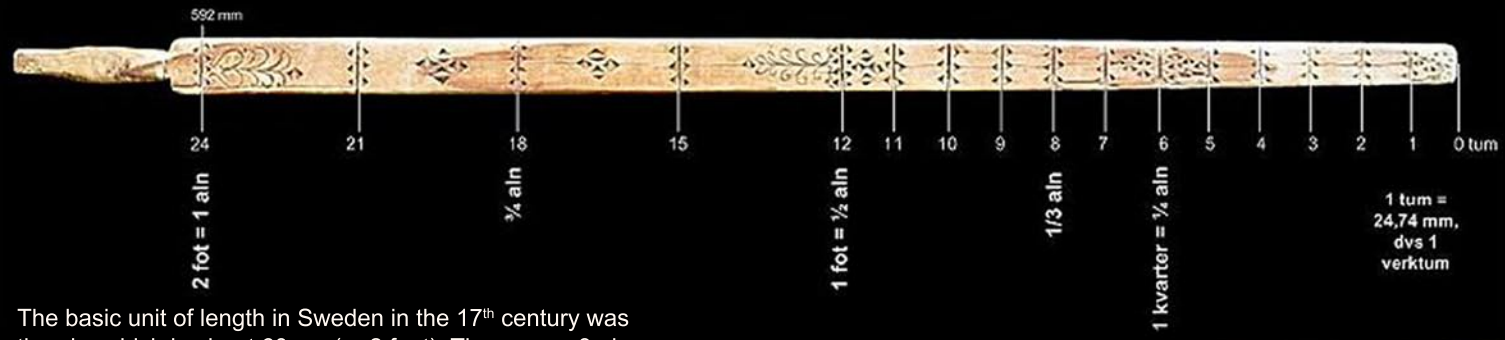
The development of teaching

When were students first taught experimental techniques in the lab?

When was it decided that a doctoral thesis had to be written independently by the student?

When did a woman get a PhD in Physics in Lund for the first time?

Standard measures



The basic unit of length in Sweden in the 17th century was the aln, which is about 60 cm (or 2 feet). There were 3 alns to a famn (an 'armful'), and 5 alns made up a stång (staff or pole). The length of the aln later became standardized and is equivalent to 0.593784 metres.

In 1666, when Lund University was founded, a kind of yardstick and a set of volumetric measuring cans developed by Georg Stiernhielm, who was the director of Antikvitetskollegium (the Council of Antiquities) were the standards of the day. These basic measures had been defined in the Swedish system of measurements in the previous year, 1665. These have been preserved and are kept at the Museum Kulturen in Lund.

The standard unit of volume was a kanna (can), which was equivalent to 2.617 litres, and was used for both liquids and dry goods. A tunna (barrel) of dry goods contained 56 kannas, or 146.55 litres.

Teaching professors

Nineteen professorships were established at the new university in Lund, two of which were in mathematics. Physics was included in the field of mathematics at that time.

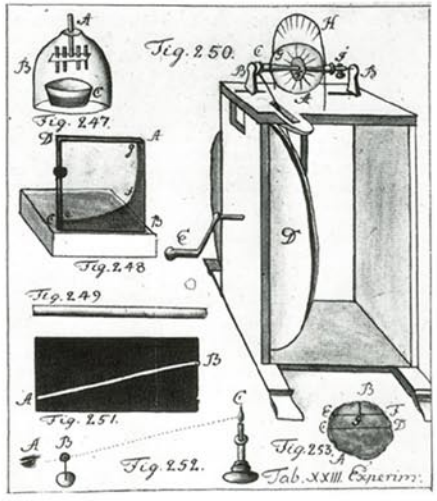
One of these professorships, which was more physically oriented, was awarded to Anders Spole, and the other, which was more applied, to Martin Nordeman. Both had been educated in Uppsala.

Spole taught trigonometry, astronomy, navigation, geography, chronology and optics, while Nordeman taught mechanics (levers, winches, the screw and the wedge), thermodynamics and surveying.

