College of Engineering
NTU Singapore
A better world through creativity and technology
At NTU College of Engineering (CoE), we develop innovative and sustainable solutions that make a positive impact on the world. We achieve this by blending creativity with technology, and providing the resources necessary for our faculty, students and researchers to push the boundaries of possibilities and realise their full potential. This has led to us being consistently ranked amongst the best in international ranking exercises on Engineering Research and Education.

Active engagement in advanced, inter-disciplinary research has enabled us to think outside the box, and develop integrated, creative solutions for issues facing society and nation.
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Overview

NTU College of Engineering (CoE) is the largest college in the University with some 2,000 faculty and staff, and 14,000 students. Through our world-class research facilities, strong links with industry giants and collaborations with renowned engineering colleges, we provide students a well-rounded education that goes beyond traditional academic boundaries.

CoE comprises six renowned schools, identified by their disciplinary focus, and research institutes such as the Energy Research Institute @ NTU (ERI@N), Nanyang Environment and Water Research Institute (NEWRI) and Singapore Centre for 3D Printing (SC3DP) which are actively engaged in inter-disciplinary research.

We strive to be a great global college for education, research and innovation in engineering and will continue to focus on developing strategic alliances with industry partners and collaborations with distinguished educational institutions. Our pursuit of excellence in research and education have contributed to the stellar performance of NTU and CoE in many international rankings of world universities. In a recent ranking (2014) released by the U.S. News of the World, NTU was ranked 5th in the world in Engineering. All our engineering schools were also ranked within the top 21 in the world in the QS World University Rankings by Subject 2015.
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Education

CoE offers a broad-based, industry-relevant and multi-disciplinary education that transcends traditional engineering boundaries and is flexible to suit personal abilities and interests. Innovations in teaching methodologies, and intensive use of technology for collaborative and participatory learning, turn classrooms into exciting hotbeds for self-discovery and learning. Equipped with core competencies and skillsets, our students are well equipped to take on the challenges of the 21st century.
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Undergraduate Education

CoE offers a variety of programmes which can accommodate the different aspirations of students. We offer eleven accredited single-degree programmes leading to the Bachelor of Engineering degree as well as double major, double degree and integrated Bachelor of Engineering and Master of Science programmes for academically strong students.

Home to more than 10,000 undergraduates, the hallmark of the engineering education at CoE is that it is industry-relevant and broad-based, extending beyond traditional engineering boundaries and flexible in allowing students to plan their learning according to their interests and strengths.

Undergraduate Programmes

Bachelor of Engineering Programmes
- Aerospace Engineering
- Bioengineering
- Chemical & Biomolecular Engineering
- Civil Engineering
- Computer Engineering
- Computer Science
- Electrical & Electronic Engineering
- Environmental Engineering
- Information Engineering & Media
- Materials Engineering
- Mechanical Engineering

Bachelor of Science Programme
- Maritime Studies

Double Major Programmes
- Civil Engineering/Electrical & Electronic Engineering/Environmental Engineering/Mechanical Engineering with a Second Major in Society and Urban Systems
- Chemical & Biomolecular Engineering with a Second Major in Food Science & Technology
- Engineering* with a Second Major in Business
- Maritime Studies with a Second Major in Business

Double Degree Programmes
- Computer Engineering and Business
- Computer Science and Business
- Engineering* and Economics

Integrated Programmes
- Renaissance Engineering Programme
- Computer Engineering and Georgia Institute of Technology Master of Science (Computer Science)
- Computer Science and Georgia Institute of Technology Master of Science (Computer Science)
- Electrical & Electronic Engineering and Georgia Institute of Technology Master of Science (Electrical and Computer Engineering)

Integrated Programmes
- Renaissance Engineering Programme
- Computer Engineering and Georgia Institute of Technology Master of Science (Computer Science)
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- Electrical & Electronic Engineering and Georgia Institute of Technology Master of Science (Electrical and Computer Engineering)

* In a chosen Engineering major

Broad-Based Learning

The undergraduate curriculum integrates engineering education with adequate content in the arts, humanities, business and social sciences, to better equip students with the competencies needed to face the changing demands of the global economy. This multi-disciplinary education arms the students not only with traditional engineering skills but also sharpens their communication, inter-personal and entrepreneurial skills that are highly valued by employers. Learning in NTU is collaborative and participatory with students taking on active roles in the classroom.

Real-World Application

One of the important aspects of engineering education in NTU is the mandatory Professional Internship which places students in the industry for a semester or longer to gain real-world, professional exposure even before they graduate. In addition, Global Immersion programmes offer students regional and international exposure, imparting global-mindedness and inter-cultural competency. These experiences add value to students’ employability and enhance career mobility upon graduation, often taking CoE’s graduates beyond Singapore’s shores.

