COUNCIL FOR HIGHER EDUCATION
המועצה להשכלה גבוהה

Committee for the Evaluation of Physics Studies

Technion – Israel Institute of Technology

The Faculty of Physics

Evaluation Report

December 2007

Contents

Chapter 1- Background

At its meeting on March 8, 2005 the Council for Higher Education (CHE) decided to evaluate study programs in the field of Physics during the academic year 2005-2006.

Following the decision of the CHE, the Minister of Education, who serves ex officio as the Chairperson of the CHE, appointed a committee consisting of:

- ***Prof. Hanoch Gutfreund*** - The Racah Institute of Physics, The Hebrew University, Committee Chairman.
- ***Prof. Daniel Ashery*** - School of Physics and Astronomy, Tel Aviv University.
- ***Prof. Moshe Deutsch*** - Department of Physics, Bar Ilan University.
- ***Prof. James Langer*** - Department of Physics, University of California Santa Barbara, U.S.A.
- ***Prof. Stephen Lipson*** – Faculty of Physics, the Technion, Haifa.

Ms. Alisa Elon- Coordinator of the committee on behalf of the Council for Higher Education.

Within the framework of its activity, the committee was requested to:

1. Examine the self-evaluation reports, which were submitted by institutions that provide study programs in Physics, and hold on-site visits to those institutions.

2. Present the CHE with final reports for the evaluated academic units and study programs - a separate report for each institution, including the committee's findings and recommendations, together with the response of the institutions to the reports.

3. To submit to the CHE a report regarding its opinion of the examined field of study within the Israeli system of higher education. The committee will submit a separate report to the CHE in this matter.

The committee's Terms of Reference document is attached as **Appendix 1**.

The first stage of the quality assessment process consisted of self-evaluation by the institutions. This process was conducted in accordance with the CHE's Guidelines for Self-Evaluation (of October 2005) and on the basis of the committee's specific instructions, as set forth in their letter to the institutions dated December 21, 2005.

Chapter 2-Committee Procedures

The committee held its first meeting on March 26, 2006 during which it discussed fundamental issues concerning Physics study programs in Israel and its quality assessment activity.

During the period June-July 2006 the committee members received the self-evaluation reports.

In November 2006, the committee members conducted a full-day visit to each of the institutions offering study programs in the field under examination. During the visits, the committee met with the relevant officials within the organizational structure of each institution, as well as faculty and students.

In order to prevent the appearance of a conflict of interests, committee members did not participate in visits to institutions in which they were faculty members. Therefore, Prof. Stephen Lipson did not take part in the committee's visit to the Technion.

This report deals with the Evaluation of the Faculty of Physics at the Technion.

The committee's visit to the Technion took place on November 16, 2006. The schedule of the visit, including the list of participants representing the institution, is attached as **Appendix 2.**

The committee members thank the management of the Technion and the Faculty of Physics for their self-evaluation report and for their hospitality towards the committee during its visit.

Chapter 3- Evaluation of the Faculty of Physics at the Technion

I. Introduction

The Technion is the oldest institute of higher education in Israel. Its cornerstone was laid in 1912 under Ottoman rule. The first 16 civil engineering and architecture students began their studies in 1924. It was accredited as an Institute of Higher Education in 1962. The current enrollment in the Technion is over 13,000, of which about 3000 study towards a M.Sc. degree and about 800 - towards the Ph.D. degree. As the premier, and for a long time the only, engineering school in Israel many of its 70,000 graduates have assumed throughout the years leading roles in the development of Israeli industry, primarily in the fields of aviation, electronics and computers.

The Technion comprises 16 engineering and natural sciences Faculties, a Faculty of Medicine, a Faculty of Architecture and Town Planning, and two Departments: Education in Technology & Science and Humanities and Arts. This provides for a significantly higher homogeneity in the study and research disciplines than all other Israeli Universities, with the exception of the Weizmann Institute's Feinberg Graduate School. This relative homogeneity facilitates policy decision making and quality control in both teaching and research.

According to the President, Prof. Apeloig, the Technion plans to freeze the total number of students, and increase the proportion of advanced degree students, particularly those studying towards the Ph.D. degree. This policy is motivated by his consideration of the student-to-faculty ratio (23:1) at the Technion to be too high, by the declining average quality of the applicants, and by the chronic uncertainty and instability in the governmental allocations to higher education budget.

The Physics study tracks at the Technion are heavily influenced by several aspects:

- All physics courses included in the curricula of all faculties of the Technion are taught by the Faculty of Physics. This means teaching physics as service courses to 4000 students per year.

- The Technion is unique among the Israeli institutes of higher education in opening the school year twice a year. While not all courses are given twice a year, this practice clearly increases significantly the teaching load on the faculty.

The impact of these features on the Physics program at the Technion are discussed below.

