WP1 Bioart report
Requirement Evaluation
Existing Curricula in the field of Bio-engineering related to the project

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1 Regional Curricula Analysis for related BIOART studies

The current chapter presents an analysis of the academic state in Israel and Ukraine with respect to bio-medical engineering curricula. Each part of the present chapter relates with a different target country.

1.1 General status in Israel regarding bio-medical studies

The academic institutions in Israel are historically separated between universities (which offer more research-oriented curricula) and colleges (which provide more practical, industry-oriented curricula). Most universities provide curricula in Bio-medical engineering, while the offer in colleges is more scarce.

1.1.1 Offer in universities

Universities are dedicated to research, and offer a huge diversity in the courses and curricula. The universities in Israel are:

- Technion (IIT)
- Hebrew University of Jerusalem (HUJI)
- Weizmann Institute of Science (WIS)
- Bar-Ilan University (BIU)
- Tel Aviv University (TAU)
- University of Haifa (HU)
- Ben-Gurion University of the Negev (BGU)
- Open University of Israel (OPENU)
- Ariel University (AU)

Besides HU, which is dedicated to social sciences, and Weizmann Institute which is dedicated to fundamental research[1], all of the aforementioned institutions deliver diplomas in engineering. However, not all universities deliver engineering diplomas in the field of interest. For example, OPENU delivers engineering diplomas in Computer Science and Industrial Engineering only. In the universities of interest (HUJI, IIT, TAU, BGU, BIU, AU), at least one specialization in Bio-medical Engineering is provided, and many of them a full diploma in Bio-medical Engineering (both at B.Sc. and M.Sc. levels) is often available.

[1]Though WIS delivers indeed courses at M.Sc. levels, they are isolated courses provided at a department level and cannot be considered *per se* as curricula or specializations.

1.1.2 Offer in colleges

Colleges have usually smaller infrastructures than universities, and many of them provides curricula in disciplines which are not directly engineering-related. For this reason, we chose to focus only on colleges which includes a faculty in Engineering. The general trend is summarized in the following table.

Institution name	Full curriculum at B.Sc. level	Specialization at B.Sc. level	Full curriculum at M.Sc. level	Specialization at M.Sc. level
Afeka College, Tel Aviv (ACT)	✓			
Hadassah Academic College, Jerusalem (HAC)	✓	✓		✓
Holon Institute of Technology, Holon (HIT)		✓		
Jerusalem College of Engineering (JCE)		✓		
Ruppin Academic Center (RAC)	✓	✓		
SCE, Beersheba and Ashdod (SCE)		✓		
Shenkar College of Engineering and Design, Ramat Gan (SCED)		✓		
Tel-Hai Academic College (THC)	✓		✓	
ORT Braude College (ORT)		✓		

Table 1: Summary of the colleges' offer in the bio-engineering field.

For convenience, Table 1 does not display the colleges which deliver curricula in engineering not related to bio-medical engineering (4 colleges in total).

The geographic position of the Higher Education Institutions (HEIs) which signed an Erasmus cooperation agreement can be found at the address `http://www.erasmusplus.org.il/map-of-institutions`. Interestingly enough, the main target institution (SCE) is located in the southern area of Israel, where the academic offer is less widespread.

1.1.3 Official procedure for the local recognition of an academic program in Israel

Requests for the opening of new curricula can be submitted twice in a year (October and March). The requesting institution must provide to the Council for High Education general information about itself (both academic and budget), the list of courses of the tentative curriculum and their associated syllabi (including the bibliography, the names of the teaching faculty, the credits for all the courses, and the number of hours), and resumes of the associated faculty.

The program must also include the required conditions of enrollment of the students. Specific infrastructure (associated laboratories, libraries, general building) must also be detailed in the request. To be recognized, the teaching faculty must include at least three Ph.D. holders with recognized academic experience. Once it is sent, the request is analyzed by a commission to ensure its legitimacy, and a series of controls must be passed before the actual opening of the new curriculum.

Table 3 includes the material to provide for the opening of the new curriculum.

General Information	Program name Diploma name as it will appear in diplomas Description of the institution/faculty Previous decisions regarding the program, if any Estimated date of opening
Program justification	Internal relevance (how it relates to the existing infrastructure) External relevance (regarding students,industry)
Infrastructure Provisional Library	Existing infrastructure (computers, classrooms, library...) Plans for development of future infrastructure Existing books on the topic of the curriculum
Organization	Team organization: head, teaching and administrative staff Students: Conditions of enrollment, required credit number from year to year
Program	Motivation, objectives and goals Overall required credits and studying hours Organization of the program (number of hours, mandatory, optional, with credits and hours,) Table of the courses, as given by the Council of Higher Education (available online)
Personal	List of involved faculty members Curriculum Vitae of the involved staff Name of the head of the program
Budget	Price proposals used for the program Description of the financial aspects (provisional budget) for the first years of the program

Table 3: List of documents to provide for the opening request of a new curriculum

Note that contrary to the development of entirely new curricula, the development of specializations under the responsibility of existing departments requires no involvement of the Council for Higher Education, and can be settled in intern.

