# The Faculty of Computer Science Curriculum Catalog 2023-2024

# Faculty members

## Dean

Raz Danny

## Professors

Attiya Hagit
Barequet Gill
Biham Eli
Bronstein Alexander
Bruckstein Alfred
Bshouty Nader
Cohen Reuven
Elad Michael
Elber Gershon
El-Yaniv Ran
Etzion Tuvi
Friedman Roy
Geiger Dan
Ishai Yuval
Kimelfeld Benny
Kimmel Ron
Kushilevitz Eyal
Lindenbaum Michael
Naor Joseph (Seffi)
Petrank Erez
Pinter Ron
Raz Danny
Rivlin Ehud
Roth Ronny
Schuster Assaf
Shachnai Hadas
Shlomi Tomer
Tsafrir Dan
Yahav Eran
Yavneh Irad

## Associate Professors

Ben-Chen Miri
Censor-Hillel Keren
Etzion Yoav
Filmus Yuval
Fischer Eldar
Gil Joseph
Mor Tal
Schwartz Roy
Yaakobi Eitan

## Senior Lecturers

Almagor Shaull
Amit Nadav
Belinkov Yonatan
Ben-David Naama
Itzhaky Shachar
Keren Sarah
Litany Or
Peleg Hila
Romano Yaniv
Rosenfeld Nir
Rothblum Ron
Rottenstreich Ori
Salzman Oren
Vizel Yakir
Weitz David
Yadgar Gala
Youngman Brit

## Emeritus Faculty

### Professors

Baram Yoram
Bar-Yehuda Reuven
Francez Nissim
Grumberg Orna
Heymann Michael
Itai Alon
Kaminski Michael
Kats Shmuel
Kohavi Zvi
Makowsky Johann
Markovitch Shaul
Moran Shlomo
Paz Azaria

Sidi Avraham
Ungarish Marius
Zaks Shmuel

**Associate Professors**
Kantorowits Eliezet
Litman Ami

## Visitors
Brezis Haim
Karp Richard
Pearl Judea

## Visiting Professor
Mendelson Avi

## Visiting Associate Professors
Yakhini Zohar

## Research Fellow
Radinsky Kira

## Secondary-Appointment Faculty
Aran Dvir
Kishony Roy
Mandel-Gutfreund Yael
Moses Yoram
Silberstein Mark
Tal Ayellet
Yizhak Keren

# About the Faculty

The Technion's Faculty of Computer Science offers undergraduate programs in computer science, software engineering, and computer engineering; combined degrees in computer science and mathematics and computer science and physics; a double degree in medicine and computer science, and MSc and PhD programs. The faculty aspires to educate outstanding scientists and engineers by providing them with extensive, comprehensive knowledge and giving them a variety of opportunities to develop managerial and technological skills, thus preparing them to lead the knowledge-intensive industries of the present and the future. The faculty selects the best candidates and maintains high academic standards, providing students with in-depth knowledge to help them succeed in the rapidly changing field of computer science.

The education and research at the Faculty of Computer Science covers a broad range of topics including theory of computation, algorithms, coding and cryptography, cyber security, machine learning, artificial intelligence, natural language processing, computer vision, image processing, computer graphics, computational geometry, robotics and automation, software engineering, compilation, formal verification of software and hardware systems, programming languages, data processing, operating systems, computer architecture, computer and internet networks, parallel and distributed algorithms, logic for computer science, bioinformatics, quantum information processing, databases, parallel and distributed programing, sorting and routing networks, geometric design, applied mathematics, numerical algorithms, optimization, and specialty courses in applied engineering and sciences.

The faculty is located in a state-of-the-art building designed for the convenience of the students and faculty members. The building's resources include auditoriums and classrooms equipped with advanced multimedia systems, a large multi-purpose center that offers a contemporary learning environment, and a modern library. The faculty building features teaching and research laboratories designed for a variety of fields, including robotics, computer vision, artificial intelligence, geometric processing, computer graphics and geometric computing, computer communication networks, software systems, computer systems, natural language processing, cyber

and information security, machine learning, information and knowledge, information and memory storage, bioinformatics, and quantum information processing.

# Undergraduate Studies

The Technion's Faculty of Computer Science offers several undergraduate programs - a general three-year program that features a track in machine learning and data analysis, and a general four-year program that features tracks in cyber and computerized system security. In addition, the faculty offers tracks in computer science and bioinformatics, software engineering, and computer engineering. Other options are combined B.Sc. programs in computer science and mathematics and in computer science and physics, and a double degree in medicine and computer science.

The curricula at the Faculty of Computer Science can be divided into three categories. The first, taught during the first three semesters, provides fundamental knowledge in the basic fields of mathematics, physics, programming, and more. The second comprises the courses required by the relevant faculties as well as courses offered by the faculties that participate in the combined B.Sc. programs. The courses in this category ensure that students acquire fundamental knowledge in the fields in which their faculties specialize so that they graduate with extensive knowledge in their selected field. The third category comprises elective courses, which allow students to specialize and delve deeper into the subjects that interest them. The program also includes lab projects, giving students practical experience as well.

Candidates must apply specifically for the B.Sc. programs in computer engineering, computer science and mathematics, computer science and physics, and the double degree in medicine and computer science when enrolling at the Technion. Students generally select the other tracks offered by the faculty towards the end of their second semester, although they can choose a specialty at a later time as well. Students also have the option of switching tracks during their studies.

## Computer science programs offered by the faculty:

### General computer science programs

There are two general B.Sc. programs in computer science - a three-year program and a four-year program. These are intended for students interested in a range of fields in computer science, including software and hardware, computer design and applications, artificial intelligence, computer science theory, and more.

- Students in the **three-year program** may select one of the following specialties:

## Machine learning and data analysis

The goal of this program is for graduates to specialize in information and signal collection, processing, and analysis, and in researching methods and algorithms in these fields. Students will learn how to process information and generate knowledge from it using signal processing tools, statistical inference, and machine learning. They will gain extensive knowledge of computer sciences and mathematical enrichment, and complete courses on collecting, processing, and learning from information. Graduates are awarded a B.Sc. in Computer Science and a certificate indicating their specialty, which is attached to their diploma and transcripts. The same applies for students in the general four-year program and the software engineering program who complete the extra requirements for this program.

## Computer science and bioinformatics

This program is offered in conjunction with the Faculty of Biology to provide students with extensive knowledge in a wide range of fields in computer science, as well as fundamental knowledge of molecular and cell biology. The program focuses on computational biology and bioinformatics software and systems, so that its graduates can join and lead the bioinformatics industries, or pursue graduate studies that combine knowledge of life sciences and computer science. Students apply for this program via the Faculty of Computer Science, and academic responsibility for their studies is shared by the Faculty of Computer Science and the Faculty of Biology. Graduates are awarded a B.Sc. in Computer Science and a certificate indicating their specialty, which is attached to their diploma and transcripts.

- Students in the **four-year program** may choose one of the following specialties:

## Cyber and computer systems security

The goal of this program is to produce graduates who specialize in cyber security. Students obtain extensive knowledge of computer science, with an emphasis on the theoretical and practical aspects of security in the digital world. Graduates are awarded a B.Sc. in Computer Science and a certificate indicating their specialty, which is attached to their diploma and transcripts.

## Software engineering

The four-year program for a B.Sc. in Software Engineering trains students who will specialize in large software systems. The program teaches a range of programing methods and systematic software analysis, design, implementation, testing, verification, maintenance, assessment, and conversion. Students acquire extensive knowledge of applied computer science and in-depth practical experience in developing software and using advanced software engineering tools.

## Computer engineering

The four-year program offers graduates a B.Sc. in Computer Engineering and an engineering degree and is run in conjunction with the Faculty of Electrical Engineering. The program aims to educate computer engineers with extensive software and hardware knowledge, who specialize in designing and developing computer-based systems.

## Combined degree in computer science and mathematics

This three-year program is run in conjunction with the Faculty of Mathematics and awards its graduates a B.Sc. in Computer Science and Mathematics. The track is intended for students with exceptional grades who are interested in gaining extensive knowledge of both computer science and mathematics, in order to join and lead in areas in the world of research and the industry that require in-depth knowledge and capabilities in both fields. This program differs from the double-degree program as students must apply separately and once accepted, enroll in a defined program in advance.

### Computer science and physics

This four-year program is offered in conjunction with the Faculty of Physics and awards its graduates a B.Sc. in Computer Science and Physics. The track is intended for students with exceptional grades who are interested in gaining extensive knowledge of both Computer Science and physics, in order to join and lead in areas of the world of research and the industry that require in-depth knowledge and capabilities in both fields. This program differs from the double-degree program as students must apply separately and register for a predefined program.

### Double degree in medicine and computer science

The Faculty of Medicine and the Faculty of Computer Science offer a program that grants a double degree for outstanding students with exceptional grades. Graduates of this program will have extensive knowledge of both computer science and medicine, enabling them to join and lead in either of the two fields and to take significant roles in research, development, and the industry in areas that require in-depth knowledge of both computers and medicine. Graduates are awarded a B.Sc. in Computer Science and a B.Sc. in Medical Sciences. The program is intended for students who are admitted for medicine studies and are interested in a second degree in Computer Science.

## Secondary Specialization

### Quantum computing

The Faculty of Computer Science also offers a scientific enrichment program in quantum computers and quantum information. Students in all tracks at the Faculty of Computer Science, including the combined tracks, can add this specialization. Students who complete this program will be awarded a certificate.

# Excellence Programs and Scholarships

## The LAPIDIM - Entrepreneurship Excellence Program

This excellence program is supported by leading companies in the industry. Its goal is to produce outstanding computer science graduates with exceptional leadership, entrepreneurship, and management skills and prepare them to take on key roles in the industry. Participants must meet all the academic requirements of the program they choose (including combined programs), and complete several managerial and entrepreneurial courses as well. Participants enjoy special benefits, including mentorship by a faculty member, tuition waivers, and a subsistence scholarship. A special state-of-the-art study area has been allocated for students in this program as well.

## The LAPIDIM - Research Excellence Program

This excellence program trains outstanding students with the potential to pursue academic careers as researchers and university faculty members. Participants must meet all the academic requirements of the program of their choice (including combined programs), complete specific program requirements and courses based on their field of research, and also attend special activities for students in this program. Participants enjoy special benefits, including mentorship by a faculty member, tuition waivers, and a subsistence scholarship. Students in this program have access to a new, modern, designated learning space.

## Enhanced Software Engineering and the PSAGOT Program for Outstanding Academic Reserve Students

The software engineering excellence program trains the next generation of research and development leaders in technology-intensive industries and in the security forces. Participants in this four-year program must meet all the academic requirements for a B.Sc. in Software Engineering and complete most of the required courses for a master’s degree.

### SAMBA – Outstanding Computer Science Students

To promote excellence, the faculty provides one-time scholarships to outstanding undergraduate students. The program is intended for all faculty students, in all tracks, including combined tracks. Scholarships will be awarded based on criteria that are updated periodically.

## Graduate Studies

Graduates with a B.Sc. in Computer Science or related fields with outstanding achievements can apply for MA or Ph.D. studies in one of the faculty's graduate programs. Students who graduate with a degree in computer engineering can choose to continue their graduate studies at the Faculty of Electrical Engineering as well. Students who specialize in bioinformatics can apply for graduate studies in molecular biology at the Faculty of Biology; students from the Computer Science and Mathematics program can continue their studies at the Faculty of Mathematics; and graduates of the Computer Science and Physics program can choose to continue their studies at the Faculty of Physics.

# Curricula

To meet the requirements for a BSc, students must accumulate as specified for each curriculum below, from each of the three categories of courses - compulsory courses, elective faculty courses, and elective Technion courses.
Each curriculum comprises 12 credits (or 10 credits in three-year programs) for elective Technion courses, of which at least 6 credits are for enrichment courses (with the exception of the double degree track in medicine and computer science); at least two credits for courses in physical education; and courses that students can choose from any of the Technion programs, provided they are eligible to register.

## The General Four-Year Track

Students must accumulate 155.0 credits, according to the following specifications:

| | |
|---|---|
| **Compulsory courses** | **87.0 credits** |
| **Elective faculty courses** | **56.0 credits** |
| **Elective Technion courses** | **12.0 credits** |

**Le** – lecture; **E** – exercise; **La** – lab; **P** – project; **C** – credits

## Compulsory Courses

Recommended courses, by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |
| 234114* | Introduction to computer science M* | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – Advanced B | 4 | - | - | - | 3.0 |
| | | 16 | 10 | 2 | - | 21.0 |
| | Physical education (choose from a list) | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

* This course must be taken in the 1st semester.
Please note: Students interested in bioinformatics should also take Biology 1 (134058) and General Genetics (134020) as early as possible.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104032 | Infinitesimal calculus 2M | 4 | 2 | - | - | 5.0 |
| 114071 | Physics 1M | 3 | 1 | - | - | 3.5 |
| 234124 | Introduction to systems programming | 2 | 2 | - | 2 | 4.0 |
| 234125 | Numerical algorithms ** | 2 | 2 | - | - | 3.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| | | 13 | 8 | - | 3 | 18.5 |
| | Physical education (choose from a list) | - | 2 | - | - | 1.0 |
| | | | 10 | | | 19.5 |

** The Numerical Algorithms course can be taken in the 2nd semester and Modern Algebra (Electrical Engineering) in the 3rd semester, or vice versa.

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 104134 | Modern algebra H *** | 2 | 1 | - | - | 2.5 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| 234292 | Logic for CS | 2 | 1 | | - | 3.0 |
| | | 13 | 7 | 1 | | 17.5 |

*** Students can take Introduction to Groups (104158) and Introduction to Rings and Fields (104279) instead of Modern Algebra and an additional math course.