II. The Faculty of Physics

A. History and structure

The Faculty of Physics was established (as a Department of Physics within the newly-formed Faculty of Science) in 1952, and included internationally-renowned physicists (Nathan Rosen, the first chairman, and David Bohm, to mention but a few). The first class of 6 students graduated in 1956. Since then the faculty of Physics awarded over 1700 Bachelors, 300 Masters and 170 Doctoral degrees. Current total enrollment in the various programs, discussed below, is 550 Bachelors, 70 Masters and 45 Doctoral students. The faculty includes 42 members, with a broad spectrum of both theoretical and experimental research interests: nanoscience, condensed matter physics, astrophysics, biophysics, optics and optoelectronics, quantum physics, superconductivity, high energy physics and more. The ratio of experimentalists to theoreticians is 20:22. There is no division into Departments within the faculty, and the Dean reports directly to the Technion's President in both academic and financial matters.

The faculty is associated with several research institutes:

- The Solid State Institute. Established in 1973, this institute is a joint venture of four faculties (Physics, Electrical Engineering, Chemistry, Materials Science).
- The Institute of Theoretical Physics. This is an intra-Faculty institute with no external partners within the Technion.
- The Nanotechnology Institute. In addition to Physics, this institute includes members from many Technion faculties, both in sciences and in engineering.
- An institute of bio- and medical engineering and science is now being established, under the directorship of Nobel laureate Prof. Aaron Ciechanover. The Faculty of Physics is also taking part in this new venture.

Although defined as research centers, these institutes serve as focal points, and seeds, for interdisciplinary degree programs, at both undergraduate and graduate levels. An M.Sc. program in nano-science and nano-technology has been recently established in the Nanotechnology Institute. The establishment of a similar program is expected in the Bioscience Institute.

B. Faculty planning and its impact on the studies program.

The Faculty has not established a long-range planning policy or program, perhaps due to the view that the implementation of such a program is nearly impossible when the number of suitable candidates available each year is small and fluctuating. Following an initial rise in the 50's and 60's, the number of faculty members peaked at 52 in the early 90's. Although the number of students (both Technion-total, and Physics) has risen continuously and steeply over the years, the number of faculty members has declined since the 1990's to the current number of 42, all but 7 of whom are Associate (12) or Full (23) Professors. Of these 9 are due to retire by 2009. Although some positions are, and will become, available through the Nanotechnology Institute, these are financed by the Institute for 5 years only, after which the positions have to be financed from the resources of the Faculty. The immediate result of the decimation of the number of the Physics faculty members is a deterioration in the quality of the undergraduate teaching, the first signs of which are already apparent, particularly in the service courses given to thousands of students in other Technion Faculties. This issue is further discussed below. Professor Apeloig blames this state of affairs on the recurrent cuts in the governmental Higher Education budget over the years, which necessitated a corresponding reduction in the number of faculty at the Technion. Nevertheless, it is our duty to warn that an intense effort of hiring new faculty is urgently called for to prevent a further workload-inflicted deterioration in the (particularly undergraduate) Physics teaching quality across the Technion, and to provide a sufficient number and variety of advisors, and advanced courses, for the graduate tracks of the Physics Faculty.

III. The Physics program

A. Governing bodies

The undergraduate and graduate programs are overseen by the respective committees within the Faculty. Final approval of the program is given by the Faculty Council. Two deans, one for each program, handle the execution of the study programs, and, in particular, the coordination of the service courses in Physics taught to students of other Faculties. In the joint 4-year programs (see below), however, while the Physics Faculty controls the Physics portions of the program, the students are registered with the engineering partners. The overall control of the joint program seems to be mostly in the hands of these partners as well.

B. Undergraduate programs

1. Study tracks

The Faculty awards two types of Baccalaureates in six different tracks, all built upon the basic skeleton of the three-year B.A. program (Track A), with courses added and removed to suit the specific needs of each track. We now discuss these six tracks, paying particular attention to their relative contributions to the teaching load, and their cost/benefit ratio within the undergraduate and graduate program of the Faculty.

Three year programs:

Physics (Track A, awarding a B.A. in Physics. About 38% of the students). This program is similar to those given in other Israeli Universities. It aims mainly to prepare the students for advanced studies in Physics, but also for R&D work in industry. Of the 118 points required, 29 are elective, of which half are within the Faculty and the rest can be taken in other Faculties within the Technion. This rather heavy program is dictated by the need to cover a broad range of classical and modern physics. Third-year courses cover solid state physics, astrophysics and nuclear and particle physics, so that the students obtain a broad view of current physics. The program provides also basic service courses in computer programming and chemistry, in addition to mathematics. There is at least one Laboratory course every semester, except for the first one, with a total of 24 one-semester lab hours within the three years. One laboratory course in chemistry, and one in computers, are also obligatory. This track serves as a basic template for all other tracks.