Research Exposure

Students inclined towards research can take up the Undergraduate Research Experience on Campus or URECA programme which offers undergraduates a head-start in research and a unique opportunity to immerse in the vibrant research culture and environment in NTU.

Special Programmes

The College offers double major and integrated Masters programmes to academically high-calibre students to realise their true potential. The College’s flagship Renaissance Engineering Programme (REP) is a co-terminal dual-degree programme that awards a Bachelor of Engineering degree and Master of Science in Technology Management degree in 4.5 years. Offered in partnership with NTU’s Nanyang Business School, Imperial College London and the University of California Berkeley, the REP develops students to become the Engineering-Business leaders of tomorrow. In addition, the College added to its repertoire, three new double major programmes recently. These include the Second Major in Food Science & Technology offered in partnership with the prestigious Wageningen University in Netherlands, the Second Major in Business in collaboration with NTU’s Nanyang Business School and the Second Major in Society and Urban Systems in collaboration with NTU’s College of Humanities, Arts and Social Sciences.

1 All Bachelor of Engineering programmes are accredited by The Institution of Engineers Singapore, the Singapore signatory of the Washington Accord, through its Engineering Accreditation Board. The Washington Accord is an international agreement for mutual recognition of the substantial equivalence of engineering academic programmes in satisfying the academic requirements for the practice of engineering at the professional level.
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- Information Engineering & Media
- Materials Engineering
- Mechanical Engineering

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Graduate Programmes
CoE offers three different graduate programmes through its six schools. Research degree programmes lead to Master of Engineering (M.Eng.) or Doctor of Philosophy (Ph.D.) degrees. Programmes by coursework lead to Master of Science (M.Sc.) degrees.

Research Programmes
Research degree is carried out under the supervision of a faculty. Research is pursued in many cutting-edge areas over a range of engineering disciplines and cross-disciplinary areas. Research students are required to take some courses and acquire stipulated academic units besides doing a research project. They will be required to pass a qualifying examination for confirmation of their candidature within 4 semesters.

Upon the completion of the research project, students are required to submit a thesis for examination and face an oral defence in front of a panel of examiners.

Scholarships are available for bright and outstanding students to pursue the Ph.D. degree.

Candidate

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<th>M.Sc. Programme</th>
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<tbody>
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<td>SCBE</td>
<td>Biomedical Engineering</td>
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<tr>
<td>CEE</td>
<td>Civil Engineering</td>
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<td></td>
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<tr>
<td>SCE</td>
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<td>EEE</td>
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<td>Power Engineering</td>
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<td>Signal Processing</td>
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<td>MAE</td>
<td>Manufacturing Systems and Engineering</td>
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<td></td>
<td>Supply Chain and Logistics</td>
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<td>Mechanical Engineering</td>
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<td>Precision Engineering</td>
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<td>Smart Product Design</td>
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Master of Science (M.Sc.) programmes

To obtain a M.Sc. degree, students are required to take a combination of prescribed courses and free electives and pass the examination. An option is also available for students to take a project dissertation, equivalent to 6 Academic Units (AUs). A list of current M.Sc. programmes available in the College is listed below.

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Joint/Dual Degree Programmes

NTU collaborates with several top overseas partners to offer dual or joint degree programmes. These programmes provide exciting interactive opportunities for our graduate students with world-class faculty and researchers, enabling them to experience and undertake energising and challenging assignments.

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Research Powerhouse

We are a global leader in research and technological inventions. Collaborating closely with other research institutes in the university such as Nanyang Environment and Water Research Institute (NEWRI), Energy Research Institute@NTU (ERI@N) and Singapore Centre for 3D Printing (SC3DP), the College further pushes research boundaries and milestones in research.

With research output ranked among the top three* universities in engineering globally, we have made our mark in innovation and technological leadership.

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**Urban Solutions**
Explosive growth of cities, shifting demographics and ageing infrastructure combined with desire for improved liveability and protection from natural disasters or man-made events are creating strong demand for new urban solutions in areas of transportation, built environment and city management.

At CoE, our research is focused on developing innovative solutions and capabilities for land capacity, sustainable transportation and good quality living environment.

**Transportation**
- Enhanced efficiency and resilience in transportation, infrastructure, freight and logistics, road capacity and performance.
- Development of technologies, systems and facilities to support sustainable mobility modes.

**Resilient Systems**
- Develop robust structures and design protection systems against potential threats from events.
- Simulate and test blast response and fire resistance.
- Advance smart solutions for emergency management.

**Liveability**
- Creation and optimal utilisation of usable space.
- Management of mega-cities for comfortable and generative environment.
- Social, psychological, health and safety of underground living.

