CURRICULUM AND SYLLABUS

MS in Biomedical Physics and Technology

Effective from the Academic Session: 2019-20

DEPARTMENT OF BIOMEDICAL PHYSICS AND TECHNOLOGY

Faculty of Science

University of Dhaka

1. ABOUT THE DEPARTMENT

The Department of Biomedical Physics and Technology is a post graduate multidisciplinary department under the Faculty of Science established in 2008. This department emphasizes research and development aimed at delivering the benefits of modern healthcare technology to the common people of Bangladesh. This department aims high to make itself one of the centerpieces in the area of Biomedical Physics, Engineering and Technology.

2. INTRODUCTION TO THE PROGRAM

2.1 Title of the program

Master of Science (M.S.)

2.2 Duration of the program

One academic year.

Activities	**Duration (weeks)**
Classes	24
Time for preparation of final examination	04
Course final examination	04
Submission of thesis/projects/practical/ seminar/internship	16
Publication of results	04

2.3 Eligibility for Admission

Bachelor degree in Biomedical Engineering, Physics, Applied Physics, Electronics, Medical Physics, Electrical & Electronic Engineering, Computer Science and Engineering, Mechanical Engineering and related subjects.

2.4 General Objectives of the Program

The Department of Biomedical Physics and Technology offers Master of Science programmes in two specialized branches: (i) *Biomedical Engineering* and (ii) *Medical Physics*. Each specialization is further divided into thesis and non-thesis groups. The general objectives of the program are to provide quality education through integration of physics, engineering and biological sciences in order to create manpower for developing healthcare technology locally, and for creating manpower to understand, install and operate sophisticated medical equipment in hospitals, and to assist medical doctors in preparing treatment plans using these devices.

3. STRUCTURE OF CURRICULUM

3.1 Name of Degree

M.S. in Biomedical Physics and Technology with two specializations (both specializations have thesis and non-thesis groups):

i) Biomedical Engineering (BME)
ii) Medical Physics (MP)

3.2 Requirements for the award of Degree

A student must earn 34 credits for thesis group and 32 credits for non-thesis group of both specializations by choosing from the offered courses with a minimum GPA of **2.5** (on a scale of 4) to be awarded the MS degree in Biomedical Physics and Technology.

3.3 Allocation of Thesis and Non-Thesis Groups

Allocation of the students to the thesis and non-thesis groups will be made by the Academic Committee based on their M.S. Admission Test results and undergraduate academic records.

3.4 Distribution of Credits

S/n	**Course Types**	**Thesis**		**Non-Thesis**	
		BME	**MP**	**BME**	**MP**
1	Core Theory Courses (A)	15	15	15	15
2	Other Core Courses (B1)	4	4	4	4
3	Other Core Course for Thesis group (B2)	6	6	-	-
4	Other Core Courses for Non-Thesis group (B3)	-	-	4	4
5	Elective Courses (C)	9	9	9	9
	Total = A + B1 + (B2 or B3) + C	***34***	***34***	***32***	***32***

A. Core courses for all students

Course Code	**Course Title**	**Credits**
BMPT 501	Introduction to Human Anatomy and Physiology	3
BMPT 502	Biophysics	3
BMPT 503	Biomedical Measurement and Instrumentation	3
BMPT 504	Medical Imaging Methods	3
BMPT 505	Research Methodology in Biomedical Physics	3
	Sub-Total A	***15***

B. Other core courses

B1. Courses Mandatory for all students

Course Code	**Course Title**	**Credits**
BMPT 511	Viva-voce	2
BMPT 512	Biomedical Measurement Laboratory	2
	Sub-Total B1	***4***

B2. Course Mandatory for Thesis Group

Course Code	Course Title	Credits
BMPT 513	Thesis	6
	Sub-Total B2	***6***

B3. Courses Mandatory for Non-Thesis Group

Course Code	Course Title	Credits
BMPT 514	Biomedical Instrumentation Laboratory	2
BMPT 515	Seminar Presentation	2
	Sub-Total B3	***4***

C. Elective courses for specialization (Sub-Total 9 credits to be taken)

All students must take 3 elective courses totaling 9 credits. To obtain specialization in one branch, students must select at least 2 courses from that specialization.