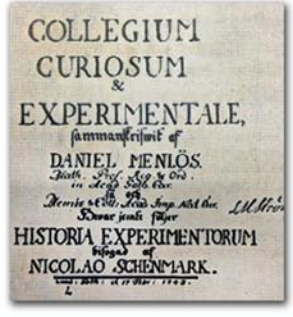
Anders Spole (1630-1699)

Spole was an enthusiastic man Spole had a private observatory with a long telescope and a large quadrant built in St. Petri Kyrkogata. The observatory was burnt down in 1676 during the Battle of Lund, and all his equipment was destroyed.

Handwritten compendia



An instrument from the Triewald Collection, used for conducting experiments with electricity.


COLLEGIUM
CURIOSUM
&
EXPERIMENTALE,
summariſtimit of
DANIEL MENLÖS
HISTORIA EXPERIMENTORUM
NICOLAO SCHENMARK.

An example of an elegant compendium by N Schenmark, entitled *Collegium Curiosum & Experimentale*, from 1743, in which the author documents Daniel Menlös' lectures.

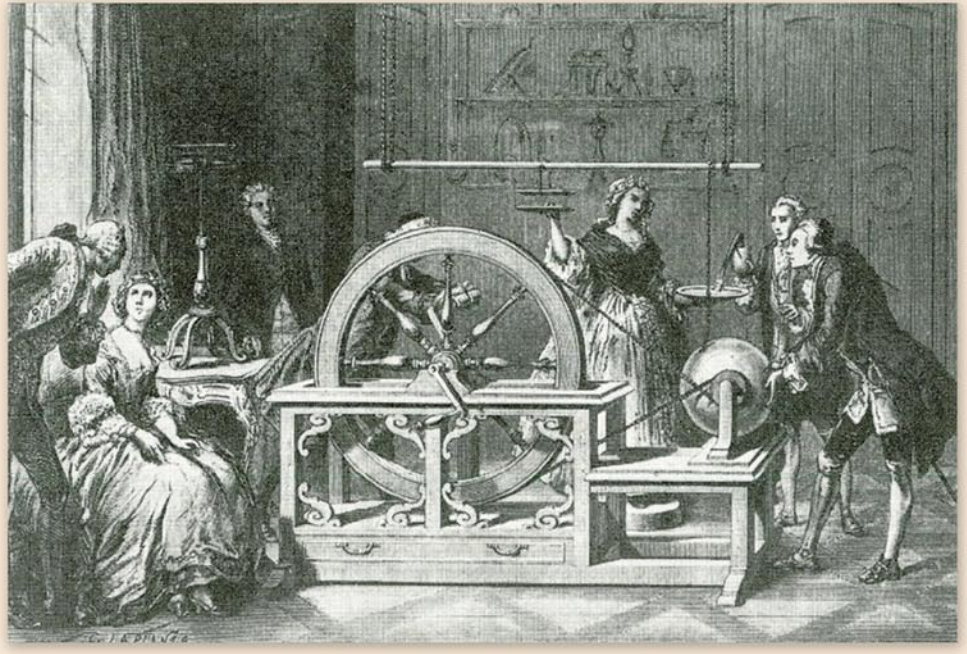
Teaching at the beginning of the 18th century consisted of lectures and demonstrations, and was characterized by the heated dispute on atomism between the followers of Aristotle and Descartes. The students compiled their own compendia, and textbooks were rare. It could take several years to complete a compendium.

Mårten Triewald purchased a number of physical instruments in England and Holland (the Triewald Collection), which he demonstrated in Stockholm in 1728-29. Daniel Menlös managed to take over the collection, and used it to secure a professorship in mathematics in Lund, which he took up in 1732.

The first assistant

Professor Menlös was the first to teach Newtonian mechanics, and it was hoped that the Triewald Collection would afford Lund University the same status as the renowned universities of England and Holland.

The collection required not only somewhere to be kept, but care and maintenance, and the position of Custos Machinarum (the Custodian of the Machines) was established in 1735. With this, the Department of Physics had obtained its first assistant.



New instruments were added to the collection, such as this electricity machine in 1754.

The development of doctoral studies

Teaching and examinations remained unchanged during the 18th century. There was only one kind of degree, the kandidat (Bachelor's) degree, after which students continued their studies pro gradu, to obtain a magister or Master's degree.

