

# The Faculty of Computer Science Curriculum Catalog 2022-2023

## Faculty members

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### Professors

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Francez Nissim  
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Heymann Michael  
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## 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, 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 programming, 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. The joint engineering program, for example, includes compulsory courses from the curriculum of the Faculty of Electrical Engineering; the bioinformatics specialty in computer sciences includes compulsory courses given by the Faculty of Biology; and students studying mathematics or physics in addition to computer science are required to take advanced courses in mathematics and physics. 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 science and mathematics and computer science and physics 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.

- Students in the **four-year program** may choose from 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.

## **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.

## **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 programming 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 electronic computer 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 once accepted, enroll in a pre-defined four-year 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.

### **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:

<b>Compulsory courses</b>	<b>87.0 credits</b>
<b>Elective faculty courses</b>	<b>56.0 credits</b>
<b>Elective Technion courses</b>	<b>12.0 credits</b>

**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 1<sup>st</sup> 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 2<sup>nd</sup> semester and Modern Algebra (Electrical Engineering) in the 3<sup>rd</sup> 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 courses:

		Credits
104135	Ordinary differential equations t <sup>(1)</sup>	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 <sup>(2)</sup>	3.5
104295	Infinitesimal calculus 3	5.0

<sup>(1)</sup> This course is considered an additional math course only for students take one of the following courses: Physics 3 (114073), Quantic physics 1 (115203), Quantic chemistry 1 (124400), or Analytic mechanics (114101).

<sup>(2)</sup> 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

\*\* See list of scientific courses below.

## 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	Physics 3H	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
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
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
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
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
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
236216	Computer graphics 1	3.0
236268	Constructive computer architecture	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
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
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
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
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 1<sup>st</sup> 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 2<sup>nd</sup> semester and Modern algebra (104134) in the 3<sup>rd</sup> 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
236496	Reverse engineering	2	1	-	1	3.0
						21/23

Semester 6		Le	E	La	P	C
236506	Modern cryptology	2	1	-	1	3.0
236490	Computer security	2	1	-	1	3.0
		4	2	-	2	6.0

## 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 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 molecular and cell biology and computer science without any further requirements.

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 155 credits as follows:

Compulsory courses	107.0	Credits
Elective faculty courses	36.0	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
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 1<sup>st</sup> 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
134133	Evolution	2	-	-	-	2.0
234124	Introduction to systems programming	2	2	-	2	4.0
234141	Combinatorics for computer science	2	1	-	1	3.0
		16	7	-	3	21.0
	Physical education (choose from the list)	-	2	-	-	1.0
			9			22.0

\*\* 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	1	3.0
234247	Algorithms 1	2	1	-	-	3.0
125801	Organic chemistry	4	2	-	-	5.0
134019	Introduction to Biochemistry and enzymology	2	2	-	-	2.5
		13	7	1	1	17.0

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
134082	Molecular biology	2	1	-	-	2.5
134142	Molecular genetics laboratory	1	-	5	-	2.5
134113	Metabolic pathways	3	1	-	-	3.5
		12	6	8	6	18.0

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
		4	2	-	1	6.0

Semester 7		Le	E	La	P	C
236524	Bioinformatics project	2	-	-	3	3.0
		2	-	-	3	3.0

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

### Elective courses

Students must complete 36 credits as follows:

At least 15 credits from List A (faculty courses) for the general four-year computer science track.

At least ten elective biology credits as follows:

At least two courses from the list below. The remaining courses can be selected from List A or B for the B.Sc. in Biology program.

		Credits
134119	Regulation of gene expression	2.5
134128	Cell biology	3.5
134111	Zoology	3.0
134040	Molecular plant physiology	3.0
134117	Physiology	3.5
134121	Microbiology and virology	3.0

The remaining 11 credits can be selected from List A for computer science or from Lists A or B for a B.Sc. in Biology.

## 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 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> 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 1<sup>st</sup> 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 <sup>(1)</sup>	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

<sup>(1)</sup> 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	3.0

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 Software Engineering Track

This track trains its graduates to specialize in large software systems. The track focuses on a range of programming 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 1<sup>st</sup> 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 6<sup>th</sup> 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 6<sup>th</sup> 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
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 4<sup>th</sup> semester.
5. We recommend taking elective faculty courses beginning from the 5<sup>th</sup> semester and advanced courses during the 7<sup>th</sup> and 8<sup>th</sup> 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 has two parent units - the Faculty of Electrical and Computer Engineering and the Faculty of Computer Science – and is fully subordinated to both 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 courses, and Technion elective courses, in the following manner:

1. All compulsory courses specified in the recommended plan below must be taken, constituting 109–111 credits.
2. At least three 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 (and then will not be considered part of the specialization group and another course will have to be chosen instead). 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 can change their minds and leave the track at any time. However, in order to receive a degree in computer science or electrical engineering, they will have to complete all

the missing compulsory courses and meet all the academic requirements for a degree in the parent unit.