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | An additional math course* | | | | | 2.5/5.0 |
| | A scientific course** | | | | | 3.0/5.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| | | | | | | 16/20.5 |

** See science courses below.

*** One of the following mathematics courses:**

| | | Credits |
|---|---|---|
| 104135 | Ordinary differential equations t [(1)] | 2.5 |
| 104033 | Vector analysis | 2.5 |
| 104174 | Algebra BM | 3.5 |
| 104122 | Complex function theory 1 | 3.5 |
| 104142 | Introduction to metric and topological space | 3.5 |
| 104285 | Ordinary differential equations A [(2)] | 3.5 |
| 104295 | Infinitesimal calculus 3 | 5.0 |

[(1)] This course is considered an additional math course only for students take one of the following courses: Introduction to quantum physics for engineering (114073), Quantic physics 1 (115203), Quantic chemistry 1 (124400), or Analytic mechanics (114101).

(2) Limited to 10 students per semester.

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | A scientific course** | | | | | 3.0/5.0 |
| 236267 | Computer architecture | 2 | 1 | - | 1 | 3.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| | | | | | | 12/14 |

## **Scientific Courses

Students must choose at least 8 credits from the following scientific courses, in accordance with chains of requirements below. If students take more than 8 credits, they will be considered elective courses from List B:

| | | |
|---|---|---|
| 114075 | Physics 2MM | 5.0 |
| 114052 | Physics 2 | 3.5 |
| 114054 | Physics 3 | 3.5 |
| 114073 | Introduction to quantum physics for engineering | 3.5 |
| 114101 | Analytical mechanics | 4.0 |
| 114246 | Electromagnetism and electrodynamics | 5.0 |
| 124120 | Principles of chemistry | 5.0 |
| 125001 | General chemistry | 3.0 |
| 125801 | Organic chemistry | 5.0 |
| 124510 | Physical chemistry | 4.0 |
| 134058 | Biology 1 | 3.0 |
| 134020 | General genetics | 3.5 |

Students must choose courses that complete one of the following chains:

**1. Physics**

| | | Credits |
|---|---|---|
| 114075 | Physics 2MM | 5.0 |
| | Or the two following courses: | |
| 114052 | Physics 2 | 3.5 |
| 114054 | Physics 3 | 3.5 |

### 2. Biology

| | | Credits |
|---|---|---|
| 134058 | Biology 1 | 3.0 |
| 134020* | General genetics * | 3.5 |

* Available for all Technion students only once a year.

### 3. Chemistry

| | | Credits |
|---|---|---|
| 124120 | Principles of chemistry | 5.0 |
| 125801 | Organic chemistry | 5.0 |
| Or | | |
| 124510 | Physical chemistry | 4.0 |

### 4. Physics-chemistry

| | | Credits |
|---|---|---|
| 124120 | Principles of chemistry | 5.0 |
| 114052 | Physics 2 | 3.5 |

## Elective Courses

Students are required to take 56 elective faculty credits from three of the eleven specialization groups listed below. This means students will attend nine different courses, three from each group, and meet any requirements defined for those groups. At least 26 credits must be accumulated from the three specialization groups selected.

Another 15 credits must be chosen from List A (all computer science faculty courses) and an 15 credits from List A or List B (elective Technion courses).

All students are required to participate in either two projects or one project and one seminar (see the Miscellaneous section for more information on the follow-up software project course).

# Specialization Groups

## 1. Computational complexity

| | | |
|---|---|---|
| 236306 | Random graphs | 2.0 |
| 236309 | Introduction to coding theory | 3.0 |
| 236313 | Complexity theory | 3.0 |
| 236315 | Algebraic methods in computer science | 3.0 |
| 236318 | Boolean Function Analysis | 2.0 |
| 236359 | Algorithms 2 | 3.0 |
| 236374 | Probabilistic methods and algorithms | 3.0 |
| 236377 | Distributed graph algorithms | 3.0 |
| 236378 | Principles of managing uncertain data | 2.0 |
| 236508 | Cryptography and complexity | 2.0 |
| 236518 | Communication complexity | 2.0 |
| 236521 | Approximation algorithms | 2.0 |
| 236525 | Introduction to network coding, bounds and construction | 3.0 |
| 236755 | Distributed algorithms | 3.0 |
| 236760 | Computational learning theory | 2.0 |

Course number 236313 is compulsory.

## 2. Algorithm theory

| | | |
|---|---|---|
| 236315 | Algebraic methods in computer science | 3.0 |
| 236357 | Distributed algorithms A | 3.0 |
| 236359 | Algorithms 2 | 3.0 |
| 236377 | Distributed graph algorithms | 3.0 |
| 236521 | Approximation algorithms | 2.0 |
| 236715 | Methods in analysis of algorithms | 3.0 |
| 236719 | Computational geometry | 3.0 |
| 236755 | Distributed algorithms | 3.0 |
| 236760 | Computational learning theory | 2.0 |
| 236779 | Foundations of algorithms for massive datasets | 2.0 |
| 238739 | Discrete algorithmic geometry | 2.0 |

### 3. Logic and its applications

| | | |
|---|---|---|
| 236025 | Automata logic and games | 2.0 |
| 236026 | Knowledge and games in distributed systems | 2.0 |
| 236304 | Logic for computer science 2 | 3.0 |
| 236342 | Introduction to software verification | 3.0 |
| 236345 | Automatic verification of hardware and software systems | 3.0 |
| 236356 | Introduction to database theory | 3.0 |
| 236378 | Principles of managing uncertain data | 2.0 |

### 4. Cryptology, cyphers, and information

| | | |
|---|---|---|
| 236309 | Introduction to coding theory | 3.0 |
| 236350 | Network security | 3.0 |
| 236379 | Coding and algorithms for memories | 3.0 |
| 236500 | Cryptanalysis | 3.0 |
| 236506 | Modern cryptology | 3.0 |
| 236508 | Cryptography and complexity | 2.0 |
| 236520 | Coding for storage systems | 2.0 |
| 236525 | Introduction to network coding, bounds and construction | 3.0 |
| 236990 | Introduction to quantum information processing | 3.0 |

Students must take either course 236309 or course 236506.

### 5. Software system development

| | | |
|---|---|---|
| 236268 | Constructive computer architecture | 3.0 |
| 236271 | Android development | 2.0 |
| 236278 | Computational accelerators and accelerated systems | 3.0 |
| 236319 | Programming languages | 3.0 |
| 236321 | Software engineering methods | 3.0 |
| 236332 | The internet of things – technologies and implementations | 2.0 |
| 236342 | Introduction to software verification | 3.0 |
| 236347 | Software synthesis and automated reasoning | 3.0 |
| 236363 | Databases | 3.0 |
| 236369 | Programing web systems | 3.0 |

| | | |
|---|---|---|
| 236376 | Operating systems engineering | 4.0 |
| 236490 | Computer security | 3.0 |
| 236491 | Secure programming | 3.0 |
| 236496 | Reverse engineering | 3.0 |
| 236700 | Software design | 3.0 |
| 236703 | Object-oriented programming | 3.0 |
| 236712 | Agile software engineering | 2.0 |
| 236780 | Algorithms for dynamic memory management | 2.0 |

Course number 236319 is compulsory.

### 6. Distributed systems and communication networks

| | | |
|---|---|---|
| 236026 | Knowledge and games in distributed systems | 2.0 |
| 236322 | Information storage systems | 3.0 |
| 236334 | Introduction to computer networks | 3.0 |
| 236341 | Internet networking | 3.0 |
| 236350 | Network security | 3.0 |
| 236351 | Distributed systems | 3.0 |
| 236357 | Distributed algorithms A | 3.0 |
| 236369 | Programing web systems | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 3.0 |
| 236377 | Distributed graph algorithms | 3.0 |
| 236422 | Advanced storage system and technologies | 3.0 |
| 236490 | Computer security | 3.0 |
| 236510 | Database management systems implementation | 3.0 |
| 236700 | Software design | 3.0 |
| 236755 | Distributed algorithms B | 3.0 |

Students must take either course 236334 or course 236370.

### 7. Computer systems

| | | |
|---|---|---|
| 236268 | Constructive computer architecture | 3.0 |
| 236278 | Computational accelerators and accelerated systems | 3.0 |
| 236322 | Information storage systems | 3.0 |
| 236334 | Introduction to computer networks | 3.0 |
| 236347 | Software synthesis and automated reasoning | 3.0 |
| 236350 | Network security | 3.0 |
| 236363 | Databases | 3.0 |
| 236369 | Programing web systems | 3.0 |
| 236376 | Operating systems engineering | 4.0 |
| 236379 | Coding and algorithms for memories | 3.0 |
| 236422 | Advanced storage system and technologies | 3.0 |
| 236490 | Computer security | 3.0 |
| 236491 | Secure programming | 3.0 |
| 236496 | Reverse engineering | 3.0 |

| | | |
|---|---|---|
| 236510 | Database management systems implementation | 3.0 |
| 236703 | Object-oriented programming | 3.0 |
| 236780 | Algorithms for dynamic memory management | 2.0 |

Course number 236363 is compulsory.

### 8. Computer vision and robotics

| | | |
|---|---|---|
| 236201 | Introduction to data processing and representation | 3.0 |
| 236330 | Introduction to optimization * | 3.0 |
| 236372 | Bayesian networks | 3.0 |
| 236777 | Deep learning and its applications | 3.0 |
| 236781 | Deep learning on computation accelerators | 3.0 |
| 236860 | Digital image processing | 3.0 |
| 236861 | Geometric computer vision | 3.0 |
| 236862 | Sparse and redundant representations and applications | 3.0 |
| 236873 | Computer vision | 3.0 |
| 236875 | Visual recognition | 3.0 |
| 236901 | Algorithmic robot motion planning | 2.0 |
| 236927 | Introduction to robotics | 3.0 |
| 238100 | Reliability in modern machine learning | 2.0 |
| 238790 | Multi-grid methods | 2.0 |
| 104177 | Differential geometry | 3.5 |

* Or course number 046197, computational methods in optimization.
Course number 236201 is compulsory.

## 9. Computational geometry and computer graphics

| | | |
|---|---|---|
| 236216 | Computer graphics 1 | 3.0 |
| 236324 | Computer graphics 2 | 3.0 |
| 236329 | Digital geometry processing | 3.0 |
| 236373 | Image synthesis | 3.0 |
| 236716 | Geometric models in CAD systems | 3.0 |
| 236719 | Computational geometry | 3.0 |
| 104177 | Differential geometry | 3.5 |
| 238739 | Discrete algorithmic geometry | 2.0 |

Course number 236216 is compulsory.

## 10. Machine learning and artificial intelligence

| | | |
|---|---|---|
| 236201 | Introduction to data processing and representation | 3.0 |
| 236299 | Introduction to natural language processing | 3.0 |
| 236372 | Bayesian networks | 3.0 |
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236756 | Introduction to machine learning | 3.0 |
| 236760 | Computational learning theory | 2.0 |
| 236777 | Deep learning and its applications | 3.0 |
| 236779 | Foundations of algorithms for massive datasets | 2.0 |
| 236781 | Deep learning on computation accelerators | 3.0 |
| 236901 | Algorithmic robot motion planning | 2.0 |
| 238100 | Reliability in modern machine learning | 2.0 |
| 094423 | Introduction to statistics | 3.5 |

Course number 236501 is compulsory.

## 11. Bioinformatics

| | | |
|---|---|---|
| 236522 | Algorithms in computational biology | 3.0 |
| 236523 | Introduction to bioinformatics | 2.5 |
| 094423 | Introduction to statistics | 3.5 |
| 124120 | Principles of chemistry | 5.0 |
| 125001 | General chemistry | 3.0 |

| | | |
|---|---|---|
| 125801 | Organic chemistry | 5.0 |
| 134019 | Introduction to biochemistry and enzymology | 2.5 |
| 134020 | General genetics | 3.5 |
| 134058 | Biology 1 | 3.0 |
| 134082 | Molecular biology | 2.5 |

Courses 236522 and 094423 are compulsory.

Please note: All the biology and chemistry courses in this specialization group, except for one, are equivalent to elective courses from List B.