Dissertations or theses were seldom written by the student himself, but often consisted of material already published, or written by the student's supervisor. The most important thing was to show that you could present your arguments in public, in Latin. It was not until 1852 that doctoral students were required to write their theses themselves.

During the 18th century, there were about 200 students studying at any one time at Lund University, several of whom were under 15 years of age.

This drawing shows a doctoral examination (Examen Rigorosum) in Lund, which was held on 19 May 1791. The examiner was Pehr Tegman, Professor of Mathematics. (The drawing is kept at Kulturen in Lund.)

Course compendia

A handwritten compendium in physics, based on the lectures of Pehr Tegman from 1794, has been preserved. It its margins are notes on experiments, written by Esaias Tegnér, a famous Swedish writer and poet. He came to Lund in 1799 and obtained his Master's degree in May 1802. He had himself copied an older compendium. From this compendium it can be seen that the course in physics included Newton's laws of motion, the history and benefits of physics, the divisibility of bodies, momentum, death force and living force, Compressibilitas, Elasticitas, Fragilitas, Centrum gravitatis, Machina simplex and electricity among others.

Esaias Tegnér 1782 - 1846

Inledning
Til
Naturkunnigheten,
Den
Academiska Ungdomen
Til tienst,
Sammanskrefven
af
Hr. PETER VAN MUSSCHENBROEK,
M. D. Phys. och Math. Professs. i Leyden.
Och nu
På Swenska öfversatt,
Samt
Med Autorens egna Tillsatser förökt.
Jemte bifogade
Anmärkningar,
af
Herr S. KLINGENSTIERNA,
Mathes. PROF. wid Kongl. Academ. i Upsala.
Stockholm och Upsala,
Hos GOTTFRIED KIESEWETTER.
Tryckt hos LOR. LUDW. GREFING.
1747.

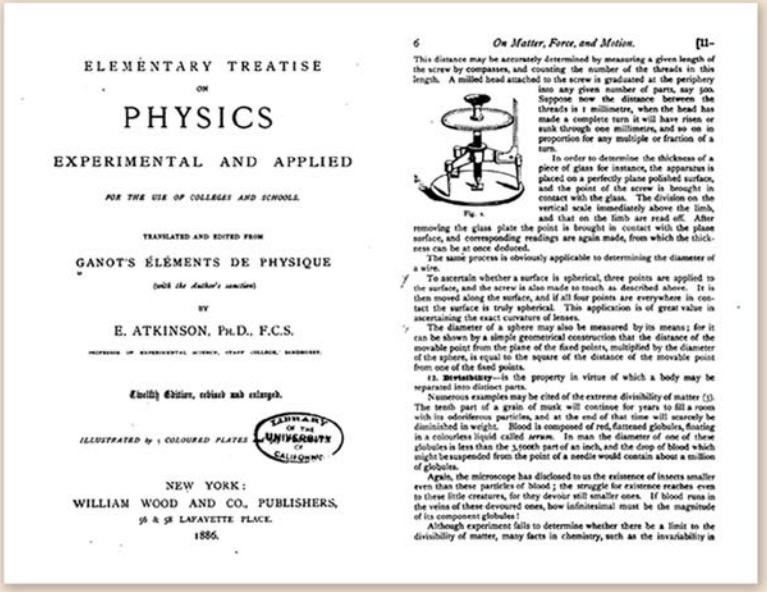
Tegnér's poetry bears witness to his education in physics. This poem was submitted to the Swedish Academy on the 30 September 1801, just before his Bachelor's examination:

Through life's torments and consolations
Go, study the hidden essence of every thing,
Let the shores of the sea of time
Bind the flight of the birds, map the course of the stars,
Cleave the beam of light, weigh the air …

The instrument collection grows

The Daguerre camera purchased by AW Ekelund in Paris in 1840.

A professorship in physics was established in 1833, to which AW Ekelund was appointed. Physics thus became a subject of its own, independent of mathematics. Ekelund set about renewing the collection of instruments, and in 1840 he purchased no less than 213 acoustic, electrostatic and optical instruments in Paris, including a Daguerre camera. This camera, a Guericke vacuum pump and Stiernhielm's measuring cans are regarded as being among the most valued items owned by the Department.



