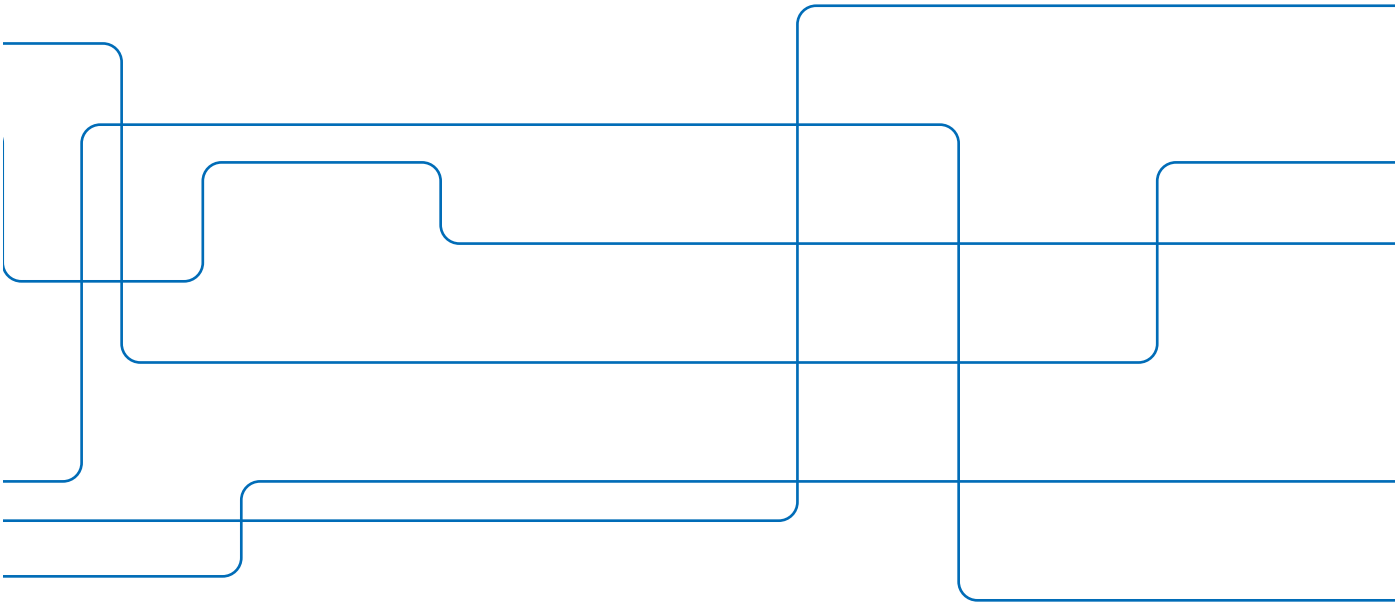
KTH ROYAL INSTITUTE
OF TECHNOLOGY

Research and education in electrical engineering and computer science



KTH School of Electrical Engineering and Computer Science

The answers lie in the borderland

Head of School and Professor Jens Zander

KTH is Sweden's leading technical university and competes with the highest ranked universities in the world in several subjects. Two of KTH's most highly distinguished subjects are electrical engineering and computer science, which have been merged into one organisational unit with the declared intent of solving the societal challenges of the future.

It is no secret that the world is facing more complex challenges than ever. In turn, the increased complexity places higher demands on KTH and on the solutions that KTH and other universities contribute to. Challenges within future transport, energy supply and digitisation are so difficult that they must be tackled from several directions if we are to respond to them.

There are five extensive research areas at KTH, each with an organisational unit working intensively with the major societal challenges. One of these is our amalgamation of electrical engineering and computer science, a combination with a broad spectrum of disciplines and knowledge that grows in interaction.

Today, and not least in the future, there is an enormous need for engineers and researchers with knowledge and understanding of both electrical engineering and computer science. This is due to technology becoming increasingly i ntegrated and systems increasingly complex. This means that our researchers and students need to be able to work more broadly and even more multidisciplinarily than before.

Our activities in electrical engineering and computer science grant us access to the large toolbox needed to solve many of the challenges of the future. This is exactly where the future lies – in the borderland where our two subject areas meet and where new knowledge, theories and practical applications can be created.