## List A: Computer science faculty courses:

| | | Credits |
|---|---|---|
| 234268 | Data structures and algorithms | 3.0 |
| 234302 | Project in compilation U | 3.0 |
| 234303 | Project in operating systems U | 3.0 |
| 234304 | Project in artificial intelligence U | 3.0 |
| 234313 | Industrial project | 3.0 |
| 234326 | Project in computer graphics U | 3.0 |
| 234329 | Project in image processing and analysis | 4.0 |
| 234493 | Introduction to cyber security | 1.0 |
| 234901 | Workshop in competitive programming | 3.0 |
| 236002 | Topics in computer science innovation | 2.0 |
| 236004 | Topics in transformers and attention | 3.0 |
| 236025 | Automata logic and games | 2.0 |
| 236026 | Knowledge and games in distributed systems | 2.0 |
| 236201 | Introduction to data processing and representation | 3.0 |
| 236203 | Advanced topics in collaborative artificial intelligence systems | 3.0 |
| 236204 | Seminar on formal methods | 2.0 |
| 236205 | Advanced topics in geometric deep learning | 3.0 |
| 236206 | Topics in sequences and De Bruijn graphs | 2.0 |
| 236216 | Computer graphics 1 | 3.0 |
| 236268 | Constructive computer architecture | 3.0 |

| | | |
|---|---|---|
| 236270 | Software project management | 3.0 |
| 236271 | Android development | 2.0 |
| 236272 | Project in Android development | 3.0 |
| 236278 | Computational accelerators and accelerated systems | 3.0 |
| 236299 | Introduction to natural language processing | 3.0 |
| 236303 | Project in natural language processing | 3.0 |
| 236304 | Logic for computer science 2 | 3.0 |
| 236306 | Random graphs | 2.0 |
| 236309 | Introduction to coding theory | 3.0 |
| 236310 | Formal language theory | 3.0 |
| 236313 | Complexity theory | 3.0 |
| 236315 | Algebraic methods in computer science | 3.0 |
| 236318 | Computer graphics 1 | 2.0 |
| 236319 | Programming languages | 3.0 |
| 236321 | Software engineering methods | 3.0 |
| 236322 | Information storage systems | 3.0 |
| 236323 | Project in data processing M | 3.0 |
| 236324 | Computer graphics 2 | 3.0 |
| 236328 | Project in computer graphics M | 3.0 |
| 236329 | Digital geometry processing | 3.0 |
| 236330 | Introduction to optimization | 3.0 |
| 236332 | The internet of things – technologies and implementations | 2.0 |
| 236333 | Project in the internet of things | 3.0 |
| 236334 | Introduction to computer networks | 3.0 |
| 236336 | Numerical solution of partial differential equations | 3.0 |
| 236340 | Project in computer communication | 3.0 |
| 236341 | Internet networking | 3.0 |
| 236342 | Introduction to software verification | 3.0 |
| 236345 | Automatic verification of hardware and software systems | 3.0 |
| 236346 | Project in computer-aided verification | 3.0 |
| 236347 | Software synthesis and automated reasoning | 3.0 |
| 236348 | Introduction to human-computer interaction | 3.0 |

| | | |
|---|---|---|
| 236349 | Project in information security | 3.0 |
| 236350 | Network security | 3.0 |
| 236351 | Distributed systems | 3.0 |
| 236356 | Database theory | 3.0 |
| 236357 | Distributed algorithms A | 3.0 |
| 236358 | Advanced topics in distributed algorithm | 2.0 |
| 236359 | Algorithms 2 | 3.0 |
| 236360 | Theory of compilation | 3.0 |
| 236361 | Project in compilation M | 3.0 |
| 236363 | Databases | 3.0 |
| 236366 | Project in operating systems M | 3.0 |
| 236369 | Programing web systems | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 3.0 |
| 236371 | Project in parallel and distributed computation | 3.0 |
| 236372 | Bayesian networks | 3.0 |
| 236373 | Image synthesis | 3.0 |
| 236374 | Probabilistic methods and algorithms | 3.0 |
| 236376 | Operating systems engineering | 4.0 |
| 236377 | Distributed graph algorithms | 3.0 |
| 236378 | Principles of managing uncertain data | 2.0 |
| 236379 | Coding and algorithms for memories | 3.0 |
| 236381 | Project in VLSI B | 4.0 |
| 236388 | Project in storage systems | 3.0 |
| 236422 | Advanced Storage System and Technologies | 3.0 |
| 236490 | Computer security | 3.0 |
| 236491 | Secure programming | 3.0 |
| 236496 | Reverse engineering | 3.0 |
| 236499 | Project in firewalls | 3.0 |
| 236500 | Cryptanalysis | 3.0 |
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236502 | Project in artificial intelligence | 3.0 |
| 236503 | Project in CS advanced programming 1 | 3.0 |

| | | |
|---|---|---|
| 236504 | Project in software | 3.0 |
| 236506 | Modern cryptology | 3.0 |
| 236508 | Cryptography and complexity | 2.0 |
| 236509 | Advanced topics in computer architecture | 3.0 |
| 236510 | Database management systems implementation | 3.0 |
| 236512 | Project in software development systems | 3.0 |
| 236513 | Advanced project in software development systems | 3.0 |
| 236515 | Advanced topics in coding theory | 2.0 |
| 236518 | Communication complexity | 2.0 |
| 236520 | Coding for storage systems | 2.0 |
| 236521 | Approximation algorithms | 2.0 |
| 236522 | Algorithms in computational biology | 3.0 |
| 236523 | Introduction to bioinformatics | 2.5 |
| 236524 | Project in bioinformatics | 3.0 |
| 236525 | Introduction to network coding, bounds and construction | 0.3 |
| 236526 | Project in CS advanced programming 2 | 3.0 |
| 236612 | Advanced topics in cryptology | 3.0 |
| 236613 | Advanced Topics in Cryptology L | 2.0 |
| 236620 | Advanced Topics in Algorithms L | 2.0 |
| 236621 | Advanced Topics in Algorithms L+T | 3.0 |
| 236622 | Advanced Topics No. 2 in Algorithms L | 2.0 |
| 236623 | Advanced Topics No. 2 in Algorithms L+T | 3.0 |
| 236624 | Advanced Topics in Formal Verification Methods L | 2.0 |
| 236625 | Advanced Topics in Formal Verification Methods L+T | 3.0 |
| 236627 | Advanced Topics in Computer Vision and Image Processing L+T | 3.0 |
| 236628 | Advanced Topics in Computer Graphics L | 2.0 |
| 236629 | Advanced Topics in Computer Graphics L+T | 3.0 |
| 236630 | Advanced topics in Natural Language Processing L | 2.0 |
| 236631 | Advanced Topics in Natural Language Processing L+T | 3.0 |
| 236632 | Advanced Topics in Bioinformatics L | 2.0 |
| 236633 | Advanced Topics in Bioinformatics L+T | 3.0 |

| | | |
|---|---|---|
| 236634 | Advanced Topics in Computer Communication Networks L | 2.0 |
| 236635 | Advanced Topics in Computer Communication Networks L+T | 3.0 |
| 236637 | Advanced Topics in Logic and Computation L+T | 3.0 |
| 236638 | Advanced Topics in Networks Design and Analysis L | 2.0 |
| 236640 | Advanced Topics in Quantum Information L | 2.0 |
| 236641 | Advanced Topics in Quantum Information L+T | 3.0 |
| 236643 | Advanced Topics in Robotics L+T | 3.0 |
| 236644 | Advanced Topics in Scientific Computing L | 2.0 |
| 236645 | Advanced Topics in Scientific Computing L+T | 3.0 |
| 236646 | Advanced Topics in Theoretical Computer Science L | 2.0 |
| 236647 | Advanced Topics in Theoretical Computer Science L+T | 3.0 |
| 236648 | Advanced Topics in Complexity L | 2.0 |
| 236649 | Advanced Topics in Complexity L+T | 3.0 |
| 236650 | Advanced Topics in Software Engineering L | 2.0 |
| 236651 | Advanced Topics in Software Engineering L+T | 3.0 |
| 236652 | Advanced Topics in Information Security L | 2.0 |
| 236653 | Advanced Topics in Information Security L+T | 3.0 |
| 236654 | Advanced Topics No. 2 in Software Engineering L | 2.0 |
| 236655 | Advanced Topics No. 2 in Software Engineering L+T | 3.0 |
| 236657 | Advanced Topics in Database Theory L+T | 3.0 |
| 236658 | Advanced Topics in Natural Computing L | 2.0 |
| 236660 | Advanced Topics in Computational Learning L | 2.0 |
| 236661 | Advanced Topics in Computational Learning L+T | 3.0 |
| 236662 | Advanced Topics in Algorithmic Game Theory L | 2.0 |
| 236663 | Advanced Topics in Algorithmic Game Theory L+T | 3.0 |
| 236664 | Advanced Topics in Biological Computing L | 2.0 |
| 236667 | Advanced Topics in machine learning and human behavior L T | 3.0 |
| 236668 | Blockchain and cryptocurrency protocols | 2.0 |
| 236669 | Advanced topics in introduction to property test | 3.0 |
| 236670 | Advanced topics in algorithms 2 | 3.0 |
| 236698 | Software quality assurance | 2.0 |

| | | |
|---|---|---|
| 236700 | Software design | 3.0 |
| 236703 | Object-oriented programming | 3.0 |
| 236712 | Agile software engineering | 2.0 |
| 236715 | Methods in analysis of algorithms | 3.0 |
| 236716 | Geometric models in CAD systems | 3.0 |
| 236719 | Computational geometry | 3.0 |
| 236729 | Project in computational geometry | 3.0 |
| 236754 | Project in intelligent systems | 3.0 |
| 236755 | Distributed algorithms B | 3.0 |
| 236756 | Introduction to machine learning | 3.0 |
| 236757 | Project in machine learning | 3.0 |
| 236760 | Computational learning theory | 2.0 |
| 236777 | Deep learning and its applications | 3.0 |
| 236779 | Foundations of algorithms for massive datasets | 2.0 |
| 236780 | Algorithms for dynamic memory management | 2.0 |
| 236781 | Deep learning on computation accelerators | 3.0 |
| 236800 | Seminar in software engineering | 2.0 |
| 236811 | Numerical analysis seminar 1 | 2.0 |
| 236812 | Numerical analysis seminar 2 | 2.0 |
| 236813 | Seminar in Algorithms | 2.0 |
| 236814 | Seminar in Formal Verification Methods | 2.0 |
| 236815 | Seminar in Computer Vision | 2.0 |
| 236816 | Seminar in Computer Graphics | 2.0 |
| 236817 | Seminar in Natural Language Processing | 2.0 |
| 236818 | Seminar in Bioinformatics | 2.0 |
| 236819 | Seminar in Computer Communication Networks | 2.0 |
| 236820 | Seminar in Coding Theory | 2.0 |
| 236821 | Seminar in Image Processing | 2.0 |
| 236822 | Seminar in Interconnection and Sorting Networks | 2.0 |
| 236823 | Seminar in Quantum Information processing | 2.0 |
| 236824 | Seminar in Robotics | 2.0 |
| 236825 | Seminar in Distributed Algorithms | 2.0 |

| | | |
|---|---|---|
| 236826 | Seminar in Databases | 2.0 |
| 236827 | Seminar in computer systems | 2.0 |
| 236828 | Project in Computer Systems | 3.0 |
| 236829 | Seminar in Approximation Algorithms | 2.0 |
| 236830 | Seminar in Concurrent Algorithms | 2.0 |
| 236831 | Seminar in Discrete Geometry | 2.0 |
| 236832 | Seminar in Concurrent Programming | 2.0 |
| 236833 | Seminar in Automata and Formal Languages | 2.0 |
| 236834 | Seminar in Information Storage Systems | 2.0 |
| 236835 | Seminar in Artificial Intelligence | 2.0 |
| 236836 | Seminar in Incentives and Learning | 2.0 |
| 236837 | Seminar on Coding in Information Storage Systems | 2.0 |
| 236838 | Seminar in Machine Learning Systems | 2.0 |
| 236860 | Digital image processing | 3.0 |
| 236861 | Geometric computer vision | 3.0 |
| 236862 | Sparse and redundant representations and applications | 3.0 |
| 236873 | Computer vision | 3.0 |
| 236874 | Project in computer vision | 3.0 |
| 236875 | Visual recognition | 3.0 |
| 236901 | Algorithmic robot motion planning | 2.0 |
| 236927 | Introduction to robotics | 3.0 |
| 236990 | Introduction to quantum information processing | 3.0 |
| 236991 | Project in quantum computing | 3.0 |
| 238100 | Reliability in modern machine learning | 2.0 |
| 238125 | Numerical algorithms m | 3.0 |
| 238739 | Discrete algorithmic geometry | 2.0 |
| 238790 | Multi-grid methods | 2.0 |
| 238900 | Theory of computation research seminar | 2.0 |
| 238901 | Logic and combinatorics research seminar | 2.0 |
| 238902 | Research seminar in combinatorics and graph theory | 2.0 |

## List B: Elective Technion courses

| | | Credits |
|---|---|---|
| 036044 | Robot path-planning and sensor based navigators | 3.0 |
| 044105 | Theory of electronic circuits | 4.0 |
| 044127 | Basics of semiconductor devices M | 3.5 |
| 044131 | Signals and systems | 5.0 |
| 044137 | Electronic circuits | 5.0 |
| 044157 | Electrical engineering laboratory 1A | 2.0 |
| 044167 | Laboratory project A | 4.0 |
| 044169 | Laboratory project B | 4.0 |
| 044202 | Random signals | 3.0 |
| 046201 | Random signal processes | 3.0 |
| 046206 | Introduction to digital communication | 3.0 |
| 046332 | Visual and auditory systems | 3.0 |
| 046880 | Logic design of VLSI systems | 3.0 |
| 048878 | VLSI architecture | 2.0 |
| 048921 | Advanced topics in vision, image structure and computer vision | 2.0 |
| 086761 | Vision-aided navigation | 3.0 |
| 094222 | Model-based system engineering | 3.5 |
| 094313 | Deterministic models in operations research | 3.5 |
| 094314 | Stochastic models in operations research | 3.5 |
| 094333 | Dynamic models in operation research | 3.0 |
| 094334 | Digital simulation of systems | 3.0 |
| 094423 | Introduction to statistics | 3.5 |
| 094591 | Introductory economics | 3.5 |
| 096200 | Mathematical tools for data science | 3.5 |
| 096211 | E-commerce models | 3.5 |
| 096224 | Distributed data management | 3.0 |
| 096250 | Distributed information systems | 3.5 |
| 096262 | Information retrieval | 3.5 |
| 096326 | Algorithms in scheduling | 3.5 |

| | | |
|---|---|---|
| 096411 | Statistical learning with data | 3.5 |
| 097317 | Cooperative game theory | 2.5 |
| 104122 | Complex function theory 1 | 3.5 |
| 104135 | Ordinary differential equations/t | 2.5 |
| 104142 | Introduction to metric and topological space | 3.5 |
| 104157 | Introduction to number theory | 3.5 |
| 104165 | Real functions | 3.5 |
| 104174 | Algebra BM | 3.5 |
| 104158 | Introduction to theory groups | 3.5 |
| 104177 | Differential geometry | 3.5 |
| 104192 | Introduction to applied mathematics | 3.0 |
| 104221 | Complex functions and integral transforms | 4.0 |
| 104223 | Partial differential equations and Fourier series | 4.0 |
| 104276 | Introduction to functional analysis | 3.5 |
| 104279 | Introduction to rings and fields | 2.5 |
| 104293 | Measure theory | 2.5 |
| 104294 | Int. to Numerical Analysis | 5.0 |
| 106378 | Set theory | 3.0 |
| 106383 | Algebraic topology | 3.0 |
| 114101 | Analytical mechanics | 4.0 |
| 114246 | Electromagnetism and electrodynamics | 5.0 |
| 115203 | Quantum physics 1 | 5.0 |
| 115204 | Quantum physics 2 | 5.0 |
| 114036 | Statistical and thermal physics | 5.0 |
| 116217 | Solid state physics | 3.5 |
| 116354 | Astrophysics and cosmology | 3.5 |
| 124120 | Principles of chemistry | 5.0 |
| 124400 | Quantum Chemistry | 5.0 |
| 124503 | Physical chemistry 1B | 2.5 |
| 124801 | Organic chemistry 1B | 2.5 |
| 125801 | Organic chemistry | 5.0 |
| 134019 | Introduction to biochemistry and enzymology | 2.5 |

| | | |
|---|---|---|
| 134020 | General genetics | 3.5 |
| 134058 | Biology 1 | 3.0 |
| 134082 | Molecular biology | 2.5 |
| 134113 | Metabolic pathways | 3.5 |
| 134128 | Cell biology | 3.5 |
| 134119 | Regulation of gene expression | 2.5 |
| 134142 | Molecular genetics laboratory | 2.5 |
| 214909 | Computer Science Problems – Soft Skills | 2.0 |

Students can also choose courses from the list of additional math courses featured as part of the general four-year study track, or other courses with the advisor's approval.

