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ABSTRACT

This report presents details from an examination of the curricula and diplomas of the Electrical Engineering departments of several major European technical universities (in the Netherlands, Sweden, Germany, Switzerland, and Belgium). The examination, a process involving department representatives of the various schools who came together to evaluate, compare, and comment on each others programs via the study of written material and site visits, was designed to achieve a common understanding and recognition of the Master of Science in Electrical Engineering degree. Report topics include (1) the procedures for the international program review; (2) the consensus on the minimum requirements, program goals, characteristics, and content of the electrical engineering program; (3) the necessary student skills, industrial training, thesis, and examinations for participation in the program; and (4) a review of student selection, level of study burden, and course completion rates. Also covered are the minimum requirements of the faculties, staff, and facilities as well as graduate quality assessment. The report further contains the faculty reports obtained from each of the nine participating universities. Appendices include course descriptions and the questionnaire and checklist used for the review. (GLR)

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IPR-EE Committee

June 1992

International Programme Review Electrical Engineering

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IPR-EE Committee

June 1992

International Programme Review Electrical Engineering

A.I. Vroeijenstijn, rapporteur

B.L.A. Waumans, chairman

J. Wijmans, vice-chairman

VSNU Vereniging van Samenwerkende Nederlandse Universiteiten

Title:

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PREFACE

This report of IPR-EE (International Programme Review Committee for Electrical Engineering) is really a unique one. It is the result of an ambitious exercise to come to a mutual understanding and recognition of the curricula and diplomas of the Electrical Engineering departments of a number of major European (technical) universities. To that end, representatives of all these departments came together in the IPR-EE Committee to evaluate, compare and comment on each others programmes via the study of substantial amounts of written material and via site visits to all the participating departments. Although it is certainly not easy to evaluate and criticize each others programmes, the participants did so with care, dedication and in a very objective way. The most precious instrument of the academic world - the objective value of the argument- was used intensively and with great consideration and constructive openness. This made the level of discussions in the plenary meetings and during the various site visits very high. I would like to compliment all committee members on this spirit of openness, thoroughness and critical objectivity. It certainly was a great pleasure to chair such a group. A special word of thanks is due to Ton Vroeijenstijn. He not only initiated the IPR-EE process largely, he also made it really work. His continuous efforts and dedication have had a major impact on the result now available.

The committee has refrained from sketching the lay-out of an ideal department; we are convinced that the differences in the EE-programmes that we encountered are not a defect but an important richness of our European systems. Therefore the departments should be valued against the particular "colour" they have chosen for themselves.

And now the result of this exercise is in your hands. This serves to underline that the participating departments are indeed academic institutes in the broad sense. The Committee favoured an open publication of the results, and without hesitation the departments agreed with this point of view. In this way they place important and sometimes subtle information on their own organizations, in the public domain. By doing so, real open discussions can take place on nature and characteristics of EE programmes.

Of course the material is of high interest to the involved institutes. They have participated because, in their spirit of quality awareness, they considered it important to be evaluated by an international committee and to learn from the characteristics of other curricula: They will know how to benefit from this report in the most direct way.

The report is also of importance to departments of Electrical Engineering in Europe that did not participate. For them, the findings can be the basis for a discussion on their own programmes. Moreover, the report can be used as a guideline for a good European Electrical Engineering department.

I think the report is also very useful for the European industrial society. They can be sure that graduates from the participating universities are, in the eyes of a major international forum, rightly entitled to the award of Master of Science in Electrical Engineering. With an increasingly integrating Europe, understanding and correct interpretation of the value of degrees of various institutes will be of crucial importance in the future. In a society, which becomes more and more international, the industry will certainly know how to benefit from this mutual understanding between departments of Electrical Engineering.

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I hope that this report will also find its way to other interested parties in our society. It is of importance to politicians, to professional societies, to education specialists and such like.

As starting point for all discussions on and with the universities, the Committee formulated the so-called "Minimum requirements for electrical and similarly named engineering programmes". This paper is included as chapter 3 in this final report and it describes the basis that was used for the evaluation. This document is largely derived from a similar document from ABET (the Accreditation Board for Engineering and Technology in the U.S.A.). There are certainly a number of differences between US and European curricula for Electrical Engineering. Nevertheless, the general framework is largely analogous and I would like to thank ABET for their permission to use and amend their material for our purposes.

Our committee was not a European accreditation committee. However, its findings could become the basis for a real European accreditation activity. I am convinced that such an accreditation process can only be successful if there is firm cooperation from the institutes. It also became clear to me that evaluation of the total curriculum is required to come to a real understanding of the programme. Reviews only based on duration or on other single characteristics are probably too simplistic to serve a real comparison purpose. It would certainly be a good idea that this IPR-EE result is used as a start for setting up a real European accreditation process.

I hope this report will find its way to many places where the quality of our academic education in Electrical Engineering is a matter of concern and consideration.

Ir. B.L.A. Waumans
Chairman IPR-EE,
Director Professional Systems
Philips Research Eindhoven

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THE INTENDED READERSHIP

This report is written in the first place for the faculties that participated. It gives the faculties feedback on the information they provided and on the discussions that took place during the visits. The Committee hopes the faculties can make use of the findings for quality enhancement.

A second group of readers is that of people with an interest in the content and design of Electrical Engineering programmes in Western-European universities, in the quality of the education and the quality of the graduates. These may be members of other faculties of Electrical Engineering, but also employers who must employ graduates in electrical engineering. These readers will find general conclusions in chapters 4 to 9 in Part I. For those who seek more details of the individual faculties, the faculty reports will be found in Part II. In this connection the course descriptions in Part III (Appendix 2) are important. It must be made clear that it is not sufficient to read only the "overall assessment" at the end of each faculty report: rather, the report must be read as a whole.

The third group of readers consists of people interested in International Programme Review and comparison of curricula. For this group Part I is of especial interest. For those who might like to use the method of International Programme Review, the questionnaire and the checklist used for the review are enclosed as Appendices 3 and 4.

PART I

GENERAL FINDINGS

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1. INTERNATIONAL PROGRAMME REVIEW ELECTRICAL ENGINEERING

1.1 Introduction

The project "International Programme Review Electrical Engineering (IPR-EE)" was initiated by the Association of Universities in the Netherlands (VSNU). In this project Electrical Engineering faculties from Sweden, Belgium, Germany, the United Kingdom, Switzerland and the Netherlands participated in an evaluation of each other's programmes (Master of Engineering or the equivalent). The purpose was to come to a mutual understanding and recognition of each other's programmes and certificates.

The choice of the faculties which participated was purely pragmatic. The Association of Universities in the Netherlands sought volunteers and approached those faculties with which it already had contacts of one kind or another.

The International Committee, in which the academic world, the employers and the professional organizations were represented, came together in a plenary meeting on 17th and 18th September 1991. At that meeting the Committee discussed the terms of reference and the working procedures; it also discussed what should be taken as the minimum requirements for Electrical Engineering. The results of the discussion are set out in a document, called "Guide for the Committee" (VSNU, 1991).

The Committee has evaluated the programmes of the various faculties by an in-depth study of formal material (curricula, examinations, faculty information, etc.). In addition -- and probably even more important -- subcommittees visited all the faculties at the various sites. The programmes have been evaluated against the background of the formulated minimum requirements.

1.2. Participating faculties

The faculties participating in the International Programme Review cannot be seen as a random sample. The countries selected were Belgium (Flemish speaking part), Germany, Sweden and the United Kingdom. France was not selected, because the structure of Higher Education is too complex, and it was judged that to achieve successful results the differences between the systems should not be too great. During the preparations for the project, ETH Zurich made known that it was interested in participating, and this the Committee welcomed. The project started with the following participants:

The Netherlands:
* Faculty of Electrical Engineering at the Eindhoven University of Technology
* Faculty of Electrical Engineering at the University of Twente
* Faculty of Electrical Engineering at the Delft University of Technology

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Sweden:

* School of Electrical and Computer Engineering at Chalmers University of Technolog
* School of Electrical Engineering and Computer Sciences at Lund University

Germany:

* School of Electrical Engineering at the Technische Hochschule, Darmstadt
* Faculty of Electrical Engineering and Information Technology at the Techni Universität, München

Switzerland:

* Faculty of Electrical Engineering at the Eidgenössische Technische Hochschule, Züri

Belgium:

* Faculty of Applied Sciences (Electrical Engineering) at the Rijksuniversiteit, Gent
* Faculty of Engineering (Department of Electrical Engineering) at the Kathol Universiteit, Louvain (Flemish: Leuven)

United Kingdom:

* Department of Electrical & Electronic Engineering, University of Bristol
* Department of Electrical Engineering, Imperial College of Science, Technology Medicine, London

During this project, problems about visiting faculties in the UK were raised by Institution of Electrical Engineers (IEE), the accrediting body for the programme Electrical Engineering in the UK and some overseas universities. The IEE interpreted aim of the project as the accreditation of UK faculties by an international committe view which the IPR-EE Committee was unable to dispel. The IEE persisted in their that the findings of the IPR-EE Committee should not be published as far as UK facu were concerned. Before the Committee visited the UK faculties, the University of Br withdrew from the project. Imperial College continued to welcome a visit, but in vie the attitude of the IEE did not wish the findings to be published in the same way as the continental faculties. A panel of the IPR-EE Committee visited Imperial College prepared a report, but this is not included in Part II. However, as one of the aim visiting a UK faculty was to provide the Committee with some experience of a academic programme, a brief description and findings are given in the Annex to Part I.

The School of Electrical Engineering at the Technische Hochschule Darmstadt decide withdraw before the second plenary meeting.

The Committee is most grateful to all the faculties for the way they have cooperated. T have done their utmost to provide the Committee with the necessary information.
The Committee was very well received by the faculties everywhere, and the intervi took place in an open atmosphere. The faculties as well as the members of the Comm very much appreciated the visits and the discussions, even though these were very consuming and required intense effort.

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I.3. The IPR-EE Committee

Every faculty visited was asked to nominate a member to the Committee. The chairman was appointed by the Netherlands Council of Employers, RCO (Raad van de Centrale Ondernemings-organisaties,) at the request of the VSNU. The vice-chairman was appointed by the (Netherlands) Royal Institute of Engineers, KIVI (Koninklijk Instituut van Ingenieurs). This was done in order to have a chairman and vice-chairman not involved in a university; at the same time input from the employers' side was guaranteed. The IPR-EE Committee had the following composition:

* **Ir. B.L.A. Waumans**, Director of Professional Systems, Philips Research Laboratories, Eindhoven, The Netherlands (Chairman);
* **Ir. J. Wijmans**, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Power Industry); formerly professor at the Delft University of Technology, The Netherlands (Vice-Chairman);
* **Drs. A.I. Vroeijenstijn**, Association of Universities in the Netherlands (VSNU), The Netherlands; (Project Leader/Secretary).

The Chairman, Vice-Chairman and Secretary acted as a Presidium.

* **Prof. dr. ir. J. van Amerongen**, Faculty of Electrical Engineering, University of Twente, The Netherlands
* **Prof. Dipl. El.Ing.ETH. H Baggenstos**, Laboratory for Electromagnetic Fields & Microwave Electronics, ETH, Zürich, Switzerland
- **Prof. B.M. Bird, Ph.D., F.I.E.E., F.Eng**, Department of Electrical and Electronic Engineering, University of Bristol, United Kingdom
* **Prof. dr. ir. W.M.G. van Bokhoven**, Faculty of Electrical Engineering, Eindhoven University of Technology, The Netherlands
* **Prof. dr. I. Brinck**, Faculty of Electrical Engineering, Tekniska Högskola. Lund, Sweden
* **Prof. dr. A.R. v. Cauwenberghe**, Faculty of Applied Science, Automatic Control, University of Gent, Belgium
* **Dr. B.J. Cory, DSc(Eng), ACGI, CEng, FIEE, Sen.MIEEE**, Department of Electrical Engineering, Imperial College, London, UK
- **Prof. Dr. A. Kündig**, Laboratory for Computer Engineering and Networks, ETH, Zürich, Switzerland
* **Prof. Dr. techn. J.A. Nossek**, Institute for Network Theory and circuit Design, Technical University, Munich, Germany
- **Prof. Dipl.-Ing. D. Oeding**, Institut für Elektrische Energieversorgung, Technische Hochschule, Darmstadt, Germany
* **Prof. dr. S. Olving**, Department of Electrical and Computer Engineering, Chalmers University of Technology, Göteborg, Sweden
* **Prof. dr. ir. R.H.J.M. Otten**, Faculty of Electrical Engineering, Delft University of Technology, The Netherlands
* **Prof. dr. ir. W.M.C. Sansen**, Faculty of Engineering (Department of Electrical Engineering), Katholieke Universiteit, Leuven, Belgium

Additional member for the visit to the Netherlands:
J.R. Thompson, BSc(Eng), CEng, FIEE, FBIM, Comwall Associates, Brightlingsea, UK

Additional member for the visit to Leuven:
Prof. Dr. J. Weiler, Leistungselektronik und Messtechnik, ETH, Zürich, Switzerland

The membership of Prof. Bird terminated when the University of Bristol withdrew from the project.The members whose names are marked with * are those who attended the second plenary meeting and have ratified the report.

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2. THE PROCEDURE OF THE INTERNATIONAL PROGRAMME REVIEW

2.1 The terms of reference; or 'What was expected from the Committee?'

In the information sent to the participating faculties and to the members of the International Committee the purposes of the project were formulated as:

* To gain experience with the international assessment of the equivalence of programmes;
* to arrive at mutual recognition of the degree programmes for Electrical Engineering, and to see if these programmes come up to the academic and social requirements for the practice of engineering at a professional level;
* To stimulate quality awareness in various institutions;
* To determine if a European counterpart for the ABET (Accreditation Board for Engineering and Technology) in the USA is feasible.

The terms of reference were formulated as follows:

- To check whether a faculty meets the minimum requirements set for graduation in Electrical Engineering. If so, the diplomas of the faculty can be recognized at an international level. *"The graduates from the faculty of Electrical Engineering X merit the title of 'Master of Electrical Engineering' "*.

- To evaluate the equivalence of the certificates. It is not intended to come to an individual ranking of the institutes, but at the end of the evaluation process the Committee will consider whether it is possible to give a quantified assessment.

- To formulate recommendations about the possibility of establishing a European system for accreditation.

The Committee agreed on the terms of reference and on the checklist for the site-visits, based on the criteria, at the plenary meeting of 17/18 September 1991.

At the same meeting, the Committee agreed upon a set of minimum requirements for electrical and similarly named engineering programmes. The proposed Programme and General Criteria, developed by the IPR-EE Committee, are largely derived from the criteria used by ABET (the Accreditation Board for Engineering and Technology) in the USA (ABET, 1991). Programme criteria relevant for electrical engineering programme review are based on the criteria developed by the Institute of Electrical and Electronics Engineers, Inc.. For the minimum requirements see chapter 3.

In this report the reader will be offered findings relating to the first two topics of the terms of reference. The Committee has assessed the different programmes leading to the degree of Master of Electrical Engineering and has tried to come to a weighted assessment. The judgements of the Committee are to be found in chapters 4 to 9 of the General Findings and in the faculty reports.

The Committee has had no time to formulate proposals for a European Accreditation Board for Engineering and Technology. In the view of the Committee the procedure that was used for the International Programme Review Electrical Engineering provides a good means for assessing programmes and faculties. The Committee recommends the faculties visited by the IPR-EE Committee to establish a committee for the development of ideas with regard to European accreditation.

2.2. The questionnaire and the written information

The VSNU developed a questionnaire for the faculties in order to obtain written information on the programme and the faculty. For the questionnaire see Appendix 3. The questionnaire was sent to the participating faculties in April 1991, with a request to complete it and send it back before the end of June. The questionnaire asked for information about:

* the students: level of attainment on entry to the course, entrance selection, drop-out rates and completion rates. student workload.
* the staff: numbers, teaching load, publication activities.
* the programme. the philosophy behind the programme, the goals and aims, the general structure of the programme, thesis work, assessment, quality assurance.
* every course: course name, responsible professor, workload, short description of the course, literature used in the course. Respondents were asked to include two examples of the examinations for each course.

The yield of the questionnaire was 22 volumes of information, in total about 6000 pages. For the list of contents of this basic information see Appendix 5. All the volumes are rich sources of knowledge about the Electrical Engineering faculties participating in the project. Readers interested in the basic material will find copies of it at the VSNU and in the institutions of the Committee members.

Together with the completed questionnaires, each faculty supplied up to 5 Master's theses. Often supplementary information such as catalogues and annual reports was also provided.

2.3. The checklist

To realize the third aim (examining the possibility of formulating a weighted judgement on quality) a checklist was developed, based on the minimum requirements.
For the checklist see Appendix 4. The checklist is a translation of the minimum requirements as formulated by the Committee. Members of the Committee gave their assessments of a particular topic on a scale ranging from 1 to 5, where 1 has the meaning "not satisfactory", 3 means "satisfactory", and 5 "more than satisfactory".

Initially the checklist was sent to all members of the IPR-EE Committee with the request to answer the questions after reading the written information. In particular the questions marked with ⊗ had to be answered. The members of a visiting panel would complete the checklist at the end of the visit. However it turned out to be difficult to complete the list on the basis only of reading the written materials, and many members of the Committee did not return the checklists. Af. - the visit to Lund the decision was taken to abandon the idea of having the list completed by non-visiting members.

At the end of every visit, the members of the visiting panel completed the list. It was sometimes not possible to give answers to certain questions because the information was missing. For example, the questions about accessibility of facilities after hours, the adequacy of the library, and contacts with professional organizations were difficult to answer. These questions are therefore left out in calculating the results. In the end 46 questions out of 58 were useable for calculation. For the presentation of the results another order has been chosen (see figure 1).

FIGURE 1: TOPICS IN THE CHECKLIST AND TOPICS IN THE PRESENTATION

categories in checklist	categories in presentation	
1. aims and objectives	1. aims and objectives	(Table 1)
2. the programme	2. the programme	
	* characteristics	(Table 2)
	* contents	(Table 5)
	* students' skills	(Table 6)
	* examinations	(Table 8)
3. the faculty and faculty staff	3. academic staff	(Table 17)
4. facilities and resources	4. facilities	(Table 18)
5. the students	--------	
6. external relations	6. external relations	(Table 19)
7. internal quality assessment	7. quality assurance	(Table 20)

A problem in interpretation of the results was caused by the fact that the subcommittee conducting visits was not always composed of the same members. The composition of the subcommittee changed every time. It is possible that one subcommittee was more severe (or more generous) in its judgement than another subcommittee. If so, one might have expected that the assessment of a set of faculties in one country would differ from that of others in a negative or positive way. This was not the case, however, as even the assessments of faculties in the same country visited by the same committee members show differences.

It was also possible to check whether there were subcommittees with more severe or more generous assessments, because in some cases some members participated in other visits too. For example, two members of the visiting panel to the Netherlands also participated in the visit to Sweden. It was calculated how their judgement for the Dutch faculties related to the assessment of the other members visiting the Netherlands. For the Netherlands the difference between the average assessment on the scale 1-5 of subset 1 (visited only the Netherlands) and of subset 2 (also visited Sweden) was 0.4 points. For the visit to Sweden the differences between the two subsets was 0.5 points. A similar calculation was done for the panel visiting Chalmers (Sweden) and ETH (Switzerland).
The difference between subset 1 (only Chalmers) and subset 2 (Chalmers and ETH) was 0.2 points. This was also the difference between the two subsets in the assessment of the ETH. It seems very probable that every visiting panel applied more or less the same standards in assessing the faculties.

In interpreting the figures in the tables, it must be realized that this is a first attempt to gain insight into quality differences between institutes. These must not be seen as absolute measurements. On the one hand, the criteria for assessment are not strictly defined, because while the Committee formulated minimum requirements there was not always

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agreement on every part (for example, the role of non-technical subjects). On the other hand, the assessment is the sum of individual opinions, sometimes influenced by national background. Where there is a broad education in his own country, the member will tend to assess another curriculum as too specialized. If importance is attached to non-technical subjects, their absence will be assessed more negatively than when only minor importance is attached.

For the presentation of the results the calculated scores are translated into symbols, as follows:

a score	< 2.5	—	= below expectations
a score of	2.5-2.9	□	= adequate
a score of	3.0-3.4	●	= more than adequate
a score of	3.5-4.0	✳	= good
a score of	> 4.0	✿	= excellent

For interpretations of the tables, one must keep in mind that the given scores represent the opinion of the members of the visiting panel at the time of the visit.

In spite of all the objections, the application of the checklist gives an indication of the quality of the curriculum and the quality of the faculty. In this sense the instrument has been shown to be useable.

2.4. The visits

An international Programme Review cannot be done on the basis of written information only. Additional information and further illustration of the facts supplied is necessary. It is important to sense the climate in a faculty, and so on. For that reason the Committee decided to visit each faculty over two days. The purpose of the on-site visit was two-fold:

1. It should assess factors that cannot be adequately described in the questionnaire. The intellectual atmosphere, the morale of the faculty and the students, the calibre of the staff and student body, and the character of the work performed, are examples of intangible qualitative factors that are difficult to document in a written statement.
2. The team should examine in further detail the material compiled by the institution and relating to:

a. Organization of the institution and of the electrical engineering division.
b. Educational programmes offered and degrees conferred.
c. Basis of requirements for admission of students.
d. Teaching staff and teaching loads.
e. Physical facilities, the educational plant devoted to engineering education.
h. Finances - investments, expenditures, sources of income.
i. Curricular content of the programme.

The visiting panels consisted of a member from each participating country, but not from the country to be visited. So the subcommittee visiting the Netherlands had a Belgian, a Swedish, a Swiss, a German and a British member. Ir. B.L.A. Waumans and Ir. J. Wijmans acted alternately as chairman. Drs. A.I. Vroeijenstijn participated as secretary on all visits. For the composition of the visiting panels, see Appendix 1.

The visits took place on the following dates:

Eindhoven	28/29 October	1991
Twente:	29/30 October	1991
Delft:	31 Oc./1 Nov.	1991
Chalmers:	19/20 November	1991
Lund:	21/22 November	1991
München:	10/12 December	1991
ETH:	12/13 December	1991
Gent:	20/21 January	1992
Leuven	21/23 January	1992
London	18/20 February	1992

The visiting panel started usually the evening before the interviews with a meeting for th formulation of questions. Non-visiting members were requested to formulate questior based on the written material and to send them to the secretary. In the meeting th chairman followed the checklist and collected questions from the members. Thos questions were the starting point for the interviews.

The first interview was usually with the Faculty Board or its equivalent. The Facul Board was asked to give more information about the level of education in secondar schools, the higher education system, and the philosophy behind the programme. Oth interviews were held with staff involved in the basic programme and with staff involved the main programme. The panels also had discussions with students of the bas programme and of the main programme. In most cases there were also interviews wi Ph.D. students. Special invitations went to the Curriculum Committee or its equivalent. between interviews the Committee visited practical rooms and laboratories. In the evenir the Committee had dinner with the Faculty Board, which provided a good opportunity exchange ideas and information in an informal way.

At the end of the visit the Committee usually took two hours to formulate its findings, complete the checklist, and where applicable, for discussion on the first draft of the repo about the faculty visited on the preceding days. Finally the Committee gave the faculty brief feedback regarding the most important findings. For an example of a programme, s Appendix 6.

After the visit to Lund the Committee members present held a discussion on the way tl visits were going. Was this what the Committee expected? Did it fulfil the expectations? was decided to continue in the established manner, the only change being no longer to a the non-visiting members to complete the checklist.

Unfortunately, it was not always possible to have members from all participating countri as members of a visiting panel, due to illness of a member or an unexpected importa meeting at home. Due to this, the visiting panel to Gent was small. Every panel acquitt itself of its task as well as possible.

2.5 From first draft to final report

The first draft of the report was mostly written on the spot. That is to say, at the end of the visit to the second faculty in a given country, the report of the first visit could be discussed by the visiting panel. The members agreed on the most important issues. They endorsed the remarks and comments. It was important to handle matters this way to prevent mixing facts, ideas and opinions on the different faculties.

The second draft was written on the basis of the remarks and comments of the members of the whole Committee, and sent back to the members of the visiting panel. The incoming commentary was processed into a new draft. This third draft was also enlarged with additional information from the basic material and with details about the curriculum, and sent to all members of the IPR-EE Committee. The members were asked:

* to read the report of their own faculty carefully and to correct factual mistakes and incorrect data;
* to determine if reading all the reports led to changes in the reports on the faculties the member had visited.

The comments and remarks of the members were assimilated into the fourth draft, which formed the basis for discussion in the second plenary meeting from 14-16 Aril 1992. The results of the second plenary meeting of April 14th-16th were:

* The Committee agreed upon the text of the report after a detailed discussion during the plenary meeting.

* The members of the IPR-EE Committee decided unanimously to publish the general findings and the faculty reports (with Appendices) in one report.

* It will be clearly stated that the content of the faculty reports is authorized by all members, with the exception of the member of the faculty concerned.

* The Committee decided to give the faculties the opportunity to make comments on the general findings and the faculty report. These comments will be included in the report.

The fifth and final draft was based on the comments and sent to the faculties with the request for commentary on it. The commentary is included in the report (see appendix 7).

3. MINIMUM REQUIREMENTS FOR ELECTRICAL AND SIMILARLY NAMED ENGINEERING PROGRAMMES

The following criteria were adopted by the IPR-EE Committee during the first plenary meeting. The Programme and General Criteria are largely derived from the criteria used by ABET (the Accreditation board for Engineering and Technology)in the USA. Programme criteria relevant for electrical engineering program review are based on the criteria developed by the Institute of Electrical and Electronics Engineers, Inc. (ABET,1991).

They were published in the Guide for the Committee and functioned as a frame of reference during the visits.

3.1. Introduction

3.1.1 General

The International Programme Review Electrical Engineering (IPR-EE) applies to engineering programmes which include "electrical", "electronics" and similar modifiers in their titles.

Engineering (and so Electrical Engineering) is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering science are applied to convert resources optimally to meet a stated objective.

3.1.2 Definition of Programme

The Committee will review those university programmes, leading to a Master's Degree in Electrical Engineering (= Ir. in the Netherlands, Dipl.-Ing. in Germany and Switzerland, Burgerlijk Ingenieur in Belgium, Civilingenjör in Sweden and Master of Engineering in the UK).

An electrical engineering programme is an organized educational experience consisting of a cohesive set of courses, or other educational modules, sequenced so that reasonable depth is obtained in the upper level courses. A definite engineering staple should be obvious in the programme and, again, depth should be reached in pursuing courses in the engineering staple.

Furthermore, the programme should develop the ability to apply pertinent knowledge to the practice of Electrical Engineering. An engineering programme must also involve the broadening educational objectives expected in modern post-secondary education. For the electrical engineering discipline, IPR-EE has developed programme criteria that define specific programme requirements within the general realm of electrical engineering.

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3.1.3 Interpretation of Criteria

Considerable latitude in the choice and arrangement of subject matter in the curriculu allowed. While the qualitative factors are more important than the quantitative assignr of credit hours to any particular area, the general principles outlined in the criteria wil checked closely by analyzing each particular curriculum. The coverage of t information rather than the offering of specific courses is the important criterion.

Methods for delivery of instruction and their use are developing, and ways for evalua the learning accomplishment are evolving as well. When a course offered as part o engineering programme employs a method for delivery of instruction that differs from more frequently encountered methods (e.g., lecture, discussion, laboratory) there must provision for evaluating the learning accomplishment to ensure that educational objec are met.

3.2. Criteria

3.2.1. Programme Criteria

These criteria are intended to assure an adequate foundation in science, engine sciences and engineering design methods, as well as preparation in a higher engine specialization appropriate to the challenge presented by today's complex and diff problems. They are intended to afford sufficient flexibility in science requirements so programmes requiring special backgrounds can be accommodated. They are designed flexible enough to permit the expression of an institution's individual qualities and id They are to be regarded as a statement of principles to be applied with judgement in case rather than as rigid and arbitrary standards. Finally, they are intended to encou and stimulate and not to restrain creative and imaginative programmes.

3.2.1.1 Curricular Objective and Content

Engineering is that profession in which knowledge of the mathematical and na sciences gained by study, experience, and practice is applied with judgement to dev ways to utilize, economically, the materials and forces of nature for the benef mankind. A significant measure of an engineering education is the degree to which i prepared the graduate to pursue a productive engineering career that is characterize continuing professional growth.

The curriculum of Electrical Engineering must provide depth and breadth in electrica electronics engineering. Depth requires the study of at least one area of electrical electronics engineering at an advanced level. Breadth requires coverage of several are electrical and electronics engineering.

This section of the criteria relates to the extent to which a programme develops the a to apply pertinent knowledge to the practice of electrical engineering in an effectiv professional manner. Included are the development of:

a) a capability to delineate and solve in a practical way the problems of society that are susceptible to electrical engineering treatment,

b) an understanding of the socially-related technical problems which confront the profession; of the ethical characteristics of the engineering profession and practice; of the engineer's responsibility to protect both occupational and public health and safety, and

c) an ability to maintain professional competency through life-long learning.

These objectives are normally met by a curriculum in which there is a progression in the course work and in which fundamental scientific and other training of the earlier years is applied in later engineering courses.

For those institutions which elect to prepare graduates for entry into the profession at the Master's level, IPR-EE expects the curricular content of the programme to include the areas of mathematics, basic sciences, general and electrical engineering sciences, electrical engineering design. The course work must include at least:

- an appropriate combination of mathematics and basic sciences,

- an appropriate combination of general and electrical engineering sciences and engineering design with a distribution of design that culminates in a meaningful, major design experience.

Appropriate implies that there is logic applied to the selection of courses and that this logic is communicated to others through published statements statements.

Distribution of design implies that design cannot be taught in one course; it is an experience that must grow with the student's development. A freshman design experience may be acceptable under this requirement. A meaningful, major design experience means that at some point, when the student's academic development is nearly complete, there should be a design experience that both focuses the student's attention on professional practice and is drawn from past course work. Inevitably, this means a course, or a project, or a thesis that focuses on design. A "major" design experience cannot be one credit of a three-credit course. Meaningful implies that the design experience is significant within the student's principal specialisation, that it draws upon previous course work, but not necessarily upon every course taken by the student.

The overall curriculum must provide an integrated educational experience directed toward the development of the ability to apply pertinent knowledge to the identification and solution of practical problems in the designated area of engineering specialization.
The curriculum must be designed to provide a sequential development leading to adv[illegible]d work, and must include both analytical and experimental studies. The objective of integration may be met by courses specifically designed for that purpose, but it is recognized that a variety of other methods may be effective.

While IPR-EE favours a flexible approach to the design of curricular content, it also recognizes the need for specific coverage in each curricular area.

(1) Mathematics; Basic Sciences.

(a) Studies in mathematics must go beyond trigonometry and must emphasize mathematical concepts and principles rather than computation. The curriculum must include at least one advanced topic such as linear algebra and matrices, probability and statistics, partial differential equations, numerical analysis, advanced calculus, or complex variables. The advanced mathematics must be used in electrical and electronic engineering courses.

(b) The objective of the studies in basic science is to acquire fundamental knowledge about nature and its phenomena, including quantitative expression. These studies must include general physics at appropriate levels. Also additional work in life sciences, earth sciences, and/or advanced physics may be utilized to satisfy the basic sciences requirement, as appropriate for the electrical engineering discipline.

(c) Course work devoted to developing skills in the use of computers or computer programming may not be used to satisfy the mathematics/basic sciences requirement.

(2) General engineering Science.

The programme must promote an awareness of the life-cycle aspects of a product and a technical background with a wider scope than electrical engineering in the narrow sense to obtain sufficient flexibility in the professional career. Subjects such as accounting, industrial processes, project management, cost analysis, environment etc. should be touched upon to acquire skills for working with professionals from other fields. Introductory courses on technical disciplines in other domains (e.g. technical mechanics, material sciences, combustion engines, chemistry) can be included to create the technical background mentioned.

(3) Electrical Engineering Sciences.

The electrical engineering sciences have their roots in mathematics and basic sciences, in particular physics, but carry knowledge further toward creative application. These studies provide a bridge between mathematics/basic sciences and engineering practice. Such subjects include electrical and electronic circuits, materials science, optics and computer science (other than computer programming skills), along with some other subjects. While it is recognized that some subject areas may be taught from the standpoint of either basic science or engineering science, the ultimate determination of electrical engineering science content is based on the extent to which there is extension of knowledge toward creative application. In order to promote breadth, the curriculum must include at least one engineering science course outside the electrical engineering discipline area.

(4) Electrical Engineering Design.

(a) Each educational programme must include a meaningful, electrical engineering design experience that builds upon the fundamental concepts of mathematics, basic science, electrical engineering science, electrical engineering design, communication skills, and humanities and the social sciences. The scope of the design experience within a programme should match the requirements of practice. Advanced courses that emphasize design must have a size and structure that provide for individual attention to each student. The requirement for "one course which is primarily design, preferably at the final-year level, and predicated on the accumulated background of the curricular components" can be satisfied in several ways. As a minimum, a course that satisfies this requirement must have a content that is more than one-half engineering design and must be in the basic or main programme. It must not be a beginning course in the programme but must have as a prerequisite at least one course in the discipline.

(b) Electrical Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering science are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include at least some of the following features: development of student creativity, use of open-ended problems, development and use of design methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact.

(5) Education in non-technical subjects

Studies in the humanities and social sciences serve not only to meet the objective of broad education but also to meet the objectives of the engineering profession. In the interest of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, it is therefore important that a faculty offers courses in the humanities and social sciences as part of the engineering programme. The characteristic of these courses is to foster awareness, not to make specialists in that field.

(6) Additional requirements

(a) Appropriate laboratory experience which serves to combine elements of theory and practice must be an integral component of every electrical engineering programme. Every student in the programme must develop a competence to conduct experimental work such as that expected of electrical engineers. It is also necessary that each student have "hands-on" laboratory experience, particularly at the upper levels of the programme. Instruction in safety procedures must be an integral component of students' laboratory experiences.

(b) Computer use. Appropriate use of computers must be integrated throughout the programme. Acceptable computer use will include most of the following: (1) programming in high level languages such as PASCAL, FORTRAN, ADA, or PL/1; (2) use of software packages for analysis and design, (3) documentation of programs, (4) use of systems software such as editors, compilers, and debugging routines, and (5) simulation of engineering problems. Access to computational facilities must be sufficient to permit students and staff to integrate computer work into course work whenever appropriate throughout the academic programme.

(c) Competency in written communication is essential for the engineering graduate. Although specific course work requirements serve as a foundation for such competency, the development and enhancement of writing skills must be demonstrated through student work in engineering courses as well as other studies. Oral communication skills must also be demonstrated within the curriculum by each engineering student.
Appropriate expertise in the English language is desirable.

(d) An understanding of the ethical, social, economic, and safety considerations in engineering practice is essential for a successful engineering career. Course work may be provided for this purpose, but as a minimum it should be the responsibility of the academic staff in engineering to infuse professional concepts into all electrical engineering course work.

(7) Relations with industry

There should be evidence that a faculty/department takes into account the requirements of industry. A faculty/department should have a good understanding of the wishes of industry a[illegible] be able to convert those wishes into an adequate curriculum. The cooperative work experience period should be more than incidental short term employment - it should be part of an industry training activity, recognized as an acceptable part of a professional employee development programme.

3.2.2 General criteria

3.2.2.1. Academic staff

This section of the criteria relates to the size and competence of the academic staff, the standards and quality of instruction in the engineering departments and in the scientific and other operating departments in which engineering students receive instruction, and evidence of concern about improving the effectiveness of pedagogical techniques.

a. The heart of any educational programme is the academic staff. All other matters are secondary to a competent qualified, and forward-looking staff that can give an overall scholarly atmosphere to the operation and provide an appropriate role model for engineering students.
b. The academic staff must be large enough to cover by experience and interest all of the curricular areas of electrical engineering and to provide technical interaction and stimulation.

c. Teaching loads must be compatible with the existing climate for research and professional development. Electrical engineering staff members, regardless of their individual capabilities, cannot function effectively either as teachers or seekers of new understanding if they are too heavily burdened with classroom assignments. Stimulation of student minds presupposes constant and energetic study by staff of new developments in areas of technology and science and in areas of instructional innovation.

d. The overall competence of the academic staff may be judged by such factors as:
- the level of academic training of its members;
- the diversity of their backgrounds;
- their non-academic engineering experience;
- their experience in teaching;
- their interest in and enthusiasm for developing more effective teaching methods;
- their level of scholarship as shown by scientific and professional publications;
- their registration as Professional Engineers;
- their degree of participation in professional, scientific and other learned societies;
- recognition by students of their professional acumen;
- and their personal interest in the students' curricular and extra-curricular activities.

e. The teaching staff in engineering must assume the responsibility of ensuring that the students receive proper curricular and career advice. Those individuals responsible for and involved in giving advice must know and understand the engineering programme accreditation criteria, as the criteria reflect the practice of engineering as a profession.

3.2.2.2. <u>Institutional Facilities</u>

a. An electrical engineering programme must be supported by adequate physical facilities, including office and classroom space, laboratories, and workshop facilities suitable for the scope of the programme's activities.

b. The libraries in support of the engineering unit must be both technical and non-technical, to include books, journals, and other reference material for collateral reading in connection with the instructional and research programmes and professional work.

c. The computer facilities available to the engineering students and staff must be adequate to encourage the use of computers as a part of the engineering educational experience. These facilities must be appropriate for engineering applications such as engineering computation, modelling and simulation, computer-assisted design, and laboratory applications.

d. The laboratory facilities must reflect the requirements of the electrical engineering programme. Attention is needed for up-dating and appropriate maintenance of the equipment.

LEGEND TO THE TABLES IN CHAPTERS 4-9

TUE	University of Technology Eindhoven
UT	University Twente
TUD	University of Technology Delft
CHA	Chalmers university of technology
LU	Lund University
TUM	Technical University München
ETH	ETH Zürich
RUG	University of Gent
KUL	Catholic University Leuven
< 2.5	below expectations —
2.5 - 2.9	adequate □
3.0 - 3.4	more than adequate ●
3.5 - 4.0	good ✳
> 4.0	excellent ✿

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4 THE PROGRAMME: GOALS, CHARACTERISTICS AND CONTENT

The leading question for the Committee has been: "Do graduates from the electrical engineering faculty visited deserve the title of 'Electrical Engineer'? Are they qualified for the title of 'Master of Electrical Engineering'?" The value of an academic degree depends on the value of the applied Academic Standards. These standards are fixed by the level of the examinations. The content and level of examinations are fixed by the programme offered; and finally the programme is defined by the formulated goals and aims (see Figure 2).

FIGURE 2: FACTORS DEFINING THE ACADEMIC STANDARD

Stated goals and aims	➤	Translation of goals/aims in the curriculum	➤	Reflection of the programme contents in the examinations and the design work	➤	The graduate: what did he/she acquire with regard to: a) knowledge b) skills c) attitudes?

4.1 Goals and aims

To verify whether one is realizing within the curriculum what one wants to realize, the implicit aims in well-formulated goals must be made explicit. For that reason, faculties were asked to give the stated goals and aims in the questionnaire. One of the first questions during the visits was "What is your philosophy behind the programme? Why are you doing what you are doing?" The Committee has tried to find an answer to the following questions:

* Are the aims and objectives clearly stated?
* Are the formulated aims and objectives realistic and achievable, in view of boundary conditions such as nominal duration of the study and the starting level of the students?
* Do the formulated aims and objectives contain a good mixture of scientific orientation and practice orientation?
* Do the formulated aims and objectives meet the minimal requirements?

The Committee received a great diversity of statements on the goals. Some very short, others more elaborate. Most formulations had the following aspects in common:
"the aim is actively to develop the ability:

* *to recognize problems, to state them and to solve them by methodological methods that have been tried and tested*
* *to autonomously study and assess new developments*
* *to cope with fast-changing requirements in a competitive professional world*
* *to tackle new problems in a fresh and creative way".*

In the eyes of the Committee, the goals must be stated in such a way that it is clear that the curriculum aims at engineering education at a scientific level. An important characteristic of an academic graduate -contrary to lower levels of education- is the ability to read and interpret the international scientific literature. In the view of the Committee, academic graduates are able to obtain new knowledge and to put their new findings into practice. This distinguishes a Master-Engineer from an engineer of a Polytechnic (HTS in the Netherlands, Fachhochschule in Germany, Industriële Hogeschool in Belgium). The faculty at Gent gives the following description of academic engineers: *"They are able to apply this (= obtained knowledge) to master complex technological problems in relation to their social, economical and environmental context and to develop new technology, as opposed to maintaining technology."*

It is the Committee's general assessment that the goals and objectives have been formulated satisfactorily (see Table 1). An exception has to be made for the faculties at Eindhoven, Twente and Delft with regard to the "realistic and achievable" aspect. Looking at the boundary conditions of the nominal duration of the curriculum of four years, it seems that the formulated goals are (over)ambitious.

A problem is that the formulation of goals and objectives is often done in an abstract and very general way. The Committee believes that the goals should be stated in a manner allowing a judgement of whether the goals have been realized (i.e. operational goal setting and management by objectives).

TABLE 1 GOALS AND OBJECTIVES
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

I GOALS AND OBJECTIVES	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
1 aims and objectives are clearly stated?	●	●	●	✳	✳	✳	●	●	✿
2 realistic and achievable?	—	—	□	✳	✳	✳	✿	●	✳
3 good mixture of scientific and practice orientation?	●	●	●	✳	✳	✳	✳	□	●
4 the goals represent the minimal requirements?	●	□	●	✳	✳	✳	✳	●	●

— below expectations; □ adequate; ● more than adequate; ✳ good; ✿ excellent

4.2 Programme characteristics

To formulate goals and objectives is one thing, to translate them into programme content is another. The curriculum must reflect the objectives: to what extent does it develop the ability to apply knowledge to the effective and professional practice of electrical engineering? To this end, the Committee investigated whether the programme offered sufficient possibilities to develop:

* educational preparedness to maintain professional competency through life-long learning
* an ability to understand, delineate and solve in a practical way the problems of industry and society that fall within the domain of electrical engineering
* an understanding of the relationship between society and the engineering profession and an understanding of the ethical, environmental, safety and public-health aspects of the engineering profession and practice.

Table 2 shows that at all faculties the curriculum generally covers the expected characteristics in a satisfactory or more than satisfactory way. All programmes are up-to-date and coherent.

All curricula, with the exception of that at Gent, are, in the Committee's opinion, more than sufficiently problem-solving oriented. One weak point in four of the nine programmes is the issue of 'understanding of the relationship between society and the engineering profession'. The low score here is connected with the limited focus on non-technical subjects (see Section 4.7).

TABLE 2: CHARACTERISTICS OF THE PROGRAMME
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

IIa Programme (characteristics)	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
1 problem-solving oriented	✳	✳	✳	●	✳	✳	✿	□	●
2 understanding the relationship between society and the engineering profession	●	✿	—	—	—	—	●	□	●
3 educational preparedness for life-long learning	●	□	✳	✿	✿	✳	✳	●	✿
14 coherency of the programme	□	□	●	●	●	✿	●	□	✿
17 the programme is up-to-date	●	●	●	●	●	✿	✿	●	✳

— below expectations; □ adequate; ● more than adequate; ✳ good; ✿ excellent

Part III Appendix 2 presents the structure of all programmes and an overview of the contents. Table 3 gives the time as a percentage of the total number of contact hours spent on the different subject requirements as set by IPR-EE in the Guide for the Committee.

TABLE 3: TIME SPENT ON DIFFERENT SUBJECTS AS A PERCENTAGE[1] OF TOTAL CONTACT HOURS
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

FACULTY	TUE*	UT	TUD	CHA	LU	TUM	ETH	RUG**	KUL**
MATHEMATICS	18	15	23	22	20	17	15	15	15
PHYSICS	6	9	10	6	[illegible]	6	9	6	12
COMPUTER SCIENCES	3	5	4	10	11	10	7	4	7
GENERAL ENGINEERING SCIENCES	1	0	2	6	2	7	0	15	20
ELECTRICAL ENGINEERING SCIENCES	38	33	24	29	41	39	35	35	33
ELECTRICAL DESIGN[2]	12	4	2	3	4	4		1	8
NON-TECHNICAL SUBJECTS	9	10	4	2	0	0	11	4	5
ELECTIVES	13	24	32	21	12	17	22	20	0
TOTAL	100	100	100	100	100	100	100	100	100
TOTAL ABSOLUTE NUMBERS	2440	2550	2130	2758	2584	2288	3024	4095	3277

*) Numbers for the Electrical Engineering programme
**) Numbers for the Electronic Engineering programme

1) Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis activity are not included in the percentage.
2) It is not always possible to distinguish between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.

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At this stage, the Committee wishes to take the opportunity to express its general ideas about an EE-programme. All the EE-programmes that the Committee has scrutinized, meet the formulated minimum requirements adequately and are satisfactory and sometimes even more. However, this does not mean they are beyond reproach. During the visits, the Committee observed a diversity in programmes: very broad, as seen in the faculties at Gent and Leuven, or specialized as in the faculties at Eindhoven, Twente and Delft. Mostly, the structure and content of a programme is defined by the national and historical context. The programmes at Gent and Leuven occupy a special position within the European scene of faculties visited, having in common the first two years for all engineering students with an emphasis on many areas of engineering sciences. The Committee appreciates the widely based Belgian programmes, however it wonders whether a greater degree of specialization is required. With regard to the more specialized curricula, the Committee considers that it may be desirable to broaden the programmes. Since graduates have to be able to adjust easily to future changes in science and technology, it would be advisable to broaden the basic courses and to widen the general engineering bases of the curriculum. The Committee considers that integrating non-technical subjects is important to understand the relationship between society and the engineering profession.

The Committee supports the necessity of specialization during the study period. However, this specialization must not be considered as a preparation for future activities in the work situation. Rather, it can be seen as the domain in which students can prove their ability to integrate the various disciplines independently. The Committee is aware of the time constraints and that it is not always easy to substitute one subject for another. But the faculties should give this some consideration.

The Committee's view of an 'appropriate' time distribution, based on its experience, is given in Table 4.

TABLE 4: AN APPROPRIATE DIVISION OF TIME ON DIFFERENT SUBJECTS AS A PERCENTAGE OF TOTAL CONTACT HOURS

	Average percentage of Table 3	Appropriate percentage
MATHEMATICS	17.8%	15-20%
PHYSICS	8.1%	8-12%
COMPUTER SCIENCES	6.8%	7-10%
GENERAL ENGINEERING SCIENCES	4.4%	5-15%
ELECTRICAL ENGINEERING SCIENCES	52.0%*)	45-55%
ELECTRICAL DESIGN	4.8%	5-10%
NON-TECHNICAL SUBJECTS	5.0%	5%

*) Including electives.

4.3 Mathematics and basic sciences

The quality of mathematics, with basic sciences like physics, as a basis for electrical engineering, is good to excellent (see Table 5). The faculties spend on average 16% of the total contact hours on mathematics (ranging from 15% to 23%). In some cases (Chalmers and Lund), the Committee wonders whether perhaps too much attention is being given to mathematics. It sometimes seems necessary for upgrading the students coming from secondary schools (see Section 6.1).

Whilst mathematics is well covered, the Committee believes that very little attention is generally paid to the other basic sciences. The objective of basic science is to acquire fundamental knowledge about nature and its phenomena, including quantitative expression. These studies should include general physics at the appropriate levels. In most cases the Committee observed a shortage of physics, chemistry and material sciences. In its opinion, 8-12% of contact hours should be spent on basic sciences like physics.

4.4 General engineering sciences

In its formulated minimum requirements, the Committee stated that: *"the programme must promote an awareness of the life-cycle aspects of a product and a technical background with a wider scope than electrical engineering in the narrow sense, to obtain sufficient flexibility in the professional career. Subjects as accounting, industrial processes, project management, cost analysis, environment, etc., should be introduced to acquire skills to work with professionals from other fields. Introductory courses on technical disciplines in other domains (e.g. mechanics, material sciences, combustion engines, chemistry) may be included to create the technical background mentioned. In order to promote such a breadth, the curriculum must include at least one engineering science course outside the electrical engineering discipline area".*

Only the faculties in Gent and Leuven spend much time on general engineering sciences, because the first two years are common for all engineering students with an emphasis on many areas of engineering science. Many faculties are assessed as meagre in the field of general engineering science (see Table 5). In the opinion of the Committee, it would be wise to devote between 5% and 15% of the contact hours to general engineering science.

4.5 Electrical engineering sciences

Table 3 shows that the average time in the programmes, spent on electrical engineering (excluding the electives), is approx. 36% of all contact hours, varying from 24% to 41%. The Committee assesses the content of Electrical Engineering in all faculties as more than adequate to excellent (see Table 5). There is a great diversity in subjects and specializations in the field of Electrical Engineering sciences. The student has sufficient possibilities to choose his or her own direction. In the opinion of the Committee, the students should be in touch with electrical engineering sciences as soon as possible and the faculty should not postpone it to the third year as is done in some cases. The Committee noted that in all faculties the level of the courses in electrical engineering sciences is good to excellent.

Although some faculties (e.g. the faculty of Twente) have opted for a curriculum limited to Information Technology and Electronics, the Committee considers it equally necessary to have general insight in Electrical Engineering at large and thus to include at least an introduction in power engineering in the programme.

4.6 Electrical engineering design

In the eyes of the Committee, design is the most important aspect of engineering. Electrical engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering science are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include at least some of the following features: development of student creativity, use of open-ended problems, development and use of design methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact.

In the opinion of the Committee, all faculties meet or exceed the minimum requirements for design (see Table 5), although it was not always easy to distinguish between design and other courses in electrical engineering sciences. Often design and design assignments are part of a course. For that reason it was not always possible to give the percentage of time spent on design (see Table 3).

4.7 Non-technical subjects

"In the interests of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, it is important that a faculty offers courses in the humanities and social sciences as part of the engineering programme. Characteristic of these courses is the fostering of awareness, and not an intention to make specialists in that field".

As shown in Table 5, the Committee's general assessment of attention to non-technical subjects is that this aspect is meagre. The faculty at Twente (with 10% of the contact hours on non-technical subjects) and the ETH (with 11%) are good in this field. Although it should not be set as a real requirement, the Committee considers it as desirable that more time be spent on non-technical subjects (the Committee recommends at least 5% of the total number of contact hours), since the engineer will often stay in the technical field for only a short time and will assume a managerial position after some period. Therefore, it is desirable to have subjects like project management, accountancy, economy and planning in the curriculum. The students should be encouraged to take several of the electives in these fields.

4.8 Outcomes of the checklist with regard to the content of the programme

TABLE 5: CONTENT OF THE PROGRAMME

(TUE. Eindhoven; UT: Twente; TUD: Delft; CHA. Chalmers; LU: Lund. TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

IIb Programme (contents)	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
4 Mathematics	●	⁜	●	✿	✿	✿	✿	✿	✿
5 Basic sciences	□	□	□	⁜	⁜	□	⁜	⁜	⁜
6 General engineering	—	—	—	●	—	□	□	⁜	⁜
7 Electrical Engineering	⁜	⁜	●	✿	●	✿	✿	●	✿
8 EE Design	●	□	●	□	□	✿	✿	□	⁜
9 Non-technical subjects	□	⁜	—	—	—	□	⁜	□	●
15 Supply of optional subjects	●	●	⁜	✿	●	✿	✿	●	—

— below expectations; □ adequate; ● more than adequate; ⁜ good; ✿ excellent

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5 STUDENT SKILLS, INDUSTRIAL TRAINING, THESIS AND EXAMINATIONS

5.1 Student skills

The IPR-EE Committee also formulated additional requirements for an electrical engineering programme regarding students' laboratory experiences, the use of computers and the attention paid by the faculty to written and oral communication. Table 6 shows that, in the opinion of the Committee, all faculties fulfil the requirements for laboratory experience more than adequately or to an even better level. The faculty at Gent meets the requirements adequately, due to the fact that the laboratory equipment is somewhat outdated, in the opinion of the Committee.

Computer experience is generally more than adequate. With regard to oral and written communication, the Committee would request that some faculties pay more attention to these skills. It is advisable to complete research projects and thesis activities with an oral presentation. In general, the Committee assesses the possibilities for students to acquire the necessary skills as satisfactory.

