Program SPECIFICATION FOR Master Degree in Medical Biophysics Code: 700

University: Alexandria **Faculty:** Medical Research Institute

Program Specification

A- Basic information

1- Program title : Master Degree in Medical Biophysics

2- Program type: **single** [√] **double** [ ] **multiple** [ ]

3- Department(s) : Medical Biophysics

4- Coordinator : Prof/ Thanaa I Shalaby

5- External evaluator(s):

Prof/ Elsayed Mahmoud Elsayed Solayman

6- Last date of program specification approval: 8/1/2017

B- Professional Information

1- Program aims to provide student knowledge on:

1- Survey of definitions and computational methods for the calculation of intermolecular forces, molecular dynamics and protein folding and biophysics and energetics of enzymatic reactions in biological systems

2- Tissue engineering theory and principles with emphasis on cell behavior and morphology. Cellular attachment, Extracellular matrix, Tissue organization, Cell culture, Synthetic biomaterials and artificial cells and organs.

3- Employment of mathematical methods to solve important problems in a wide variety of fields of biology and medicine

4- Theory and measurement of radiation as applied in medicine and the laboratory with emphasis on wide variety of radiation sources from health physics perspective, and Radiation risks and radiation protection guidelines, including international current regulations.

5- Introduction to the electrical and computer engineering contributions to biomedical engineering

6- The biological transport of cell biology include: Convection laws, Diffusion, Active transport, Osmosis, mass and energy which applied in cellular and organ level (e.g. respiratory system and renal physiology)

7- Electrical biophysics of nerve and muscle. Electrical conduction in excitable tissue. Quantitative models for nerve and muscle including the Hodgkin-Huxley equations. Bio mapping potential, Cardiac electrophysiology, and Functional electrical stimulation.

8- Fundamental principles of mechanics applied to the study of biological systems. Passive mechanical behaviors of biological materials. Measurement of nonlinear strain in tissues, arterial flow. Mechanical interactions of implants with tissue. Skeletal muscle mechanics. Segmental biomechanics. Control of motion

9- The physical principals of magnetic resonance imaging and its clinical applications. Strategies for fast imaging, Clinical MRI techniques. Topics include: Proton environments and T1 relaxation, Transverse magnetization and T2 contrast, Magnetic field gradient, Pulse sequences, Signal-to-noise ratio and spatial resolution, Receiver coils, Magnetic field strength, Gradient echo and spin echo, multi echo techniques

10- Physics and mathematics of three-dimensional reconstruction techniques in medical imaging. Projection slice theorem.Back -projection techniques. Analytical and iterative reconstruction algorithms. Numerical methods.Applications in X-Ray Computed Tomography. Single Photon Emission Computed Tomography, Positron Emission Tomography, Nuclear Magnetic Resonance.

11- The biophysics principals of Ultrasound and lasers, Acoustic-wave propagation in biological materials, Ultrasound laboratory equipment. Basic concepts for a laser, different types of lasers, Laser interaction with biological tissues. Laser in Medicine and Biology and LASER Regulation

12- The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.

13- Theory, fundamental and operating principles techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). The structure and function of the electron microscopes (TEM, SEM, and STEM), Tissue preparation for both types of scopes, freeze fracture and image analysis.

14- Photographic techniques and some special applications to include energy dispersive spectroscopy (EDS

15- The therapeutic medical devices such as Pacemakers and defibrillators, Neural assist devices, Prosthetic joints, Physical therapy equipment, Cardiac valves, angioplasty, Arterial stents, Anesthesia machine and ventilator, Artificial kidney and pancreas, gastrointestinal therapy, Photodynamic therapy,Computerized Tomography, Magnetic Resonance Imaging, Radiotherapy linear accelerator, Gamma Camera, Positron Emission Tomography

16- Mathematical and computational methods and concepts needed in the analysis of a wide range of medical and biological phenomena.

17- The quantitative analysis of chemical signaling using: Bioelectronics, electron transport and second messenger production.Receptor/Ligand binding and trafficking. Signal transduction and Cellular responses such as adhesion and migration.

2- Intended learning outcomes (ILOS)

a- knowledge and understanding:

a1-Discuss the structure and function for biological macromolecules from a theoretical prospect, intermolecular forces of biomolecular interactions like protein/DNA complexes and energetic of enzymatic reactions

a2-Discuss tissue engineering theory and principles, different types of stem cells, extracellular matrix biochemistry and cell culture conditions

a3-Explain the role and bases of mathematical modeling in medicine, bioheat transfer and hyperthermia and artificial neural network modeling and its applications

a4-Discuss radiation and its different types, measurements of radiation dose, tissue sensitivity and the factors affecting the biological effects of radiation and protection from radiation hazards

a5-Recall basics of biomedical engineering. the principles of electrophysiology.

a6-Discuss the difference between active transport, diffusion and osmosis, mass and energy transport in biological system.

a7-Discuss the biophysics of nerve and muscle, electrical conduction in excitable tissue and bio-potential mapping.