1.2 Existing curricula at B.Sc. level

The next section provides a more detailed analysis of the existing curricula in Bio-engineering, with emphasis on bionic members when available. Since bionic members form a specific

field of bio-medical engineering, it is of importance to consider it as a specialization of a more general bio-medical engineering diploma, and to consider the existing curricula in its wholeness, without focusing for the moment on the subject of interest. Tables summarizing the existing curricula (full and specializations) are presented in sections B.3 and B.1. Regarding Mechanical Engineering, all departments do offer courses on robotics and control, such as Introduction to Robotics, Control theory, Kinematics of Machinery, that are relevant to BIOART. Hence, the summary table appearing in the appendix includes only courses that are unique and are not part of the core courses offered on Mechanical Engineering. Similarly, only courses related to the topic at hand appear in Chemical Engineering.

1.2.1 University curricula

IIT has a full curriculum in bio-medical engineering both in B.Sc. and M.Sc. Its B.Sc. program includes general courses during the first two years, and three specializations in bio-medical signals and imaging, bio-mechanics and bio-materials engineering. Each specialization includes mandatory courses and optional courses, possibly common to several specializations. Besides this full curriculum, Technion's department of Electrical Engineering provides a specialization in bio-medical signal and image processing, and its department of Chemical Engineering has one specialization in materials and one in biochemical processes. The Mechanical Engineering faculty in IIT provides several courses that are relevant to artificial implants and bio-engineering in general. The courses are part of the curricula of the programs on Robotics, Mechatronics, and control, and Bio-mechanics that are designed for mechanical engineering student.

TAU has a full curriculum in bio-medical engineering at B.Sc and M.Sc levels. When compared to IIT, it appears that TAU's curriculum is more material-oriented, whereas IIT focuses more on signal processing, at least at the level of mandatory courses. B.Sc. specializations are in signal processing and bio-materials. Furthermore, TAU's department of material engineering has in its curriculum some relevant courses, which are summarized as well in the appendix's tables. From the side of Mechanical Engineering, relevant courses for BIOART are mostly offered by the Medical Engineering department, but are open for the Mechanical Engineering students. They are not summarized in the present report.

BGU's department of and Chemical Engineering offers a specialization related in processes and advanced materials, in which appear some relevant courses. Furthermore, BGU's department of Bio-medical Engineering deliver both B.Sc. and M.Sc. diplomas. Its B.Sc. has specializations in signal processing applications and bio-mechanics. The program on biomedical engineering and biomechanics is a specialization option offered to the Mechanical Engineering students. Parts of this program may be used as introductory courses for the BIOART curriculum.

AU offers three specializations which may be related to the topic at hand: bio-medical devices (related to Electrical Engineering), materials and biotechnology (related to Chemical Engineering). No full curriculum is available. The program on Mechanical Engineering and mechatronics offers the common courses on control, robotics, and mechatronics. No Bio-engineering course is available.

1.2.2 College curricula

SCED has a specialization in material engineering for medical applications, depending on the department of Chemical Engineering. Furthermore, RAC provides a specialization in bio-medical devices, which is very developed. This specialization depends on the department of Electrical engineering. SCE's department of Mechanical Engineering offers the common courses in Mechatronics, Control, and Robotics. In addition, a single course in Anatomy, Physiology and Biomechanics is offered. ORT's program has a specialization in Biomechanics. Within this specialization, the courses Biomechanics of implants, Anatomy, and Rehabilitative Biomechanics are relevant to the project.

1.3 Existing curricula at M.Sc. level

1.3.1 University curricula

IIT's and TAU's M.Sc. program includes a large panel of courses covering a wide spectrum of bio-medical applications. Most of the courses are related to departments' area of expertise, and some of them are directly related to the topic of artificial members. Besides these courses, the students are requested to attend departmental seminars, and to make a final research project. BGU's offer in terms of courses is reduced when compared to IIT and TAU, but the students can complete their courses requirements by taking additional advanced courses from B.Sc or related M.Sc courses from other departments.

HUJI has currently no B.Sc program in bio-medical engineering. However, it holds a research center in the field (opened in 2005) which is worldly renowned, and an M.Sc. program recently opened. Enrolled students stem usually from the school of Computer Science, who took a specialization in Bioinformatics. However, the analysis of the curriculum shows that it is more oriented to general biotechnology, bioinformatics and medicine, and has little connection with the program's main topic. Therefore, we chose not to include it in the present report.