# The Cyber and Computer Systems Security Specialization Program

The goal of this program is to produce graduates who specialize in cyber security. Students will obtain an extensive background in computer science with an emphasis on theoretical and practical aspects of security in the digital world. Graduates receive a B.Sc. in Computer Science and a conformation document indicating their specialization attached to their diploma and transcripts.

Please note: This recommended curriculum only applies to the winter semester.

Students must accumulate 155 credits as follows:

| | |
|---|---|
| Compulsory courses | 106.0 credits |
| Core courses | 8.0 credits |
| Elective faculty courses | 29.0 credits |
| Elective Technion courses | 12.0 credits |

Le – Lecture; E – Exercise; La – Lab; P – Project; C – Credits

## Compulsory courses

Recommended courses, by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 234114 | Introduction to computer science M* | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – advanced B | 4 | - | - | - | 3.0 |
| | | 16 | 10 | 2 | - | 21.0 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

* This course must be taken during the 1st semester.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104032 | Infinitesimal calculus 2M | 4 | 2 | - | - | 5.0 |
| 114071 | Physics 1M | 3 | 1 | - | - | 3.5 |
| 234124 | Introduction to systems programming | 2 | 2 | - | - | 4.0 |
| 234125 | Numerical algorithms ** | 2 | 2 | - | - | 3.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| 234493 | Introduction to cyber security | 1 | - | - | - | 1.0 |
| | | 14 | 8 | - | 3 | 19.5 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 10 | | | 20.5 |

** Numerical algorithms (234125) can be taken in the 2nd semester and Modern algebra (104134) in the 3rd semester, or vice versa.

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 104134*** | Modern algebra H* | 2 | 1 | - | - | 2.5 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| 234292 | Logic for CS | 2 | 1 | - | - | 3.0 |
| 236491 | Secure Programming | 2 | 1 | - | 1 | 3.0 |
| | | 15 | 8 | 1 | 1 | 20.5 |

*** Students can take Introduction to groups (104158) and Introduction to rings and fields (104279) instead of Modern algebra H and the additional math course.

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | An additional math course* | | | | | 2.5/5.0 |
| | A scientific course** | | | | | 3.0/5.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| | | | | | | 16/20.5 |

* One of the **math courses** specified in the general four-year study track.
** The scientific course requirements are the same as those for the general four-year study track, i.e., at least 8 credits from the courses on the scientific course list in the general four-year track, while meeting the requirements of one of the chains.

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | A scientific course** | | | | | 3.0/5.0 |
| 236267 | Computer architecture | 2 | 1 | - | 1 | 3.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| 236334 | Introduction to computer networks | 2 | 1 | - | 1 | 3.0 |
| 236350 | Network security | 2 | 1 | - | 1 | 3.0 |
| | | | | | | 18/20 |

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236506 | Modern cryptology | 2 | 1 | - | 1 | 3.0 |
| 236490 | Computer security | 2 | 1 | - | 1 | 3.0 |
| 236496 | Reverse engineering | 2 | 1 | - | 1 | 3.0 |
| | | 6 | 3 | - | 3 | 9.0 |

## Elective courses

Students are required to take 37 elective faculty credits, as follows. They must complete three different courses (at least 8 credits) from the list of core courses below, and one of the 11 specialization groups defined for the general four-year track. Completing a group means taking three different courses from the group (at least 8 credits) that are not part of the compulsory or core requirements, and meeting any requirements defined for that group.

Twelve additional credits need to be chosen from List A (computer science faculty courses) and another 9 credits from List A or List B (elective Technion courses) of the general four-year study track.

Each student is required to participate in either at least two projects or one project and one seminar. These must include at least one of the following projects: Information security (236349) or Firewalls (236499).

## Core courses

Students are required to take three of the following courses (at least 8 credits):

| | | Credits |
|---|---|---|
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236342 | Introduction to software verification | 3.0 |
| 236500 | Cryptanalysis | 3.0 |
| 236508 | Cryptography and complexity | 2.0 |
| 236990 | Introduction to quantum information processing | 3.0 |
| 236376 | Operating systems engineering | 4.0 |
| 236341 | Internet networking | 3.0 |

# The General Three-Year Study Track Curriculum

Students must accumulate 118.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 84.0 credits |
| Elective faculty courses | 24.5 credits |
| Elective Technion courses | 10.0 credits |

The division to semesters is only a recommendation.
The 1st, 2nd, 3rd, and 4th semesters are the same as the general four-year program.
Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses, by semesters:

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | A scientific course** | | | | | 3.0/5.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| | | | | | | 9/11 |

** The scientific course requirements are the same as for the general four-year program, i.e., at least 8 credits from the list of scientific courses for the general four-year program, in accordance with one of the chains.

## Elective Courses

Students are required to complete 24.5 elective faculty credits, including at least 18 credits from List A (faculty courses) and at least one project. The remaining elective courses can be chosen from Lists A or B of the general four-year program.

# The Machine Learning and Data Analysis specialization program

Graduates of this program will specialize in information and signal collection, processing, and analysis; and method and algorithm research in these fields. The track focuses on the principles of handling information and generating content from it using signal processing tools, statistical inference, and machine learning. The program provides its graduates with a broad background in computer science,

mathematical enrichment, and information collection, processing, and learning. Graduates are awarded a B.Sc. in Computer Science, and a conformation document indicating their specialization attached to their diploma and transcripts.

Please note: Students will only be admitted to this track during the winter semester.

To complete the three-year degree program, students must accumulate 120.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 85.5 credits |
| Core courses | 12.0 credits |
| Elective faculty courses | 13.0 credits |
| Elective Technion courses | 10.0 credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses, by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |
| 234114 | Introduction to computer science M* | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – advanced B | 4 | - | - | - | 3.0 |
| | Physical education courses | 16 | 10 | 2 | - | 21.0 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

* This course must be taken during the 1st semester.

| Semester 2 | Le | E | La | P | C |
|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 104032 | Infinitesimal calculus 2M | 4 | 2 | 2 | - | 5.0 |
| 114071 | Physics 1M | 3 | 1 | 1 | - | 3.5 |
| 234124 | Introduction to systems programming | 2 | 2 | 2 | 2 | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | 1 | 1 | 3.0 |
| 104174 | Algebra BM (1) | 3 | 1 | 1 | - | 3.5 |
| | | 14 | 7 | 7 | 3 | 19.0 |
| | Physical education (choose from a list) | - | 2 | 2 | - | 1.0 |
| | | | 9 | 9 | | 20.0 |

(1) Or Modern Algebra H (104134) for 2.5 credits, in addition to an elective faculty credit.

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 234292 | Logic for computer science | 2 | 1 | - | - | 3.0 |
| | | 13 | 8 | 1 | - | 18 |

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 236756 | Introduction to machine learning | 2 | 1 | 2 | - | 3.0 |
| | A scientific course** | | | | | 3.0/5.0 |
| | | | | | | 16.5/18.5 |

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236201 | Introduction to data processing and representation | 2 | 1 | - | 1 | 3.0 |
| | A scientific course** | | | | | 3.0/5.0 |
| | | | | | | 9/11 |

** The scientific course requirements are the same as for the general four-year program, i.e., at least 8 credits from the list of scientific courses for the general four-year program, while meeting the requirements of one of the chains.

## Elective Courses

Students must complete 25 elective faculty credits, including at least four courses (12 credits) from the list of core courses below.

Each student must participate in at least one faculty project constituting at least 3 credits (aside from those defined as “not recognized for the project requirements for the degree”). The other elective courses can be chosen from List A (faculty courses) in the general four-year program.

## Core Courses

Students are required to take at least four courses from the following list (at least 12 credits):

| | | Credits |
|---|---|---|
| 094423 | Probability M | 3.5 |
| 236330 | Introduction to optimization | 3.0 |
| | Or | |
| 046197 | Computational methods in optimization | 3.0 |
| 236299 | Introduction to natural language processing | 3.0 |
| 236363 | Databases | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 3.0 |
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236667 | Advanced topics in machine learning and human behavior I T | 3.0 |
| 236860 | Digital image processing | 3.0 |
| 236777 | Deep learning and its applications | 3.0 |

| | | |
|---|---|---|
| 236781 | Deep learning on computational accelerators | 3.0 |
| 236901 | Algorithmic robot motion planning | 2.0 |

Completion of the machine learning and information analysis program will be noted in a conformation document that will be attached to the graduate's diploma for the general four-year program or the software engineering program, provided that the graduates met all the requirements and reached the quota of credits needed to receive a degree in the regular program they selected. In addition, graduates must meet all special core and compulsory requirements for the machine learning and information analysis program.

Compulsory subjects for this program that are not required for the general four-year program or the software engineering program are Introduction to data processing and representation (236201) and Instruction to machine learning (236765).

Compulsory and core courses for this specialization that are included in the four-year program's specialization groups will be counted towards completing the requirements for the selected group.

Introduction to artificial intelligence (236501) will be counted towards meeting the requirements for core courses in the software engineering program. The stage 2 project in software engineering will be counted towards the requirement to complete a project for the specialization program.

# The Computer Science Bioinformatics Specialization Program

**(In collaboration with the Faculty of Biology)**

The rapid advancements in modern biology are facilitating extensive use of innovative computational methods and algorithms. The decoding of the human genome is revolutionizing our understanding of evolution and human biology and changing our approach to diseases and to the development of medications and early diagnosis methods.

This goal of this program is to qualify graduates who will join and lead bioinformatics industries, or pursue graduate studies in biology and computer science.

Graduates receive a B.Sc. in Computer Science and a confirmation document indicating their specialization along with their diploma and transcripts.

## The curriculum

Students must accumulate 124 credits as follows:

| | | |
|---|---|---|
| Compulsory courses | 91.5 | Credits |
| Elective faculty courses | 22.5 | Credits |
| Elective Technion courses | 10.0 | Credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses, by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |
| 234114 | Introduction to computer science M* | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 134058 | Biology 1 | 3 | - | - | - | 3.0 |
| | | 15 | 10 | 2 | - | 21.0 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 12 | | - | 22.0 |

* This course must be taken during the 1st semester.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104032 | Infinitesimal calculus 2M | 4 | 2 | - | - | 5.0 |
| 114071 | Physics 1M ** | 3 | 1 | - | - | 3.5 |
| 134020 | General genetics | 3 | 1 | - | - | 3.5 |
| 234124 | Introduction to systems programming | 2 | 2 | - | 2 | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| | | 14 | 7 | - | 3 | 19.0 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 9 | | | 20.0 |

** Physics 1M (114071) can be deferred to later semesters.

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 234292 | Logic for computer science | 2 | 1 | - | - | 3.0 |
| 125001 | General chemistry*** | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – Advanced B | 4 | - | - | - | 3.0 |
| | | 17 | 8 | 1 | - | 21.0 |

*** Students can take Principles of chemistry (124120) instead.

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 094423 | Introduction to statistics | 3 | 1 | - | - | 3.5 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| 134019 | Introduction to Biochemistry and enzymology | 2 | 2 | - | - | 2.5 |
| | | 9 | 5 | 1 | - | 12.0 |

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104134 | Modern algebra H | 2 | 1 | - | - | 2.5 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 236523 | Introduction to bioinformatics | 2 | 1 | - | - | 2.5 |
| | | 6 | 4 | 3 | 6 | 9.5 |

Choose from the Biology A list: Molecular biology or Genetics lab

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236522 | Algorithms in computational biology | 2 | 1 | - | - | 3.0 |
| 236524 | Project in bioinformatics | 2 | - | - | 3 | 3.0 |
| | | 6 | 2 | - | 4 | 9.0 |

Note: Students can only join this program for the winter semester.

## Elective courses

Students must complete 22.5 credits as follows:

1) At least 8 credits from List A (faculty courses) for the general four-year computer science track.
2) At least 14.5 elective biology credits as follows:

**Biology A:**

Students must choose one of the following course clusters (7.5 credits)****

| Molecular cluster | | |
|---|---|---|
| 125801 | Organic chemistry | 5.0 |
| 134082 | Molecular biology | 2.5 |

| Microbiology and evolution cluster | | |
|---|---|---|
| 134121 | Microbiology and virology | 3.0 |
| 134133 | Evolution | 2.0 |
| 134142 | Genetics laboratory | 2.5 |

**** It is advised to begin during Semester 4

**Biology B:**

Students must choose at least two additional courses from the following list:

| | | |
|---|---|---|
| 134119 | Regulation of gene expression | 2.5 |
| 134128 | Biology of the cell | 3.5 |
| 134113 | Metabolic pathways | 3.5 |
| 066529 | Bioinformatics of cancer | 3.0 |
| 134156 | Molecular biophysics | 3.0 |
| 125801 | Organic chemistry | 5.0 |
| 134082 | Molecular biology | 2.5 |

| | | |
|---|---|---|
| 134121 | Microbiology and virology | 3.0 |
| 134133 | Evolution | 2.0 |
| 134142 | Genetics laboratory | 2.5 |

The remaining credits (to reach a total of 14.5) shall be taken from List A or List B of the B.Sc. track in biology.