ELEMENTARY TREATISE
ON
PHYSICS
EXPERIMENTAL AND APPLIED
FOR THE USE OF COLLEGES AND SCHOOLS.
TRANSLATED AND EDITED FROM
GANOT'S ÉLÉMENTS DE PHYSIQUE
(with the Author's sanction)
BY
E. ATKINSON, PH.D., F.C.S.
Eighth Edition, revised and enlarged.
ILLUSTRATED by 1 COLOURED PLATES
NEW YORK:
WILLIAM WOOD AND CO., PUBLISHERS,
56 & 58 LAFAYETTE PLACE.
1886.

6 *On Matter, Force, and Motion.* [11-

This distance may be accurately determined by measuring a given length of the screw by compasses, and counting the number of the threads in this length. A milled head attached to the screw is graduated at the periphery into any given number of parts, say 100. Suppose now the distance between the threads is 1 millimetre, when the head has made a complete turn it will have risen or sunk through one millimetre, and so on in proportion for any multiple or fraction of a turn.

Fig. 1.

In order to determine the thickness of a piece of glass for instance, the apparatus is placed on a perfectly plane polished surface, and the point of the screw is brought in contact with the glass. The division on the vertical scale immediately above the limb, and that on the limb are read off. After removing the glass plate the point is brought in contact with the plane surface, and corresponding readings are again made, from which the thickness can be at once deduced.

The same process is obviously applicable to determining the diameter of a wire.

To ascertain whether a surface is spherical, three points are applied to the surface, and the screw is also made to touch as described above. It is then moved along the surface, and if all four points are everywhere in contact the surface is truly spherical. This application is of great value in ascertaining the exact curvature of lenses.

The diameter of a sphere may also be measured by its means; for it can be shown by a simple geometrical construction that the distance of the movable point from the plane of the fixed points, multiplied by the diameter of the sphere, is equal to the square of the distance of the movable point from one of the fixed points.

12. **Divisibility**—is the property in virtue of which a body may be separated into distinct parts.

Numerous examples may be cited of the extreme divisibility of matter (5). The tenth part of a grain of musk will continue for years to fill a room with its odoriferous particles, and at the end of that time will scarcely be diminished in weight. Blood is composed of red, flattened globules, floating in a colourless liquid called *serum*. In man the diameter of one of these globules is less than the 3,000th part of an inch, and the drop of blood which might be suspended from the point of a needle would contain about a million of globules.

Again, the microscope has disclosed to us the existence of insects smaller even than these particles of blood; the struggle for existence reaches even to these little creatures, for they devour still smaller ones. If blood runs in the veins of these devoured ones, how infinitesimal must be the magnitude of its component globules!

Although experiment fails to determine whether there be a limit to the divisibility of matter, many facts in chemistry, such as the invariability in

The textbook for the introductory course was Ganot's well-known book, *Traité elementaire de Physique*. Students who had taken the course could become physics teachers, and the course was also taken by medical students.

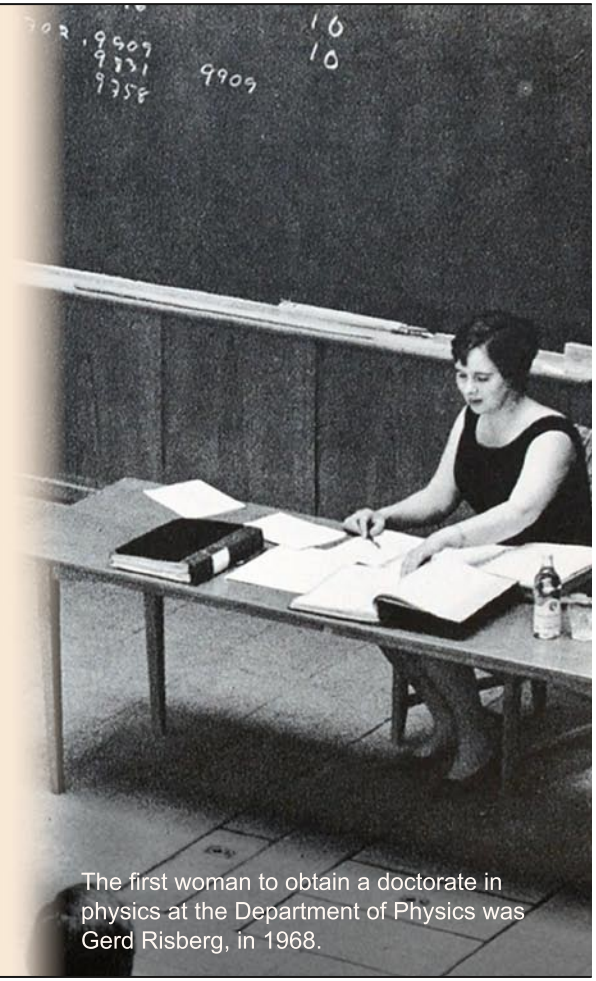
KAV Holmgren arrived in Lund in 1861. He had attended Uppsala University, and understood the importance of laboratory work in teaching. Students were already able to work in laboratories in Uppsala, and Holmgren made it possible for students who were especially interested in physics to have access to laboratory experiments in Lund.