Physics and Mathematics. (Track C, awarding a B.A in Physics & Mathematics. About 4% of the students). This is modeled on Track A, with the mathematics courses augmented mostly at the expense of the second and third year lab courses and the more specialized third year courses in astrophysics and elementaary particles. Of the total number of 124 points, 32 are elective. Although providing a somewhat restricted physics education, particularly in modern physics, the restriction is not excessive and is offset by the broader mathematical education. The cost of the program in terms of teaching load is minimal, since the physics courses taken are those of the other programs. At the same time the stable, though small (20-25), enrollment over the last five years seems to justify keeping this program active.

Four year programs:

Physics (Track B, awarding a B.Sc. in Physics. About 3% of the students). This is basically Track A, with an additional year dedicated to specialization in optics and optoelectronics. The program caters to a large extent to students wishing to work in the high-tech industry, or to those who wish to study towards a higher degree, but prefer first to broaden their knowledge base. A total of 155 points are required, of which 45 are electives. This program does not seem to have a great attraction for the students. The enrollment over the last 5 years fluctuates between 9 and 20 students. Unlike Track C, this track requires not only setting up specific courses (optics, laser physics, opto-mechanics, fiber optics) but also a special laboratory course (Optical Measurements). Although these courses are probably taken as electives by other students, such practice may be restricted by the specific pre-requirements of each course. It seems therefore that this track represents some drain on the Faculty's teaching resources. In view of this, and the low and fluctuating enrollment, an examination by the Faculty of the need for this track seems advisable.

Physics and Electrical Engineering (Track D, awarding a B.Sc. in EE and a B.A. in Physics. About 38% of the students). The program aims at providing a degree in EE, with a strong background in physics. As such, the Physics part of the program is smaller than that of EE, and is based on Track A, with fewer electives and a number of courses removed, notably the third year laboratory. A total of 177 points are required. The students in this program are registered in the Faculty of EE. Many of them are doing their army service in one form or another. The program is highly attractive to students, with a high and stable yearly enrollment.

Physics and Materials Engineering (Track F, awarding a B.Sc. in ME and a B.A. in Physics. About 16% of the students). This is the oldest two-faculty track in the Faculty of Physics, and has served, with few changes, as a template to the other two-faculty programs. Aims, study program and student registration are very close to those of the EE-Physics program. The stable enrollment indicates a real demand for this program.

Physics and Computer Sciences (Track F, leading to a B.A in CS and a B.A. in Physics). This is a new program, with equal parts of Physics and Computer Sciences, and a total of 157.5 points, similar to track B. The program is new and the enrollment is still low, with only 4 students in the 2004/5 academic year. It is therefore too early to assess the viability of this track at the present time.

2. Admission to undergraduate studies

Admission to the undergraduate programs is decided upon a weighted average of the matriculation and Psychometric grades. The admission weighted grade is generally 80. Admission grades to the two-faculty programs are higher: 81 for the ME-Physics, 89 for the CS-Physics, and 92 for the EE-Physics programs. The Dean of Undergraduate Studies, Prof. Pinkus, noted that there is a constant decline, across the board, in the quality of high-school graduates reaching the Technion. The number of high-school students electing to matriculate in physics and mathematics at the high (5-point) level decreases continuously. Among those who do, the level of preparedness for undergraduate studies is also declining steadily. This requires taking special measures, particularly during the first semester.

3. Undergraduate laboratories

First year: Basic experiments, most based on air tracks. Equipment is very outdated, but kept in reasonable working order. A recurring complaint among students who have taken this laboratory is its "cook book" structure, where all steps are dictated, and there is no room for curiosity-driven exploration and student initiative. This deficiency is somewhat alleviated by the "project lab", which is taken for half a semester in lieu of the regular lab. Students in tracks A and B are required to take either this lab or a second-year project lab. With 12 places per semester in the first year project lab and 24 places per semester in the second year project lab, almost every student in tracks A and B can carry out a project during his first or second year. This lab is important for developing the student's curiosity-driven "research" skills. To further develop these skills, an effort should be made to render the contents of the standard laboratory less "cook book"-like and more initiative-driven.

The standard first year laboratory course is also taken by students of other Faculties as a service course. We have been told, however, that there is a growing tendency on the part of other Faculties to avoid including this lab course in their curricula, perhaps due to its much higher budgetary cost as compared to that of a course consisting of conventional frontal lectures. This tendency should be strongly discouraged by the Technion authorities, since carrying out experiments, even "cook book" ones, is indispensable for developing physical insight as well as a good understanding of physics.