a8-State the fundamental principles of mechanics applied to the study of biological systems, nonlinear strain in tissues and Arterial flow, motion control mechanisms

a9-Discuss the physical principals of magnetic resonance imaging, the T1 &T2 relaxation factors and the Magnetic field gradient, the pulse sequences, Signal-to-noise ratio and spatial resolution

a10-Recall the advanced Physics and mathematics of three-dimensional reconstruction techniques in medical imaging, the slice projection theorem of medical imaging, the different image reconstruction algorithms, different numerical methods and its applications in X-Ray Computed Tomography, positron emission tomography and nuclear magnetic resonance .

a11-Discuss the acoustic-wave production and the piezoelectric effects, Laser beam production, the physical parameters by which laser dose can be calculated, the Laser hazard to be avoid during applications

a12-Discuss hypertension, atherosclerosis, coronary artery, peripheral and cerebrovascular diseases. in vivo vascular imaging principles and approaches such as flow restriction models.

a13-Recall the basic structure and function of transmission electron microscopy, mechanisms of illumination and interaction with biological tissue, the basics of structure and function of scanning electron microscopy, signal detectors of scanning electron microscopy.

a14-Explain the working idea for some physical therapy equipment, the artificial kidney and artificial pancreas and the bases of Computerized Tomography, Magnetic Resonance Imaging.

a15-Discuss topics on linear algebra like vectors, matrices, vector spaces, determinants, eigen values and linear transformations, topics on advanced calculus such as double and triple integrals, Fourier transforms, infinite series, improper integrals, Gamma and Beta functions and functions of complex variables and topics on ordinary and partial differential equations.

a16-Discuss chemical signaling, the quantitative analysis of chemical signaling and receptor/ligand binding and trafficking

a17-Discuss the standard methods of preparing experimental research design, the basics of scientific writing, the elementary statistical analysis methods of experimental data and ethics of scientific research, publishing and copyrights.

b- Intellectual skills:

b1- Compare between different experimental methods used to study properties of biological molecules.

b2- Compare between different tissue engineering processes.

b3- Examine a biomedical systems with appropriate mathematical model.

b4- Compare between different radio diagnostic and therapeutic modalities.

b5- Evaluate different physical parameters related to image quality and processing.

b6- Compare between the different medical imaging techniques.

b7- Compare between the bio-transport mechanisms in living system.

b8- Analyze the cardiac electrophysiology.

b9- Calculate both the nonlinear strain in tissues and arterial flow rate.

b10- Analyze different numerical methods in X-Ray Computed Tomography, Nuclear Magnetic Resonance and positron emission tomography .

b11-Describe the acoustic-wave production and the piezoelectric effects and Laser beam production.

b12-Evaluate the applicability of different vascular imaging techniques based on the anatomical, physiological and physical parameters.

b13-Compare between column design in transmission and scanning electron microscope and between different mechanisms of electron beam interaction with specimen

b14-Examine the functionality of Neural assist devices, Prosthetic joints, Cardiac valves

b15-Develop mathematical equations to represents a biological system using linear algebra, advanced calculus, ordinary and partial differential equations

b16-Analyze chemical signaling using bioelectronics

b17-Differentiate between different methodologies used to carry out a scientific research.

c- professional and practical skills:

c1-Use methods for separation and concentration calculation of proteins and nucleic acids.

c2-Illustrate cells components and tissue types by light and electron microscope.

c3-Demonstrate cell culture conditions scaffold preparation techniques

c4-Employ a computer algorithm to formulate a mathematical model for testing.

c5-Apply the radiation dose and the maximum permissible dose of radiation laws in therapy planning.

c6-Demonstrate the use of low dose electromagnetic magnetic field in medical applications

c7-Demonstrate the ECG and EMG apparatus in the lab.

c8-Employ mathematical equations to calculate mass and energy in bio transport of biological cell.

c9-Evaluate the electrical conduction in excitable tissue of experimental animals.

c10-Use mathematical equations to evaluate some mechanical parameters of biomaterials.

c11-Use computerized methods to calculate MRI physical parameters

c12-Use computer programming languages to run analytical and iterative reconstruction algorithms

c13-Demonstrate image processing techniques used in clinical X-ray computed tomography

c14-Demonstrate the different types ultrasound and laser devices.

c15-Practice the ultrasound and laser experimental procedures used in biomedical research.

c16-Apply equations to calculate laser dose.

c17-Apply mathematical equations to calculate the peripheral blood flow rate using different imaging techniques.

c18-Use computational methods for vascular images processing.

c19-Interpret vascular imaging outcomes and judge vessels health.

c20-Practice the preparation of buffers, fixatives, dehydration embedding resins used in specimen preparation for transmission electron microscopy.

c21-Demonstrate the cutting sectioning and staining of samples, the preparation of support films and negative staining, the ultrastructure and cell components under the screen of electron microscopy .