During his work in the laboratory in the old Department of Physics at the turn of the century, Enoch Thulin determined the specific heat of metals, the expansion coefficient of air, the linear expansion coefficient of metals and measured the angles between the planes in crystals.

Three pioneering women

Anna-Clara Romanus-Alfvén (1874 - 1947) was one of the very first women to study at the Department of Physics, when she took the introductory course in physics in 1897. After obtaining a licentiate degree in medicine in Lund in 1906, she practiced as a doctor in Norrköping, among other places. In 1908, Anna-Clara became the mother of a future Nobel Laureate in Physics, Hannes Alfvén, and later the grandmother of a professor in accelerator physics, Mikael Eriksson.

Louise Petrén-Overton (1880 - 1977) was one of the first women to conduct practical experiments at the Department, in 1900. In 1912 she became the first Swedish woman to obtain a doctoral degree in mathematics. At that time, there were 600 students at the university, 10 of which were women, and two of these were studying the natural sciences.



The first woman to obtain a doctorate in physics at the Department of Physics was Gerd Risberg, in 1968.

The need for physicists increases

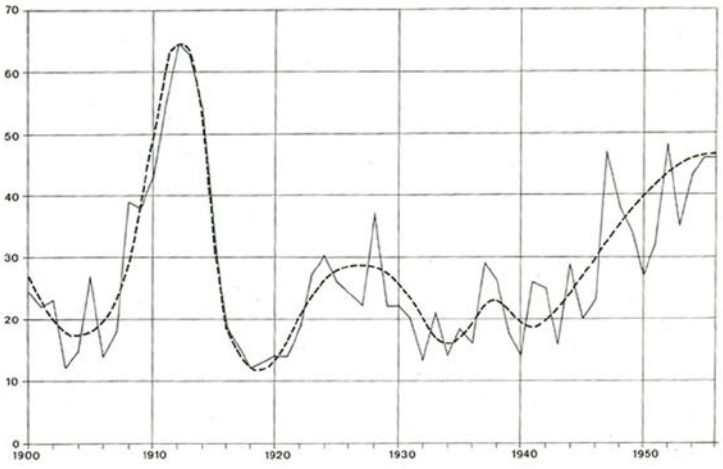


Diagram of the variations in the number of students in physics for a Magister's Degree 1900 - 1954. Solid lines gives present annual changes.

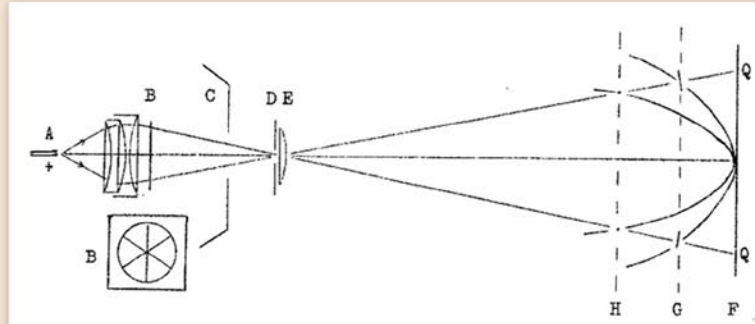
The dashed curve gives the tendency of development.