TABLE 5: STUDENT SKILLS
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

IIc Programme (students skills)	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
10 Laboratory experience	✻	●	●	✻	✿	✿	✿	□	●
11 Computer experience	✿	●	●	●	✿	✿	✿	✿	✿
12 Written communication	✻	□	●	●	●	●	✻	●	●
13 Oral communication	●	□	●	●	□	□	✻	●	●

— below expectations; □ adequate; ● more than adequate; ✻ good; ✿ excellent

5.2 Industrial training

All faculties, with exception of Gent and Leuven, require students to undertake a period of industrial training. Munich require 26 weeks in total. The first half must have been completed before the end of the second year, mostly during vacations. The remaining 13 weeks prior to the Masters' examinations. Chalmers demand 680 hours' (17 weeks') industrial training, Lund requires 520 hours (13 weeks), the faculties of Eindhoven, Twente and Delft require 400 hours (10 weeks).

The Committee considers it important to receive training in the form of factory-floor experience. Industrial training is valuable as technical training, provided that it is well-organized and the quality is controlled. It must be significant for the study and can be undertaken in the vacations. The faculty must play an active role in organizing industrial training and should not leave it to the student to arrange him/herself.

5.3 Thesis

The Committee paid special attention to the thesis at the end of the study period. In the eyes of the Committee, the thesis is that part of the curriculum where students can integrate their knowledge of various discipline under the supervision of a mentor. The Committee also observed a great variety of methods when studying the thesis phase.

Common features are:

* it is undertaken in the last year of the programme
* it is a research and design project, aimed at recognizing, formulating, describing and solving a relevant problem in electrical engineering
* it is usually concluded with a written report and an oral presentation.

The time spent on the thesis is divergent (see Table 7). Gent and Leuven programme only 300 and 360 hours respectively, but in this case the faculties know that students spend more than twice or three times this amount of time on their theses. Normally all students exceed the programmed time. This is due to their enthusiasm, or to the faculty or to industry. In the opinion of the Committee, the curriculum must be based on realistic time spent, including thesis activities. The faculty must restrain the student's own enthusiasm or the requirements of industry.

The Committee considers that spending six months (approx. 1000 hours) full-time on the thesis is appropriate. Therefore, the Committee, albeit not unanimously, do not support the wishes of the faculties of Eindhoven, Twente and Delft to raise the final thesis period to 9 months instead of the current 6 months. In the opinion of the Committee, the three months can be better used for other activities which the university can provide, e.g. advanced theoretical teaching.

The thesis is usually undertaken in the faculty, sometimes in industry, and sometimes also in other faculties and hospitals. The Committee noted that a high percentage of theses are undertaken in industry only at Chalmers and Lund. The Committee supports the idea that some theses be undertaken in industry, because it gives the faculty the opportunity to keep in touch with industrial developments, although care should be taken here. The thesis must remain part of the curriculum and not degenerate into a service to a company. There must be good control over coaching and the assessment of the thesis. The responsibility must lay with the university and not with the company. It must be clear that the aim of "integration of disciplines" is actually being achieved.

The Committee requests that special attention be given to rating individual performance in those cases where the thesis is undertaken in teams, as in the case of the ETH. In general, the Committee judges the level of the theses to be satisfactory.

TABLE 7: HOURS, PROGRAMMED FOR THE THESIS
(TUE: Eindhoven, UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
Programmed hours for thesis	1040	1000	950	800	600	1040	640	300	360

5.4 Examinations

Nearly all the faculties visited have two formal examinations: at the end of the first or second year and at the end of the programme. The faculties of Eindhoven, Twente and Delft have what is known as the "propedeuse" at the end of the first year. TUM and the ETH have the first "Vordiplom" after the first year and the second "Vordiplom" after the second year. RUG and KUL have what is known as the "Kandidatuur" at the end of the second year.

The Vordiplom and Kandidatuur mark the transition from the basic programme to the main programme. The Dutch Propedeuse examination does not really have this function, because the basic programme continues into the second year. The Propedeuse functions as a selection mechanism. The second formal examination is the Masters examination, entitling those completing the examination successfully to bear the title of 'Master of Electrical Engineering'.

The Committee observed a large variety of examination cultures. The faculties at Chalmers and Lund have chosen a system of 7 weeks' lectures and examinations in the eighth week. The faculties at Eindhoven, Twente have an examination period at the end of each trimester (the Dutch academic year consists of three trimesters). The faculty of Delft has four examination periods (of 1, 2 or 3 weeks) at the end of each eight week teaching period. Moreover there is an additional examination period just before the start of the new academic year (though not all subjects are examined during this latter period). TUM and the ETH have a system of examinations taken outside the normal course periods. Students are allowed to prepare for their examinations for about 2 to 3 weeks in the spring recess and 8 to 10 weeks in the summer recess. Gent has a yearly system for organizing the courses, but the first examination must be taken at the end of the semester. A second chance is given in September. Leuven has an annual system. a student must successfully complete the examination at the end of the year. If not, a second trial is possible in September. A student who fails must repeat the year.

Every examination system has advantages and disadvantages. In the opinion of the Committee, it is important not to have too frequent nor too small-scale examinations. This offers possibilities for keeping the students working (which may be advantageous in the first and possibly second year), but the student loses the possibility to integrate larger parts of knowledge. It is preferable to test knowledge in small pieces in the first and second years and to set more complex examinations in later years.

The Committee requested examples of examinations for each course. It has studied the examinations, looking at the following aspects:

* is the level of the examinations satisfactory?
* do the examinations reflect the aims of the courses?
* is the faculty's procedure for examinations a good one?

Looking at Table 8, it can be seen that the Committee has generally assessed the examination as adequate or more than adequate. In the opinion of the Committee, in some cases the examinations are oriented more to reproducing knowledge than to understanding.

Another problem the Committee met is the repetition of examinations. Often the student may make several attempts at the same examination, sometimes unlimited. In the opinion of the Committee, the number of attempts should be limited with respect to an awareness of time and resources. In general, the level of examinations is satisfactory and reflects the stated goals and objectives.

TABLE 8: THE EXAMINATIONS
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

II. Programme (examinations)	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
20. Level examinations	✳	●	●	□	□	●	✳	●	✳
21. Examinations/goals	●	□	●	●	✳	✳	✳	□	●
III.2 Procedures for examination	●	□	●	●	✳	●	✳	□	□

— below expectations; □ adequate; ● more than adequate; ✳ good; ✿ excellent

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6 THE STUDENTS

6.1 Previous schooling

In an International Programme Review, assessing programme and standards, one of the factors influencing the level is the previous schooling of the freshmen entering the programme. For that reason, the Committee has tried to obtain an insight into the level of secondary education, especially the knowledge in the field of mathematics and physics.

A Dutch student entering university will have had 14 years of schooling: 8 years' basic schooling (2 years' prep school and 6 years' elementary school) and 6 years' secondary school of the "VWO" type. The electrical engineering faculties do require mathematics and physics.

A Swedish student entering university will have had 12 years of schooling, 9 years' primary school and 3 years' Gymnasium. The minimum requirements for all university education is graduation from a secondary-school (Gymnasium) course lasting at least two years. There is also a minimum requirement of at least three years' mathematics, physics and chemistry for an engineering education. This can be followed either in the upper three years of a scientific programme (Naturvetenskaplig linje) or in the upper three years of a technical programme (Teknisk linje). But students may come from other streams as well, although 90 percent will have followed the science or technical stream.

In Germany, the normal qualification for freshmen is the "Abitur" (final examination after 13 years' education, beginning at the age of six).

In Switzerland the normal qualification for freshmen is the "Maturität" (final examination) at a recognized Swiss "Gymnasium" after 12-13 years of education (depending on the canton). Alternatively, ETH will accept students who have passed a special entry examination equivalent to the "Maturität".

Freshmen at the Belgian universities will have had 6 years of elementary schooling (age 6 to 12 years) and 6 years secondary school. Belgium has obligatory schooling up to the age of 18 years. Secondary schools are divided into three streams: General, Technical and Professional. The General secondary school (Hoger secundair onderwijs) gives access to the university.

The requirements for the final examination for mathematics and physics at secondary-school level are more or less the same in the different countries, as far as the Committee could assess. Only with regard to Sweden, the Committee has the impression that the previous schooling of the students may be slightly limited in some aspects, e.g. mathematics. The secondary school does not provide homogeneous input. The spread in programmes in secondary schools leads to a situation where the university is forced to level out big differences in mathematics, physics and language during the first year.

The level of school leavers can be considered as equal. A problem is that some faculties cannot demand subjects like mathematics and physics on entrance. The Dutch and the Swedish faculties may do so, however they are not allowed to select on mark .

6.2 Selection

The Committee noted that entrance selection occurs only in Belgium. The general secondary school gives access to the university on the understanding that students undertake an entrance examination for the engineering studies. This entrance examination concerns only mathematics. The objective is not to limit the number of students wishing to enter, but to select the good students. A committee of the deans of the Flemish engineering faculties decides on the level and content of examinations. The percentage of students that pass the entrance examination is 60 - 65%.

To gain admittance to higher education programmes in Sweden, a student must first fulfil the general entrance requirements that are common to all first-degree study programmes. Some disciplines can add special requirements. So electrical engineering requires mathematics, chemistry and physics. There was a central entrance selection by UHÄ (National Board of Universities and Colleges), based on the grade-point average for all subjects in the secondary school examination certificate. Points could also be added for work experience exceeding 1.5 years which has the effect that work experience is necessary for students with a low grade-point average. If the number of applicants exceeds the number of available places, a selection is made from the qualified applicants. In 1990, there were 64,000 applicants for all university programmes, while only 23,000 were admitted. To be accepted, the student must usually be among the best 40% in his class. The selection has recently changed. More students will be accepted with the grade-point average as the only parameter (2/3), since the possibility to add work experience credit is removed. An alternative selection mechanism consists of a test of study ability where work-experience points may be added, however not until after five years' work experience.

The faculties of Eindhoven, Twente and Delft, the TUM and the ETH have no entrance selection. Every secondary school leaver of the VWO-type, or the Abitur or Maturität respectively, can enter the university. Special rules are applied for applicants from abroad.

It is a fact that Gent and Leuven have the highest completion rates of all the faculties visited (see Section 6.6). Chalmers also has a higher rate than the others. Nevertheless, the Committee is not totally convinced of the value of an entrance examination or entrance selection. The average completion rate of the 4 faculties with possibility for selection is 63%, for the others the average rate is 56%.

The Committee thinks it is important that a faculty can demand of the students entering the university that mathematics and physics be part of the final secondary school examination and that their marks are at a satisfactory level. If a faculty is not allowed to reject students with low marks, the faculty should provide the students with good information regarding the necessity for having good marks in those subjects.

6.3 Student numbers

Table 9 gives the number of freshmen and the total number of students for 1985 and 1990. Table 10 gives the number of applicants and the real intake. Differences can only be seen in the case of Chalmers, Lund, Gent and Leuven. Normally a student can apply to more universities.

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The Committee noted that the influx of freshmen has declined during recent years. In the Netherlands, the university faculties, industry and government are worried about the drop in intake and are taking actions to raise the numbers of EE-freshmen.

TABLE 9: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS IN 1985 AND 1990
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

FACULTY	NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
	TOTAL		% FEMALE		TOTAL		% FEMALE	
	1985	1990	1985	1990	1985	1990	1985	1990
TUE	244	194	2.0%	2.6%	1111	1048	1.1%	2.0%
UT	146	152	2.1%	4.6%	776	763	1.2%	2.1%
TUD	348	247	1.7%	3.2%	1497	1433	1.7%	3.4%
CHA	229	219	7.0%	9.0%	1086	1063	9.0%	10.0%
LU	156	186	10.9%	4.3%	750	1150	?	?
TUM	748	625	?	6.9%	3191	3573	?	4.6%
ETH	305	202	1.3%	2.5%	1249	1394	1.3%	1.2%
RUG	147	163	9.2%	14.0%	627	628	7.8%	12.1%
KUL	227	206	11.9%	15.5%	855	732	4.5%	6.4%

There are very few female Electrical Engineering students in most of the faculties visited. Only Gent and Chalmers have more than 10% female students. The reason for the low female participation is not clear, but probably originates already at the secondary-school level and the somewhat dull image of EE, partly due to its high mathematics and physics content. In the opinion of the Committee, the electrical engineering faculties should try to attract more female students.

TABLE 10: APPLICANTS AND INTAKE 1985 AND 1990

FACULTY	1985		1990	
	APPLICANTS	INTAKE	APPLICANTS	INTAKE
TUE	244	244	194	194
UT	146	146	152	152
TUD	348	348	247	247
CHA	2251	229	1741	217
LU	1666	156	1360	186
TUM	748	748	625	625
ETH	305	305	202	202
RUG	213*)	147	226	163
KUL	414*)	227	375	206

*) This number is 55% (RUG) or 45% (KUL) of all applicants for the faculty of Applied Sciences, reflecting the portion of students who will normally opt for EE.

6.4 Study burden

The study burden and the real time that the student spends on his/her study are, in addition to the structure and organization of the programme, influenced by the effective duration of the study and the completion rates. The Committee has tried to gain an insight into the study burden by calculating the programmed hours and the real time spent on the study. Table 11 contains absolute figures. One lecture hour is counted as one hour, although sometimes this may last only 45 minutes.

There is a great variety in the percentage of contact hours. The TUM only approx. 26% contact hours constitute the total programmed hours, while other faculties offer between 35% and 40%. Delft even has 45% contact hours. Big differences were also observed between the number of practical hours. Chalmers, Lund, Munich and the ETH programme less than 10% of the contact hours for practicals.

The ratio of contact hours (lectures, tutorials, practicals and research projects) to individual study is mostly approx. 2 contact hours versus 3 hours' individual study. Students spend approx. 40% of their time at the university and are expected to spend about 60% on individual study. Only Delft and Chalmers have a ratio of 1:1. Many lectures are coupled with tutorials, i.e. small working groups for exercises. In general, the numbers given for lectures is, on average, about 60% 'real' lectures and 40% tutorials.

It is difficult to obtain clear figures on the real amount of time the students spend on their study. Although the figures will always result in some discussion, the Committee has attempted to gain an impression by canvassing both students and staff. Programmed hours are compared with estimations of the real time. Whichever way the figures are interpreted, it is certain that the Dutch students and the students at Lund are spending less time on their study than their colleagues in other faculties (see the last two columns of Table 11).

TABLE 11: TOTAL STUDY BURDEN

	Lec-tures	Practi-cals	Total contact hours	Industrial training	The-sis	Total programmed hours (including individual study)	Estimate of real time spent on the study yearly	Estimate of real time spent on the study in total
TUE*)	1449	971	2420	400	1040	6720	1400-1600	7700-8800
UT	1744	706	2550	400	1000	6500	1400-1600	8260-9440
TUD	1579	551	2130	400	950	6720	1400-1600	7980-9120
CHA	2250	508	2758	680	800	7200	1800-2000	8820-9800
LU	2089	505	2594	680	600	7200	1600	8120-9280
TUM	1937	351	2288	1040	1040	8600	1800-2000	10.620-11.800
ETH	2492	532	3024	720	640	8530	1800-2000	9900-11.000
RUG**)	2070	2025	4095	0	300	10.150	2000-2100	10.600-11.130
KUL***)	2473	804	3277	0	360	9400	1900-2000	10.070-10.600

*) Numbers for the Electrical Engineering programme

**) Numbers for the Electronic Engineering programme

***) Numbers for the Energy programme.

6.5 Average duration of the study

Table 12 gives data about the nominal duration of the programme for electrical engineering and the effective length of the study.

TABLE 12: NOMINAL DURATION OF THE MASTER's PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA. Chalmers; LU: Lund: TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

FACULTY	NOMINAL	EFFECTIVE	DISCREPANCY NOMINAL-EFFECTIVE
TUE	4.0	5.5	37.5%
UT	4.0	5.9	47.5%
TUD	4.0	5.7	42.5%
CHA	4.5	4.9	8.9%
LU	4.5	5.8	28.9%
TUM	5.0	5.9	18.0%
ETH	4.5	5.5	22.0%
RUG	5.0	5.3	6.0.%
KUL	5.0	5.3	6.0%

EE-programmes in the Netherlands have the shortest nominal duration of all the faculties visited. The nominal duration is 4 years, set by the Dutch law as in the case of other university studies. However, a substantial discrepancy exists between the real duration (average 5.6 years) and the nominal curriculum length, this being in excess of more than 40%. One reasons for this is that by the same law, an enrolment time of six years is permitted. The students may take two years for the 'propadeuse' and 4 or 5 years for the main programme. The Committee was surprised to observe an almost overall opinion among students that there is a 'right' to study for a period of six years and therefore absolutely no reason to complete their study in a shorter time. Recently, the duration of students grants was restricted to five years, and for most engineering programmes to 5.5). It became clear to the Committee that it is difficult for students to complete their study in 4 years. The programme is heavily loaded, even when taking into account the relatively low study effort of the student (see Section 6.4). Therefore the Committee considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would enable many students to study according to the schedule. A further six months would be necessary to widen the programme even more, unless this were achieved at the expense of specialization, which cannot be considered as desirable. At the same time, the students should be motivated to spend more time on their study and the faculties must improve the structure of their programmes. The effective study may not be increased.

For the Swedish faculties, since 1986 the nominal duration of the study is 4.5 years. This was changed from 4 to 4.5 without any increase in study burden and without extra financing. The effective time for Chalmers is 4.9. In the opinion of the Committee, one reason for the small difference between nominal time and real time is the financial pressure on the students. They have to borrow money and have heavy debts at the end.

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Another reason is the structure of the programme. The students are closely monitored during the initial phases of their study. The quarterly periods of 8 weeks with examinations in the last week also have an effect. The students also devote considerable time to their studies. Although the students at Lund feel the same financial pressures as their colleagues at Chalmers, the average duration of the study is much higher: 5.8 years. So probably the structure of the programme and the way the students are monitored are more important factors than the financial aspect.

The faculty of Munich has a nominal time of 5 years and an effective duration of 5.9, due to the fact that many students must earn money for living expenses.

The Belgian faculties have a nominal duration of 5 years and an effective time of 5.3, the lowest discrepancy of all faculties. This small difference may be due to the scholastic structure of the curriculum.

In considering the data, the Committee concludes that an effective duration of approx. 5.5 years seems to be typical for electrical engineering at Western European (mainland) universities, independent of the nominal duration.

6.6 Completion rates

It is difficult to obtain clear data about completion rates and drop-out figures. The Committee has attempted to collect data for the students starting in the 1982/1983 academic year, a group that could be monitored from start to finish. All data in Table 13 have been provided by the faculties, but it was not always possible to trace the definitions used. Although great care should be taken when interpreting the data, not attaching too much significance to the figures, they do give some indications for the successful completion of the study by the students.

The figures for drop-out after 1 year were surveyed to determine how selective the first year is. Drop-out is defined as the percentage of students that are no longer officially registered as students in the electrical engineering programme after one year. The drop-out at the Eindhoven, Twente and Delft faculties is high. With no constraints on entrance selection, this may be considered as normal. Chalmers and Lund have a very low drop-out in the first year, but when the overall completion rates are studied, it is found that they are losing many students in later years. The same applies to the ETH. The Committee could not find an explanation for the fact that Gent and Leuven have an entrance examination and still have drop-out rates of 25% and 15% respectively for all engineering freshmen.

Looking at the completion rate in nominal time, it can be concluded that it is nearly impossible for Dutch students to complete their studies within the nominal time. Only at Gent and Leuven do 60% of all students finish in nominal time. Looking at the overall completion rate, the faculties of Eindhoven, Twente and Delft reflect the lowest output, and in the eyes of the Committee this is too low. The ETH, Gent and Leuven are in the upper region, Gent being on top with 71%. Looking at the overall completion rate, the Committee concludes that an output rate of 60/65% can be considered an average for electrical engineering at West European (mainland) universities.

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TABLE 13: DROP-OUT RATES AND GRADUATES FOR THE 1982/1983 ACADEMIC YEAR
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	FRESHMEN	DROP-OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D. AFTER 10 YEARS
TUE	187	24.0%	1.0%	44.0%	57.0%	5.0%
UT	152	28.2%	7.0%	41.0%	45.0%	7.5%
TUD	19[illegible]	29.0%	4.0%	43.0%	54.0%	15.0%
CHA	230	3.0%	45.0%	60.0%	65.0%	8.0%
LU	156	3.0%	16.0%	56.0%	60.0%?	<[illegible].0%
TUM	701	16.0%	8.0%	38.0%	58.0%	12.4%
ETH	257	8.0%	24.0%	66.0%	67.0%	16.0%
RUG	139	25.0%	58.0%	68.0%	71.0%	7.5%
KUL	227	15.0%	60.0%	63.0%	65.0%	9.0%

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7 THE FACULTY

7.1 The organization

The IPR-EE committee has not only formulated minimum programme criteria, but also criteria regarding the faculty. The Committee believes that: *"the heart of any educational programme is the faculty. All other matters are secondary to a competent, qualified, and forward-looking faculty that can give an overall scholarly atmosphere to the operation and provide an appropriate role model for engineering students."*

The higher education system only can be observed within the national context. Organization, structure and decision-making process are fixed by national laws and regulations and tradition. When studying a faculty, outsiders from abroad will observe circumstances that differ from their own situation. National prejudices may play a particular role here and be more pronounced than studying the programme. The comments and remarks of the Committee that have been presented in the faculty reports and partly summarized here, should therefore be seen more as 'wondering why' rather than 'knowing better'. On the other hand, outsiders from abroad may sometimes observe shortcomings that insiders in the system may take for granted.

The Committee noted that the decision-making process seems to be very complex at the faculties of Eindhoven, Twente and Delft. The responsibilities are dispersed. The Committee has the impression that the numerous laws and regulations from the government are sometimes taken for granted, and these sometimes prove obstructive. Collective bodies are involved in all important issues, and there is a tendency to avoid personal responsibility and accountability. Formally speaking, the dean is left with little executive power in relation to his responsibilities as dean of the faculty. This limits the executive managerial power in comparison to the problems with which a dean is faced. The Committee also observed a low level of participation by full professors in the curriculum committee. In the opinion of the Committee, the active presence of professors in such a committee is a necessity. It would also seem that, in the Dutch situation, full professors are obliged to spend excessive time on managerial tasks.

The Committee observed a complex organizational structure at Lund. The relation between the different programmes (basic programme, main programme and Ph.D. programme) seems weak, due to different organizational structures and separate executive boards. The organization at Chalmers did not give rise to any comment.

In Munich, the Committee found a faculty where the organization is based on strong autonomous chairs that are coordinated comparatively weakly, while there are also structurally responsible levels above the chair. In the opinion of the Committee, coordination above the chair level is desirable.

The faculty has a matrix organization at the ETH. There are two committees: the department board, responsible for research organization and infrastructure, and the faculty board, charged with teaching. The Committee was impressed by the well-organized school. As at the classical Von Humboldt University, professors are independent, but it seems that the matrix organization assures the coordination above the level of the chairs.

Regarding the two Belgian faculties visited, the Committee had the impression of well-organized faculties, although along somewhat traditional lines.

Looking at the different faculties with diverging organizational structures and decision-making processes, the Committee firmly believes that all faculties must guarantee the presence of a well-functioning curriculum committee, in which full professors are participating, and are responsible for designing the curriculum and innovative elements within the programme. This is independent of the prevailing structure.

7.2 The academic staff

The Committee has studied the position of faculty staff. It has looked at the size of the staff, the didactic and scientific qualifications, the range of specialization and the balance between teaching and research. In the opinion of the Committee, an electrical engineering faculty (or department or school) must be large enough, with respect to experience and interest, to cover all the curricular areas of electrical engineering and to provide technical interaction and stimulation. Table 14 gives the size of the academic and non-academic staff.

Wherever possible, the Committee has classified the academic staff into 5 groups:

* full professors
* associate professors/senior lecturers
* assistant professors/junior lecturers
* research assistants/Ph.D. students
* others (= often students/assistants or external individuals (industry) for part-time teaching.

TABLE 14: ACADEMIC AND NON-ACADEMIC STAFF: NUMBER OF PERSONS AND FULL-TIME EQUIVALENTS 1990
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	NUMBER OF PERSONS AND (FULL-TIME EQUIVALENTS)						
FACULTY	Full professors	Associate professors	Assistant professor	Research assistant	Others	Total academic staff	Non-academic staff
TUE	24 (17.4)	15 (14.5)	49 (47.0)	20 (20.0)	113 (9.6)	221 (108.5)	119 (111.9)
UT	11 (9.7)	10 (10.0)	33 (32.2)	41 (33.1)	74 (20.3)	169 (105.3)	105 (94.0)
TUD	30 (20.6)	27 (24.9)	61 (55.9)	46 (21.3)	85 (47.6)	249 (170.3)	176 (175.7)
CHA	22 (20.0)	27 (24.0)	10 (8.0)	138 (130.0)	49 (40.0)	246 (222.0)	121 (90.0)
LU	11 (10.8)	34 (33.3)	13 (12.1)	100 (57.8)	0	158 (114.0)	65 (59.2)
TUM	21 (21.0)	14 (14.0)		161 (161.0)		196 (196.0)	143 (?.?)
ETH	18 (18.0)	3 (3.0)	1 (1.0)	300(270.0)	40 (?.?)	362 (?.?)	85 (58.0)
RUG	9 (9.0)	8 (7.5)	5 (5.0)	118 (117.5)		140 (139.0)	38 (38.0)
KUL	12 (12.0)	2 (0.2)	21 (2.2)	122 (118.2)	18 (3.0)	165 (135.6)	42 (32.4)

The Committee considers the size of the staff at Eindhoven, Chalmers and Leuven to be adequate, in view of covering the necessary specializations. The Committee has some doubts about the size of the staff at Twente, Lund and Gent. Is it possible to adequately cover the broad field of electrical engineering that is necessary for the curriculum? The size of the staff at Delft and the ETH is relatively good. The capacity of the staff of Munich is good, when looking at specialization, but small compared with the number of students.

Table 15 relates the size of staff to the number of students. The faculties were requested to calculate the amount of time staff members spend on teaching, not only lecturing, but also the time required for preparation and examinations. In the faculties at Eindhoven, Twente and Delft the nominal teaching load is 40%. The remainder of the time consists of 40% research and 20% management. Ph.D. students (AiOs) are expected to spend approx. 15% of their time on teaching. The Committee observed that not all full professors spend the nominal time on teaching. The Committee assessed the teaching load at Twente and Delft as rather small. The teaching load was also acceptable at Chalmers, but certainly moderate. The teaching loads of the full professors in the other faculties could be assessed as normal, i.e. approx. 40% of their time.

The teaching load of the entire staff can also be calculated by transforming the total amount of time spent on teaching by all the academic staff to full-time teaching equivalents. One full-time equivalent (FTE) is valued at 40 hours. The total number of students is divided by the FTE-teaching. The average for all faculties is 24 students per FTE-teaching, but the range is large (from 14 to 45). The ETH, Gent and Leuven have low numbers of students per FTE-teaching (15, 14 and 15 respectively). Munich has the highest number, 45. Looking at the huge numbers of students, the Committee assesses the size of staff in these faculties to be too small.

TABLE 15: STUDENT/STAFF RATIO AND GRADUATE/STAFF RATIO 1990
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBERS OF GRADUATES	NUMBER OF STUDENTS PER STAFF MEMBER	NUMBER OF GRADUATES PER STAFF MEMBER
TUE	36	1048	124	29	3.4
UT	27	763	68	28	2.5
TUD	48	1433	208	30	4.3
CHA	50	1063	160	21	3.2
LU	62	1150	120	19	1.9
TUM	79	3573	409	45	5.2
ETH	92	1394	192	15	2.1
RUG	45	628	107	14	2.4
KUL	35	732	104	21	2.9

How effective is teaching? Although care must be taken not to attach too much significance to the figures, the number of graduates per FTE-teaching staff provides some information on the results of the effort invested in teaching. The average number is 2.7, ranking from 1.9 (Lund) to 5.2 (Munich). Although Munich has the highest number of students per FTE-teaching, it also has the highest output per teaching effort. This might be explained by a lack of bureaucracy, excellent staff and the possibility to attract good students.

The Committee noted weak participation in the basic programme by full professors in the faculties visited in the Netherlands and Sweden. The Committee recommends far greater involvement in teaching in the basic programme.

It is difficult, and during such a short visit quite impossible, to assess the didactic qualities of the staff by one's own observation. In general, the didactic expertise of the staff seems adequate. In interviews with the students, the Committee observed that they are generally content with the teaching methods.

Looking at the research/teaching ratio, the Committee noted a certain imbalance at most universities. Most academic staff inclines toward research. The Committee will plead for more attention to teaching and for teaching and research to be assigned equal importance in the career of a staff member.

TABLE 16: NUMBER OF REFEREED RESEARCH PAPERS
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	1986	1987	1988	1989	1990	RATIO 1:number of papers per staff member (excluding "others")	RATIO 2:number of papers per staff member(including "others")	RATIO 3:number of papers per FTE-staff members
TUE	76	131	139	144	162	1.5	0.7	1.5
UT	13	142	117	149	215	2.2	1.3	2.0
TUD	207	200	233	304	356	2.2	1.4	2.1
CHA	105	105	130	130	179	0.9	0.7	0.8
LU	?	?	129	125	?	0.8	0.8	1.1
TUM	235	237	202	259	322	1.6	1.6	1.6
ETH	219	189	318	320	362	1.0	1.0	?
RUG	111	103	109	128	148	1.1	1.1	1.1
KUL	100	128	129	132	153	1.0	0.9	1.1

The academic level is generally adequate to good, as far as the Committee was able to judge. An indication of scientific activity which the Committee used is the number of papers that have been refereed. Also the figures may be somewhat doubtful in this respect, because it is not always clear what faculties consider to be "refereed papers", but the Committee believes that such an indication is useful. Table 16 indicates the number of publications for 1986-1990.

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Three publication ratios are given. The first is calculated by dividing the number of publications by the numbers of academic staff. The category "others" is not counted in the numbers of academic staff as this group often contains student assistants and individuals from industry with some teaching, but who are not expected to publish. The average number is 1.4, and the range is from 0.8 to 2.2. The second ratio is calculated including the "others" category. The average number is now 1.1, while the range is from 0.8 to 1.6 The third ratio is calculated counting with total FTEs for the academic staff. The average number is 1.5, and the range is from 0.8 to 2.1.

In its checklist, the Committee also paid attention to staff competency. Table 17 summarizes the Committee's opinions. The situation is generally more than adequate and in several cases good to excellent.

TABLE 17: THE ACADEMIC STAFF
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

III. ACADEMIC STAFF	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
4. competency/qualification staff	●	●	✳	✿	✳	✿	✿	✳	✿
5. scientific/professional publications	□	●	✳	✳	●	✿	✿	✳	✳
6. range of specialization in the staff	□	●	✳	✳	✳	✳	✳	●	✿
7. size of staff	✳	□	✳	□	—	✿	✿	—	●
8. balance research and teaching	□	—	—	□	□	✳	✳	□	□

— below expectations; □ adequate; ● more than adequate; ✳ good; ✿ excellent

7.3 The facilities

The visiting panels also paid attention to the facilities: lecture halls, practical rooms, computer and laboratory facilities. The Committee abandoned the plan also to assess library facilities, since there was insufficient time to inspect the libraries. The assessment of the teaching equipment is based mainly on information provided by the students. The Committee did visit laboratories. The Committee focused particularly on the practicals in the basic courses, although research laboratories were visited too. In general, the equipment levels in the laboratories is satisfactory to excellent. Only in Gent did the Committee observe that the equipment was slightly outdated. The computer facilities are also adequate, although students sometimes complained about access to PCs, e.g. Lund. Table 18 presents the Committee's checklist assessment. The overall assessment of the facilities is more than adequate to excellent.

TABLE 18: FACILITIES
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

IV. FACILITIES	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
1. teaching/laboratories	✳	●	✳	✳	✿	✳	✿	□	✳
2. laboratory equipment	✳	●	✳	✳	✿	●	✿	□	●
3. research equipment	✳	✳	✳	✳	✿	✿	✿	●	●
5. computer facilities	✳	●	✳	✳	✳	✿	✿	●	✿

— below expectations; □ adequate; ● more than adequate; ✳ good; ✿ excellent

7.4 External relations

The Committee studied the relations with industry and with other faculties. International relations and the participation in, for example, the ERASMUS project was also a subject of scrutiny. Within the frame of references, the Committee formulated that: *"evidence should exist that a faculty takes the requirements of industry into account. A faculty should have a good understanding of the wishes of industry and be able to convert those wishes into an adequate curriculum"*.

Relations with industry

The faculties of Eindhoven, Twente and Delft do not have members from industry in their faculty boards. There is no formal involvement in curriculum innovation, sometimes in a more informal way as a member of an advisory board. Contacts with industry are often on an individual basis.

In Sweden the Committee observed a strong connection between the faculty and industry. Members from industry are included in the faculty board. Many informal contacts also exist. Influence on the curriculum takes place via membership of the board and of the curriculum committee.

Industry is not involved in curriculum development in the German faculty. Contacts with industry are good. Most full professors have industrial backgrounds.

The Committee noted many informal contacts at the ETH, however no formal regulations. Involvement in the curriculum is also on an informal advisory basis.

The two Belgian faculties have good contacts with industry, but often again on an informal basis.

It is the Committee's opinion that all faculties should strive to formalize their individual contacts with industry. Both the university and industry will benefit from such interaction. An attempt should be made to involve industry in programme development in a more formal way, via membership of the board or membership of the curriculum committee.

Relations with other faculties

With regard to the relations with other faculties in the same country, the Committee observed that formal contacts between the faculties sometimes do exist. The Committee believes that more cooperation between faculties in other universities is desirable, especially in the field of curriculum innovation. The Committee thinks that the German "Fakultätentag" is a good example of cooperation between electrical engineering faculties.

International relations and student exchanges

The Committee observed a low degree of international connections in some faculties. One reason might be the difficulty for staff to secure sabbatical leave. Some participation in ESPRIT and JESSI does occur, but most contacts are on an ad hoc basis. There is only limited participation in ERASMUS. The international relations for the faculties in general are judged to be more than adequate or more than satisfactory. See the Committee's assessment in Table 19.

TABLE 19: EXTERNAL RELATIONS
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

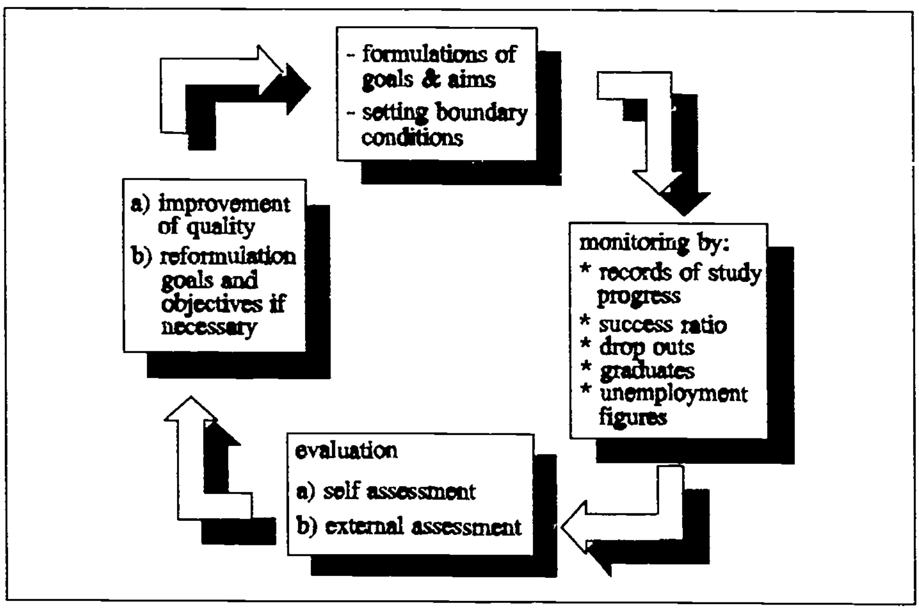
VI. EXTERNAL RELATIONS	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
1. Industry	□	□	●	✿	✿	●	●	●	✻
3. Other faculties	□	□	●	✻	□	●	●	●	●
4. International	□	□	●	✿	✻	●	✻	●	✻
5. Participation ERASMUS etc.	□	□	●	—	□	●	●	●	●

— below expectations; □ adequate; ● more than adequate; ✻ good; ✿ excellent

7.5 Internal quality assessment

The assurance of academic standards is only possible by continuous attention to quality in an well-organized method. None of the faculties visited had a system for internal quality assessment as shown in the diagram in Figure 3.

FIGURE 3: A SYSTEM FOR INTERNAL QUALITY ASSURANCE



This does not mean that faculties pay absolutely no attention to quality. Most faculties do have formal course evaluations, often based on student inquiries. The curriculum committee or programme committee often plays a role in evaluation. At some locations (Chalmers and Munich) the Committee observed little attention to evaluation and quality management. Further, student influence on quality assessment and improvement seemed to be small. The Committee was able to understand this attitude, in part, because the programmes were good. Nevertheless, attention will need to be paid to necessary adaptations and innovations.

The existence of systematic reporting of student progress, of initial graduate employment, a systematic report of the staff's grant and publications are rare in the faculties, though indispensable for real quality management.

The Committee noted also that in general very few programmes are offered for staff development. Where these do exist, it is done on a voluntary basis.

Only the faculties at Eindhoven, Twente and Delft are subject to an external quality assessment, organized by the Association of Universities in the Netherlands (VSNU). In Sweden, plans for external assessment are being developed. The ETH often participates in international reviews, mostly for research. The faculty at Munich has some external quality assurance for the programme, especially the Grundstudium (basic programme), through the inter-faculty meetings (Fakultätentag), where the basic programmes of all faculties are discussed.

The Committee's assessment of the faculties with respect to "Quality assurance" is not high (see Table 20). In the opinion of the Committee, it will be necessary to set up an internal quality assessment as indicated in Figure 3.

TABLE 20: INTERNAL QUALITY ASSURANCE
(TUE: Eindhoven; UT: Twente; TUD: Delft; CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

V. QUALITY ASSURANCE	TUE	UT	TUD	CHA	LU	TUM	ETH	RUG	KUL
procedures for curriculum design/renovation	□	✻	✻	●	—	□	●	□	●
III.9 staff development programmes	—		□	□	—	—	□	□	●
1. systematic report of student progress	●	□	□	□	□	—	—	□	—
2. systematic report of initial employment	—	●	—	—	—	—	—	□	●
3. systematic report of staff's R&D-grants	—	✻	●	●	□	—	—	□	□
4. systematic report of staff's publications	●	●	●	●	●	●	□	□	□
5. adequate evaluation system	●	●	●	□	□	—	—	—	□
6. climate for regular quality assurance	●	□	●	●	—	—	□	□	

-- below expectations; □ adequate; ● more than adequate; ✻ good; ✿ excellent

8 THE GRADUATE

8.1 Assessment

As already stated at the beginning of Chapter 4, the leading question for the Committee was: "Do graduates from the electrical engineering faculty visited deserve the title of "Electrical Engineer"? Are they entitled to bear the title "Master of Electrical Engineering"? The answers to this question will be given below for each faculty with the same words that the visiting panels used in the faculty reports.

EINDHOVEN
The Committee assesses the quality of the typical graduate as good in his field of specialization. This field is somewhat narrow to adequately support adaptation to future changes in Electrical Engineering. The graduate is entitled to bear the title "Master of Electrical Engineering". The Committee feels that the graduate in Information Engineering is not entitled to bear the title "Matster of *Electrical* Engineering".

TWENTE
The Committee assesses the quality of the graduate as good in his field of specialization. This field is rather narrow to adequately support adaptation to future changes in electrical engineering. The graduate deserves the title "Master of *Electrical* Engineering".

DELFT
The Committee has the impression that the quality of the graduate is very good in his field of specialization. This field is rather narrow to adequately support adaptation to future changes in electrical engineering. The graduate deserves the title "Master of Electrical Engineering".

CHALMERS
The Committee expresses its feeling that the school delivers good and mature engineers. The average age is high, compared with other countries. The graduate has a good theoretical basis, but lacks experience in design projects. Nevertheless, in the opinion of the Committee, the graduate deserves the title "Master of Electrical Engineering".

LUND
The Committee expresses its feeling that the school delivers good and mature engineers. The average age is high, compared with other countries. The graduate has had more a science-oriented than professional engineering-oriented education. He lacks experience in design projects. In the opinion of the Committee the graduate deserves the title of "Master of Electrical Engineering".

MUNICH
The Committee expresses its feeling that the school delivers good, but specialized engineers. The graduate is much older than in most other countries. The graduate has a good theoretical basis and deserves the title "Master of Electrical Engineering".

ETH
The Committee expresses its feeling that the faculty delivers excellent graduates, well-educated in the area of their specialization, however the basis could be broader. Without hesitation, the graduate deserves the title "Master of Electrical Engineering".

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GENT
The Committee expresses its feeling that the faculty delivers technically adequately educated graduates with a broad basis. Adaptation to society might be a concern. According the Committee, the graduate deserves the title "Master of Electrical Engineering".

LEUVEN
The Committee expresses its feeling that the faculty delivers technically excellently educated graduates with a broad basis. According the Committee, the graduate deserves the title "Master of Electrical Engineering".

8.2. Destination of the graduates

Electrical engineering graduates easily obtain jobs. In the Netherlands, government and employers are worried about the shortage of engineers (not only electrical engineers) and are therefore trying to attract more students. It is more difficult to obtain jobs at present in Sweden due to the economic recession.

The Committee noted that some faculties do not have real insight in the employment of their graduates. The Committee sees this as a shortcoming. It is necessary to have good records of the graduates' first jobs. Table 21 presents the distribution of the graduates over various destinations.

TABLE 21: DESTINATION OF THE GRADUATES
(TUE: Eindhoven; UT: Twente; TUD: Delft: CHA: Chalmers; LU: Lund; TUM: Munich; ETH: Zürich; RUG: Gent; KUL: Leuven)

	INDUSTRY	UNIVERSITY/RESEARCH	CIVIL SERVICES	OTHERS	TOTAL
TUE	80.0%	17.0%	3.0%	0	100%
UT	30.0%	20.0%	40.0%	10%	100%
TUD	?	?	?	?	
CHA	90.5%	6.5%	3.0%	0	100%
LU	65.0%	15.0%	20.0%	0	100%
TUM	?	?	?	?	
ETH	85.0%	15.0%		0	100%
RUG	76.0%	13.0%	11.0%	0	100%
KUL	70.0%	22.0%	8.0%	0	100%

8.3. Conclusion

The Committee concludes that electrical engineers, graduating from the faculties visited, can be considered to be at comparable technical and academic levels. The Committee observed substantial similarities. The Committee believes that the titles used by the faculties visited (e.g. Ingenieur in the Netherlands; Civilingenjör in Sweden; Diplom-Ingenieur in Germany; Dipl. El. Ing. ETH at the ETH; and Burgerlijk Electrotechnisch Ingenieur in Belgium) all can translated, in US-terminology, to M. Sc. in Electrical Engineering.

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9 OVERALL CONCLUSIONS AND RECOMMENDATIONS

1 All electrical and similarly-named engineering programmes scrutinized meet the minimum requirements as formulated by the IPR-EE committee. As far as could be judged, the Committee has the impression that the English M.Eng. programmes of 4 years are below the level of the Master of Engineering programmes in West European (mainland) universities (see the annex to this general report).

2 All graduates of the faculties/departments visited on the European mainland deserve the title of 'Master of Electrical Engineering' (see Chapter 8).

3 Although the level of programmes and the standards of the graduates are adequate to excellent, the Committee recommends that the programmes be broadened. More attention should be paid to basic sciences, general engineering sciences and non-technical subjects. The Committee supports the necessity of specialization during the study period. However, this specialization must not be considered as a preparation for future activities in employment. It may rather be seen as a domain in which students can prove their ability to integrate the different disciplines independently (see also Section 4.2).

4 The Committee recommends that more attention be paid to formulating goals and aims. This should be done in such a way to allow the easy verification of whether the goals have been realized: operational goal setting and management by objectives (see Section 4.1).

5 The Committee recommends those faculties having no requirements for industrial training to introduce this as an extra-curricular activity, to be completed during the vacation (see Section 5.2).

6 In the opinion of the Committee, faculties should pay attention to the thesis as that part of the curriculum, in which the students can demonstrate their ability to integrate knowledge and disciplines. In the view of the Committee, the time permitted for the thesis should be approx. 6 months (1000 hours) full-time (see Section 5.3)

7 In the eyes of the Committee, it is desirable for an electrical engineering faculty to have the opportunity to set minimum requirements for the knowledge of mathematics and physics on entry to the university (see Section 6.2).

8 The Committee advises the faculties to improve the information on electrical engineering courses for school leavers with a view to attracting more female students.

9 In the view of the Committee, the completion rates in some faculties can be increased. It must be possible to realize a minimum completion rate of 60/65%.

10 The Committee believes that an effective study period of 5.5 years would seems to be typical for the Western European (mainland) universities. The effective length of the study is fixed, among other things, by the efforts of the students and the organization of the programme. It became clear to the Committee that the nominal study time is too short in the Netherlands. The Committee therefore considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more would be needed, unless it were done at the expense of specialization, which is not desirable (see Section 6.4).

11 The Committee would advise the faculties at Twente, Lund and Gent to reconsider the size of their staff and to look for an adequate coverage of the specializations in electrical engineering (see Section 7.2).

12 The Committee pleads for more attention to teaching and for less emphasis on research. Teaching should have the same importance as research in the career of staff members (see Section 7.2)

13 The Committee recommends that faculties involve industry in programme development and curriculum innovation (see Section 7.4).

14 The Committee advises that greater exchanges of students and staff should take place between the faculties/departments concerned.

15 In the opinion of the Committee, faculties/departments should improve their internal quality assurance and replace ad hoc evaluation and student involvement by systematic quality assurance, based, among other things, on monitoring student progress, completion rates and initial employment figures (see Section 7.5).

16 The Committee recommends that electrical engineering faculties/departments meet on a regular basis to discuss their programmes and academic standards, both nationally and internationally.

ANNEX

ELECTRICAL ENGINEERING AT IMPERIAL COLLEGE

Imperial College was established in 1907 by Royal Charter following the merging of three institutions founded in the mid and late nineteenth century. Imperial is part of the University of London which is the largest university in the United Kingdom. The University is organized on a federal pattern with each college having a very large measure of autonomy. Imperial College was originally formed from three existing prestigious educational institutes: the Royal College of Science, the Royal School of Mines and the City and Guilds College. In 1988 Imperial College merged with the fourth constituent college, St.Mary's Hospital Medical School.
The constituent colleges maintain close links with Imperial College whilst retaining distinct identities and dividing the main subject areas between them. The City and Guilds College specializes in engineering. The Department of Electrical and Electronic Engineering is one of the departments in the City and Guilds College.

The entrance requirements for the Department of Electrical & Electronic Engineering are at least three suitable subjects at A(dvanced) level. At A level the student has studied the subject very profoundly. The AS level is less profound; 2 subjects at AS level count for 1 at A level. The subjects offered should include Mathematics (one A level or two distinct AS levels) and either Physics or Engineering Science. Successful applicants with A levels normally achieve grades of at least BBC, while a majority obtain ABA (on the scale A-E) or better. Strength in Mathematics and a science subject (preferably Physics) is normally expected. In the GCSE (General Certificate of Secondary Education) or equivalent, a grade C is required in English.

In the opinion of the Committee the entrance level of the freshmen is very high with regard to Mathematics and Physics, but low in general education such as Humanities and languages, due to the system of early specialization in secondary school. The Committee has the impression that there could be a lowering of the entrance level through the shift from A-level to AS-level.

Every student has to apply for entrance through the UCCA (University Central Council for Admissions). The student can apply for 5 universities. The list of applicants goes to the universities and the university distributes the list to the departments. Candidates who are considered likely to receive offers of admission are invited to Imperial College for interview. There is a confidential report from the secondary school. For the Department of Electrical & Electronic Engineering, in addition to an interview, the final decision is made on the confidential report and the expected A level grades. The number of overseas applicants exceeds the number of available places by a factor 10 to 1, so that only the very best overseas applicants can be offered places. Conditional offers for such applicants are likely to be at AAB level.

In 1990 there were 116 freshmen, while the total number of students in the Department of Electrical and Electronic Engineering was 317. At Imperial College the number of women students is low. The number of overseas students is high, up to 30% of the total number.

The Department currently runs the following undergraduate courses:

* a 3-year Honours degree course in Electrical and Electronic Engineering leading to th award of a B.Eng. degree;
* a 4-year Honours degree course in Electrical and Electronic Engineering leading to th award of an M.Eng. degree.

The Committee has especially paid attention to the 4-year M.Eng. programme, the 4T stream. In the opinion of the Committee the 4T M.Eng. programme is the only programm that can broadly be compared with the continental Master's degree programmes th Committee has seen on the Continent.

The first two years of study consist of mandatory technical courses with some choice non-technical studies. This introduction to Electrical Engineering provides a sol foundation for subsequent more specialized and elective studies.

The first two years of the course are common to all students; binding decisions about lat patterns of study are not made until the end of year two, but a condition of entry to ye three of the 4D stream is the satisfactory completion of industrial training with approved sponsor, normally undertaken during a pre-university year. Advice on choice given at the end of year two. Entry to year three of either 4D or 4T stream is restricted students with good academic records.

The course consists of lectures with supporting study groups, practical work involving s laboratory exercises, and project tasks. A personal tutorial scheme is organized. Studen are encouraged and assisted to obtain industrial experience during the vacation.

Following this core programme students choose one of three routes, with either one furth year of predominantly technical studies leading to the B.Eng. degree, or two further yea of study leading to an M.Eng. degree. In the 4-year course there is a distinction betwe the 4T stream (= Technical course) with predominantly technical studies, and the 4D Dainton) stream with a balance between technical and industrial & business studies. "*T 4T stream offers students the opportunity to follow their specialist studies to a mo advanced level than is possible in a 3-year course. It thereby provides an engineeri qualification to as high a level as that of any first degree awarded in the Europe Community. The choice of specialist options allows a flexible mix of both technical a business courses, or a concentration on technical studies. The 4D course is intended f students whose firm intention is to seek careers in industry and who expect to move, at fairly early stage, into positions of managerial responsibility. For this reason there is significant business and management content in the last two years of the 4D programm* (prospectus on Electrical and Electronic Engineering at Imperial College, page 15).

In the 4th year the students have to do an individual project. In the judgement of t Committee the level of this final project cannot be compared with the work for the thes in the continental universities. It is more equivalent to the research project done before t Master's thesis.

The Department has a term system, two periods of 11 weeks plus one of 8 weeks. The total programmed time for the B.Eng. programme is around 2800 hours, that is about 950 yearly; for the M.Eng programme it is about 3600 hours, 900 hours yearly. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2 contact hours to 3 hours of self study. The students spend about 40% of their time at the University and spend about 60% on self study.

Many lectures are coupled with tutorials, small working groups for exercises. So the figure for lectures covers about 50% 'actual' lectures and 50 % tutorials. For the B.Eng. students there is an individual project of 120 hours in the 3rd year; for the M.Eng. students this individual project is in the 4th year and counts 350 hours. This individual project is considered to have the same function as the continental thesis work.

The Committee thinks the quality of the highly talented graduate of the 4T-programme can be judged as good. But his field of specialization is somewhat too narrow adequately to support adaptation to future changes in Electrical Engineering.

In the opinion of the Committee, the programme of Imperial College is tailored to excellent students, who will become excellent engineers, whether the programme is good or not. But with an average student population the programme will fail. In the opinion of the Committee, the programme does not meet the minimum requirements set by the IPR-EE Committee, and so the graduates of the 4T M.Eng. programme do not reach the same level as their colleagues at the other faculties which were visited. The level of the Master's degree is therefore considered as not equivalent to that of the Master's degree in the other countries visited.
According to information from Imperial College, it is not the M.Eng. which should be compared with the level of the Master of Electrical Engineering degrees in the universities visited by the Committee, but rather the qualification of Chartered Engineer. Before a graduate can act as an independent engineer, he has to fulfil the requirements for becoming a Chartered Engineer. While the university offers the academic qualification, the title Chartered Engineer gives the professional qualification. The requirements are:
* completing an Honours degree, B.Eng. or M.Eng., including a project;
* the course must be accredited by IEE;
* 2 years of supervised training, including 6 months objectives training;
* 2 years responsibility requirement: to show that the individual can act as a professional engineer.