1.3.2 College curricula

The only college with an accredited M.Sc. course is THC. It is essentially dedicated to vegetal biology, agronomy and medication development, and is little connected to the topic of interest (artificial members).

1.4 Preliminary analysis and discussion

Currently in Israel, it appears that is no special program directly related to artificial implants. However, some courses offered in separate departments can be the core courses for the planned curriculum.

From the preliminary scan of the existing curricula in Israel, we can distinguish between three different kind of courses in B.Sc. curricula:

- General courses, which belong to general engineering knowledge, and are usually common to all curricula of all institutions. Courses of these kind seem mandatory to any future curriculum in the field of bio-engineering, as a guarantee of uniformity between the proposed material and existing curricula, and for many of them already exist (in one form or another) in the existing departments of the target institutions.

- Related courses, belonging to the field of bio-engineering. Such courses should be carefully chosen, as they define the orientation of future specializations.
- Specific courses, dealing with a very oriented area of bio-engineering. Such courses define the specializations by themselves, and should be chosen accordingly to two criteria: their academic level and their relevance for the industry in the field. IIT's offer in that matter in of interest, and we believe that closely related courses should be developed for the new BIOART curriculum.

From an academic point of view, the written material (describing both the B.Sc. proposal and the M.Sc. proposal) should be prepared, even if not directly implemented. A possible strategy for the practical implementation would be to develop at first specializations related to artificial members, under the common responsibility of, and open to students from, all the involved departments. In a second step, the full B.Sc. proposal should be released to the Council for Higher Education, in order to strengthen the proposal with previous specializations running for several years. The last step would include consolidation of the B.Sc. program, and release the M.Sc. proposal once the critical mass in terms of number of students enrolled in the B.Sc. program is attained.

2 Regional Labor Market Requirement Analysis

As it can be seen from the website of the Ministry of Science (`https://www.science.co.il/biomedical/Companies.php`), the industry dealing with biotechnology in Israel is extremely developed. Furthermore, the existing help and facilities to create start-up companies, from incubators and accelerators to governmental financial help, show that Israel is indeed a start-up nation. Entrepreneurship has a large place in the Israeli culture, and numerous students fund their company after a B.Sc. diploma. In this context, we dispose of a large industry and medical infrastructure for counsel and help in the development of the new curriculum.

2.1 Preliminary Work

The Israeli team met with the following people:

- Dr. Dan Rappaport, CTO of the Mindup incubator (venture including numerous companies and hospitals), with a broad experience in the field of Bio-engineering.
- M. Yehuda Oppenheimer, CEO of the start-up YOYS, developing solutions for active noise cancellation.

The involved parties showed interest in proceeding further with us, and assured that they will remain available for advice in future developments. The following questions were asked:

1. What are the trends in the field in the industry?
2. What are the needs of the industry in the field?
3. How can be envisaged a collaboration with academia ?

4. What are the required skills in the field (general, specific)?

5. Is it possible to include the students in the industry by means of internships, final-year projects, collaboration in research projects, etc? If so, how can it be implemented in practice?

A summary of the answers we obtained to these questions appear in the following subsections.

2.2 Trends and requirements in the industry

The topic of bio-medical engineering is well implanted in Israel, and is one of the most wanted field in the industry. Though, historically, bio-medical engineering in Israel was a mix of mechanical and electrical engineering, nowadays material engineering and biochemistry plays also a large part in the recent developments. The Israeli industry shows a very strong expertise in the domain of stents (metal, plastic or biological material tube inserted into anatomic vessels or ducts to maintain them open), which at some points connects to the topic of bionic members. Eventually, the main subject of artificial members can be drawn to many different directions, ranging from tissue engineering to bio-medical signal processing and bio-mechanics. Though transverse, the topic of bio-compatibility can also be investigated.

The typical profile expected by the industry is mixed. Candidate in the field should exhibit a good potential in algorithms, good programming skills (in Matlab, Python or any relevant modern language) and abilities to analyze data using computer means. They should also show a good potential in research processes, project management and clinical research.

2.3 Possible collaboration with academia

From the industry point of view, the collaboration with academia is one of the key points for a successful implementation of the new curriculum. From a practical aspect, it is essential to include in the curriculum internships (which may be done in the framework of final-year projects), clinical research periods, and courses in entrepreneurship.

Regarding the organization of the curriculum, it would be valuable for the students to include courses in system engineering and project management, since they will in practice have to deal with complex systems involving the contribution of several fields altogether. This point should be investigated during the development of the curriculum.

3 SWOT Analysis

This section presents a summary of the strengths and weaknesses to be aware of during the completion of the project.

3.1 Strengths

S1: SCE is the largest college in Israel, by the number of students that graduate yearly. Therefore, students wishing to enroll can be easily found, and students who already graduated can serve as potential partners/connections with the industry world.