# The Software Engineering Track

This track trains its graduates to specialize in large software systems. The track focuses on a range of programing methods and systematic handling of software analysis, content, application, testing, verification, maintenance, assessment, and conversion. The track provides graduates with extensive knowledge of applied computer science and in-depth practical experience in creating software and using advanced software engineering tools. Graduates receive a B.Sc. in Software Engineering. This track is open to any student in the faculty who's academic status is in order.

## Curriculum

Students must accumulate 159.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 109 credits |
| Core courses | 9.0 credits |
| Elective faculty courses | 29.5 credits |
| Elective Technion courses | 12.0 credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses, by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |
| 234114 | Introduction to computer science M * | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – Advanced B | 4 | - | - | - | 3.0 |
| | | 16 | 10 | 2 | - | 21.0 |
| | Physical educations (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

* This course must be taken in the 1st semester.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104032 | Infinitesimal calculus 2M | 4 | 2 | - | - | 5.0 |
| 104134 | Modern algebra H | 2 | 1 | - | - | 2.5 |
| 114071 | Physics 1M | 3 | 1 | - | - | 3.5 |
| 234124 | Introduction to systems programming | 2 | 2 | - | 2 | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| | | 13 | 7 | - | 3 | 18.0 |
| | Physical educations (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 9 | | | 19.0 |

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| | A scientific course** | | | | | 3.0/5.0 |
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 234292 | Logic for computer science | 2 | 1 | - | - | 3.0 |
| 236319 | Programming languages | 2 | 1 | - | - | 3.0 |
| | | | | | | 21/23.0 |

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | A scientific course** | | | | | 3.0/5.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 236703 | Object oriented programming | 2 | 2 | - | - | 3.0 |
| | | | | | | 16.5/18.5 |

** Scientific course requirements are the same as those for the general four-year study track: at least 8 credits from the scientific course list in the general four-year track, while completing one of the chains.

**For students who begin their studies in the winter semester:**

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236267 | Computer architecture | 2 | 1 | - | 1 | 3.0 |
| 236322 | Information storage systems | 2 | 1 | - | 1 | 3.0 |
| 236342 | Introduction to software verification | 2 | 1 | - | 1 | 3.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 2 | 1 | - | 1 | 3.0 |
| | | 12 | 6 | - | 5 | 18.0 |

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 236334 | Introduction to computer networks | 2 | 1 | - | 1 | 3.0 |
| | | 4 | 3 | - | 1 | 6.0 |

We recommend completing a project during the 6th semester.

| Semester 7 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234311 | Yearly Project in Software Engineering - Stage A | 2 | - | - | 4 | 3.0 |

| Semester 8 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234312 | Yearly Project in Software Engineering - Stage B | 2 | - | - | 6 | 3.5 |

**For students who begin their studies in the spring semester:**

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236267 | Computer architecture | 2 | 1 | - | 1 | 3.0 |
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 236334 | Introduction to computer networks | 2 | 1 | - | 1 | 3.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| | | 102 | 6 | - | 3 | 15.0 |

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 236322 | Information storage systems | 2 | 1 | - | 1 | 3.0 |
| 236342 | Introduction to software verification | 2 | 1 | - | 1 | 3.0 |
| 234311 | Yearly Project in Software Engineering - Stage A | 2 | - | - | 4 | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 2 | 1 | - | 1 | 3.0 |
| | | 8 | 3 | - | 7 | 12.0 |

We recommend completing a project during the 6th semester.

| Semester 7 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234321 | Yearly Project in Software Engineering— Stage B | 2 | - | - | 6 | 3.5 |

| Semester 8 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | Elective courses | | | | | |

## Elective Courses

Students must complete 38.5 elective faculty credits, including at least three courses (9.0 credits) from the list of core courses below. 29.5 of the elective faculty credits must include at least 15 courses from List A (faculty courses) and at least one project. The other elective courses can be taken from Lists A or B (see the general four-year program) or as approved by the advisor.

Note: Students can choose to take Micro Economics 1 (094503) as an elective course from List B in the software engineering track.

## Core Courses

Students are required to take three of the following courses:

| | | Credits |
|---|---|---|
| 236270 | Software project management | 3.0 |
| 236321 | Software engineering methods | 3.0 |
| 236347 | Software synthesis and automated reasoning | 3.0 |
| 236350 | Network security | 3.0 |
| 236363 | Databases | 3.0 |
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236700 | Software design | 3.0 |

# The Excellence Program for Advanced Software Engineering

The program produces highly skilled software engineers by teaching scientific-technological knowledge in a broad range of software engineering fields and enriching fundamental fields in science and design.

The track is intended for outstanding students, specifically outstanding academic reserve students in the Psagot program. The program allows participants to complete their undergraduate studies in software engineering and take master's courses toward their M.Sc. over the course of four years.

Students must meet all the requirements of the software engineering track and complete an additional 14 credits based on the requirements for a master's degree.

Some clarifications:

1. Students will be accepted for this program in the first semester if they have especially high grades, as determined periodically. Being accepted for this program guarantees admission to the software engineering track.
2. Students may join this track at any time during their computer science studies. However, a cumulative GPA of 90 or higher is required, not including elective courses.
3. Students must maintain a GPA of at least 85 throughout the entire course of their studies to remain in this track.
4. We recommend taking an additional scientific course or the Numerical Algorithms course in the 4th semester.
5. We recommend taking elective faculty courses beginning from the 5th semester and advanced courses during the 7th and 8th semesters.
6. We recommend taking most of the core courses required for the software engineering track as elective faculty courses.
7. Students who receive approval for their M.Sc. thesis proposal will require only 12 credits (instead of 14) to complete their studies. These students will complete an additional 6 credits later on, during their master's studies.
8. The additional 14 credits will be recognized for a master's degree only if approved in advance by the vice dean of the Technion's Graduate School before taking the course (and provided that the minimum required grade is obtained).
9. Students who meet the admission requirements for a master's degree will be able to register for at the end of the third year of their undergraduate studies.
10. Graduates can specialize in any topic researched at the faculty during their master's studies.
11. Only students who are admitted to the track and complete their studies within five years will be recognized as track graduates.
12. Graduates will be awarded a certificate by the faculty.

# The Computer Engineering Track

The track provides a framework for undergraduate studies that produces computer engineers with extensive software and hardware knowledge who specialize in designing and building electronic systems (including computers).
The computer engineering track is run jointly by the Faculty of Electrical and Computer Engineering and Computers and the Faculty of Computer Science – and is fully subordinated to both faculties, its parent faculties. Computer engineering does not constitute an independent academic unit. Instead, it is run by the directors of the parent units and the curriculum comprises courses from faculties. Graduates receive a B.Sc. in Computer Engineering when they complete their requirements.

Students must accumulate at least 158.5 credits from the following four groups of courses: compulsory courses, core courses, elective faculty courses, and Technion elective courses (including 6 enrichment credits).

The requirements for obtaining 158.5 credits shall be filled as follows:

1. All compulsory courses specified in the recommended plan below must be taken, constituting 112.5–114.5 credits.
2. At least two courses from the list of core courses must be selected.
3. Several courses from the lists of elective courses offered by the Faculty of Computer Science and Faculty of Electrical and Computer Engineering must be taken to complete at least two specialization groups. If a course that appears on the list of core courses is also compulsory for a specialization group, it can either be considered part of the specialization group (and then will not be considered as a core course) or a core course (which will not be considered part of the specialization group). At least 146.5 credits in total must be accumulated from compulsory, core, and elective courses (see also the section on elective courses below).
4. 12 credits from elective Technion courses, comprising at least 6 credits from enrichment courses, 2 credits from PE courses, and elective Technion courses, subject to the enrollment terms defined for each course.

Students interested in obtaining a high school teaching certificate should contact the undergraduate studies secretariat at the parent unit for details.

The number of students permitted to switch to different tracks that require registration will be limited to a figure defined each year by the heads of the parent units. The criteria for switching to a different track will be published on the websites of the parent units.

## Admission

**1.** A limited number of students are admitted to this track each year. The number of students admitted is determined every year by the heads of both parent units.

**2.** Students admitted to the track will be affiliated with one of the two parent units, based on the year of registration. All students who register in a given year will be affiliated with the same parent unit, and the students who register the following year will be affiliated with the other unit. The parent unit will handle any administrative requests that the student may have. Therefore, all academic, administrative, and disciplinary matters will be addressed by the head of that unit. Students may register for any courses offered by either of the units, regardless of their administrative affiliation with a parent unit.

**3.** Students who complete their studies in the computer engineering track can pursue graduate studies in either of the parent units without having to complete any additional courses, provided this is congruent with the Technion's Graduate School regulations.

**4.** Student advisors: The parent unit appoints special advisors for students in the computer engineering track. Students admitted to the track are referred to their respective advisors.

Students in this track will have the option of receiving secondary-specialization certification in quantum computing.

## Curriculum

Students are required accumulate 158.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 112.5–114.5 credits |
| Core courses | 6.0 credits |
| Elective faculty courses | 26.0–28.0 credits |
| Elective Technion courses | 12.0 credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044102 | Safety in electrical engineering laboratories* | 4 | - | - | - | - |
| 104012 | Differential and integral calculus 1T. | 4 | 3 | - | - | 5.5 |
| 104016 | Algebra 1M | 4 | 2 | - | - | 5.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 114071 | Physics 1M | 3 | 1 | - | - | 3.5 |
| 234114 | Introduction to computer science M** | 2 | 2 | 2 | - | 4.0 |
| | | 19 | 10 | 2 | - | 21.0 |

* Once during the semester, according to instructions to be published separately.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104013 | Differential and integral calculus 2T (1) | 4 | 3 | - | - | 5.5 |
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 104136 | Ordinary differential equations M | 3 | 2 | - | - | 4.0 |
| 114075 | Physics 2MM | 4 | 2 | - | - | 5.0 |
| 044252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| | | 17 | 11 | - | - | 22.5 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | 17 | 13 | | | 23.5 |

*Compulsory course taken as part of the 12 general Technion elective credits.

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234124 | Introduction to systems programming | 2 | 2 | - | - | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | - | 3.0 |
| 044105 | Theory of electronic circuits | 3 | 2 | - | - | 4.0 |
| 104220 | Partial differential equations T | 2 | 1 | - | - | 2.5 |
| 104215 | Complex functions A | 2 | 1 | - | - | 2.5 |
| 104214 | Fourier series & integral transforms | 2 | 1 | - | - | 2.5 |
| | | 13 | 8 | - | - | 18.5 |
| 324033 | Technical English – Advanced B | 4 | - | - | - | 3.0 |
| | | 17 | 8 | - | - | 21.5 |

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044131 | Signals and systems | 4 | 2 | - | - | 5.0 |
| 104034 | Introduction to probability H | 3 | 1 | - | - | 3.5 |
| 044127 | Basics of semiconductor devices | 3 | 1 | - | - | 3.5 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 114073 | Introduction to quantum physics for engineering | 3 | 1 | - | - | 3.5 |
| | | - | 7 | - | - | 21.5 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | 17 | 9 | 2 | - | 22.5 |

*Compulsory course taken as part of the 12 general Technion elective credits.

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044137 | Electronic circuits | 4 | 2 | - | - | 5.0 |
| 044157 | Electrical engineering laboratory1A | - | - | 3 | 3 | 2.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Or | | | | | |
| 046209 | Structure of operating systems | 2 | 2 | - | - | 3.5 |
| | And | | | | | |
| 046210 | Laboratory in operating systems | - | - | 4 | - | 1.0 |
| 104134 | Modern algebra H | 2 | 1 | - | - | 2.5 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| 046267 | Computer architecture** | 2 | 1 | - | - | 3.0 |
| | Or | | | | | |
| 236267 | Computer architecture | 2 | 1 | - | 1 | 3.0 |
| | | 12 | 7 | 6/7 | 3/10 | 20.0 |

* Students can choose either Operating Systems (234123) or Structure of Operating Systems (046209 + 046210).
** Students can choose one of these two courses.

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044167 | Project A | 2 | - | 4 | - | 4.0 |
| | Or | | | | | |
| | A computer science project* | | | | | 3.0/4.0 |
| | | | | | | 3.0/4.0 |

| Semester 7 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044169 | Project B | - | - | 4 | - | 4.0 |
| | Or | | | | | |
| | A computer science project* | | | | | 3.0/ 4.0 |
| | | | | | | 3/4 |

* All project courses at the Faculty of Computer Science (aside from those defined in the syllabus as “not recognized for fulfilling the project requirements for a degree”).

## Core Courses

Students are required to choose two courses from the following list:

| | | Credits |
|---|---|---|
| 044198 | Introduction to digital signal processing | 3.0 |
| 044202 | Random signals | 3.0 |
| 236334 | Introduction to computer networks | 3.0 |
| | Or | |
| 044334 | Computer networks and internet 1 | 3.0 |
| 234292 | Logic for computer science | 3.0 |
| 236343 | Theory of computation | 3.0 |

One course will not be considered both a core course and a specialization course for accumulating the required number of credits.

## Elective Courses

## Specialization groups:

The recommended elective courses have been divided into 12 specialization groups. Each student is required to complete at least two different groups. Completing a group means taking the courses that are compulsory for the group and a minimum of three additional courses from the list. Two groups will be considered different if they include at least six different courses. The other elective courses can be chosen from all the full list of courses offered by the Faculty of Electrical and Computer Engineering and the Faculty of Computer Science.