The minimum total time required to become a Chartered Engineer is 7 years.

PART II

FACULTY REPORTS

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10 FACULTY OF ELECTRICAL ENGINEERING AT THE EINDOVEN UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS

Date of visit: 28/29 October 1991

1.Introduction

The International Programme Review Electrical Engineering (IPR-EE) started with visits to the Netherlands. The first faculty to be visited was the Faculty of Electrical Engineering at the University of Technology of Eindhoven. For the members of the Committee see appendix 1.

The faculty of Electrical Engineering is one of the 8 faculties at the Eindhoven University of Technology. The university was founded in 1956. The total number of students in the university is approximately 6600, of which 15% (about 1050) are in the faculty of Electrical Engineering.

Before 1976 Dutch universities were conventional "Von Humboldt" institutions. They have since evolved into organizations where staff and students participate in self-government. Each level - 'vakgroep' (department, section or research group), faculty and university - has its own executive board and a council. The council deals with general policy and the budget, the executive board with the implementation of the decisions of the council and with administrative issues. The council, an elected body, is composed of people working or studying within the unit concerned. The ratio of students to staff is determined by government. Society at large is represented on the University Council by members from outside the university. The Executive Board at the institutional level has three members, all appointed by the Minister of Education & Science. One is chairman of the Board, and one is the University Rector, who also serves as chairman of the Board of Faculty Deans. The third is a member from outside the university. The chairman of the University Council has the right to attend meetings of the Executive Board. Both the University Council and the Executive Board have responsibilities assigned to them by law. In matters concerning the budget and general policy (except for personnel policy) the Executive Board reports to the Council.

At faculty level there is a Faculty Board and a Faculty Council. The Faculty Board has a maximum of five members, of whom the majority are academic staff. The chairman of the Faculty Board is the Dean, and its members are elected by the Faculty Council. Its responsibilities are the organization and co-ordination of teaching and research, the preparation and implementation of decisions of the Faculty Council, supervision, the setting up of advisory committees on appointments, and the preparation of the Annual Report. The Faculty Council has a maximum of 15 members, at least half from the academic staff. In addition to the Board and the Council, there are two permanent committees: a Standing Committee for Advice on Research and the Studierichtings-commissie (curriculum committee) for advice on teaching.

The faculty is subdivided into 13 'vakgroepen', to be translated as "research groups" or "departments". The 'vakgroepen' are fairly independent. The 'vakgroepen" are:
1. Digital systems
2. Telecommunications
3. Electronic devices
4. Electronic circuits
5. Electrical energy systems
6. High voltage technology
7. Information and communication theory
8. Medical electrical engineering
9. Electromechanics and power electronics
10 Measurement and control
11.Automatic design of systems
12.Circuit theory and electromagnetic theory
13.Electrical materials

In the opinion of the committee, the organizational structure (dean, board, council, sections and 'vakgroep' (research-group)) is clear, but the decision making process seems to be very complex. Responsibilities are dispersed. The Committee has the impression that the numerous laws and regulations from the government are sometimes taken for granted, and these sometimes prove obstructive. Collective bodies are involved in all important issues, but there is a tendency to avoid personal responsibility and accountability. The Dean retains formaly little executive managerial power in relation to his responsibilities and problems as dean of the faculty.

The Committee remarked a lack of cohesion between the staff members, caused by the decision to set up two curricula: Electrical Engineering and Information Engineering. The Committee often had the impression of talking to two separate faculties. The Committee noticed little involvement of professors in the important organizational entities. In the opinion of the Committee the presence of professors in the Curriculum Committee is a necessity. This will make this committee a more creative body rather than a regulatory body. The organization offers little challenge or incentive to people within it. The Committee wishes to state clearly that the organization offers the opportunity to achieve a good university level of education through the strong connection between research and teaching.

2. The student

* Students' level of attainment on entry

The Dutch student entering the university has had 14 years of schooling: 8 years basic schooling (2 years preparatory school and 6 years elementary school), and 6 years secondary school of the "VWO" type. The requirements for the VWO-examination for Mathematics are: rational-functions and root functions; logarithmic and exponential functions, number e; goniometric functions; graphs of these functions; equations and inequalities in connection with three functions, systems of equations and inequalities; formula of sine, cosine, tangent; limits, continuity and discontinuity of functions; differentiability, derivative functions, rules for differential calculus; primary functions, partial integration, definite integral; differential; curves in parameter presentation. Positions of points, lines and planes; sectional planes with prisms and pyramides; parameter presentation and equations of lines and planes; perpendicular position and rectangular projection; mirror images, translation and rotations in space; inner product, normal vector of a plane; calculation of angles and distances; sphere, cylinder and cone with tangents and tangent planes; solids of revolution and calculation of volumes. Requirements for Physics are: mechanics, forces, motion, impulse, energy; wave theory with acoustics, optics, electromagnetic waves; liquids, gases, thermodynamics; electricity and magnetism; atom models, energy levels, radioactivity, fission and fusion; cosmic physics; biophysics (ear and eye, radiation and tissue, circulation of the blood).

The Committee formed the impression that the level of attainment of the students on entry is adequate for the curriculum, notwithstanding the overall dropout rate of more than 40 per cent. Preparedness in the exact natural sciences appears to be good.

In reality the students enter Eindhoven at two different levels. 58% of the freshmen come directly from secondary schools. The others come to the university after finishing the HBO (polytechnic); these follow a modified programme. After an examination in certain subjects in November of the first year, they get the propaedeutic certificate and may continue with their studies. Graduates from the polytechnic (3 years of courses and 1 year of industrial training) can add the 'Ir.'-title to the 'Ing.'-title after 2.5 years. If they fail the examination in November they can follow the normal programme of four years.

* Selection

The Dutch universities have no entrance selection. Every school-leaver after secondary education (VWO-type) can enter university. In some cases the faculty may, as an entrance qualification, require two subjects, such as mathematics and physics for Electrical Engineering. In principle, selection takes place in the first year, called the 'propedeuse'. This is one of the reasons for the high dropout rate (about 25%) in the first year. When a student does not pass the propedeuse in two years, he must leave. The faculty tries to make clear as early as possible who is likely to drop out.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The influx of freshmen has declined during recent years, and although this also applies to other technical disciplines, for EE the decline has been the sharpest. Faculty, industry and government are worried about the small intake and are taking actions to raise the numbers of EE-freshmen. There are very few female students. The cause of this is not clear, but it probably originates at secondary school level and in the rather dull image of EE, due partly to its high content of mathematics and physics. The Committee noticed that there are also very few foreign students. In the opinion of the Committee the faculty of Electrical Engineering should co-operate with the other two faculties in improving the image of Electrical Engineering and attracting students, especially more female students. This should be done also at secondary school level.

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The reasons for choosing Eindhoven rather than Delft or Twente are regional (parents living nearby), or because of the special Information Engineering option. Students choose the university and not the polytechnic because of the freedom of course choice, freedom in planning, and the more scientific challenge. The Committee was impressed by the large number of intelligent, serious and open minded students it met.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
244	194	2.0%	2.6%	1.111	1.048	1.1%	2.0%

In the absence of entrance selection and of a numerus clausus, there is no difference between the number of applicants and the actual intake.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
244	244	194	194

* Average duration of study, Completion rates

The nominal duration of the Electrical Engineering programme is 4 years, set by the Dutch law like for other university studies. But there is a substantial discrepancy between the real duration (average 5.5 years) and the nominal curriculum length, an excess of 40%. One of the reasons is that by the same law, an enrolment time of six years is permitted. The students may take two years for the propaedeutic and 4 or 5 years for the main programme. The Committee was surprised to observe that overwhelmingly students considered that there is a 'right' to study for six years and so there is no reason at all to complete in a shorter time. Recently the duration of student grants was restricted to five years, but for most engineering programmes it is 5.5 years.

TABLE 3: NOMINAL DURATION AND THE EFFECTIVE LENGTH OF STUDIES

NOMINAL	EFFECTIVE
4.0	5.5

A course duration of 5.5 years seems to the Committee to be typical for Western European (continental) universities. The effective length of the course is fixed by, among other factors, the efforts of the students and the organization of the programme. It became clear to the Committee that it is difficult for students to finish their studies in 4 years. The programme is heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). The Committee therefore considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more would be needed, unless it were done at the expense of specialization, which is not desirable.

TABLE 4: DROP OUT RATES AND GRADUATES. COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME *)	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D AFTER 10 YEARS
187	24.0%	1.0%	44.0%	57.0%	5.0%

*) percentage calculated on the number of freshmen.

The Committee noted a high dropout rate in the first year. For the cohort 1982/1983 it was 24%. For the years 1985/1990 the average is 23%. In view of the absence of selection on entry, this could be seen as 'normal'. The first year of study acts largely as a selection mechanism. About 22% of the freshmen pass the propaedeutic examination in 1 year and about 60% after two years. Regarding the overall completion rate of 57%, the Committee assesses this as rather low. An overall completion rate of 60/65% seems to be average for Electrical Engineering in West-European universities (see the general conclusion in Part I, paragraph 6.6).

In the view of the Committee one of the reasons for the low completion rate is the organization of the curricula and its logistics. The curricula are too tightly structured (too compressed): the slightest delay causes lack of synchronization and thus more delay, because lectures and practicals are not offered in every trimester. It is possible that the new curricula may reduce the actual duration of studies and raise completion rates, but this remains to be seen.

3. Goals and aims

The faculty has formulated its aims as follows:
"The electrical engineer must possess the skills which will allow him in a professional manner to distinguish between, formulate and solve problems in the field of electrical engineering. In terms of knowledge this means knowledge of mathematics and fundamental physics (E-course) or mathematics and fundamental informatics (IT-course); knowledge of basic subjects involved in electrical engineering; knowledge of a number of electrical-engineering subjects (E-course) or knowledge of a number of electrical engineering and informatics subjects (IT-course) in preparation for his final examination subjects; and knowledge of a number of optional subjects which the student considers useful and desirable for his future work as an electrical engineer.

In terms of skills: on the basis of a rough description of a problem area, he can, from his own study of literature and other sources of information, state a problem; he can set up a working plan to solve the stated problem within a given time; he can work on the stated problem by means of scientific methods; he can analyse the results of the project; he can produce a written and an oral report on the project and its results.

In terms of attitudes the aim in the teaching programme is actively to develop the student's orientation and ability, both as an individual and as a member of a team, to recognise problems as research problems, to state them and to solve them by methodological ways that have been tested for soundness" (Basic information, Volume 1, pages 134/135)

The Committee assesses the goals and aims in principle as acceptable, although somewhat more emphasis on the 'designing, synthesising engineer' would be appropriate. In the opinion of the Committee, the Electrical Engineer on the Information Engineering course must be familiar with fundamental physics as far as knowledge is concerned. It should be noted however that the ambitions are high, both for the faculty and the students. Goals and aims could be formulated more clearly and in a manner which aids operational judgements. The theoretical level is indicated by the statement that the graduates should be able to learn from scientific literature and draw their own conclusions. The committee agrees totally with this.

4. The programme

The faculty offers two programmes: Electrical Engineering (EE) and Information Engineering (IE). Graduates from both streams gain the title of Electrical Engineer ("elektro-technisch ingenieur", abbreviated "Ir."). The IE programme has run since the academic year 1986/1987. Around 25% of all EE students are in this programme. The programmes are organized separately. Until 1990 the first year (the 'propedeuse') consisted of a common course for both programmes. Since 1990 EE and IT each have their own 'propedeuse'.

4.1. <u>The philosophy behind the programme</u>

The faculty has stated the philosophy behind the programme as follows:
"*<u>Electrical Engineering</u> is concerned with the application of knowledge of electromagnetic phenomena for the purposes of energy transformation and information processing, to which the following appertain:*
- *analysis, design and fabrication of components and systems;*
- *maintenance and control systems;*
- *research instituted in order to find new applications.*

EE is based on physics, namely the theory of electromagnetic fields, solid state physics and plasma physics; mathematics; and material science. Characteristics of the programme are generation and distribution of electrical energy; electromechanics; electrical measuring and control technology; electronics; telecommunication; computer technology. Electrical engineering differs from information engineering in that the former puts its emphasis on the application of physical principles and the design and realization of hardware in the widest sense. EE differs from technical physics because technical physics is more oriented to the fundamental laws of nature and the structure of matter. Electrical engineering however is more oriented to application, specifically to electromagnetic phenomena.
<u>Information Engineering</u> can be described as knowledge of, and skills in, the working and processing of information by electrical engineering, together with the technology required. Such knowledge and skill extend over hardware (in the form of electronic circuits and auxiliaries) and software (in the form of systems programming and electrical engineering application). This includes:
- *analysis, design and realization (specification, implementation, verification and testing, well-founded selection of hardware and/or software realization);*
- *maintenance. management and maintaining (modernizing, optimalizing, keeping things manageable and secure in use);*

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- *making things applicable (telecommunication, control systems, interfaces, operating systems, databases, compilers, CAD, CAM, ergonomics.*
- *social consequences of information engineering.*

It is based on electronics, informatics, systems theory and telecommunications. Information Engineering differs from electrical engineering in that, in the former, electromagnetism and semiconductor physics are background knowledge. The accents are shifted from components and physics (in the case of electrical engineering) to systems and informatics in that of information engineering. IT differs form Informatics in that information engineering is more oriented to the applications of electrical engineering than informatics is" (Basic Information, volume 1, page 128/129).

4.2. The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2.

Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements, set by IPR-EE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

4.3 Mathematics; Basic sciences

Subjects such as analysis, linear algebra, statistics and numerical mathematics are in the basic programme. 19% of the programme consists of mathematics, which may be considered as normal. In the opinion of the Committee some of the basic sciences must be stressed more, such as physics. Physical principles amounts to only 6% of EE, and in the IE course physics is largely omitted, which the Committee considers a serious omission.

4.4. General Engineering Sciences

The curriculum does not satisfy, in the opinion of the Committee, the minimum requirements for General Engineering Sciences. There is only a little Mechanics; Chemistry is largely absent, as is an introduction to some other engineering field. The "peripheral" activities are meagre, due to the reduction from 5 to 4 years.

4.5. Electrical Engineering Sciences

The Committee assesses the part of Electrical Engineering Sciences as good in the EE curriculum (especially High current and high voltage is well represented), but thinks Electrical Engineering Sciences are not adequately represented in the IT-programme. The Committee has the impression that there are many specialist courses with only a few students.

4.6. Electrical Design

The Committee has the impression that the requirements for Electrical Design are well met. The IC-design course (mandatory for both EE and IT), including the testing of the manufactured multi-project wafer, seems to be quite good. The Committee received notice of the existence of the two years design course after graduation. This course contains 50% courses and 50% design. It can be seen as an intermediate step to design in industry.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.
A (Electrical Engineering programme)

YEAR	1	2	3	4	TOTAL
MATHEMATICS	11.0	4.8	2.6		18.4
PHYSICS	1.1	4.4			5.5
COMPUTER SCIENCES	2.5				2.5
GENERAL ENGINEERING SCIENCES	1.0				1.0
ELECTRICAL ENGINEERING SCIENCES	11.0	13.1	14.3		38.4
ELECTRICAL DESIGN[2]	2.0		2.0	8.2	12.2
NON-TECHNICAL SUBJECTS		3.4	5.1		8.5
ELECTIVES[3]			8.9	4.4	13.3
TOTAL	28.6	25.7	32.9	12.6	100% 2440 hrs
THESIS				1000 h	

B (Information Engineering programme)

YEAR	1	2	3	4	TOTAL
MATHEMATICS	11.0	4.8	2.6		18.4
PHYSICS					0
COMPUTER SCIENCES	11.9	10.4	8.2	8.2	38.7
GENERAL ENGINEERING SCIENCES					0
ELECTRICAL ENGINEERING SCIENCES	4.9	8.7	3.3		16.9
ELECTRICAL DESIGN[2]	1.6		2.0		3.6
NON-TECHNICAL SUBJECTS		3.4	5.1		8.5
ELECTIVES[3]			8.9	4.4	13.3
TOTAL	29.7	27.4	27.8	12.6	100% 2459 hrs
THESIS				1000 h	

[1] Percentages are calculated on the aggregate number of contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis work are not counted in the percentage.
[2] It is not always possible to make a distinction in Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES an ED must be added.
[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

4.7. Non-Technical subjects

Under the heading "non-technical subjects" two courses/practicals are included, aimed at learning the skills necessary for the management of a technical task-oriented group. The purpose of the " Management course" (30 hours), given in the 2nd year, is learning to

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manage a group and gaining insight into styles of managing. In the 3rd year the student has to do 100 hours of project-management. With project-management the group-leader has the management of 6-8 first or second year students. The student is assessed in the way (s)he manages a group. The way the non-technical subjects are treated raises no comments from the Committee, but perhaps Accounting could be part of the curriculum. With regard to project management, this seems to the Committee to be a good way to teach the students responsibility and co-operation. The practical involves some 500 hours, including home work and reporting. The Committee thinks that perhaps this is too many hours, although the principle of group work etc. is certainly good. But the Committee wonders whether it could be achieved in a shorter time.

4.8 Additional requirements

The IPR-EE Committee has formulated additional requirements regarding students' laboratory experience, the use of computers, and the attention paid by the faculty to written and oral communication (Guide for the Committee, page 10). With regard to these requirements, the Committee has nothing to remark.

4.9. Master's thesis

The faculty gives the following description of the thesis work: "*The study is completed by performing a (mostly) practical design task or research subject under supervision of a mentor. This work has to be concluded by a thesis discussing the results of the work and by an oral presentation of the activities of the project. The total duration of this final period is 6 months (1000 hours). The student is assumed to work mainly on his own (marginally supervised) and address theoretical and practical aspects of his project. The overall end goal can be phrased as 'being able to recognise, formulate, describe and solve a relevant problem in Electrical Engineering using an academic level of approach and to report on the results'. The full work for the thesis is discussed and rated in a final examination committee which actually decides on the award of the degree of Electrical Engineer. Depending on the marks obtained, the work can be credited with 'honours of the jury' (in Dutch 'met lof')*" (Basic Information, volume 1, page 152).

The Committee offers no observations concerning the master's thesis, which appears to be satisfactory. The Committee, albeit not unanimously, does not support the wishes of the Faculty to raise the final thesis period to 9 months instead of the current 6 months. In the opinion of the Committee, the three months can be better used for other activities which the university can provide, e.g. advanced theoretical teaching.

4.10. Examinations: regulations and requirements

In the opinion of the Committee examinations and assessment are more than adequate. Regarding the examinations and their requirements the faculty has given the following information: "*During the full course track, examinations will take place to judge the quality and the amount of knowledge that the student has gathered up so far, as well as the level of utilization and ability to operate with that knowledge. The purpose of these examinations is twofold: first they are a signal to the student about his actual progress, and second they implicitly place the course parts into a sequence of elements of an* *appropriate size. The latter serves to place certain landmarks on the track by which the faculty can: a)check the student's progress; b) act upon his status by informing him about his relative position on the average course time-line; c) allow him to proceed or not, depending on his scores. Students whose pace of study is unduly slow will be advised by the department on a personal basis how to overcome their problems.*

The examinations take place after each trimester and are repeated in the next term for those who did not succeed. The examination period lasts about 4 weeks and is free from lecturing; in each period about 5 trimester-courses on average are examined. In the first 2 years, examinations are mostly in written form. In the later part of the study more oral examinations are taken, depending on the number of candidates. The full course has two major academic examinations: the '<u>propedeuse</u>', which covers the complete range of first year courses and consists of the integral results on all of them, parts of which may have been passed in the previous examination period; and the '<u>doctoraal</u>' or Master's examination, which covers the last three years of the total course of four years. Both these examinations are discussed by a jury and the appropriate grade is awarded. The '<u>propedeuse</u>' actually has to be completed within two years after commencing the study, with exceptions to be handled by the Faculty Board in specific cases. By government regulations, the study has to be completed within six years.

Intermediate examinations can be repeated as often as desired within the above time limits. During the programme, the students also have to complete a number of general laboratory exercises as well as some special laboratory exercises connected to particular courses. In addition, all students must finish an IC design course, in which they have to design and measure a medium scale digital IC using general CAD-tools (the IC is produced by in-house MOS technology). Further practical work is performed on two projects; each has a duration of 20 days (200 hours) under close supervision of a mentor, and has to be completed with an activity report. An oral presentation on one of them must be given. Every student also has to work through a library exercise by which they are trained to search for literature in a systematic way (duration 1 day)" (Basic Information, Volume 1, page 153/154).

4.11 <u>Study burden</u>

The faculty has a trimester system. with examinations at the end of each trimester. As is to be seen in Table 6, the total time programmed is 6800 hours, that is 1700 yearly. At Eindhoven the faculty counts in terms of credit points: 1 credit point is 4 hours and one year counts 400 credit points. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2:3. The students spend about 40% of their time at the university and are expected to spend about 60% on self study.

TABLE 6: TOTAL STUDY BURDEN

	Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
EE	1449	971	2420	400	1040	6720
IE	1449	1010	2459	400	1040	6800

Many lectures are coupled with tutorials, small working groups for exercises. Thus the figure for lectures is made up of about 75% 'real' lectures and 25% tutorials. In year 3 there is an assignment, a research project of circa 50 half-days (200 hours). The same in the 4th year. For the masters thesis 1040 hours are programmed, but too often the students exceed this time.

It is not clear how many hours the students spend on their study. Somewhere between 30 and 40 hours a week during 40 weeks a year is the estimate of both the faculty staff and the students. According to the information from the faculty, the student has to spend 25 hours a week at the university and about 10 hours on self study. In the report of the National Visiting Committee Electrical Engineering (1990), the time, spent by the student on his study, is estimated to be about 1300-1400 hours annually. This is net study time; it is about 1600 hours gross. To lighten the study burden it will be necessary to improve the logistics. Action is being taken, but it is unknown what the experience with the new curricula will be.

4.12. Overall assessment of the programme

The Committee finds it difficult to give an overall assessment of the programmes, and will therefore split the assessment into one of EE and one of IE. For both streams the Committee wishes to emphasise that the guidance of second year student by third year students (also in social aspects) seems to work very well, and this is a very positive point. Within the limited scope of the goals and aims, the Committee considers that the programme for Electrical Engineering meets the minimum requirements, although it contains little general engineering sciences. There is little Mechanics, and Chemistry is omitted. The programme satisfies the requirements, set in the terms of reference, bearing in mind the foregoing remarks.
The Information Engineering curriculum tends to be more Information Sciences than Information Engineering. The Information Science curriculum may certainly be valuable but not as an Electrical Engineering curriculum. Especially the complete separation of EE and IE, even in the first year, seems to be a problem. The Committee feels that the graduate in IE is not entitled to bear the title of *Electrical* Engineer. The separation in the first year seems to have gone too far. The basic programme for IE is not adapted to the place of Information Engineering in Industry. The Committee recommends that a clear decision be taken. At the request of the Faculty Board, the Committee expresses its view that the best way would be to reunite the two streams into a common basic programme, and to specialize at a latter stage.

5. The Academic Staff

The academic staff fall into four main categories:

* full professors (hoogleraar);
* associate professors or senior lecturers (UHD=universitaire hoofddocent)
* assistant professors or junior lecturers (UD= universitaire docenten)
* research assistants or Ph.D. students (AIO's= Assistenten in opleiding).

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The number of staff (Table 7) seems to be adequate, but not excessive. The Committee considers the proposed reduction of the number of professors not appropriate.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	full time equivalent	number of persons
• Full professors	17.4	24
• Associate professors/senior lecturers (UHD)	14.5	15
• Assistant professors/junior lecturers(UD)	47.0	49
• Research assistants/Ph.D.students	20.0	20
• Others	9.6	113
Total academic staff	108.5	221
Non-academic staff	111.9	119

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
36*)	1048	124	29	3.4

*) Including service teaching from other faculties

The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full-time equivalents of 40 hours weekly) for teaching. This ratio is 29 (see Table 8). The Committee considers the teaching load adequate. A possible measure of teaching effectiveness is the number of graduates per FTE-teaching. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 3.4 graduates per FTE-teaching.

The Committee observed that participation in the basic programme by the full professors was weak. It recommends a much greater involvement of full professors in teaching in the basic programme. The didactic expertise of the staff seems to be adequate. In interviews with students, in general the Committee found them content with the manner of teaching. The teaching is monitored by the Curriculum Committee and by student evaluations.

The academic level is satisfactory. The academic staff and the professors endorse the integration of research with teaching as necessary to universities. The Committee considers the scientific activities as sufficient. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 1.6. The Committee observes a lack of international activities, judged by the publications, conferences and participation in European programmes. As far as can be judged from their publications, there are some staff members who perform at the highest international level. Although possibilities for sabbatical leave are offered, the Committee advises the Faculty explicitly to promote the opportunity for sabbatical leave.

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

FACULTY	1986	1987	1988	1989	1990
Number of papers	76	131	139	144	162
Number of papers per staff member (excluding "others")					1.6

The Committee has observed that there are few incentives for the staff. The Committee remarked that there is no formal programme for staff development, although there are opportunities to follow courses at the Educational centre.

6. Resources and Facilities

All Dutch universities are financed by the state on an equal footing. The university receives a lump sum, and the central Board divides the money among the faculties. In Table 10 some figures concerning the finances are given.

Based on information given by the students, the teaching equipment seems to be appropriate. The laboratory equipment for teaching is adequate. The high voltage laboratory was very well equipped for a university level activity, and was very impressive. The Committee thinks the computer facilities are suitable too.

TABLE 10: INCOME AND EXPENDITURES OF THE FACULTY

INCOME		EXPENDITURES	
State	88.0%	Education	33.5%
Industry	9.3%	Research	66.5%
Research foundations	2.4%	Total	100%
Other	0.3%		
Total	100%		

7. The internal Quality Assurance

The Faculty gives as information that *"the programme is under continuous evaluation by the lecturers and students as well as by the Curriculum Committee (Studierichtingscommissie). At regular intervals (say once in 5 years) the programme is revised on the basis of new developments that have taken place in the past period. Many courses are based on excellent English or American textbooks and keep up with new editions. Further, additional study notes and hand-outs are frequently issued to the students to cover the newest subjects"* (Basic Information, Volume 1, page 155).

The Committee observed that an overall quality assurance system, in the sense normal in industry, does not exist. But discussions especially with the Curriculum Committee showed activity in the field of evaluation. The students play a role in feedback by filling in a questionnaire.

8. External relations

The Faculty describes contacts with industry as follows:
"Industry is not directly involved in setting up the various courses, but people in industry certainly influence the contents of the programme through contacts with the lecturers and by way of special colloquia. Furthermore there is more or less regular contact about many aspects of academic education between the various sector heads of the faculty (e.g. communications and electronics) and the directors of related principal industrial laboratories. In addition the faculty employs a number of part-time professors from industry who form an excellent liaison with the industrial world. A further link between university and industry is established by students conducting their final work for the masters degree in industry, under the joint supervision of local research people and university teachers. The research activities of the university show a more structured relation between the university and industry. First of all there is the possibility of contract research, financed by industry, on subjects that are of mutual interest. Special sponsoring of local research is another form of support, for example by donating special equipment. Further, there are governmental programmes, set up in collaboration with industry, to co-ordinate university research on special projects. These programmes deliver grants for 4-year Ph.D. studies on a common subject under the particular programme. At regular intervals, progress in these projects is discussed together with people in industry, often giving rise to new ideas and/or projects. Finally the university has direct co-operation with some joint industrial-university institutes, such as for example the Institute for Perception Research" (Basic Information, Volume 1, page 123 and 157).

The Committee assesses the relationships with industry as adequate. The university has a number of relationships, those of the faculty are mainly with Philips. These are often personal relationships; there are no formal procedures. The Committee advises the organization of a more formal interaction between university and industry. The university will benefit from such interaction. Contact with other faculties seems also adequate.

9. International relations

The Faculty participates in ESPRIT and has good contacts with Montpellier. But it seems to the Committee that in general the relationships are on an ad hoc basis. One of the reasons may be the difficulty for the staff in obtaining sabbatical leave. There are also few visiting professors.

10. The graduate

The Committee assesses the quality of the typical graduate as good in his field of specialization. This field is somewhat narrow to adequately support adaptation to future changes in Electrical Engineering. The graduate is entitled to bear the title of Electrical Engineer (this is not the case for the IE stream). The graduates easily obtain jobs, and there is no unemployment. Based on information about 200 graduates, graduated in the period 1985-1990, a global indication of the destination of the graduates can be given (see Table 11).

TABLE 11: DESTINATION OF GRADUATES

Philips	35.0%
Other industrial companies	45.0%
Research organizations	5.0%
Universities/research	12.0%
Medical laboratories	3.0%

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ The Committee has the view that the programme for Electrical Engineering meets the minimum requirements, although there is little of general engineering sciences in the programme. The graduate is adequate in his field of specialization, which is however somewhat narrow. The graduate is entitled to bear the title "Master of Electrical Engineering".

+ In general, the Committee has a good impression of the faculty. The faculty staff appeared well qualified and motivated. Staff/student relationships appeared good. The Committee was impressed by the laboratories, which are excellent. The Committee was also impressed by the guidance during laboratory work.

+ The Committee supports the plans to achieve a pass rate of 60% in the first year with maintenance of quality. The Committee hopes the reforms will be successful.

+ The Committee considers the relation between teaching and research to be good. Because of this, the faculty is able to achieve a good university level of engineering education.

+ The Committee was impressed by the students it has met. The students the Committee saw were a good 'product' of the programme. For that reason, the Committee must conclude that it is a good Faculty.

- The Information Engineering curriculum tends to be more Information Sciences than Information Engineering. The Committee has the opinion that the graduate in IE is not entitled to bear the title "Master of *Electrical* Engineering".

- A weak point is the split in EE and IE. The faculty has to make a decision on this. In the opinion of the Committee the best way is to restore the combined basic education of both streams. There is a need for strengthening the foundations of Information Engineering. There is a lack of Physics.

- It became clear to the Committee that it is difficult for students to finish their study in 4 years. The programme is heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). Therefore the Committee considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more is needed, unless it is done at the expense of specialization, which is not desirable.

- The Committee considers a greater involvement of the professors in the curriculum necessary, especially in the basic course. Professors should certainly participate in the Curriculum Committee.

- Regarding the faculty, the Committee observes that there is much activity and discussion. What is missing is a general strategy for say 5 years from now. The faculty must try to formulate a common strategy and a common goal supported by the staff. This demands substantial managerial efforts.

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11 FACULTY OF ELECTRICAL ENGINEERING AT THE UNIVERSITY OF TWENTE, THE NETHERLANDS

Date of visit: 29/30 October 1991

1. Introduction

The Faculty of Electrical Engineering is one of the 10 faculties at the University of Twente. The university was founded in 1961. The total number of students is approximately 6600, of which 11% (about 750) are in the Faculty of Electrical Engineering.

Before 1976 Dutch universities were conventional "Von Humboldt" institutions. They have since evolved into organisations where staff and students participate in self-government. Each level - 'vakgroep' (department, section or research group), faculty and university - has its own executive board and a council. The council deals with general policy and the budget, the executive board with the implementation of the decisions of the council and with administrative issues. The council, an elected body, is composed of people working or studying within the unit concerned. The ratio of students to staff is dictated by law. Society at large is represented on the University Council by members from outside the university. The Executive Board at the institutional level has three members, all appointed by the Minister of Education & Science. One is chairman of the Board, and one is the University Rector, who also serves as chairman of the Board of Faculty Deans. The third is a member of the University Council from outside the university. The chairman of the University Council has the right to attend meetings of the Executive Board. Both the University Council and the Executive Board have responsibilities assigned to them by law. In matters concerning the budget and general policy (except for personnel policy) the Executive Board reports to the Council.

At faculty level there is a Faculty Board and a Faculty Council. The Faculty Board has a maximum of five members, of whom the majority are academic staff. The chairman of the Faculty Board is the Dean, and its members are elected by the Faculty Council. Its responsibilities are the organisation and coordination of teaching and research, the preparation and implementation of decisions of the Faculty Council, supervision, the setting up of advisory committees on appointments, and the preparation of the Annual Report. The Faculty Council has a maximum of 15 members, at least half from the academic staff. In addition to the Board and the Council, there are two permanent committees: a Standing Committee for Advice on Research, and the Studierichtingscommissie (curriculum committee) for advice on teaching. The faculty is subdivided into 6 'vakgroepen', to be translated as "research groups" or "departments". The 'vakgroepen' are fairly independent. The 'vakgroepen' are:
1. Control Systems and Computer Engineering
2. IC-technology and Electronics
3. Bio-information technology
4. Transduction and Material science
5. Information theory, communication theory and system theory
6. Telecommunications

In the opinion of the Committee, the organisational structure (dean, board, council, sections and 'vakgroep' (research-group)) is clear, but the decision making process seems to be very complex. Responsibilities are dispersed. The Committee has the impression that the numerous laws and regulations from the government are sometimes taken for granted, and these sometimes prove obstructive. Collective bodies are involved in all important issues, but there is a tendency to avoid personal responsibility and accountability. The Dean retains formaly little executive managerial power in relation to his responsibilities and problems as dean of the faculty.

The Committee observed that there are some "strong" personalities who make the strategy and set the pace. This should be regarded as a positive sign as the strategic direction given by individuals seems to be taken on by the committees.

The Committee holds the view that the new model of education, towards which the faculty strives, is necessary, but its introduction should be monitored very carefully. The Committee would also press for changes in the processes of decision making, and for greater clarity concerning responsibilities and accountability.

2. The student

* Students' level of attainment on entry

The Dutch student entering the university has had 14 years of schooling: 8 years' basic schooling (2 years' preparatory school and 6 years' elementary school), and 6 years' secondary school of the "VWO" type. The requirements for the VWO-examination for Mathematics are: rational-functions and root functions: logarithmic and exponential functions, number e; goniometric functions; graphs of these functions; equations and inequalities in connection with three functions, systems of equations and inequalities; formula of sine, cosine, tangent; limits, continuity and discontinuity of functions; differentiability, derivative functions, rules for differential calculus; primary functions, partial integration, definite integral; differential; curves in parameter presentation. Positions of points, lines and planes; sectional planes with prisms and pyramides; parameter presentation and equations of lines and planes; perpendicular position and rectangular projection; mirror images, translation and rotations in space; inner product, normal vector of a plane; calculation of angles and distances; sphere, cylinder and cone with tangents and tangent planes; solids of revolution and calculation of volumes.

Requirements for Physics are: mechanics, forces, motion, impulse, energy; wave theory with acoustics, optics, electromagnetic waves; liquids, gases, thermodynamics; electricity and magnetism: atom models, energy levels, radioactivity, fission and fusion; cosmic physics; biophysics (ear and eye, radiation and tissue, circulation of the blood).

The Committee formed the impression that the level of attainment of the students on entry is adequate for the curriculum, notwithstanding the overall dropout rate of more than 40 per cent. Preparedness in the exact natural sciences appears to be good.

* Selection

The Dutch universities have no entrance selection. Every school-leaver after secondary education (VWO-type) can enter university. In some cases the faculty may, as an entrance qualification, require two subjects, such as mathematics and physics for Electrical Engineering. In principle, selection takes place in the first year, called the 'propedeuse'. This is one of the reasons for the high dropout rate (circa 25%) in the first year. When a student does not pass the propedeuse in two years, he must leave. The faculty tries to make clear as early as possible who is likely to drop out.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The influx of freshmen has declined during recent years, and although this also applies to other technical disciplines, for EE the decline has been the sharpest. Faculty, industry and government are worried about the small intake and are taking actions to raise the numbers of EE-freshmen. There are very few female students. The cause of this is not clear, but it probably originates at secondary school level and in the rather dull image of EE, due partly to its high content of mathematics and physics. The Committee noticed that there are also very few foreign students. In the opinion of the Committee the faculty of Electrical Engineering should cooperate with the other two faculties in improving the image of Electrical Engineering and attracting students, especially more female students. This should be done also at secondary school level.

The choice of Twente has a regional character (parents living nearby), but is often also based on the Twente campus concept, the personal treatment and the small scale of the university. In the eyes of the Committee the faculty has good students, especially in the end phase; however they were less mature and less confident than the students in other institutes the Committee has visited.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
146	152	2.1%	4.6%	776	763	1.2%	2.1%

In the absence of entrance selection and of a numerus clausus, there is no difference between the number of applicants and the actual intake.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
146	146	152	152

* Average duration of study, Completion rates

The nominal duration of the Electrical Engineering programme is 4 years, set by the Dutch law like other university studies. But there is a substantial discrepancy between the real duration (average 5.9 years) and the nominal curriculum length, an excess of more than 47%. One of the reasons is that by the same law, an enrolment time of six years is permitted. The students may take two years for the propaedeutic and 4 or 5 years for the main programme. The Committee was surprised to observe that overwhelmingly students considered that there is a 'right' to study for six years and so there is no reason at all to complete in a shorter time. Recently the duration of student grants was restricted to five years, but for most engineering programmes it is 5.5 years.

TABLE 3: NOMINAL DURATION AND THE EFFECTIVE LENGTH OF STUDIES

NOMINAL	EFFECTIVE
4.0	5.9

A course duration of 5.5 years seems to the Committee to be typical for Western European (continental) universities. The effective length of the course is fixed by, among other factors, the efforts of the students and the organisation of the programme. It became clear to the Committee that it is difficult for students to finish their studies in 4 years. The programme is heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). The Committee therefore considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more would be needed, unless it were done at the expense of specialization, which is not desirable.

TABLE 4: DROP-OUT RATES AND GRADUATES, COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME *)	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D AFTER 10 YEARS
152	28.2%	7.0%	41.0%	45.0%	5-10%

*) percentage calculated on the number of freshmen.

The Committee noted a high dropout rate in the first year. For the cohort 1982/1983 it was 28%. For the years 1985/1990 the average is 27%. In view of the absence of selection on entry, this could be seen as 'normal' although a little high. The first year of study acts largely as a selection mechanism. About 24% of the freshmen pass the propaedeutic examination in 1 year and about 50% after two years. Regarding the overall completion rate of 45%, the Committee assesses this as rather low. An overall completion rate of 60/65% seems to be average for Electrical Engineering in West-European universities (see the general conclusion in Part I, paragraph 6.6). In the view of the Committee one of the reasons for the low completion rate is the organisation of the curricula and its logistics. The curricula are too tightly structured (too compressed): the slightest delay causes lack of synchronisation and thus more delay, because lectures and practicals are not offered in every trimester. It is possible that the new curricula may reduce the actual duration of studies and raise completion rates, but this remains to be seen.

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3. Goals and aims

The faculty has formulated its aims as follows: *"The title of 'Ingenieur' is in Electrical Engineering. Twente focuses on Information Techniques as that part which deals with low-current electrical engineering. It covers a course ranging from the conversion of information into the electrical domain (sensing), through manipulation (measurement, distribution, control), to conversion into the non-electrical domain (transducing). The global objective is to give students an overview of these fields, with depth in one of the specializations, and the general skills and knowledge needed to follow and assess new developments. The ability to learn autonomously is an objective of training. In terms of knowledge this means that knowledge is required of the bases and concepts over the full breadth of the above course. Thorough knowledge of one application in the above course (roughly categorised under either Sensors & actuators and IC-techniques, mechatronics, tele-informatics or bio-informatics) is required. In terms of skills: the general skills required are the ability to study autonomously and assess new developments in Information Technology, and in a development environment to contribute to product development in at least one field. It is required that the graduate should be able to study new fields dissimilar to his own fields of specialization. In terms of attitudes : an attitude of independence in the setting and completion of tasks is aimed for. An orientation to project planning and the assessment of the general (social) implications of tasks should be mastered."* (Basic information, Volume 2, pages 70/71)

The Committee considers that the goals and aims for the old curriculum are not clearly stated. The goal of autonomous learning is an important one, and the committee sees it as positive. Therefore the aims, although somewhat limited, are reasonable. In the view of the Committee the objectives should be stated in a manner which allows one to judge whether the objectives have been met (i.e. operational goal-setting and management by objectives).

4. The programme

The faculty offers one degree programme: Electrical Engineering (EE) leading to the title of "Elektrotechnisch Ingenieur" (Electrical Engineer), abbreviated "Ir.".

4.1 The philosophy behind the programme

The faculty has stated the philosophy behind the programme as follows: *"The present programme is the result of a process essentially of condensation that has taken place over the last two decades. Starting with a 5.5 years programme, there was a reduction first to 5 years, and somewhat later to 4 years. The present curriculum bears traces of the earlier programmes in the sense that subjects are condensed into shorter courses rather than deleted. This is the main factor in the faculty (changes occurred in secondary schools also) contributing to the low throughput now experienced. The first year is meant to give an overview of Electrical Engineering as a science, it is meant to be selective (students must sense the difficulty of the study), and it is meant to be allocative (the faculty must be able to judge from their performance if students are capable). This leads to a spread of subjects, and also to depth in those subjects represented in the rest of the curriculum.*
The second year still contains compulsory subjects, in preparation for further specialization through electives and a free choice of larger project work " (Basic Information, Volume 2, page 59).

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4.2 The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements, set by IPR-EE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	TOTAL
MATHEMATICS	7.7	5.6	2.0		15.3
PHYSICS	3.8	4.0	1.0		8.8
COMPUTER SCIENCES	2.8	2.5	0		5.3
GENERAL ENGINEERING SCIENCES	0	0	0		0
ELECTRICAL ENGINEERING SCIENCES	7.5	7.8	18.1		33.4
ELECTRICAL DESIGN[2]	0.4	1.8	1.6		3.8
NON-TECHNICAL SUBJECTS	2.4	4.0	2.1	1.0	9.5
ELECTIVES[3]	0	0	12.0	12.0	24.0
TOTAL	24.6	25.7	37.0	13.0	100 % 2550 hours
THESIS				1000 hours	

1) Percentages are calculated on the aggregate number of contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis work are not counted in the percentage.
2) It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.
3) When the student has to choose electives in different years, the hours are counted for each year proportionally.

4.3 Mathematics; Basic sciences

Some 15% of the programme consists of mathematics, which may be considered as normal. The content of the programme exceeds the minimum requirements. The basic sciences show some gaps; possibly subjects such as chemistry could be included. There could be more of classical Physics (mechanics, thermodynamics, fluid dynamics etc.) as a basis for general engineering.

4.4 General Engineering Sciences

The curriculum does not satisfy, in the opinion of the Committee, the minimum requirements for General Engineering Sciences. Materials and Chemistry are largely missing. The committee wonders how it is possible to specialize in chemical sensors without materials chemistry.

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4.5 Electrical Engineering Sciences

The committee assesses Electrical Engineering Sciences as good, though somewhat meagre because of the omission of power engineering. Although the faculty has made a choice for a curriculum limited to Information Technology and Electronics, the Committee considers it necessary to have general insight in Electrical Engineering at large and thus to include at least an introduction to power engineering and electromechanical engineering.

4.6 Electrical Design

The Committee has the impression that the requirements for Electrical Design are adequate. Design is embedded in a number of courses and in the practical laboratories. In the specialization part of the course, design is highly developed from the viewpoint of education.

4.7 Non-Technical subjects

The non-technical subjects are treated well (9.5%), establishing the profile of this university. There is a strong emphasis on social sciences in the broadest sense. This is one of the special commitments of this university. There is an excellent coverage of courses. The Committee questions whether there may be an overemphasis on social sciences in the basic studies. It is not clear to the Committee whether the non-technical subjects are integrated in the 'technical projects'.

4.8 Additional requirements

The IPR-EE Committee has formulated additional requirements regarding students' laboratory experience, the use of computers, and the attention paid by the faculty to written and oral communication (Guide for the Committee, page 10). With regard to these requirements, the Committee has nothing to remark.

4.9 Master's thesis

The faculty gives the following description of the work for the thesis: *"The work for the Ir. [title of "ingenieur"] thesis covers a period of 6 months (1000 hours) of (not necessarily consecutive) research in the faculty (sometimes in industry or at another European university through the Erasmus scheme). A committee is formed to supervise the study, involving at least one professor and 2 other academic staff. The work is assessed through the report, the conduct of the project, and a 45 minute oral presentation for the research group at the end. Generally the work carried out fits into the research programme of the group, usually involving Ph.D fellows as daily supervisors."* (Basic Information, volume 2, page 77).

The Committee offers no observations concerning the master's thesis, which appears to be satisfactory. The Committee, albeit not unanimously, does not support the wishes of the Faculty to raise the final thesis period to 9 months instead of the current 6 months. In the opinion of the Committee, the three months can be better used for other activities which the university can provide, e.g. advanced theoretical teaching.

4.10. Examinations: regulations and requirements

About the examinations and the requirements for examinations the faculty has provided the following information: "*Examination is through the accumulation of credits. Generally all credits must have a pass mark, which is set at 55%. Credits can be acquired through course examinations which are scheduled after the lecturing period. Some extra examinations are scheduled in the yearly programme. There is no formal limit to the number of attempts for one course. Most courses are examined in a three hour paper session, but for some electives oral examinations take place. There are two formal examinations, one for the propaedeutic (1st year) and one final (4th year). These are merely meetings of the lecturing staff checking whether students have acquired the necessary credits. These formal meetings take place 4 times per year, and students have to indicate whether they want to be considered for a particular meeting. The meeting has the jurisdiction to declare candidates 'passed'. Course grades cannot be changed in these meetings and there is no weighting attached to the credits. Fixed rules exists for the acceptance of scores of 50% in courses for the propaedeutic exam: they have to be compensated by high grades for similar courses.*" (Basic Information, Volume 2, page 78).

The Committee has some doubts regarding assessment and examination. Based on the examinations it was shown, the Committee has the impression that examinations in the basic courses do not always reflect the basic material. The students claim that many examinations include problems which recur frequently and thus are easier to tackle, making it less important to study the content in any depth. Students learn to spot examination questions rather than study the subject matter.

4.11 Study burden

As is to be seen in Table 6, the total time programmed is 6500 hours, that is 1625 yearly. At Twente the faculty counts in terms of credit points: 1 credit point is 25 hours and one year counts 65 credit points. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2:3. The students spend about 40% of their time at the university and are expected to spend about 60% on self study. Many lectures are coupled with tutorials, small working groups for exercises. Thus the figure for lectures is made up of about 60% 'real' lectures and 40% tutorials.

TABLE 6: TOTAL STUDY BURDEN

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
1744	706	2550	400	1000	6500

In year 3 there are two practical assignments, one of 100 hours and one of 250 hours. In the 4th year there are 16 credit points (400 hours) for industrial training.
For the master's thesis 1000 hours are programmed, but too often the students exceed this time.

It is not clear how many hours the students spend on their study. According to the information from the faculty, the student has to spend 25 hours a week at the university and about 10 hours on self study.

In reality, the faculty estimates the time as some 40 hours a week during 40 weeks, that is about 1600 hours yearly. In the report of the National Visiting Committee on Electrical Engineering (1991), the time spent by a student on his studies is estimated to be about 1300-1400 hours annually. This is net study time; it is about 1600 hours gross.

4.12. Overall assessment of the programme

Within the limited scope of the goals and aims, the Committee has the opinion that the (old) programme is acceptable, although there is little general engineering, physics and electrical engineering. Attention to social sciences early in the course, though valuable, is excessive. Moreover, there is too much emphasis on specialization at the expense of the basics.

The Committee was impressed by the attention given to curriculum renewal. It has been decided to introduce a block scheme for first year studies with effect from September 1992. In essence, the present courses running in parallel in the first year will be replaced by blocks of 2-4 weeks, each examined at the end of the period. It is hoped that this approach will lead to a significant increase in linkage, which with the present parallel system is weak. It is hoped that the block system will improve the climate of study, encouraging the students to work harder, and will lead to a much higher pass rate in the first year and eventually to more students completing the whole course in 4 years. Possible disadvantages are a loss of freedom for the students, and some disadvantages for students who miss a block through illness.

The introduction of the scheme was initiated by an ad hoc curriculum innovation committee, containing strong personalities in the faculty. Whilst there are some reservations, the faculty and staff seem to be cooperating vigorously in the scheme. The Committee sees the change from a parallel course system to a block system as exciting. Such a large scale experiment is risky for students and staff.
The Committee would have preferred a smaller scale experiment, for example one trimester. In the opinion of the Committee it is, however, an indication that there is much dynamic thinking and decision making ability in the organisation.

5. The Academic Staff

The academic staff fall into four main categories:
* full professors (hoogleraar);
* associate professors or senior lecturers (UHD=universitaire hoofddocent)
* assistant professors or junior lecturers (UD= universitaire docenten)
* research assistants or Ph.D. students (AIO's= Assistenten in opleiding).

The committee has the impression that the size of the staff (see Table 7) is rather small, in relation to the numbers of students and looking at the number of full time professors, even by comparison with other Dutch institutes. One may wonder if a faculty of this size can cover the broad field of Electrical Engineering adequately.

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TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	full time equivalent	number of persons
* Full professors	9.7	11
* Associate professors /senior lecturers (UHD)	10.0	10
* Assistant professors /junior lecturers(UD)	32.2	33
* Research assistants PhD. students	33.1	41
* Others	20.3	74
Total academic staff	105.3	169
Non-academic staff	94	105

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
27*)	763	68	28	2.5

*) including service teaching from other faculties

The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. This ratio is 28 (see Table 8). In the opinion of the Committee the teaching load of the full professors is too low (about 20% of their time, about 3 hours a week). The Committee observed that the staff is strongly oriented toward research. The students of the first and second year do complain that it is difficult to see a professor outside the lectures. The Committee recommends a greater involvement of professors in teaching in the basic programme.

A possible measure of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 2.5 graduates per staff member.

The didactic expertise of the staff seems to be adequate. In interviews with students, in general the Committee found them content with the manner of teaching. The teaching is monitored by the Curriculum Committee and by student evaluations.

The academic level is satisfactory. The Committee assesses the scientific activities as being of satisfactory level. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 2.2 (see Table 9). There are many research projects in sensors. The committee considers the activities in informatics, optics, including lasers and electronics to be satisfactory.

TABLE 9: NUMBER OF REFERRED RESEARCH PAPERS

	1986	1987	1988	1989	1990
Number of papers	13	142	117	149	215
Number of papers per staff member (excluding "others")					2.2

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The staff do not often utilise the privilege of sabbatical leave, although the Faculty Board encourages this. The Committee found, however, that a sabbatical year is difficult to obtain. It considers that the staff should make more use of the possibility of sabbatical leave. There is no formal programme for staff development, although there are opportunities to follow didactic courses at the Educational centre. The Committee supports the view that teaching should have the same importance in the career of a staff member as research.

There seems to be difficulty in appointing good professors. The Committee expresses the feeling that action must be taken with regard to recruitment policy. A vacancy in electronics has existed for 5 years now, and in telematics the post of one full time professor is shared between part-time professors. Problems with recruitment have to do with personal income, the region, the fact that researchers in an industrial environment do not have the same managerial commitments, and the fact that it is often impossible to allocate appropriate numbers of academic staff to the newly appointed professor.

6. Resources and Facilities

All Dutch universities are financed by the state on an equal footing. The university receives a lump sum, and the central Board divides the money among the faculties. In Table 10 some figures concerning the finances are given.

Based on information given by the students, the teaching equipment seems to be adequate. The laboratory equipment is satisfactory. Especially Mesa (Research Institute for Micro-electronics, Materials Engineering, Sensors & Actuators) is superb, and should be a notable centre of excellence. The computer equipment is acceptable too.

TABLE 10: INCOME AND EXPENDITURES OF THE FACULTY

INCOME		EXPENDITURES	
State	80.0%	Education	23.9%
Industry	11.5%	Research	63.9%
Research foundations	8.5%	Other	12.2%
Other		Total	100%
Total	100%		

7. The internal Quality Assurance

The faculty gives as information that: *"at present a substantial curriculum review is in progress, changing the structure drastically and at the same time 'modernising' where necessary courses and laboratory work. Reviews take place regularly, and the involvement of academic staff in state-of-the art research maintains the momentum in adapting the curriculum to modern technologies."* (Basic information, Volume 2, page 79).