In 1905, laboratory exercises were introduced in secondary schools, and this affected teaching at universities. It was also decided that all middle schools should have the same national curriculum. This led to a sharp increase in the number of students applying to study to become physics teachers. During a few years around 1910, the number of physics students rose from about 15 to over 60 per year. As a result of this, Manne Siegbahn was able to collect a group of postgraduate students who were employed as supervisors for these students, and research in physics flourished.

Public demonstrations in physics

Students were trained to carry out physical demonstrations in public; one course being led from 1949 to 1967 by Osvald Lundquist, the last of Manne Siegbahn's postgraduate students. His experiments could be carried out in secondary schools using the equipment available in the schools, and are described in two compendia entitled *Experimental Physics*.

The equipment was to be easy to understand, and the student was to demonstrate a physical phenomenon, such as wave motion on the surface of a liquid, the heat generated by an electric current, the crystal diode and the transistor, and make measurements.

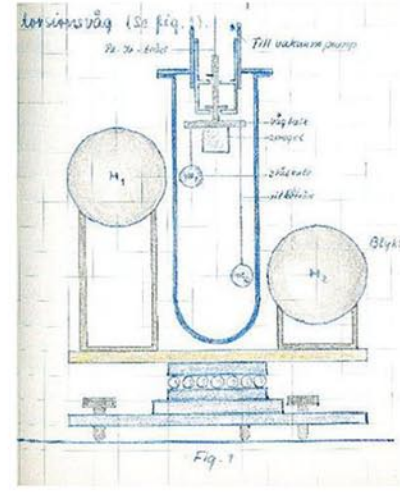


A page from one of Osvald Lundquist's popular compendia on experimental physics.

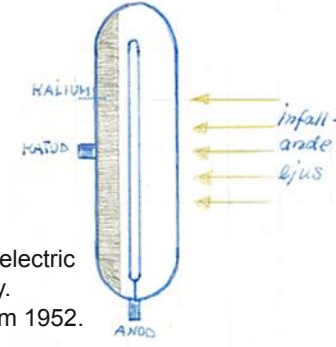
The second half of the 20th century

Teaching in physics continued to develop. A balcony was constructed in the Rydberg lecture hall at the Department of Physics to allow more advanced demonstrations. Teaching in the laboratories included classic as well as modern experiments, e.g. the determination of the gravitational constant, and the ratio of Planck's constant to the electronic charge, h/e, from the photoelectric effect. The latter was demonstrated by John Koch, aided by Nils Ryde and Lennart Minnhagen, who later became professors at the department.

During the 1950s, more advanced courses in atomic spectroscopy, electronics and nuclear physics were introduced. These included week-long laboratory practicals, and became very popular.



Determination of the gravitational constant.



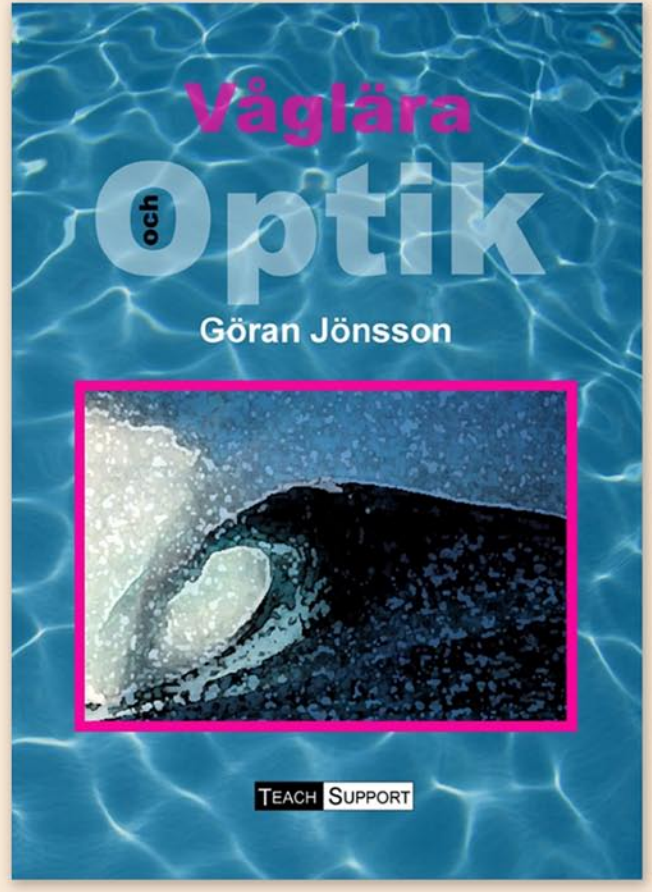
Determination of h/e from the photoelectric effect, according to Einstein's theory.
From Hans Ryde's lab write-ups from 1952.