S2: It is also dedicated to engineering only, and all the departments deal with a specific field. Therefore, there already exists a strong infrastructure, in terms of existing laboratories, library resources, computer rooms, etc.

S3: SCE collaborates regularly with the industry, and holds yearly academic-industry forums, workshops, etc. This existing collaboration can be used for the project's purpose.

3.2 Weaknesses

W1: One main difficulty will be to adapt the level of the course to a diverse population. The program has to be multidisciplinary, and will include students from different departments and backgrounds.

W2: The use of the budget is not clearly defined, and the team members are unaware of what is allowed to do with it. The publication of a budget summary could solve the issue.

W3: Interdisciplinary raises also numerous questions to be addressed. The choice is unclear whether we should build a specific curriculum or specializations, or refine existing courses in the direction of biotechnology.

W4: It is unclear how the interaction between the departments will be in practice, as it is the first time they have to work on a common curriculum.

3.3 Opportunities

O1: Many work opportunities are available in Israel in the field of biotech, and the development of a new curriculum in the field will help the students to insert in the industry world.

O2: There exists much more research centers dedicated to biomedical engineering than curriculum. The development of a joint curriculum could improve the academic collaboration between researchers and institutions.

3.4 Threats

T1: The development of a new joint curriculum in biotechnology could encourage larger universities to update their own curriculum. This would threaten the viability of the project inside the colleges.

T2: Similarly, the industry world could prefer university graduates, even though the developed curriculum fits the needs of the industry.

The aforementioned analysis is summarized in the SWOT graph presented in Figure 1.

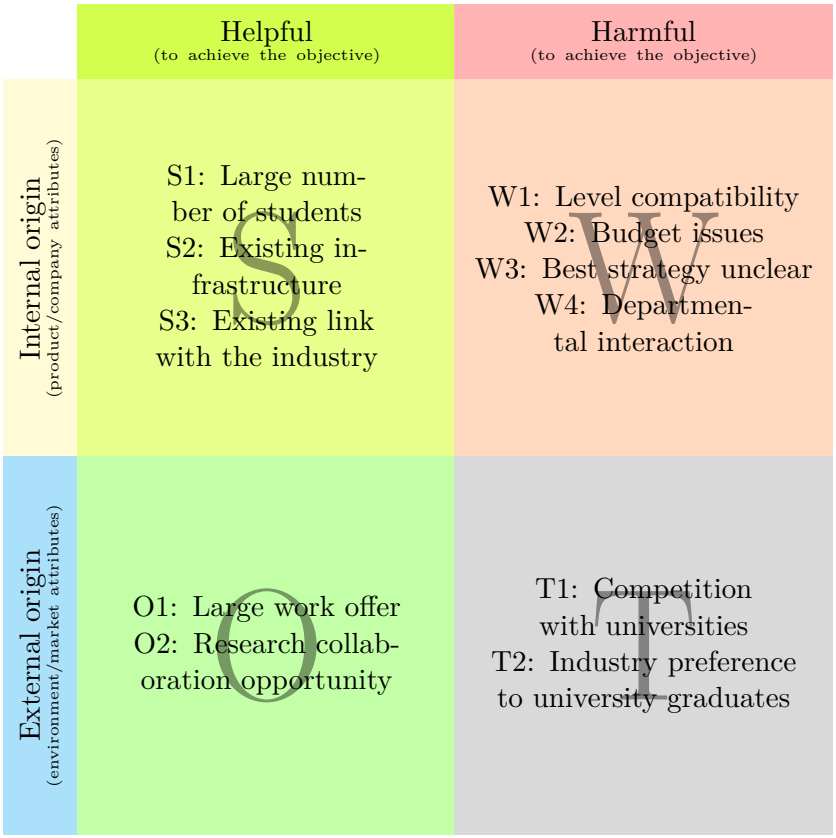

Figure 1: Academic SWOT summary table (Israel)

A List of related courses in universities

A.1 List of biomedical courses proposed as a specialization – B.Sc Level

A.1.1 Electrical Engineering

Course name	IIT	BUI	TAU	AU
Introduction to biological signals and systems	✓			
Audio and visual systems Control systems	✓ ✓			
Introduction to control for biomedical systems	✓	✓		
Biological neural networks	✓			
Spatial signal processing	✓			
Introduction to medical imaging	✓	✓		✓
Introduction to biology	✓	✓	✓	
Introduction to biophysics	✓		✓	
Methods for biological signals analysis	✓	✓		
General chemistry	✓			
Introduction to chemistry	✓		✓	