There is no formal quality assurance system, but there seems to be very strong and intensive control of the educational activities by the various committees. The Dean of Education plays an important role and creates an atmosphere of renewal.

8. External relations

The faculty describes contacts with industry as follows:

"Through the research there are many contacts with industry. On the level of curriculum development there are few systematic contacts. Staff from the faculty use their sabbaticals in industry (usually abroad however), and several staff from industry are connected to the faculty as part-time professors or part-time research/teaching staff. By tradition industrial involvement in the university curricula is very limited, and the same is true of financial contributions from industry to university life." (Basic Information, Volume 2, page 81)

It is stated elsewhere that the faculty has many formal agreements with industry. There is no formal connection between industry and the Faculty Board, though the faculty has an advisory board with members drawn from industry. The Committee suggests the establishment of more formal relationships. With regard to cooperation with other institutes, the faculty aims to conduct research as much as possible with institutes outside the faculty. This has been successful for telematics, bio-informatics and mechatronics.

9. International relations

There is some involvement in ESPRIT and JESSI. Otherwise it seems that there are few international relationships such as having visiting professors. There are very few students abroad. The professors should be encouraged to take sabbatical leave.

10. The graduate

The Committee assesses the quality of the typical graduate as good in his field of specialization. This field is somewhat narrow to adequately support adaptation to future changes in Electrical Engineering. The graduate merits the title of Electrical Engineer.

The graduates easily obtain jobs, and there is no unemployment. Although members of the faculty do not keep good records on the destination of former students, their impressions suggest the distribution shown in Table 11. The Committee considers the distribution between industrial and research jobs to be normal.

TABLE 11: DESTINATION OF GRADUATES

Industrial company	30%
Governmental institutions	30%
Continuing for PhD	20%
Foreign countries	10%
Teaching, consulting, general job	10%

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ In the opinion of the Committee the (old) programme meets the minimum requirements set for Electrical Engineering. On the whole the Committee assessed the situation as satisfactory. The Committee has the impression that the quality of the graduate is acceptable in his field of specialization, which is however somewhat narrow. The graduate merits the title of Electrical Engineer.

+ The commitment to a complete renewal of the organisation of the course in the first year is quite impressive. Although the Committee considers the experiment may . risky and its success questionable, the attempt itself is a positive sign that some strong personalities have taken on leadership and responsibility. This is important, because the Committee noticed in some cases a limited identification of the staff with the faculty. This is especially true as far as the present basic programme is concerned.

+ In the view of the Committee the future of this faculty seems to be good because of the dedication of all parties to improving their performance.

+ The Committee noted the extent of social science teaching, a valuable feature of this faculty, although in the opinion of the Committee perhaps offered too early in the programme.

+ In the eyes of the Committee the faculty has good students, especially in the end phase.

- In the opinion of the Committee the number of staff is too small to cover the broad field of Electrical Engineering adequately.

- It became clear to the Committee that it is difficult for students to finish their study in 4 years. The programme is too heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). Therefore the Committee considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more is needed, unless it is done at the expense of specialization, which is not desirable.

- In the opinion of the Committee there is too little time spent on teaching by the professors. The Committee recommends a far greater involvement of professors in teaching in the basic programme. There should be more incentives for participating in teaching.

- The basic programme seems to be rather limited for an Electrical Engineering course. There is little or no attention given to basic science and to power engineering. This is a serious drawback.

- In the opinion of the Committee, the completion rate is too low and the average study time too high.

12 FACULTY OF ELECTRICAL ENGINEERING AT DELFT UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS

Date of visit: 31 October/1 November 1991

1. Introduction

The International Programme Review Electrical Engineering (IPREE) started with visits to the Netherlands. The third faculty to be visited was the Faculty of Electrical Engineering at Delft University of Technology. For the members of the Committee see appendix 1.

The Faculty of Electrical Engineering is one of the 12 faculties at Delft University of Technology. The old Polytechnic (1864) became the Technical University in 1905. The total number of students in the University of Delft is approximately 12.650 from which 11% (about 1450) in the Faculty of Electrical Engineering.

Before 1976 Dutch universities were conventional "Von Humboldt" institutions. They have since evolved into organizations where staff and students participate in self-government. Each level - 'vakgroep' (department, section or research group), faculty and university - has its own executive board and a council. In 1986 the council was given authority in respect of budget and personnel distribution. The council deals with general policy and the budget, the executive board with the implementation of the decisions of the council and with administrative issues. The council, an elected body, is composed of people working or studying within the unit concerned. The ratio of students to staff is dictated by law. Society at large is represented on the University Council by members from outside the university. The Executive Board at the institutional level has three members, all appointed by the Minister of Education & Science. One is chairman of the Board, and one is the University Rector, who also serves as chairman of the Board of Faculty Deans. The third is a member from outside the university. The chairman of the University Council has the right to attend meetings of the Executive Board. Both the University Council and the Executive Board have responsibilities assigned to them by law. In matters concerning the budget and general policy (except for personnel policy) the Executive Board reports to the Council.

At faculty level there is a Faculty Board and a Faculty Council. The Faculty Board has a maximum of five members, of whom the majority are academic staff. The chairman of the Faculty Board is the Dean. and its members are elected by the Faculty Council. Its responsibilities are the organization and coordination of teaching and research, the preparation and implementation of decisions of the Faculty Council, supervision, the setting up of advisory committees on appointments, and the preparation of the Annual Report. The Faculty Council has a maximum of 15 members, at least half from the academic staff. In addition to the Board and the Council, there are two permanent committees: a Standing Committee for Advice on Research and the Studierichtingscommissie (curriculum committee) for advice on teaching.

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The Faculty is subdivided into 13 'vakgroepen', to be translated as "research groups" or "departments". The 'vakgroepen' are fairly independent. The 'vakgroepen" are:

1. Electromagnetic research
2. Telecommunication and remote sensing technology
3. Telecommunication and traffic-control systems
4. Electronics
5. Electronic instrumentation
6. Electrical Materials
7. Electronics for digital systems
8. Computer architecture and digital technique
9. Control engineering
10. Information theory
11. Network theory
12. Electrical power systems & High-voltage technology
13. Power Electronics and electrical machines

The Committee has the impression that adequate management support is lacking. "Vakgroepen", and sometimes even individuals, seem to have conflicting interests which make it difficult to take necessary actions.

2. The student

* Students' level of attainment on entry

A Dutch student entering university will have had 14 years of schooling: 8 years' basic schooling (2 years' prep school and 6 years' elementary school) and 6 years' secondary school of the "VWO" type. The requirements for the VWO-examination for Mathematics are: rational-functions and root functions; logarithmic and exponential functions, number e; goniometric functions; graphs of these functions; equations and inequalities in connection with three functions, systems of equations and inequalities; formula of sine, cosine, tangent; limits, continuity and discontinuity of functions; differentiability, derivative functions, rules for differential calculus; primary functions, partial integration, definite integral; differential; curves in parameter presentation. Positions of points, lines and planes; sectional planes with prisms and pyramides; parameter presentation and equations of lines and planes; perpendicular position and rectangular projection; mirror images, translation and rotations in space; inner product, normal vector of a plane; calculation of angles and distances; sphere, cylinder and cone with tangents and tangent planes; solids of revolution and calculation of volumes.
Requirements for Physics are: mechanics, forces, motion, impulse, energy; wave theory with acoustics, optics, electromagnetic waves; liquids, gases, thermodynamics; electricity and magnetism: atom models. energy levels, radioactivity, fission and fusion; cosmic physics; biophysics (ear and eye, radiation and tissue, circulation of the blood).

The Committee formed the impression that the level of attainment of the students on entry is adequate for the curriculum, notwithstanding the overall dropout rate of more than 40 per cent. Preparedness in the exact natural sciences appears to be good.

* Selection

The Dutch universities have no entrance selection. Every school-leaver after secondary education (VWO-type) can enter university. In some cases the Faculty may, as an entrance qualification, require two subjects, such as mathematics and physics for Electrical Engineering. Engineering faculties do require mathematics and physics from VWO-students. These students and those from the vocational engineering schools form by far the majority of the freshmen. Others have to take entrance examinations. In principle, selection takes place in the first year, called the 'propedeuse'. This is one of the reasons for the high dropout rate (about 25%) in the first year. When a student does not pass the propedeuse in two years, he must leave. The Faculty tries to make clear as early as possible who is likely to drop out.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The influx of freshmen has declined during recent years, and although this also applies to other technical disciplines, for EE the decline has been the sharpest. Faculty, industry and government are worried about the small intake and are taking actions to raise the numbers of EE-freshmen. There are very few female students. The cause of this is not clear, but it probably originates at secondary school level and in the rather dull image of EE, due partly to its high content of mathematics and physics. In the opinion of the Committee the Faculty of Electrical Engineering should cooperate with the other two faculties in improving the image of Electrical Engineering and attracting students, especially more female students. This should be done also at secondary school level.

The number of foreign students, specially students from China and Indonesia, is higher than in the other faculties of Electrical Engineering in the Netherlands.

The choice of Delft by students is based on the fame of the university, the attraction of Delft as a place to live compared with Eindhoven or Twente, and the fact that there are more and better student activities.

The students made a very good impression: mature and open-minded. Although it may be that here too the students were carefully selected, the Committee liked the interviews. The Committee noted that student life is appreciated so much that other students make a butt of the person who would prefer to finish his studies in 4 or 4.5 years.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
348	247	1.7%	3.2%	1497	1433	1.7%	3.4%

In the absence of entrance selection and of a numerus clausus, there is no difference between the number of applicants and the actual intake.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
348	348	247	247

* Average duration of study, Completion rates

The nominal duration of the Electrical Engineering programme is 4 years, set by the Dutch law as in the case of other university studies. But there is a substantial discrepancy between the real duration (5.7 years) and the nominal curriculum length, an excess of 42.5%. One of the reasons is that by the same law, an enrolment time of six years is permitted. The students may take two years for the propaedeutic and 4 or 5 years for the main programme. The Committee was surprised to observe that overwhelmingly students considered that there is a 'right' to study for six years and so there is no reason at all to complete in a shorter time. Recently the duration of student grants was restricted to five years, but for most engineering programmes it is 5.5 years.

TABLE 3: NOMINAL DURATION AND THE EFFECTIVE LENGTH OF STUDIES

NOMINAL	EFFECTIVE
4.0	5.7

A course duration of 5.5 years seems to the Committee to be typical for Western European (continental) universities. The effective length of the course is fixed by, among other factors, the efforts of the students and the organization of the programme. It became clear to the Committee that it is difficult for students to finish their studies in 4 years. The programme is heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). The Committee therefore considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more would be needed, unless it were done at the expense of specialization, which is not desirable.

TABLE 4: DROP OUT RATES AND GRADUATES GENERATION 1982/1983

FRESHMEN	% DROP-OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME *)	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph D after 10 years
191	29.0%	4.0%	43.0%	54.0%	15%

*) The numbers are based on the influx directly from VWO.

The Committee noted a high dropout rate in the first year. For the cohort 1982/1983 it was 29%. For the years 1985/1990 the average is 26%. In view of the absence of selection on entry, this could be seen as 'normal', although a little high. The first year of study acts largely as a selection mechanism. About 23% of the freshmen pass the propaedeutic examination in 1 year and about 57% after two years. Regarding the overall completion

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rate of 54%, the Committee assesses this as low. An overall completion rate of 60/65% seems to be average for Electrical Engineering in West-European universities (see the general conclusion in Part I, paragraph 6.6).

In the view of the Committee one of the reasons for the low completion rate is the organization of the curricula and its logistics. The curricula are too tightly structured (too compressed): the slightest delay causes lack of synchronization and thus more delay, because lectures and practicals are not offered in every trimester. It is possible that the new curricula may reduce the actual duration of studies and raise completion rates, but this remains to be seen.

3. Goals and aims

The Faculty has formulated its aims as follows:

"The electrical engineering curriculum of Delft University of Technology is designed to develop and/or test the following abilities in students:

1. He has the skills to work with professionals, also from other disciplines, towards common or given objectives:

a) he is able to recognise, classify and formulate technological problems and can discuss them with professionals from all relevant disciplines;

b) he is able to analyse and solve problems within his speciality, taking into account all life-cycle aspects of the product;

c) he appreciates the impact of his design decisions on the life cycle of the product under design;

d) he can communicate about methods and results of electrical engineering in the accepted language and terminology of the field, both orally and in writing.

2. He has acquired the ability to master the details of any branch of electrical engineering within an acceptable initiation period, and can then use creativity in that branch to reach objectives within constraints:

a) he has a functional understanding of system engineering;

b) he has a perception of the nature of Physics that enables him to discover, study and understand the potential for electrical engineering application in physical phenomena;

c) he has the deductive skills, acquired by the study of calculus, algebra and probability theory, to rigorously analyse methods and results of electrical engineering and to derive new facts and algorithms;

d) his proficiency in electrical engineering is based on a representative knowledge of the fields and intellectual skills for which mathematical modelling and system approach are pivotal;

e) he can apply a derivative and a lateral way of thinking.

3. His professional activities harmonize with his personal and social life:

a) he is aware of the consequences of his professional actions on personal and social welfare;

b) he furthers through his behaviour the general comprehension of the possibilities and limitations of practice.

In terms of knowledge this means a substantive knowledge of terminology, facts, laws of the disciplines, character of the disciplines and the interrelation between disciplines. With regard to the methodology there should be knowledge of conventions, definitions and *processes, analysis, measurement, algorithmic paradigms. In term of skills this means, among other things, the abilities to derive models and algorithms, carry out system analyses, determine test procedures, establish and explain discrepancies. In the framework of application: implement synthesis-procedures and generate solutions. He must be able to formulate objectives, work toward objectives, organize work within constraints, evaluate progress and methods, and test against objectives. In terms of attitudes this means among others communicative skills."* (Basic information, Volume 1, pages 78/79).

The Committee concludes that the Faculty has formulated many aims, without defining the academic level of the engineer. What is the difference between the education of an engineer at university level and an engineer at polytechnic level? As the Faculty educates a genuine academic engineer, this should be explicitly mentioned in the goals and aims. The graduates must in any case be able to understand and make operational the international literature.

4. The programme

The Faculty offers one degree programme: Electrical Engineering (EE) leading to the title "Elektrotechnisch Ingenieur", abbreviated "Ir." (Electrical Engineer).
The Curriculum Committee (Studierichtingscommissie), in which here professors also participate, is designing a new programme. The share of the compulsory courses in the whole curriculum is being increased. There is also a broadening of the subjects in the first year. It is intended to lead the student to three different "destinations": 1. research, 2. design, 3. product manufacturing. The Committee likes the idea of the three streams, but thinks the translation of the ideas into practice may be difficult.

4.1. The philosophy behind the programme

The Faculty has stated the philosophy in the same way as the goals and aims (see above, paragraph 3).

4.2. The structure of the programme

Structure of the programme and an overview of the contents are given in appendix 2.

Table 5a gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements, set by IPREE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects. The numbers given are based on the old curriculum. The new curriculum will be replacing this curriculum from September 1991 onwards. For the compulsory part, the first nine periods (10 weeks each), the new curriculum has been established by the Council. Table 5a shows the percentages for the old curriculum.

The faculty has provided the figures of table 5b to show the shift in attention for the different subjects. The percentage are calculated as percentage of all programmed hours (contact hours and self study hours). Also the time for thesis and industrial training are included.

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TABLE 5a: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	TOTAL
MATHEMATICS	14.1	8.5			22.7
PHYSICS	6.1	3.4			9.5
COMPUTER SCIENCES	2.0	1.9			3.8
GENERAL ENGINEERING SCIENCES	1.9	0			1.9
ELECTRICAL ENG SCIENCES	13.0	10.8			23.8
ELECTRICAL DESIGN[2]	0	2.0			2.0
NON TECHN. SUBJECTS	0.8	0.8	2.7		4.4
ELECTIVES[3]	0	0	28.0	3.9	31.9
TOTAL	37.8	27.4	30.1	3.9	100% 2130 hrs
THESIS				950 hrs	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis work are not counted in the percentage.

[2] It is not always possible to make a distinction in Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES an ED must be added.

[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

TABLE 5b: SHIFT IN ATTENTION FOR THE DIFFERENT SUBJECTS IN THE OLD AND THE NEW CURRICULUM

YEAR	1		2		3		4		TOTAL	
	old	new	old	new	old	new	old	new	old	new
MATHEMATICS	9.0%	8.9%	7.7%	7.1%					16.7	16.0
PHYSICS	3.9	4.2	3.7	4.5	0.0	0.9			7.6	9.6
COMP SCIENCE	2.2	3.0	2.3	1.2	0.0	0.0			4.5	4.2
G E S	0.6	0.9	0.0	3.0	0.0	1.8			0.6	5.7
E E S	8.3	7.7	9.2	6.8	0.0	4.8			17.5	19.3
E D	0.0	0.3	1.1	2.4	0.0	3.0			1.1	5.7
N T S	1.0	0.0	1.0	0.0	2.0	X.X			4.0	X.X
ELECTIVES					23.0	X.X	4.9	X.X	27.9	X.X
IND.TRAINING							5.9	X.X	5.9	X.X
THESIS							14.2	X.X	14.2	X.X

X.X = not yet known

During the first year (the propaedeutic programme) a major part of the curriculum is devoted to basic mathematics and physics, as well as an introduction to electrical engineering. The P-phase programme is identical for all students.

In the 'old' programme the second year is a continuation of the P-programme. The accent is shifted from mathematics and physics to electrical engineering. During this year students have to decide whether they want to continue in the mainstream of electrical engineering or wish to differentiate into Avionics or Computer Systems. At the beginning of the third year the student reaches a point of differentiation: he/she is committed to the Avionics programme, to the Computer Systems programme, or to one of the five sector programmes of the mainstream. Changing after that point entails an extra study burden. In the second half of the 3rd year or the first half of the 4th year and in addition to courses and practical work, the student should complete an initial research project in industry. In addition the student has to spend some practical work in industry. The final year involves work on one of the major research projects of the university's research programme, and the writing of a thesis to do with his involvement in the project. The thesis indicates the level the student has reached on completing his electrical engineering course.

In the new programme the initial 2.25 years are identical for all students. After this common part three streams are planned: research, design, and product manufactoring. Until now only this core curriculum has been accepted by the Council (based on Basic Information, Volume 1, pages 68/69).

4.3. Mathematics; Basic sciences

The Committee observed that there is quite a good and solid mathematical education in the compulsory part of the programme (about 23%). Also physics is adequate (9.5%). There are some omissions: no chemistry or material sciences.

4.4. General Engineering Sciences

Although the new curriculum is better than the previous one, it is still rather specialised, hindering flexible adaptation of the graduates to future developments outside their direct area of specialisation.

4.5. Electrical Engineering Sciences

The Committee assesses the quantity of Electrical Engineering Sciences as more than adequate.

4.6. Electrical Design

The Committee has the impression that the requirements for Electrical Design are well met.

4.7. Non-Technical subjects

The Committee noted that social sciences are hardly present in the old curriculum. In the new curriculum there is a first year course in socio-economic aspects of production (1.5 credit point), an a second year course centred around the theme economic product life cycle (1 credit point). Finally, in the second year there is a group activity on chip design in which a number of social sciences aspects are incorporated

4.8 Additional requirements

The IPREE Committee has formulated additional requirements regarding laboratory experiences of the students, the use of the computer, the attention paid by the Faculty to written and oral communication (Guide for the Committee, page 10). The Committee assesses the additional requirements as more than adequate. It might be good to make the Library-retrieval practical compulsory.

4.9. Master's thesis

The Faculty gives the following description of the thesis: *"For his final individual project and Master's thesis, the student has to join one of the specialisation or working groups of the Faculty (see paragraph 1). The Board of the group will appoint a professor and one or more mentors. The work towards the Master's degree is done under the guidance of the mentors. The student and the mentors agree on an assignment that should be completed within 6 months (950 hours of workload). The student reports on this work in written form, and usually also in an oral presentation. The work is assessed by a committee of at least two persons, but preferably three or four, including the assigned professor and mentors. The committee discusses the work with the student in a session of about one hour. For the purpose of a thorough evaluation, the student has to make a draft report available one month before the meeting with the committee. The committee grades the work on a scale 0-10; the minimal passing grade should be closer to 6 than to 5."* (Basic Information, Volume 1, page 86)

The Committee offers no observations concerning the master's thesis, which appears to be satisfactory. The Committee, albeit not unanimously, does not support the wishes of the Faculty to raise the final thesis period to 9 months instead of the current 6 months. In the opinion of the Committee, the three months can be better used for other activities which the university can provide, e.g. advanced theoretical teaching.

4.10. Examinations: regulations and requirements

The Faculty does not give much information about the examinations and the requirements for examinations. There are two formal examinations, one for the propaedeutic (1st year) and one for the final (4th year). Most examinations for the doctoraal courses (3rd and 4th year) are oral examinations. Only when the examination grade is 6 or higher (on a scale of 0-10) does the course count for the final degree examination, though some compensation rules apply (see Basic Information, Volume 1, page 87).

The Committee judged the method of assessment and examination as more than adequate. The level of the examinations is satisfactory.

4.11 Study burden

According to Dutch law a maximum of 6720 hours may be programmed over four years, to be counted in credit points, units of 40 study hours. This comes down to 42 points or 1680 hours per year. As is to be seen in Table 6, the total time programmed is 6720 hours, that is 1680 yearly.

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The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 1:1. The students spend circa 50% of their time at the university and are expected to spend about 50% on self study.

TABLE 6: TOTAL STUDY BURDEN

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
1579	551	2130	400	950	6720

Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 60% 'real' lectures and 40% tutorials (this applies to the first year).

In year 3 there is a research project of 240 hours. In the 3rd or 4th year the student has to fulfil a period of practical work in industry during 400 hours. For the masters thesis 950 hours are programmed, but too often the students exceed this time.

It is not fully clear how many hours the students spend on their study. According to information from the Faculty, the student should spend 35-55 hours a week for study activities l.e 20-25 hours on lectures and in laboratories and 25-35 hours a week on self study (tutorials included). In the report of the National Visiting Committee Electrical Engineering (1990), the time, spent by the student on his study, is estimated to be about 1300-1400 hours annually. This is net study time; it is about 1600 hours gross. It seems that the students do not spend enough time on their study. In the first year much time is spent on 'adaptation to student-life'. To lighten the study burden it will be necessary to improve the logistics. Action is being taken, but it is unknown what the experience with the new curricula will be.

4.12. Overall assessment of the programme

The programme in general is sound and well balanced, and has the broadest curriculum of the three Dutch faculties, even though it is a little light on general engineering sciences and virtually lacking in non-technical subjects. In the core of the new curriculum they are completely absent. The Committee formed a favourable opinion of what has been achieved. Due to the significant emphasis on research the basic programme suffers from a lack of staff involvement and student guidance. It is noticeable that this is not the case with the doctoraal and Ph.D. programmes. The Committee is interested in the future of the new programme. The overall opinion on the new curriculum is that it appears satisfactory. The Committee stresses the need for care and the necessity for carefully monitoring the progress and results.

5. The Academic Staff

The academic staff fall into four main categories:
* full professors (hoogleraar);
* associate professors or senior lecturers (UHD=universitaire hoofddocent)
* assistant professors or junior lecturers (UD= universitaire docenten)
* research assistants or Ph.D. students (AIO's= Assistenten in opleiding).

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The number of staff (see Table 7) seems to be adequate and is relatively large, compared with the other two faculties. This has a positive effect on all topics and subjects discussed by the Committee.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	full time equivalent	number of persons
• Full professors	20.6	30
• Associate professors/senior lecturers (UHD)	24.9	27
• Assistant professors/junior lecturers(UD)	55.9	61
• Research assistants/Phd. students	21.3	46
• Others	47.6	85
Total academic staff	170.3	249
Non-academic staff	175.7	176

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
48*	1433	208	30	4.3

*) including service teaching from other faculties

The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full-time equivalents of 40 hours weekly) for teaching. This ratio is 30 (see Table 8). The Committee considers the teaching load adequate. A possible measure of teaching effectiveness is the number of graduates per FTE-teaching. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 4.3 graduates per FTE-teaching.

The teaching load of the staff is light in the opinion of the Committee. The Committee observed that the main emphasis of the staff is on research. There are no real incentives for good teaching apart from the pleasure of attracting good students. The participation of full professors in the basic courses is lacking. The Committee recommends a far greater involvement of professors in teaching in the basic programme. The teaching expertise of the staff seems to be adequate. In the interviews with the students, the Committee found that in general they are content with the way of teaching. The teaching is monitored by evaluation by the Committee for Evaluation of Education (Onderwijsevaluatiecommissie, OEC), by student evaluations and by a mentor system. Educational contributions should be given greater importance; in comparison with research contributions they are underestimated. There is no formal programme for staff development.

The Committee considers the academic level of the staff as very good. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group "others"). The number of publications per staff member is 2.2. There is a great involvement in research programmes with industry and European Organisations.

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TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

FACULTY	1986	1987	1988	1989	1990
number of papers	207	200	233	304	356
number of papers per staff member (excluding "others")					2.2

There seems to be difficulty in filling vacancies. Salaries should be made more competitive with industry, so that talented people can be attracted to a university appointment. The Committee was unable to obtain a clear view of the policy on recruitment.

6. Resources and Facilities

All Dutch universities are financed by the state on an equal footing. The university receives a lump sum, and the central Board divides the money among the faculties. In Table 10 some figures about the finances are given.

TABLE 10: INCOME AND EXPENDITURES OF THE FACULTY

INCOME		EXPENDITURES	
State	87.5%	Education	32.0%
Industry	12.5%	Research	63.0%
Research foundations		Other	5.0%
Other		Total	100%

Based on information given by the students, the teaching equipment seems to be adequate. The laboratory equipment is appropriate. The DIMES laboratory (Delft Institute for Microelectronics and Submicro-technology)is excellent. It is very expensive to update the equipment in a rapidly developing environment. The computer equipment is satisfactory. The Committee has the impression that Delft is far ahead in using the computer in education.

7. The internal Quality Assurance

The Faculty gives as information about the way the programme is kept up to date:
"This is primarily the responsibility of the teaching staff. To enable the staff to do this task properly: a) their research is for a large part funded by the university itself; b) taking part in the activities of the international scientific community through international journal contributions and visits to international conferences is encouraged; c) links with industry and other external organisations are supported by making resources available and handling the formal arrangements; d) an extensive up-to-date library is maintained.
There is a "Studierichtingscommissie" (Curriculum committee)that advises the Board, the Council, and the "vakgroep" on issues concerning the education programme, either upon request or by its own initiative. Suggestions for changes from the teaching staff should also go through the Committee, upon whose recommendation the Council decides in these matters. The Faculty appoints guest professors and part-time professors from industry to update its staff, and through the staff its education programme. Guest professorships serve not only purposes of scientific or technological updating. Recently, a guest professorship served to acquaint the staff with the possibilities of CAL (computer aided learning) in

electrical engineering. In appointing full professors the Faculty intends to recruit externally whenever possible, in contrast to the past when the majority of appointees came from the Faculty itself." (Basic Information, Volume 1, page 88)

The Committee observed that an overall quality assurance system, in the sense normal in industry, does not exist. But discussions especially with the Committee for Evaluation of Education (Onderwijsevaluatiecommissie, OEC) showed activity in the field of evaluation. There is some evaluation of teaching quality by the student organisation and by the OEC. The Faculty should provide more supervision and advice for students in the first year, and maintain records of student progress. There should also be a record of the initial employment of graduates.

8. External relations

The Faculty describes contacts with industry as follows:
"No account is kept of the contacts of members of staff with industry. Some indication of their number can be found in the total of officially recognised journeys within the country by members of staff: 855 in 1990. Members of staff have direct contacts with relevant industrial partners, sometimes arising from longstanding links, sometimes on account of, for example, European Community or Dutch research programmes. Of course there are also research programmes based on bilateral cooperation. There are informal contacts by way of lectures in the department, Dutch and international commissions, congresses, meetings of alumni, and so forth. Part-time members of staff often have their principal occupation in industry; several staff members are appointed as consultants. Post-university courses lead to contacts between staff and lecturers from industry and between staff and participants in the course." (Basic Information, Volume 1, page 63)

The Committee assesses the relations with industry as quite good. Contact with other institutes seems to be adequate.

9. International relations

There are many international relationships due to active participation in research programmes (ESPRIT, JESSI) and due to personal connections. In the field of education there is the so-called "Six Angle Network" for international cooperation and exchange. The faculty is active both in presenting intensive courses and with students participating in courses abroad.

10. The graduate

The Committee assesses the quality of the typical graduate as good in his field of specialisation. This field is somewhat narrow to adequately support adaptation to future changes in Electrical Engineering. The graduate deserves the title "Master of Electrical Engineering. The graduates easily obtain jobs, and there is no unemployment. The Faculty has no information available to give a global indication of the destination of the graduates. The Committee considers this a shortcoming.

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ In the opinion of the Committee the Faculty certainly meets the minimum requirements set for Electrical Engineering. In spite of the four constraints on the nominal programme, the Faculty still made an effort to offer a broad programme. The Committee has the impression that the quality of the graduate is very good in his field of specialisation, which field is however somewhat narrow. The graduate merits the title "Master of Electrical Engineering".

+ The Committee considers the academic level of the staff to be very good.

+ The students the Committee has met made a very good impression: mature and open-minded.

+ The Committee supports the curriculum innovations and likes the idea of the three streams, but it did not find a clear approach on the way the idea will be translated into practice in the curriculum. It advises caution and much attention to monitoring the results of the curriculum change.

+ Links with industry and international links are more than adequate.

- It became clear to the Committee that it is difficult for students to finish their study in 4 years. The programme is too heavily loaded, even taking into account the relatively low study effort of the students (see 4.11). Therefore the Committee considers it necessary to change the nominal 4 years to at least 4.5 years, without expanding the curriculum. Such a move would make it possible for many students to study according to the schedule. For further broadening of the programme half a year more is needed, unless it is done at the expense of specialisation, which is not desirable.

- The assessment of the new curriculum is that it appears satisfactory. Though the new curriculum is certainly a step in the right direction, it is still too light on general engineering issues, especially in non-EE subjects such as chemistry and material sciences.

- The teaching load of the staff is low in the opinion of the Committee. The Committee noted that the main emphasis of the staff is on research. There are no real incentives for good teaching, which is a serious drawback, particularly in the basic part. There is too little participation of full professors in the basic programme. The Committee recommends a greater involvement.

- The Committee has the impression that improved management support is essential. Everyone seems to know what to do and is prepared to take action, but there is a lack of the managerial will, structure and responsibility requisite for taking necessary action.

- In formulating goals and aims, the Faculty should emphasize that it educates people who can autonomously read and interpret scientific literature. This identifies the academic level.

ERIC

13 SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING AT CHALMERS UNIVERSITY OF TECHNOLOGY, SWEDEN

Date of visit: 19/20 November 1991

1. Introduction

The second country to be visited in the framework of the International Programme Review Electrical Engineering (IPREE) has been Sweden. The first faculty in Sweden was the "Sektionen för Elektro- och Datorteknik" (School of Electrical and Computer Engineering) at Chalmers university of technology. For the members of the Committee see Appendix 1.

The school of Electrical Engineering is one of the 9 schools at Chalmers University of Technology. The university was founded in 1829. The total number of students at Chalmers University is about 5000, of whom 22% (about 1100) belong to Electrical Engineering. The School of Electrical and Computer Engineering is responsible for a 4.5 year Master's course in Electrical Engineering (EE). The School shares the responsibility for a 4.5 year Master's course in Information Science and Computer Technology with the school of Mathematical and Computing Sciences. The present Programme Review covers the Electrical Engineering course only.

All Swedish universities, with the exception of the University of Agricultural Sciences, fall under the jurisdiction of the Ministry of Education and Cultural Affairs. Until the present time the National Board of Universities and Colleges (UHÄ) has been the government authority responsible for higher education and research. Emphasis was placed on the evaluation, follow up and supervision of university matters, including legal aspects. It was also UHÄ's responsibility to provide information and service to students as well as to universities and university colleges, and to admit students to the general study first degree programmes. There is a recent government proposal that this National Board should be closed down, and this proposal will probably be accepted by parliament.

The university has a University Board, consisting of six representatives of the wider society, two professors, and two representatives of the students. The Rector of the University is Chairman of the Board. The Board is responsible for the overall planning of higher education and research within the university. Each of the nine schools at Chalmers has a Board (11 members) which contains a few external (industrial) members as well as a few students. The Academic staff is in a majority. The Board has full overall responsibility for research in the School and education in the EE programme.

The Dean of the School is the chairman and the executive member of the Board. Under the Board there is a working committee for research and post-graduate teaching, and another for the undergraduate EE teaching (M.Sc. Committee). The School is divided into departments, each governed by a Departmental Board. The Head of the Department (Prefekt) is Chairman of the Board. Academic staff, other staff, elected by their colleagues, and student representatives are members of the Departmental Board.

The School (Sektion) is divided into 14 departments (institutionen):
1. Electromagnetic field theory
2. Optoelectronics and electrical measurement
3. Radio and space science
4. Applied electron physics
5. Solid state electronics
6. Applied electronics
7. Medical electronics
8. Control engineering
9. Computer engineering
10. Network theory
11. Information Theory
12. Electrical machinery and power electronics
13. Electrical Power systems
14. High voltage technology

The Committee has no comments on the organizational structure and management. The organization looks coherent and consistent.

2. The student

* Previous schooling.

Until now about 30 per cent of the freshmen in the Schools for Electrical Engineering have come directly from secondary school. The Swedish student entering the university has had 12 years' schooling, 9 years' elementary school and 3 years' Gymnasium. The minimum requirement for all university education is graduation from a course of at least two years at secondary school (Gymnasium). For Engineering education there is also a minimum requirement of at least three years of mathematics, physics and chemistry. This can be done either in the scientific upper three years programme (Naturvetenskaplig linje), or in the technical upper three years programme (Teknsik linje). Students may come from other streams also; however 90 per cent have come through the science or technical streams.

The topics in mathematics on the scientific and technical level at secondary school include: characteristics of and calculations with different number sets (natural, integer, rational, real and complex numbers). Powers and logarithms. The calculator. Vectors in plane and space. Orthogonal coordinate system in plane and space. General function theory. Limits, continuity, derivatives and integral. Rational and trigonometric functions. Exponential and logarithmic functions. Area and volume calculation. Probability and statistics.
The topics in physics are mechanics with heat theory, forces, motion, impulse, energy, gases. Electric field, direct current, magnetic fields and induction, alternating current. Wave theory with acoustics and optics, electromagnetic waves. Atom models, energy levels, radioactivity, fission, fusion. Cosmic physics and geophysics. Measuring techniques.

The Committee has formed the view, based on information on secondary schools and information from the academic staff, that there may be some problems with the quality of secondary education. The previous schooling of the students seems in some aspects, e.g. mathematics, to be a little limited. The secondary school does not provide an homogeneous input into Electrical Engineering. The spread in the programmes in secondary schools leads to a situation where the university is obliged, in the first year, to level out big differences in mathematics, physics and languages.

* <u>Selection</u>

To be admitted to higher education programmes in Sweden, a student must first fulfil the general entrance requirements which are common to all first degree study programmes. Some disciplines can add special requirements. So Electrical Engineering requires mathematics, chemistry and physics. There was a central entrance selection by UHÄ (National Board of Universities and Colleges), based on the grade point average of all subjects in the examination certificate from secondary school. Points could also be added for work experience exceeding 1.5 years, which has the effect that work experience is necessary for students with a low grade point average. If the number of applicants exceeds the number of available places, a selection is made from among qualified applicants. In 1990 there were 64.000 applicants for all university programmes , but only 23.000 were admitted. To be accepted the student must <u>de facto</u> usually be among the best 40% in his class. The method of selection has recently changed. More students will be accepted with grade point average as the only parameter (2/3), since the possibility of adding credit for work experience has been removed. As an alternative selection mechanism there is a test of ability to study: here points for work experience may be added, though not until after five years of work experience.

* <u>Student numbers</u>

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The percentage of female students is high, compared with other countries. There are a few foreign students.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
229	219	7%	9%	1086	1063	9%	10%

Of the total number of applicants, about 400 give Chalmers as their first choice. The number of places is decided annually by government. The reasons for choosing Chalmers were often the fame of the university and the charm of living in Göteborg. Although it probably met a special selection of students with a positive attitude, the Committee was impressed by the large number of intelligent, serious and open-minded students. They are hard working, dedicated and well at ease with English. On the other hand the Committee had the impression that they were a little too "obedient" and not always critical.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
2251	229	1741	217

* Average duration of study, completion rates.

Since 1986 the nominal duration of the study period for the degree has been 4.5 years. This was changed from 4 to 4.5 without any increase of the study burden and without extra financing. The figure for the average actual duration of study, given by the School, is 4.9 years. A duration of 5.5 years seems to the Committee to be typical for the Western European (continental) universities. The effective length of the study period is determined by, among other things, the effort of the students and the organization of the programme. One reason for the small difference between nominal time and real time is the financial pressure on the students. They have to take loans and will be heavily in debt by the end of their course. Another reason is the structure of the programme. The students are well monitored in the initial phases of their study. Also the quarterly periods of 8 weeks with examinations in the last week have an effect. In addition, the students devote considerable time to their studies (see also 4.11).

TABLE 3: NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES

NOMINAL	EFFECTIVE
4.5	4.9

TABLE 4: DROP-OUT RATES AND GRADUATES, COHORT 1982/1983

FRESH-MEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D AFTER 10 YEARS
230	3%	45%	60%	65%	8%

The completion rate of the students cohort 1982/1983, used for international comparison, is 65 percent. For the period 1979/1985, Chalmers has an average rate of 67 percent. An overall completion rate of 60/65% seems to be an average for Electrical Engineering in the West-European universities (see the general conclusion in Part I, paragraph 6.6). The Committee wonders about an average completion rate of 67%, taking into account that the schools of Electrical Engineering receive freshmen from the best 40% of graduates of secondary schools. Moreover hard working seems to be a norm accepted by the students. One reason why the rates are lower than expected may be the fact that a significant number of students (it is said to be about 10%) go into industry before completing their studies and so do not get a degree.

3. Goals and aims

Chalmers has formulated the goal in terms of the academic level for all nine schools as follows: *"A Chalmers M.Sc. graduate is expected to possess an independent ability to acquire and to make professional use of up-to-date world knowledge available through scientific literature or conferences in his/her area of specialization".*
The School of Electrical and Computer Engineering has formulated the goals as follows:

"To educate Masters of Engineering Science with a high level of competence in engineering, and professionally applicable knowledge and skills concerning the realization of technology and its consequences for man, society and nature. The education must have a scientific basis, with a core of science and engineering subjects, leading to the production of graduates with the ability to obtain and apply new knowledge and technology in their areas. The M.Sc. graduate should be able to work in an international environment. It is the aim of the School that at least 10% of the graduates should have spent at least 3 months abroad in one of the programmes in which the School participates. The education aims to maintain and further the competence in engineering that is required in order to employ technology in the service of society and the individual in an efficient and up-to-date manner. The contents and the organization of the education are such that the graduate, after some years of professional experience within his area, can be expected to be responsible for the development or exploitation of new technology of internationally high standards. The ability to utilize technology is obviously an objective. In both cases it is a question of shaping products, processes, and working environments, with regard to the means available, and to the needs of man and the goals of society concerning social conditions, resource management, environment, and economy.

In terms of knowledge this means knowledge and skill in

a) mathematical and scientific subjects as well as fundamental and application-oriented technological subjects;
b) other subjects of importance for a professional life;
c) the connection between scientific and technological evolution and the life of man;
d) the scarcity of energy as of other natural resources, and the importance of good use of these.

In terms of skills the education should develop the abilities to:

a) identify, formulate, solve, and present a problem;
b) search for and retrieve information;
c) communicate in at least one foreign language, and to use technical literature and terminology in that language;
d) rapidly collect new knowledge in the areas of electrical engineering, and to apply new discoveries for the development and renewal of technology;
e) conduct electronic development and research work, thereby being able to carry out electronic experiments and measurements and to evaluate the results thereof;
f) construct electrotechnical products and systems to specifications;
g) use a system-oriented way of reasoning in planning, evaluation and optimizing;
h) describe electrotechnical processes with mathematical and physical models, and judge the applicability and limitations of these models in different situations;
i) exploit the possibilities of computer technology in the development of technological systems and the solution of problems.

In terms of attitudes the education should be such that the students acquire knowledge and skills, and develop their ability critically to judge phenomena of different sorts. The education should provide preparation for professional life, and further development within their profession." (Basic Information, Volume 1, pages 186/187

The Committee judges the formulation of goals and aims as good; however the translation into practice in the programme sometimes fails. Although the formulations "system thinking" and "environmental awareness" etc are stressed, this is not adequately reflected in the study programme. It should be noted that the translation of the aims and goals into practice in the programme is done in a way which does not leave the students much time for non-technical subjects and student life.

4. The programme

The School offers the degree programme Electrical Engineering, leading to the title civilingenjör.

4.1. The philosophy behind the programme

The School has stated the philosophy behind the programme as follows:
"The course of study is a theoretical education comprising 4.5 years of study. The graduate electrical engineer has a broad field of professional activity and is often employed in electrotechnical industry e.g. in companies working with telecommunications, computer, and power technology.

An electrical engineer may also work in other kinds of companies, since the technology is also used for control in the processing industry, measurements and calculations of various kinds, informatics etc. The programme aims to provide the students with a structured way of thinking and reasoning in the process of problem solving.

The capacity of the electrical engineer to work effectively with technology is influenced by his/her knowledge of language, oral and written communications, economics, industrial organization, etc. Courses in these areas are available as electives in the curriculum.

The term "technology" is to be understood in a broader sense, encompassing the product itself as well as the method or the process behind it. Moreover the economics of production, organization and marketing, from the perspective of producers as well as consumers, are included. In order to graduate from the course of study, the student has to complete 17 weeks of work outside the school, the aim of which is to make the student accustomed to a working environment and to the interrelations between individuals and groups of individuals." (Basic Information, Volume 1, page 177)

4.2. The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPREE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	15.2	7.1				22.3
PHYSICS	0	6.4				6.4
COMPUTER SCIENCES	2.1	5	2.6			9.7
GENERAL ENGINEERING SCIENCES	0	6.1	0			6.1
ELECTRICAL ENGINEERING SCIENCES	5.8	0	23.4			29.2
ELECTRICAL DESIGN[2]		2.6	0			2.6
NON-TECHN. SUBJECTS	1.9		0	0.5		2.4
ELECTIVES[3]	0	0	0	21		21
TOTAL	25	27.2	26	21.5		100% 2758 hrs
THESIS					800 hours	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for industrial training and thesis work are not counted in the percentage.
[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.
[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

"The first three years consist entirely of compulsory courses and are thus identical for all, or almost all, students. The first year consists of mathematics, computer science and a language, together with some electrical engineering courses. The second year contains mechanics, physics courses, and mathematics-related courses. Students wishing to follow the mathematical field of study make their choice during the second year, and then study a reduced set of otherwise compulsory third year courses. The third year consists of engineering courses."(Basic Information, Volume 1, page 178)

4.3. Mathematics; Basic sciences

The coverage of mathematics and the basic sciences (22% of the total contact hours) is excellent, but in the opinion of the Committee perhaps overemphasized.

4.4. General Engineering Sciences

The Committee noted a lack of chemistry, construction techniques, and materials science. Consequently the general basis is somewhat narrow.

4.5. Electrical Engineering Sciences

The Committee judges the coverage of Electrical Engineering Sciences in the programme as excellent. The Committee observed that Power Engineering was present in the basic curriculum. The programme is reasonably balanced in the compulsory part as a whole, but out of balance in the different years: in the first year 23 per cent of the total hours of the year, in the second year 10 per cent, and in the third year 90 per cent.
The emphasis lies on micro-electronics and communications, which is an important speciality in view of the presence of Ericson.

4.6. Electrical Design

The Committee has its doubts about meeting the minimal requirements for Electrical Design. It is very difficult to assess training for the design process. The VLSI design is good, the lack of analogue design is a weakness. In the opinion of the Committee there could be more design activities throughout the curriculum.

4.7. Non-Technical subjects

The Committee assesses the non-technical subjects as weak. There are no formal requirements matching the high aims, formulated in the objectives. The student has in principle the possibility of choosing some electives in the field of non-technical subjects. The Committee thinks this ought to be done in the compulsory part as well. There is an emphasis on English, especially business and professional English, in the compulsory part. In the opinion of the Committee, credit points should not be awarded for this.

4.8 Additional requirements

The IPREE-Committee has formulated additional requirements regarding laboratory experience of the students, the use of the computer, the attention paid by the academic staff to written and oral communication (Guide for the Committee, page 10). With regard to computer programming and engineering, the Committee considers the exposure to and training in computer programming and computer use as more than adequate. However, computer engineering (e.g. using computers in real-time systems) deserves more space in the curriculum.

Before graduation, a 17 weeks industrial (factory floor) experience is required. The aim is to make the student accustomed to a working environment and the interrelations between individuals and groups of individuals. In the eyes of the Committee this is acceptable, but the School has to be careful where the students do their work experience. It seems that the Master's thesis sometimes fulfils the function of a practical training period in industry, while it should really be an exercise in integrating disciplines under careful monitoring.

4.9 Master's thesis

The School gives the following description of the thesis work:
"In the Master's thesis (examensarbete) the student should tackle a problem and apply the knowledge he has acquired earlier in the course. The Master's thesis is assigned 20.0 units (= 800 hours). The actual time for completion of the thesis varies. The student can do the Master's thesis either in one of the departments of the university or in industry. If the student does the thesis in industry, the topic of the thesis must be approved, and the complexity of the task judged, in advance, by an examiner at one of the departments of the school. He is then also the person who finally approves and grades the thesis, and the student has to maintain contact with him while actually performing the work at a company. It is quite common that the theses are written in industry, and many companies provide the students with catalogues or suggested topics for the thesis at the company. The thesis can be written individually or in groups of usually two students." (Basic Information, Volume 1, page 194).

The Committee observed a very strong connection between thesis activities and industry, and expresses its concern about the large number of theses which are produced in industry. The thesis is part of the curriculum where students can integrate their knowledge in various disciplines under the supervision of a master. It should therefore be done in a concentrated period at the end of the curriculum. There must be good control over coaching and the assessment of the thesis. The responsibility must lie in the university and not in the company. The thesis produced in industry is problematic also because those students are paid by industry. This diverts students from thesis activities in the School.

The Committee feels that the thesis in the curriculum offers more opportunities for education than are being used. The department must place more value on the thesis, and try to encourage theses to be produced in the department. When industry is willing to pay for the thesis, it is better to make the payment to the School and not to the individual student.

4.10. Examinations: regulations and requirements

About the examinations and the requirements for examinations the School has given the following information:
"The most common type of assessment at the school is the written examination. Certain course do have examinations in the form of project work with oral presentation. The courses that have this form of examination are to be found among the elective courses, and it is more common in the advanced courses than it is in the basic courses. However this is not a very common form of examination.

The school year is divided into four quarters of seven weeks each, and the examinations are given in the eighth week, with some exceptions. The students normally have about three examinations in this so-called examination week. In addition to these four examination periods, the School year contains three more main examination weeks which are mostly used for the re-examination of students who did not pass the examination the first time. The examinations are usually of a problem-oriented form where the students have to show ability to apply the methods learned in the course; but theory is also tested. Since attendance at lectures and tutorials is voluntary, the examination results alone are the basis for grading, and classroom performance does not affect the grade. Some courses have problems that have to be solved and handed in as the course proceeds, and the department giving the course then sometimes decides that performance at these problems can affect the examination score in a positive way. It is decided beforehand what score is required on the examinution in order to pass. The students may take an examination as many times as needed to pass, and even after passing they may resit it in order to get a better grade. Where the course includes laboratory exercises, completion of these is compulsory for receiving a final grade on the course. The course can also contain other mandatory tasks such as design exercises etc." (Basic Information." Volume 1, page 195)

The Committee judges the manner of assessment and examination as adequate. But the Committee feels that it is not a good idea to allow an examination to be repeated again and again to improve the grade. The number of attempts should be limited, taking account of constraints on time and money.

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4.11. Study burden

As is to be seen in Table 6, the total programmed period is 7200 hours, that is about 1600 yearly. Chalmers assesses in terms of study points. One week's full time study is equivalent to one point, and one term's full time study to 20 points. 1 credit point is about 40 hours and one year counts for 40 credit points. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 1:1. The students spend about 50% of their time at the university, and are expected to spend about 50% on self study.

TABLE 6: TOTAL STUDY BURDEN

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
2250	508	2758	680	800	7200

Many lectures are coupled with tutorials, small working groups for exercises. So the figure for lectures is about 55% 'real' lectures and 45% tutorials. The first three years consist entirely of compulsory courses and are thus identical for all, or almost all, students. The 4th year is the year of the electives. For the Master's thesis 800 hours (20 credit points) hours are programmed. It is not clear how many hours the students spend on their studies. According to the School, the nominal study burden is about 1400 hours yearly (= 9 months), that is about 40 hours a week. The students appeared to be very motivated and hard working. According to their statements they studied 50/60 hours a week, for about 9 months, making 1800/2000 hours yearly. It appears that the study burden is out of balance. An 8-week period starts with few hours and ends at the time of examination with 60/70 hours. Notwithstanding the predictable exaggeration by students, the programmed study burden is in the judgement of the Committee underestimated. However the programme is completed by 50 per cent of the students in 4.9 years.

4.12 Overall assessment of the programme

The total programme is more than acceptable. It is a rather broad engineering programme. In the opinion of the Committee the programme could be made more coherent by shifting basic topics of Electrical Engineering to years 1 and 2, to a greater extent than is currently done. Although the programme is a good programme for the 4.5 years and meets the minimal requirements, the Committee considers there is room for improvement. The staff and the students should stay critical towards the programme. The curriculum should lead to more 'independent' students. They are well guided throughout the curriculum, but maybe they should be left rather more alone.

5. The Academic Staff

The academic staff fall into four main categories:
* full professors
* senior lecturers
* assistant lecturers
* research assistants

The Committee considers the size of the academic staff as adequate (See Table 7). The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. This number is 21 (see Table 8). A possible measurement of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 3,2 graduates per FTE-teaching.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	Full time equivalent	Persons
* Full professors	20	22
* Associate professors/senior lecturers	24	27
* Assistant professors/junior lecturers	8	10
* Research assistants/Ph.D students	130	138
* Others	40	49
Total academic staff	222	246
Non-academic staff	90	121

The teaching load is, in general terms, acceptable but certainly moderate. The Committee has the impression of an unbalance between research and teaching, caused by the fact that associate professors were allowed only to teach until a few years ago. Although the law has been changed, the practice seems to be the same. The Committee noted also a rather low involvement of full professors in the basic programme. The Committee feels that presence of full professors is critical in this phase. There are also no formal staff development programmes. The didactic expertise of the staff seems to be adequate. In the interviews with the students the Committee observed that the students are generally satisfied with the manner of teaching. The academic level can be considered as very good. There is a heavy emphasis on research, to be seen in the large number of Ph.D. students (138), and a yearly output of 25 Ph.D.s.

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
50	1063	160	21	3.2

The Committee wonders about the two degrees: Licentiate and Doctorate. After the Master's degree about one fifth of the graduates go on to doctoral programmes. There are two types: a) the Licentiate and b) the Ph.D. A Licentiate in engineering takes two and half years, and the Ph.D. five to six years. Although the Licentiate is intended as a final degree, most of the students used the Licentiate as an intermediate stage leading to the Ph.D.

The scientific activities are sufficient. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff

member is 0.9, which can be considered as rather low (see Table 9).
There seem to be very strong areas, e.g. radio astronomy, and some weaker areas, e.g. analog IC design, which indeed seems to be non-existent.