### 1. Computer networks, distributed systems, and computer structures

| | |
|---|---|
| 044334* | Computer networks and internet 1 |
| | Or |
| 236334* | Introduction to computer networks |
| 046005* | Computer networks and internet 2 |
| | Or |
| 236341 | Internet networking |
| 236357 | Distributed algorithms A |
| 236755 | Distributed algorithms |

| | |
|---|---|
| 046237 | Integrated circuits—introduction to VLSI |
| 236351 | Distributed systems |
| 046272 | Distributed systems principles |
| 046273 | Distributed functional programming |
| 236322 | Information storage systems |
| 236370 | Concurrent and distributed programming for data processing and machine learning |
| 236376 | Operating systems engineering |
| 236490 | Computer security |
| 236491 | Secure programming |
| 236496 | Reverse engineering |
| 236350 | Network security |
| 046853 | Advanced Computer Architecture |
| 046268 | Constructive Computer Architecture |
| | Or |
| 236268 | Constructive computer architecture |
| 046275 | Dynamic binary translation optimization |
| 046278/ 236278 | Computational accelerators and accelerated systems |
| 046265 | Architectures and circuits with memristors |
| 046279 | High performance parallel programming |
| 046280 | Principles and tools for computer security |
| 046881 | Hardware formal verification |

044334/236334 are compulsory.
* Students who take 044334 can only take 046005; students who take 236334 can only take 236341.

## 2. Communication theory

| | |
|---|---|
| 044334* | Computer networks and internet 1 |
| | Or |
| 236334* | Introduction to computer networks |
| 046005* | Computer networks and internet 2 |
| | Or |
| 236341 | Internet networking |
| 044148 | Waves and distributed systems |
| 044198 | Introduction to digital signal processing |
| 044202 | Random signals |
| 046201 | Introduction to random signal processing |
| 046204 | Analog communication |
| 046205 | Introduction to coding design |
| 046206 | Introduction to digital communication |
| 046208 | Modern communication techniques |
| 046733 | Information theory |
| 046734 | Quantum information theory |
| 046743 | Spatial Signal Processing |
| 046868 | Foundations of Stochastic Processes |
| 236309 | Introduction to cypher theory |
| 236525 | Introduction to network coding, bounds and construction |
| 236520 | Coding for storage systems |

044202 and either 046206 or 046204 are compulsory.
* Students who take 044334 can only take 046005; students who take 236334 can only take 236341

## 3. Algorithms, cyphers, cryptography, and complexity

| | |
|---|---|
| 046205 | Introduction to cypher theory in communication |
| 234129 | Introduction to set theory and automata for CS |
| 236309 | Introduction to cypher theory |
| 236313 | Complexity theory |
| 236343 | Theory of computation |
| 236359 | Algorithms 2 |

| | |
|---|---|
| 236374 | Probabilistic methods and algorithms |
| 236500 | Cryptanalysis |
| 236506 | Modern cryptology |
| 236525 | Introduction to network coding, bounds and construction |
| 236520 | Coding for storage systems |
| 236522 | Algorithms in computational biology |
| 236719 | Computational geometry |
| 236760 | Digital image processing |
| 236990 | Introduction to quantum information processing |

236343 is compulsory.

**4. Signal and image processing**

| | |
|---|---|
| 044198 | Introduction to digital signal processing |
| 044202 | Random signals |
| 046200 | Image processing and analysis |
| | Or |
| 236860 | Digital image processing |
| 046010 | Statistical inference |
| 046345 | Computer graphics |
| | Or |
| 236216 | Computer graphics 1 |
| 046197 | Computational methods in optimization |
| | Or |
| 104193 | Optimization theory |
| | Or |
| 236330 | Introduction to optimization |
| 046201 | Introduction to random signal processes |
| | Visual and auditory systems |
| 046745 | Digital signal processing |
| 046746 | Applications and algorithms in computer vision |
| | Or |
| 236873 | Computer vision |

| | |
|---|---|
| 236373 | Image synthesis |
| 236861 | Geometric computer vision |
| 046733 | Information theory |
| 046747 | Deep learning: Speech signals |
| 046831 | Introduction to medical imaging |
| 046195 | Machine learning |
| | Or |
| 236756 | Introduction to machine learning |
| 236329 | Digital geometry processing |
| 236862 | Sparse and redundant representations and applications |

044198 and either 044202, 046200, or 236860 are compulsory.

## 5. Intelligent systems

| | |
|---|---|
| 046345 | Computer graphics |
| | Or |
| 236216 | Computer graphics 1 |
| 236501 | Introduction to artificial intelligence |
| 236901 | Algorithmic robot motion planning |
| 236927 | Introduction to robotics |
| | Or |
| 046212 | Introduction to robotics H |
| 046010 | Statistical inference |
| 046213 | Mobile robots |
| 234292 | Logic for computer science |
| 236372 | Bayesian networks |
| 236373 | Image synthesis |
| 236716 | Geometric models in CAD systems |
| 236756 | Introduction to machine learning |
| | Or |
| 046195 | Machine learning |
| 236760 | Computational learning theory |
| 236781 | Deep learning on computation accelerators |

| | |
|---|---|
| | Or |
| 046211 | Deep learning |
| 046203 | Planning and reinforcement learning |
| 236329 | Digital geometry processing |
| 236861 | Geometric computer vision |
| 236873 | Computer vision |
| | Or |
| 046746 | Applications and algorithms in computer vision |
| 046747 | Deep learning fot speech signals |
| 046853 | Advanced Computer Architecture |
| 046200 | Image processing and analysis |
| | Or |
| 236860 | Digital image processing |
| 236862 | Sparse and redundant representations and applications |

046345 / 236216 or 236501 or 236972 / 046212 are compulsory.

### 6. Integrated electronic circuits

| | |
|---|---|
| 044139 | DC-DC converters |
| 044231 | Electronic devices 1 (MOS) |
| 046237 | Integrated circuits-introduction to VLSI |
| 046903 | RF CMOS integrated circuits |
| 046265 | Architecture and circuits with memristors |
| 046129 | Solid state physics EE |
| 044140 | Electromagnetic fields |
| 044148 | Waves and distributed systems |
| 046187 | Analog circuit design |
| 046189 | Design of active filters |
| 046773 | Electro-optic semiconductor devices - detectors |
| 046851 | Semiconductor lasers |
| 046880 | Logical design of VLSI systems |
| 046881 | Hardware formal verification |

044231 and 046237 are compulsory.

**7. Software systems and advanced programming**

| | |
|---|---|
| 236319 | Programming languages |
| 236322 | Information storage systems |
| 236321 | Software engineering methods |
| 236490 | Computer security |
| 236491 | Secure programming |
| 236496 | Reverse engineering |
| 236350 | Network security |
| 046266 | Formal languages and compilation |
| | Or |
| 236360 | Theory of compilation |
| 236363 | Databases |
| 236370 | Concurrent and distributed programming for data processing and machine learning |
| 236376 | Operating systems engineering |
| 236703 | Object-oriented programming |
| | Or |
| 046271 | Object-oriented Programming and Design\ |
| 236351 | Distributed systems |
| 236501 | Introduction to artificial intelligence |
| 236700 | Software design |
| 236780 | Algorithms for dynamic memory management |
| 236781 | Deep learning on computation accelerators |
| 046272 | Distributed systems principles |
| 046273 | Distributed functional programming |
| 046275 | Dynamic binary translation optimization |
| 046277 | Correctness guarantees for software |
| 046278 | Computational accelerators and accelerated systems |
| | Or |
| 236278 | Computational accelerators and accelerated systems |

| | |
|---|---|
| 046279 | High performance parallel programming |
| 046280 | Principles and tools for computer security |

**8. Control and robotics**

| | |
|---|---|
| 044139 | DC-DC converters |
| 044191 | Control systems 1 |
| 046192 | Control systems 2 |
| 046203 | Planning and reinforcement learning |
| 044198 | Introduction to digital signal processing |
| 044202 | Random signals |
| 046042 | Introduction to power systems smart grids |
| 046189 | Design of active filters |
| 046196 | Nonlinear control systems |
| 046197 | Computational methods in optimization |
| | Or |
| 236330 | Introduction to optimization |
| | Or |
| 104193 | Optimization theory |
| 236756 | Introduction to machine learning |
| | Or |
| 046195 | Machine learning |
| 236901 | Algorithmic robot motion planning |
| 236927 | Introduction to robotics |
| | Or |
| 046212 | Introduction to robotics |
| 046213 | Mobile robots |

044191 is compulsory.

**9. Programming languages, formal and natural languages**

| | |
|---|---|
| 234129 | Introduction to set theory and automata for CS |
| 234292 | Logic for computer science |
| 236319 | Programming languages |

| | |
|---|---|
| 236299 | Introduction to natural language processing |
| 236342 | Introduction to software verification |
| 236345 | Automatic verification of hardware and software systems |
| 046277 | Correctness guarantees for software |
| 046266 | Formal languages and compilation |
| | Or |
| 236360 | Theory of compilation |
| 236780 | Algorithms for dynamic memory management |

234129 is compulsory.

## 10. Quantum technologies

Please note: Introduction to quantum physics for engineering (114073) is a prerequisite for the group so we recommend taking it as early as possible.

| | |
|---|---|
| 046243 | Quantum technologies |
| 126604 | Laboratory in Quantum Technologies A |
| | Or |
| 126605 | Laboratory in Quantum Technologies B |
| 236990 | Introduction to quantum information processing |
| | Or |
| 116031 | Introduction to quantum information and computation |
| 046240 | Superconducting quantum devices |
| 046241 | Quantum mechanics |
| 046052 | Quantum optoelectronics |
| 046232 | Topics in nano-electronics |
| 046734 | Quantum information theory |
| 116037 | Noisy quantum computing |

Course number 046243 and either 236990 or 116031 are compulsory.

Three courses are required to complete this group.

## 11. Energy and power systems

| | |
|---|---|
| 046042 | Introduction to power systems and smart grids |
| 044139 | Dc-dc converters |
| 034034 | Electric actuators |

| | |
|---|---|
| 044191 | Control systems 1 |
| 044198 | Introduction to digital signal processing |
| 046044 | Renewable energy systems |
| 046045 | Design of power electronics circuits |
| 046197 | Computational methods in optimization |
| 034035 | Thermodynamics 1 |

Students can choose one of two alternative courses – Optimization theory (104193) or Introduction to optimization (236330).

The compulsory courses are 046042 and 044139 or 034034.

Three courses are required to complete this group.

### 12. Principles in physics for computer engineering

| | |
|---|---|
| 044124 | Physical electronics |
| 046225 | Physical principles of semi-conductors |
| 044231 | Electronic devices 1 (MOS) |
| 046237 | Integrated circuits – Introduction to VLS1 |
| 046052 | Quantum optoelectronics |
| 046129 | Solid state physics Ee |
| 046241 | Quantum mechanics |
| 044239 | Microelectronics processing |
| 046012 | Introduction to flexible organic electronics |
| 046230 | Advanced electron devices |
| 046235 | Integrated power management devices |
| 046239 | Laboratory course in nano-electronics |
| 046242 | Statistical physics for electrical engineering |
| 046243 | Quantum technologies |
| 046265 | Advanced memristor-integrated circuits and architectures |
| 046773 | Electro-optical semi-conductor devices detectors |
| 046968 | Micro-machining and micro electromechanical systems |

Physical electronics (044124) is a compulsory course.

# The B.Sc. Program in Computer Science and Mathematics

**(In collaboration with the Faculty of Mathematics)**

The Faculty of Computer Science and the Faculty of Mathematics offer a combined program for students with particularly high admission scores.

Graduates receive a B.Sc. in Computer Science and Mathematics.

**Admission**

1. The program is intended for outstanding students, or those who at least meet the admission requirements of each of the faculties.
2. Students can choose to belong to either of the faculties. The faculty they choose will be considered their “parent unit.”
3. Both faculties will define the same criteria for allowing students to transfer to this program based on their academic achievements.
4. All students in this program who's academic status is in order may switch to any other program offered by either of the two faculties.

Students must accumulate 152.0 credits as follows:

| | |
|---|---|
| Compulsory courses | 107.5–109.5 credits |
| Elective faculty courses | 32.5–34.5 credits |
| Elective Technion courses | 10.0 credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104195 | Infinitesimal calculus 1 | 4 | 3 | - | - | 5.5 |
| 104066 | Algebra A | 4 | 3 | - | - | 5.5 |
| 234114 | Introduction to computer science M | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English-Advanced B | 4 | - | - | - | 3.0 |
| | | 16 | 10 | 2 | - | 21.0 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104281 | Infinitesimal calculus 2 | 4 | 2 | - | - | 5.0 |
| 104168 | Algebra B | 4 | 2 | - | - | 5.0 |
| 234124 | Introduction to systems programming | 2 | 2 | - | 2 | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| 114071 | Physics 1M | 3 | 1 | - | - | 3.5 |
| | | 15 | 8 | - | 3 | 20.5 |
| | Physical education (choose from the list) | - | 2 | - | - | 1.0 |
| | | | 10 | | | 21.5 |

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104295 | Infinitesimal calculus 3 | 4 | 2 | - | - | 5.0 |
| 104293 | Set theory | 2 | 1 | - | - | 2.5 |
| 104222 | Probability Theory | 3 | 1 | - | - | 3.5 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| | | 15 | 7 | 1 | - | 19.0 |

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104142 | Introduction to metrics and topological space | 3 | 1 | - | - | 3.5 |
| 104285 | Ordinary differential equations A | 3 | 1 | - | - | 3.5 |
| 104158 | Introduction to theory of groups | 3 | 1 | - | - | 3.5 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| | | 13 | 5 | 1 | - | 16.5 |

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104122 | Complex function theory 1 | 3 | 1 | - | - | 3.5 |
| 104279 | Introduction to rings and fields | 2 | 1 | - | - | 2.5 |
| 104294 | Introduction to numerical analysis | 4 | 2 | - | - | 5.0 |
| Or | | | | | | |
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| | A scientific course** | | | | | 5.0 |
| | | | | | | 17/ 19 |

** Students are required to choose one or two scientific courses to complete one of the following chains. Any credits beyond the required 5 credits will be considered elective faculty credits.