C22-Demonstrate clinical MRI, clinical linear accelerator and kidney dialysis machine

c23-Use computer programming languages like FORTRAN and C++ to test algorithms and validate mathematical models.

c24-Demonstrate bioelectronics acquisition of chemical signals.

c25-Use computer software to process the chemical signals harvested by bioelectronics

c26-Demonstrate cell adhesion and migration using light and electron microscope

c27-Use the appropriate research methodology to conduct a research .

c28-Apply statistical methods to analyze experimental data .

c29-Use the principal of scientific writing to avoid literal mistakes and misrepresentations.

c30-Illustrate the ethical issues related to the scientific research

d- General and transferable skills:

d1 Develop skills in reading

d2- Develop team work.

d3- Use information technology.

d4- Increase written and oral skills.

3- Academic standards

3a External references for standards (Benchmarks)

Generic Academic Reference Standards if the National Authority for Quality Assurance and Accreditation of Education (NAQAAE)

3b Comparison of provision to selected external references

Generic Academic Standards	**ARS of MSc in Medical Biophysics**
A1- Basic facts , theories, of the specialty and related subjects/ fields	a1- Recognize the principals of bioelectricity, biotransport and biomechanics a2- Discuss advanced topics about different medical imaging modalities a3- Recognize the role of biomedical engineering in advancing all of biomedical sciences a4- Discuss advanced topics on radiation biophysics and dosimetry a5- Recognize the different research methodologies, statistical analyses and ethical considerations

A2-Mutual relation between professional practice and effects on environment	a1- Recognize the principals of bioelectricity, biotransport and biomechanics b2- Judge the applicability of different image modalities in diseases and organ dysfunction diagnosis b3-Evaluate many biophysical parameters used in radiodiagnosis and radiotherapy c4- Demonstrate the design and working of some medical therapeutic devices
A3- Main scientific advances in the field of practice	c3- Use computer software to test mathematical models represent some biomedical systems. c4- Demonstrate the design and working of some high technology medical therapeutic devices
A4- Fundamentals of ethical & legal practice	Recognize ethical and legal considerations in laboratory practice through thesis work a5- Recognize the different research methodologies, statistical analyses and ethical considerations
A5 -Quality standards of the practice	Ensure the quality of practice through experimental quizzes and practical exams
A6- Basics and ethics of scientific research	- Design, conduct & publish scientific research through thesis work a5- Recognize the different research methodologies, statistical analyses and ethical considerations
B1- Interpret, analyze & evaluate the information to solve problems	b1-Construct mathematical methods to represent biomedical systems b2- Judge the applicability of different image

	modalities in diseases and organ dysfunction diagnosis b3-Evaluate many biophysical parameters used in radiodiagnosis and radiotherapy b4-Analyze chemical signaling in cellular communications, adhesion and migration.
B2- Solve some problems that do not conform to classic data (incomplete data)	b1-Construct mathematical methods to represent biomedical systems b3-Evaluate many biophysical parameters used in radiodiagnosis and radiotherapy
B3- Integrate different information to solve professional problems	b3- Interpret abnormal lab results concerning different diseases in different organs
B4- Conduct a scientific research &/Or write scientific systematic approach to a research problem (hypothesis)	Conduct a scientific research &/Or write scientific systematic approach to a research problem (hypothesis) through thesis work a5- Recognize the different research methodologies, statistical analyses and ethical considerations
B5- Evaluate risks imposed during professional practice	b3-Evaluate many biophysical parameters used in radiodiagnosis radiotherapy, radiation hazards and radiation safety
B6- Plan for professional improvement	c1-Practice versatile procedures to prepare tissue samples to be studied under the electron microscope. c2- Use Ultrasound and laser devices in lab to study the mechanisms of interaction between ultrasound waves and laser photons with the biological tissues

	c3- Use computer software to test mathematical models represent some biomedical systems. c4- Demonstrate the design and working of some high technology medical therapeutic devices
B7- Take professional decisions in wide range of professional situations	b2- Judge the applicability of different image modalities in diseases and organ dysfunction diagnosis
C1- Competent in all basic and some of the advanced professional skills (to be determined according to the specialty board/ department)	c1-Practice versatile procedures to prepare tissue samples to be studied under the electron microscope. c2- Use Ultrasound and laser devices in lab to study the mechanisms of interaction between ultrasound waves and laser photons with the biological tissues c3- Use computer software to test mathematical models represent some biomedical systems. c4- Demonstrate the design and working of some high technology medical therapeutic devices
C2- Write and appraise reports	Write and appraise reports through assignments and case studies
C3-Evaluate methods and tools used in specialty	b1-Construct mathematical methods to represent biomedical systems c3- Use computer software to test mathematical models represent some biomedical systems. c5- construct simulation models and prototypes to serve the recent challenges of medical technology
D1- Communicate effectively using all methods	d2- Develop team work and communication skills
D2- Use information technology to improve his/her professional practice	d3- Use information technology.
D3- Practice self appraisal and determines his learning needs	d1-Develop skills in reading. d2- Develop team work and communication skills

	d4- Increase written and oral skills.
D4- Share in determination of standards for evaluation of others (e.g.: subordinates/ trainees etc.)	Share in determination of standards for evaluation of others through thesis and seminars
D5-Use different sources of information to obtain data	Use different sources of information to obtain data through thesis work
D6-Work in teams	d2- Develop team work, communication skills and time management
D7-Manage time effectively	d2- Develop team work, communication skills and time management
D8-Work as team leader in situations comparable to his work level	d2- Develop team work, communication skills and time management
D9-Learn independently and seek continuous learning	Learn independently and seek continuous learning through thesis work Follow the study tracks of previous MSc and PhD graduates to benefit from their experience