Teacher training

During the 1960s, the one-year course in physics included not only classical subjects, but also atomic physics, nuclear physics and the theory of relativity.

The number of physics students fell during the 1970s, due partly to an earlier dip in the birth rate, and partly to the anti-nuclear power movement. It was thus decided that it was time to modernise teaching in physics and to offer courses covering a broader field.

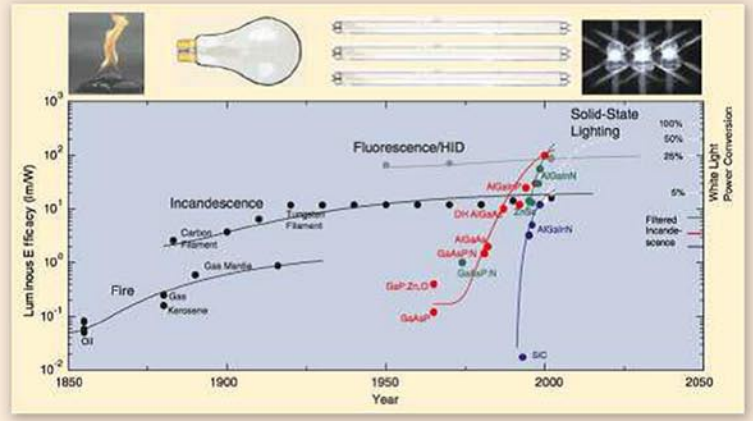
A new teacher education programme was introduced with the motto, *Start your teacher training with physics*. The mid-1990s saw increased numbers of students, some from other countries, and lectures started to be given in English.



Several lecturers at the Department of Physics wrote their own textbooks.

Teaching at the faculty of engineering

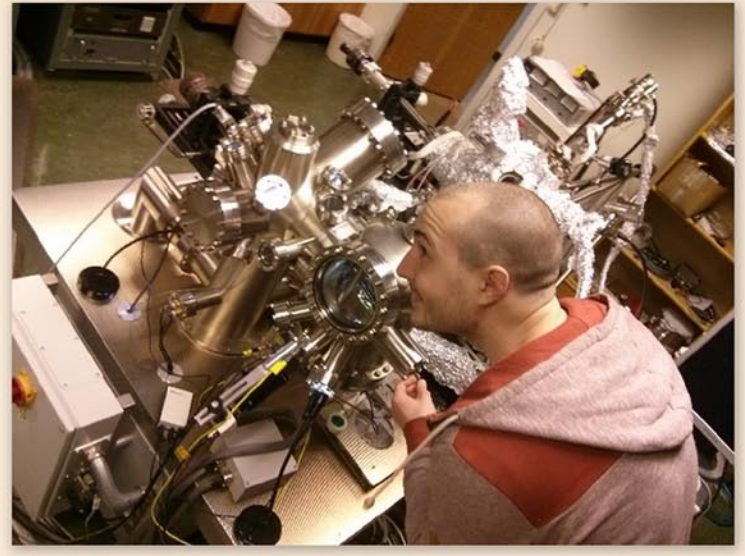
The aim of undergraduate teaching within the Faculty of Engineering is to provide sound knowledge in practical physics. The programme starts with mathematics, providing the basis for deeper knowledge in various applications. The first degree is completed with a project supervised by a lecturer from one of the research divisions of the department. One of the strengths of the education provided is the broad research carried out in engineering physics within the faculty, which provides students with opportunities to carry out projects of high quality.