Jens Zander

Head of School and Professor, School of Electrical Engineering and Computer Science

Read more at kth.se/en/eecs

Electrical engineering and computer science places high on subject rankings

KTH achieves a high position on ranking lists of excellence in electrical engineering and computer science. On the Shanghai Ranking's subject ranking (ARWU) in 2018, KTH places top 50 in eight subjects, five of which the School of Electrical Engineering and Computer Science have made a strong contribution to:

- automation and control: 15
- transport science and technology: 18
- telecommunication engineering: 19
- energy science and engineering: 48
- electrical and electronic engineering: 50

KTH is ranked number 26 in the world in electrical engineering (QS) and number 54 in the world in computer science (THE).

Contact and management

KTH is led by a president together with a deputy president, dean of faculty, vice dean of faculty and vice presidents. Get in touch with KTH: kth.se/en/om/kontakt

The School of Electrical Engineering and Computer Science is led by a head of school, deputy heads of school, head of administration and director of third-cycle studies. Get in touch with the school here: kth.se/en/eecs/kontakt/

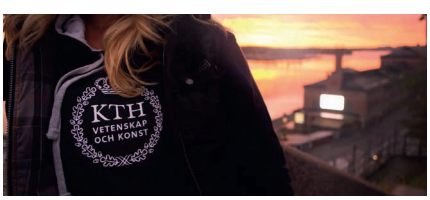
A modern campus in several parts of Stockholm

KTH's campus area extends all over Stockholm, from its central areas to Södertälje, Flemingsberg and Kista. The operation in electrical engineering and computer science is located on KTH's campus in Kista and Valhallavägen.

Kista is one of the world's strongest ICT clusters and home of over 1 000 ICT companies such as Ericsson, IBM, Tele2, Microsoft and Intel. With an expansive business community, residential areas, student residences and good communications, Kista is one of Stockholm's most dynamic areas.

KTH Campus at Valhallavägen is home to the majority of the programmes in engineering as well as the University of Dance and Circus, the Swedish Defence University and the University College of Opera. Over the next few years, approximately 700 student residences will be built at KTH Campus.

About KTH



Read more about KTH: kth.se/en

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A new generation of engineers

The complex problems and challenges facing society are placing new demands on the role of the engineer. In KTH's educational programmes in electrical engineering and computer science, we use new teaching methods to combine education with research.

KTH is Sweden's highest ranked technical university and educates students at first, second and third-cycle level. After their studies, the students work in all types of sectors and are highly sought after by both industry and public organisations. Of the students who study programmes within electrical engineering and computer science, 99 % find a job a year after graduation, a figure that shows that our programmes maintain high quality and have high societal relevance.

Looking ahead, society is facing new challenges that demand advanced technological solutions. In order to contribute to these, we must constantly improve and renew ourselves. One of the most important and prioritised areas is broadened recruitment. The activities in electrical engineering and computer science aim to disseminate knowledge about the role of the engineer to young people in different demographic groups, such as through participation in the Politician Week Järva and through Giants, an annual campaign and event where young people can meet female role models in the field.

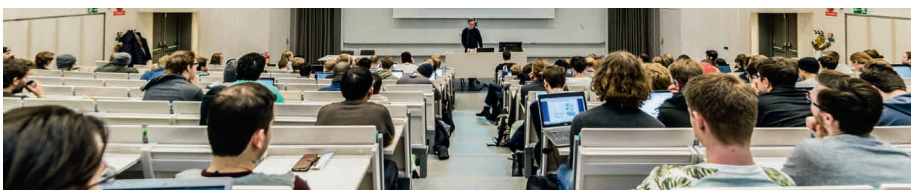
The engineers of the future need an even broader subject competence as well as the ability to communicate and collaborate. Thanks to challenge-driven courses and study programmes, such as project courses, our students help companies and organisations solve problems, work together and report their results in new ways.

KTH's teachers in electrical engineering and computer science use new methods and pedagogical tools to shape the next generation of engineers where digitisation and sustainability comprise important parts. Digital teaching makes the education even more flexible and inclusive, and courses in sustainability give the students a unique perspective and the opportunity for reflection.

Our programmes are closely related to research with subject width, giving students access to new knowledge and research methods. The programmes are currently undergoing a change to become even broader, and the first new degree programme students are expected to take their examinations in 2025.