**Future Healthcare**
Ageing population has increased the demand for therapeutic treatments. Our research in medical technology is aligned with Singapore’s position as Asia’s bio-cluster.

**Rehabilitation and Medical Robotics**
- Medical robotics technology for faster patient recovery, less invasive and safer procedures.
- Neuron cognitive study of human movements.
- Wearable sensors and haptic devices for home and tele-rehabilitation.
- Techniques, technologies, and systems in medical informatics and systems to overcome the frailties of the human body.

**Biotechnology**
- Bioengineer healthcare treatments, including tissue/organ replacement, therapeutic medical devices, diagnostic solutions.
- Anti-microbial coatings.
- New technologies in genomics, microbial engineering, stem cell engineering, microscopy and measurement technology, manufacturing of biologics, and plant biotechnology.

**Advanced Materials and Manufacturing**
Singapore has the edge to be the advanced manufacturing hub of Asia and to tap opportunities from disruptive technologies such as additive manufacturing. The materials industry which cuts across multiple sectors will support the future of manufacturing.

**Additive Manufacturing**
- Lightweight materials.
- Fabricate and customise medical devices and implants.
- Novel printers, materials and issues related to certification and qualification.

**Advanced Materials**
- Tailor materials for medical applications.
- Functional defence materials and platforms for materials development, device design and system integration.
- Materials for renewable energy and environmental applications.
- Fabricate prototype devices from novel materials.
- Materials and technologies inspired by nature.

**Engineering Digital Economy**
The Infocomm Media (ICM) Masterplan 2025 is to establish Singapore as a Smart Nation that leads the world in tapping the potential of ICM to drive economic growth, social cohesion and better living. We conduct cutting-edge research on infocomm technology to respond to this new digital economy development.
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Advanced Communications
• Multi-user test beds to measure and evaluate new communication technologies.
• Digital information processing, inter-operability and wireless/quantum communications, and terabit optical transmission technologies.
• Heterogeneous networks, large scale MIMO (multiple-input multiple-output), cognitive radio, optical fibre networks, wireless sensor networks, mesh networking, software-defined networking and 4/5G networks to reshape the communication industry.
• 5G HetNets and TV White Spaces.

Achievement
• Built a no-line-sight localisation test-bed to support applications for police, fire service and search and rescue operation.

Environment and Water

• Low carbon technology through development of catalysts, green solvents, new chemical processes, control strategies and system modelling and optimisation.
• Advanced environmental and water technologies, such as novel membranes and bioprocesses, for high performance water reclamation, solid wastes and water resource management as well as energy recovery.

Energy

• Conversion of solar energy to clean fuels, improved storage, transport and consumption techniques.
• Convert natural resources and bio-feedstock into value-added chemicals and fuels.
• Research on energy optimisation for smart buildings.
• Intelligent power distribution and energy optimisation for built environment, aerospace and marine applications.

Satellite Engineering

• Satellites for communications, weather study, observation of climatic changes and natural disasters.
• New satellite technology for future generations of satellites flying in formation and constellation.
• Create versatile nano-satellite mission for in-orbit technology demonstration.

Achievements
• Completed and launched the first four Singapore-built satellites (X-SAT, VELOX-I, VELOX-II & VELOX-PIII) between April 2011 to June 2014.
• To launch a climate monitoring satellite named VELOX-CI and a communication satellite named VELOX-II in 2015/16. An electric propulsion demonstration satellite named VELOX-III will be built by 2016.

Food Science and Technology

• Food products/ingredients and their effects on health.
• Sustainable production and ingredient production through process engineering and biotechnology (bio-refinery).

Resource Resilience

Singapore has finite space, limited water supplies, and no natural resources. The government has made sustainable development, the use of renewable energy, and the efficient use of resources, primary considerations in all its future planning efforts.

Big Data

Singapore continues to expand its capabilities in data and analytics. The knowledge created enables us to deal with priority issues such as healthcare and underpin our development towards being a Smart Nation and a regional analytics hub.

Internet of Things (IoT)

• Pervasive, low-power, self-sustainable sensing, networks, actuating technologies, and applications for smart city, buildings and transportation.
• Internet for serving general public, but with special emphasis on people with special needs (e.g., elderly, minors, and disabilities).
• Research in real-time big data and multimedia analytics.
• Cyber-physical system security.
• Vehicular technologies or smart transportation.
• Physical analytics beyond big data.

Achievements
• Developed a non-GPS localisation technique to identify object’s locations for urban environments.
• Developed indoor localisation service.
• Implemented indoor energy harvesting for supporting sensing, networking, and actuating.
• Successfully developed co-existence mechanisms for massive wireless devices.
• Implemented crowd-sensing system development from both technological and social aspects.
• Launched environmental monitoring with low cost sensing infrastructure.