In his project from 2012, Filip Halvardsson presented a new technique for studying the growth of nanowires.

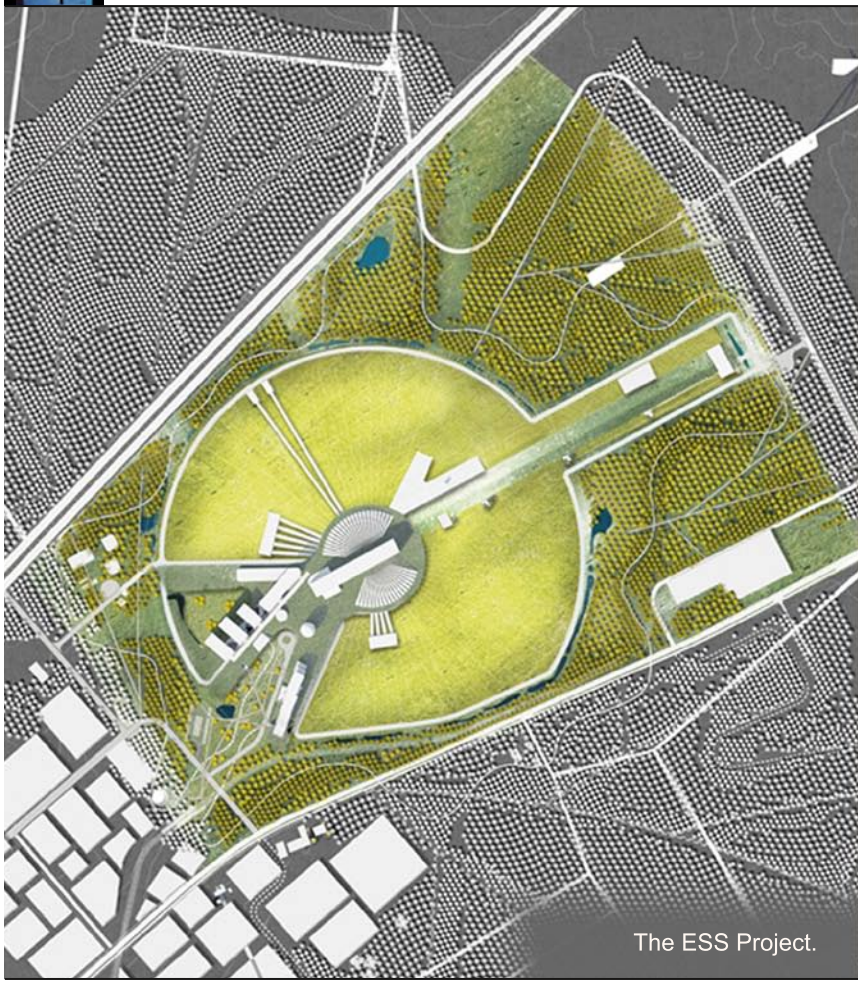
Teaching at the Faculty of Science

The *Experimental Seminars course* at the Faculty of Science has attracted considerable attention, both in Sweden and other countries. Visiting lecturers from many different countries have been involved. Students can choose which experiment they want to perform, and the presentation of their results at a seminar provides good practice in communication skills. The course is carried out in close collaboration with research divisions within the faculty. The example given below is from the Division for Synchrotron Radiation Research.



Johan Knutsson, a PhD student and supervisor at the Division for Synchrotron Radiation Research, setting up an electron microscope.

Science vs. engineering



The ESS Project.

Areas within the Faculty of Science.	Compulsory courses within the Faculty of Engineering.
• Physics • Meteorology • Astrophysics • Chemical physics • Theoretical physics • Hospital physicist (5 years) • Specialist Teacher Training (4½-5 years)	• Quantum physical concepts • Statistical thermodynamics and applications • Atomic and nuclear physics and applications • Solid state physics • Vector analysis • Wave theory and optics

One of the greatest advantages of teaching physics in two different faculties in a single large department is that they have positive effects on each other. When teaching by the Science Faculty was extended to include students destined for other professions than teaching in the increasingly technological world, the courses taught by the two faculties came closer together.