Molecular biology and genetic engineering		✓	✓	
Introduction to lasers			✓	
Wave transmission in biological matters			✓	
Image processing			✓	
Biomedical image processing		✓	✓	✓
Electrical conduction in cells			✓	
Advanced semiconductors			✓	
Introduction to material engineering			✓	
Physics of materials			✓	
Computational materials			✓	
Big data analysis		✓	✓	
Quantitative physiology		✓		
Biosensors and biochips		✓		
Nano-medicine		✓		
Biomedical devices				✓
Biomedical optics				✓
Introduction to behavioral sciences				✓

A.1.2 Chemical and Material Engineering

Course name	IIT	BGU	TAU	AU
Polymers 1	✓	✓		
Polymers 2	✓			
Applied polymers in biotechnology	✓			
Biomaterials	✓	✓	✓	
Bioengineering of the cell	✓			
Introduction to materials		✓		✓
Nano structures in soft materials		✓		
Structure and properties of advanced materials		✓		✓
Cell and tissue mechanics			✓	
Cell and tissue engineering			✓	
Polymeric biomaterials			✓	

A.1.3 Mechanical Engineering

Course name	IIT	BGU	TAU	AU
Kinematics in biomechanics and robotics	✓			
Tribiology in biology and bionics	✓			
Biomechanics of cells and molecules	✓			
Introduction to integrated sensing systems	✓			
Biophysics and neurophysiology for engineers	✓			
Anatomy and Biomechanics of human body		✓		
Technology of medical systems		✓		
Development of medical technology		✓		

Biomechanics and rehabilitation in sport		✓		
Nanotechnology		✓		

A.2 List of biomedical courses proposed as a specialization in Electrical Engineering – M.Sc Level

Course name	IIT	TAU
Introduction to organic material and devices	✓	
Image processing and analysis	✓	✓
Introduction to biological systems	✓	
Visual and auditory systems	✓	✓
Introduction to medical imaging	✓	✓
Bioexcitable systems	✓	
Laboratory in biomedical systems and signals	✓	✓
Diffuse optics approach in biomedical engineering	✓	
New Directions in Systems and Control Theory Inspired by Systems Biology		✓
Electrophysical and Electromechanical Materials Processing		✓
Advanced Optical Microscopy and Its Applications in Biomedicine		✓

A.3 List of full curriculum biomedical courses – B.Sc Level

A.3.1 Ground courses

Course name	IIT	TAU	BGU
Safety in electrical labs	✓		
Intro to biomedical engineering		✓	
Linear algebra	✓	✓	✓
Calculus 1	✓	✓	✓
Physics 1	✓	✓	✓
General chemistry	✓	✓	✓
Biology 1	✓		
Calculus 2	✓	✓	✓
Ordinary differential equations	✓	✓	✓
Physics 2	✓		✓
Organic chemistry 1	✓		✓
Programming language	✓(C)	✓(Python)	✓(Matlab)
Technical English	✓	✓	✓
Electrical circuits	✓		✓
Complex functions and integral transforms	✓	✓	✓
Partial diff. eqs. and Fourier series	✓	✓	✓
Physical chemistry	✓		

Introduction to biochemistry and enzymology	✓	✓	
Anatomy and microanatomy	✓		✓
Signals and systems	✓	✓	✓
Biophysics and neurophysiology for engineers	✓		✓
Biological fluid mechanics	✓	✓	✓
Introduction to biomechanics	✓	✓	Mb
Metabolic cycles	✓		
Physiology of corporeal systems	✓	✓	✓
Bioelectricity	✓		
From cell to cell tissue	✓	Od	
Introduction to optics and photonics	✓		
Transmission effects in physiological systems	✓	✓	
Bioengineereing laboratory (3)	✓	✓	✓
Biochemical standards	✓		✓
Clinic Engineering project	✓		
Biology of the cell		✓	✓
Physics laboratory		✓	✓
Intro to electrical circuits		✓	
Intro to electronic circuits		✓	
Thermodynamics		✓	✓
Physiological systems in human body (2)		✓	
Electromagnetic waves for bioengineering		✓	✓
Biomaterials		✓	Ob
Mechanics laboratory		✓	Mb
Introduction to Control in Bio-Medical Systems		✓	✓
Computational methods in bioengineering		✓	
Vector analysis			✓

A.3.2 Specialization courses

x-y-z x: Required total, y: mandatory, z: optional			
Biomedical signals and Imaging (a) **Biomechanics and flow (b)** **Tissue and biomaterials engineering (c)** **Biomechanics, biomaterials and tissue engineering (d)** M: mandatory, O: optional, ✓: part of ground courses			
Course name	IIT (5-2-3)	TAU	BGU (5-3-2)
Bioelectrical phenomena	Ma		Ma
Applications of biomedical optics	Ma		✓
Methods for biological signals analysis	Ma		Ma
Introduction to medical imaging	Ma	Ma	
Introduction to control for biomedical systems	Mab		
Introduction to probability	Mab	✓	✓
Nanoparticles in biology, mechanics and rheology	Mbc		