4- curriculum structure and contents

4.a program duration: from 2 to 5 years

4.b program structure :

4.b.i- No. of hours per week in each year/semester: from 12 to 14 hours per week in each semester

Semester	**Number of hours**
First semester	**9 credit hours**
Second semester	**6 credit hours**
Third semester	**9 credit hours**
Forth semester	**6 credit hours**
Thesis	**8 credit hours after finishing 12 credit hours at least**

4.b.ii- No. of credit hours	**Lectures**	**20**	**Practical**	**10**	**Total**	**30**
	Compulsory	**24**	**Elective**	**6**	**Optional**	**0**

4.b.iii- No. of credit hours of basic science courses	**No.**	**30**	**%**	**100**
4.b.iv- No. of credit hours of courses of social sciences and humanities.	**No.**	**0**	**%**	**0**
4.b.v- No. of credit hours of specialized courses	**No.**	**24**	**%**	**80**
4.b.vi- No. of credit hours of other courses	**No.**	**0**	**%**	**0**
4.b.vii- Practical/Field Training	**Yes**	**-**	**No**	**√**

4.b.viii- Program levels (in credit-hours system)

Student is required to pass at least 12 credit hours with CGPA not less than C+ before submitting a thesis proposal.

5- Program Courses

5.1- Compulsory (24)

Code No.	Course Title	No. of credit hours	No. of hours /week	
			Lecture	Practical
1712701	Biophysics of proteins and nucleic acids-I	3	2	2
1712702	Fundamentals of tissue engineering -I	3	2	2
1712703	Introduction to mathematical modeling in medical biophysics-I	3	2	2
1712704	Advances in radiological biophysics and dosimetry-I	3	2	2
1712705	Advances in biomedical engineering -I	3	2	2
1712706	Biotransport -I	3	2	2
1712707	Bioelectricity	3	2	2
1712708	Biomechanics	3	2	2

5.2- Elective (6)

Code No.	Course Title	No. of	No. of hours /week

		credit hours	Lecture	Practical
1712709	Advanced topics in magnetic resonance imaging	3	2	2
1712710	3-D Reconstruction techniques in medical imaging	3	2	2
1712711	Advanced topics in ultrasound and laser biophysics	3	2	2
1712712	Advances in vascular imaging techniques	3	2	2
1712713	Advanced topics in electron microscopy	3	2	2
1712714	Advances in therapeutic medical devices	3	2	2
1712715	Mathematical methods I	3	2	2
1712716	Analysis of chemical signaling	3	2	2
1712717	Journal club in medical biophysicsI	3	2	2
1701720	Biochemistry	3	2	2
1703720	Physiology	3	2	2
1704720	Pharmacology	3	2	2
1706720	Bacteriology	3	2	2
1707720	Parasitology	3	2	2
1709720	Histochemisty and cell biology I	3	2	2
1721720	Medical statistics	3	2	2

5.3- Optional – (none)

6- Program admission requirements

Graduate students with a degree of science, education, engineering, applied medical science, medicine, dentistry, pharmacy, nursing, veterinary medicine, physiotherapy, or any degree relevant to medical biophysics and recognized by the council of the medical biophysics department

7- Regulations for progression and program completion

For the progression and completion of the program to obtain the degree of master in medical biophysics, the student must complete 38 credit hours with CGPA of at least C+ and submit a thesis validity report.

8- Evaluation of program intended learning outcomes

Evaluator	tool	Sample
1- Senior students	Questionnaire	All the students
2- Alumni	NA	NA
3- Stakeholders (Employers)	NA	NA
4- External Evaluator(S) External Examiner (s)	**Prof/ Elsayed Mahmoud Elsayed Solayman**	NA
5- Other	NA	NA

Dates of previous editions/revisions

Editions/revisions number	Date
Edition no 1	**2009**
Edition no 2	**2011**
Edition no 3	**5/6/2014**
Edition no 3, revision no 1	**12/2014**
Edition no 3, revision no 2	**10/2016**
Edition no 3, revision no 3	**6/9/2017**

Program coordinator :

Name: Prof/ Thanaa I Shalaby
Signature ……. Date ……

Program Courses vs teaching and learning methods Matrix

	801	*802*	*803*	*804*	*805*	*806*	*807*	*808*	*809*	*810*	*811*	*812*	*813*	*814*	*815*	*816*	*817*	*820*
Lectures	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Practical sessions	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Seminars	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
group discussion	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
self learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
brain storming	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Program Courses vs Program ILO's Matrix