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

## Admission

1. A limited number of students from the Faculty of Electrical and Computer Engineering and the Faculty of Computer Science are admitted to the track. The number of students admitted from each unit is determined by the heads of both parent units, following consultations at the computer engineering track committee.
2. Students admitted to the track remain affiliated with their parent unit. Therefore, all academic, administrative, and disciplinary matters will be addressed by the head of that 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.

## Curriculum

Students are required accumulate 158.5 credits as follows:

Compulsory courses	109–111 credits
Core courses	9.0 credits
Elective faculty courses	26.5–28.5 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
044102	Safety in electrical engineering laboratories	4 <sup>***</sup>	-	-	-	-
104031	Infinitesimal calculus 1M	4	3	-	-	5.5
104166	Algebra AM*	4	3	-	-	5.5
234114	Introduction to computer science M <sup>**</sup>	2	2	2	-	4.0
324033	Technical English – Advanced B	4	-	-	-	3.0
		14	8	-	-	18.0
	Physical education (choose from the list)	-	2	-	-	1.0
			10			19.0

\* Electrical and computer engineering students will take Algebra 1/Extended (104016).

\*\* Electrical and computer engineering students will take Introduction to Computer Science H (234117).

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

Semester 2		Le	E	La	P	C
104032	Infinitesimal calculus 2M <sup>(1)</sup>	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 education (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
114075	Physics 2MM	4	2	-	-	5.0
094412	Probability M*	3	2	-	-	4.0
104285	Ordinary differential equations A <sup>(1)</sup> **	3	1	-	-	3.5
104033	Vector analysis <sup>(1)</sup>	2	1	-	-	2.5
234218	Data structures 1	2	1	1	-	3.0
		18	9	1	-	23.0

\* Electrical and computer engineering students will take Introduction to Probability (104034) in the 4<sup>th</sup> semester.

<sup>(1)</sup> Instead of the three courses 104032, 104285, and 104033, electrical and computer engineering students will take 104013 and 104035 in the 2<sup>nd</sup> semester.

\*\* Computer science students can take Ordinary Differential Equations T (104135) for 2.5 credits and add another credit from an elective faculty course, instead of 3.5 credits for Ordinary Differential Equations A (104285).

Semester 4		Le	E	La	P	C
044105	Theory of electronic circuits	3	2	-	-	4.0
104214	Fourier Series and Integral Transforms	2	1	-	-	2.5
104215	Complex Functions A	2	1	-	-	2.5
234118	Computer organization and programming	2	1	1	-	3.0
234247	Algorithms 1	2	1	-	-	3.0
044127	Basics of semiconductor devices	3	1	-	-	3.5
		14	9	1	-	18.5

Semester 5		Le	E	La	P	C
044131	Signals and systems	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
104220	Partial Differential Equations/T	2	1	-	-	2.5
236267	Computer architecture*	2	1	-	1	3.0
		10	6	6/7	3/9	17.0

† Students can choose either Operating Systems (234123) or Structure of Operating Systems (046209 + 046210).

\* Electrical and computer engineering students can take Computer Architecture (046267).

Semester 6		Le	E	La	P	C
044137	Electronic circuits	4	2	-	-	5.0
114073	Physics 3H	3	1	-	-	3.5
044167	Project A	2	-	4	-	4.0
	Or					
	A computer science project*					3.0/4.0
						11.5/12.5

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 three 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
234129	Introduction to set theory and automata for CS	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 ten 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
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

044334/236334 or 236357 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
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
236861	Geometric computer vision
046733	Information theory
046831	Introduction to medical imaging
046195	Machine learning
234125	Numerical algorithms
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
234292	Logic for computer science
236372	Bayesian networks
236716	Geometric models in CAD systems

236756	Introduction to 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
046853	Advanced Computer Architecture
046200	Image processing and analysis
	Or
236860	
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)
046235	Integrated power management devices
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

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
044193	Project in linear control
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
236901	Algorithmic robot motion planning
236927	Introduction to robotics
	Or
046212	Introduction to robotics

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: 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	Quantum information theory
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.

## 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

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

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

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

## 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	Quantum information theory (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 5<sup>th</sup> and 6<sup>th</sup> 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 2 (114249) and Principles of Chemistry (124120) in the 4<sup>th</sup> and 5<sup>th</sup> 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 218.5 credits as follows:

Compulsory courses	205.0 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 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> 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 4<sup>th</sup> semester in the general four-year track.