Heat transfer in biological systems	Mb		Mb
Treating ultrasound	Mb		
Flow in respiratory systems	Mb		
Flow in cardiovascular systems	Mb		
Controlled drug absorption	Mc		
Tissue and replacement engineering	Mc	Md	
Flow in Biological Systems		Md	✓
Research methods in cell and tissue engineering		Md	
Biomedical measurements		Mda	
Wave propagation in biological tissues		Ma	
Visual systems processes analysis	Oa		
Medical ultrasound	Oa		Oab
Data analysis and parametric estimation	Oabc		Oab
Magnetic resonance	Oa		
Cardiovascular systems engineering principles	Oabc		
Medical devices, standards and safety	Oa		✓
Introduction to molecule sensing	Oac		
Computer-assisted medical devices	Oab		Oab
Genetic circuits	Oac		Oab
Nuclear medicine and radiotherapy	Oa		
Numerical analysis	Oab	✓	
Introduction to programming systems	Oa		Oab
Digital signal processing	Oa		Ma
Statistical signal processing	Oa		Oab
Neural networks	Oa		
Optimization methods	Oa		
Image processing	Oa	✓	Oa
Stochastic processes	Oa		Oa
Audio and video systems	Oa		
Computer vision algorithms	Oa		
Introduction to statistics	Oab	✓	Oa
Tissue biomechanics	Obc	Od	Ob
Cell bioengineering	Obc		
Orthopedic members and tissue replacements	Obc		
Introduction to robotics	Ob		Ob
Computer assisted flow theory	Ob		
Neural networks for diagnosis and control	Ob		
Cinematics in robotics and biomechanics	Ob		Mb
Electrokinesis in nano/micro-flows	Ob		
Dynamics	Ob		
Solid mechanics	Ob	✓	
Finite-elements methods	Ob		Ob
Elements of biology and biotechnology	Oc		
Biochemical sensors	Oc		Mb

Design of micromechanical devices	Oc		Oab
Polymers and biotech applications	Oc	Od	
Genetics	Oc		Oab
Molecular biology	Oc	Od	
Gene expression regulation	Oc		
Molecular biology	Oc		
Microbiology and rheology	Oc		
Development biology	Oc		
Basics of immunology	Oc		
Neural prosthetics		Od	
Design of the brain		Od	
Organs and replacement members		Od	
Biomedical signal processing laboratory			Ma
Introduction to photo-electronics			Oa
Complex systems mechanics			Ob
Material sustainability in bioengineering			Mb
Biomechanics of bones and arteries			Ob

A.4 List of full curriculum biomedical courses – M.Sc Level

Course name	IIT	BUI	TAU	BGU
Biological Processes	✓			
Advanced Topics in Biomedical Eng 1	✓		✓	
Advanced Topics in Biomedical Eng 2	✓		✓	
Advanced Topics in Biomedical Eng 3	✓		✓	
Advanced Topics in Biomedical Eng 4	✓		✓	
Bio-Electrical Phenomena	✓			
Nano-Particles in Biology Mechanics	✓			
From Cells to Tissues	✓			
Biomedical Optics	✓			
Analysis of Biological Signals	✓			✓
Process Analysis in the Visual System	✓			
Flow in Biological Systems	✓			Od
Ultrasound in Medicine Priniples Apps	✓			
Data Analysis and Parameter Estimation	✓		✓	✓
Engineering Principles in Biology Biotec	✓			
Classification and Clustering in Biological systems	✓		✓	✓
Principles of Medical Imaging	✓		✓	
Principles of M.R. in Medical Imaging	✓		✓	
Rehabilitational Biomechanics	✓		✓	✓
Tissue Biomechanics	✓		✓	
Bioengineering of the Cell	✓			
Heat Transfer in Biological Systems	✓			
Orthopedic Implants and Tissue Substitutes	✓			✓