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Number of papers	105	105	130	130	179
Number of papers per staff member (excluding "others")					0.9

Personnel management appears to be rather good. There are well-balanced incentives to do good work. There are financial rewards for staff members fulfilling the criteria for good performance. It is certainly a good idea to attract engineers from industry to help in evening practicals.

6. Resources and Facilities

All Swedish universities are financed by the state. In the eyes of the Committee the funding is good; the funding by research foundations is notably high. There is a little funding by industry. In Table 10 some figures about the finances are given.

TABLE 10: INCOME AND EXPENDITURES OF THE SCHOOL

INCOME		EXPENDITURES	
State	58.8%	Education	32.7%
Industry	11.1%	Research	67.3%
Research foundations	30.1%	Total	100%
Other			
Total	100%		

The teaching equipment is good, as far as it was possible to judge. The laboratories were very well equipped with modern materials. For the practical work, there was a friendly and stimulating atmosphere. With regard to computer equipment and teaching, there would seem to be scope for greater use of computers. The Committee has the impression that there is little computer-aided instruction, e.g in terms of simulation packages.

7. The internal Quality Assurance

On internal quality assessment, the School gives no information. With regard to external quality assessment and accreditation, the School says: " *No system at the moment. Through the existing regulations in Sweden (made by the Government and the National Board of Universities, UHÄ) the level of education on different campuses is already quite similar, so the need for accreditation has been low. However, this will change with increased internationalization and a new role for UHÄ has already been discussed.*" (Basic Information, Volume 1, page 199).

The Committee saw little attention to evaluation and internal quality management. It is possible that this is closely related to the evident high esteem for their own curriculum.

8. External relations

The School describes contacts with industry as follows:

"1. The Board of the School of Electrical and Computer Engineering has three members from industry;
2. Some, but not very many, research projects have grants from industry;
3. There are many informal contacts between the individual researchers and industry. Almost every researcher has at least a couple of contacts. The vast majority of research contracts are funded by the government (with money from company taxes), but industry has some influence on the research through the informal industrial contacts;
4. Industry will buy courses for their internal staff development from our teachers.

Industrial companies often market themselves among the students. The Student Union organizes company exhibitions every year where the companies can exhibit themselves and make personal contacts with the students. Larger companies invite groups of students, especially from the third and fourth years, for a visit to the company. Many student clubs and activities are sponsored by companies as another way of marketing among students. It is quite common that the Master's thesis is written at a company, and the companies then provide catalogues for the students to choose the topics". (Basic Information, Volume 1, page 173 and page 198.

The Committee noticed and appreciated very strong links with industry. shown in a formal way by the fact that the Board has members from industry. There are also many informal ties with industry. The connections are a little biased, focused on a few big companies. The contacts with other institutes depend on the Chair holder, but are to be considered as adequate.

9. International relations

The School has several contacts within Europe, especially with the U.K.

10. The graduate

The Committee expresses its view that the School produces good and mature engineers. They are hard working and highly motivated; but possibly this derives from their greater average age, compared with those of other countries. The graduate has a good grounding in theory, but is lacking in experience of handling electrical design projects, except in the context of work for the thesis. There is an emphasis on solving well defined problems. Nevertheless the graduate merits the title of Electrical Engineer in the judgement of the Committee. Until now students have not had problems in obtaining jobs, but nowadays it is becoming more difficult due to economic recession in Sweden. Table 11 gives the distribution of the destination of 1357 Chalmers graduates. Of all graduates 90% find a job in industry, and 10% in the non-industrial sector, of which 6,5% are in universities. The Committee has no comments.

TABLE 11: DESTINATION OF GRADUATES

Industrial companies	90.5%
testing/patents	1.4%
universities	6.5%
secondary school	0.5%
medical (hospitals)	1.2%

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult t a balance in the comments. It is not always the same matters in a faculty which attr attention of the Committee. The Committee has tried to formulate the five most imp positive remarks and five negative ones. The reader must understand that it i sufficient only to read the summary: the whole report must be read to reach a understanding.

+ The programme offered at Chalmers is good and meets the minimum requireme by the Committee in the Guide for the IPREE. The Committee has the c impression that the quality of the graduates is good and that they merit th "Master of Electrical Engineering".

+ The Committee was impressed by Chalmers. It saw a good, well equipped schoo a competent staff.

+ The Committee observed that the School has very good relations with industry.

+ The Committee is impressed by the amount of basic sciences of high quality, s mechanics. In the view of the Committee there is too much analytical emphasis a little synthesis.

+ The Committee met a good number of bright and mature students. The students very good in English.

- The Committee felt the lack of a critical attitude towards the curriculum, from th of the staff as well as from that of the students.

- With regard to the thesis, the Committee expresses its concern about the large n of theses which are produced in an industrial setting. The thesis is part curriculum where students can integrate their knowledge in various disciplines the supervision of a master. The Committee feels that within the curriculum the offers more educational potential than is being realized in Chalmers.

- The Committee considers a greater involvement of the full professors in the programme to be necessary.

- The Committee noted a very meagre provision of non-technical subjects. Because in practice most engineers will stay only a relatively short time in the technical field, and after some time will take up managerial positions, it is advisable to make provision in the curriculum for non-technical subjects, such as project management and accountancy.

- With regard to the elective courses, the Committee observed a high degree of freedom of choice. In principle, it is possible to graduate in a certain field without enough knowledge in that field. The choices should therefore receive the explicit prior approval of a full professor.

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14 SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES AT LUND UNIVERSITY, SWEDEN

Date of visit: 21/22 November 1991

1. Introduction

The second country to be visited in the framework of the International Programme Review Electrical Engineering (IPREE) was Sweden. The second faculty in Sweden was the "Sektionen för Elektroteknik och Datateknik" (School of Electrical Engineering and Computer Sciences) at Lund University. For the members of the Committee see Appendix 1.

The School of Electrical Engineering is part of the Institute of Technology, one of the nine areas at Lund University. Lund university was founded in 1666. The Institute of Technology (Lunds Tekniska Högskola, LTH) was founded in 1961 and became part of the university in 1969. The Institute of Technology has about 5000 undergraduate students, of whom 23% (1150) are enrolled in Electrical Engineering. The Institute of Technology is divided into 6 schools, one of which is the School of Electrical Engineering and Computer Sciences. The school offers two programmes: a) Electrical Engineering and b) Computer Science. The IPREE Committee has looked only at the programme for Electrical Engineering.

All Swedish universities, with the exception of the University of Agricultural Sciences, fall under the jurisdiction of the Ministry of Education and Cultural Affairs. Until the present time the National Board of Universities and Colleges (UHÄ) has been the government authority responsible for higher education and research. Emphasis was placed on the evaluation, follow up and supervision of university matters, including legal aspects. It was also UHÄ's responsibility to provide information and service to students as well as to universities and university colleges, and to admit students to the general study first degree programmes. There is a recent government proposal that this National Board should be closed down, and this proposal will probably be accepted by parliament.

Lund University has a University Board, consisting of 8 members appointed by the Government, 4 members elected by the academic staff and 2 members elected by the students. The Vice-Chancellor - elected by the academic staff, other staff, and students, and then confirmed by the Government - is Chairman of the Board. The Board is responsible for the overall planning of higher education and research within the university.

At School level there is a Study Programme Committee (linjenämnd), responsible for the planning and coordination of one or more study programmes. Academic staff, other staff (appointed by their colleagues), students, and industry are represented on the committee. There is also a board responsible for planning and administering postgraduate studies and research. The school is divided into departments, each governed by a Departmental Board. The Head of the Department (Prefekt) is Chairman of the Board. Academic staff, and other staff, elected by their unions, and student representatives are members of the Departmental Board. The School has a Board of Research and Graduate Programmes, and a Board of Undergraduate Programmes.

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The School is divided into 9 departments:
1. Telecommunication Theory
2. Communication systems
3. Information Theory
4. Applied Electronics
5. Computer Science
6. Computer Engineering
7. Electromagnetic Theory
8. Electrical Measurements
9 Industrial Electrical Engineering/Industrial Automation.

The Committee observed that the organizational structure is complex, and that the two sectors (basic programme and main programme) are markedly disconnected. The relationship between the different programmes (basic programme, main programme and Ph.D programme) seems to be weak, caused by different organizational structures and separate executive boards. The organization seems not strong enough to acquire the authority needed to make breakthrough decisions. The role of the programme committee is unclear. In the opinion of the IPREE Committee it is not good to have advisory and decision-making functions in one and the same committee. According to the academic staff, the visibility of engineering education seems to be hindered by the fact that it is part of a large university. In the opinion of the Committee the School should increase the visibility of Electrical Engineering.

2. The student

* Previous schooling.

Until now about 30 per cent of the freshmen in the Schools for Electrical Engineering have come directly from secondary school. The Swedish student entering the university has had 12 years' schooling, 9 years' elementary school and 3 years' Gymnasium. The minimum requirement for all university education is graduation from a course of at least two years at secondary school (Gymnasium). For Engineering education there is also a minimum requirement of at least three years of mathematics, physics and chemistry. This can be done either in the scientific upper three years programme (Naturvetenskaplig linje), or in the technical upper three years programme (Teknsik linje). Students may come from other streams also; however 90 per cent have come through the science or technical streams.

The topics in mathematics on the scientific and technical level at secondary school include: characteristics of and calculations with different number sets (natural, integer, rational, real and complex numbers). Powers and logarithms. The calculator. Vectors in plane and space. Orthogonal coordinate system in plane and space. General function theory. Limits, continuity, derivatives and integral. Rational and trigonometric functions. Exponential and logarithmic functions. Area and volume calculation. Probability and statistics. The topics in physics are mechanics with heat theory, forces, motion, impulse, energy, gases. Electric field, direct current, magnetic fields and induction, alternating current. Wave theory with acoustics and optics, electromagnetic waves. Atom models, energy levels, radioactivity, fission, fusion. Cosmic physics and geophysics. Measuring techniques.

The Committee has formed the view, based on information on secondary schools and information from the academic staff, that there may be some problems with the quality of secondary education. The previous schooling of the students seems in some aspects, e.g. mathematics, to be a little limited. The secondary school does not provide an homogeneous input into Electrical Engineering. The spread in the programmes in secondary schools leads to a situation where the university is obliged, in the first year, to level out big differences in mathematics, physics and languages.

* Selection

To be admitted to higher education programmes in Sweden, a student must first fulfil the general entrance requirements which are common to all first degree study programmes. Some disciplines can add special requirements. So Electrical Engineering requires mathematics, chemistry and physics. There was a central entrance selection by UHÄ (National Board of Universities and Colleges), based on the grade point average of all subjects in the examination certificate from secondary school. Points could also be added for work experience exceeding 1.5 years, which has the effect that work experience is necessary for students with a low grade point average. If the number of applicants exceeds the number of available places, a selection is made from among qualified applicants. In 1990 there were 64.000 applicants for all university programmes , but only 23.000 were admitted. To be accepted the student must de facto usually be among the best 40% in his class. The method of selection has recently changed. More students will be accepted with grade point average as the only parameter (2/3), since the possibility of adding credit for work experience has been removed. As an alternative selection mechanism there is a test of ability to study: here points for work experience may be added, though not until after five years of work experience.

The academic staff expresses a wish for more involvement in the selection procedure. They would like to have a process of selection by themselves to determine which students will enter Lund and which ones not. Although this seems not to comply with current governmental procedures, it may be possible to find means to achieve this.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The percentage of female students in 1990 is low, but in the previous 5 years the average was 10 per cent. It is not clear whether the low figure for 1990 is a unique dip. There are a few foreign students.

The reasons students had for choosing Lund were often the small scale ot Lund, the good student life, and proximity to the student's home. The students the Committee spoke to were selected by the Students Union and not by the academic staff. They made a good impression. The freshmen, who had been at the university for only a few months, had a good opinion of the academic staff. The students in later years and the Ph.D. students were open-minded, mature (and often quite old), and critical. The students are hard working, due to the facts that every 8 weeks there are examinations, and that there are many tutorials and contact hours (about 30 hours a week).

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TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
156	186	10.9%	4.3%	750	1150	?	?

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
1666	156	1360	186

* Average duration of study, completion rates.

Since 1986 the nominal duration of the study period for the degree has been 4.5 years. This was changed from 4 to 4.5 without any increase of the study burden and without extra financing. The figure for the average actual duration of study, given by the School, is 5.8. A duration of 5.5 years seems to the Committee to be typical for the Western European (continental) universities. The effective length of the study period is determined by, among other things, the effort of the students and the organization of the programme. The Committee wonders why there is such a discrepancy between nominal time and real time. One reason may be that the students have a more relaxed attitude with regard to the financial pressure on student funding. In the opinion of the Committee the system for ensuring completion in a reasonable time frame is weak.

TABLE 3: NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES

NOMINAL	EFFECTIVE
4.5	5.8

The completion rate of the student cohort 1982/1983, used for international comparison, is 56% per cent after 6 years (see Table 4). The completion rate after more than 6 years is not known, but estimated at 60%. An overall completion rate of 60/65% seems to be average for Electrical Engineering in the Western European universities (see the general conclusion in Part I, paragraph 6.6). The Committee thinks that a completion rate of 60% is rather low, taking into account that the schools of Electrical Engineering receive freshmen from the best 40% of graduates of secondary schools. One reason why the rates are lower than expected may be the fact that a significant number of students (it is said to be about 10%) go into industry before completing their studies and so do not get a degree.

TABLE 4: DROP-OUT RATES AND GRADUATES, COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D after 10 years
156	3%	16%	56%	60%?	<5%

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3. Goals and aims

The School has formulated the goals as follows: *"There is an official declaration about this which is two pages long. In brief, our aim is to give our students extensive knowledge in the fundamental sciences as a basis for education in the applied areas. The aim is to produce engineers with the capacity to develop (or to lead the development of) new technology (as opposed to handling, maintaining and supporting existing technology)."*(Basic Information, Volume 1, page 223).

The Committee regrets that the declaration was not translated. But with respect to what was learnt during the visit, the Committee judges the formulation of the aims as good. The Committee has the impression that the goals are more science oriented than engineering oriented, perhaps due to the university environment.

4. The programme

4.1. The philosophy behind the programme

The School has stated the philosophy in the same way as the goals (see 3).

4.2. The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPREE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	TOTAL
MATHEMATICS	12.3	8.0			20.3
PHYSICS	6.3			3.1	9.4
COMPUTER SCIENCES	5.9	3.1	2.0		11.0
GENERAL ENGINEERING SCIENCES	0		2.0		2.0
ELECTRICAL ENGINEERING SCIENCES	2.1	10.7	19.8	8.5	41.1
ELECTRICAL DESIGN[2]		4.2			4.2
NON-TECHNICAL SUBJECTS					0
ELECTIVES[3]	0	0		11.5	11.5
TOTAL	26.6	26	23.8	23.1	100% 2584 hrs
THESIS				600 hours	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis work are not counted in the percentage.

[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.

[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

During the first year a major part of the curriculum is devoted to basic mathematics and physics, as well as an introduction to computer science. In the first year all the courses are compulsory and identical for all students. In the second year most courses are compulsory too and identical for all students. A few courses are optional (almost every student takes Computer Programming 2). In the 3rd year the compulsory courses have a marked emphasis on electrical engineering. In the spring semester the student makes a choice between specializations: Electronics or Telecommunications. Each specialization has three sector programmes.

4.3. Mathematics; Basic sciences

Mathematics and the basic sciences are very well covered, but in the opinion of the Committee perhaps overemphasized. Probably there is too much Analysis, while more Discrete Mathematics are required. There is little or no thermodynamics. The interaction with Electrical Engineering is rather small.

4.4. General Engineering Sciences

The requirements for General Engineering Sciences are hardly met. The Committee noted a lack of Chemistry and Mechanics. Thus the general basis may be considered rather narrow.

4.5. Electrical Engineering Sciences

The Committee judges the Electrical Engineering Sciences as good, in terms of coverage in the programme. However, the programme begins Electrical Sciences too late: it would be better for the motivation of students to have it earlier in the programme. The Committee noted that there is not explicitly a power engineering course in the basic programme, although it appear that power engineering topics are included in some courses.

4.6. Electrical Design

The minimum requirements for Electrical Design are met. Both digital and analog design are present. Design is covered by shorter projects and also by the thesis.

4.7. Non-Technical subjects

The Committee noted the absence of non-technical subjects in the compulsory programme. The student has the possibility to choose some electives in the field of non-technical subjects, but there is a lack of pressure to follow some course work where items like project planning and management are treated. The Committee thinks the best way to proceed is to include these in the compulsory programme.

4.8 Additional requirements

The IPREE-Committee has formulated additional requirements regarding laboratory experiences of the students, the use of the computer, the attention paid by the academic

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staff to written and oral communication (Guide for the Committee, page 10). With regard to these requirements, the Committee has no remarks to offer. Before graduation, a period of 17 weeks industrial experience is required, of which 11 weeks must be factory floor experience. The aim is to accustom the student to a working environment and to the interrelations between individuals and groups of individuals.

4.9 Master's thesis

The School gives the following description of the thesis work:
"During the final ninth term the master's thesis is completed. The programmed time is 15 credit points (= 600 hours). The student chooses among projects which are offered to him/her, or proposes himself/herself one of the following subjects: Electromagnetic theory, Electrical measurements, Applied Electronics, Telecommunication theory, Communication systems, Information theory, Industrial engineering and automation, Computer engineering, Computer science, Mathematics, Mathematical statistics, Physics, Solid state Physics, Automation control, Solid Mechanics. A supervisor is appointed. If the project takes place in an industrial laboratory, the firm provides an additional supervisor. The project is, after completion, presented to the department and scrutinized at a seminar" (Basic Information, Volume 1, page 240).

The Committee observed a very strong connection between thesis work and industry, and expresses its concern about the large number of theses which are produced in an industrial setting. The thesis is part of the curriculum where students can integrate their knowledge in various disciplines under the supervision of a master. It should therefore be done in a concentrated period at the end of the curriculum. There must be good control over coaching and the assessment of the thesis. The responsibility must lie in the university and not in the company.

The thesis produced in industry is problematic also because those students are paid by industry. This diverts students from thesis activities in the School.

The Committee feels that the thesis in the curriculum offers more opportunities for education than are being used. The department must place more value on the thesis, and try to encourage theses to be produced in the department. When industry is willing to pay for the thesis, it is better to make the payment to the School and not to the individual student.

4.10. Examinations: regulations and requirements

About the examinations and the requirements for examinations the School has given the following information: *"Examinations take place at the conclusion of each course. Practically all examinations are written ones. The student who is failed is allowed (de facto if not de jure) an indefinite number of repeat attempts"* (Basic Information, Volume 1, page 241).

The Committee judges the manner of assessment and examination as more than adequate, while offering the opinion that there are too many examinations. The level is good, but some of the examinations are descriptive in nature and not always oriented to the right approach. There is too much solving of standard problems and often too much asking for facts. The Committee feels also that it is not a good idea to allow an examination to be repeated to improve the grade. The number of attempts should be limited, taking account of constraints on time and resources.

4.11. Study burden

The year is divided into four quarters of seven weeks each, and the examinations are given in the eighth week. Lund conducts assessment in terms of study points. One week's full time study is equivalent to 1 point, and one term's full time study to 20 points. One credit point is approximately 40 hours, and one year counts 40 credit points. For the whole study for Electrical Engineering 180 credit points are required (=7200 hours), as is to be seen in Table 6. The total programmed hours amount to about 1600 yearly. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2:3. The students spend about 40% of their time at the university and are expected to spend about 60% on self study.

TABLE 6: TOTAL STUDY BURDEN (ELECTRONICS)

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
2089	505	2594	680	600	7200

Many lectures are coupled with tutorials, small working groups for exercises. So the number for lectures is about 40% 'real' lectures and 60% tutorials. It is not clear how many hours the students spend on their studies. According to the School, the nominal study burden is about 1400 hours yearly (= 9 months), that is about 40 hours a week. According to information from the students, they studied 1600 hours yearly (during some 9 months). It appears that the study burden is out of balance. In the 8 weeks period of a course it starts with few hours, rising by the time of the examination to 60/70 hours in a week. In the judgement of the Committee the time needed for the programmed study burden is underestimated, although the programme is finished by 50 per cent of the students in about 5 years.

4.12 Overall assessment of the programme

The Committee's impression is that the programme is more oriented to a scientific career and less to an engineering career. Engineering capabilities are largely acquired via elective courses. The programme is not always very consistent. In view of the limited time of 4.5 years, Electrical Engineering starts too late as a result of the amount of mathematics and physics in the first year. The coordination between mathematics and physics should be improved. The Committee noted also a lack of intergration between the basic programme (years 1 and 2) and the programme in years 3 and 4. The Committee judged the programme as strongly directed, leaving little room for "free thinking". Nevertheless, the Committee thinks the total programme is acceptable, though improvement in several respects is needed. The Committee remarked that the students became acquainted with the use of the library only at a very late stage of their studies. It recommends that students in the first year be trained in information retrieval and library use.

5. The Academic Staff

The academic staff fall into four main categories:

* full professors
* senior lecturers
* assistant lecturers
* research assistants

The Committee wonders if the number of full professors is adequate to cover the broad field of Electrical Engineering .:ecessary for the curriculum (see Table 7). The size of the staff is adequate with regard to the number of students. The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full-time-equivalents of 40 hours weekly) for teaching. This number is 19 students per FTE-teaching (see Table 8). A possible measurement of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 1.9 graduates per FTE-teaching.

The teaching load of the staff can be considered as normal. The Committee considers a greater involvement of the full professors in the curriculum necessary. Full professors should certainly participate in the basic programme. The Committee noted that the full professors put more emphasis on research than on teaching. There is an emphasis on teaching by the associate professors.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	Full time equivalent	Persons
* Full professors	10.8	11
* Associate professors/senior lecturers	33.3	34
* Assistant professors junior lecturers	12.1	13
* Research assistants Ph.D. students	57.8	100
* Others		
Total academic staff	114	158
Non-academic staff	59.2	65

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
62	1150	120	19	1.9

The didactic expertise of the staff seems to be adequate. In the interviews with the students, the Committee observed that generally they are content with the way of teaching.

The academic level can also be considered good, though there is a rather low number of publications. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 0.8, which can be considered rather low (see Table 9).

There are good international contacts. The school has many Ph.D. students, but output is low (only 5 Ph.Ds yearly) and the period of study long (6 years). The Committee wonders about the two degrees: Licentiate and Doctorate. After the Master's degree about one fifth of the graduates go on to doctoral programmes. There are two types: a) the Licentiate and b) the Ph.D. A Licentiate in engineering takes two and half years, and the Ph.D. five to six years. Although the Licentiate is intended as a final degree, most of the students used the Licentiate as an intermediate stage leading to the Ph.D.

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Number of papers			129	125	
Number of papers per staff member (excluding "others")				0.8	

The system of personnel management is not clear to the Committee. There is an impression that government regulations impose a considerable reduction of freedom, and the School asserts that the government hinders it in making decisions.

6. Resources and Facilities

All Swedish universities are financed by the state. In the eyes of the Committee the funding is good, but there is little funding by industry. The School complains about shortage of money. In Table 10 some figures about the finances are given.

TABLE 10: INCOME AND EXPENDITURES OF THE SCHOOL

INCOME		EXPENDITURES	
State	78.0%	Education	51.0%
Industry	3.6%	Research	49.0%
Research foundations	18.4%	Total	100%
Total	100%		

The teaching equipment is adequate, as far as it was possible to judge. The laboratories were very well equipped with modern materials. There are good procedures and enthusiastic students. Although the computer equipment in the basic part is good, the students complained about the poor access to computer equipment.

7. The internal Quality Assurance

There is no internal quality assurance system, however there is an institutionalized and regular assessment after the completion of each course. Sometimes the students do some evaluation, but the questions do not always represent the quality issues under scrutiny.

8. External relations

Links with industry are reported as follows: " *Industrial representation in study programme committee. Considerable portion of Master's theses in industrial laboratories. Regular visits to relevant industries. No sponsoring; no grants*". (Basic Information, Volume 1, page 219).

Although there are formal ties through the fact that the Board has members from industry, and although there are also many informal ties with industry, the Committee learned that there are very few contracts with industry. Contacts with other institutes are at a questionable level, from the institutional perspective, though adequate on a personal basis. There is a wish to have better contacts with other institutes.

9. International relations

International relationships can be considered as good, although a little limited.

10. The graduate

The Committee feels that the school produces good and mature engineers, although in the opinion of the Committee they are rather old (graduating at an age of 27/28 years). The graduate has had more a science-oriented than a professional engineering-oriented education. He is lacking some experience in design projects. In the opinion of the Committee the graduate merits the title of Electrical Engineer. Till now, students have not had problems in obtaining jobs. But nowadays, due to an economic recession in Sweden, it is becoming more difficult. Table 11 gives the distribution of the destination of Lund's graduates. Of all graduates, 65% find a job in industry, and 35% in the non-industrial sector, of which 15% are in a university or in research. The Committee has no comments.

TABLE 11: DESTINATION OF GRADUATES

Industrial companies	65.0%
Government	20.0%
Universities/research	15.0%

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ The programme offered at Lund is acceptable and meets the minimum requirements set by the Committee in the Guide for the IPREE.

+ The Committee has the impression that the quality of the Lund graduate is good and that (s)he merits the title "Master of Electrical Engineering", although (s)he has had more a science-oriented than a professional engineering-oriented education.

+ The School as a whole made a good impression. People were enthusiastic and critical. Everything seems up to date.

+ The Committee has a good impression of the students. The students of the later years and the Ph.D. students were mature, but rather old. The students seem to be more relaxed and less "4.5 years" oriented.

+ The Committee judged the quality of the staff as good; the working environment is pleasant, open and good.

- The organization is complex and not very effective. Organization and managerial strength need to be improved, with more coherence between the basic and advanced programmes, and better integration of Mathematics and Electrical Engineering.

- With regard to the thesis, the Committee expresses its concern about the large number of theses which are produced in an industrial setting. The thesis is part of the curriculum where students can integrate their knowledge in various disciplines under the supervision of a master. The Committee feels that within the curriculum the thesis offers more educational potential than is being realized in Lund.

- The Committee considers a greater involvement of the full professors in the curriculum necessary. In particular full professors should certainly participate in the basic programme. The Committee wonders whether the number of full professors is adequate to cover the required specializations.

- The Committee noted a very meagre provision of non-technical subjects. Because in practice most engineers will stay only a relatively short time in the technical field, and after some time will take up managerial positions, it is advisable to make provision in the curriculum for non-technical subjects, such as project management and accountancy.

- With regard to the elective courses, the Committee observed a high degree of freedom of choice. In principle, it is possible to graduate in a certain field without enough knowledge in that field. The choices should therefore receive the explicit prior approval of a full professor.

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15 FACULTY OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY AT THE TECHNISCHE UNIVERSITÄT MÜNCHEN, GERM

Date of visit: 10/12 December 1991

1. Introduction

The third country in the International Programme Review Electrical Engineering (IPRE was Germany. Here the Technische Universität München was involved. The choice München was made on purely pragmatic grounds, because the VSNU had connectio with München. For the members of the Committee see Appendix 1.

The Technische Universität München was founded in 1868 as a Polytechnic school. 1970 the Hochschule was renamed Technische Universität. At the moment the Univers of München has 11 Schools (Fachbereiche). The total number of students at the TUM about 24.000, of whom 15% (about 3700) are in the School of Electrical Engineering.

The Technische Universität is responsible for its own administration, whilst remaini under state (Land and Federal) legal control. The central bodies of the University are President, the University Senate and the Standing Committees. The President (Präsident) head of the university and acts as external representative. There are two Vice-Preside elected by the Assembly (Versammlung). The first Vice-President (Vizepräsident) is President's representative and is Chairman of the University Senate. The Chancel (Känzler) is a civil servant for life, attending to day-to-day administrative affairs accordi to the Presidents's instructions; he is in charge of the budget.
The Assembly (Versammlung) is responsible for fundamental university political matte the enactment of and changes to the basic regulations of the University, as well as receipt and debate of the President's annual report. The Assembly elects the President a Vice-president. It elects also the members of the three Standing Committees. The th Standing Committees are for Finances, Construction, and Planning. These Committees chaired by the Chancellor, the second Vice-President and the President respectively. T Senate is responsible for academic affairs, e.g. examination regulations, acade appointments, and honorary academic awards.

The TUM has one School (Fachbereich) of Electrical Engineering, including a Information Technology. The staff of the Faculty is organized into five Institutes. E Institute consists of several Chairs, each one headed by a full professor. The Institutes a
1. Power Engineering
2. Information Technology
3. Fundamental Electrical Engineering
4. Circuitry
5. Automation Technology

In the view of the Committee it is difficult for an outsider to get a clear view about way the school is managed. It is difficult to get data, especially financial data.The Sch does not seem to have a real managerial structure above the level of the Chair hol There is little evidence of thinking in terms of cost/benefit analyses. The organizat places emphasis on the position of the Chair. The administrative section which monit student data, research data, etc. is minimal.

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2. The student

* Starting level of the student

The normal qualification for the freshman is the "Abitur" (final examination after 13 years' education, beginning at the age of 6). The requirements for Mathematics are, depending on the type of secondary school (Gymnasium): analysis (real functions only), analytical geometry, stochastics. For Physics the requirements are; elementary mechanics, optics, heating, nuclear physics. Knowledge of mathematics and physics depends on the type of Gymnasium and on the student's choice in secondary school. 80% of the freshmen had mathematics and physics at "Abitur" level. The average age of students on entry is 21.9 years.

In the opinion of the Committee the level of attainment of the school-leavers is satisfactory although not always so in mathematics and physics.

* Selection

Because of the absence of a numerus clausus (a quota for the number of students) and of prior selection, the selection is done in the first two years by the Vordiplom, a set of examinations normally taken at the end of the first and second years. The student can sit the examinations only twice; sometimes, when the expectation of passing is high, he may be allowed a third attempt. When the student fails the Vordiplom, he has to leave and can no longer study Electrical Engineering at a German university. He can still go to a Fachhochschule (Polytechnic).

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The number of female students is not high, although higher than in most of the other schools visited. The number of foreign students is also low.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
748	625	?	6.9%	3191	3573	?	4.6%

As already remarked, the School did not apply for a numerus clausus (numerical quota). The intake is therefore very large; but there is a high percentage of "no-show" students, since many enroll merely to keep options open, there being nothing to lose by enrolling. However, in the view of the Committee 600 freshmen in the first semester is too large a number to handle. It is impossible to effect a good transmission of knowledge to audiences of more than 600 students. As a result, students stay away from lectures.

Because of the absence of entrance selection and the absence of a numerus clausus, there is no difference between the number of applicants and the real intake.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
748	748	625	625

* Average duration of study, completion rates

The nominal duration of the Electrical Engineering programme is 5.0 years, comprising 4 years of courses, 6 months for the Master's thesis, and 6 months industrial training. The average real duration is now 5.9 years (11.8 semesters). The real study time had been increasing: in 1970 it was 11.1 semesters, in 1987 12.3 semesters. It is now declining again: 11.8 semesters.

A duration of 5.5 years seems to the Committee to be typical for the Western European (continental) universities. The effective length of study is, among other factors, determined by the efforts of the students and the organization of the programme.

TABLE 3:NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES IN YEARS

NOMINAL	EFFECTIVE
5.0	5.9

The completion rate in the nominal time is low (8%), while the total completion rate is 58%. Of all graduates, only 38% finish their study in 6 years. An additional 20% graduate after 8 years (see Table 4). An overall completion rate of 60/65% seems to be an average for Electrical Engineering in the West-European universities (see the general conclusion in Part I, paragraph 6.6).

TABLE 4: DROP-OUT RATES AND GRADUATES, COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6YEARS	Ph.D after 10 years
701	16%	8%	38%	58%	12.4%

In the eyes of the Committee one possible reason for the high drop-out rate and the long time of enrolment is the fact that the students are left too much to their own fate. There is no student counselling, and no recording of student progress. A further reason is that many students must earn money for living expenses.

3. Goals and aims

The Faculty has described the goals and aims as follows

" The general goal is to educate and train electrical engineers to be able to cope with fast-changing requirements in a competitive professional world. They must be able to approach new problems in a fresh and creative way, to adapt to new technological situations, and to broaden their ideas and knowledge, on the basis of a solid education.

In terms of knowledge: because of the above global goal, it is important that the programme concentrates on the teaching of methods rather than of facts. Basic electrical engineering methods, which are based on a sound understanding of mathematics and physics, form a knowledge base which will enable engineers to contribute significantly to the solution of important problems.
In terms of skills: the knowledge of methods is most successful if it is accompanied by appropriate skills in using a broad range of available tools to achieve the necessary efficiency. These skills range from efficient use of the ubiquitous personal computer to efficient use of CAD tools for, e.g., IC design, and of simulation tools to evaluate, e.g., dynamical systems, or to handle modern test equipment.
In terms of attitudes: the ability to tackle new problems in a fresh and creative way, to acquire knowledge and skills independently, and to present one's own work effectively, are some of the attitudes students need to acquire and to develop in seminars."(Basic Information, Volume 1, page 23).

The Committee judges the formulation of goals and aims as good. The Committee has no comments on it, with the exception of the non-technical subjects (see 4.5)

4. The programme

The Faculty offers the degree programme Electrical Engineering, leading to the title Diplom-Ingenieur.

4.1. The philosophy behind the programme

The Faculty has stated that the philosophy behind the programme is as follows:
"Electrical Engineering has reached a state where engineers in industry are specialising in a great variety of directions. These directions are increasingly time-variant. It is therefore the aim of the programme to provide a methodical education which will enable our students later to adapt flexibly to various fields of specialization. This is the reason for having the first two years of the programme consist of the same obligatory courses for all students. Later on, the students can choose between four programmes within electrical engineering. The programme is evolving and developing over the decades and years and is more or less constantly adapted to the actual situation. The basic programme especially has been recently revised". (Basic Information, Volume 1, page 17).

4.2. The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPREE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

"The first two years of the programme (Grundstudium, Studium vor dem Vordiplom) are identical for all electrical engineering students. This part is devoted to basic mathematics and physics, as well as field and circuit theory, computer science and mechanical engineering. It is intended to provide a comparable basis at all German Universities to

make it easy for students to change from one university to another. The examinations are taken in two blocks after the first and after the second year respectively. 13 weeks of practical work, which can be done during the vacations, is part of the basic programme.
The main programme (Hauptstudium, Studium nach dem Vordiplom) offers the choice between four specializations ("directions"):

A) Power engineering; (10% of the students)
B) Communication and computer engineering (60% of the students)
C) Electronics (10% of the students)
D) Automation and control engineering (20% of the students)

In each of these directions of study there is a block of mandatory courses (about one half of the main programme courses), a block of courses which the student can choose from a specific limited list (about a quarter of the main programme), and a block of courses which can be chosen almost freely. With the aid of these choices available, it is possible to create core topics, e.g information processing, solid-state electronics.
In addition to this part of the main programme, another 13 weeks of practical work has to be carried out, and a diploma thesis must be produced." (Basic Information, Volume 1, pages 18/19).

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	8.5	6.8	1.7			17.0
PHYSICS	3.4	2.8				6.3
COMPUTER SCIENCES	3.4	1.7	5.1			10.2
GENERAL ENGINEERING SCIENCES	4.5	2.3				6.8
ELECTRICAL ENGINEERING SCIENCES	7.4	14.7	16.4			38.6
ELECTRICAL DESIGN[2]			3.9			3.9
NON-TECHNICAL SUBJECTS						0
ELECTIVES[3]				17.0		17.0
TOTAL	27.2	28.4	27.2	17.0		100% 2288 hrs
THESIS					1040 hrs	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for Industrial training and thesis work are not counted in the percentage.
[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.
[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

4.3. Mathematics; Basic sciences

The Committee assesses Mathematics as excellent, however much emphasized in the first two years. The students also remark that Mathematics is very intensive. A reason for the emphasis seems to be the necessity to upgrade the students coming from secondary schools. The attitude is somewhat directed to problem solving rather than linked with technical applications. There is no Chemistry; Physics and Materials courses are considered as rather restrictive.

4.4. General Engineering Sciences

The Committee judged the amount of General Engineering Sciences as meagre. There is no civil engineering course, nearly no thermodynamics (some theory, but no applications -- hence no motivation for students), and there is little attention given to mechanical engineering. Consequently the general basis is rather narrow.

4.5. Electrical Engineering Sciences

The Committee judges the Electrical Sciences in the programme in general terms as excellent. There is a wide range of courses to be selected. The package is balanced and addresses many advanced topics in Electrical Engineering. Only the subject of Electrical motors is restricted.

4.6. Electrical Design

The Committee assesses Electrical design as well done, with plent of CAD in evidence. There are electronic design courses in integrated circuits and in advanced control which are supported by modem equipment (work stations).

4.7. Non-Technical subjects

The Committee assesses the non-technical subjects as weak. There are no formal requirements for the students. They can take courses in the elective part, but there is little room for it. In the opinion of the Committee, the School should encourage the students to take electives in this field, perhaps by making a selection of non-technical subjects compulsory.

4.8 Additional requirements

The IPREE-Committee has formulated additional requirements regarding laboratory experience of the students, the use of the computer, and the attention paid by the Faculty to written and oral communication (Guide for the Committee, page 10). With regard to these requirements, the Committee has no remarks to make. The School requires 26 weeks of practical training in industry. The Committee judges this as adequate and very important. The Committee has the impression that the School shares this view and takes appropriate measures to organize this practical work.

4.9. Master's thesis

In the written information, the Faculty writes about the thesis only that an individual thesis has to be done over a period of 6 months, supervised by any of the staff. During the interviews the Committee noted that the Faculty pays special attention to the Master's thesis. In the opinion of the Committee, six months for the thesis, combined with an oral presentation and assessment report, is most acceptable. The thesis is often a research oriented task, with a few produced in industry. With regard to the project work, the Committee noticed that such work is not compulsory, due to the shortage of manpower. Because students do not often choose the project option, they save three months in study time.

4.10. Examinations: regulations and requirements

About the examinations and the requirements for examinations the Faculty has given the following information: *"The Examinations are typical written examinations. The duration is 20 minutes per lecture hour per week. In the first part of the programme there is the examination called "Vordiplom", held after the 3rd and 4th semesters. The final examination is the "Hauptdiplom", held after the 7th and 8th semesters."* (Basic Information, Volume 1, page 33).

The Committee judges the assessment and examination as more than adequate. The examinations are of good quality, dealing with analytical topics only. Students complain that not enough time is allowed to answer questions properly.

4.11 Study burden

As can be seen in Table 6, the total programmed study burden is 8600 hours, or about 1700 yearly. The Faculty at München does not use a credit point system. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2:3. The students spend about 40% of their time at the university and are expected to spend about 60% on self study.

Many lectures are coupled with tutorials and small working groups for exercises. So the number of lectures is about 60% 'real' lectures and 40% tutorials.

TABLE 6: TOTAL STUDY BURDEN

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
1937	351	2288	1040	1040	8600

There is in total 26 weeks (1040 hours) practical work (industrial training), the first part to be done in the basic studies, the second part in the Hauptstudium. For the Master's thesis 6 months full time (1040 hours) are programmed. It is not clear how many hours the students spend on their study. According to the information from the Faculty, the student has to spend 25 hours a week at the university and about 25 hours on self study. According to their statements, the students spend 50/60 hours a week, 1800/2000 hours yearly. The programme is completely filled up. Due to the minimal support in the basic programme leading to the Vordiplom, and the large number of students, the load is above average, because many students do not take advantage of the lectures, but study at home from extensive lecture notes.

4.12 Overall assessment of the programme

The total programme in the eyes of the Committee is, as far as Electrical Engineering is concerned, very good and exceeds the minimum requirements, but it is also narrow. There is a lack of non-technical subjects. The programme is, in the view of the Committee, overloaded. It seems difficult to suggest improvements. but there should be a regular assessment by a special committee and not by casual action.

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5. The Academic Staff

The academic staff fall into four main categories:

* Ordentliche Professors (C4)
* Ausserordentliche Professors (associate professors)(C3,C2)
* Akademische Rat (= Dr.Ing.) in charge of the technical facilities of the Faculty.
* Assistenten/Wissenschaftliche Mitarbeiter (normally with a Dipl.Ing. degree and conducting research work towards a doctoral thesis on a special contract).

The Committee considers the size of the academic staff as very good for covering the full range of subjects; but the staff is too small in relation to the very large number of students (see Table 7). The teaching load of the full professors is about 40% of their time (8 hours lectures and additional activities). The lectures are mainly given by the professors. The research assistants are in charge of tutorials, practicals etc. Each assistant has 50% time for research and 50% for teaching/adminstration, at least in their first 2 years. The Committee considers the teaching load as rather high. The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. This number is 45 (see Table 8).

A possible measurement of teaching effectiveness is the number of graduates per FTE-teaching. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 5.2 per FTE-teaching. This can be considered as high. A possible explanation for it can be the absence of bureaucracy, the presence of an excellent staff, and the opportunity to attract good students.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	Full time equivalent	Persons
* Full professors	21	21
* Associate professors/senior lecturers	14	14
* Assistant professors/junior lecturers		
* Research assistants/Ph.D. students	161	161
* Others		
Total academic staff	196	196
Non-academic staff	?	143

As already stated, in the view of the Committee the teaching load of the Ph.D. students is high. For that reason it is difficult to finish the Ph.D. in less than 6 years.

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
79	3573	409	45	5.2

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The didactic expertise of the staff seems not always to be adequate, according to the students. Many students prefer to study at home instead of going to a lecture. The Ph.D. students, in charge of 50% of the teaching/administration, expressed a desire for training in teaching methods. The Committee advises that attention should be paid to this, and also that the comments of the students should be listened to. Student-organized questionnaires on lectures could provide useful feedback for staff to improve their presentation. The Committee observed hardly any student-oriented learning approach. Attention to student feedback and student progress is not pronounced.

The academic level can be considered as excellent, together with the scientific activities. There is high quality research, mostly done in projects as contract research. The number of publications is good. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 1.6 (see Table 9). The staff seems to spend a lot of time writing text books.

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Number of papers	235	237	202	259	322
Number of papers per staff member (excluding "others")					1.6

Research assistants have a contract of normally two three-year periods and then have to leave. Exceptionally an additional year can be granted. Full professors are appointed for life. New professors are attracted from outside the school. The Committee consider this recruitment policy very worthwhile. It guarantees a fresh input of staff members with experience in industry. There is no formal staff development programme.

6. Facilities and Resources

The funding seems to be adequate. But it was not possible to obtain figures. Money from sources other than the government flows directly to the Chair holder.

TABLE 10: INCOME AND EXPENDITURES OF THE FACULTY

INCOME		EXPENDITURES	
State	75%	Education	50%
Industry	5%	Research	50%
Research foundations	20%	Total	100%
Others			
Total	100%		

The teaching equipment is good, as far as it was possible to judge. The number of students is now becoming a problem. The laboratories were very well equipped. The high-voltage laboratory is excellently equipped, as are the facilities for CAD and IC design. Basic semi-conductors has its own facilities, for which the equipment is somewhat simple, but still adequate. The computer facilities are excellent too, despite the large number of students.

7. The internal Quality Assurance

The Committee noted little attention to evaluation and internal quality management. The students have little influence on the quality. The students would like to have more influence by providing feedback, but are somewhat ignored. There is no formal feedback mechanism and there is no systematic recording of student progress.

8. External relations

The links with industry can be considered as good. All professors have an industrial background and keep good contacts. There could be more evidence, e.g. a list of industrial contracts could be published. The contact with other institutes is good. The faculties of electrical engineering meet each other in the "Fakultätentag" This meeting of the faculties plays a role in maintaining the comparability of the Vordiplom (the first 2 years of study). It should be possible for students to change from one university to another. The Fakultätentag also plays a role in maintaining the academic level. Thus there is some external assurance of quality.

9. International relations

International relationships can be considered as good. The Faculty participates in several European programmes (e.g. Erasmus) and cooperates with several universities abroad. The Committee recommends the introduction of validation procedures at university and perhaps faculty levels, so that credits acquired abroad can be recognized. If not, sending students abroad is only window dressing.

10. The graduate

The Committee expresses its feeling that the School produces good but specialized engineers. The students are hard working and motivated. The graduate has a good theoretical basis and merits the title of Electrical Engineer. Until now, the students have not had problems in obtaining jobs. There are enough employment possibilities in and around München. The graduates obtain jobs in industry, consulting engineering, research/university and central government, but no percentages are given.

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ The Committee has no doubt at all that the programme offered by the School of Electrical Engineering at the Technische Universität München meets the minimum requirements set by the IPREE Committee in the Guide.

+ The Committee assesses the quality of the graduate as good, although in some respects too narrowly specialized. In the opinion of the Committee the graduate merits the title "Master of Electrical Engineering".

+ The Committee considers it very valuable that full professors also participate in the basic programme.

+ The Committee was impressed by the students. The students of the later years and the Ph.D. students were mature, but relatively old, due to the entry age of 22 years.

+ The Committee met an excellent, enthusiastic faculty staff. The working environment is inspiring. The school is well organized. There is little bureaucracy, due to the absence of an organizational structure above the Chairs.

- The presence of subjects in the field of General Engineering Sciences is adequate, although more attention could be given to this.

- The Committee noted minimal requirements for non-technical subjects. Because the engineer will often stay a short while in the technical field, after some time assuming a managerial position, it is desirable to have subjects in the curriculum like project management and accountancy. It is not enough to offer some possibilities in the electives. If they are not to be included in the compulsory part, the School should certainly do more to stimulate the students to take them as electives.

- There should be more attention to evaluation and quality assurance, including a better monitoring of student progress. The school has to look for ways of innovating and updating the programme. The Faculty should organize student feedback on a regular basis.

- The Committee remarked that the large number of students in the first year causes a high rate of absenteeism in course attendance.

- The teaching load of the staff is considered to be high, taking into account the huge number of students. The Committee has the feeling that the Ph.D. students have too heavy a teaching load, which may be a reason for the length of time needed for finishing their Ph.D. work.

16 FACULTY OF ELECTRICAL ENGINEERING AT THE EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE ZÜRICH, SWITZERLAND

Date of visit: 12/13 December 1991

1. Introduction

The fourth country in the International Programme Review Electrical Engineering (IPR-EE) was Switzerland. The Committee visited the Faculty of Electrical Engineering at the Eidgenössische Technische Hochschule Zürich. For the members of the Committee see Appendix 1.

The Faculty (Fachabteilung) for Electrical Engineering is part of the ETH Zürich. The ETH was founded by the Swiss Federal Government as a Polytechnicon in 1854. The School for Electrical Engineering is one of the 19 schools of the ETH. Until 1935 Electrical Engineering was embedded in Mechanical Engineering; since then it has been a separate school. In 1991/92 the ETH has about 11.200 students, of whom 12% (1394) are in the School of Electrical Engineering.

The ETH is governed under the jurisdiction of the Board of the Swiss Federal Institutes of Technology, which reports directly to the Swiss Government. ETH Zurich is headed by a President, who is also Vice-President of the Board of the Swiss Federal Institutes of Technology. The President and four Vice-Presidents (namely the Vice-President for Academic Affairs, called Rektor, the Vice-President for Research, the Vice-President for Planning and Development and the Vice-President for Administration) form the Administrative and Executive Committee. The Vice-President for Academic Affairs is responsible for student-oriented affairs (admission, teaching, examinations, advisory services). He is assisted by three "Prorektoren" for degree courses, doctorates and postgraduate studies.

The "Department", i.e. the research side of the Faculty, is divided into 14 Laboratories:

1. Electronics
2. Integrated Systems
3. Biomedical Engineering and Medical Informatics
4. Reliability
5. Electromagnetic Fields and Microwave Electronics
6. Military Security Technology
7. Communication Technology
8. Signal and Information Processing
9. Computer Engineering and Networks
10. Automatic Control
11. Power Electronics and Electrometrology
12. Electric Power Transmission and High Voltage
13. Electrical Machines
14. Electrical Engineering Design

The ETH has a matrix organization. For Electrical Engineering there are two committees:

1. The Department Board: a committee comprising all professors, representatives of all Laboratories/Chairs, and 2 members representing non-academic staff. The committee is responsible for research organization and infrastructure.
2. The Faculty Board, a committee comprising all professors active in the Abteilung [see below] and charged with teaching, with additional members representing part-time lecturers, academic staff and students.

The Committee was impressed by the well organized school. As in the classical Von Humboldt university, the professors are independent. For an outsider it is difficult to get a clear view about the matrix organization. Since in the case of the Electrical Engineering Faculty the Department (research unit) and the Abteilung (teaching unit) seem to coincide, it appears that this matrix organization does not cause problems for the staff.

2. The student

2.1. Starting level of the student

The normal qualification for the freshman is the "Maturität" (final examination) at a recognized Swiss Gymnasium after 12-13 years of education (depending on the canton). Alternatively ETH accepts students who have passed a special entry examination equivalent to the Maturität. The level of the Maturität is good. The average age of the students on entry is 20 years.

The requirements for Mathematics are numbers and polynoms; equations 1. and 2. order; relations and projections; functions; trigonometry; vectro spaces; statistics and probability; algorithms and computer practice; descriptive geometry. The principle aims are: to know general structures on mathematical objects; to understand functional relations and to apply mathematical knowledge to other knowledge branches. For Physics the requirements are physical quantities, definitions and principle relations in mechanics, thermodynamics, electricity and wave theory. The principle aims are: to understand elementary physical events and principles; to comprehend mathematically simple facts and to understand natural laws relative validity.

2.2. Selection

There is no formal prior selection; because of its absence the selection is done in the first two years. The Vordiplom is used as a selection mechanism. In the first year the drop-out rate is about 8%. The Vordiplom is split into the first Vordiplom at the end of the 2nd semester and the second Vordiplom at the end of the 4th semester. The student can sit the examinations only twice. About 33% of the students do not pass the Vordiplom.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The number of freshmen dropped drastically between 1987 and 1990. The number of women is very low. In the opinion of the Committee the Faculty should endeavour to attract more women students. The number of foreign students is about 11%.

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
305	202	1.3%	2.5%	1249	1394	1.3%	1.2%

Because of the absence of entrance selection and the absence of a numerus clausus (numerical quota), there is no difference between the number of applicants and the real intake.

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
305	305	202	202

* Average duration of study, completion rates

The nominal duration of the Electrical Engineering programme is 4.5 years, comprising 4 years of courses and 4 months for the Master's thesis. The average duration is now 5.5 years (11 semesters). A duration of 5.5 years seems to the Committee to be typical for the Western European (continental) universities. The effective length of the study is determined by, among other factors, the efforts of the students and the organization of the program.

TABLE 3:NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES IN YEARS

NOMINAL	EFFECTIVE
4.5	5.5

The completion rate in nominal time is 24%, the total completion rate is 67%. From all graduates, 66% finish their study in 6 years. An additional 1% get their grade in more than six years (see Table 4). An overall completion rate of 60/65% seems to be an average for Electrical Engineering in the West-European universities (see the general conclusion in Part I, paragraph 6.6).

TABLE 4: DROP-OUT RATES AND GRADUATES. COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D after 10 years
257	8%	24%	66%	67%	16%

The Committee was impressed by the intelligence and maturity of the students. The students do not seem very interested in other activiti s (student committees, other social activities and so forth).

3. Goals and aims

The Faculty has described the goals and aims as follows:
"To provide a "general purpose" E.E. education at university level, with the possibility, however, either to specialize in a particular area (e.g. for those aiming at a position in R&D), or to pursue a broad spectrum of interests (e.g. for those aiming rather at management positions).

In terms of knowledge: through the first two years of studies with a majority of mandatory courses, we ensure that all E.E.s get a sound education in higher mathematics, in physics, in informatics, and last but not least, in the fundamentals of E.E.

In terms of skills: Electrical Engineers should be able to successfully complete a 4 month project involving development work, both hardware- and software-oriented. They should be able to present the results of their work clearly and precisely both in written and in oral form at the level of scientific conferences.

In terms of attitudes: ability to work independently and to set his/her own goals" (Basic Information, Volume 2, pages 105/106).

The Committee judges the formulation of goals and aims as sufficient.

4. The programme

The Faculty offers the degree programme Electrical Engineering (Elektrotechnik), leading to the title Dipl. El.Ing. ETH.