Semester 5		Le	E	La	P	C
	Computer science					
124120	Principles of chemistry	4	2	-	-	5.0
236343	Theory of computation	2	1	-	1	3.0
236360	Theory of compilation	2	1	-	-	3.0
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
						22.0

\* 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:					
236503	Project in CS advanced programming 1 *	-	-	-	7	3.0
	Medicine:					
125802	Organic Chemistry Rbm	4	2	-	-	5.0
274143	Clinical Tuesday - Being a Doctor (2) **	-	-	6	-	2.0
274165	General Genetics ***	3	1	-	-	3.5
274182	Biostatistics	2	2	-	-	3.0
						16.5

\* 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 take five courses from the list of courses below. The courses taken for this specialization track can overlap with the compulsory or elective courses taken as part of the regular degree. Students in three-year programs must complete at least 2.5 credits beyond the credit quota required for their degree. Students in four-year programs will not be required to add credits.

The following two courses are compulsory:

a. Introduction to Quantum Information (236990): 3 credits.

\* Students can take Introduction to Quantum Information and Computation (116031) for 3.5 credits, instead of Course 236990.

b. Theory of Computation (236343): 3 credits.

Students must complete three of the four following requirements:

a. Quantum course: Quantum Chemistry 1 <sup>\*\* (1)</sup> (124400): 5 credits.

\*\* Students can take Quantum Physics (115203) for 5 credits (appropriate for students in the cs-physics track) or Quantum Mechanics (046241) for 3.5 credits (appropriate for students in the computer engineering track) instead of Quantum Chemistry (124400).

b. An advanced quantum information courses: One of the following: Advanced Topics in Quantum Information (236640/41) for 2 or 3 credits, 236823 for 2 credits; Quantum Information Processing Lab (236823) for 2 credits; or Advanced Quantum Information (116040) for 2 credits.

c. An advanced course in quantum technologies: One of the following: Quantum Technologies (046243) for 3 credits; Quantum Technologies (116083) for 2 credits; Project in Quantum Computing (236991) for 3 credits; Noisy Quantum Computing (116037) for 2 credits; Quantum Technology Lab A (126604) for 2 credits; or Advanced Quantum Technology Lab (126605) for 4 credits.

d. A core course: One of the following: Complexity Theory (236313) for 3 credits; Introduction to Coding Theory (236309) for 3 credits; Communication Complexity (236518) for 2 credits; Algorithms 2 (236359) for 3 credits; Approximation Algorithms (236521) for 2 credits; Introduction to Optimization (236330) for 3 credits; Computational Methods in Optimization (046197) for 3 credits; Logic for CS (234292)<sup>(2)</sup> for 3 credits; Introduction to Data Processing (236201) for 3 credits; Network Security (236350) for 3 credits; Modern Cryptology (236506) for 3 credits; Introduction to Computer Networks (236334) for 3 credits, Computer Networks and Internet 1 (044334) for 3 credits; Concurrent and Distributed Programming (236370) for 3 credits; or Introduction to Artificial Intelligence (236501) for 3 credits.

Please note:

<sup>(1)</sup> There are four prerequisites for Quantum Chemistry 1 (124400):

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 2 (104032) along with Vector Analysis (104033). Courses 104135 and 104033 appear in the list of additional math courses above.

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

<sup>(2)</sup> Logic for CS is for computer engineering students only.

# Students who do not choose the quantum course option will need to add one of the following:

i. Physics 3H (114073) - Note the prerequisites and proximity of this course.

or

ii. Physics 3 (114054) and Integral Calculus 2 (104004), as well as Ordinary Differential Equations H (104131) (or an overlapping course).

or

iii. Physics 3 (114054) and Vector Analysis (104033), as well as Ordinary Differential Equations H (104131) (or an overlapping course).

## The Lapidim Program

Lapidim is the excellence program at 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
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 and the extra courses required (if applicable) will be coordinated with the advisor and the committee coordinator and approved by the graduate studies committee.

### Requirements for all M.Sc. Tracks

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 must complete 40 credits, of which 18 credits are from fields in their specialty field, according to a curriculum built in coordination with their advisor. In addition, they will require 2 credits from the Advanced Graduate English course, and will submit an M.Sc. thesis worth 20 credits.

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 from the Advanced Graduate English course, and will submit an M.Sc. thesis worth 20 credits.

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. Limor Gindin: tel. 077-8874226 email. [limorg@cs.technion.ac.il](mailto:limorg@cs.technion.ac.il)
- Link to the Faculty of Computer Science website:  
<https://graduate.cs.technion.ac.il/en/graduate-studies/>