Second year: Here more advanced laboratories are carried out (for one semester) such as NMR, esr, and "crystallography" by microwaves on an array of ordered macroscopic scatterers. There is more room for initiative here, although the experiments are still mostly predetermined. Most of the equipment is very old, and kept in working order by the skills of the laboratory technicians only.

The first- and second-year laboratories are supported by 5 technicians, who have at their disposal a small dedicated machine shop. The departmental machine shop also supports the lab as needed. This is a large number in comparison with other institutes, although by no means larger than is necessary considering the hundreds of service-course students taking the first-year labs yearly. The Faculty should be congratulated on insisting on the importance of the laboratory courses, and on allocating the necessary resources to keep them in working order.

Third year: The two-semester laboratory courses are a real feather in the cap of the Faculty. The 30 or so experiments in plasma physics, advanced optics, solitons, superconductivity etc. offer a broad choice of interesting and modern experiments. In some of the experiments (e.g. coherent optics) the students build their own experiments out of components. In many there is a two-level structure, in which the student can decide, after carrying out the first level, whether to continue to the more advanced second level, or move on to another experiment. Some of these second-level experiments are actually a small project, originating in ideas offered by the students. The students are encouraged to prepare posters on these, and present them at the end of the year. We were told that on average one paper per year is published based on the work carried out in this laboratory. This is very unusual for a third-year undergraduate laboratory, and the Faculty should be congratulated on this achievement. New experiments are added yearly, some of which are developed in the graduate laboratory course. This lab is supported by 3 technicians, one of whom has expertise in electronics and computers.

4. Comments on the undergraduate studies

Overall, the undergraduate program provides a broad selection of tracks, catering for those who are interested mainly in Physics, and also for those who are interested in other fields but wish to acquire a strong background in Physics. The main track, Track A, as well as the 4 year track B, provide a well-rounded education in physics, with a good coverage of several major modern sub-fields of physics (Astrophysics, condensed matter, nuclear and particle physics). We are pleased to see the relatively large proportion of laboratory courses in the program.

In the two-Faculty 4-year tracks, the time restrictions render the physics coverage skeletal, but perhaps still acceptable for the declared goal of a background discipline. On the other hand, the students in these programs are generally of a very high quality, and many continue their graduate studies at the Faculty of Physics. For example, 50% of the Physics Faculty's M.Sc. students come from the joint EE-Physics undergraduate track. We were told that the students in these programs are enrolled solely in, and their studies monitored by, the corresponding Engineering partner faculties. This issue came up recurrently as a sore point in discussions with both students and faculty members during our visit. While this seems to be a purely administrative matter, it does have subtle implications on the way the students regard, and are attracted to, these programs. It may be advisable to look for ways to bolster the "sense of belonging" of the students in these programs to the Faculty of Physics. A joint enrollment and monitoring may be one step in this direction.

An additional problem arises from the policy of the Technion that all courses in a given discipline should be taught by the corresponding Faculty. While in principle this is a logical approach, in practice this may lead to an inefficient use of the teaching times, and insufficient coverage of the specific subjects needed in a different discipline. In particular, the mathematics courses in the Faculty of Physics are taught by the Faculty of Mathematics, in their full mathematical rigor, which is mostly not required for applications in physics. Moreover, as the service courses in mathematics are tailored to the needs of the majority of the participants, which are from engineering faculties, and not to those of the physics students' minority. Thus, for example, the mathematics related to algorithms receives much attention, while other subjects (Fourier transforms were pointed out by the students in this context) which are of importance in physics, may receive less attention. We have been told that in a non-negligible number of cases the mathematics required in a specific physics course has to be re-taught by the physics lecturer, at the expense of having to reduce the physics contents of the course. In some universities these problems are avoided by having the physics faculty teach also the mathematics courses, or by the faculty of mathematics offering a course specially tailored to the needs of physics students. Considering the already heavy teaching load of the faculties, these may not be the optimal solutions for the Technion. However, this issue, raised by both faculty and students, seems to deserve the attention of the Faculty's curriculum committee.

C. Graduate programs

The focus of the advanced degree programs is the individual research project carried out under the supervision of a faculty member. In addition, course work to a total of 32 points for M.Sc. and 9 points for Ph.D., has to be completed. About 2/3 of the M.Sc. courses are mandatory, and include advanced courses in statistical mechanics, quantum theory, and electrodynamics, in addition to advanced specialized courses in a number of fields. We consider the inclusion of an advanced laboratory course (one semester, 8 hour per week) in the M.Sc. curriculum to be very commendable.

Six topical seminars are held weekly, where the graduate students are exposed to cutting-edge research in Israel and abroad in a number of research fields. There is also a weekly colloquium, of a more general nature. However, we note that in contrast with most other universities in Israel, attendance of the graduate students at the weekly colloquium is not mandatory.