1. The physics chain

| | | Credits |
|---|---|---|
| 114075 | Physics 2MM | 5.0 |
| | Or the two following courses | |
| 114052 | Physics 2 | 3.5 |
| 114054 | Physics 3 | 3.5 |

2. The biology chain

| | | Credits |
|---|---|---|
| 134058 | Biology 1 | 3.0 |
| 134020* | General genetics | 3.5 |

* 134020 opens for enrollment only once a year for all Technion students.

3. The chemistry chain

| | | Credits |
|---|---|---|
| 124120 | Principles of chemistry | 5.0 |
| 125801 | Organic chemistry | 5.0 |
| Or | | |
| 124510 | Physical chemistry | 4.0 |

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104192 | Introduction to applied mathematics | 3 | - | - | - | 3.0 |
| 106156 | Mathematical logic | 3 | - | - | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| | | 10 | 3 | 3 | 6 | 13.5 |

Semester 7

Elective courses

### Elective Courses

Students can choose from the list of compulsory and elective courses offered by the Faculty of Mathematics or the Faculty of Computer Science that are not compulsory courses in this program and do not overlap with any compulsory courses. Elective courses must include at least one seminar from the Faculty of Mathematics and one project from the Faculty of Computer Science. In any event, students must accumulate at least 14 credits from each faculty.

## The B.Sc. Program in Computer Science and Physics

**(In collaboration with the Faculty of Physics)**

The Faculty of Computer Science and the Faculty of Physics offer a combined program for students with particularly high admission scores.

Graduates receive a B.Sc. in Computer Science and Physics.

**Admission**

1. The program is intended for a limited number of outstanding students, or those who at least meet the admission requirements of each of the faculties.
2. Students will only be admitted for the winter semester.
3. Students can choose to belong to either of the faculties. The faculty they choose will be considered their “parent unit.”
4. Both faculties will define the same criteria for allowing students to transfer to this program based on their academic achievements.
5. All students in this program who's academic status is in order may switch to any other program offered by either of the two faculties.

Students must accumulate 163.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 127.5 credits |
| Elective faculty courses | 26.0 credits |
| Elective Technion courses | 10.0 credits |

Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses by semesters:

| Semester 1 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044102 | Safety in electrical engineering laboratories * | 4* | - | - | - | - |
| 104031 | Infinitesimal calculus 1M | 4 | 3 | - | - | 5.5 |
| 104166 | Algebra AM | 4 | 3 | - | - | 5.5 |
| 234114 | Introduction to computer science M | 2 | 2 | 2 | - | 4.0 |
| 234129 | Introduction to set theory and automata for CS | 2 | 2 | - | - | 3.0 |
| 324033 | Technical English – Advanced B | 4 | - | - | - | 3.0 |
| | | 16 | 10 | 2 | - | 21.0 |
| | Physical education (choose from the list). | - | 2 | - | - | 1.0 |
| | | | 12 | | | 22.0 |

* Once during the semester, according to instructions that will be published separately.

| Semester 2 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 044252/ 234252 | Digital systems and computer structure | 4 | 2 | - | - | 5.0 |
| 104032 | Infinitesimal calculus 2M | 4 | 2 | - | - | 5.0 |
| 234124 | Introduction to systems programming | 2 | 2 | - | 2 | 4.0 |
| 234141 | Combinatorics for computer science | 2 | 1 | - | 1 | 3.0 |
| | | 12 | 7 | - | 3 | 17.0 |
| | Physical education (choose from the list). | - | 2 | - | - | 1.0 |
| | | | 9 | | | 18.0 |

| Semester 3 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 094412 | Probability M | 3 | 2 | - | - | 4.0 |
| 104134 | Modern algebra H | 2 | 1 | - | - | 2.5 |
| 104033 | Vector analysis | 2 | 1 | | | 2.5 |
| 114020 | Physics lab 1M | - | - | 3 | - | 1.5 |
| 114074 | Physics 1P | 4 | 2 | - | - | 5.0 |
| 234218 | Data structures 1 | 2 | 1 | 1 | - | 3.0 |
| 234292 | Logic for computer science | 2 | 1 | - | - | 3.0 |
| | | 15 | 8 | 4 | - | 21.5 |

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104285 | Ordinary differential equations A * | 3 | 1 | - | - | 3.5 |
| 114021 | Physics lab 2M | - | - | 3 | - | 1.5 |
| 114076 | Physics 2P | 4 | 2 | - | - | 5.0 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| | | 13 | 7 | 7 | 6 | 20.5 |

* Students can replace this course with Ordinary Differential Equations/T (104135) for 2.5 credits and add another credit from an elective course at one of the faculties.

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 104214 | Fourier Series and Integral Transforms | 2 | 1 | - | - | 2.5 |
| 104220 | Partial Differential Equations/T | 2 | 1 | - | - | 2.5 |
| 104215 | Complex functions A | 2 | 1 | - | - | 2.5 |
| 114101 | Analytical mechanics | 3 | 2 | - | - | 4.0 |
| 114086 | Waves | 3 | 1 | - | - | 3.5 |
| | | | 6 | | - | 15.0 |

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| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 114035 | Physics Laboratory 3 | - | - | 3 | - | 1.5 |
| 115203 | Quantum physics 1 | 4 | 2 | - | - | 5.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 114246 | Electromagnetism and electrodynamics | 4 | 2 | - | - | 5.0 |
| 114036 | Statistical and thermal physics | 4 | 2 | - | - | 5.0 |
| | | 12 | 6 | 3 | - | 16.5 |

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| Semester 7 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 234125 | Numerical algorithms | 2 | 2 | - | - | 3.0 |
| 115204 | Quantum physics 2 | 4 | 2 | - | - | 5.0 |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 124108 | Introduction to chemistry for physicists | 3 | 1 | - | - | 3.5 |
| | | 11 | 6 | - | 1 | 14.5 |

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| Semester 8 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| 114037 | Physics lab 4MH | - | - | 3 | - | 1.5 |
| Elective courses | | | | | | |

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## Elective Courses

Students must choose at least 10 credits from the physics faculty and 10 credits from the computer science faculty. The 10 computer science credits must include at least one project. The 10 physics credits must include at least 9 credits from the CS-P1 list below.

Students who take course 104135 for 2.5 credits instead of 104285 for 3.5 credits must complete an additional credit (for a total of 27 elective credits).

Computer Architecture (236267) is compulsory for students planning to pursue master's studies in computer science.

Courses 236990, 116031, and 236823 on quantum information will be considered elective physics or mathematics courses, according to the student's choice.

The remaining elective courses (6 credits) can be selected from the list of elective computer science and physics courses.

With the approval of the advisor, 6 elective credits can be selected from List B for computer science, or in special cases, can be courses that do not appear on the regular lists.

The CS-P1 list

Credits

| | | |
|---|---|---|
| 114210 | Optics (Semester B) | 3.5 |
| 116029 | Introduction to biophysics (Semester A) | 3.5 |
| 116027 | Physics of Fluids | 3.5 |
| 116031 | Introduction to quantum computation and information (Semester B) | 3.5 |
| Or | | |
| 236990 | Introduction to quantum information processing | 3.0 |
| 116354 | Astrophysics and cosmology (Semester A) | 3.5 |
| 116004 | Physics of nuclear and elementary particles (Semester B) | 3.5 |
| 114250 | Physics lab 5T | 3.0 |
| Or | | |
| 114252 | Project T (in the Faculty of Physics) | 3.0 |
| 116217 | Solid state physics (Semester A) | 3.5 |

# Double Degree in Medicine and Computer Science

The Faculty of Medicine and the Faculty of Computer Science offer a double degree program intended for outstanding students with particularly high admission scores.
The track's goal is provide its graduates with extensive knowledge of both computer science and medicine, so that they will be able to join and become leaders in each of the fields, and work in research, development, and industry fields that require in-depth knowledge of both.
The program is intended for students who are accepted for medical school and wish to add a degree in computer science.
Graduates of this unique program are awarded the degrees of B.Sc. in Computer Science and B.Sc. in Medical Sciences. Graduates can earn an M.D. degree after completing all the requirements of the double degree program as well as three years of clinical training and one year of internship (see the Faculty of Medicine's academic regulations regarding clinical training).

## About the Program

During the first two years, students complete the basic courses and other computer science courses. In the 5th and 6th semesters, courses from the Faculty of Medicine will be incorporated in the curriculum in addition to computer science courses. In the last semesters (7 – 10), students will complete medical courses only.
Students are required to take scientific courses Physics R 2 (114249) and General and Physical Chemistry for Med (124507) in the 4th and 5th semesters, respectively. Students are not given a choice regarding the scientific courses, as these courses are a compulsory part of the medical curriculum.
During this a five-year program, students complete the entire curriculum in computer science and medical sciences.
Students will complete their requirements for each of the degrees based on the regulations of the relevant faculty.
Students may transition to the clinical division only after meeting all the requirements of the double degree, and in accordance with the regulations of the Faculty of Medicine.
All the allowances in this program apply to students who complete both degrees. To complete only one degree, students must fulfill all the requirements of that degree.

## Curriculum

To complete a degree in computer science and para-clinical medical studies, students must accumulate 221.5 credits as follows:

| | |
|---|---|
| Compulsory courses | 208.0 credits |
| Elective engineering courses (*) | 8.5 credits |
| Elective medical courses | - |
| Advanced technical English B** | 3.0 credits |
| Elective Technion courses: Physical education | 2.0 |

* Elective engineering courses 236201, 236501, and 236523 are an inherent part of the program
** When required, this course must be completed by the 4th semester.
The 1st, 2nd, and 3rd semesters include only computer science courses, just as in the general four-year track.
Le – lecture; E – exercise; La – lab; P – project; C – credits

## Compulsory Courses

Recommended courses by semesters:

| Semester 4 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | Computer science courses only | | | | | |
| | An additional math course* | | | | | 2.5/5.0 |
| 114249 | Physics 2 R** | 3 | 1 | - | - | 3.5 |
| 234118 | Computer organization and programming | 2 | 1 | 1 | - | 3.0 |
| 234123 | Operating systems | 2 | 2 | 3 | 6 | 4.5 |
| 234247 | Algorithms 1 | 2 | 1 | - | - | 3.0 |
| 236201 | Introduction to data processing and representation | 2 | 1 | - | 1 | 3.0 |
| | | | | | | 19.5/22 |

* One of the courses specified for the 4th semester in the general four-year track.

** Science course is not optional

| Semester 5 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | **Computer science** | | | | | |
| 124507 | General and physical chemistry for Med* | 4 | 2 | - | - | 5.0 |
| 236501 | Introduction to artificial intelligence | 2 | 1 | - | - | 3.0 |
| 236523 | Introduction to bioinformatics | 2 | 1 | - | - | 2.5 |
| | **Medicine** | | | | | |
| 274167 | Cell Biology | 3 | 1 | - | - | 3.5 |
| 274142 | Clinical Tuesday – Being a Doctor (1) ** | - | - | 6 | - | 2.0 |
| 274257 | Anatomy A | 5 | - | 3 | - | 6.0 |
| | | | | | | 22.0 |

* Scientific course - compulsory
** Clinical Tuesday (1) will be given as a concentrated course during the summer if it cannot be included in the schedule.

| Semester 6 | | Le | E | La | P | C |
|---|---|---|---|---|---|---|
| | **Computer science** | | | | | |
| 236343 | Theory of computation | 2 | 1 | - | 1 | 3.0 |
| 236360 | Theory of compilation | 2 | 1 | - | - | 3.0 |
| 236503 | Project in CS advanced programming 1 * | - | - | - | 7 | 3.0 |
| | Medicine: | | | | | |
| 125803 | Organic Chemistry for Med | 2 | 2 | - | - | 3.0 |
| 274143 | Clinical Tuesday - Being a Doctor (2) ** | - | - | 6 | - | 2.0 |
| 274165 | General Genetics *** | 3 | 1 | - | - | 3.5 |
| 274266 | Anatomy B | 5 | - | 3 | - | 6.0 |
| | | | | | | 23.5 |

* With the approval of the head of the track, students can also take a different project from those offered by the Faculty of Computer Science.
** Clinical Tuesday (2) will be given as a concentrated course during the summer if it cannot be incorporated in the schedule.
*** Compulsory scientific course

Semesters 7–10 comprise medical courses only, as specified for this track in the Faculty of Medicine's catalogue.

## Secondary Specialization in Quantum Computation

Quantum computers and quantum information (including quantum communication and cyphers) is rapidly evolving in Israel and around the globe. The Faculty of Computer Science, in coordination with the Technion's Helen Diller Quantum Center, offers a scientific enrichment program that focuses on this field. The program provides students with a multidisciplinary perspective of this evolving subject.

The program is open to undergraduate students at the faculty. Students can be admitted to the track after completing at least 30 credits with a GPA of at least 85, or a GPA of 80–85 with the approval of an advisor.

Students who complete this specialization are awarded a certificate. The certificate will be signed by the dean of the faculty and the head of the Quantum Center.

The certificate will be awarded after the student has completed all the requirements for one of the tracks offered by the faculty as well as the requirements for this secondary specialization track. The undergraduate secretariat at the faculty will be responsible for monitoring the student's progress and ensuring that all the requirements are met.

To complete this track, students are required to choose one of the following two options:

Option 1: Five courses, one from each group.

Must meet the requirements for Groups A, B, and C1.

Must meet the requirements for two of the three groups D, E, and F.

Option 2: The student must meet the requirements for each of the six groups A, B, C2, D, E, F.

There may be an overlap between courses in the specialization program and compulsory and elective courses that students take as part of their regular studies. Students in three-year tracks are required to complete at least 2.5 credits beyond the required number of credits required for their degree. Students in four-year tracks shall not be required to complete extra credits.