Read more at kth.se/studies

Degree programmes for sustainable social development

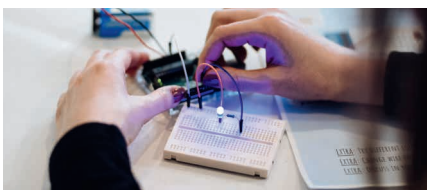


In electrical engineering and computer science, students at all levels can include a sustainability profile in their education by choosing freestanding courses, programmes or a specialisation with sustainability focus. These are based on the UN's climate targets and support KTH's strategic work with sustainability. Professor Viktoria Fodor and Associate Professor Markus Hidell are both Vice Director of First and Second Cycle Education in electrical engineering and computer science.

"We have a unique breadth of competencies and programmes. Our students gain important knowledge and need a sustainability perspective to be able to develop technical solutions for the future. By keeping to UN's climate targets, we can create a balance between ecological, economic and social aspects of sustainable development", says Markus Hidell.

"Next we need to ensure that many of our teachers have competence in sustainable development as well, and that there is breadth and depth in the range of courses that are linked to this area", Viktoria Fodor adds.

Learning by doing



Project courses are available for several of the programmes in electrical engineering and computer science. These courses provide a first experience of working life and give students the opportunity to convert their theoretical knowledge into practical solutions. Amongst other things, our students have created electric pianos, electric motors, robots and installations. Many of the projects consist of real problems that come directly from the industry and public sector.

Course in ethical hacking

Technical development makes it difficult to protect information and data. KTH's course in ethical hacking helps organisations to understand the methods used by hackers, a key to protecting themselves from cyberattacks.

"It is very useful to allow ethical hackers test the security of their own systems", says course co-ordinator and Professor Pontus Johnson.

The course involves five weeks of distance education and is given continuously.

Broadening the image of the engineer

The great need for engineers places high demands on KTH's student recruitment. In order to attract students from more demographic groups to our programmes at first cycle level, the activities in electrical engineering and computer science work to broaden the image of what an engineer does and who he/she is.

With the slogan "The future is too important to be left to men" KTH arranges Giants, an event that female students in upper-secondary school from all over Sweden are invited to. The day, which has been arranged since 2014, focuses on courses and programmes in IT, data and electrical engineering, amongst other subjects. Visitors can participate in workshops, get information about KTH's programmes and listen to inspiring speeches by female industrial talents.

To encourage the interest in KTH's master programmes from international students, we participate in international recruitment forums and work on building relationships with companies and universities around the world.

Research for a sustainable world

KTH's research in electrical engineering and computer science is world-leading in several areas. Using theoretical and multidisciplinary approaches, our researchers produce sustainable and pioneering solutions to real societal problems and challenges, both nationally and internationally.

Modern electrical engineering and computer science span a broad area, far beyond its historical roots. The research in this area includes energy systems, systems engineering, electronics, communication systems, computer science, software development and human-computer interaction. Our researchers contribute to solutions in intelligent transport, robotics, secure infrastructure, smart cities, medical technology, media technology, interaction design, machine learning and speech and music communication.

Economic, social and environmental sustainability is one of KTH's priority areas. The research in electrical engineering and computer science contributes to the sustainable development through innovations, applications and pioneering technical development but also by disseminating knowledge and helping decision makers to make conscious choices. Our contribution spans from renewable energy production and smart electricity networks to medical applications and technology for modern geriatric care, the development of national and international policies and electric and self-driving vehicles.

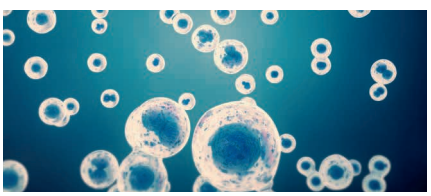
Electrical engineering and computer science at KTH belong to the world's elite in its field. Two contributory factors for this are a strong international faculty and leading research environments with long-term theoretical development carried out in co-operation with industry. A significant proportion of the faculty and the doctoral students are recruited internationally and the majority conduct research in international networks. This is the result of a conscious strategy to attract the very best researchers and talents – wherever they are.

