localization; IPv6; internet of things; energy saving; smart grid.

2190479   Graphics Computing   3(3-0-6)

Hierarchy of graphics software, use of graphics API: simple color models (RGB, HSB, CMYK) ; homogeneous coordinates, affine transformations: scaling, rotation and translation; viewing transformation clipping, raster and vector graphics system.

2190517   Software Architecture   3(3-0-9)
        CONDITION: PRER 2190426, 2190423

Principles of software architectures; architectural styles; architectural description language; software architectural analysis and design; software architecture specification tools; software architecture-based testing; use of software architectures in the software development process; software design pattern; continuous Integration and continuous delivery.

2190518   Data Engineering and Big Data   3(3-0-9)
        CONDITION: PRER 2190101

Data gathering and cleansing; data modeling; data ingestion; structured and unstructured data stores; big data platform; workflow management.

2190519   Computer Vision   3(3-0-9)

Digital image formation and representation; image enhancement; feature detection; color; texture; image segmentation; object recognition; deep learning for computer vision; object detection; 3D vision; dynamic vision; vision- based application development and deployment.

2190521   Cloud Computing   3(3-0-9)
        CONDITION: PRER 2190472, 2190250

Definition and benefits of cloud computing; cloud migration; infrastructure-as-aservice; platform- as- a- service; storage- as- a- service; auto- scaling and service availability; virtualization technologies and software- defined networks for cloud; cloud security

2190523 Game Design   3(3-0-9)

Player psychology; brainstorming techniques; Game Elements and Game Development Process; Playtesting and Game Balancing; Principles of Puzzle Design; Level Design; User Interface Design; Game Community

2190524   Embedded Systems Programming   3(3-0-9)

Limitations of embedded processors; embedded software development environment; reading and writing digital I/O; configuring timers/counters, analog to digital converter and communication modules: SPI, I2C, WiFi, Bluetooth; real-time operating system: multitask programming, inter- process communication; power management for optimization of performance and power consumption; interrupt service routines; configuring security modules; secured communication.