Cloud Computing

• New approaches and technologies for fast and rich mobile object search with constrained network and computational resources, compact and innovative feature coding, scalable indexing and search algorithms.
• Large-scale image/video classification and search.
• Large-scale 3D scene understanding and search.
• Face recognition and retrieval, especially in social media contexts.
• Deep learning for large-scale image recognition and search.
• Semantic image segmentation and co-segmentation.
• Large-scale image/multi-object search.
• Cloud-based solution, fine-grained classification and retrieval.

Achievements
• Emerging applications and use cases over cloud platform.
• Cloud resource management and service orchestration via advanced optimisation algorithms.
• Critical infrastructure (e.g. green data centre) for cloud computing and its enabling technologies (software-defined systems, new hardware, etc).
• Real-time data analytics in the cloud.
• Hardware accelerated heterogeneous cloud infrastructure.
• Energy efficient cloud infrastructure.

Visual Analytics

• HPC cloud and its support for scientific computing: developed transformation-based monetary cost optimisations for scientific workflows.
• Energy saving: leveraged smart power management and renewable energy to reduce the carbon footprint of cloud computing.
• Multi-user test beds to measure and evaluate new communication technologies.
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Infocomm technology is one of Singapore’s most significant service sectors, so the use of secure, resilient and robust technologies are critical to ensure our national reputation as a trustworthy and secure business hub. The global cyber security market which is expected to grow to about US$120.1 billion by 2017 at a compound annual growth rate of 11.3% from 2012 to 2017, spells exciting opportunities for our investment in this area.

**Cyber Security**

- Trustworthy systems: develop new approaches for risk assessment, vulnerability detection and security enhancement in complex cyber-physical systems.
- Cyber situational awareness: build scientific foundation for a theoretically-grounded and empirically-validated algebraic model of data that supports a wide range of scalable analytical techniques to enhance cyber situational assessment and awareness.
- Insider threats: multi-disciplinary study for detecting and tracking insider threats.
- Cyber-physical systems security: modeling cyber-physical attacks in perspective of novel computing devices and architectures.
- Scalable malware and vulnerability detection using programming analysis for binary, source code and JavaScripts.

**Achievements**

- Hardware security: identifying security flaws in the testing phase of integrated circuits.
- Security verification for security protocols, runtime security policy, mobile computing, trust platform and cloud computing.

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**Research in numbers**

- 120 Industrial partners
- 2,300 Research publications
- 7.8 citations per publication on SCI
- 178m Research grants
- 280 Patents/licences filed/signed
- 100 Academic and research organisations
- 2 Engineering disciplines in top 10 QS World Rankings by Subject 2015
- 54 books and chapters and presented
- 1000 papers at 650 conferences
- 35 Research Centres and Institutes

*All figures are correct as at July 2014. QS World University Rankings by Subject 2015 are correct as at April 2015.*
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Academia Sinica • Aspin Kemp & Associates • Austrian Institute of Technology • Ben-Gurion University of the Negev • Cambridge University • CISRI • Danone Delta Ltd • Elbit Systems Israel and C41 Ltd • Emory University • Exxon Mobil • Fraunhofer Institute • FrieslandCampina • Georgia Institute of Technology • Hebrew University of Jerusalem • Imperial College London • Linköping University • Lucent Technologies • Microwave Tubes Research & Development Centre • MIT • National Dental Care • National Heart Centre System • National Taiwan University • NEC • Nestle • NJIT • Northwestern University • Oxford University • Qatar University • Queensland University of Technology • Rolls Royce • Royal Institute of Technology • Russian Academy of Science • SIIRD SingTel • ST Engineering • STMicroelectronics • STATS ChipPAC Ltd • Technical University Darmstadt • Technical University of Munich • Technion-Israel Institute of Technology • Texas State University • Thales Alenia Space • Tokyo Institute of Technology • UC-Berkeley • UC-Merced • UIUC • Universidad Nacional de La Plata, Argentina • Universidad de Buenos Aires • Universidad Federal do Rio de Janeiro • University of Strathclyde • Université de Technologie de Troyes • University of Melbourne • University of Michigan • University of Rochester • University of Southampton • University of Tokyo • University of Washington • University of Waterloo • University of Wisconsin • Wageningen University • Waseda University • Zhejiang University
Faculty

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In order to attract exceptional young academics from around the world, the University launched the Nanyang Assistant Professorship (NAP) scheme in 2007. NAP recipients receive start-up grants of up to S$1 million. They also have the chance to lead multi-disciplinary research teams. NTU has more than 30 NAP awardees in the University, with approximately half of them in the College of Engineering.

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