On average, each staff member supervises 3 graduate students, although for some the numbers are much larger, reaching 7-9 students in extreme cases. Care should be exercised to prevent deterioration in the quality of the graduate supervision for such large numbers of supervised graduate students, particularly when the supervisor's undergraduate teaching load is already heavy.

D. Issues brought up by students

The discussion with the students was overshadowed by the aftermath of the Second Lebanon War, and the serious tuition disruption it caused at the Technion. The students complained of an unaccommodating and inflexible approach on the part of the Faculty on issues related to the completion of the semester, the alleviation of the examination load, and on dealing with specific problems of individuals who have been called up for army service. While these complaints should be taken with a grain of salt due to the nearness of the events to our visit, and the consequent emotional heat involved, the discussion did bring up a real need to strengthen the communication channels between the students and the faculty, and provide a greater involvement and influence of the students in fine-tuning the various study tracks, particularly under unusual conditions. This could be done either informally, or by encouraging the establishment of a formal representative body of the students, who would meet regularly, or upon need, with the Dean and other officers of the faculty. We were told by both the present and the elected Deans that steps are being taken to heal the rift with the students and establish a better rapport with them both at a formal and an informal level.

Other issues raised by the (undergraduate and graduate) students are:

- The first and second year laboratories are too much "cook book" like. We concur with this observation. Some students remarked that the "ancient equipment" often breaks down and does not always allow a smooth, uninterrupted completion of experiments. Such occurrences were, however, not frequent enough to render this an acute problem.
- The exercise classes of 40-45 students are too large to allow a good interaction with the students. This view was expressed both by undergraduates, who receive the tuition in these classes, and the graduate students who teach them.
- Some students consider the amount of undergraduate computer and programming courses insufficient (for jobs outside the Technion, as well as for advanced degree studies). This issue deserves investigation.
- In some cases the laboratory experiments are based on theoretical material that is taught only after the experiments are done (e.g. solid state physics in Laboratory 4). Some of the mathematics courses do not provide the mathematical tools in time for the physics courses requiring them. Fourier transforms were mentioned as an example.
- Access to the computer room needs to be extended to late hours. We were told by the Dean that this problem is now being solved.

E. Issues brought up by faculty

A recurrent theme in the discussion with the faculty was the heavy teaching load. Not all of it is reflected in the official programs. For example, since Technion regulations do not allow opening a course with less than 5 students, some graduate courses are conducted in the format of guided reading and study groups. Another task not appearing in the schedule are the 4th year projects, often carried out in the Faculty of Physics, rather than the partner Engineering Faculty, under the supervision of a faculty member. Several semi-informal courses are also off the official list of courses. Examples are the "Science Club" supervised by faculty members, and the

"Discovery" course, where selected guest scientists in a variety of scientific disciplines lecture on their fields. The opening of the school year twice a year (in which the Technion is unique among Israeli universities) was also specified as a major cause of the heavy teaching load. These issues, and their impact on the Physics programs, are further discussed below in the context of the service courses.

The faculty observed that, in general, the quality of the students admitted to the undergraduate programs is reasonable. The best students, though, are coming from the joint two-faculty programs. As for the graduate programs, all agreed on the high quality of the students, most of whom come from within the Technion, and a small part arriving from outside the Technion.

The beneficial influence of the new institutes, in particular the Nanotechnology Institute, was highlighted by several faculty members. The availability of set-up funds by the Institutes allows hiring high-quality researchers. The institutes also provide the graduate students with access to modern and often expensive equipment not available in the Faculties. The institutes also make possible attractive new interdisciplinary research, and study programs based on this research. A new M.Sc. program in nanotechnology has just been installed, and similar programs with the Life Sciences Institute are under consideration.

IV. The impact of research on the Physics undergraduate and graduate programs

The research interests of the faculty members span a broad range of fields within physics, providing well-qualified potential lecturers for a broad range physics courses. The realization of this possibility, however, is hampered by the heavy workload discussed above. The research fields include condensed matter physics, astrophysics, nanoscience, high-energy physics (with participation in international projects like ATLAS), optics and electro-optics, nuclear and atomic physics, biophysics, quantum physics, and more. The research institutes further broaden this scope. The significant (~50%) proportion of experimentalists provides for a strong support of the laboratory courses, especially in the more advanced third year undergraduate and advanced graduate lab courses. The broad range of research fields also helps in attracting a significant number of graduate students not just from among the Faculty's undergraduates, but also from other Faculties within the Technion (through the two-faculty joint undergraduate programs) and from outside the Technion.