Course code	Course title	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16	a17
1712701	Biophysics of proteins and nucleic acids-I	√																
1712702	Fundamentals of tissue engineering -I		√															
1712703	Introduction to mathematical modeling in medical biophysics-I			√														
1712704	Advances in radiological biophysics and dosimetry-I				√													
1712705	Advances in biomedical engineering -I					√												
1712706	Biotransport -I						√											
1712707	Bioelectricity							√										
1712708	Biomechanics								√									
1712709	Advanced topics in magnetic resonance imaging									√								
1712710	3-D Reconstruction techniques in medical imaging										√							
1712711	Advanced topics in ultrasound and laser biophysics											√						
1712712	Advances in vascular imaging techniques												√					
1712713	Advanced topics in electron microscopy													√				
1712714	Advances in therapeutic medical devices														√			
1712715	Mathematical methods I															√		
1712716	Analysis of chemical signaling																√	
1712717	Journal club in medical biophysicsI																	√

Course code	Course title	b1	b2	b3	b4	b5	b6	b7	b8	b9	b10	b11	b12	b13	b14	b15	b16	b17
1712701	Biophysics of proteins and nucleic acids-I	√																
1712702	Fundamentals of tissue engineering -I		√															
1712703	Introduction to mathematical modeling in medical biophysics-I			√														
1712704	Advances in radiological biophysics and dosimetry-I				√													
1712705	Advances in biomedical engineering -I					√												
1712706	Biotransport -I						√											
1712707	Bioelectricity							√										
1712708	Biomechanics								√									
1712709	Advanced topics in magnetic resonance imaging									√								
1712710	3-D Reconstruction techniques in medical imaging										√							
1712711	Advanced topics in ultrasound and laser biophysics											√						
1712712	Advances in vascular imaging techniques												√					
1712713	Advanced topics in electron microscopy													√				
1712714	Advances in therapeutic medical devices														√			
1712715	Mathematical methods I															√		
1712716	Analysis of chemical signaling																√	

1712717	Journal club in medical biophysicsI																	√

Course code	Course title	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16
1712701	Biophysics of proteins and nucleic acids-I	√															
1712702	Fundamentals of tissue engineering -I		√														
1712703	Introduction to mathematical modeling in medical biophysics-I			√													
1712704	Advances in radiological biophysics and dosimetry-I				√												
1712705	Advances in biomedical engineering -I					√											
1712706	Biotransport -I						√		√								
1712707	Bioelectricity							√		√							

1712708	Biomechanics										√						
1712709	Advanced topics in magnetic resonance imaging											√	√				
1712710	3-D Reconstruction techniques in medical imaging													√			
1712711	Advanced topics in ultrasound and laser biophysics														√	√	√

Course code	Course title	C17	c18	c19	c20	c21	c22	c23	c24	c25	c26	c27	c28	c29	c30
1712712	Advances in vascular imaging techniques	√	√	√											
1712713	Advanced topics in electron microscopy				√	√									
1712714	Advances in therapeutic medical devices						√								
1712715	Mathematical methods I							√							
1712716	Analysis of chemical signaling								√	√	√				
1712717	Journal club in medical biophysicsI											√	√	√	√

Course code	Course title	d1	d2	d3	d4
1712701	Biophysics of proteins and nucleic acids-I	√	√	√	√
1712702	Fundamentals of tissue engineering -I	√	√	√	√
1712703	Introduction to mathematical modeling in medical biophysics-I	√	√	√	√
1712704	Advances in radiological biophysics and dosimetry-I	√	√	√	√
1712705	Advances in biomedical engineering -I	√	√	√	√
1712706	Biotransport -I	√	√	√	√
1712707	Bioelectricity	√	√	√	√
1712708	Biomechanics	√	√	√	√
1712709	Advanced topics in magnetic resonance imaging	√	√	√	√
1712710	3-D Reconstruction techniques in medical imaging	√	√	√	√
1712711	Advanced topics in ultrasound and laser biophysics	√	√	√	√
1712712	Advances in vascular imaging techniques	√	√	√	√
1712713	Advanced topics in electron microscopy	√	√	√	√
1712714	Advances in therapeutic medical devices	√	√	√	√
1712715	Mathematical methods I	√	√	√	√
1712716	Analysis of chemical signaling	√	√	√	√
1712717	Journal club in medical biophysicsI	√	√	√	√