4.1. The philosophy behind the program

The Faculty has stated the philosophy behind the programme as follows:
"The programme aims at educating Electrical Engineers able to fill positions both in R&D, and in management and government agencies. Usually Electrical Engineers should be able to take on responsibilities after 2 to 4 years practice in, e.g., industry. In our experience, ETH's electrical engineers may be regarded as equivalent to M.S.level engineers from good universities in the U.S.A. Special emphasis is given to practical work in various laboratories throughout the studies. Originally Electrical Engineering was studied as a branch of Mechanical Engineering. However, a split was made some 50 years ago and the study programs have been regularly adapted to the needs of new technologies and industry" (Basic Information, Volume II, page 101).

4.2. The structure of the program

The structure of the programme and an overview of the contents are given in appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPR-EE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE[1] OF TOTAL CONTACT HOURS.

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	9.3	5.6				14.9
PHYSICS	3.7	5.6				9.3
COMPUTER SCIENCES	3.6	3.7				7.3
GENERAL ENGINEERING SCIENCES						0
ELECTRICAL ENGINEERING SCIENCES	9.3	11.1	3.7	11.1		35.2
ELECTRICAL DESIGN[2]						
NON-TECHNICAL SUBJECTS	1.9	1.9	5.6	1.9		11.3
ELECTIVES[3]	0	0	11.1	11.1		22.2
TOTAL	27.8	27.9	20.4	24.1		100% 3024 hrs
THESIS					640 hours	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for industrial training and thesis work are not counted in the percentage.

[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the ETH the percentages for EES and ED are added.

[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

The Faculty gives the following description of the program:
"The EE studies comprise: Grundstudium: Basic education with 4 major "pillars", i.e. Mathematics, Physics, Electrical Engineering, and Informatics. Its normal duration is 4 semesters (2 years). Along with this technical education, all students have to sign up for courses with at least 2 hours per week in non-technical subjects offered by the section in Humanities and Social Sciences; ETH offers a wide spectrum of such courses, ranging from e.g. Italian Literature to Bookkeeping. Fachstudium: Increasing specialization in EE subjects. In the 5th and 6th semesters, a selection has to be made from ten core courses (Kernfächer). These are:

* *Electronic systems*
* *Physical electronics*
* *Circuits and Fields*
* *Communication technology*
* *Time-discrete systems and stochastical signals*
* *Computers in real time systems*
* *Linear control systems*
* *Power electronics*
* *Transmission on Lines and Power systems*
* *Electrical Machines and Drives*

The student has also to make a choice among a much wider range of "Hauptfächer" (EE topics and some computer science courses) and "Nebenfächer" (all courses offered at the ETH, including EE). In the 7th and 8th semesters 50% of the time is devoted to "Hauptfächer" and "Nebenfächer" type courses, with the rest of the time available to accomplish so-called "Studienarbeiten", i.e. semester projects. The latter may be regarded as forerunners of the diploma project; as such they allow students to gradually get acquainted with solving typical engineering problems, i.e., where some effort has to be made to delimit the project reasonably and to establish a workplan. Note that all

"Kernfächer" and "Hauptfächer" courses qualify as such only if they contain either written exercises or laboratory work, thus allowing some monitoring of the student's progress.

Besides this technical education students have to take 4 so-called "MTU" two-hour courses. MTU stands for "Man, Technology and Environment"; a choice may be made among some 8 courses on subjects related to law, sociology, environment, engineering management, etc. Also, in direct relation to one of the courses, groups of e.g. 4 to 6 students have to work on a small project of an interdisciplinary nature" (Basic Information, Volume 2, pages 102/103).

4.3. Mathematics;Basic sciences

The Committee assesses Mathematics and Basic Sciences as good to excellent.

4.4. General Engineering Sciences

The Committee noted that General Engineering Sciences are adequate. There is some Chemistry, but in the view of the Committee there could be more.

4.5. Electrical Engineering Sciences

The Committee judges the Electrical Engineering Sciences in the programme as excellent in general terms, although in some respects restricted. Many specialized courses with modern topics are offered (neural nets, VLSI design, fibre optics).

4.6. Electrical Design

The Committee assesses Electrical Design as good to excellent, as there are many design projects in telecommunications, VLSI, and power engineering, for example.

4.7. Non-Technical subjects

The Committee assesses the non-technical subjects in the basic part as weak. The two hours are hardly taken seriously by the students. In the opinion of the Committee, the school should pay more attention to the use of the 2 hours in the basic program.
The treatment of non-technical subjects in the main programme (Man, Technology and Environment), is good.

4.8 Additional requirements

The IPREE-Committee has formulated additional requirements regarding laboratory experience of the students, the use of the computer, the attention paid by the Faculty to written and oral communication (Guide for the Committee, page 10). With regard to these requirements, the Committee has no remarks to offer. The School requires 18 weeks of practical training in industry. The Committee judges this as important.

4.9. Master's thesis

"The diploma thesis project lasts 4 months, to be finished with a written report and oral presentation. Most of these projects are directly related to a research project at one of the EE laboratories; thus students get acquainted with working in the context of some larger undertaking. It should be noted that well over 50% of these diploma projects are carried out in groups of two. Also, the diploma project may be constructed as a sort of continuation of one of the semester projects, thus opening the possibility of devoting approximately 6 person-months to one particular project. A small minority of diploma projects are undertaken in industry. Such projects will be supervised and assessed by an ETH professor; as a rule, those responsible in industry must be well known to ETH staff (e.g., if they are former Ph.D. students)" (Basic Information, Volume 2, page 114).

In the opinion of the Committee, 4 months for the thesis is probably too short, but intensive, hence acceptable. The Committee asks that special attention be given to rating individual performance in cases where the thesis is done in teams. The project work (Studienarbeit) is judged as very good by the Committee.

4.10. Examinations: regulations and requirements

The ETH maintains a system of examinations taken outside the normal course periods. Thus, students are allowed to prepare for their examinations for about 2 to 3 weeks (in the Spring recess) or 8 to 10 weeks (in the Summer recess). This system is preferred to end-of-term examinations since it allows study of the course contents in a broader context.

The Committee judged the examination system and the examinations as good

4.11 Study burden

As can be seen in Table 6, the total programmed study burden is about 8530 hours, making about 1850 yearly. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 1:3.

Many lectures are coupled with tutorials and small working groups for exercises. So the number of lectures is about 60% 'real' lectures and 40% tutorials.
There is in total 18 weeks (± 720 hours) practical work (industrial training), the first part to be done before the 3rd semester, the second part before the 8th semester. For the Master's thesis 4 months full time (640 hours) are programmed.

TABLE 6: TOTAL STUDY BURDEN

Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
2492	532	3024	720	640	8530

According to the Faculty, the nominal study burden is about 1800 hours yearly (= 2 semesters of 14weeks each). The study burden per week is about 30 contact hours and about 20 hours self study. According to their statements, the students spend 50/60 hours a week, 1800/2000 hours yearly. The programme is completely filled up. The Committee assesses the study burden as high, but acceptable. The question is whether the students find their way to an independent style of working with such a comparatively high number of contact hours.

4.12 Overall assessment of the program

The total programme is very good to excellent in the eyes of the Committee, and exceeds the minimum requirements. However there should be a regular assessment of the curriculum and the courses by a standing committee, including students, to maintain this level. In the opinion of the Committee an institute with the reputation of the ETH should aim at more courses given in English in order to attract more foreign students.

5. The Academic Staff

The academic staff fall into five main categories:

* Ordentliche Professoren (full professors);
* Ausserordentliche Professoren (Associate professors);
* assistant professors;
* part-time lecturers (recruited from industry and to some extent among ETH researchers).
* assistenten/Wissenschaftliche Mitarbeiter (normally with a Dipl.Ing. degree and conducting research work towards a doctoral thesis);

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF

	Full time equivalent	Persons
* Full professors	18	18
* Associate professors/senior lecturers	3	3
* Assistant professors junior lecturers	1	1
* research assistants Ph.D. students	270	300
* Others (part-time lecturers)	?	40
Total academic staff	292	362
Non-academic staff	58	85

The Committee considers the size of the academic staff as adequate (see Table 7). The teaching load of the full professors is about 50% of their time (8 hours lectures and additional activities). The lectures are mainly given by the professors. The research assistants are in charge of tutorials, practicals etc. The average assistant spends 70% of his time on research and 30% on teaching/administration.

TABLE 8: STAFF/STUDENT RATIO

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
92	1394	192	15	2.1

The Committee considers the teaching load as normal. The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. The number of students is 15 per FTE-teaching (see Table 8). A possible measurement of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 2.1 graduates per FTE-teaching.

The didactic expertise of the staff in general seems to be adequate, judging from student opinions. The Faculty is planning to introduce courses of training in teaching methods. Students speak of a serious problem in the lack of adequate staff (assistant professors) for monitoring thesis and Ph.D. work. The Committee advises the Faculty to pay attention to this, and also to listen to the comments of the students. Student-organized questionnaires on lectures could provide useful feedback for staff to improve their presentation. The academic level can be considered as good to very good. The Committee was surprised to find that there is no formal record of publications available. The scientific activities are considered as very good. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 1.0 (see Table 9).

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Numbers of papers	219	189	318	320	362
Numbers of papers per staff member (excluding "others")					1.0

Both the full and the associate ETH professors are in "tenure track" positions; re-election takes place for the first time after 3 years, and then every ten years. Associate professors may be transferred to full professor status after 6 years. Assistant professors are elected for an initial 3 years period and may then be re-elected for one further 3 years period. Thus, unless afterwards chosen for a tenure-track position, assistant professors must leave after a maximum of 6 years. There does not exist a real recruitment policy, but since the Faculty has a good reputation and enough financial resources, it is rather easy to get good people. The use of sabbaticals should be encouraged more than appears to be the case.

6. Facilities and Resources

The funding of the school is extremely good. The teaching equipment is excellent, as far as it was possible to judge. In Table 10 some figures about finances are given.

The Laboratory equipment is excellent too. There are modern provisions, used in advanced practical courses. The computer equipment is very good. At the Vordiplom level there are many Macintosh computers; in the later stages there are many workstations with mainframe computers available.

TABLE 10: INCOME AND EXPENDITURES OF THE DEPARTMENT

INCOME	%	EXPENDITURES	%
State a)	76.4	Education	40% d)
Industry	7.8	Research	60% d)
Research foundations b)	13.7	Total	100
Others c)	2.1		
Total	100%		

a) To cover all educational activities and some core research work, a basic allocation of staff is provided by the Federal Government. Figures given are a rough estimate as financing is outside departmental bookkeeping.

b) A minor part of this sum is provided by industry through a joint government/industry program (KWF).

c) This is a rough estimate only.

d) As many activities cannot clearly be allocated to either education or research (e.g. guiding students projects which contribute to research), the split is a crude estimate only.

7. The internal Quality Assurance

" An expert team with professors and scientists from other countries assesses the department every five years on average. The last such one-week assessment took place in December 1990 "(Basic Information, Volume 2, page 119).

The Committee noted, however, that there is little attention to evaluation and internal quality management. The students have little influence on the quality; they should have more influence by providing feedback, for which at present there is little encouragement. There is no formal feedback mechanism. There is no systematic record of student progress. There is too little attention to quality assessment. On the other hand, the ETH often takes part in international external reviews.

8. External relations

"There are formal contacts with industry, notably through the KWF (Kommission zur Förderung der wissenschaftliche Forschung), which is a Federal Programme in which the Government pays 50% of the cost of research projects and industry provides the other 50%. Also industry is consulted when study plans are changed. Informal contacts are maintained through colloquia, seminars, lecturers from industry, etc." (Basic Information, Volume 2, page 97).

The links with industry can be considered as good, however often based on individual contacts. Contacts could be improved on a more formal basis. Participation of members from industry in appointment and Chair committees would be an advantage, as would also be their participation in curriculum committees. The contacts with other institutes are good, although the Committee thinks that contacts with Lausanne might be improved.

9. International relations

International relationships can be considered as good. The ETH is well known and has a high reputation worldwide.

10. The graduate

The Committee judges that the Faculty produces excellent graduates, well educated in the area of their specializations; however the basis could be broader. The students are hard working and motivated. The graduate merits without any hesitation the title of Electrical Engineer. Until now, the students have not had problems in obtaining jobs. Of all graduates, 15% go into research, the rest into industry.

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ The Committee has no doubt at all that the programme offered by the School of Electrical Engineering at the Eidgenössische Hochschule Zürich exceeds the minimum requirements set by the IPR-EE Committee in the Guide. The Committee assesses the quality of the graduate as very good. (S)he merits without any hesitation the title "Master of Electrical Engineering".

+ The teaching load of the staff is considered as normal. The Committee considers it very valuable that full professors, more or less as a matter of principle, participate in the basic program.

+ The Committee was impressed by the students. The students of the later years and the Ph.D. students were mature. The students are hard working and very busy; perhaps sometimes they have too little time for other things. The complaint was sometimes heard that they are left too much on their own. The Committee recommends an examination of ways of giving students instruction in effective studying, in use of the library, etc. It might perhaps be done by introducing tutorship in the first year.

+ The Committee met an excellent, self-confident, enthusiastic staff. The Committee judged the quality of the staff as very good, and the working environment as inspiring.

+ The Faculty is certainly a high quality faculty, which is excellently equipped and well organized. The structure, with both a Department board and a Faculty board, is confusing.

- The Committee found that the role of the curriculum committee is not clear. In the opinion of the Committee there should be a standing committee, a formal body with real authority. The presence and input from students should be more formalized than it is now. Organized feedback from the student side on courses and curriculum should be encouraged. The Committee recommends also a regular evaluation of the programme by the Faculty.

- The Committee noted that the 2 hours for non-technical subjects in the Grundstudium programme is not really used. The attendance is not checked. The Committee advises that this omission be rectified.

- With regard to the time for the thesis, the Committee expresses its feeling that four months is the minimum. Maybe some extension might be considered.

- Although there are already several possibilities for staff development courses, the Committee asks for more attention to courses in teaching methods for some professors.

- The Committee advises the Faculty to pay attention to the complaint of some Ph.D. students about the high number of Ph.D. students per full professor.

17 FACULTY OF APPLIED SCIENCES (ELECTRICAL ENGINEERING) AT THE RIJKSUNIVERSITEIT GENT, BELGIUM

Date of visit: 20/21 January 1992

1. Introduction

The fifth country in the International Programme Review Electrical Engineering (IPR-EE) was Belgium. In Gent the Committee visited the Faculty of Applied Sciences (Faculteit der Toegepaste Wetenschappen). For the members of the Committee see Appendix 1.

The Faculty of Applied Sciences is one of the 10 faculties of the University of Gent. The University was founded in 1817, the Faculty of Applied Sciences in 1835. The University of Gent is a state university, funded by the Flemish Ministry of Education. The University has about 15000 students, the Faculty of Applied Sciences about 1500 students, about 630 of them in the field of Electrical Engineering.

The Faculty of Applied Sciences is divided into 30 laboratories (research groups). For teaching purposes, the Faculty is divided into 'Afdelingsraden' (departments).
At Faculty level there is a Faculty Board and a Faculty Council. The Council consists of the full professors, representatives from the scientific personnel, and 6 student members. All decisions are made in the Faculty Council. The Dean is responsible for the implementation of the decisions of the Council. The Faculty has a programme or curriculum committee, in charge of curriculum innovation. The proposals of the committee go to the Council for decision.

The Faculty offers a wide range of programmes leading to all classical engineering degrees, with the exception of agriculture: Architecture, Civil Engineering, Nautical Engineering, Mechanical Engineering, Electrical Power, Electronics, Applied Physics, Metallurgy, Chemical Engineering and Textile Engineering. There is no organizational structure covering the whole Electrical Engineering curriculum. The Department of Electrical Engineering is only responsible for teaching in the last 3 years of the curriculum. It consists of 6 laboratories:

1. Electronics and metrology
2. Electromagnetism and acoustics
3. Automatic control
4. Electrical motors
5. Theoretical electricity
6. Communications

A separate Basic Education Department ("Afdelingsraad kandidatuur") is responsible for teaching in the first two years ("kandidatuur"). For the purpose of this comparative review a proportional part (55%) of this Department was added to the EE Department to constitute a fictitious "EE Faculty". Coordination between both departments takes place within the Faculty of Applied Sciences.

The Committee has the impression of a somewhat traditional organization. There is an appearance of democracy, but there are few opportunities for the individual. The Committee could not discover managers with personal responsibility.

2. The student

* Starting level of the student

The freshmen at the University of Gent have had 6 years of elementary schooling (age 6 to 12 years). Schooling is obligatory up to the age of 18 years. The secondary school (6 years) is divided into three streams: General, Technical, and Professional secondary school. The General secondary school (Hoger secundair onderwijs) gives access to the university.

The requirements for the final examination of the secondary school for Mathematics are the same as those of the entrance examination supplemented by McLaurin and Taylor series; arithmetic and geometric series; elementary probability; algebraic structures, groups, rings, fields; spherical coordinates. For Physics the requirements are a) Mechanics: forces, motion, impulse, energy; b) Heat, temperature; c) Waves, acoustics and optics; d) Electric fields, electrostatics, magnetism, introduction to induction, basic rules of d.c.; e) Atom model (Bohr), energy levels, elementary introduction to fission; f) Liquids, gases, hydrostatics.

The Committee has no comments on the starting level, taking into account the provisions for selection.

* Selection

The general secondary school gives access to the university, on the understanding that students have to pass an entrance examination for engineering studies. This entrance examination covers only Mathematics. The objective is not to limit the number of students allowed to enter, but to select the good students. A committee of the Deans of the Flemish engineering faculties decides on the level and content of examinations. The requirements for the entrance examination are Geometry: transformation, projections, rotations, mirror image points, lines, planes, distance, orthogonality, angle, sphere, parallelepiped, pyramid, cylinder, cone, vector spaces, parameter and cartesian equations of lines, planes, curves, conics (reduction, classification, asymptotes, focal points), polar coordinates. Algebra: real and complex numbers, polynomials, rational functions, matrices, determinants, rank, inverse matrix, linear equations, linear and quadratic inequalities. Analysis: functions, derivative, limits, continuity, extremity, inflection, graph of a function, primitive function, integrals; linear, homographic, quadratic, power, rational, exponential, logarithmic, trigonometric, inverse trigonometric functions. Trigonometry: standard formulae (sum, difference, Simpson, half angle), trigonometric equations, solution of triangles. Numerical calculations with pocket calculator.

There is common recognition of the examination among the three faculties of Engineering (Gent, Brussels and Leuven). In 1990 there were 410 participants in the entrance examination in Gent (1400 in all Flanders). Of the 410 applicants, 297 passed the examination, that is to say 72%.

* Student numbers

Table 1 gives the number of freshmen and the total number of students for the years 1985 and 1990. The number of freshmen is a fictitious number, because all engineering students start with a common basic programme of two years (see 4.2). But on average, about 55% of the engineering students choose Electrical Engineering. So 55% of the total number of freshmen in the Faculty of Applied Sciences is assumed to be the number of freshmen for Electrical Engineering. The total numbers are counted as follows (1st year = 55% total freshmen + 2nd year (= 1st year number minus 25% drop-out) + 3rd, 4th and 5th years students Electrical Engineering).

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
147	163	9.2%	14.0%	627	628	7.8%	12.1%

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
213*)	147	226	163

*) The number is 55% of all applicants for the Faculty of Applied Sciences, reflecting the proportion of students who will normally opt for EE.

The number of students choosing electrical engineering is stable and is about 55% of the students who enter the Faculty. The number of female students is fairly high in comparison with other countries. The number of foreign students is very low.

* Average duration of study, completion rates.

The nominal duration of the Electrical Engineering programme is 5 years, containing 2 years (1st cycle) common to all students, and 3 years of Electrical Engineering. The average real study time is 5.3 years. Considering a real study time of 5.5 years to be typical for the Western European (continental) universities, the Committee thinks that the average of 5.3 is most satisfactory. Gent shows the smallest difference between nominal and effective time of all the faculties visited by the Committee.

TABLE 3: NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES IN YEARS

NOMINAL	EFFECTIVE
5.0	5.3

The drop out in the first year is 25%. Looking at the drop-out figures after 1 year in other countries, this number is high, taking into account the entrance examination. After the first year the drop-out rate is very low. Therefore the overall completion rate is higher than elsewhere in the faculties visited by the Committee. The completion rate in nominal time is high, 58%. The total completion rate is about 71%. Of all graduates, 68% finish their study in 6 years. An additional 3% of the students get their degree after more than 6 years (see Table 4). An overall completion rate of 60/65% seems to be an average for Electrical Engineering in the West-European universities (see the general conclusion in Part I, paragraph 6.6). The Committee thinks that the completion rate is excellent. It is the highest of all faculties visited.

TABLE 4: DROP-OUT RATES AND GRADUATES. COHORT 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D after 10 years
139	25%	58%	68%	71%	7.5%

3. Goals and aims

The Faculty has described the goals and aims as follows:

"- *to educate students to be able:*
 * *to perform a logical analysis of complex problems of an electrotechnical nature, and to propose a workable solution in the socio-economic industrial environment*
 * *to perform as a high level academic engineer*
 * *to cope in a creative way with new problems in a changing world, in a changing technological environment*
- *to prepare for lifelong learning;*

The general accent is on mathematical and physical modelling from a systems point of view. Special focus points are modelling, analysis, synthesis and design, CAD.
In terms of knowledge: this means that the principal knowledge is centred upon an understanding of physical laws and limits in electronic systems. Polyvalent mathematical and physical basis, enhanced with numerical techniques and informatics; analysis and design techniques for complex systems. Fundamental knowledge is emphasized, as opposed to encyclopedic knowledge of facts which becomes more rapidly obsolete. Knowledge of technological mainstreams.
In terms of skills: this means good
- *problem formulation using literature search and own insight;*
- *setting up of a working plan to solve the problem in due time (on time schedule);*
- *use of scientific expertise and scientific methods to solve practical problems, i.e. identification of fundamental properties of complex systems analysis and modelling of basic components/systems and their interrelationships; applying modern design techniques (VLSI, CAD);*
- *analysis (criticism) of the proposed solution;*
- *presentation of the problem and its solution in a written and oral report (communicative skills).*

In terms of attitudes:
- an open mind regarding the continuous changes in a conservative society;
- "cool analysis" in the midst of the hectic world of new features and products;
- placing techniques in the proper social, economic and environmental context;
- mastering the art of decision making" (Basic Information, Volume 2, pages 21/22).

The Committee judges the content of the objectives as good, but they could be formulated in a more operational form suited for evaluation of actual results.

4. The programme

The Faculty offers two programmes in Electrical Engineering, leading to the title "Burgerlijk Elektrotechnisch Ingenieur" (Civil Electrical Engineer):
1. Power Engineering ("Elektrische Energietechniek, sterkstroom");
2. Electronic Engineering ("Zwakstroom").

4.1. The philosophy behind the programme

" The Technical Faculty of the University of Gent is a faculty with a long history. It started some 150 years ago, under the name "Ecoles Spéciales", and it was closely modelled on the French model of "Les Grandes Ecoles", especially "L'Ecole Polytechnique". Today the simplicity of the structures still closely resembles the original organization. The philosophy has been and still is based on its official name: Faculty of Applied Sciences, where the words "Sciences" and "Applied" play a fundamental part. First of all the accent is on science: in the first two years the programme is for a large part common to all engineering disciplines, and its aim is to provide the student with a polyvalent scientific background. Technical courses only turn up at graduate level, and aim to bring the student to a high level of understanding of the basic models and systems in electrical engineering. Again, the accent is on mathematical tools and physical modelling, less on technology. This general philosophy tries to educate intellectuals, trained in the structures and mathematical analysis of EE-systems, to such a level that they are able to apply this logic in order to master complex technological problems, in relation to their social, economical and environmental context, and to develop new technology as opposed to maintaining existing technology. This last aim is pursued by a separate kind of engineers called "industrieel ingenieur" who are educated in a 4 year curriculum at technical colleges ('Industriële Hogeschool')" (Basic Information, Volume 2, page 17).

4.2 The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2.

Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPR-EE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE [1] OF TOTAL CONTACT HOURS

A. Electronic engineering

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	10.2	3.8	1.1	0		15.1
PHYSICS	1.1	4.4	0	0		5.5
COMPUTER SCIENCES	1.5	1.1	0	1.7		4.3
GENERAL ENGINEERING SCIENCES	4.9	6.6	3.1	0.6		15.2
ELECTRICAL ENGINEERING SCIENCES	0	2.2	19.2	13.6		35.0
ELECTRICAL DESIGN[2]	0	0	0	1.2		1.2
NON-TECHNICAL SUBJECTS	0.6	0.6	0	2.4*)		3.6
ELECTIVES[3]			0.6	3.6	15.9	20.1
TOTAL	18.3	18.7	24.0	23.1	15.9	100% 4095 hrs
THESIS					240 hours	

*) 2.4% of the electives has to be non-technical subjects.

B. Power engineering

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	10.2	3.8		0		14.0
PHYSICS	1.1	4.4		0		5.5
COMPUTER SCIENCES	1.5	1.1		0		2.6
GENERAL ENGINEERING SCIENCES	4.9	6.6	10.5	2.1		24.1
ELECTRICAL ENGINEERING SCIENCES	0	2.2	14.9	15.2	4.7	37.0
ELECTRICAL DESIGN[2]	0	0				
NON-TECHNICAL SUBJECTS	0.6	0.6	0	1.3	0.5	3.0
ELECTIVES[3]			0.6	4.3	9.8	14.1
TOTAL	18.3	18.7	25.4	22.9	15.0	100% 4140 hrs
THESIS					300 hours	

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for industrial training and thesis work are not counted in the percentage.

[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.

[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

Teaching is organized in 2 semester periods of about 3.5 months each (October to January; late February to May).

The programme of the first two years is identical for almost all engineering students. These two years are especially devoted to mathematics, physics, chemistry, mechanics, informatics, electricity, metallurgy. See also the remarks under 4.1.

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After the second year, the end of the first cycle, there is a formal examination, the "kandidatuur" (candidature). In the 3rd year the electrical engineering students have to choose a specialization, either Electrical (Power) Engineering or Electronic Engineering.

4.3. Mathematics; Basic sciences

The Committee assesses Mathematics as at an excellent level. Much time is spent on Mathematics (53% of the time in the first year and 22% in the second year, in total 15% of the total contact hours). The question is whether 600 hours of mathematics is not too much. The content of the courses is conventional. Abstract Algebra is only briefly taught. The change to computer graphical techniques is an improvement. Physics in the old curriculum is not well adapted and is inaccessible. The new curriculum may be an improvement.

4.4. General Engineering Sciences

General Engineering Sciences are present in large measure in the first two years of the programme - the first cycle - (25% of all contact hours for Power Engineering and 15% for Electronic Engineering). There are a large number of technical disciplines included: civil engineering, mechanical engineering and chemical engineering. The Committee wonders if the programme in the first cycle is coherent enough. There is more emphasis on applied areas of engineering (civil, mechanical, chemical etc.) rather than on the general basis of engineering (mechanics, strength of materials etc).

4.5. Electrical Engineering Sciences

The Committee judges the Electrical Engineering Sciences in the programme as good, however not very broad, in contrast with the breadth aimed at in the 1st cycle. The laboratory exercises in the later years seem very basic, simple and traditional. Regarding the content, the Committee wonders whether the share of Electrical Sciences could be enlarged.

4.6. Electrical Design

Electrical Design is taught and practised in the compulsory course "Electrical Radiation" (half of the lectures and 60 hours practicals). The total time for the compulsory design part is only 1.2% of the total contact hours.

4.7. Non-Technical subjects

The Committee assesses the non-technical subjects in the basic part as meagre. There are short courses in Economics and Industrial Law in the first cycle. But, for example, marketing, accounting and product life-cycle are missing. The students have to choose at least 100 hours of non-technical subjects as electives.

4.8. Additional requirements

The IPR-EE Committee has formulated additional requirements regarding laboratory experience of the students, the use of the computer, the attention paid by the Faculty to written and oral communication (Guide for the Committee, page 10). The Committee has no comments on the requirements outlined, but noted that the Faculty does not require practical training in industry. In the opinion of the Committee this is a shortcoming.

4.9. Master's thesis

"During the final year a thesis has to be submitted, supervised by at least one staff member. The work is done by the student for nearly half his/her time (45%) during one year (October-June). The jury consists of 3 staff members. One member from industry is added if the thesis results from an industry-university cooperation project. The thesis is presented in a public session (end of May, presentation time 30 min)" (Basic Information, Volume 2, page 36).

In the programme, 240 hours (Electronic Engineering) or 300 hours (Power Engineering) are programmed for the thesis. The Committee finds this nominal time an underestimate. The students spend far more time on their thesis (about 600/700 hours). As far as it is possible to judge, the Committee thinks that the level of the thesis is at a normal university level.

4.10. Examinations: regulations and requirements

"In the first two years most examinations are written (many open book, others closed book). In later years most examinations are oral. The duration is 2 to 3 hours per examination. They are organized in regular 3 week periods at the end of each semester (early February and late June). A student has to pass the examination at the end of the year. If not, a second attempt is possible in September. When the student fails, (s)he has to repeat the year. Examinations are weighted (with credit points) proportional to the course load (lecture time + 1/3 exercise time)" Basic Information, Volume 2, page 37).
Up till now, during each semester there is usually one written examination per course, or about one every fortnight. These interim evaluations count for 1/3 of the final examination. The Committee observed that the interim evaluations overtax the students, who work for the evaluations under continual stress. They skip lectures, due to lack of time. The Committee supports the suggestion of the Faculty to abolish the interim evaluations. The Committee has the impression that the examinations are mainly based on exercise routine and not on understanding.

4.11 Study burden

As is to be seen in Table 6, the total programmed study burden is about 10.000 hours, which makes about 2000 yearly. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 2:3. The students spend about 40% of their time at the university and are expected to spend about 60% on self study.

TABLE 6: TOTAL STUDY BURDEN

	Lectures	Practicals	total contact hours	indus- trial training	thesis	total programmed hours (including self study)
Electronic engineering	2070	2025	4095	0	300	10.150
Power engineering	2115.	2025	4140	0	240	. 10.150

There is no distinction given between lectures and tutorials (small working groups for exercises). The ratio lectures/practicals is 1:1. According to the Faculty, the nominal study burden is about 2000 hours yearly (= 2 semesters of 15 weeks each). The study burden per week is about 30 contact hours and about 30 hours self study. According to their statements, the students spend more than 50/60 hours a week, 2000/2100 hours yearly on their studies. The programme is completely filled up. The Committee assesses the study burden as too high. There is a discrepancy between the burden of the first year and that of the second. The latter is far heavier. The students take hard work for granted: "It is all in the game".

4.12 Overall assessment of the programme

The programme of Electrical Engineering meets, in the eyes of the Committee, the minimum requirements. In the European context of the faculties which were visited, the curriculum of the University of Gent takes a special place, with its first two years common for all engineering students, with education in many areas of engineering. The programme includes sufficient mathematics and physics. The Electrical Engineering part is somewhat limited in the programme, due to the philosophy of providing a broad education. The Committee judges the programme as too compact. The students have virtually no time for digesting the subject matter.

5. The Academic Staff

The academic staff fall into five main categories:
* gewoon hoogleraren (ordinarius) (full professors);
* hoogleraren (full professors);
* hoofddocenten (associate professors/senior lecturers);
* docenten (assistant professors/junior lecturers)
* assistenten (normally conducting research work towards a doctoral thesis).

The Committee considers the size of the academic staff for Electrical Engineering to be relatively small. In Table 7 the numbers of staff members are given. The figures are calculated for a fictitious 'department' of Electrical Engineering.

The average teaching load of the professors is about 30% of their time (6 hours lectures + additional activities). The lectures, also in the basic years, are given mainly by the professors. Research assistants are in charge of tutorials, practicals etc. The average assistant spends 75% of his time on research and 25% on teaching/administration. The Committee considers the teaching load as normal The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. The number of students per staff member is 14 (see Table 8). This can be considered as rather low, compared with other faculties. A possible measurement of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This is 2.4 graduates per FTE-teaching.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF 1990

	Full time equivalent	Persons
Academic Staff:		
* Full professors	9	9
* Associate professors/senior lecturers	7.5	8
* Assistant professors/junior lecturers	5	5
* Research assistants/Phd. students	117.5	118
Total academic staff	139	140
Non-academic staff	38	38

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
45	628	107	14	2.4

The didactic expertise of the staff in general seems to be adequate, to judge from what the students say. The staff have the opportunity to follow staff development courses on a voluntary basis. The Committee wonders about the added value of the lectures, when the students skip them so easily. The academic level can be considered as appropriate. Also the scientific activities seems to be satisfactory. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 1.1 (see table 9).

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Number of papers	111	103	109	128	148
Number of papers per staff member (excluding 'others')					1.1

The full professors are appointed for life. Salaries are fixed by law, and there are no differences in the salaries of full professors in Gent or, e.g., Leuven. The Committee has the impression that new personnel are often recruited from within the university. The fact that by law undergraduate courses must be given in Dutch hinders international recruitment. The Committee noted that the University does not officially offer the opportunity for sabbatical leave.

6. Facilities and Resources

The funding in general is satisfactory; there are complaints about state funding, but perhaps no more than seems to be routine everywhere. In Table 10 some figures about finances are given.

TABLE 10: INCOME AND EXPENDITURES OF THE FACULTY

INCOME	excl.salaries	incl.salaries	EXPENDITURES	excl. salaries	incl. salaries
State	9.8%	32%	Education	9.8%	32%
Industry	90.2%	68.0%	Research	90.2%	68%
Research foundations			Total		100%
Total	100%	100%			

The teaching equipment, as far as it was possible to judge, is adequate, but not very modern. The laboratory equipment is adequate, but dated too, at least the equipment for the laboratory exercises. The Opto- Electronics laboratory is very impressive indeed. The computer equipment is good.

7. The internal Quality Assurance

"The programme is evaluated regularly. Important changes are made whenever there are vacancies to be filled. Students do participate at all levels: in the EE Department Council (Afdelingsraad), Engineering Faculty Education Committee, Engineering Faculty Council, and University Board. The content of the courses is continuously updated by the lecturers. Where appropriate modern technologies are used, and training is provided in the practical exercise sessions. International contacts, participation at international conferences, and publishing in international journals are encouraged " (Basic Information, Volume 2, page 38).

The Committee noted the absence of an internal quality assessment system. There is little attention to internal quality management. Quality seems to be assumed rather than tested. The students have little influence on the quality. The students should have more influence by providing feedback, but there is no formal feedback mechanism.

8. External relations

" Relations with industry are maintained in several ways:
- *visits to industry by the students;*
- *a number of students have industrial training during the summer; this is mainly organized through the student's union;*
- *some Master's thesis work is carried out in close cooperation with industry, or in connection with industrial research contracts;*
- *consultancy, both to industry and public authorities;*
- *research contracts with industry, either bilateral or sponsored by European or national authorities;*

- *organization of training seminars and short courses for and/or by professional organizations.*

Direct sponsorship on the programme occurs only occasionally" (Basic Information, Volume 2, page 40).

The links with industry can be considered as good, however often based on individual contacts. The contact with other institutes seems to be limited.

9. International relations

International relationships can be considered as good.

10. The graduate

The Committee considers that the Faculty produces graduates who have had a technically adequate education with a broad basis. Adaptation to society might be a question mark. The students are hard working and motivated. The Committee finds that the graduate merits the title of Electrical Engineer. Until now the students have not had problems in obtaining jobs. Of all graduates, 13% go into research, 76% into industry and services, 8% into central government (public office), and 3% into non-university education (see Table 11)

TABLE 11: DESTINATION OF GRADUATES

Industrial companies	76.0%
Government	8.0%
Universities/research	13.0%
Non-university education	3.0%

11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

\+ The Committee has no doubt that the programme, leading to the degree of Electrical Engineering, offered by the Faculty of Applied Sciences at the RUG, meets the minimum requirements set by the IPR-EE Committee in the Guide. The Committee has the impression that the quality of the graduate is good and that (s)he merits quite rightly the title "Master of Electrical Engineering".

+ The Committee encountered a programme, unique in comparison with the other faculties it visited outside Belgium, which offers an education in many areas of engineering. On the one hand the Committee can appreciate this; on the other hand the Committee noted that little attention is given to, for example, seeing industries as technical-economic-social systems in which engineers play a dominant role.

+ The teaching load of the staff is considered as normal. The Committee considers it very valuable that full professors also participate in the basic programme.

+ The Committee met an enthusiastic faculty staff. The Committee judged the quality of the staff as good and the working environment as inspiring.
In the opinion of the Committee the level of research is good to excellent; in certain fields even at top level.

+ The Committee was impressed by the students. They are hard working and very busy; it may be that they sometimes spend too little time on other things.

- The programme is overloaded. It puts the students into a continuous rather than an occasional situation of stress.

- With regard to the time for thesis work, the Committee expresses its view that the nominal time is underestimated. In reality the students spend far more time.

- The Committee assesses the non-technical subjects in the basic part of the programme as meagre. Because the engineer will often stay only a short while in the technical field, after some time assuming a managerial position, it is desirable to have such subjects in the curriculum as project-management and accountancy.

- Quality Assurance is nearly non-existent and could be improved. The Committee advises the Faculty to set up a Quality Assurance system.

- The organization seems traditional, with a decision-making process which is complex because it involves the whole Faculty of Applied Sciences. There is a lack of an EE-identity in the whole organization.

18 FACULTY OF ENGINEERING (DEPARTMENT OF ELECTRICAL ENGINEERING) AT THE KATHOLIEKE UNIVERSITEIT LEUVEN, BELGIUM

Date of visit: 21/23 January 1992

1. Introduction

The fifth country in the International Programme Review Electrical Engineering (IPR-EE) was Belgium. In Leuven the Committee visited the Faculty of Engineering (Faculteit der Toegepaste Wetenschappen), in which the Department of Electrical Engineering is responsible for the programmes Power Engineering and Electronics, after the first two years of general engineering education. For the members of the Committee see Appendix 1.

The Faculty of Engineering is one of the 10 faculties of the University of Leuven. Leuven University was founded in 1425, and is the oldest Catholic university still in existence and the oldest university of the Low Countries. The Catholic University of Leuven is a private university with a board of trustees consisting of the Flemish bishops and 4 lay-men. But the University is funded by the Flemish government on an equal basis with i.a the State University Gent. The University of Leuven has about 25,000 students, of whom about 3,000 are in the Faculty of Engineering. Of these 3,000 students about 732 are studying for Electrical Engineering, although the formal choice is only made in the 3rd year.

The Faculty offers a wide range of programmes leading to all classical engineering degrees: Architecture, Civil Engineering, Mine Engineering, Mechanical Engineering, Electrical Power, Electronics, Computer Sciences, Metallurgy and Chemical Engineering. The Faculty of Engineering is divided into 7 departments.

At Faculty level there is a Faculty Board and a Faculty Council. The Council consists of the full professors, representatives from the scientific personnel, and 6 student members. All decisions are made in the Faculty Council. The Dean is responsible for the implementation of the decisions of the Council. The Faculty has a programme or curriculum committee, in charge of curriculum innovation. The proposals of the committee go to the Council for decision. At departmental level the Council of the Department is the highest authority. The department has a chairman. The Standing Committee on Education gives advice on all problems related to educational matters. It reports directly to the Faculty.

The department of Electrical Engineering has 3 research units:
1. ESAT (= Electronics, Systems, Automation, Technology, Telecommunication)
2. V.I.T. (= Power & Industrial applications);
3. T.E.O. (= Applied Electronics & Optics).

For the purpose of the International Programme Review Electrical Engineering, the Committee looked at Electrical Engineering: Energy and Electrical engineering: Electronics.

The Committee has the impression of a somewhat traditional, but very well run organization, with well defined personal responsibilities. Lines of decision making are very clear but somewhat traditional and top down. The bottom-up lines are weak. In the Faculty of Engineering, Electrical Engineering has its own organizational identity.

2. The student

* Starting level of the student

The freshmen at the University of Leuven have had 6 years of elementary schooling (age 6 to 12 years). Schooling is obligatory up to the age of 18 years. The secondary school (6 years) is divided into three streams: General, Technical, and Professional secondary school. The General secondary school (Hoger secundair onderwijs) gives access to the university.

The requirements for the final examination of the secondary school for Mathematics are the same as those of the entrance examination supplemented by McLaurin and Taylor series; arithmetic and geometric series; elementary probability; algebraic structures, groups, rings, fields; spherical coordinates. For Physics the requirements are a) Mechanics: forces, motion, impulse, energy; b) Heat, temperature; c) Waves, acoustics and optics; d) Electric fields, electrostatics, magnetism, introduction to induction, basic rules of d.c.; e) Atom model (Bohr), energy levels, elementary introduction to fission; f) Liquids, gases, hydrostatics.

The Committee has no comments on the starting level, taking into account the provisions for selection.

* Selection

The general secondary school gives access to the university, on the understanding that students have to pass an entrance examination for engineering studies. This entrance examination covers only Mathematics. The objective is not to limit the number of students allowed to enter, but to select the good students. A committee of the Deans of the Flemish engineering faculties decides on the level and content of examinations. The requirements for the entrance examination are Geometry: transformation, projections, rotations, mirror image points, lines, planes, distance, orthogonality, angle, sphere, parallelepiped, pyramid, cylinder, cone, vector spaces, parameter and cartesian equations of lines, planes, curves, conics (reduction, classification, asymptotes, focal points), polar coordinates. Algebra: real and complex numbers, polynomials, rational functions, matrices, determinants, rank, inverse matrix, linear equations, linear and quadratic inequalities. Analysis: functions, derivative, limits, continuity, extremity, inflection, graph of a function, primitive function, integrals; linear, homographic, quadratic, power, rational, exponential, logarithmic, trigonometric, inverse trigonometric functions. Trigonometry: standard formulae (sum, difference, Simpson, half angle), trigonometric equations, solution of triangles. Numerical calculations with pocket calculator.

There is common recognition of the examination among the three faculties of Engineering (Gent, Brussels and Leuven).

In 1990 there were 833 candidates for the entrance examination in Leuven (1400 in all Flanders). Of the 833 applicants, 458 passed the examination, that is to say 55%. The on average about 60-65% are admitted. Over the last few years the percentage has declined, probably caused by a large number of students who do not show up after acceptance.

2.3. Student numbers

Table 1 gives the number of freshmen and the total number of students for the year 1985 and 1990. The number of freshmen is a fictitious number, because all engineering students start with a common basic programme of two years (see 4.2). But according to the Annual Report of the Department of Electrical Engineering 1990, about 45% on average of the engineering students choose Electrical Engineering. So 45% of the total number of freshmen in the Faculty of Engineering is assumed to be the number of freshmen for Electrical Engineering. The total numbers are counted as follows (1st year = 45% total freshmen + 2nd year (= 1st year number minus 25% drop-out) + 3rd, 4th and 5th years students Electrical Engineering).

TABLE 1: NUMBER OF FRESHMEN AND TOTAL NUMBER OF STUDENTS 1985 AND 1990

NUMBER OF FRESHMEN				TOTAL NUMBER OF STUDENTS			
TOTAL		% FEMALE		TOTAL		% FEMALE	
1985	1990	1985	1990	1985	1990	1985	1990
227	206	11.9%	15.5%	855	732	4.5%	6.4%

TABLE 2: APPLICANTS AND INTAKE 1985 AND 1990

1985		1990	
APPLICANTS	INTAKE	APPLICANTS	INTAKE
414*)	227	375	206

*) The number is 45% of all applicants for the Faculty of Engineering, reflecting the proportion of students who will normally opt for EE.

The number of students for EE is decreasing. The number of female students is fairly high in comparison with other countries, but the number of foreign students is very low.

* Average duration of study, completion rates.

The nominal duration of the Electrical Engineering programme is 5 years, containing 2 years (1st cycle) common to all students, and 3 years of Electrical Engineering. The average real study time is 5.3 years. Considering a real study time of 5.5 years to be typical for the Western European (continental) universities, the Committee thinks that the average of 5.3 is most satisfactory. Leuven, with Gent, shows the smallest difference between nominal and effective time of all the faculties visited by the Committee.

TABLE 3: NOMINAL DURATION OF THE MASTER'S PROGRAMME AND THE EFFECTIVE LENGTH OF STUDIES IN YEARS

NOMINAL	EFFECTIVE
5.0	5.3

The drop out in the first year is 15%. Looking at the drop-out figures after 1 year in other countries, this number is high, taking into account the entrance examination. After the first year there is still a drop out of 17% of the students.

The completion rate in the nominal time is high, 60%. An additional 5% of the students get their degree after more than 6 years (see Table 4). The total completion rate is about 65%. An overall completion rate of 60/65% seems to be an average for Electrical Engineering in the West-European universities (see the general conclusion in Part 1, paragraph 6.6). Therefore the Committee thinks that the completion rate is good.

TABLE 4: DROP-OUT RATES AND GRADUATES GENERATION 1982/1983

FRESHMEN	% DROP OUT AFTER 1 YEAR	COMPLETION RATE IN NOMINAL TIME	COMPLETION RATE AFTER 6 YEARS	COMPLETION RATE AFTER MORE THAN 6 YEARS	Ph.D after 10 years
227	15%	60%	63%	65%	9.0%

3. Goals and aims

The Faculty has described the goals and aims as follows:
"The curriculum in Electrical Engineering has as a general goal: to educate students with a suitable background in mathematics and physics so that they can successfully be employed, and take responsibility for electrical and electronic matters in industrial companies, planning and consulting centres, research centres, and in the public utility sector.
In terms of knowledge this means especially: advanced mathematics, general knowledge about modern engineering disciplines, advanced knowledge about Electrical and Electronic Engineering Sciences and specialized knowledge in one of the four Electrical disciplines.
In terms of skills, the ability to:
- *take the responsibility in technical projects, studies, and departments of industrial companies;*
- *perform research work in academia or in industrial companies;*
- *give sound and science-based advice to decision-making people in technical projects and problems;*
- *understand complex systems for technical-commercial applications;*
- *understand the social, economic, and juridical dimensions of an industrial company.*

In terms of attitudes, readiness to:
- *combine technical knowledge with a firm cultural background;*
- *be able to communicate with colleagues at the same professional level for team work;*
- *be able to communicate with people from both higher and lower hierarchical level (e.g. oral expression, written reports)"* (Course description Leuven, pages 29/30).

The Committee judges the formulation of the objectives as clear. With respect to the ethical part, the goals are exceptional. The Committee thinks the goals could be formulated in a more operational form suited for evaluation of actual results.

4. The programme

The Faculty offers the programme Electrical Engineering, leading to the title "Werktuigkundig-Elektrotechnisch Ingenieur" (Master of Science in Electrical Engineering).

4.1. The philosophy behind the programme

The Faculty says that *"the underlying philosophy has been discussed and agreed in a working group consisting of academic and scientific staff, representatives of student organizations, representatives of professional associations of engineers, staff engineers, and managers from industry"* (Course description Leuven, page 26). But the Faculty forgets to set out the underlying philosophy, unless the next statement may be interpreted as such: *" After graduation, the university engineers become employed for conceptual work, product design, research and theoretical studies. Later on many of them become staff members and members of the boards of directors of middle and large companies, both in the private and in the public sector"*(Course description Leuven, page 26).

4.2 The structure of the programme

The structure of the programme and an overview of the contents are given in Appendix 2. Table 5 gives the time, as a percentage of the total number of contact hours, spent on the different subject requirements set by IPR-EE in the Guide for the Committee. These are: Mathematics and Physics, General Engineering Sciences, Electrical Engineering Sciences, Electrical Design and Non-technical subjects.

Teaching is organized in 2 semester periods of about 3.5 months each (October to January; late February to May). The programme of the first two years is identical for almost all engineering students, as it covers general and basic knowledge. At the end of the second year (the end of the first cycle), there is a formal examination, the "kandidatuur" (candidature). In the 3rd year the electrical engineering students choose from the options Energy or Electronics. The latter has the following specializations:
* Automation & Computer systems
* Micro electronics
* Telecommunication
* Mechatronics
* Industrial Management

4.3. Mathematics; Basic sciences

The Committee assesses Mathematics as being at an excellent level. Much time is spent on Mathematics (53% of the time in the first year, and 22% in the second year). The examinations are good, but the content of the courses is conventional. Abstract Algebra and Discrete Mathematics are not included in the basic part, but are taken care of in the 4th year.

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE [1] OF TOTAL CONTACT HOURS.
A. Energy

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	9.3	5.8				15.1
PHYSICS	6.6	5				11.6
COMPUTER SCIENCES	1.6		2.9	1.3	1	6.8
GENERAL ENGINEERING SCIENCES	2.0	7.3	5.8	3.1	1.5	19.7
ELECTRICAL ENGINEERING SCIENCES			9.7	14.1	9.6	33.4
ELECTRICAL DESIGN[2]		5	1.2	0.9	1.1	8.2
NON-TECHNICAL SUBJECTS	0.9		0.7	1.8	1.1	4.5
ELECTIVES[3]	0	0				0
TOTAL	20.4	23.1	20.3	21.2	14.3	100% 3277 hrs
THESIS					360 hrs	

TABLE 5: TIME SPENT ON DIFFERENT SUBJECTS AS PERCENTAGE [1] OF TOTAL CONTACT HOURS.
B. Electronics

YEAR	1	2	3	4	5	TOTAL
MATHEMATICS	9.3	5.8				15.1
PHYSICS	6.6	5.0				11.6
COMPUTER SCIENCES	1.6		3.7	1.3	1.1	7.6
GENERAL ENGINEERING SCIENCES	2.0	7.3	5.2	0.6	1.6	16.7
ELECTRICAL ENGINEERING SCIENCES			9.8	11.0		20.8
ELECTRICAL DESIGN[2]		5.0	0.9	3.1		9.0
NON-TECHNICAL SUBJECTS	0.9		0.8	1.8	1.1	4.6
ELECTIVES[3]	0	0		0.4	13.0	13.4
TOTAL	20.4	23.1	20.4	18.2	16.6	100% 3255 hrs
THESIS					360hrs	100%

[1] Percentages are calculated on the total contact hours (lectures, practicals, research projects). Programmed hours for industrial training and thesis work are not counted in the percentage.

[2] It is not always possible to make a distinction between Electrical Engineering Sciences (EES) and Electrical Design (ED). For the total amount of Electrical Engineering subjects, the percentages for EES and ED must be added.

[3] When the student has to choose electives in different years, the hours are counted for each year proportionally.

4.4. General Engineering Sciences

General Engineering Sciences are present in considerable quantity in the first two years of the programme - the first cycle - (20% of all contact hours). There are a large number of technical disciplines included: civil engineering, mechanical engineering and chemical engineering. The Committee wonders if the programme in the first cycle is coherent enough. There is more emphasis on applied areas of engineering (civil, mechanical, chemical etc.) rather than on the general basis of engineering (mechanics, strength of materials etc).

4.5. Electrical Engineering Sciences

In the programme Electronics is 20% of the contact hours are earmarked for the specialization, in this case Electrical Engineering. In the programme Energy this figure is 33% of the contact hours. The Committee judges the Electrical Sciences in the programme as well balanced.

4.6. Electrical Design

The Committee was unable to get a clear picture of Electrical Design. Its place in the programme is not clear, but it is certainly present. As far as the Committee could judge, the quality is good. However, the Committee obtained the impression that students do not have a clear idea of the goals.

4.7. Non-Technical subjects

In the whole programme 5% is earmarked for non-technical subjects. The Committee assesses the non-technical subjects as consisting of unrelated scattered items. Unfortunately marketing, accounting and product life cycle are missing.

4.8 Additional requirements

The IPREE-Committee has formulated additional requirements regarding laboratory experience of the students, the use of the computer, the attention paid by the Faculty to written and oral communication (Guide for the Committee, page 10). The Committee has no comments on the requirements outlined, but noted that the Faculty does not require practical training in industry. In the opinion of the Committee this is a shortcoming.