V. The impact of service courses on the quality of teaching and research

The Faculty teaches physics to 4000 students per semester. Lectures are given in parallel classes of ~200 students. Exercise sessions are given also in parallel, in groups of 45 students. This is the formal picture. However, in practice, migration to the best lecturer(s), and/or lectures given at convenient times, increase these numbers considerably (with a corresponding decrease in attendance at lectures by less popular lecturers). The effectiveness of teaching in such large classes is considerably reduced, since direct student-teacher interaction is practically eliminated. Classrooms for such large audiences are not always available, and tend to be overcrowded. Although exercise sessions are conducted in smaller classes, which provide better direct interaction possibilities, it is clearly not possible to check each and every weekly homework assignment. The e-learning methods introduced to take care, mostly (but not only) of the weekly assignments are rated low by both students and faculty. One problem pointed out to us is that the e-learning program provides answers only, not the full solutions. Another is that the proportion of multiple-choice questions in the pool of homework questions, as compared to the open questions requiring a full solution by the student, is still too large, even though new open questions are regularly being added. In addition, core courses are video-recorded, and can be downloaded and watched by the students. According to Prof. Rosen, Senior VP of the Technion, e-learning has solved, albeit only in part, the problem of checking the weekly homework assignments of 700 students, which could not be done in the pre-e-learning era. He is aware of the deficiencies of the e-learning system, and a sustained effort is being made to improve it. It seems, however, that a satisfactorily efficient level in the application of e-learning has not yet been reached. Finally, it should be pointed out that in key courses, e.g. quantum mechanics, the weekly assignments and exams are checked individually by teaching assistants, in spite of the large (120) enrollment.

Another consequence of the heavy teaching load due to service courses is the general scarcity of elective undergraduate courses, and advanced graduate specialized courses. As the slack in the teaching assignments to faculty is close to zero, the availability of faculty for preparing such courses depends on marginal factors such as how many faculty members are available and which are on sabbatical.

In summary, the very heavy teaching load has serious deleterious consequences for the quality of teaching, and the variety of elective courses, both at undergraduate and graduate levels. We suggest that high priority be assigned to finding solutions to this problem. A return to the practice of student registration only once per year, as is the practice in all other Israeli universities, may provide some relief. Hiring additional faculty would be a direct and more effective solution, which, however, depends on the availability of suitable high-quality candidates, even when positions are available. In the long run, an increase in the proportion and number of graduate (and in particular Ph.D.) students within the student body of the faculty may provide more teaching assistants and provide a relief in the tight situation of the homework and exercise class size problems.

VI. Summary

Overall, the quality of the physics education provided by the Technion is high. The undergraduate programs offered are generally attractive, as indicated by both the enrollment stability, and number of students in these programs. The graduate programs attract also a considerable number of students, mostly from inside the Faculty of Physics but also from other faculties and from outside the Technion. The plan of increasing the proportion of the graduate students (particularly the Ph.D. students) without increasing the number of students is both logical and commendable.

Faculty planning, and hiring of new faculty, requires high-priority thought and action, considering that about 25% of the already-decimated number of faculty members are due to retire by 2009. This problem is further aggravated by the existing heavy teaching load imposed on the Faculty by the service courses, and the consequent signs of decline in the quality of frontal teaching, exercise classes, and may even impact in the long run the research projects of the graduate students.

In addition to the above, several other issues require prompt consideration and action by the appropriate authorities within the Faculty and/or by the Technion's management:

- The quality of teaching in the service courses, the accompanying exercise sessions, and in particular, the homework is severely declining. The heavy teaching load renders the current state of these courses poor, and the e-learning tools introduced seem to have been unable, at this stage, to provide more than a partial relief. Standardization and controls of these courses should also be implemented to ensure a uniform level of requirements and examinations, course coverage, etc. among the different lecturers of the same course.

- The ties of the students in the two-faculty undergraduate tracks to the Faculty of Physics need to be enhanced, perhaps by sharing the responsibilities for, and monitoring of, the students' progress between the two faculties involved.
- The first and second year laboratories need investments in new equipment, and an urgent revision of the experiments and instruction books.
- An improvement in the student-faculty relations within the Faculty should be actively sought by both parties, at the formal as well as the informal, levels.
- The attraction/cost ratio of the two-faculty, 4-year undergraduate programs is mostly favorable. The need for the CS-Physics program, as well as the 4-year B.Sc program, however, should be re-evaluated in the coming years.

Signed By:

Prof. Hanoch Gutfreund
Chairman

On behalf of the committee

APPENDICES

APPENDIX 1

Terms of Reference of the Committee

COUNCIL FOR HIGHER EDUCATION המועצה להשכלה גבוהה

18 October 2006

To:

Prof. Hanoch Gutfreund - The Racah Institute of Physics, the Hebrew University
Prof. Daniel Ashery - School of Physics and Astronomy, Tel Aviv University
Prof. Moshe Deutsch - Department of Physics, Bar Ilan University
Prof. James Langer - Department of Physics, University of California Santa Barbara, U.S.A.
Prof. Stephen Lipson- Faculty of Physics, the Technion, Haifa

Esteemed Gentlemen,

I hereby appoint you as members of the Council for Higher Education's (CHE) Committee for the Evaluation of Physics Studies within institutions of higher education in Israel.