KTH's researchers have access to unique infrastructures, including the PDC Parallel Data Centre, a cleanroom for the manufacture of integrated circuits, a high voltage lab, robotics lab, fusion experiment reactor and a visualisation studio. Here, researchers can carry out advanced calculations, tests and visualisations that benefit both basic and applied research.

Through collaborations between applied and fundamental research groups, we find ourselves at the very leading edge of research and social development.

Read more at kth.se/en/eecs/forskning

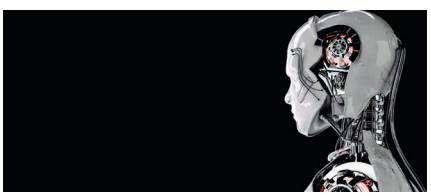
An important step in cancer treatment



Researchers have produced a multi-faceted synthetic plastic material that can be used to encapsulate living cells, a technique that could, in the future, be a cytotoxin factory working locally in the tumours of cancer patients.

"We have produced a way to encapsulate cells and then use these capsules as a drug. Encapsulating cells is something that has been done previously but our method is both easier and better", says Wouter van der Wijngaart, Professor in micro and nano systems.

Increasing the understanding of AI



KTH is part of Wallenberg AI, Autonomous Systems and Software Program (WASP), one of Sweden's largest research programmes. The programme's investment in AI can be split into two elements: one that focuses on machine learning, deep learning and the next generation of AI and one with the purpose of increasing the understanding of the mathematics behind the technology.

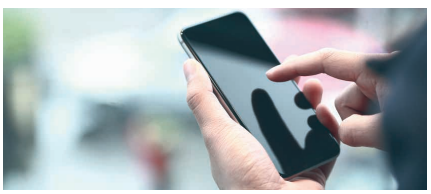
"We will focus on the areas that benefit Sweden, in both the long and short terms", says Danica Kragic, Professor in robotics and responsible for WASP-AI at KTH.

The world's smartest electricity network

Smart Grid Gotland, one of the world's foremost smart electricity network projects, in which KTH was one of the parties, has crossed the finishing line. As a result of upgrading the energy system on Gotland with smart electricity network technology, it was shown that:

- It's possible to increase wind power in existing networks
- Length and frequency of interruptions can be reduced by 25 percent
- Smart technology is a cost-effective alternative to conventional network reinforcement

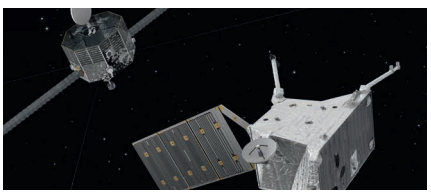
Next generation of mobile network



KTH has a long tradition of contributing to the development of the next generation of mobile networks, through international EU projects such as METIS and WINNER.

Together with Ericsson and Telia, researchers are now taking the next step towards the implementation of 5G. KTH researchers will be testing and evaluating the 5G technology in new real-time applications. A live-in- lab for studying the effects of immersive digital technology is being built and will be completed in 2020.

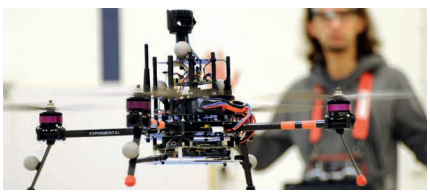
KTH technology for Mercury



KTH technology is on its way to Mercury. The space probe, MMO, will explore the planet's magnetosphere which interacts with the solar wind. There have only been two previous attempts to explore Mercury due to its extreme weather conditions.

"KTH is involved in this project because we have lengthy experience of similar tasks in space where electrical fields have been required to be measured", says Tomas Karlsson, Associate Professor in space and plasma physics.

A choir of robots



KTH researchers have enabled a group of robots to follow motion commands. The group consists of drones that will take part in opera performances by singing and dancing while being directed by humans in real time.

The drones have been built using 3D printing and are equipped with speakers and sensors. A motion capture system registers the leaders position who in turn control the drones' movements and actions. This makes it possible for robots to adapt to changes in their surroundings and find own unique movement paths.

A partner for the future

KTH's activities in electrical engineering and computer science are performed in collaboration with the surrounding society. The academic breadth of the subject combined with a wide range of arenas for collaboration make us an attractive partner for external partnerships.