Program Aims vs Program ILO's Matrix

No.	Aim	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16	a17
1	Survey of definitions and computational methods for the calculation of intermolecular forces, molecular dynamics and protein folding and biophysics and energetics of enzymatic reactions in biological systems	√																
2	Tissue engineering theory and principles with emphasis on cell behavior and morphology. Cellular attachment, Extracellular matrix, Tissue organization, Cell culture, Synthetic biomaterials and artificial cells and organs.		√															
3	Employment of mathematical methods to solve important problems in a wide variety of fields of biology and medicine			√														
4	Theory and measurement of radiation as applied in medicine and the laboratory with emphasis on wide variety of radiation sources from health physics perspective, and Radiation risks and radiation protection guidelines, including international current regulations.				√													
5	Introduction to the electrical and computer engineering contributions to biomedical engineering					√												
6	The biological transport of cell biology include: Convection laws, Diffusion, Active transport, Osmosis, mass and energy which applied in cellular and organ level (e.g. respiratory system and renal physiology)						√											

7	Electrical biophysics of nerve and muscle. Electrical conduction in excitable tissue. Quantitative models for nerve and muscle including the Hodgkin-Huxley equations. Bio mapping potential, Cardiac electrophysiology, and Functional electrical stimulation.							√										
8	Fundamental principles of mechanics applied to the study of biological systems. Passive mechanical behaviors of biological materials. Measurement of nonlinear strain in tissues, arterial flow. Mechanical interactions of implants with tissue. Skeletal muscle mechanics. Segmental biomechanics. Control of motion								√									
9	The physical principals of magnetic resonance imaging and its clinical applications. Strategies for fast imaging, Clinical MRI techniques. Topics include: Proton environments and T1 relaxation, Transverse magnetization and T2 contrast, Magnetic field gradient, Pulse sequences, Signal-to-noise ratio and spatial resolution, Receiver coils, Magnetic field strength, Gradient echo and spin echo, multi echo techniques									√								
10	Physics and mathematics of three-dimensional reconstruction techniques in medical imaging. Projection slice theorem.Back - projection techniques. Analytical and iterative reconstruction algorithms. Numerical methods.Applications in X-Ray Computed Tomography. Single Photon Emission Computed Tomography, Positron Emission Tomography, Nuclear Magnetic Resonance.										√							
11	The biophysics principals of Ultrasound and lasers, Acoustic-wave propagation in biological materials, Ultrasound laboratory equipment. Basic concepts for a laser, different types of lasers, Laser interaction with biological tissues. Laser in Medicine and Biology and LASER Regulation											√						
12	The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.												√					

13	Theory, fundamental and operating principles techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). The structure and function of the electron microscopes (TEM, SEM, and STEM), Tissue preparation for both types of scopes, freeze fracture and image analysis.													√				
14	Photographic techniques and some special applications to include energy dispersive spectroscopy (EDS														√			
15	The therapeutic medical devices such as Pacemakers and defibrillators, Neural assist devices, Prosthetic joints, Physical therapy equipment, Cardiac valves, angioplasty, Arterial stents, Anesthesia machine and ventilator, Artificial kidney and pancreas, gastrointestinal therapy, Photodynamic therapy,Computerized Tomography, Magnetic Resonance Imaging, Radiotherapy linear accelerator, Gamma Camera, Positron Emission Tomography															√		
16	Mathematical and computational methods and concepts needed in the analysis of a wide range of medical and biological phenomena.																√	
17	The quantitative analysis of chemical signaling using: Bioelectronics, electron transport and second messenger production. Receptor/Ligand binding and trafficking. Signal transduction and Cellular responses such as adhesion and migration.																	√

No.	**Aim**	**b1**	**b2**	**b3**	**b4**	**b5**	**b6**	**b7**	**b8**	**b9**	**b10**	**b11**	**b12**	**b13**	**b14**	**b15**	**b16**	**b17**

1	Survey of definitions and computational methods for the calculation of intermolecular forces, molecular dynamics and protein folding and biophysics and energetics of enzymatic reactions in biological systems	√																
2	Tissue engineering theory and principles with emphasis on cell behavior and morphology. Cellular attachment, Extracellular matrix, Tissue organization, Cell culture, Synthetic biomaterials and artificial cells and organs.		√															
3	Employment of mathematical methods to solve important problems in a wide variety of fields of biology and medicine			√														
4	Theory and measurement of radiation as applied in medicine and the laboratory with emphasis on wide variety of radiation sources from health physics perspective, and Radiation risks and radiation protection guidelines, including international current regulations.				√													
5	Introduction to the electrical and computer engineering contributions to biomedical engineering					√												
6	The biological transport of cell biology include: Convection laws, Diffusion, Active transport, Osmosis, mass and energy which applied in cellular and organ level (e.g. respiratory system and renal physiology)						√											
7	Electrical biophysics of nerve and muscle. Electrical conduction in excitable tissue. Quantitative models for nerve and muscle including the Hodgkin-Huxley equations. Bio mapping potential, Cardiac electrophysiology, and Functional electrical stimulation.							√										
8	Fundamental principles of mechanics applied to the study of biological systems. Passive mechanical behaviors of biological materials. Measurement of nonlinear strain in tissues, arterial flow. Mechanical								√									