You are kindly requested to operate in accordance with the Appendix to the Terms of Reference of Evaluation Committees (study-programs), which is attached to this Terms of Reference document.

The Committee is requested within the framework of its activity to:

1. Examine the self-evaluation reports which shall be submitted by the institutions that provide study-programs in Physics, and hold on-site visits to those institutions.
2. Present the CHE- by January 2007- with final reports regarding the evaluated academic units and study-programs- a separate report for each institution including the Committee's findings and recommendations, together with the institutions' responses to the reports.

Within the framework of the final reports, the Committee is requested to refer to the following topics, among others, in relation to each of the study-programs:

1. The goals and aims of the evaluated academic unit and study-programs.
2. The study-program and its standard.
3. The academic staff.
4. The students.
5. The organizational structure — both academic and administrative - of the academic unit and study-program.
6. The broad organizational structure (school/faculty) in which the academic unit and the study-program operate.
7. Physical and administrative infrastructure available to the study-program.
8. Internal mechanisms for quality assessment
9. Conclusions of the academic unit and the study-program.
10. Other topics to be decided upon by the Evaluation Committee.

In addition to its final reports concerning each study program under examination, the committee shall submit to the CHE the following documents:

1. A report regarding Physics Studies within the Israeli system of higher education.
2. A proposal concerning standards for Physics Studies.

Professor Hanoch Gutfreund shall preside over the Committee as Chairman.
Ms. Einav Broitman shall coordinate the Committee's activities.

Yours sincerely,

Yuli Tamir
Minister of Education
Chairperson of the Council for Higher Education

cc: Ms. Riki Mendelzvaig, Secretary of the Council for Higher Education
Ms. Michal Neumann, in charge of the Quality Assessment Unit
Ms. Einav Broitman, coordinator of the committee

Enclosure:
Appendix to the Terms of Reference of Evaluation Committees (study-programs).

November 2005

Appendix to the Terms of Reference of Evaluation Committees (Study-Programs)

1. General

On June 3, 2003 the Council for Higher Education (CHE) decided to establish a system for quality assessment and assurance in Israeli higher education. Within this framework, study-programs are to be evaluated once in six years and institutions once in eight years. The quality assessment system came into effect in the academic year of 2004-2005.

The objectives of the quality assessment activity are:

- To enhance the quality of higher education in Israel;
- To create an awareness within institutions of higher education in Israel of the importance of this subject and to develop internal mechanisms for the evaluation of academic quality on a regular basis;
- To provide the public with information regarding the quality of study programs in institutions of higher education throughout Israel;
- To ensure the continued integration of the Israeli system of higher education in the international academic arena.

It is not the CHE's intention to rank the institutions of higher education according to the results of the quality assessment activity. The evaluation committee is requested not to make comparisons between the institutions.

2. The Evaluation Committee

2.1 The CHE shall appoint a Committee to carry out quality assessment of the study-programs.

2.2 A senior academic figure in the examined field shall be appointed as Chairman.

2.3 The Committee shall include 3 to 5 senior academic figures in the field from leading institutions in Israel and abroad. In exceptional cases, and in cooperation with the committee chairman, an authoritative figure who is not on the academic staff of an institution of higher education may be appointed as a committee member.

2.4 In the event that a member of the committee is also a faculty member in an institution being evaluated, he will not take part in discussions regarding that institution.

3. The work of the Evaluation Committee

3.1 The Committee shall hold meetings, as needed, before visiting the institution, in order to evaluate the material received.

3.2 The committee shall visit the institution and the academic unit being evaluated within 3-4 months of receiving the self-evaluation report. The purpose of the visit is to verify and update the information submitted in the self-study report, clarify matters where necessary, inspect the educational environment and facilities first hand, etc. During the visit the committee will meet with the heads of the institution, faculty members, students, the administrative staff, and any other persons it considers necessary.

3.3 In a meeting at the beginning of the visit, the committee will meet with the heads of the institution (president/rector, dean), the head of the academic unit and the study-programs, in order to explain the purpose of the visit. At the end of the visit, the committee will summarize its findings, and formulate its recommendations.

3.4 The duration of the visits will be coordinated with the Chairman of the Committee according to the issue, and in any event will not be less than one day.

3.5 Following the visit, the committee will write its final report, including its recommendations, which will be delivered to the institution and the academic unit for their response. The institution's and the academic unit's response will not result in changes to the content of the Committee's report, unless they point out errors in the data or typographical errors in the Committee's report. In such cases, the committee will be able to make the required corrections in its final report.