BME			MP		
Course Code	**Course Title**	**Credits**	**Course Code**	**Course Title**	**Credits**
BMPT 521	Bioelectromagnetism and Biophotonics	3	BMPT 531	Medical Radiation Physics	3
BMPT 522	Biomedical Signal & Image Processing	3	BMPT 532	Radiation Biology	3
BMPT 523	Biomedical Control System	3	BMPT 533	Physics of Radiation Therapy	3

3.5 Explanation of Credits and Contact Hours

Course Type	Credits	Contact Hours
Theory	3	45
Laboratory	2	60

4. ASSESSMENT

4.1 Theory Courses

Assessment Criteria	Marks %
Attendance	05
Continuous Assessment	35
Final Examination	60
Total	100

4.2 Laboratory Courses

Assessment Criteria	Marks %
Attendance	05
Continuous Assessment	45
Final Examination	50
Total	100

4.3 Thesis

Assessment Criteria	Marks %
Oral on thesis	40
Dissertation	60
Total	100

4.4 Attendance

Students having attendance **75% or above** in each course will be eligible to sit for the final examinations. Students having attendance less than **75% but ≥ 60%** may be considered to sit for the examination subject to payment of non-collegiate fees according to university rules. **Students having attendance less than 60% will not be eligible to appear at the final examination**. The marks distribution for attendance is given below:

Attendance (%)	Marks (%)
90 and Above	*5*
85 to 89	*4*
80 to 84	*3*
75 to 79	*2*
60 to 74	*1*
Less than 60	*0*

4.5 Grading System and Calculation of GPA

Marks Obtained (%)	Letter Grade	Grade Point
80 and Above	**A+**	*4.00*
75 to 79	**A**	*3.75*
70 to 74	**A-**	*3.50*
65 to 69	**B+**	*3.25*
60 to 64	**B**	*3.00*
55 to 59	**B-**	*2.75*
50 to 54	**C+**	*2.50*
45 to 49	**C**	*2.25*
40 to 44	**D**	*2.00*
Less Than 40	**F**	*0.00*
	I	*Incomplete*

Only 'D' or higher grade will be counted as credits earned by a student. Grade point average (GPA) will be calculated as the weighted average of the grade points obtained by a student in all the courses completed in a year. GPA will be calculated according to the following formula:

$$GPA = \frac{\sum(grade\ points\ obtained\ in\ a\ course\ \times\ total\ credit\ for\ that\ course)}{\text{total credits taken at a given year}}$$

5. RE-ADMISSION AND IMPROVEMENT POLICY

As per Faculty of Science M.S. Programs guidelines.

SYLLABUS OF INDIVIDUAL COURSES

A. CORE COURSES FOR ALL STUDENTS

(15 CREDITS)

Starts from *BMPT 501*

BMPT 501 Introduction to Human Anatomy and Physiology (3 credits)

a) Course Description

This course is designed to help learners comprehend the basics of Human Anatomy and Physiology. Emphasis have been given to the different types of systems of the human body, its structure and its working mechanism applicable for non-medical students.

b) Course Objectives

1. Orientate students to different systems of the human body.
2. Introduce students to different physiological processes.
3. Familiarize students with different segments of the human body and their functionalities.
4. Expose students to different working mechanism of the body parts and different conditions.

c) Course Contents

	Content	Contact hours
1.	***Introduction to the human body & Homeostatsis:*** Structural levels of human body; goal & importance of physiology; Homeostasis; Major functional systems and control systems of the body.	(2h)
2.	***Cellular & Tissue System:*** Structure of the Cells; prokaryote vs. eukaryote, functions; Sub-cellular organelles and their structures; Different cell types and their roles in physiology; Different Tissue types: Epithelial, Nerve, Muscle, Collagen and Connective; Characteristics and functions of different tissues; Neoplasm and tumors; characteristic feature of benign and malignant tumors.	(6h)
3.	***Musculoskeletal System:*** Classification, characteristics, function and structure of major muscle, bones, joints and cartilages.	(4h)
4.	***The Skin:*** Structure of the skin, function of the skin; wound healing.	(2h)
5.	***Blood and Circulation System:*** Composition and function of blood, Blood Flow, Blood Pressure, The Microcirculation and the Lymphatic System: Capillary Fluid Exchange, Interstitial Fluid, and Lymph Flow.	(4h)
6.	***Central and Peripheral Nervous system:*** A general outline of organization, Neurons, Nerve, Fibers, Synapse, Neuro-transmitters; Functional organization and functions of major levels of CNS and PNS, Somatosensory subsystem and motor system of the body; Structure and Functions of cerebellum, Basal ganglia,	(8h)

Limbic systems and Hypothalamus; Autonomic Nervous system; States of Brain Activity—Sleep, Brain Waves, Epilepsy and Circadian Rhythm.