KTH has been working strategically with collaboration for a long period of time. As a result of the strategic partnerships and the broad networks of researchers and teachers, we can ensure that our work in electrical engineering and computer science is of relevance to the needs and challenges of society today. This is particularly important when designing our educational programmes.

Our students develop their skills through dissertations and project courses based on assignments with solutions that will be used in reality. They acquire practical experience while solving problems for companies and organisations. External stakeholders may also contribute to education through their own advanced courses at master level.

Lifelong learning is the next stage, where we offer contract education in ethical hacking and have the technology to perform distance education when requested.

Electrical engineering and computer science are found in highly topical areas such as robotics and AI, software-development, IT and system security and digitalisation. In these areas, KTH is internationally prominent and has partnerships with universities in countries such as Singapore and the USA. The sharing of knowledge is a prerequisite for relevant research and for contributing to the global challenges that the world faces.

Within our research infrastructures and research centres, external stakeholders meet students, researchers and teachers. We are currently making strategic investments in research centres related to electrical engineering and computer science. Centres are effective models for collaboration as researchers from industry can share experiences with teachers and, at the same time, meet the doctoral student who could be their next recruitment.

Our software development centre (CASTOR) and centre for digitalisation are examples of two of the latest areas of collaboration, created to meet the needs that we and KTH's strategic partners have identified.

Teachers and researchers in electrical engineering and computer science collaborate with stakeholders such as ABB, Saab, Volvo and Microsoft, but also in networks such as CERN, SNIC and Myfab. The breadth of arenas makes us a partner for the entire chain, from sharing knowledge and technology to competence development and producing applications.

Read more at kth.se/en/eecs/samverkan

CASTOR – a centre for advanced software technology

In the CASTOR centre, KTH boosts advanced software development in Sweden along with Saab and Ericsson. Software is everywhere, from the large data centers running Internet services 24/7, to the tens of computers in cars and the connected 'things' that are present in our societies. The increasingly complex software systems places high demands, both on research and new technologies.

"There is lot to be done to find the right topics, the right instruments for collaboration, the right, meaningful outputs. And I am also actively looking for new partners to strengthen the visibility and chances of impact of our research", says Benoit Baudry, Centre Manager and Professor in computer science.

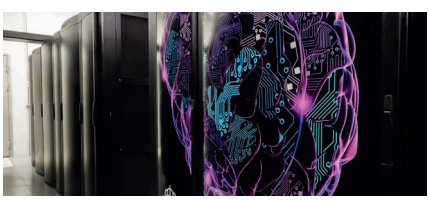
CASTOR will look at the challenges within the area of complex software, including security and compatibility between open source software and ordinary systems.

A hub for digitalisation

KTH plans to start a new research centre within digitalisation in 2019. In the centre, academia, industry and society can work together to create the technology of the future for a digital transformation.

Multidisciplinary research groups will look at challenges and opportunities within smart cities, digital industry, health and well-being. The environment will consolidate KTH's research and training in the area, leaving both national and international footprints.

Thousands of computers in one



PDC Center for High Performance Computing is a leading super data centre for academic research. The centre can be used by Swedish and European researchers through SNIC (Swedish National Infrastructure for Computing), PRACE (Partnership for Advanced Computing in Europe) and by industry through cooperation projects.

The PDC's main system is Beskow, a Cray XC40 with over 2000 nodes, 67 000 cores and a top performance close to 2.5 petaflops. It is one of the largest systems for scientific calculations in the Nordic region.

Lab for future transports

In the Smart Mobility Lab (SML), students, researchers and industry work together to create the cost-efficient and climate-smart transport systems of the future.

The lab performs small-scale tests in several areas, one major being self-driving vehicles. Through a guidance head office with direct connection to the vehicles, cars can be driven in one area while the driver is positioned in another.

SML is the stage between simulations and large-scale tests, providing quick results to a low cost.

A creative workshop

Kista Mentorspace is an open meeting place for sharing and developing knowledge within electrical engineering and computer science. The site is used by pupils at comprehensive school, doctoral students and companies who, through this space, have the possibilities to work together.

Kista Mentorspace also has tools and software for developing ideas, building prototypes and producing concepts.