4. The Evaluation Committee's Report

4.1 The final report of the evaluation committee shall address every institution separately.

4.2 The final report shall include recommendations on the subjects listed in the guidelines for self-evaluation, and in accordance with the Committee's Terms of Reference.

4.3 The recommendations can be classed as one of the five following alternatives:

4.3.1 ***Congratulatory remarks and minimal changes recommended, if any.***

4.3.2 ***Desirable changes recommended*** at the institution's convenience and follow-up in the next cycle of evaluation.

4.3.3 ***Important/needed changes requested for ensuring appropriate academic quality*** within a reasonable time, in coordination with the institution (1-3 years).

4.3.4 ***Essential and urgent changes required, on which continued authorization will be contingent*** (immediately or up to one year).

4.3.5 ***A combination of any of the above.***

4.4 The committee's report shall include the following:

4.4.1 **Part A — General background and an executive summary:**

4.4.1.1 General background concerning the evaluation process, the names of the members of the committee, a general description of the institution and the academic unit being assessed, and the committee's work.

4.4.1.2 An executive summary which will include a description of the strengths and weaknesses of the academic unit and program being evaluated, according to the subjects listed in the body of the report and a list of recommendations for action.

4.4.2 **Part B — In depth description of subjects examined:**

4.4.2.1 This part will be composed according to the topics examined by the evaluation committee, in accordance with the committee's Terms of Reference and the report submitted by the institution, and at the discretion of the committee.

4.4.2.2 For each topic examined - the report will present a summary of the findings, the relevant information and an analysis thereof, and conclusions and recommended actions.

4.4.3 **Part C — Summary and recommendations:**

4.4.3.1 A short summary of every one of the topics described in detail in Part B, including the committee's recommendations.

4.4.3.2 Comprehensive conclusion/s and recommendation/s regarding the evaluated academic unit and the study-programs.

4.4.4 **Part D- Appendices:**

The appendices shall contain the committee's Terms of Reference, relevant information about the institution and the evaluated academic unit, the schedule of the on-site visit.

4.5 The final report will be delivered to the institution, with the deadline for its and the academic unit's response noted.

4.6 The Committee's final report together with the response of the institution and the academic unit will be brought before the CHE.

4.7 The CHE will discuss these documents and formulate its decisions within (approximately) a year from the time the guidelines for self-evaluation were sent to the institutions.

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APPENDIX 2

The schedule of the visit

Physics, Technion
Schedule for the committee's site visits

Time	Subject	Participants
09:00-09:30 President Office, Senate Building, 5th floor	Opening session with heads of the institution, the senior staff appointed to deal with the quality assessment and the heads of the academic unit	1. President Prof. Yitzhak Apeloig 2. Senior Vice President Prof. Aviv Rosen 3. Dean of Graduate School Prof. Moshe Shpitalni 4. Dean of Undergraduate Stdies Prof. Allan Pinkus
09:30-11:30 Rm. 605, Lidow Physics Complex	Meeting with the school's academic and administrative leadership - the decision makers of the academic unit	1. Dean Prof. Eitan Ehrenfreund 2. Elected Dean Prof. Joseph Avron 3. Head- self evaluation committee Prof. Eric Akkermans 4. Deputy Dean for undergraduate studies Prof. Noam Soker 5. Deputy Dean for graduate studies Assoc. Prof. Yoram Rozen 6. Prof. Emil Polturak, special advisor to the Dean
11:30-13:00 11:30-12:15 3rd year lab 12:15-13:00 1st year lab	Tour of Teaching laboratories, meeting with Teaching Assistants (labs' instructors)	1. First year lab instructors 2. Third year lab instructors.
13:00-14:00 Rm. 605 Lidow Physics Complex	Lunch	Committee members only
13:45-14:45 Rm. 605 Lidow Physics Complex	Meeting with senior academic staff*	1. Prof. Michael Gronau 2. Prof. Shmuel Fishman 3. Prof. Uri Sivan 4. Prof. David Gershoni 5.
14:45-15:45 Rm. 605 Lidow Physics Complex	Meeting with graduate students (MA and PhD) and Teaching Assistants*	6 representatives at the most
15:45-16:45 Rm. 605 Lidow Physics Complex	Meeting with undergraduates*	Second and third year 6 representatives at the most

16:45-17:30 Dean's office, Rm. 402 Lidow Physics Complex	Summary meeting with the head of the academic unit and the person in charge of quality in the institution	1. Dean, Prof. Eitan Ehrenfreund 2. Dean Elect, Prof. Joseph Avron 3. Senior Vice President Prof. Aviv Rosen
17:30-18:00 Rm. 605 Lidow Physics Complex	Closed meeting	Committee members

* ישיבות אלו יתקיימו ללא נוכחות של הנהלת המוסד ו/או החוג