	interactions of implants with tissue. Skeletal muscle mechanics. Segmental biomechanics. Control of motion																	
9	The physical principals of magnetic resonance imaging and its clinical applications. Strategies for fast imaging, Clinical MRI techniques. Topics include: Proton environments and T1 relaxation, Transverse magnetization and T2 contrast, Magnetic field gradient, Pulse sequences, Signal-to-noise ratio and spatial resolution, Receiver coils, Magnetic field strength, Gradient echo and spin echo, multi echo techniques									√								
10	Physics and mathematics of three-dimensional reconstruction techniques in medical imaging. Projection slice theorem.Back -projection techniques. Analytical and iterative reconstruction algorithms. Numerical methods.Applications in X-Ray Computed Tomography. Single Photon Emission Computed Tomography, Positron Emission Tomography, Nuclear Magnetic Resonance.										√							
11	The biophysics principals of Ultrasound and lasers, Acoustic-wave propagation in biological materials, Ultrasound laboratory equipment. Basic concepts for a laser, different types of lasers, Laser interaction with biological tissues. Laser in Medicine and Biology and LASER Regulation											√						
12	The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.												√					
13	Theory, fundamental and operating principles techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). The structure and function of the electron microscopes (TEM, SEM, and STEM), Tissue preparation for both types of scopes, freeze fracture and image analysis.													√				
14	Photographic techniques and some special applications to include energy dispersive spectroscopy (EDS														√			

15	The therapeutic medical devices such as Pacemakers and defibrillators, Neural assist devices, Prosthetic joints, Physical therapy equipment, Cardiac valves, angioplasty, Arterial stents, Anesthesia machine and ventilator, Artificial kidney and pancreas, gastrointestinal therapy, Photodynamic therapy,Computerized Tomography, Magnetic Resonance Imaging, Radiotherapy linear accelerator, Gamma Camera, Positron Emission Tomography														√		
16	Mathematical and computational methods and concepts needed in the analysis of a wide range of medical and biological phenomena.															√	
17	The quantitative analysis of chemical signaling using: Bioelectronics, electron transport and second messenger production. Receptor/Ligand binding and trafficking. Signal transduction and Cellular responses such as adhesion and migration.																√

No.	**Aim**	**c1**	**c2**	**c3**	**c4**	**c5**	**c6**	**c7**	**c8**	**c9**	**c10**	**c11**	**c12**	**c13**	**c14**	**c15**	**c16**	**c17**
1	Survey of definitions and computational methods for the calculation of intermolecular forces, molecular dynamics and protein folding and biophysics and energetics of enzymatic reactions in biological systems	√																
2	Tissue engineering theory and principles with emphasis on cell behavior and morphology. Cellular attachment, Extracellular matrix, Tissue organization, Cell culture, Synthetic biomaterials and artificial cells and organs.		√	√														
3	Employment of mathematical methods to solve important problems in a wide variety of fields of biology and medicine				√													

4	Theory and measurement of radiation as applied in medicine and the laboratory with emphasis on wide variety of radiation sources from health physics perspective, and Radiation risks and radiation protection guidelines, including international current regulations.					√	√											
5	Introduction to the electrical and computer engineering contributions to biomedical engineering							√										
6	The biological transport of cell biology include: Convection laws, Diffusion, Active transport, Osmosis, mass and energy which applied in cellular and organ level (e.g. respiratory system and renal physiology)								√									
7	Electrical biophysics of nerve and muscle. Electrical conduction in excitable tissue. Quantitative models for nerve and muscle including the Hodgkin-Huxley equations. Bio mapping potential, Cardiac electrophysiology, and Functional electrical stimulation.									√								
8	Fundamental principles of mechanics applied to the study of biological systems. Passive mechanical behaviors of biological materials. Measurement of nonlinear strain in tissues, arterial flow. Mechanical interactions of implants with tissue. Skeletal muscle mechanics. Segmental biomechanics. Control of motion										√							
9	The physical principals of magnetic resonance imaging and its clinical applications. Strategies for fast imaging, Clinical MRI techniques. Topics include: Proton environments and T1 relaxation, Transverse magnetization and T2 contrast, Magnetic field gradient, Pulse sequences, Signal-to-noise ratio and spatial resolution, Receiver coils, Magnetic field strength, Gradient echo and spin echo, multi echo techniques											√						

10	Physics and mathematics of three-dimensional reconstruction techniques in medical imaging. Projection slice theorem.Back -projection techniques. Analytical and iterative reconstruction algorithms. Numerical methods.Applications in X-Ray Computed Tomography. Single Photon Emission Computed Tomography, Positron Emission Tomography, Nuclear Magnetic Resonance.												√	√				
11	The biophysics principals of Ultrasound and lasers, Acoustic-wave propagation in biological materials, Ultrasound laboratory equipment. Basic concepts for a laser, different types of lasers, Laser interaction with biological tissues. Laser in Medicine and Biology and LASER Regulation														√	√	√	
12	The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.																	√

No.	Aim	c18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
12	The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.	√	√											
13	18- Theory, fundamental and operating principles techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). The structure and function of the electron microscopes (TEM, SEM, and STEM), Tissue preparation for both types of scopes, freeze fracture and image analysis.			√	√									
14	19- Photographic techniques and some special applications to include energy dispersive spectroscopy (EDS					√								