4.9. Master's thesis

During the final year a thesis must be submitted, supervised by at least one staff member. In the programme about 360 hours is demanded for the thesis.
"The Master's thesis has the aim of allowing the student to cope with a well-defined problem and to work it out in a far more detailed way than is ever possible in an ordinary course. This problem must be interesting enough to motivate the effort. It must preferably contain practical as well as theoretical problems. The theoretical aspects are desirable because the education of an engineer is not aimed at technology but at development, study, and deep knowledge of the phenomena which appear in apparatus and processes. The practical work forces the student to dig into the hard matter, to realize contacts with industry and in general the problems which occur with every practical realization.

The Master's thesis allows the future engineer to take up an active, personal role in development of the theory which he absorbed rather passively during the courses. He should be confronted with the most current technical problems, with publications old as well as new, in such a way that he gets acquainted with information sources which will be very valuable for him in the future. In a nutshell: the Master's thesis is necessary and important for the training and education of an engineer" (Course description Leuven, page 45).

The Committee assesses the time programmed for the thesis as too low, a fact recognized also by the staff. The students spend far more time on their thesis (about 700 hours). Sometimes they must be prevented from using too much time. As far as it is possible to judge, the Committee judges the level of the thesis at a normal university level; however the reports are very bulky and sometimes too "flat". The Faculty has proposed to reduce the size from 200 pages to 60 pages.

4.10. Examinations: regulations and requirements

The examinations are organized in regular 3 week periods at the end of each year (late June). A student should pass the examination at the end of the year; if not, a second attempt is possible in September. When the student fails, (s)he has to repeat the year. The present trend in the programme is a reduction in the number of examinations.

The Committee has the impression that the examinations are mainly based on exercise routine and not on understanding. The examinations are too often oriented to reproducing material. The students complain about the fact that questions are set on which information is given only in the lectures. Attendance at the lectures is therefore necessary, and it is alleged that some teachers tend to use this to force the students to be present.

4.11 Study burden

As is to be seen in Table 6, the total programmed study burden is about 9400 hours, which makes about 1880 yearly. The ratio of contact hours (lectures, tutorials, practicals and research projects) to self study is about 1:2. The students spend about 35% of their time at the university and are cxpected to spend about 65% on self study.

TABLE 6: TOTAL STUDY BURDEN

	Lectures	Practicals	total contact hours	industrial training	thesis	total programmed hours (including self study)
Energy	2473	804	3277	0	360	9400
Electronics	2676	579	3255	0	360	9400

Many lectures are coupled with tutorials (small working groups for exercises). So the number of lectures is about 75% 'real' lectures and 25% tutorials. The ratio of real lectures to practicals is 2:1.

According to the Faculty, the nominal study burden is about 1900 hours yearly (= 2 semesters of 13 weeks each). The Faculty operates the rule: 1 lecture hour requires 3 hours of self study. The study burden per week is about 15 lectures a week and 7 hours practicals or tutorials (= about 50 hours). According to the statements of the students, they spend about 50 hours a week during about 9 months (assuming they pass their examination the first time), that is 1900/2000 hours yearly. When they fail and have to repeat the examination in September the study burden is much higher.

In the judgement of the Committee, the programme is completely filled up and the study burden is too high. The students take hard work for granted: "It is all in the game".

4.12 Overall assessment of the programme

The Committee sees the programme of Electrical Engineering as meeting the minimum requirements. In the European context of the faculties which were visited, the curriculum of the University of Leuven takes a special place, with its first two years common for all engineering students, with education in many areas of engineering sciences. The programme includes sufficient mathematics and physics. The Electrical Engineering part is well balanced.

The Committee judges the programme as too compressed. The students have virtually no time for gaining perspective.

5. The Academic Staff

The academic staff fall into five main categories (since the coming into effect of the new University Law last year):

* gewoon hoogleraren (ordinarius) (full professors);
* hoogleraren (full professors);
* hoofddocenten (Associate professors/senior lecturers);
* docenten (assistant professors/junior lecturers)
* assistenten (normally conducting research work towards a doctoral thesis).

The Committee considers the size of the academic staff for Electrical Enginee·ing as adequate. All relevant fields seem to be covered. In Table 7 the numbers of staff members are given. The figures are calculated for the department of Electrical Engineering (including a proportional number of the staff of the first two years).
The average teaching load of the professors is about 30% of their time (6 hours lectures + additional activities). The lectures, also in the basic years, are given mainly by the professors. The research assistants are in charge of tutorials, practicals etc. The average assistant spends 75-80% of his time on research and 25-20% on teaching/administration.

TABLE 7: ACADEMIC AND NON-ACADEMIC STAFF

	Full time equivalent	Persons
* Full professors	12.0	12
* Associate professors/senior lecturers	0.2	2
* Assistant professors/junior lecturers	2.2	21
* Research assistants/Ph.D. students	118.2	122
* Others (part-time lecturers)	3	18
Total academic Staff	135.6	175
Non-academic staff	32.4	42

The average teaching load of the professors is about 30% of their time (6 hours lectures + additional activities). The lectures, also in the basic years, are given mainly by the professors. The research assistants are in charge of tutorials, practicals etc. The average assistant spends 75-80% of his time on research and 25-20% on teaching/administration.

TABLE 8: STUDENT/STAFF RATIO AND GRADUATES/STAFF RATIO 1990

FTE-TEACHING ACAD. STAFF	NUMBER OF STUDENTS	NUMBER OF GRADUATES	NUMBER OF STUDENTS PER FTE-TEACHING	NUMBER OF GRADUATES PER FTE-TEACHING
35	732	104	21	2,9

The Committee considers the teaching load as normal.The number of students per staff member is calculated by dividing the number of students by the total amount of time (in full time equivalents of 40 hours weekly) for teaching. This number is 21 (see Table 8). A possible measurement of teaching effectiveness is the number of graduates per staff member. This number is calculated by dividing the number of graduates by the total amount of FTEs for teaching. This number is 2.9 graduates per FTE-teaching.

The didactic expertise of the staff in general seems to be adequate, to judge from what the students say, although there are complaints about some lectures. The students assess their professors by evaluation of individual teachers and awarding the "Golden Chalk". The staff have the opportunity to take staff development courses on a voluntary basis. The Committee formed the impression that the Department of EE is more research-oriented than education-oriented. The academic level can be considered as good. Also the scientific activities seem to be good, and even excellent in some well circumscribed fields. However the publication ratio is not high. The number of papers per staff member is calculated by dividing the number of refereed papers by the number of staff members (academic staff, excluding the group 'others'). The number of publications per staff member is 1.0 (see Table 9).

TABLE 9: NUMBER OF REFEREED RESEARCH PAPERS

Year	1986	1987	1988	1989	1990
Number of papers	100	128	129	132	153
Number of papers per staff member (excluding "others")					1.0

The full professors are appointed for life. Salaries are fixed by law, and there are no differences in the salaries of full professors in Leuven or, e.g., Gent. The Committee has the impression that new personnel are often recruited from within the university. The fact that by law undergraduate courses must be given in Dutch hinders international recruitment, although this does occasionally occur.

With regard to sabbatical leave, the Faculty offers the opportunity for any member of the academic staff, after a full-time active period of 6 years, to take a sabbatical period of one year at the most.

6. Facilities and Resources

The funding in general is good. In Table 10 some figures about finances are given.

The teaching equipment is good, so far as it was possible to judge, as is the Laboratory equipment. The computer equipment is excellent.

TABLE 10: INCOME AND EXPENDITURES OF THE DEPARTMENT

INCOME	excl.salaries	inc.salaries	EXPENDITURES	excl. salaries	incl. salaries
State	2.6%		Education	10.0%	32%
Local government	7.2%				
Industry	5.4%		Research	90.0%	68%
Research foundations	84.8%		Total	100%	100%
Total	100%	100%			

7. The internal Quality Assurance

The Committee noted very little attention to internal quality management. Quality seems to be assumed rather than tested. In the view of the Committee the Faculty should set up a structural quality assurance system.

8. External relations

Relations with industry are maintained in different ways:
* all research units have research projects with industry;
* all staff members are called in by industry to act as consultants on various levels.
* seminars and short courses are offered for industrial participants.
* some Master's theses are produced in or in cooperation with industry.

The Committee assesses the links with industry as good. Contacts with other institutes seem to be good too.

9. International relations

International relationships can be considered as good and intensive. There are very few foreign students in Leuven.

10. The graduate

The Committee considers that the Faculty produces graduates who have had an excellent technical education with a broad basis. The students are hard working and motivated. The Committee finds that the graduate merits the title of Electrical Engineer. Until now the students have not had problems in obtaining jobs. Of all graduates, 22% go into research and/or education, 70% into industry and services, and 8% into central government (public office) (see Table 11).

TABLE 11: DESTINATION OF GRADUATES

Industrial companies	70.0%
Government: education	22.0%
Government: civil service	8.0%

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11. Overall assessment

Giving an overall assessment of a faculty is a precarious undertaking. It is difficult to find a balance in the comments. It is not always the same matters in a faculty which attract the attention of the Committee. The Committee has tried to formulate the five most important positive remarks and five negative ones. The reader must understand that it is not sufficient only to read the summary: the whole report must be read to reach a sound understanding.

+ The Committee has no doubt that the programme leading to the degree of Electrical Engineering, offered by the Faculty of Engineering at the Catholic University Leuven, meets the minimum requirements set by the IPR-EE Committee in the Guide, and even more than that. The Committee assesses the quality of the graduate as good. He/she merits the title "Master of Electrical Engineering".

+ The Committee encountered a programme, unique in comparison with the other faculties it visited outside Belgium, which offers an education in many areas of engineering.

+ The teaching load of the staff is considered as normal. The Committee considers it very valuable that full professors also participate in the basic programme.

+ The Committee judged the quality of the staff as good and the working environment as inspiring. In the opinion of the Committee the level of research is good to excellent; in certain fields at top level. The Committee was impressed by the students. They are hard working and motivated.

+ The Committee met a well organized and well managed Department of Electrical Engineering, with a clear personal leadership and responsibility.

- The programme is heavily loaded. The Committee has some doubts about the ratio 1 hour lecture: 3 hours self study.

- The Committee assesses the nominal time calculated for the thesis (360 hours) as too low. The staff know it. The students spend far more time on their theses.

- The programme is very rigid. The students are not unanimously pleased with the rigid system. There is little scope for choosing electives freely.

- In the view of the Committee it is inappropriate to oblige the students to attend lectures by giving out some information in the lectures only.

- Quality Assurance is nearly non-existent and should be improved. The Committee advises the Faculty to set up a Quality Assurance system.

PART III

APPENDICES

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APPENDIX 1: COMPOSITION OF THE VISITING PANELS

The visting committee for the Dutch faculties:

* Ir. B.L.A. Waumans, Director of Professional Systems, Philips Research Laboratories, Eindhoven, The Netherlands. (chairman)
* J.R. Thompson, BSc(Eng), CEng, FIEE, FBIM, Comwall Associates, Brightlingsea, UK
* Prof. dr. ir. W.M.C. Sansen, Department Elektrotechniek, Katholieke Universiteit, Leuven, Belgium (Eindhoven and Twente)
* Prof. dr. A.R. v. Cauwenberghe, Faculty of Applied Science, Automatic Control, University of Gent, Belgium (Delft)
* Prof. Dr. techn. J.A. Nossek, Institute for Network Theory and circuit Design, Technical University, Munich, Germany
* Prof. dr. S. Olving, Department of Electrical and Computer Engineering, Chalmers University of Technology, Göteborg, Sweden
* Prof. Dipl. El.Ing.ETH. H Baggenstos, Laboratory for Electromagnetic Fields & Microwave Electronics, ETH, Zürich, Switzerland
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), Utrecht, The Netherlands (secretary)

The visting committee for the Swedisch faculties:

* Ir. B.L.A. Waumans, Director of Professional Systems, Philips Research Laboratories, Eindhoven, The Netherlands (chairman)
* Ir. J. Wijmans, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Power Industry); formerly professor at the Delft University of Technology, The Netherlands; (visit to Chalmers)
* Prof.dr.ir. J. van Amerongen, Faculty of Electrical Engineering University of Twente, The Netherlands
* Prof. B.M. Bird, Ph.D., F.I.E.E., F.Eng, Department of Electrical and Electronic Engineering, University of Bristol, United Kingdom
* Prof.Dip.-Ing. D. Oeding, Institut für Elektrische Energieversorgung, Technische Hochschule Darmstadt, Deutschland
* Prof. Dr. A. Kündig, Laboratory for Computer Engineering and Networks, ETH, Zürich, Switzerland
* Prof. dr. ir. W.M.C. Sansen, Department Elektrotechniek, Katholieke Universiteit, Leuven, Belgium
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), The Netherlands (secretary).

The visting committee for the German faculties:

* Ir. J. Wijmans, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Power Industry); formerly professor at the Delft University of Technology, The Netherlands; (chairman)
* Prof.dr.ir. W.M.G. van Bokhoven, Faculty of Electrical Engineering, Eindhoven University of Technology, The Netherlands
* Prof. dr. A.R. v. Cauwenberghe, Faculty of Applied Science, Automatic Control, University of Gent, Belgium
* Prof. DR. I. Brinck, Faculty of Electrical Engineering, Tekniska Högskola Lund, Sweden (Darmstadt);
* Dr. B.J. Cory, DSc(Eng), ACGI, CEng, FIEE, Sen.MIEEE, Department of Electrical Engineering, Imperial College, London, UK
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), The Netherlands (secretary).

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The visting committee for the ETH :

* Ir. B.L.A. Waumans, Director of Professional Systems, Philips Research Laboratories, Eindhoven, The Netherlands. (chairman)
* Ir. J. Wijmans, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Power Industry); formerly professor at the Delft University of Technology, The Netherlands;
* Prof.dr.ir. W.M.G. van Bokhoven, Faculty of Electrical Engineering, Eindhoven University of Technology, The Netherlands
* Prof. dr.A.R. v. Cauwenberghe, Faculty of Applied Science, Automatic Control, University of Gent, Belgium
* Prof. Dr. techn. J.A. Nossek, Institute for Network Theory and circuit Design, Technical University, Munich, Germany
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), The Netherlands (secretary).

The visting committee for the Belgian faculties:

* Ir. J. Wijmans, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Pow Industry); formerly professor at the Delft University of Technology, The Netherlands (chairman);
* Prof.dr.ir. R.H.J.M. Otten, Faculty of Electrical Engineering, Delft University of Technology, The Netherlands
* Prof. dr. S. Olving, Department of Electrical and Computer Engineering, Chalmers University of Technology, Göteborg, Sweden
* Prof. Dr. J. Weiler, Leistungselektronik und Messtechnik, ETH, Zürich, Switzerland (visit to Leuven)
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), Utrecht, The Netherlands (secretary)

The visting committee for Imperial College, UK:

* Ir. J. Wijmans, former chairman of the board of KEMA (Testing, Research & Development and Engineering Consultants to the Electric Power Industry); formerly professor at the Delft University of Technology, The Netherlands (Chairman);
* Prof. dr. ir. W.M.G. van Bokhoven, Faculty of Electrical Engineering, Eindhoven University of Technology, The Netherlands
* Prof. dr. I. Brinck, Faculty of Electrical Engineering, Tekniska Högskola, Lund, Sweden
* Prof. dr. A.R. v. Cauwenberghe, Faculty of Applied Science, Automatic Control, University of Gent, Belgium
* Prof. Dr. A. Kündig, Laboratory for Computer Engineering and Networks, ETH, Zürich, Switzerland
* Prof. Dr. techn. J.A. Nossek, Institute for Network Theory and circuit Design, Technical University, Munich, Germany
* Drs. A.I. Vroeijenstijn, Association of Universities in the Netherlands (VSNU), The Netherlands, secretary).

APPENDIX 2: CURRICULUM DESCRIPTION

Legend to the tables:

* L= Lectures & Tutorials
  P= Practicals/research assignments

* The columns "L" and "P" contains absolute numbers of hours per subject. The last column gives the percentages of the total number of contact hours.

* The programmed hours for thesis and industrial training are not included in the total numbers of contact hours

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CURRICULUM DESCRIPTION EINDHOVEN

The faculty offers two programmes: Electrical Engineering (EE) and Information Engineering (IE). Graduates from both streams gain the title Electrical Engineer. The porgramme IE is running since the academic year 1986/1987 with about a quarter of the students. Circa 25 % of all EE students are in this curriculum. The programmes are organised separately. Up till 1990 the first year (the 'propedeuse') was in common for both courses. Since 1990 EE and IT have their own 'propedeuse'.

ELECTRICAL ENGINEERING	INFORMATION ENGINEERING
1st year: propedeuse 100 % compulsory at the end P-examination	1st year: propedeuse 100 % compulsory at the end P-examination
2nd year: 100 % compulsory	2nd year: 100 % compulsory
3d year: 46% compulsory (357 hours) 28% electives (216 hours) 26% research project (200 hours)	3d year: 46% compulsory (357 hours) 28% electives (216 hours) 26% research project (200 hours)
4th year: electives (108 hours) research project (200 hours) industrial training (400 hours) thesis (1040) Master degree exam	4th year: electives (108 hours) research project (200 hours) industrial training (400 hours) thesis (1040) Master degree exam

Notes:

1 The faculty has a trimester system. At the end of each trimester there are examinations.
2 The total programmed hours is circa 6800 hours, that is circa 1700 yearly.
3 The faculty of Eindhoven is counting with credit points. 1 credit point is 4 hours.
4 The yearly study load is 400 credit points
5 The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 2:3. Te students spend circa 40% of their time at the university and are expected to spend about 60 % on self study.
6 Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 75% 'real' lectures and 25 % tutorials.
7 In year 3 there is a research project of circa 50 half-days (200 hours). The same in the 4th year.
8 In the 3rd or 4th year the student has to fulfil a period of practical work in industry during 400 hours.
9 For the masters thesis 1040 hours are programmed, but too often the students exceed this time.

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YEAR 1: PROPAEDEUTIC YEAR ELECTRICAL ENGINEERING	L		P		%
MATHEMATICS		270			11.0
* analyses 1,2 & 4 * linear algebra 1-2	162 108				
PHYSICS		27			1.1
* mechanics	27				
COMPUTER SCIENCE		36			2.5
* introduction computer & programming	36				
GENERAL ENGINEERING SCIENCE				24	1.0
* mechanical engineering					
ELECTRICAL ENGINEERING SCIENCES		189		81	11.0
* circuit theory 1-3 * fields in electrical engineering * measurement techniques * electrical engineering labs	117 36 36		 81		
ELECTRICAL DESIGN		27		21	2.0
*design of digital systems	27		21		
NON TECHNICAL SUBJECTS					
TOTAL		549		150	28.6

YEAR 2: ELECTRICAL ENGINEERING	L		P
MATHEMATICS		117	
* Elementary probability theory * analysis 3 * introduction to signal theory	27 54 36		
PHYSICS		108	
* quantum and statistical physics * semiconductors materials * electromagnetic theory	36 36 36		
COMPUTER SCIENCE			
GENERAL ENGINEERING SCIENCE			
ELECTRICAL ENGINEERING SCIENCES		216	
* digital electronics * digital signal processing * semiconductor devices * intro into electromechanics and power electronics * control systems * electrical engineering lab * technical project	36 36 36 36 36		 54 30
ELECTRICAL DESIGN			
NON TECHNICAL SUBJECTS			
* engineering & society			54
* management course			30
TOTAL		441	

YEAR 3 : ELECTRICAL ENGINEERING	L		P		%
MATHEMATICS		27		36	2.6
* introduction into numerical methods	27	36	24		
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		108		242	14.3
* electromagnetic theory * telecommunication * intr. in power distribution, transportation & generation * control systems	36 36 36		12 15		
PRACTICAL ASSIGNMENT			200		
ELECTRICAL DESIGN				48	2.0
* integrated circuit design			48		
NON TECHNICAL SUBJECTS				106	5.1
* literature research * project management			6 100		
ELECTIVES		216			8.9
TOTAL		351		432	27.8

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YEAR 4: ELECTRICAL ENGINEERING	L		P	
MATHEMATICS				
PHYSICS				
COMPUTER SCIENCE				
GENERAL ENGINEERING SCIENCE				
ELECTRICAL ENGINEERING SCIENCES				
ELECTRICAL DESIGN				
ASSIGNMENT				20
NON TECHNICAL SUBJECTS				
ELECTIVES		108		
TOTAL		108		
TOTAL HOURS YEAR 1-4		1449		
INDUSTRIAL TRAINING				
THESIS			1040	

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YEAR 1: PROPAEDEUTIC YEAR: INFORMATION ENGINEERING	L		P		%
MATHEMATICS		270			11.0
* analyses 1,2 & 4	162				
* lineair algebra 1-2	108				
PHYSICS					
COMPUTER SCIENCE		153		132	11.9
* set theory	45				
* computer programming	18		24		
* logic			27		
* formal methods in computing science	45				
* automation theory	45				
Information engineering labs			81		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		117			4.9
* circuit theory 1-3	7				
ELECTRICAL DESIGN		27		12	1.6
*design of digital systems	27		12		
NON TECHNICAL SUBJECTS					
TOTAL		567		144	29.7

YEAR 2: INFORMATION ENGINEERING	L		P		%
MATHEMATICS		117			4.8
* Elementary probability theory	27				
* analysis 3	54				
* introduction to signal theory	36				
PHYSICS					
COMPUTER SCIENCE		99		150	10.4
* advanced programming	18			27	
* computer architecture	27			15	
* information theory	36				
* information engineering lab				54	
* technical project				54	
GENERAL ENGINEERING SCIENCE					0
ELECTRICAL ENGINEERING SCIENCES		207			8.7
* digital electronics	36				
* digital signal processing	36				
* network models	27				
* stochastic signal theory	36				
* intr. into wave phenomenon	36				
* control systems					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS				94	3.4
* engineering & society			54		
* management course			30		
TOTAL		423		234	27.4

YEAR 3 : INFORMATION ENGINEERING					
	L		P		%
MATHEMATICS		27		36	2.6
* introduction into numerical methods	27	36	24		
PHYSICS					
COMPUTER SCIENCE				200	8.2
PRACTICAL ASSIGNMENT			200		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		54		27	3.3
* telecommunication * control systems * integrated circuit technology	36 18		 12 15		
ELECTRICAL DESIGN		36		48	2.0
* introduction to CAD * integrated circuit design	36		 48		
NON TECHNICAL SUBJECTS		18		106	5.1
* industrial engineering (optional) * literature research * project management	18		 6 100		
ELECTIVES		216			8.9
TOTAL		351		432	27.8

YEAR 4: INFORMATION ENGINEERING					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
ASSIGNMENT				200	8.2
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
ELECTIVES		108			4.4
TOTAL		108		200	12.6
TOTAL HOURS YEAR 1-4		1449		1010	100%
INDUSTRIAL TRAINING				400	
THESIS			1040		

CURRICULUM DESCRIPTION <u>TWENTE</u>

The faculty offers one program: Electrical Engineering

1st year: propedeuse 100 % compulsory at the end P-examination
2nd year: 100 % compulsory
3rd year: 20% compulsory (162 hours) 38% electives (320 hours) 42% research project (350 hours)
4th year: 26 hours non technical subjects compulsory industrial training (400 hours) thesis (1000) Master's degree exam

Notes:

1 The faculty has a trimester system. At the end of each trimester there are examinations.

2 The total programmed hours is circa 6500 hours, that is 1625 yearly.

3 The faculty of Twente is counting with credit points. 1 credit point is 25 hours.

4 The yearly study load is circa 65 credit points

5 The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 2:3. The students spend circa 40% of their time at the university and are expected to spend about 60 % on self study.

6. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 60% 'real' lectures and 40 % tutorials.

7 In the 3rd and 4th years, the student has to choose for electives, in total 32 credit points (800) hours.According to the ratio 40% contact hours - 60% self study, there are given 320 hours for electives in the tables.

8 In year 3 there are two practical assignments, one of 100 hours and one of 250 hours.

9 In the 3rd or 4th year the student has to fulfil a period of practical work in industry during 400 hours.

10 For the masters thesis 1000 hours are programmed, but too often the students exceed this time.

ERIC

YEAR 1: PROPAEDEUTIC YEAR	L		P		%
MATHEMATICS		189			7.7
• calculus I+II	99				
• linear structure	45				
• engineerings math I	45				
PHYSICS		88		14	3.8
• physics	44				
• electromagnetic fields I	44				
• elementary physics			14		
COMPUTER SCIENCE		68		24	2.8
• fundamentals of digital techniques	32		6		
• introduction in programming	36				
GENERAL ENGINEERING SCIENCE					0
ELECTRICAL ENGINEERING SCIENCES		132		68	7.5
• semiconductors electronics			45		
• circuit analysis	44		9		
• electronics	44		8		
• technical system theory	44				
• measurements & instrumentation			6		
ELECTRICAL DESIGN				10	0.4
			10		
NON TECHNICAL SUBJECTS				64	2.4
• social sciences			64		
TOTAL		477		162	24.6

YEAR 2	L		P		%
MATHEMATICS		138			5.6
• probability theory	54				
• engineerings math II	48				
• linear systems	36				
PHYSICS		99			4.0
• introduction solid state physics	54				
• electromagnetic fields II	45				
COMPUTER SCIENCE		45		16	2.5
• systems programming	27		8		
• micro computer techniques	18		8		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		162		29	7.8
• measurements techniques			21		
• linear systems	72				
• systematics analyses of electronic systems	36				
• semiconductor devices	27				
• communication techniques	27				
• non-linear electronics			8		
ELECTRICAL DESIGN		27		17	1.8
• design of electronic circuits	27				
• computer aided design		9			
• lab realization in materials		8			
NON TECHNICAL SUBJECTS				100	4.0
• social sciences			100		
TOTAL		471		162	25.7

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YEAR 3	L		P		%
MATHEMATICS		26		24	2.0
• discrete math & programming methods	26		24		
PHYSICS		26			1.0
• electromagnetic waves	26				
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		78		366	18.1
• stoch. signal theory • continuous and discrete control theory • transduction techniques	26 26 26		16		
PRACTICAL ASSIGNMENT			350		
ELECTRICAL DESIGN				40	1.6
• design realisation			40		
NON TECHNICAL SUBJECTS				52	2.1
• social sciences			52		
ELECTIVES		320			12.0
TOTAL		450		382	37.0

200

YEAR 4	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		26			1.0
• social sciences	26				
ELECTIVES		320			12.0
TOTAL		346			13.0
TOTAL HOURS YEAR 1-4		1744		706	100%
INDUSTRIAL TRAINING				400	
THESIS				1000	

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CURRICULUM DESCRIPTION DELFT

The faculty offers one program: Electrical Engineering

1st year: propedeuse 100 % compulsory at the end P-examination
2nd year: 100 % compulsory
3rd year: 30% compulsory (168 hours) 31% electives (188 hours) 39% research project (240 hours)
4th year: industrial training (400 hours) thesis (950) Master degree exam

Notes:

1. The structure of the programme and an overview of the contents are based on information on the old programme.

2. The total programmed hours is 6720 hours, that is 1680 yearly.

3. The faculty of Delft is counting with credit points. 1 credit point is 40 hours.

4. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 1:1. The students are expected to spend circa 50% of their time at the university and expected to spend about 50 % on self study.

5. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 60% 'real' lectures and 40 % tutorials.

6. In year 3 there is a research project of 240 hours.

7. In the 3rd or 4th year the student has to fulfil a period of practical work in industry during 400 hours.

9. For the masters thesis 950 hours are programmed, but too often the students exceed this time.

ERIC

YEAR 1: PROPAEDEUTIC YEAR	L		P		%
MATHEMATICS		**294**		**7**	**14.1**
* linear algebra * calculus * numerical methods	112 182		7		
PHYSICS		**112**		**18**	**6.1**
* theoretical mechanics * physics lab * electricity and magnetism	56 56		18		
COMPUTER SCIENCE		**21**		**21**	**2.0**
* pascal programming	21		21		
GENERAL ENGINEERING SCIENCE				**40**	**1.9**
*technical drawing			40		
ELECTRICAL ENGINEERING SCIENCES		**232**		**44**	**13.0**
* switching theory * circuit theory * electronics	40 92 96		12 32		
ELECTRICAL DESIGN		**0**		**0**	**0**
NON TECHNICAL SUBJECTS		**16**			**0.8**
* social sciences	16				
TOTAL		**675**		**130**	**37.8**

YEAR 2	L		P		%
MATHEMATICS		**182**			**8.5**
* complex functions * signals and networks 1 * probability and statistics * random signals * differntial equations	32 36 48 24 42				
PHYSICS		**73**			**3.4**
* waves * quantum physics * electrical materials	8 21 24				
COMPUTER SCIENCE		**40**			**1.9**
* computer & operating systems	40				
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		**176**		**54**	**10.8**
* electronic measurement * electronics * signals and networks 2 * systems and controlems * telecom & information systems	24 40 32 56 24		18 20 16		
ELECTRICAL DESIGN				**43**	**2.0**
* design task * microprocessort interfaces			19 24		
NON TECHNICAL SUBJECTS		**16**			**0.8**
* electrical engineering and society	16				
TOTAL		**487**		**97**	**27.4**

YEAR 3	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		21		40	2.7
* social sciences * oral & written presentation	21		40		
ELECTIVE PROGRAM		168			7.9
* courses	168				
ELECTIVES		144		284	20.1
* courses * lab work * project	144		44 240		
TOTAL		333		324	30.7

YEAR 4	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
ELECTIVES		84			3.9
* courses	84				
TOTAL		84			3.9
TOTAL HOURS YEAR 1-4		1579		551	100%
INDUSTRIAL TRAINING				400	
THESIS				950	

CURRICULUM DESCRIPTION CHALMERS

The faculty offers one program: Electrical Engineering .

1st year: 100 % compulsory
2nd year: 100 % compulsory
3rd year: 100% compulsory
4th year: 2% compulsory (9 hours) 98% electives (575 hours) industrial training (680 hours) (in 4th or 5th year)
5th year (first half): thesis (600) Master degree exam

Notes:

1. The faculty has a system of periods of 8 weeks: 7 weeks lectures/practical, the 8th week exams.

2. The faculty of Chalmers is counting with credit points. 1 credit point is 40 hours and one year counts circa 40 credit points.

3. Total programmed hours: 7200 (180 credit points); circa 1600 yearly.

4. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 1:1. The students spend circa 50% of there time at the university and spend about 50 % on self study.

5. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 55% 'real' lectures and 45 % tutorials.

6. In the 4th years, the student has to choose for electives, in total circa 35 credit points (1600) hours.
   According to the ratio 50% contact hours - 50% self study, there is counted with 560 contact hours for electives in the 4th year.

7. There are three possible directions for specialisation: General (75% of the students), Computer technology and Mathematics.

8. In year 4 or 5 the students have to fulfil a training in industry during 680 hours.

9. For the masters thesis 800 hours are programmed.

YEAR 1	L		P		%
MATHEMATICS		**420**			15.2
* calculus 1 * calculus 2 * calculus 3 * calculus 4 * linear algebra	98 84 84 84 70				
PHYSICS					
COMPUTER SCIENCE		**42**		**15**	2.1
* computer programming	42		15		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		**121**		**36**	5.8
* electronic circuits * electric network theory A * electrical measurement * switching circuit theory, intro	34 3[illegible] 36 16		 36 		
ELECTRICAL DESIGN		**?**		**?**	?
NON TECHNICAL SUBJECTS		**40**		**12**	1.9
*English	40		12		
TOTAL		**623**		**63**	25.4

YEAR 2	L		P		%
MATHEMATICS		**210**			7.1
* probability & statistics * fourier analysis * analytic functions	56 84 70				
PHYSICS		**155**		**21**	6.4
* physics 1 * physics 2 * electromagnetism	77 75		10 11		
COMPUTER SCIENCE		**110**		**28**	5.0
* computer programming, advanced * numerical analysis	46 64		16 12		
GENERAL ENGINEERING SCIENCE		**166**			6.0
* Mechanics A * Mechanics B	70 96				
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN		**56**		**16**	2.6
* switching circuit theory and logic design	56		16		
NON TECHNICAL SUBJECTS					
TOTAL		**697**		**65**	27.2

YEAR 3	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		46		26	2.6
*basic computer organization & assembly language programming	46		26		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		535		112	23.4
* electrical network theory B+C	63		12		
* Electromagnetic field theory A+B	161				
* Electrical measurement B			36		
*Electronic circuits	42		28		
* Automatic control	112		12		
* Semi-conducts devices			12		
* Electric power engineering	52		12		
	56				
	49				
ELECTRICAL DESIGN		?		?	?
NON TECHNICAL SUBJECTS					
ELECTIVES					
TOTAL		581		141	26.0

YEAR 4	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		4		9	0.5
* information retrieval	4		9		
ELECTIVES		345		230	21.0
TOTAL		349		239	21.5
TOTAL HOURS YEAR 1-4		2250		508	100%
INDUSTRIAL TRAINING				680	
THESIS (in the first half of the fifth year)				800	

CURRICULUM DESCRIPTION LUND

The faculty offers one program: Electrical Engineering .

1st year: 100 % compulsory	
2nd year: 100 % compulsory	
3rd year: ELECTRONICS 90% compulsory (513 hours; same subjects as telecommunications) 10% electives in electronics	3rd year: TELECOMMUNICATIONS 90% compulsory (513 hours; same subjects as electronics) 10% electives in telecommunication
4th year: 15% compulsory (same subjects as telecommunication) 35% electives in electronics 50% electives in sector programs Industrial training (680 hours) (in 4th or 5th year)	4th year: 15% compulsory (same subjects as electronics) 22.5% electives in telecommunications 62.5% electives in sector programs Industrial training (680 hours) (in 4th or 5th year)
5th year (first half): thesis (600 hours) Master degree exam	5th year (first half): thesis (600 hours) Master degree exam

Notes:

1. The faculty has a system of periods of 8 weeks: 7 weeks lectures/practical, the 8th week exams.
2. The faculty of Lund is counting with credit points. 1 credit point is 40 hours and one year counts circa 40 credit points.
3. Total programmed hours: 7200 (180 credit points); circa 1600 vearly.
4. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 2:3. The students spend circa 40% of their time at the university and spend about 60 % on self study.
5. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 40% 'real' lectures and 60 % tutorials.
6. In the 3rd year, the student has to choose for specialisation: electronics or telecommunication.
7. In year 4 or 5 the students have to fulfil a training in industry during 680 hours.
8. In the first half of the 5th year the students have to do the thesis work. For the masters thesis 600 hours are programmed.

YEAR 1	L		P		%
MATHEMATICS		322			12.3
* calculus, one variable 1 * calculus, one variable 2 * calculus, several variables * linear algebra * analytic functions	64 70 70 48 70				
PHYSICS		120		46	6.3
COMPUTER SCIENCE		128		28	5.9
* computer programming 1 * numerical methods	76 52			20 8	
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		56			2.1
* elementary circuit theory	56				
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
TOTAL		626		74	26.6

YEAR 2	L		P		%
MATHEMATICS		210			8.0
* linear systems * probability theory * statistical methods	98 70 42				
PHYSICS					
COMPUTER SCIENCE		42		42	3.1
* introduction to computers * computer programming II (is optional, but most students choose it)	14 28		14 28		
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		239		41	10.7
* Electromagnetic fields * Analog & digital Electronic circuits	140 99		41		
ELECTRICAL DESIGN		84		28	4.2
* switching circuit theory and digital design	84		28		
NON TECHNICAL SUBJECTS					
TOTAL		575		111	26.0

YEAR 3 : ELECTRONICS	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		28		28	2.0
*computer architecture	28		28		
GENERAL ENGINEERING SCIENCE		56			2.0
Engineering Mechanics	56				
ELECTRICAL ENGINEERING SCIENCES		401		112	19.8
* stationary processes	38		4		
* Automatic control	61		12		
* Electrical measurement & instrumentation	44		36		
* Telecommunication theory, systems and signals	96		16		
* Communication theory	54		16		
* Electric motion control	54		16		
OPTIONAL:					
* advanced Analog circuits and systems	30		40		
or					
* digital signal processing	54		12		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
TOTAL		429		140	23.8

YEAR 4: ELECTRONICS	L		P		%
MATHEMATICS					
PHYSICS		56		28	3.1
* semiconductor physics	56		28		
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		110		110	8.5
* computer controlled systems	68		16		
* transducers in measurement systems	42		24		
* digital systems lab project			70		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
ELECTIVES (to choose out of the sector programs)		200		100	11.5
TOTAL		366		238	23.1
TOTAL HOURS YEAR 1-4		2089		505	100%
INDUSTRIAL TRAINING					
THESIS (in the first half of the fifth year)				600	

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YEAR 3: TELECOMMUNICATION	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		28		28	2.0
*computer architecture	28		28		
GENERAL ENGINEERING SCIENCE		56			2.0
Engineering Mechanics	56				
ELECTRICAL ENGINEERING SCIENCES		401		112	19.8
* stationary processes	38		4		
* Automatic control	61		12		
* Electrical measurement & instrumentation	44		36		
* Telecommunication theory, systems and signals	96		16		
* Communication theory	54		16		
* Electric motion control	54		16		
OPTIONAL:					
* digital transmission systems	46		10		
or					
* telecommunication	58		12		
or					
* information theory	56				
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
TOTAL		429		140	23.8

YEAR 4: TELECOMMUNICATION	L		P		%
MATHEMATICS					
PHYSICS		56		28	3.1
* semiconductor physics	56		28		
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		90		36	4.8
* radio electronics	42		28		
* analog transmission	48		8		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
ELECTIVES (to choose out of the sector programs)		260		90	13.3
TOTAL		406		154	21.2
TOTAL HOURS YEAR 1-4		2036		563	100%
INDUSTRIAL TRAINING					
THESIS (in the first half of the fifth year)				600	

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CURRICULUM DESCRIPTION MÜNCHEN

<table>
<tr><td colspan="4">1st year:
100 % compulsory
At the end Vordiplom I</td><td rowspan="2"></td></tr>
<tr><td colspan="4">2nd year:
100 % compulsory
At the end Vordiplom II
520 hours (13 weeks) industrial training, also to be done in vacations)</td></tr>
<tr><td>POWER ENGINEERING

3rd year:
90% compulsory
10% electives</td><td>COMMUNICATION & COMP. ENG

3rd year:
90% compulsory
10% electives</td><td>ELECTRONICS

3rd year:
90% compulsory
10% electives</td><td>AUTOMATION & CONTROL ENG

3rd year:
90% compulsory
10% electives</td><td rowspan="3">H
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M</td></tr>
<tr><td>4th year:
100% electives</td><td>4th year:
100% electives</td><td>4th year:
100% electives</td><td>4th year:
100% electives</td></tr>
<tr><td colspan="4">5th year: Industrial training: 520 hours (13 weeks)
Thesis: 1040 (6 months full time)</td></tr>
</table>

Notes:

1. The faculty has a semester system. One semester is 13 weeks lectures and practicals.
2. The total programmed study load is circa 8600, that is circa 1700 yearly.
3. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 2:3. The students spend circa 40% of there time at the university and spend about 60 % on self study.
4. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 60% 'real' lectures and 40 % tutorials.
5. The first two years are identical for all electrical engineering students. There are two formal exams: Vordiplom I and II.
6. In the 3rd year, the student has to choose for electives a) Power engineering (10% of the students) b) Communication and computer engineering (60%) c) Electronics (10%) or d) Automation and control engineering (20%).
7. The 4th year contains a block of electives, which the student can choose from a specific limited list, and a smaller block of courses, which can be taken almost freely.
8. The student has to fulfil 26 weeks (1040 hours) industrial training in total: 13 weeks in the basic course (Grundstudium) and 13 weeks in the main course (Hauptstudium). It can be done in the vacations.
9. The thesis work is done in the 5th year and is programmed at 1040 hours (6 months full time).

ERIC

YEAR 1: Vordiplom I	L		P		%
MATHEMATICS		195			8.5
* mathematics	195				
PHYSICS		78			3.4
* electricity	78				
COMPUTER SCIENCE		78			3.4
* basic computer science	78				
GENERAL ENGINEERING SCIENCE		104			4.5
* technical mechanics	104				
ELECTRICAL ENGINEERING SCIENCES		169			7.4
* circuit analysis * electrical measurement	130 39				
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
TOTAL		624			27.2

YEAR 2 Vordiplom II	L		P		%
MATHEMATICS		156			6.8
* mathematics	156				
PHYSICS		65			2.8
* physics	65				
COMPUTER SCIENCE				39	1.7
* computer science			39		
GENERAL ENGINEERING SCIENCE		52			2.3
* mechanical apparatus	52				
ELECTRICAL ENGINEERING SCIENCES		260		78	14.7
* basic signal theory * electrical dynamics * electrical energy * electrical measurement * materials of electronics * basic electrical engineering lab	39 78 39 39 65		 52 26		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
TOTAL		533		117	28.4
PRACTICAL WORK IN INDUSTRY (13 weeks)				520	

YEAR 3: COMMUNICATION AND COMPUTER ENGINEERING
(60% of the students)

	L		P		%
MATHEMATICS		39			1.7
* statistics	39				
PHYSICS					
COMPUTER SCIENCE		117			5.1
* computer science * computer network * computer science for controlling	39 39 39				
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		325		52	16.4
* electrical circuits * basic controlling * high frequency technique * communication * electronic devices	78 52 39 78 78		52		
ELECTRICAL DESIGN		39		52	3.9
* circuit design * CAD	39		52		
NON TECHNICAL SUBJECTS					
TOTAL		520		104	27.2

YEAR 4: COMMUNICATION AND COMPUTER ENGINEERING
(60% of the students)

	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS					
ELECTIVES (circa 6 subjects & 2 practicals)		260		130	17.0
TOTAL		260		130	17.0
TOTAL HOURS YEAR 1-4		1937		351	100%
INDUSTRIAL TRAINING (13 weeks) (2nd part)				520	
THESIS (6 months full time)				1040	

CURRICULUM DESCRIPTION ZÜRICH

The faculty offers one program: Electrical Engineering .

1st year: 100 % compulsory At the end Vordiplom I 240 hours (6 weeks) industrial training, to be done before the 3rd semester	
2nd year: 100 % compulsory At the end Vordiplom II	
3rd year: 27% compulsory courses (non technical; 156 hours) 55% electives = 18% fundamental courses; 25% primary courses 12% secondary courses 18% advanced lab work	
4th year: 8% compulsory courses (non technical; 52 hours) 46% electives = 15% fundamental courses; 21% primary courses; 10% secondary courses 46% project assignment 480 hours (12 weeks) industrial training, to be done before the 8th semester.	
5th year: Thesis: 640 hours (4 months full time)	

Notes:

1. The faculty has a semester system. One semester contains 14 weeks lectures and practicals.
2. The total programmed study load is circa 8530, that is circa 1900 yearly.
3. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 1:1. The students spend circa 50% of their time at the university and is expected to spend about 50% on self study.
4. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 60% 'real' lectures and 40 % tutorials.
5. The first two years are identical for all electrical engineering students. There are two formal exams: Vordiplom 1 and II.
6. In the 3rd year, the student has to choose for one of the 10 directions.
   * Electronic systems* Physical electronics* Circuits and Fields * Communication technology* Time-discrete systems and stochastical signals* Computers in real time systems* Linear control systems* Power electronics* Transmission on Lines and Power systems* Electrical Machines and Drives
7. The 4th year contains a project assignment of 312 hours per semester = 600 hours.
8. The student has to fulfil 18 weeks (720 hours) industrial training in total: 6 weeks in the basic course (Grundstudium) and 12 weeks in the main course (Fachstudium) before the 8th semester.
9. The thesis work is done in the 5th year and is programmed at 640 hours (4 months full time).

YEAR 1: GRUNDSTUDIUM	L		P		%
MATHEMATICS		280			9.3
* analyses 1+2 * linear algebra * discrete mathematics	196 42 42				
PHYSICS		112			3.7
* mechanics 1+2	112				
COMPUTER SCIENCE		112			3.6
* computer engineering 1+2	112				
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		238		42	9.3
* electrical circuit and fields 1+2 * signals and systems 1+2 * electrical engineering 1+2	140 98		42		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		56			1.9
* social sciences	56				
TOTAL		798		42	27.6

YEAR 2: GRUNDSTUDIUM	L		P		%
MATHEMATICS		168			5.6
* analyses 3+4 * probability theory * discrete mathematics	126 42				
PHYSICS		168			5.6
* physics	168				
COMPUTER SCIENCE		112			3.7
* computer engineering 3+4	112				
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		294		42	11.1
* electrical circuit and fields 3+4 * electronics * signals and systems 3+4 * electrical engineering 3+4	112 98 84		42		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		56			1.9
* social sciences	56				
TOTAL		798		42	27.9

YEAR 3: FACHSTUDIUM					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		336		112	14.8
Electives: * fundamental courses * primary courses * secondary courses * advanced lab work	 112 154 70 		 112		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		168			5.6
* Man, technology, Environment * social sciences	112 56				
TOTAL		504		112	20.4

YEAR 4: FACHSTUDIUM					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		362		336	22.1
Electives: * fundamental courses * primary courses * secondary courses * project work	 112 154 70 		 336		
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		56			1.9
* social sciences	56				
TOTAL		392		336	24.0
TOTAL IN YEARS 1-4	2492		532		100%
INDUSTRIAL TRAINING 18 WEEKS (6 weeks has to be done before the 3rd semester, the other weeks before the 8th)			720		
THESIS (In first half 5th year)			640		

CURRICULUM DESCRIPTION GENT

The faculty offers one program: Electrical Engineering .

1st year: 100 % compulsory identical for all engineering students		FIRST CYCLE
2nd year: 100 % compulsory dentical for all engineering students At the end candidate's exam ("kandidatuur)		
POWER ENGINEERING 3rd year: ~100% compulsory courses (1054 hours) max. electives (22,5 hours)	ELECTRONIC ENGINEERING 3rd year: ~100% compulsory courses (960) hours) max. electives (22.5 hours)	2ND CYCLE
POWER ENGINEERING 4th year: 81% compulsory courses (769 hours) 19% electives (180 hours)	ELECTRONIC ENGINEERING 4th year: 74% compulsory courses (698 hours) 26% electives (247 hours)	
POWER ENGINEERING 5th year: 35% compulsory courses (217 hours) 65% electives (405 hours) Thesis 240 hours	ELECTRONIC ENGINEERING 5th year: 100% electives (652 hours) Thesis 300 hours	

Notes:

1. The faculty has a semester system. One semester is 3.5 months of lectures and practicals.
2. The total programmed study load is circa 10.150, that is circa 2000 yearly.
3. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 2:3. The students spend circa 40% of their time at the university and is expected to spend about 60% on self study.
4. There is no distinction between lectures and tutorials (small working groups for exercise). The ratio lectures/practicals is 1:1.
5. The first two years are identical for all engineering students. There is a formal exam: the candidate ("kandidatuur").
6. In the 3rd year, the student has to choose for the specialisation: Electronic Engineering or Power Engineering.
9. The thesis work is done in the 5th year and is programmed at 300 or 240 hours. The work is done by the student nearly half time (45%) during one year (October-June). The students exceed often the nominal programmed hours

YEAR 1: COMPULSORY FOR ALL ENGINEERING STUDENTS	L		P		%
MATHEMATICS		225		195	10.2
* analytical geometry * linear algebra * mathematical analyses	22,5 45 157,5		15 45 135		
PHYSICS		22,5		22,5	1.1
* general physics	22,5		22,5		
COMPUTER SCIENCE		45		15	1.5
* introduction into computer science * numerical analyses	22,5 22,5		0 15		
GENERAL ENGINEERING SCIENCE		112, 5		90	4.9
* anorganic chemistry * theoretical mechanics	45 67,5		45 45		
ELECTRICAL ENGINEERING SCIENCES		0		0	O
ELECTRICAL DESIGN		0		0	0
NON TECHNICAL SUBJECTS		22,5		0	0.6
* fundamentals of economics	22,5		0		
TOTAL		427, 5		322,5	18.3

YEAR 2: COMPULSORY FOR ALL ENGINEERING STUDENTS	L		P		%
MATHEMATICS		90		67,5	3.8
* probability & statistics * mathematical analyses	45 45		22,5 45		
PHYSICS		90		90	4.4
* general physics * quantum mechanics	67,5 22,5		67,5 22,5		
COMPUTER SCIENCE		22,5		22,5	1.1
* computer programming	22,5		22,5		
GENERAL ENGINEERING SCIEN- CES		157,5		112,5	6.6
* organic chemistry * metal working principles * technical thermodynamics * fluid mechanics * metallurgy * theoretical mechanics	22,5 22,5 45 22,5 22,5 22,5		 22,5 45 22,5 22,5		
ELECTRICAL ENGINEERING SCIENCES		45		45	2.2
* introduction into circuit analyses	45		45		
ELECTRICAL DESIGN		0		0	0
NON TECHNICAL SUBJECTS		22,5		0	0.6
* industrial laws	22,5		0		
TOTAL		427,5		337,5	18,7

YEAR 3: POWER ENGINEERING	L	L	P	P	%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE		202,5		232,5	10.5
* elasticity & strength of materials	45		60		
* kinematics & dynamics of machinery	45		60		
* practical knowledge of metals and	22.5		0		
their	22.5		0		
testing	22.5		60		
non metallic materials	22.5		22.5		
* CAD-techniques in mech eng.					
fuel technology	22.5		30		
* strength of materials II					
ELECTRICAL ENGINEERING SCIENCES		258,75		360	14.9
* electric fields, energy, forces	45		60		
* heat transfer I	22.5		30		
* turbomachinary I+II	56,25		90		
* electr. machines I	45		60		
* automatic control I	15		90		
* electronic systems & instrumentation	45		30		
ELECTRICAL DESIGN	?		?		?
NON TECHNICAL SUBJECTS		0		0	0
OPTIONAL COURSES		0		0	0
TOTAL		461,25		592,5	25,4

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YEAR 3: ELECTRONIC ENGINEERING	L	L	P	P	%
MATHEMATICS		22,5		22,5	1.1
* mathematical analysis	22.5		22.5		
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE		67,5		60	3.1
* elasticity & strength of materials	22.5		30		
* introduction mechanical engineering			30		
* introduction civil engineering	22.5		0		
	22.5				
ELECTRICAL ENGINEERING SCIENCES		337,5		450	19,2
* electrical system dynamics	45		60		
* fund. elect.measurement	45		90		
* Electr. fields, energy & forces	45		60		
* electronics I	45		30		
* semiconductors	22.5		30		
* automatic control			60		
* Electr. radiation(fields) I	45		60		
* electrical machines I	45		60		
	45				
ELECTRICAL DESIGN	?		?		?
NON TECHNICAL SUBJECTS		0		0	
OPTIONAL		22,5		0	0.6
TOTAL		450		532,5	24.0

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YEAR 4: POWER ENGINEERING					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE		56,3		30	2.1
* metal constructions * steam technology	22,5 33.8		30		
ELECTRICAL ENGINEERING SCIENCES		270		360	15.2
* reciprocating machines * electrical system dynamics * industrial elec. measurement * electr. machines II+III * automatic control I * electr. power systems:control&operations * optimal control * nuclear fuel & nuclear reactor *electrical power systems(network)analysis	22,5 45 22,5 45 22,5 45 22,5 22,5 22,5		60 60 30 60 30 60 30 30		
ELECTRICAL DESIGN	?		?		?
NON TECHNICAL SUBJECTS		22,5		30	1.3
* introduction into industrial management	22,5		30		
OPTIONAL COURSES		90		90	4.3
.					
TOTAL		438.8		510	22.9

YEAR 4: ELECTRONIC ENGINEERING					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		45		22,5	1.7
* computer architecture * interface&peripheral computer equipment	22,5 22,5		22, 5		
GENERAL ENGINEERING SCIENCE		22,5		0	0.6
* introduction mechanical engineering II	22,5				
ELECTRICAL ENGINEERING SCIENCES		225		330	13.6
* circuit theory * electr. radiation (fields) II+III * electronics II * electrical machines II * electr. ı :operties of materials * introo. tion telecom. engineering * light teci . ology	22,5 45 45 22,5 22,5 45 22,5		30 60 90 30 30 60 30		
ELECTRICAL DESIGN		22,5		30	1.2
*electrical radiation design	22,5		30		
NON TECHNICAL SUBJECTS		90			2.4
OPTIONAL COURSES		67,5		90	3.6
TOTAL		472,5		472.5	23.1

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YEAR 5: POWER ENGINEERING					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES		112,5		82,5	4.7
* electrical power stations * electrical machines	67,5 45		22,5 60		
ELECTRICAL DESIGN	?		?		?
NON TECHNICAL SUBJECTS		22,5		0	0.5
* logistic system management	22,5				
OPTIONAL COURSES		225		180	9.8
TOTAL		360		262,5	15.0
TOTAL YEARS 1-5		2115		2025	100%
THESIS				240	

YEAR 5: ELECTRONIC ENGINEERING					
	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCE					
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN	?				
NON TECHNICAL SUBJECTS					
OPTIONAL COURSES		292,5		360	15.9
TOTAL		292,5		360	15.9
TOTAL YEARS 1-5		2070		2025	100 %
THESIS		300			

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CURRICULUM DESCRIPTION LEUVEN

The faculty offers one program: Electrical Engineering .