Research and education that make a difference

As a university KTH is a part of developing the society of tomorrow, a responsibility in which the dissemination of knowledge is important. Researchers and teachers in electrical engineering and computer science share their knowledge in multiple ways, primarily through the students that they educate.

Societal impact runs like a common thread through KTH's education, research and co-operation. That includes everything from creating innovations and educating the workforce of tomorrow to influencing decision makers and paving the way for start-ups like Furhat and Forseeti, two pioneers in their respective fields.

The operation in electrical engineering and computer science strive to conduct excellent research and education with well-developed and pronounced societal impact. This is done in a number of ways, such as linking education to research, having a close co-operation with KTH's strategic partners and encouraging our researchers to reflect on their role in the societal development.

Our primary contribution to society is the students at bachelor, master and research level. Thousands of young people are currently being educated in the subject of electrical engineering and computer science, and they will have a direct influence on the digital and technological development. The programmes' teachers often divide their time between teaching and conducting world-leading research. This gives our students access to leading knowledge of high international quality, making them attractive in the employment market.

At third-cycle level, the doctoral students often work closely with industry and applied research that quickly reaches the users in society. Our doctoral students are offered a course in which communication, innovation and societal impact are in focus. The participants learn to work strategically to raise the awareness of stakeholders about their research. This is done by using media such as film, social media, physical meetings and presentations.

KTH has structures to help students, researchers and teachers to strengthen the impact of their work. Support for innovations and ideas, assistance with applications, and well-established contacts with external parties are some of the tools increasing the opportunities for direct influence on the society of today and tomorrow.

Read more at kth.se/en/eecs

Excellent research environments

KTH's operation in electrical engineering and computer science has access to several unique research enviroments:

- Anechoic Chamber
- ELAB clean room laboratory
- Electrum clean room laboratory
- Fusion Experiment EXTRAP T2R
- High Voltage Lab
- KTH R1 Experimental Performance Space
- Lab for Media and Interaction Technology
- Maxwell Laboratory
- PDC Center for High Performance Computing
- PMIL Lab
- Robotics Lab
- Smart Mobility Lab
- Space and Presence Laboratory
- Space Electronics Lab
- Sustainable Power Lab
- Usability, Haptics and Interaction
- Visualization Studio VIC

Trained to make impact

It's becoming increasingly important to be able to describe the impact of research on society. Researchers in electrical engineering and computer science have created a course in which doctoral students practice on viewing their work in a larger perspective.

In the course "From Research to Impact", the participants are given tools to climb the steps of the Technology Readiness Level (TRL) scale and communicate research results to their stakeholders and end-users in an effective way.

Striking the perfect balance

The perfect balance between theory and practice is the foundation of the Bachelor of Science in Electrical Engineering programme. Since the introduction of project and impact courses, the CDIO model and the implementation of the Bologna model, the programme has become the most popular in Sweden with more first-hand applicants than any other comparable programme. In addition, the proportion of female applicants was 20 % in 2017, which was the highest figure throughout Sweden.

Furhat – the social robot

Furhat, the social robot, is the culmination of 15 years of research at KTH in language-based dialogue systems, 3D animations and human-data interaction. To create the Furhat robot head, a first-class animation system that projects images through a transparent mask is used.

Today, Furhat is a company with a market that includes everything from manufacturing and training to video conferencing, e-health and entertainment. The product is also available for companies and universities to buy.

Open code at world-leading companies

The Gecode toolkit is used to develop application-based systems and applications for configurations, design, diagnostics, logistics and planning. The tool, which is based on open source code, is used by both academia and large companies such as Ericsson, Quintiq and SAP. Gecode has been downloaded tens of thousands of times and has recieved several awards.

Gecode was created by professor Christian Schulte together with fellow researchers in electrical engineering and computer science at KTH.

Production: KTH School of Electrical Engineering and Computer Science. Text: Louise Gustafsson, KTH. Photos and illustrations:Adam af Ekenstam, Abraham Engelmark, Patrik Lundmark, iStock, Kyriaki Sarampasina, Tobias Ohls, Linus Hallgren, NASA, Petter Cohen; , WASP, Håkan Lindgren, Jann Lipka, Andreas Bergsten, Maria Malmqvist, Inicio. Print: Elanders, mars 2019.