15	The therapeutic medical devices such as Pacemakers and defibrillators, Neural assist devices, Prosthetic joints, Physical therapy equipment, Cardiac valves, angioplasty, Arterial stents, Anesthesia machine and ventilator, Artificial kidney and pancreas, gastrointestinal therapy, Photodynamic therapy,Computerized Tomography, Magnetic Resonance Imaging, Radiotherapy linear accelerator, Gamma Camera, Positron Emission Tomography						√							
16	20- Mathematical and computational methods and concepts needed in the analysis of a wide range of medical and biological phenomena.							√	√	√				
17	21- The quantitative analysis of chemical signaling using: Bioelectronics, electron transport and second messenger production.Receptor/Ligand binding and trafficking. Signal transduction and Cellular responses such as adhesion and migration.										√	√	√	√

No.	**Aim**	**d1**	**d2**	**d3**	**d4**
1	Survey of definitions and computational methods for the calculation of intermolecular forces, molecular dynamics and protein folding and biophysics and energetics of enzymatic reactions in biological systems	√	√	√	√

2	Tissue engineering theory and principles with emphasis on cell behavior and morphology. Cellular attachment, Extracellular matrix, Tissue organization, Cell culture, Synthetic biomaterials and artificial cells and organs.	√	√	√	√
3	Employment of mathematical methods to solve important problems in a wide variety of fields of biology and medicine	√	√	√	√
4	Theory and measurement of radiation as applied in medicine and the laboratory with emphasis on wide variety of radiation sources from health physics perspective, and Radiation risks and radiation protection guidelines, including international current regulations.	√	√	√	√
5	Introduction to the electrical and computer engineering contributions to biomedical engineering	√	√	√	√
6	The biological transport of cell biology include: Convection laws, Diffusion, Active transport, Osmosis, mass and energy which applied in cellular and organ level (e.g. respiratory system and renal physiology)	√	√	√	√
7	Electrical biophysics of nerve and muscle. Electrical conduction in excitable tissue. Quantitative models for nerve and muscle including the Hodgkin-Huxley equations. Bio mapping potential, Cardiac electrophysiology, and Functional electrical stimulation.	√	√	√	√
8	Fundamental principles of mechanics applied to the study of biological systems. Passive mechanical behaviors of biological materials. Measurement of nonlinear strain in tissues, arterial flow. Mechanical interactions of implants with tissue. Skeletal muscle mechanics. Segmental biomechanics. Control of motion	√	√	√	√
9	The physical principals of magnetic resonance imaging and its clinical applications. Strategies for fast imaging, Clinical MRI techniques. Topics include: Proton environments and T1 relaxation, Transverse magnetization and T2 contrast, Magnetic field gradient, Pulse sequences, Signal-to-noise ratio and spatial resolution, Receiver coils, Magnetic field strength, Gradient echo and spin echo, multi echo techniques	√	√	√	√
10	Physics and mathematics of three-dimensional reconstruction techniques in medical imaging. Projection slice theorem.Back -projection techniques. Analytical and iterative reconstruction algorithms. Numerical methods.Applications in X-Ray Computed Tomography. Single Photon Emission Computed Tomography, Positron Emission Tomography, Nuclear Magnetic Resonance.	√	√	√	√

11	The biophysics principals of Ultrasound and lasers, Acoustic-wave propagation in biological materials, Ultrasound laboratory equipment. Basic concepts for a laser, different types of lasers, Laser interaction with biological tissues. Laser in Medicine and Biology and LASER Regulation	√	√	√	√
12	The theoretical background and theory of function of cutting-edge technologies used to image blood vessels, particularly for: Cardiovascular, Cerebrovascular, and Peripheral vessel disease.	√	√	√	√
13	Theory, fundamental and operating principles techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). The structure and function of the electron microscopes (TEM, SEM, and STEM), Tissue preparation for both types of scopes, freeze fracture and image analysis.	√	√	√	√
14	Photographic techniques and some special applications to include energy dispersive spectroscopy (EDS	√	√	√	√
15	The therapeutic medical devices such as Pacemakers and defibrillators, Neural assist devices, Prosthetic joints, Physical therapy equipment, Cardiac valves, angioplasty, Arterial stents, Anesthesia machine and ventilator, Artificial kidney and pancreas, gastrointestinal therapy, Photodynamic therapy,Computerized Tomography, Magnetic Resonance Imaging, Radiotherapy linear accelerator, Gamma Camera, Positron Emission Tomography	√	√	√	√
16	Mathematical and computational methods and concepts needed in the analysis of a wide range of medical and biological phenomena.	√	√	√	√
17	The quantitative analysis of chemical signaling using: Bioelectronics, electron transport and second messenger production. Receptor/Ligand binding and trafficking. Signal transduction and Cellular responses such as adhesion and migration.	√	√	√	√