<table>
<tr><td colspan="2">1st year:
100 % compulsory

identical for all engineering students</td><td rowspan="2">F I R S T

C Y C L E</td></tr>
<tr><td colspan="2">2nd year:
100 % compulsory
identical for all engineering students
At the end candidate's exam ("kandidatuur)</td></tr>
<tr><td>ENERGY
3rd year:
100% compulsory courses</td><td>ELECTRONICS
3rd year:
100% compulsory courses (963 hours)</td><td rowspan="3">2 N D

C Y C L E</td></tr>
<tr><td>ENERGY
4th year:
98% compulsory courses (674 hours)
2% electives (15 hours)</td><td>ELECTRONICS
4th year:
97% compulsory courses (560 hours)
3% electives (15 hours)</td></tr>
<tr><td>ENERGY
5th year:
75% compulsory courses (356 hours)
3% electives (15 hours)
22% project work

Thesis 360 hours</td><td>ELECTRONICS
5th year:
22% compulsory (122 hours)
78% electives (445 hours)
To choose between:
* Industrial management
* Micro electronics
* Telecommincation
* Automation & computer systems
* Mechatronics
Thesis 360 hours</td></tr>
</table>

Notes:

1. The faculty has a semester system. A semester is 3.5 months of lectures/practicals.
2. The total programmed study load is circa 9400, that is circa 1880 yearly.
3. The ratio contact hours (lectures, tutorials, practicals and research projects) versus self study is circa 1:2. The students spend circa 35% of their time at the university and is expected to spend about 65% on self study.
4. Many lectures are coupled with tutorials, small working groups for exercises. So the numbers for lectures is about 75% 'real' lectures and 25 % tutorials.
5. The first two years are identical for all engineering students. There is a formal exam every year. After the second year it is called the candidate exam ("kandidatuur"). It is not different from the exams at the end of every other year.
6. In the 3rd year, the student has to choose for the specialisation Energy or Electronics.
7. The thesis work is done in the 5th year and is programmed at 360 hours. The students always exceed the nominal programmed time (is often 600..900 hours).

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YEAR 1: COMPULSORY FOR ALL ENGINEERING STUDENTS	L		P		%
MATHEMATICS		230		75	9.3
* Algebra and analytical geometry * differential and integral Calculus * analytical geometry * numerical statistics * description design * graphic design	72 73 38 24 23		75		
PHYSICS		180		18	6.6
* general physics I * analytical mechanics * thermodynamics	90 67 43		18		
COMPUTER SCIENCE		54			1.6
* introduction into computer programming	54				
GENERAL ENGINEERING SCIENCE		52		16	2.0
* chemistry * theoretical mechanics	52		16		
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		30			0.9
* philosophy	30				
TOTAL		566		109	20.4

YEAR 2: COMPULSORY FOR ALL ENGINEERING STUDENTS	L		P		%
MATHEMATICS		173		19	5.8
* differential equations * numerical variational calculus * probability calculus	100 30 43		19		
PHYSICS		145		20	5.0
* general physics *grafostatistics and intro into structural analyses	100 45		20		
COMPUTER SCIENCE					
GENERAL ENGINEERING SCIENCES		182		60	7.3
* analytical mechanics II * quantum mechanics * material science * general and physical chemistry * anorganic chemistry * organic chemistry	45 30 23 30 15 39		60		
ELECTRICAL ENGINEERING SCIENCES					
* introduction into circuit analyses					
DESIGN				165	5.0
* graphic practical * project			105 60		
NON TECHNICAL SUBJECTS					
TOTAL		500		264	23.1

YEAR 3: ELECTRICAL ENGINEERING : OPTION ENERGY

	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		68		30	2.9
* software systems * switching theory & microprocessors	30 38		8 12		
GENERAL ENGINEERING SCIENCE		171		21	5.8
* applied material science * fluid mechanics * system theory * applied kinematics & dynamics * applied thermodynamics & heat transfer * thermodynamics II	41 23 22 37 11 37		8 13		
ELECTRICAL ENGINEERING SCIENCES		245		73	9.7
* control theory * general electricity * analyses of networks & systems * basic electronic circuits * electromagnetic wave propagation & microwaves * electrical machines I * generation & distribution of electrical energy * Surveying	20 37 44 30 27 57 30		5 15 5 8 13 15 12		
ELECTRICAL DESIGN		30		12	1.2
* Electrotechnical design project	30		12		
NON TECHNICAL SUBJECTS		23			0.7
* principles of economics	23				
OPTIONAL COURSES					
TOTAL		537		136	20.3

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YEAR 4: ELECTRICAL ENGINEERING : OPTION ENERGY

	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		43			1.3
* software design methodology	43				
GENERAL ENGINEERING SCIENCE		76		26	3.1
* material science * energy conversion system * knowledge based system	13 41 22		8 8 10		
ELECTRICAL ENGINEERING SCIENCES		331		123	14.1
* industrial electro heating * data communication and data transfer * electrical machines II * electrical drives * stochastic signal analysis * integrated electronic circuits * application of electricity * electrical measurement * high voltage	30 15 48 30 48 47 70 15 28		20 8 55 8 7 15 10		
ELECTRICAL DESIGN		30			0.9
* seminar: design in power engineering	30				
NON TECHNICAL SUBJECTS		60			1.8
* industrial economy * psychology & social sciences in industrial management	30 30				
OPTIONAL COURSES * **deontology (optional 15 hrs)**					
TOTAL		540		149	21.2

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YEAR 3: ELECTRICAL ENGINEERING: OPTION ELECTRONICS	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		87		31	3.7
* software systems	30		8		
* switching theory & microprocessors	57		13		
GENERAL ENGINEERING SCIENCE		154		15	5.2
* applied material science	41		8		
* fluid mechanics	22				
* system theory	23				
* applied kinematics & dynamics	38				
* thermodynamics & heat transfer for non-mechanical engineers	30		7		
ELECTRICAL ENGINEERING SCIENCES		254		60	9.8
* control theory	20		5		
* electrotechnics	30		8		
* analyses of networks & systems	54		10		
* basic electronic circuits	30		7		
* electromagnetic wave propagation & microwaves	60		15		
* physics of semiconductors	60		15		
ELECTRICAL DESIGN		30		12	0.9
* Electrotechnical design project	30		12		
NON TECHNICAL SUBJECTS		23			0.8
* principles of economics	23				
OPTIONAL COURSES					
TOTAL		548		106	20.4

YEAR 4: ELECTRICAL ENGINEERING : OPTION ELECTRONICS	L		P		%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		44			1.3
* software design methodology	44				
GENERAL ENGINEERING SCIENCE		13		7	0.6
* material science	13		7		
ELECTRICAL ENGINEERING SCIENCES		333		38	11.0
* energy conversion systems	41		8		
* electrical machines & drives	45		15		
* models, sensors, circuits,technology	60		15		
* information theory	75				
* stochastic signal analysis	75				
* integrated electronic circuits	37				
ELECTRICAL DESIGN		100			3.1
* design of digital integrated circuits	75				
* project 'design of elctronic systems'	25				
NON TECHNICAL SUBJECTS		60			1.8
* industrial economy	30				
* psychology & social sciences in industrial management	30				
OPTIONAL COURSES *** deontology (optional 15 hrs)**					0.4
TOTAL		550		45	18.2

YEAR 5: ELECTRICAL ENGINEERING: OPTION ELECTRONICS					
		L		P	%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		23		10	1.1
*computer control	23		10		
GENERAL ENGINEERING SCIENCE		52			1.6
* Technical management * Environment protection * chemical processes	15 15 22				
ELECTRICAL ENGINEERING SCIENCES					
ELECTRICAL DESIGN					
NON TECHNICAL SUBJECTS		37			1.1
* religion * industrial law	15 22				
OPTIONAL COURSES To choose between: * Industrial management * Micro electronics * Telecommincation * Automation & computer systems * Mechatronics *training in communication skills (15hrs)		400		45	13.0
TOTAL		512		55	16.6
TOTAL YEARS 1-5		2676		579	
THESIS				360	

245

YEAR 5: ELECTRICAL ENGINEERING: OPTION ENERGY					
		L		P	%
MATHEMATICS					
PHYSICS					
COMPUTER SCIENCE		23		10	1.0
*computer control	23		10		
GENERAL ENGINEERING SCIENCE		52			1.5
* Technical management * Environment protection * chemical processes	15 15 22				
ELECTRICAL ENGINEERING SCIENCES		188		128	9.6
* application of electricity II * electrical drives II * power electronics * nuclear reactor engineering * electrotechnology & normalisation PROJECT WORK	45 60 30 30 23		 15 8 105		
ELECTRICAL DESIGN		30		8	1.1
* design of digital electronic systems	30		8		
NON TECHNICAL SUBJECTS		37			1.1
* religion * industrial law	15 22				
OPTIONAL COURSES * training in communication skills (15hrs)					
TOTAL		330		146	14.3
TOTAL YEARS 1-5		2473		804	100%
THESIS				360	

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APPENDIX 3: THE QUESTIONNAIRE

QUESTIONNAIRE

INTERNATIONAL PROGRAM REVIEW

OF

ELECTRICAL ENGINEERING

with participating universities in Belgium, Germany, the Netherlands, Sweden and the United Kingdom

Organized by the Association of Universities in the Netherlands (VSNU).

April 1991.

ERIC

A GENERAL INFORMATION

1 Name of the university:
(vernacular and english)

Faculty/Department:
(vernacular and english)

Address:

Postal address:

Telephone: ____________________

Fax: ____________________

Dean of the department:

Person to be contacted: ____________________

Telephone: ____________________

Fax: ____________________

2 Finance

Please give a brief and global description of the most important sources of income of the faculty (the state, local government, industry, research foundations, ...) and the corresponding amounts received each year for 1986 until 1990 (amounts in local currency).

	1986	1987	1988	1989	1990
income : State Local government Industry Research Foundations other:					
total					

expenditures: education research other:					
total					

Remarks:

B SPECIFIC INFORMATION.

The requested information concerns the program leading to a Master's degree (MSc, drs (ir.), Diplom-Ingenieur (Technische Universität/ Hochschule), Licentiaat (Burgerlijk Ingenieur), Civilingenjör (first degree)) in Electrical Engineering. The program starts from the preliminary secondary school. So it is possible that this program includes a three year BSc program preliminary to a one or two year MSc program (especially in the UK).

1 The students

1.1 Applications received and the actual intake

year	applications	intake
1985		
1986		
1987		
1988		
1989		
1990		

1.2 Number of freshmen starting in the first year of the program

year	total	male	female	% foreigners
1985				
1986				
1987				
1988				
1989				
1990				

1.3 Total number of students

year	total	male	female	% foreigners
1985				
1986				
1987				
1988				
1989				
1990				

1.4 Entrance level

Please specify the normal published entry qualifications required for freshmen (e.g. related to the secondary schools).

Please detail on the subjects on mathematics and physics given on the secondary schools. Are these subjects obligatory for starting the study for Electrical Engineer.

1.5 Entrance selection

If there is an entrance selection, please specify minimum requirements on the basis of which admission has been made the last five years. Describe the selection procedure.

1.6 For the last five years:

a) what is the average age of the freshmen?

b) What is the percentage of the freshmen coming straight from the secondary school?

1.7 How many students are admitted in higher years.

year	in year 2	in year 3	in year 4	in year 5
1985 1986 1987 1988 1989 1990				

1.7 Drop-out rate

Starting with a cohort of freshmen, how is the drop-out rate after one year and how is the total drop-out rate (drop-out related to the number of freshmen).

year	number of freshmen	% drop-out after 1 year	% drop-out after 8 years
1985 1986 1987 1988 1989 1990			

1.8 <u>Success ratio</u>

How many of the freshmen starting in a particular year gets its Master's degree (drs. licentiaat, dipl.ing., civilingenjör) after 4, 5, 6, 7, 8 year and later.

year	(1)	% yr. 4	% yr. 5	% yr. 6	% yr. 7	% yr. 8	% > yr.8
1985 1986 1987 1988 1989 1990							

(1) number of freshmen starting in year .
yr. 4 % graduates of freshmen of year .. after 4 years
yr 5· idem for 5 years
etcetera

1.9 <u>What is the duration (years of courses) of the MSc-program</u> (drs., licentiaat, dipl.ing., civilingenjör) in years.

1.10 What is the <u>effective length of studies</u> (what is the average time in years for a student to become graduated).

1.11 Indicate <u>the percentage of MSc graduates with a Ph.D after a period of 10 years</u> after graduation.

1.12 <u>Student workload</u>

Can you give a global indication on the actual workload of an average student (so not the time the student has to study, but the actual time a student really spends on his study):

Workload in hours;

lectures - other: time spent in the university for being present during the lectures, ...

self-study : private study time (in the student's study)

	in year 1	in year 2	in year 3	in year 4	in year 5
lectures tutorials practical exams other self-study					

Remarks:

1.13 Can you give a global indication on the destination of graduates. (e.g. industrial company; consulting engineers; central government;research/university; non-engineering; ...)

2 The staff

2.1 For the last three years give the size of the staff (in FTE unweighted and in numbers of persons).

year	academic staff		non academic staff	
	fte	persons	fte	persons
1988 1989 1990				

2.2 Give the percentage of the academic staff with a Ph.D.

1988 % of the persons (see 2.1)
1989 %
1990 %

2.3 Describe the number of staff members with a special scientific qualification (e.g. a Noble prize; Member of the Royal Academy; special awards; etc.).

2.4 Give the number of professors appointed by industry:

year	full-time	part-time
1988 1989 1990		

2.5 Describe the contacts of the staff with industry, formal and informal.

2.6 Describe the criteria for appointment of the academic staff.

2.7 Describe the staff development programs.

2.8 Describe the possibilities for a sabbatical leave and how these are used.

2.9 Give the <u>number of refereed research papers</u> during the last (five) years.

year:	1986	1987	1988	1989	1990
papers:					

2.10 Indicate the percentage of the staff total <u>workload</u> used for education.

2.11 For the last five years give the average <u>student/staff</u> ratio (FTE unweighted). How is this determined. Are there trends.

2.12 Describe the education support facilities and service (department) in your faculty.

3 THE PROGRAM

3.1 Philosophy

Please state briefly the aims, philosophy and origins of the program.

3.2 Outline of program structure

Provide a block diagram for the program structure clearly showing core and options, and all possible routes through the total overall course.

This diagram gives the global outline. More details are to be given in 3.4.

(See example in appendix 1.)

3.3 Goals and objectives

Describe the goals and objectives general and in terms of knowledge, skills and attitudes to be reached for the total MSC (drs., dipl.ing., licentiaat, civilingenjör) program:

a general

b in terms of knowledge

c in terms of skills

d in terms of attitudes

3.4.a. <u>Format for structure of the program</u>

For an explanation and example see appendix 2
Please give a separate table for each year

YEAR 1

course nr.	course (subject) name	timetable workload in hrs. lect.	tutor.	pract.	other	given in semes.	credit points
1	2	3	4	5	6	7	8
---- ----	total					---- ----	

legend: page 26

3.4.b <u>Format for structure of the program</u>

YEAR 2

course nr.	course (subject) name	timetable workload in hrs. lect.	tutor.	pract.	other	given in semes.	credit points
1	2	3	4	5	6	7	8
---- ----	total					---- ----	

legend: page 26

3.4.c. Format for structure of the program

YEAR 3

course nr.	course (subject) name	timetable workload in hrs.				given in semes.	credit points
		lect.	tutor.	pract.	other		
1	2	3	4	5	6	7	8
---- ----	total					---- ----	

legend: page 26

3.4.d. Format for structure of the program

YEAR 4

course nr.	course (subject) name	timetable workload in hrs.				given in semes.	credit points
		lect.	tutor.	pract.	other		
1	2	3	4	5	6	7	8
---- ----	total					---- ----	

legend: page 26

3.4.e. Format for structure of the program

YEAR 5

course nr.	course (subject) name	timetable workload in hrs.				given in semes.	credit points
		lect.	tutor.	pract.	other		
1	2	3	4	5	6	7	8
---- ----	total					---- ----	

legend: page 26

LEGEND: FORMAT FOR STRUCTURE OF THE PROGRAM

1 number of the course corresponding with the course number of the course description.

2 name of the course given in English

3 timetable workload in net hours for lectures

4 timetable workload in net hours for tutorials

5 timetable workload in net hours for practical work

6 timetable workload in net hours for other forms of education

7 this course is given in semester (1, 2, 3, or 4), or dimester (1 or 2)

8 credit points given for this course

ERIC Full Text Provided by ERIC

3.5 <u>Courses</u> (To be filled in by the responsible professor.)

DESCRIPTION OF COURSES	course number:	The course number must correspond with the numbers in 3.2 and 3.4.

Course name (english): compulsory/ elective/optional

Course name (vernacular):

Responsible professor:

Course given by:

Total workload for the student - lectures, exercises, etc:
(in hours) - self-study :

Assessment:

Course contents:

<u>Literature</u> used:

Please include two recent <u>examinations</u> given at the end of this course.

3.6 <u>Practical work</u> (To be filled in by the responsible professor.)

Give a description of the practical work.

- place in the program - structure - open ended or well determined -compulsory or free - in the university or in industry - mini projects - micro-processor usage - computing experience.

number in 3.2 and 3.4:

273

272

3.7 Project work (To be filled in by the responsible professor.)

Give a description of the project work.

- place in the program - individual/group - structure - presentation - industrial involvement - attention to non-technical skills.

number in 3.2 and 3.4:

3.8 Master's theses

Describe how the MSc study is completed: the work for the Master's thesis.

Please add five recent Master's theses to this form.

ERIC Full Text Provided by ERIC

3.9 **Assessment**

Give details of the assessment/examination procedures.

* Level/style of examinations, particularly final year.
* Examining strategy and philosophy.
* Examining regulations - role of projects, design exercises; weighing; other regulations.
* Examination schedule in relation to the program.

3.10 Describe how the program is kept up to date with modern technologies, CAD, CAM, computing.

4. Alumni

Describe the contacts with your alumni. Are they in any way involved in course development. If yes, how are they involved.

5 Relations with industry

Contacts with the professional world are important for the Engineering Sciences. Can you briefly describe how these contacts take place in your faculty. Features to be considered:

* Industrial/academic liaison in course development.
* Industrial contacts.
* Industrial visits (excursions)/lectures

* Sponsorships on the program
* Grants from industry, consultancies, post-graduate courses etc..
* ....

6. <u>The accreditation/quality assessment system</u>

Please give a brief description of the accreditation/quality assessment system (if there is any).

7. <u>Recent report of a visitation or accreditation</u>

Please include a recent report of a visiting committee or accreditation visit.

8 <u>Recent reports on education, research and finance</u>

Please include recent reports on education, research and finance.

9 <u>Prospectus</u>

Please include a prospectus on your MSc program.

10 <u>Planning</u>

Please include a recent planning document

REMARKS

When you like to make some general remarks about your program or about the international program review you can do it here. Send the questionnaire with the appendices as soon as possible, but not later than June the 15 th 1991 to:

Drs. A.I. Vroeijenstijn
Postbus 19270
3501 DG Utrecht
Holland

APPENDIX 1: __Outline of program structure__ (See 3.2)

Provide a block diagram for the program structure clearly showing core and options, and all possible routes through the total overall course.

This diagram gives the global outlines. More details are to be given in 3.4.

THE FIRST YEAR (THE PROPAEDEUTIC PROGRAM)
During the first year (the P-phase program) a major part of the curriculum is devoted to basic mathematics and physics, as well as to an introduction to electrical engineering. The P-phase program is identical for all students

__P-program phase__

- analysis
- linear algebra
- informatics
- physics I&II
- networktheory I
- electronics I & II
- digital techniques I
- introduction to social sciences I

↓

P examination

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3.2 (continue if necessary)

THE "DOCTORAAL" PHASE PROGRAM
The D-phase program is a three-year program of which the first year is a continuation of the P program. The accent is shifted from mathematics and physics to electrical engineering. During the first D year students must decide whether they will continue in the mainstream of electrical engineering or wish to differentiate into Avionics or Computer Systems. Halfway through the second D year every student reaches a point of differentiation: he/she is bound to the Avionics program, to the Computer Systems program or to one of the five sector programs of the mainstream. In the second half of the second D year and in the third year, the student must, in addition to courses and practical work, complete an initial research project in industry.
The final year involves work on one of the major research projects of the university's research program and the writing of a thesis to do with his involvement in the project. The thesis indicates the level the student has reached on competing his electrical engineering course.

A schematic representation of the first, second and third year of the D-phase program is given below.

__First D year__

- analysis
- theory of complex functions
- statistics
- physics III, part I
- theory of stochastic signals
- systems and control
- electronics III
- basic electric measurements
- introduction computer hardware & software
- signals and linear systems
- telecommunications
- introduction to social science II

+

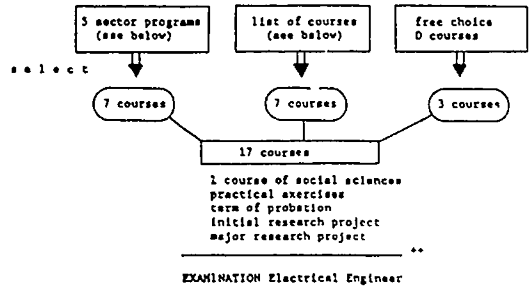
MAINSTREAM	physics III, part II electrical materials
	OR
AVIONICS	aircraft performance theory aircraft instrumentation I
	OR
COMPUTER SYSTEMS	data structures and algorithms digital techniques II

283

3.2 (continue if necessary)

Second and third D year

MAINSTREAM



In the first half of the second D year the student selects seven courses from the five sector programs, at least three courses from one sector

The codes mentioned below refer to the list of D courses which is given at the end of this section.

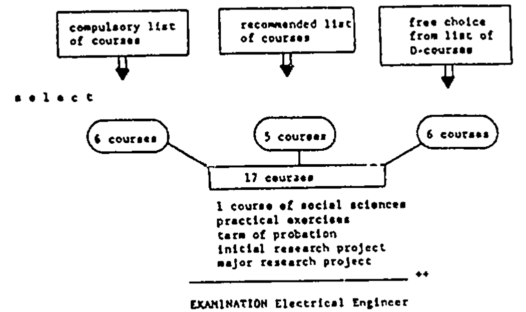
The five sector programs:

I:	Electrical Power Systems	1 11, 1 28, 1 31, 1 36, 1 42, 1 44, 1 45
II:	Telecommunications.	1 12, 1 13, 1 77, 1 75, 1 76, 1 90, 1 107A
III:	Electronics:	1 3, 1 12, 1 16, 1 19, 1 24, 1 61, 1 65
IV.	Signals and Systems:	1 5, 1 73A, 1 73B, 1 85, 1 86, 1 87
V:	Information Technology:	a 206, 1 72, 1 85, 1 91, 1 102A, 1 122

The remaining ten courses must be selected from the list of D courses

3.2 (continue if necessary)

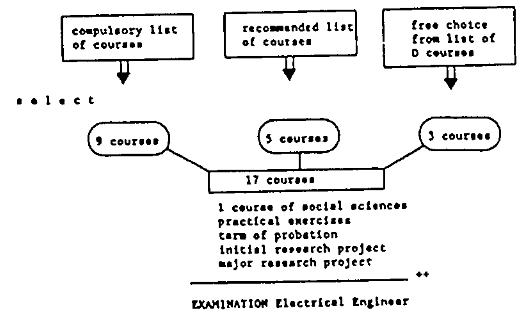
COMPUTER SYSTEMS



Compulsory program: a 137, a 235, a 243, 1 111, 1 102A, 1 122

Recommended courses: a 109, a 140, a 149, a 172, a 217, a 221, a 222, 1 3, 1 72, 1 85, 1 92, 1 96, 1 102B, 1 120

AVIONICS



Compulsory program: lr 2, 1 9, 1 24, 1 72, 1 75., 1 87, 1 85, 1 104

Recommended courses: c8 111 part 11, lr 3, lr 4, lr 5, lr 8, lr 12, 1 87, lr 9311, lr 94, 1 105, 1 120

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3.2 (continue if necessary)

1 4 computer aided circuit design
1 5 digital signal processing
1 6 digital signal processing (sc.)
1 7 computer aided circuit design (sc.)
1 9 propagation of radio beams
1 11 electromagnetic fields and forces
1 12 electromagnetic radiation
1 13 electromagnetic wave conduction
1 14A numerical calculus of electromagnetic fields A
1 14B numerical calculus of electromagnetic fields B
1 15A optical wave conductors and components
1 15B inverse diffusion and profiling
1 16 introduction to quantum electronics
1 17 sensor systems for robot applications
1 19 introduction to semiconductor physics
1 20 sensors
1 21 physics of semiconductor elements
1 22 technology of integrated circuits
1 24 electronic instumentation I
1 25 electronic instrumentation II
1 26 displays and actuators
1 27A energy transmission sc A
1 27B energy transmission sc. B
1 28 energy transmission
1 29 energy transmission II
1 30 transients in power transmission systems
1 31 power electronics
1 32 power electronics II
1 33 power electronics sc
1 36 power plants and substations
1 37 power plants and substations II
1 38 electrical drives
1 39 electrical drives II
1 42 high-voltage technology
1 43 high voltage technology II
1 44 electrical machines IA
1 45 electrical machines IB
1 46 electrical machines II
1 47 electrical machines III
1 57 introduction electric power technology
1 58 analogue IC-technology
1 61 analogue signal processing techniques
1 62 electronic image techniques
1 64 electronic design techniques
1 65 pulse electronics
1 67 VLSI electronics
1 68 bipolar digital IC-technology
1 72 information theory
1 73A image processing and patern recognition
1 73B statistic signal processing
1 73C biomedical and biological signal analysis
1 73D cluster analysis
1 73E coding
1 73F statistics information theory

3.2 (continue if necessary)

1 73G cryptography
1 73H digital signal coding
1 74 industrial aspects of telecommunications
1 75 signal transmission I
1 76 transmission lines in telecommunications
1 77 signal transmission II
1 78 communication systems
1 79 microwave technology
1 80 antennas and propagation
1 81 information-transmission techniques
1 82 antenna systems
1 85 digital control systems
1 86 system theory
1 87 modeling and simulation
1 88A fuzzy control
1 88B adaptive control systems
1 88C robot control systems
1 91 digital techniques II
1 92 testing of computer systems
1 93 digital technology III
1 96 computer performance
1 97 binary arithmetic
1 98 automatic traffic systems
1 99 telecommunication systems
1 100 electronic automatic telephone systems
1 101 automatic road traffic systems
1 102A data communication
1 102B data communication networks
1 104 location systems
1 105 radar
1 106 medical technology
1 107A glass fiber technology I
1 107B glass fiber technology II
1 110 process computer systems
1 111 computer architecture
1 112 computer architecture sc.
1 114 phase lock and frequency synthesis techniques
1 115 reliability engineering
1 120 microprocessors
1 122 computer organization
1 129 biomedical technology
lr 2 aircraft properties I
lr 3 aircraft properties II
lr 4 aircraft properties III
lr 5 position control of spaceships
lr 8 aerospace technology
lr12 space systems
lr93II aircraft instrumentation II
lr94 airnavigation
TC1 basic robotics

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3.2 (continue if necessary)

In addition to the courses listed below the student can also choose some of the courses taught by the Departments of Philosophy and Technical Social Sciences of the Delft University of Technology in the fields of Economics, Law, Industrial Organisation, Sociology, Psychology or Philosophy.

D courses with code

Lectures given by the Department of:
a. Technical Mathematics and Informatics
c. Applied Physics
i. + bw Mechanical Engineering
l. Electrical Engineering
lr. Aerospace Engineering
ii. Philosophy and Technical Social Sciences

a 59 speciel mathematical functions
a 68 partial differential equations
a 76 diffraction of acoustic waves
a 77 waves in elastic media
a 78 integral transformations
a 81 stochastics, special subjects
a 83 seminar calculations
a 85 algorithms
a 87 introduction to operational analysis
a 89A digital simulation
a 94 applied statistics
a 100 fuzzy sets
a 105 numerical analysis
a 109 numerical mathematics
a 112B linear algebra on supercomputers
a 116 parallel calculus
a 127A introduction to mathematical logic
a 137 theoretical informatics I
a 140 intro[illegible]ction to discrete mathematics
a 149 combinatoric algorithms
a 172 process synchronization
a 206 data structures and algorithms
a 217 translation of programming languages
a 219 system programming
a 221 parallel algorithms and parallel computers
a 222 artificial intelligence techniques
a 235 introduction to data bases
a 243 software engineering
bw 73 dynamics of machinery
c 20 theoretical physics I
c 33 intergated optics
c 34 pattern recognition
c 36a basic acoustic
c 56 physical sense perception
i 10 transformation of energy
i 41 combustion technology
l 2 design VLSI arrays
l 3 integrated electronic systems

APPENDIX 2: Structure content of the program (See 3.4)

For each year of the program, please give the structure of the standard program: code, name of the course, hours of instruction; hours of study, credit points. This more detailed information has to correspond with 3.2.
The following structure on the information is used within the lines of the format. See the next page for a description of the first year.

Year ...

compulsory program

course -1, -2, -3 -----> mathematics
-4, -5 -----> physics
-6, -7, -8 -----> electronics
-9 -----> social sc.

courses have to be chosen out of:

-course -10, -11, -12 -----> information theory
-13
-14, -15 -----> statistics
-
-

optional courses

-course -25, -26, -27 etcetera
-

etcetera

(courses are grouped by discipline)

Please give a separate table for each year of the program

3.4.a **Format for structure of the program**

YEAR 1

course nr.	course (subject) name	timetable workload in hrs.				given in semes.	credit points
		lect.	tutor.	pract.	other		
1	2	3	4	5	6	7	8
	mathematics						
:	analysis 1 (a 3)	40	40			1	3.0
	analysis 2 (a 3)	40	40			2	3.0
	analysis 3 (a 3)	20	20			3	2.5
	analysis 4 (a 3)	30	30			4	2.5
2	linear algebra 1 (a 31)	40	40			1	3.0
	linear algebra 2 (a 31)	40	40			2	3.0
	information theory						
3	informatics (a 133)	30				4	1.5
	physics						
4	physics 1 (c 10)	20	20			1	1.5
	physics 1 (c 10)	20	20			2	1.5
5	physics 2 (c 7)	20	20			3	1.5
	physics 2 (c 7)	20	20			4	1.5
	electrical engineering						
6	networktheory 1.1 (1 1)	20	20			1	1.5
	networktheory 1.2 (1 1)	20	20			2	1.5
	networktheory 1.3 (1 1)	20	20			3	1.5
7	electronics 1 (1 59)	30	20			3	2.0
	electronics 2 (1 52)	30	20			4	2.0
8	digital techniques 1 (1 121)	30	20			3	2.0
	soc'al sciences						
9	social sciences 1	20				4	1.5
	practical work						
10	technical drawing			40			1.0
11	electrical engineering			56			1.5
12	physics			35			1.0
1	analysis 1 (a 3)			13			0.5
3	informatics (a 133)			50			1.0
4	digital techniques 1			20			0.5
---- ----	total	490	410	214		---- ----	42.0

LEGEND: FORMAT FOR STRUCTURE OF THE PROGRAM

1 number of the course corresponding with the course number of the course description.

2 name of the course given in English

3 timetable workload in net hours for lectures

4 timetable workload in net hours for tutorials

5 timetable workload in net hours for practical work

6 timetable workload in net hours for other forms of education

7 this course is given in semester (1, 2, 3, or 4), or dimester (1 or 2)

8 credit points given for this course

APPENDIX 4: THE CHECKLIST

CHECKLIST FOR COMPARATIVE ANALYSIS OF THE ELECTRICAL E ENGINEERING PROGRAMS

The type of information outlined in this list is intended to reflect a range of background and performance characteristics relating to Electrical Engineering. The range of characteristics is not comprehensive, and the information provided below must be interpreted in conjunction with other relevant and qualitative background information.

The purpose of this list is to provide basic information for a comparative analyses of Electrical Engineering and a tool for the committee.

The checklist is based on the list of criteria/ frame of references of the committee.

Members, not participating in the visit of the faculty concerned, have to answer the questions marked with ⊗.

Return the checklist 14 days before the visit starts.

The members of the committee, visiting the faculty, have to answer all the questions.

Name of the member:______________________________

(The data will be reported anonymously)

NAME OF THE INSTITUTION:

I. AIMS AND OBJECTIVES

⊗ 1. Are the aims and objectives clearly stated:

NOT AT ALL		YES		VERY GOOD
1	2	3	4	5

REMARKS

⊗ 2. Are the formulated aims and objectives realistic and achievable, looking at the boundary conditions like the nominal duration of the study and the starting level of the students?

NOT AT ALL		YES		VERY GOOD
1	2	3	4	5

REMARKS

----

3. Are the formulated aims and objectives a good mixture of scientific orientation and practice orientation?

⊗ 4. The formulated aims and objectives represent the minimal requirements?

II. THE PROGRAM

⊗ 1. The program offers enough possibilities to develop a capability to delineate and solve in a practical way the problems of society that are susceptible to electrical engineering treatment?

2. The program offers enough possibilities to develop an understanding of the socio-technical, ethical, environmental, safety an public health aspects of the engineering profession and practice.

⊗

3. The program offers enough possibilities to develop an ability to maintain professional competency through life-long learning

4. The requirements for Mathematics are satisfactory translated in the program?

5. The requirements for the other Basic Sciences are satisfactory translated in the program?

⊗ 6. The requirements for General Engineering Sciences are satisfactory translated in the program?

7. The requirements for Electrical Engineering Sciences are satisfactory translated in the program?

8. The requirements for Electrical Engineering Design are satisfactory translated in the program?

9. There is attention in the curriculum for education in non-technical subjects?

10. The laboratory experiences of the students are satisfactory?

11. The experiences of the students in using the computer are satisfactory?

12. The attention for written communication is satisfactory?

13. The attention for oral communication is satisfactory?

14. Is the program offered by the faculty coherent?

⊗ 15. Is the supply of optional subjects satisfactory?

⊗ 16. Is the balance between generalisation and specialisation satisfactory?

17. The content of the program is up-to-date?

18. The program shows the importance of industrial projects satisfactory?

19. The course-material (books etc.) used in the program is up-to-date?

20. The level of the examinations is satisfactory?

21. The examinations reflect the aims of the courses?

22. The majority of students can finish the study in the nominal time?

III. THE FACULTY AN FACULTY STAFF

1. The faculty's procedures for curriculum design are good?

2. The faculty's procedures for examinations are good?

3. The general approach of the faculty to the methods of transfer of knowledge to the students is student-oriented?

4. The competency/qualifications of the academic staff is satisfactory?

5. The level of scholarship as shown by scientific and professional publications is satisfactory?

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6. The current range of specialisations among he academic staff is satisfactory (that is to say not too narrow an not too broad)?

7. The size of the academic staff is large enough to cover all of the curricular areas of electrical engineering.

8. The balance between research and teaching responsibilities of academic staff is satisfactory?

9. Staff development programs are satisfactory?

IV. FACILITIES AND RESOURCES

1. The student teaching and laboratory areas are adequate or not?

2. Is the equipment used essentially for teaching purposes on the whole adequate?

3. Is the equipment used predominantly for research purposes on the whole adequate?

4. Are the library resource materials available to staff and students adequate?

5. Are the computer facilities available to staff and students adequate?

6. The laboratory facilities reflect the requirements of the electrical engineering program satisfactory?

7. Are the facilities available to staff and students accessible after hours?

V. THE STUDENTS

⊗ 1. The preliminary education of the freshman is adequate?

2. The selection of students is adequate?

3. The graduate can be defined as generalist?

4. The graduate can be defined as a specialist?

⊗ 5. The graduates do get very easily a job?

VI. EXTERNAL RELATIONS

⊗ 1. The nature and level of interaction between the faculty and industry is satisfactory?

2. The nature and level of interaction between the faculty and relevant professional associations is satisfactory?

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3. The nature and level of interaction between the faculty and other faculties/departments of electrical engineering is satisfactory?

4. The nature and level of the international contacts is satisfactory?

5. Is there adequate participation in international programs (e.g ESPRIT, COMMETT, ERASMUS is satisfactory?

VII. INTERNAL QUALITY ASSESSMENT AND MANAGEMENT

1. The faculty maintain a formal and systematic record for student progress:

2. The faculty maintain a formal and systematic record for initial employment of graduates:

3. The faculty maintain a formal and systematic record for staff research and development grants:

4. The faculty maintain a formal and systematic record for staff publications:

5. The faculty has a good evaluation system, including student evaluation:

6. There exists a good climate for regular quality assurance?

VIII. SUMMARY

⊗ 1. The formulation of the goals and the transformation in the curriculum is satisfactory?

2. The program is satisfactory and meets the minimum requirements?

3. The faculty and faculty staff meet the minimum requirements?

4. The graduates meets the minimum requirements?

⊗ 5. The external relations are satisfactory?

⊗ 6. The internal quality assessment and management are satisfactory?

APPENDIX 5: REFERENCES

* ABET, Criteria for accrediting programs in engineering in the United States

* IPREE, Guide for the Committee

* IPREE, Basic Information, Volume 1

* IPREE, Basic Information, Volume 2

* IPREE, Course description Eindhoven , Volume 1-4

* IPREE, Course description Twente, Volume 1

* IPREE, Course description Delft, Volume 1

* IPREE, Course description Chalmers, Volume 1-4

* IPREE, Course description Lund, Volume 1-3

* IPREE, Course description München, Volume 1

* IPREE, Course description ETH, Volume 1-2

* IPREE, Course description Gent, Volume 1

* IPREE, Course description Leuven, Volume 1

All the volumes are rich sources of knowledge about the Electrical Engineering faculties participating in the project. Readers interested in the basic material will find copies of it at the VSNU and in the institutions of the Committee members.

APPENDIX 6: PROGRAM OF A SITE VISIT

GENT: SUNDAY 19 JANUARY -TUESD... 21 JANUARY 1992

TIME	SUNDAY 19 JANUARY 1992
???	arrival of the members in the hotel. Arcade hotel Nederkouter 24-25 Gent phone: + 32 91 25 07 07 fax: + 32 91 23 59 07
19.00-20.00	dinner with the members
20.00-22.00	meeting of the committee in the hotel; preparation of the interviews next day.

TIME	MONDAY 20 JANUARY 1992
09.00-10.15	reception by faculty board Room: Conferentiekamer Laboratorium Electromagnetisme en Acustica St.Pieternieuwstraat 41 (left entry of Technicum-building, 1st floor. phone: +91 64 33 16
10.15-11.15	interview with Academic Staff (basic program)
11.15-12.00	interview with students (basic program)
12.00-13.30	LUNCH
13.30-14.00	visit to practicals
14.00-15.00	interview with Academic Staff (specializations)
15.00-16.00	visit to laboratories/practicals at different places
16.00-17.00	interview with students (specializations) and PhD. students
17.00-18.00	interview with curriculum/program committee
20.00-22.00	dinner with faculty board

TIME	TUESDAY 21 JANUARY 1992
08.30-09.00	meeting of the committee
09.00-09.45	second meeting faculty board
10.00-12.00	discussion on the findings
12.00 - 12.30	closing session with the faculty board
12.30-13.30	LUNCH
14.00	departure by train to Leuven

APPENDIX 7: COMMENTARY OF THE FACULTIES

I. FACULTY OF ELECTRICAL ENGINEERING AT THE EINDHOVEN UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS

"The Faculty Board agrees with the concern of the IPR-EE Committee about the restrictions due to a four years programme. But it is impossible to implement a great deal of the recommendations of the Committee within a programme with a duration of four years, without decreasing the level of the programme in other aspects. Nevertheless the Faculty is already discussing how to improve the programme and the IPR-EE report will be very useful for this discussion.

The Faculty Board wonders at some assessments of the Committee which show a great discrepancy with the figures concerning the same subjects.

Table 3, page 33[*)]*, shows that TUE has the highest percentage of time spent on electrical design and is one of three universities with the highest percentage of time spent on non-technical subjects. In spite of these figures the assessment in table 5, page 37, is relatively low on these subjects. The remarks of the Committee on these subjects on page 75 doesn't confirm the assessment in table 5, page 37.*

The Faculty Board wonders why in table 16, page 54, the publication ratio is used for the academic staff including "others". In Eindhoven these "others" are all student assistants in the laboratory courses of the compulsory part of the programmes. These second and third year students are not expected to publish at all. When this fact is taken into account it has its influence on the assessment about the scientific/professional publications of Eindhoven in table 17, page 55.

In the overall assessment (page 83) the Committee considers the relation between teaching and research to be good. In our opinion the score in table 17, page 55, has to be brought in line with this assessment.

The faculty is not divided in two separate parts by the introduction of two curricula . Still 45 % of the lectures in the basic programmes (first seven trimesters) presented by the faculty members is a part of both the EE and IE programme. The same staff members are involved in coaching EE as well as IE students during their assignments and master's thesis project. In our opinion the discussion with the Committee has shown that a curriculum can only be a compromise of different wishes. And it has shown that the discussion how to find a better compromise is still going. One of the main topics in this discussion will be the position of the Electrical Engineering Science in the IE programme."

[*)] page numbers, mentioned in the commentary of the faculties are adjusted to this edition of the report.

2. FACULTY OF ELECTRICAL ENGINEERING AT THE UNIVERSITY OF TWENTE, THE NETHERLANDS

Preliminary

As stated in various sections of the report, starting from the academic year '92-'93 a new curriculum will be in effect which will fundamentally differ from the existing programme. We have addressed problems of formulation of goals, coherence, efficiency, participation of senior staff in teaching and student effort already to a large extent. Many of the comments found in the report of the committee are recognised by the faculty and we would like to express our appreciation for the large effort put into this project and the clear way conclusions are stated. The faculty subscribes to the general findings of the committee, but wishes to make some comments on details.

Faculty report

page 86, line 15:
The introduction of the new curriculum will be monitored very carefully by a Quality Control Committee, which will perform a qualitative and quantitative evaluation of every block in the new first year 'block programme'.

page 90, table 5:
Twente carries a first year course "Technical Systems Theory", especially designed to provide a general 'umbrella' above engineering in general. This course certainly has elements of 'general engineering sciences'.

page 91, line 44:
In the view of the faculty a judgement of the final year thesis is perhaps the most important parameter of comparison between the quality of curricula. Although final year thesis differs in time and level of specialisation between universities, we feel that this difference could have been corrected by in-depth comparison of this often concluding element of the educational process. Our experience within Erasmus contacts with over twenty European universities is that the quality of the Dutch project work is extremely good. The faculty is disappointed that the committee has not attached more weight to such a comparison, evaluatinf the differences in engineering ability in all its aspects.

page 93, line 29:
A small scale experiment for the new 'block structure' has of course been envisaged. Due to the large number of parameters, such a small experiment would have been inconclusive (there are always things within the structure than can be improved). The system has to run for 2-3 years to adjust its interna' parameters and be tested for its usefulness.

page 94, line 36
Comparing numbers of published papers per staff members of Twente to other universities visited, we have the impression Twente comes out as excellent, in fact top of the list! (refer to table 16, page 54).

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General findings

<u>*page 37, table 5:*</u>
There seems a contradiction between the conclusion in this table regarding EE design and the comments on page 91, line 13. 'Highly developed' seems more than 'adequate'.

<u>*page 39, table 6:*</u>
It is not clear to the faculty on which basis it is concluded that Twente comes out as adequate in oral and written communication. Nearly all theses are written in English and the quality of the oral presentations, to our judgement, seems overall good. Maybe the communication skills here refer to maturity of the students?

<u>*page 55, table 17:*</u>
There again seems a contradiction between table 17 and 16 on item 5 (publications), 'more than adequate' seems meagre for a top score on publications.

<u>*page 57, line 41:*</u>
The faculty participate in several Erasmus networks, establishing links with some 25 European universities.

<u>*page 59, line 22*</u>.
The Twente programme is judged as good in the fields of specialisation, but somewhat narrow. Within the constraints of 4 years it seems impossible to qualify good in both fields (as in fact the committee also concluded). Comparing this judgement with e.g. table 5, page 37, the faculty is somewhat puzzled by this outcome.

3. FACULTY OF ELECTRICAL ENGINEERING AT DELFT UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS

The TUD refrains from discussion and comments.

4. SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING AT CHALMERS UNIVERSITY OF TECHNOLOGY, SWEDEN

"We at Chalmers University of Technology are pleased to have had the opportunity to participate in this evaluation and are encouraged by the good assessment that we have received in the report. The results of the evaluation will be of great value to us. The few areas where the findings are not excellent will be even more valuable in our continuous work to improve the education we offer. Clearly the Committee grasped the crucial points of our education very well. The facts contained in the report are essentially correct and the overall conclusions will not be affected by our few minor objections. We have for some time been engaged in the development of the process of quality assessment both internally at Chalmers and between Swedish universities. To take part in this European evaluation and to benefit from the experience of VSNU in quality assessment is of great significance for us. It is important that the process of evaluation of the engineering education founded on quality assessment will continue and in addition result in a closer cooperation between the universities in Europe"

5. SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES AT LUND UNIVERSITY, SWEDEN

"Before giving specific comments regarding the report about our faculty, we feel that we have to discuss the general format chosen by the committee for this report. One part of the report contains descriptions of each faculty, its curriculum, its organization, the structure of its programme, etc. We find this part of the report very interesting and we are impressed by the amount of information transmitted by these descriptions. In another general part of the report, the committee assumes a normative role.

The committee seems to find it difficult to accept that engineering education has different traditions in different countries and that there does not, of course, exist any "best" way of arranging such education. In our view it is not necessary or even desirable to make electrical engineering programmes more similar in order to regard them as equivalent.

We are somewhat surprised that in comparison of the contents of the programmes between LU and CHA the committee gives CHA higher rating concerning "Electrical Engineering" and "Supply of optional subjects". In particular within the area of telecom we have an excellent undergraduate programme with a rich supply of high quality optional courses. our coverage of this important area within research and education is the broadest in Sweden. The rating "below expectation" concerning "general engineering" probably reflects the misapprehension (page 136) that we are supposed to lack, e.g. mechanics.

We will consider the advice given by the committee. particularly regarding the importance of larger projects and the role of industry in diploma thesis preparation.

Finally, we note that the committee discusses various reasons for the rather long duration of studies (compared with CHA, for instance, where identical rules apply). We are disappointed that the committee makes no attempt to investigate whether we quite simply demand a higher level of achievement from our students."

6. FACULTY OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY AT THE TECHNISCHE UNIVERSITÄT MÜNCHEN, GERMANY

No comments

7. FACULTY OF ELECTRICAL ENGINEERING AT THE EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE ZÜRICH, SWITZERLAND

No comments

8. FACULTY OF APPLIED SCIENCES (ELECTRICAL ENGINEERING) AT THE RIJKS-UNIVERSITEIT GENT, BELGIUM

"In general we appreciate the report and we congratulate the Committee with its tremendous and very useful work. However, as far as the findings about our University are concerned, it should be considered that the size of the visiting Committee was rather small (3 persons from 2 different countries only). The following remarks might improve the intelligibility of the report.

In Section 4.1. the text is very appreciative with respect to Gent, but in table 1 we get only "more than adequate".

In the text of Section 4.2. the University of Gent is specifically mentioned as having a not-sufficiently problem-oriented curriculum. We think this conclusion is unjustified. Is probably based on the fact that only one course of the core-curriculum is specifically design-oriented. Several optional courses are design-oriented, and all courses are very strongly problem-oriented (in many courses half of the examination is based on problem solving). Also in table 3, the percentage spent on electrical design is underestimated because optional courses are not taken into account.

In the same Section 4.2., the programmes of the Belgian Universities are described as being very broad. The Committee has not taken into account that the total number of contact hours is very large (see table 3) and that in absolute numbers the hours of specialization are as large as in other universities. The faculty in any case considers stronger specialization as unwanted.

In Section 4.7. the committee underestimated the amount of non-technical subjects at the University of Gent: only 4% (90 contract hours) must be chosen, but 90+135=225 hours can be chosen. The average student chooses halfway between these numbers.

With regard to Section 6.2., lines 35-40, we would like to stress that our faculty is convinced that the highest completion rates at the Belgian Universities are caused by the entrance examinations (and also by the continuous evaluations of the students progress). The completion rate in the Belgian Universities is 68 % as compared to 56 % in the Universities without selection.

With regard to Section 6.5. we are convinced that the difference in drop-out rates for engineering freshmen between Gent (25%) and Leuven (15%) is simply a difference in definition: the Gent number refers to those that never enter the second year, and the Leuven number to those that leave the faculty after the first year. With the same definition, we know the numbers to be comparable. Furthermore, we believe that the filtering in the first year is very effective, as the total drop-out nearly occurs in this year.

With regard to Section 7.2., we find the text in disagreement with the numbers of table 14. For instance the number of full time equivalents in Gent is larger than in Leuven. In table 17 this is translated in "below expectations" for Gent and "more than adequate" for Leuven, whilst the reverse could be expected. Also the number of total academic staff (non-full-timers included) does not warrant such drastic conclusions.

The faculty report rightfully mentions that the total time for compulsory design courses is only 1.2% of the total contract hours i.e. 52.5 hours of a total of 4095 hours. Besides 6.7% i.e. 275 hours are devoted to optional design courses. On the average half of them are chosen by the students. Hence the electrical design part of the curriculum varies from 1.2 to 7.9% with an average of 4.5%."

9. FACULTY OF ENGINEERING (DEPARTMENT OF ELECTRICAL ENGINEERING) AT THE KATHOLIEKE UNIVERSITEIT LEUVEN, BELGIUM

"1 The IPR-EE committee has rightly observed that the education in Electrical Engineering in Leuven is based indeed on a very broad education in all aspects of engineering. This is estimated to be of utmost importance to us as it keeps all channels open for further education in interdisciplinary sciences and post-academic specialisation.

2 The nominal time for the thesis is only 360 hours. The actual time spent by students is closer to 800 hours, which corresponds to about 3 to 4 months full-time effort.

3 The program is quoted to be very rigid and to allow little time for elective courses. We have given preference to series of selective courses (consisting of 11 courses) in order to guarantee a minimum level of education in each particular discipline. A student can choose between five different kinds of disciplines. On top of that a student can substitute one of two courses provided his thesis advisor agrees. The program is thus not that rigid.

Also, foreign students can make up a custom made program, again under supervision of their thesis advisor. In this way a very flexible program is made up indeed."

10. DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING, IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE.

At the request for permission to publish some information about the Department of Electrical and Electronic Engineering at Imperial College of Science Technology and Medicine, the Head of the Department came with the following reaction:

"First let me say that we do not want to stand in your way in publishing this. However, for your information there are items in this which are not very accurate or clear, and perhaps you would like me to spell them out.

1. page 65, lines 16/17

4T students select their courses from the widest possible range. It is not clear to me what is referred to in the phrase 'this field of specialization is too narrow'. Which field of specialization do you mean?

2. page 65, line 20

Our courses are designed for our national entry portfolio, (or 'average student population') as are those of other countries in Europe. Your reference to 'average student population' implies a whole raft of questions about what rules govern the entering student population for that country. Your statement on this could be misused- as our programme patently does not fail for a U.K. 'average student population'.

3. page 65, line 21

While this statement is correct I would have been happier had the committee referred to enormous differences in style and culture and considered whether the comparison can be made fairly. Your committee states that the graduates are "good" and "will become excellent engineers". How can it then be said that they do not meet a minimum standard."

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