7. ***Special Senses:*** Organization and Functions of Vision, Hearing and Equilibrium, Smell and Tastes. (3h)
8. ***Cardiovascular System:*** Properties of cardiac muscle; Heart as a pump: Components, parts, heart and blood vessels, general, portal and Regional circulation; Conductive system of heart. Cardiac cycles, heart sound; Basic ECG, Cardiac output and venous return; Cardiac Arrhythmias and their Electrocardiographic Interpretation; Blood pressure and its regulation. (4h)
9. ***Respiratory system:*** Respiratory apparatus and Mechanism, Respiratory unit and respiratory membrane, Pulmonary & Alveolar ventilation; Pulmonary volumes and capacities and dead space, Diffusion of Gases through the respiratory membrane, Transport of Oxygen & Carbon dioxide in blood. (3h)
10. ***Digestive system:*** Outline of its different parts with their functions; Motility, Digestion and absorption in GI Tract; Transport of food; Digestive juices- origin, forms and functions; Structure and function of liver, Liver function tests; Introduction to Metabolism and Body Temperature regulation. (3h)
11. ***Renal System:*** The special fluid system of the body; Interstitial Fluid and Edema; General outline of Uro-Genital Component parts; Physiology of kidneys; Mechanism of urine formation; Regulation of Extra Cellular Fluid and acid-base balance; Kidney Diseases and kidney function tests. (3h)
12. ***Endocrine and Reproduction System:*** Definition, Classification, mechanism of action, regulation of secretion of hormones; Clinical importance of endocrine system; Major Hormone disorders; Insulin, Glucagon, and Diabetes Mellitus. Physiology of reproductive system and pregnancy. (3h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Understand and explain different systems of human body.
- Distinguish various physiological processes.
- Relate human anatomy and physiology in biomedical physics studies.
- Utilize biological knowledge into biomedical engineering and technological problem solving.

e) Instructional Strategies

- Lecture-demonstration
- Question-answer
- Hospital visit
- Case Study
- Participatory teaching approach

f) Student Assessment

- Continuous Assessment
  - Assignment
  - Presentations
  - Incourse written examinations

- Final written examination

g) References

1. Human Anatomy & Physiology. 9th Edition. Elaine N. Marieb, Katja N. Hoehn. Pearson.
2. Textbook of Medical Physiology. Guyton and Hall. Elsevier.
3. Ganong's Review of Medical Physiology. Mcgrawhill.
4. Online Materials, Articles and Journals on demand.

BMPT 502 Biophysics (3 credits)

a) Course Description:

Biophysics is an interdisciplinary science that employs and develops theories and methods of the physical sciences for the investigation of biological systems. This course is designed as a broad introduction into the field of biophysics for graduate students with the background in Physics and Engineering. The course focuses on applying the principles, theories, and methods of Physics to understand the function of living organism, in particular, main organ systems of the human body. The course aims to balance the need for rigorous mathematical treatment with the simplicity of presentation.

b) Course Objectives:

(a) Provide students with a foundation in the basic concepts of Biophysics.

(b) To help students to understand physical principles that underlie the dynamics of life from the macro to molecular scale.

(c) To help students to understand physical issues concerning the human body, in part by solving problems to further this understanding.