Engineering Aspects in Cardiovascular systems	✓		✓	
Introduction to Control in Bio-Medical Systems	✓		✓	
Medical Instrumentation Standards Safety	✓			
Intro. to the Cardiovascular System	✓		✓	
Controlled Drug Delivery	✓		✓	
Engineered Tissue Substitutes	✓			
Eng. Analysis of Respiratory Systems	✓		✓	
Principles of Biochemical Sensors	✓			
Fund. of Biomed. Optics and Photonics	✓		✓	
Therapeutic Ultrasound	✓			
Biophysics and Neurophysiology	✓			
Bioengineering of Biomolecular Sensing	✓			
Respiratory Flows Inhalation Therapy	✓			
Design of Medical Instrumentation	✓			
Cardiovascular Flows and Blood Circulation	✓			
Methods in Biomolecular Analysis	✓			
Entrepreneurship in Bio Medical Eng.	✓			
Design and Fabrication of Genetic Circuits	✓			
Nuclear Medicine and Radiotherapy Physics	✓			
Transport Phenomena in Phys. Systems	✓			
Control of Cellular Bioenergetics	✓		✓	
Adv. Methods of Ultrasound in Medicine	✓			
Bioimaterials	✓		✓	
Adv. Seminar in Biomedical Engineering	✓			
Excitation Contraction Coupling in the Neural system	✓			
Neural Recording	✓			
Analytic Methods				✓
Neural Prosthetics			✓	✓
Physiological insights in motricity				✓
Integro-differential equations			✓	
Estimation Theory			✓	
Functional Analysis			✓	
Natural polymers for biomedical applications			✓	
Wounds mechanics, tissue disease and physiomechanics of the cicatrization			✓	
Bone biomechanics			✓	
Reproduction systems biomechanics			✓	
Stress physiology			✓	
Use and applications of stem cells			✓	
Electrical analog models for physiological flow systems			✓	
Computer vision for bioengineering			✓	
Optical methods for diagnosis in medicine			✓	
Advanced topics in bioelectronics			✓	
Advanced topics in ion channels modeling			✓	

Wave propagation in biological tissues			✓	
Biomedical image processing			✓	
Communications in bioengineering			✓	
Electrical signals and propagation in cells			✓	
Polymeric biomaterials			✓	
Artificial Members and Organs			✓	

B List of related courses in colleges

B.1 List of biomedical courses proposed as a specialization – B.Sc Level

Course name	RAC	HIT	SCED	SCE	ORT
Introduction to bioengineering	✓		✓		
Fundamentals of biology and chemistry	✓	✓			
Fundamentals of medicine	✓				
Clinical medicine for engineers	✓				
Medical image processing	✓	✓			
Random signal processes	✓	✓			
Biological signal processing	✓	✓			
Biological signal processing laboratory	✓	✓			
Biomedical devices and apparati	✓	✓			
Introduction to medical imaging	✓	✓			
Biomedical systems laboratory	✓	✓			
Systems for MRI imaging	✓				
Advanced topics in signal and image processing	✓				
Optics for medicine	✓				
Lasers for medicine	✓				
Polymers for chemical engineering			✓		
Anatomy and physiology of the human body		✓		✓	
Introduction to speech processing		✓			
Biomolecules structures		✓			
Design of biomedical research		✓			
Design of neuroprosthetics		✓			
Machine Learning		✓			
Biomechanics of implants					✓
Anatomy					✓
Rehabilitative Biomechanics					✓

B.2 List of biomedical courses proposed as a specialization – M.Sc Level

N/A

B.3 List of full curriculum biomedical courses – B.Sc Level

B.3.1 Ground courses

Course name	ACT	HAC	RAC	THC
Calculus 1	✓	✓	✓	✓
C language	✓		✓	
Introduction to medical technology	✓			
Chemistry for medical engineering	✓			
Calculus 2	✓	✓	✓	✓
Mechanics	✓	✓	✓	
Biology for engineering	✓			
Introduction to probability and statistics	✓	✓	✓	✓
Ordinary differential equations	✓			✓
Engineering graphics for medical engineering	✓			
Complex functions	✓			
Harmonic analysis	✓			
Physics - electricity and magnetism	✓	✓	✓	✓
Physics - electricity and magnetism laboratory	✓			✓
Solid mechanics 1	✓			
Physiology for engineers	✓			
Thermodynamics and heat transfer	✓			✓
Partial differential equations	✓			
Wave theory for medical engineering	✓			
Modern physics for medical engineering	✓			
Physiology and system controls	✓		✓	
Electronics	✓			
Medical electronics laboratory	✓			
Matlab	✓			
Fluid mechanics	✓			
Solid mechanics 2	✓			
Linear systems and control theory	✓			✓
Medical sensors	✓			
Physiological mechanics	✓			
DSP	✓			
Radiation in medicine: imaging and theory	✓			
Numerical analysis	✓			
Digital systems in medicine	✓			
Medical engineering laboratory (matlab)	✓			
General course	✓			
Image Processing	✓			
Advanced Signal Processing and its Medical Applications	✓			