**The groups are as follows:**

a) **The following course in computation**

| | | Credits |
|---|---|---|
| 236343 | Theory of computation | 3.0 |

**b) One of the following two introductory courses**

| | | Credits |
|---|---|---|
| 236990 | Introduction to quantum information processing | 3.0 |
| | Or | |
| 116031 | Theory of computation | 3.5 |

**c)**

**1. One of the following quantum courses**

| | | Credits |
|---|---|---|
| 124400 | Quantum chemistry 1 * | 5.0 |
| | Or | |
| 115203 | Quantum physics 1 (for CS and physics students) | 5.0 |
| | Or | |
| 046241 | Quantum mechanics (for computer engineering students) | 5.0 |

*Note the four prerequisites for Quantum Chemistry 1: Physics 2 (114052) and Principles of Chemistry (124120), which appear on the list of scientific courses in the physics-chemistry chain.

Ordinary Differential Equations H (104131) is included in Ordinary Differential Equations T (104135), and Differential and Integral Calculus 2 (104004) is included in Infinitesimal Calculus 2M (104032) along with Vector Analysis (104033).

Courses 104135 and 104033 appear in the list of additional math courses.

The list of scientific courses and additional math courses can be found in the general four-year track section.

**2. Choose one of the three options below as pre-quantum courses:**

| | | Credits |
|---|---|---|
| **Option 1** | | |
| 114073 | Introduction to quantum physics for engineers | 3.5 |
| **Option 2** | **The following three courses:** | |
| 114054 | Physics 3 | 5.0 |
| 104004 | Differential and Integral Calculus 2 | 5.0 |
| 104131 | Ordinary Differential Equations H | 2.5 |
| **Option 3** | **The following three courses:** | |
| 114054 | Physics 3 | 5.0 |
| 104033 | Vectorial analysis | 2.5 |
| 104131 | Ordinary Differential Equations H | 2.5 |

**d) Advanced course in quantum information: One of the following:**

| | | Credits |
|---|---|---|
| 236640 | Advanced topics in quantum information L | 2.0 |
| 236641 | Advanced topics in quantum information L+T | 3.0 |
| 236823 | Quantum information processing lab | 2.0 |
| 116040 | Advanced quantum information | 2.0 |
| 046734 | Quantum information theory | 3.0 |

**e) Course in quantum technology: One of the following courses:**

| | | Credits |
|---|---|---|
| 046243 | Quantum technologies | 3.0 |

| | | |
|---|---|---|
| 116083 | Quantum technologies | 2.0 |
| 236991 | Project in quantum computing | 3.0 |
| 116037 | Noisy quantum computing | 2.0 |
| 126604 | Laboratory in quantum technologies A | 2.0 |
| 126605 | Laboratory in quantum technologies B | 4.0 |

f) **Core courses: One of the following:**

| | | Credits |
|---|---|---|
| 236313 | Complexity theory | 3.0 |
| 236309 | Introduction to coding theory | 3.0 |
| 236518 | Communication complexity | 2.0 |
| 236359 | Algorithms 2 | 3.0 |
| 236521 | Approximation algorithms | 2.0 |
| 236330 | Introduction to optimization | 3.0 |
| 046197 | Computational methods in optimization | 3.0 |
| 234292 | Logic for CS * | 3.0 |
| 236201 | Introduction to data processing and representation | 3.0 |
| 236350 | Network security | 3.0 |
| 236334 | Introduction to computer networks | 3.0 |
| 044334 | Computer networks and internet 1 | 3.0 |
| 236370 | Concurrent and distributed programming for data processing and machine learning | 3.0 |
| 236501 | Introduction to artificial intelligence | 3.0 |
| 236756 | Introduction to machine learning | 3.0 |

*Logic for CS – for computer engineering students only.

# The Lapidim Program

Lapidim programs are excellence programs offered by the Faculty of Computer Science at the Technion for outstanding undergraduate students.

## The Lapidim - Entrepreneurship Excellence Program

This excellence program is intended for outstanding students with exceptional leadership and management capabilities, to prepare them for taking on key roles in the industry.

Participants must complete all the academic requirements of one of the tracks offered by the faculty (including joint programs) and accumulate at least 12 credits from managerial and entrepreneurial courses. In addition, they participate in special activities that expose them to the worlds of academia, industry, and technology in meetings with senior executives, entrepreneurs, venture capitalists, incubators, and more.

Students can choose the additional 12 credits from the following list, or other courses with the approval of the program’s coordinator:

| | | Credits |
|---|---|---|
| 094423 | Introduction to statistics | 3.5 |
| 094564 | Introduction to financial management | 2.5 |
| 094591 | Introductory economics | 3.5 |
| 094816 | Marketing for high-tech start-up | 2.0 |
| 095605 | Introduction to psychology | 2.5 |
| 096211 | Electronic commerce models | 3.5 |
| 096570 | Game Theory and Economic Behavior | 3.5 |
| 096617 | Cognition and decision making | 2.5 |
| 096807 | Social ventures | 3.5 |
| 097317 | Corporate game theory | 2.5 |
| 097800 | Principles of marketing | 3.5 |
| 214909 | Computer science problems - soft skills | 2.0 |
| 236002 | Topics in computer science innovation | 2.0 |
| 236700 | Software design | 3.0 |
| 324864 | Entrepreneurship 1 | 1.0 |
| 324442 | Israeli labor law | 2.0 |
| 324520 | Business Entrepreneurship | 2.0 |
| 324521 | Entrepreneurship in Organizations | 2.0 |
| 324540 | Legal Aspects of Busine entrepreneurship | 2.0 |
| 324247 | Entrepreneurship and Design | 2.0 |
| 324542 | A Journey into Global Hi-Tech Companies | 2.0 |

The benefits associated with this program include full exemption from tuition fees, a monthly allowance (for ten months a year), and personal mentorship with a faculty member. A dedicated state-of-the-art study area can be used by students in the program.

Clarifications:

1. Spaces are limited and are mainly intended for new students with particularly high achievements during their first year. Admission to the program is based on a special screening process.
2. To stay in the program, students must achieve a GPA of at least 86 and accumulate 18 credits or more every semester.
3. Graduates are awarded a Lapidim graduate certificate by the faculty.
4. The scope of financial support will be determined once a year based on the resources available.
5. The required entrepreneurship and managerial courses can be considered elective courses for the degree (provided all the degree requirements are met in full).

For additional information, see the program's website:
http://lapidim.cs.technion.ac.il

## The Lapidim – Research Excellence Program

The program trains outstanding students with potential to pursue an academic career as future researchers and university faculty members. Emphasis is placed on the important qualities needed to be successful faculty members, i.e., academic excellence, a passion for science and research, and the ability to drive a research team.

Program participants must meet all the requirements of their selected track (including joint programs) as well as the requirements listed below, and actively participate in the program's special activities.

- Completing Introduction to Departmental Research (236001).
- Drafting a research proposal that is approved for master's studies during their undergraduate studies, under the supervision of a faculty member.
- Completing three advanced courses that are related to their research topic, in addition to the track requirements and with the approval of the academic director of the program.

Participants are entitled to special benefits during the program, including full exemption from tuition fees, a monthly subsistence stipend for ten months of the

year, and personal mentorship by a faculty member. A dedicated state-of-the-art study area is available to students in this program.

Clarifications:

1. Spaces are limited and are mainly intended for new students with particularly high achievements during their first year. Admission to the program is based on a special screening process.
2. To stay in the program, students must achieve a cumulative GPA of at least 88 and accumulate 18 credits or more every academic semester for as long as they remain in the program.
3. Graduates are awarded an Academic Leadership Graduate certificate by the faculty.
4. The scope of financial support will be determined once a year based on the resources available.

## Miscellaneous

1. The requirement to complete compulsory courses can be met even when there are slight changes in the number of credits granted for certain compulsory courses in the catalogue, provided all the compulsory courses are completed and the total number of credits required for the degree as stipulated in the catalogue is met. Missing credits can be completed by taking elective faculty courses.
2. The requirement to complete two projects can be met by taking a project in one semester and continuing it into the following semester as part of Course 236504. In such cases the project will be graded at the end of the first semester as well. However, the Project in Software course cannot be taken more than once.
3. Undergraduate students can only enroll in one seminar per semester.

# Graduate Studies

The Faculty of Computer Science offers the following continuing education programs: M.Sc. in Computer Science, M.Sc. in Science, and Ph.D. degrees. Outstanding students can transfer to a direct Ph.D. track during their master's studies.

The faculty aims to train students to become outstanding scientists and engineers, provide them with vast knowledge and engineering capabilities, and help them develop managerial and technological skills so they will be able lead present and future science-based industries. To that end, the faculty selects the best candidates and maintains high academic standards, providing students with broad and in-depth knowledge to help them succeed in the rapidly developing field of computer science.

**Specialization and Research Fields in the Faculty**

Extensive teaching and research on a broad range of topics takes place at the faculty:

- Theory of algorithms (serial and distributed, deterministic and probabilistic)
- Cypher theory (source encryption, channel encryption, and error correction codes)
- Cryptography
- Quantum information processing
- Computational complexity theory
- Logic for computer science
- Data structures
- Databases
- Models and performance assessment of computer systems
- Machine learning
- Numerical algorithms
- Parallel and distributed programming
- Sorting and routing networks
- Geometric design
- Formal specification of complex systems
- Formal verification of software and hardware systems
- Programming languages
- Software engineering

- Simulation
- Computer communication networks
- Computational linguistics and natural language processing
- Artificial intelligence
- Neural networks
- Expert systems
- Computational geometry
- Computer graphics
- Digital image processing
- Computer vision
- Robotics
- Discrete event systems
- Bioinformatics

In addition to the theoretical research possibilities in these fields, the faculty has a wide range of research labs for diverse fields including robotics, computer vision, artificial intelligence, computational geometry, computer graphics, computer communication networks, software systems, computer systems, natural language processing, information and cyber security, machine learning, information and learning, information and memory storage, bioinformatics, and quantum information processing.

The faculty is located in a state-of-the-art building designed for the convenience of the faculty members and students. The building's resources include auditoriums and classrooms equipped with some of the most advanced multimedia systems, a large multi-purpose center that provides a novel learning environment, and a cutting-edge library that serves as a contemporary learning center.

# Master's Studies

### Admission to the M.Sc. in Computer Science Track

Students who have completed their undergraduate studies with honors at the Faculty of Computer Science, or in one of the tracks the faculty offers in collaboration with other faculties, can be admitted to this track. Candidates who have completed their undergraduate studies in other institutions may need to complete several courses. The professional achievements of candidates and their practical experience and recommendation letters will be taken into account during the screening process. In principle, this program is available to Technion students only, though outstanding external students will be considered in special cases.

### Admission to the M.Sc. in Science Track

Students who have completed their undergraduate studies with honors in scientific or engineering programs will be admitted to this track. To apply, students must ask a faculty member to serve as their advisor. The curriculum for these tracks will be coordinated with the advisor and the committee coordinator and approved by the graduate studies committee.

### Requirements

Master's students are required to complete several courses and complete a research thesis or final paper under the supervision of a faculty member.

Students who completed B.Sc studies in electrical engineering and physics in the Faculty of Electrical Engineering and Computers will require another 38 credits, of which 16 are dedicated to an academic-related specialization, based on a curriculum coordinated with the advisor. The additional credits shall comprise 2 credits in Advanced Graduate English and 20 credits for an M.Sc. thesis.

Graduates of a four-year B.Sc track must complete 40 credits, of which 18 credits are from their specialty field, according to a curriculum built in coordination with their advisor. In addition, they will require 2 credits in Advanced Graduate English, and 20 credits for an M.Sc. thesis.

Graduates of the general three-year undergraduate program are required to complete 52 credits in total. These must include 30 credits from courses, including at least six elective computer science courses that are not advanced topics; and a project or seminar from at least four of the 11 specialization groups in the general four-year study track, as specified in the Faculty of Computer Science catalog for

graduate studies. Students must complete any extra courses required before beginning the M.Sc. program. Six of the 30 cumulative credits required for the degree can be undergraduate-level credits. In addition, they will require 2 credits in Advanced Graduate English, and 20 credits for an M.Sc. thesis.
Computer Architecture (236267) and Theory of Computation (236343) are compulsory courses. Students who did not take them during their undergraduate studies must complete them as part of their continuing education program for a master's degree.
To find a thesis advisor, students need to contact a faculty member who specializes in their fields of interest. External graduate students cannot choose an adjunct professor as their advisor. The research can be theoretical or an advanced engineering project. In special cases, students will be permitted to submit a final paper instead of a thesis, and in such cases they will need to accumulate 8 additional credits.

## Doctoral Studies

### Admission

Outstanding students with a master's degree in a relevant field will be admitted to this program. Prior to their admission, students must secure an advisor who is a faculty member and define their research field. The PhD curriculum and the course completion program for students without a background in computer science will be determined on an individual basis by the advisor and the graduate studies committee. External students cannot choose an adjunct professor as their advisor. As a rule, students must be full-time internal students at the faculty for at least one year during their studies.

### Study Requirements

Course requirements for doctoral students at the faculty are as follows:
1. Advanced computer science courses (or computer science courses that are part of both the undergraduate and graduate programs) - at least 12 credits.
2. Students in the direct Ph.D. track are required to complete 6 credits in addition to the credit requirements for a master's degree.

## Additional Information Resources

- A detailed catalogue for graduate studies at the Faculty of Computer Science is available at the graduate studies office at the faculty or on the faculty's website.
- Information for candidates can be obtained from the graduate studies office at the faculty.

Please contact Ms. Anna Kleiner: tel. 077-8874226 email. akleiner@cs.technion.ac.il or Ms. Sharon Emuna: tel. 077-8874342 email. sharonem@cs.technion.ac.il

- Link to the Faculty of Computer Science website: https://graduate.cs.technion.ac.il/en/graduate-studies/