Computer Embedded System Process Control	✓			
Heat and Mass Transfer in Biological Systems	✓			
Computational Methods in Engineering	✓	✓		✓
General and Systemic Pathology	✓			
Advanced Flow and its Medical Applications	✓			
Advanced Applications of Image Processing and its Medical Applications	✓			
Biochemistry 1		✓	✓	✓
Computational biochemistry 1				✓
Biochemistry 2		✓		✓
Biochemistry 2 laboratory		✓		✓
Basics of molecular biology		✓	✓	
Organic chemistry		✓	✓	✓
Organic chemistry laboratory		✓		
Analytic chemistry		✓		✓
General chemistry		✓	✓	✓
Analytic and general chemistry laboratory		✓		✓
Physical chemistry		✓	✓	✓
Introduction to biology		✓		
Microbiology		✓	✓	✓
Microbiology laboratory		✓		✓
Immunology 1		✓	✓	✓
Microbiology laboratory		✓		
Biochemistry laboratory		✓		
Vegetal biotechnology		✓		
Vegetal biotechnology laboratory		✓		
Advanced molecular biology		✓		
Cell biology		✓		✓
Cell biology laboratory				✓
Genetics		✓	✓	✓
Molecular genetics				✓
Molecular genetics laboratory				✓
Endocrine system physiology		✓	✓	
Physiological systems		✓		
Advanced molecular biology laboratory		✓		
Immunology 2		✓		
Virology		✓		✓
Virology laboratory		✓		
Pharmacology and metabolism		✓		
Production in biotechnology		✓		
Genetic ground of diseases		✓		
From genetic engineering to gene therapy		✓		✓

Selected topics in biotechnology			✓	✓
From cell to tissue			✓	✓
From cell to tissue laboratory			✓	✓
Botany			✓	✓
Botany laboratory				✓
Environmental biotechnology				✓
Fermentation and bioreactors				✓
Fermentation and bioreactors laboratory				✓
Antibodies in biotechnology				✓
Fermentation and bioreactors				✓
Environmental biotechnology laboratory				✓
Animal cell cultures				✓
Stem cells				✓
Climatology			✓	
Oceanography 1			✓	
Oceanography 2			✓	
Ecology of mediterranean sea			✓	
Geology			✓	
Chemical Oceanography			✓	
Physical Oceanography			✓	
Biological Oceanography			✓	
Marine zoology			✓	
Introduction to bioinformatics			✓	
Biomorphology			✓	
Water treatment			✓	
Marine natural materials			✓	
Bioinformatics			✓	

B.3.2 Specialization courses

x-y-z x: Required total, y: mandatory, z: optional			
Mechanics of physiological systems (a) **Medical information systems (b)**			
Course name	ACT (8-4-4)	HAC	THC (x-2-x)
Mandatory courses			
Mechanical design for Medical Engineering	Ma	✓	
Material for Medical Engineering and Implants	Ma		
Medical Mechanics Laboratory	Ma		
Introduction for Tissue Engineering	Ma		
Information Systems Analysis	Mb		
Data mining	Mb		
Database and Data-Warehouse Systems	Mb		
Chromatography			M

Analytic spectroscopy			M
Industrial microbiology			M
Enzyme technologies			M
Optional courses			
Clinical Engineering and Health Technology Management	Oab	✓	O
Clinical Trials	Oab	✓	✓
Medical Ethics	Oab	✓	✓
Exposure to the Medical Industry and Medical Centers	Oab	✓	
Introduction to Medical Application	Oab	✓	✓
Selected Topics in Medical Image Processing	Oab		
Application of Internet Technology	Ob		
Algorithms and Data Structures	Ob		
Networked Information	Ob		
Health Information System and System in Telemedicine	Ob		
Computer networks	Ob		
Engineering Economics	Ob		✓
Data Security	Ob		
Object Oriented Programming and Design	Ob		
Computer Communication	Ob		
Introduction to Java Programming	Ob		
Information Theory	Ob		
Selected topics on disease theory			O
Active principles in plants			O
Introduction to pharmacology			O
Clinical biochemistry			O
Vegetal genetic engineering			O
Introduction to neurobiology			O
GSP			O
Design of medications			O

B.4 List of full curriculum biomedical courses – M.Sc Level

x-y-z x: Required total, y: mandatory, z: optional	
Course name	THC
Mandatory courses	
Safety in laboratory	✓
Gene therapy	✓
Vegetal biotechnology	✓
Statistics for biology	✓
R programming	✓

Safe approaches for new medications	M
Selected topics in agronomy	M
Business aspects in biotechnology	✓
Advanced bioinformatics	✓
Antibiotics materials	✓
Quantitive and population genetics	✓
Enzymes and proteins biochemistry	M
Molecular origins of cancer	M
Optional courses	
Human molecular genetics	O
Diagnostics and veterinarian research	O
Mushroom biotechnology	O
Pollination and fertilization	O
Computational genetics	O
Paper reading	O
Free radicals and oxydative stress	O
Diabetes: physiology, diagnosis and treatement	O
Medical biotechnology	O
Animal diseases	O
Vegetal development biology	O
Biochemistry of infectious reactions	O
Biology of the yeast	O