c) Course Contents

	Content	Contact hours
1.	***Properties and structure of macromolecules:*** Atomic and Molecular forces. Types of macromolecules, Amino acids, peptide bond, Levels of protein structure, Nucleic acids, Structure of DNA, RNA, Viruses, Methods of replication, Genetic Code, Transcription, Translation; X-ray diffraction, Spectroscopy, NMR.	(8h)
2.	***Basic Enzyme Behavior:*** Michaelis Menten mechanism, Enzyme inhibition, allostery and co-operativity MWC model.	(3h)
3.	***Neurobiophysics:*** Overview of the nervous system, Neural communication, Basic membrane properties, Diffusion Fick's law, selectivity of ion channels, Membrane potential, Action potential, Propagation of action potential, equivalent dipole and volume conductor fields, electrical model of a nerve fibre, conduction velocity, conduction in myelinated nerve fibres, neuromascular junction, neurotransmitter, Muscle action potential, major disorders of the neuromuscular system and their effects on conduction – nerve block, demyelination.	(8h)
4.	***Physics of the Senses:*** Vision- Eye accommodation, light and dark adaptation, color vision, Visual evoked potentials, vision defects and corrections; Hearing: Ear canal resonance, sound transmission and amplification through ossicles, Cochlear function, Otoacoustic Emission, Hearing threshold in terms of Sound pressure level (SPL) and Hearing threshold level (HTL), hearing defects in terms of HTL; smell, taste, touch.	(8h)
5.	***Cardiovascular system:*** Natural pacemakers of the heart – SA node, AV node, HP-bundle; mechanism of pacemaker cells in creating oscillations, ECG, Mechanics of fluid and its application in blood flow, Pumping action of heart and blood flow cycle, valves, arterial and venous system, blood pressure and	(8h)

blood flow in vessels, laminar and turbulent blood flow, work done by the heart, Cardiac output & venous return.

6. ***Lungs and Respiration:*** Mechanism of breathing in terms of pressure creation by body, Pressure and Volume related functions of lungs during tidal breathing and forced maneuvers, the same in lungs with disorders, airway resistance. (4h)

7. ***Biomechanics:*** Mechanical properties of biological tissues, musculoskeletal system, mechanism of muscle contraction, skeletal joints, forces and stresses in human joints, Neuromascular control, Gait; Sports, occupational and clinical biomechanics. (6h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Explain the major classes of biomolecules with regards to structure, energetic stability and function.
- Describe enzymes and kinetics of enzymatic reactions. Explain models for enzyme-substrate binding and inhibition.
- Define the fundamental concepts of biophysics and explain the integration of physical theory and models into human physiological processes including neural, cardiovascular and respiratory systems.
- Understand the kinetics of human movements. Identify, analyze, and solve various biomechanical problems.
- Identify/justify the biophysics tools for biomedical study/research.

e) Instructional Strategies

- Lecture
- Discussion
- Seminar
- Demonstration

f) Student Assessment

- Continuous Assessment
    - Quiz
    - Assignment
    - Presentations
    - Problem Solving
- Final written examination

g) References:

1. B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose, Medical Physics and Biomedical Engineering, CRC press
2. Roland Glaser, Biophysics: An Introduction, Springer.
3. Daniel Goldfarb, Biophysics DeMYSTiFied, McGraw-Hill Education.
4. Rodney Cotterill, Biophysics: An Introduction, John Wiley & Sons.
5. Irving P. Herman, Physics of Human Body, Springer.
6. Duane Knudson, Fundamentals of Biomechanics, Springer.

BMPT 503 Biomedical Measurement and Instrumentation (3 credits)

a) Course Description

This course covers the basic and advanced topics of biomedical measurement and instrument design. The detection of measurable physiological signals and physiological outcome of evoked and stimulated phenomena are studied. The measurement of physical properties of bodily fluids are covered. This course gives an introduction to some basic sensors used in biomedical measurements and discusses the process of converting biosignals into measurable electric signals. Amplification techniques, stimulation circuits, isolation techniques and noise reduction techniques are studied. A basic introduction to analog-digital conversion and hardware interfacing is covered. This course also gives an introduction to biomedical rehabilitation equipment and their fundamental design techniques and measuring processes. It also gives a brief insight about patient safety requirements in instrument designing.

b) Course Objectives

To help students to:

i) Understand the methods of measuring biological signals and biological stimulations.
ii) Familiarize the procedures for designing and implementation of biomedical circuitry.
iii) Utilize the procedures for designing and implementation of rehabilitation equipment.
iv) Evaluate the ethical practices for patient safety.

c) Course Contents

	Content	**Contact hours**
1.	***Biomedical measurements***	***(15h)***
(a)	Overview of Biomedical signals, Measurement techniques of biosignals, Basic biopotentials (ECG, EMG, EEG, EOG, ECoG, EGG)	(7h)
(b)	Measurement of evoked responses: Sensory evoked response (visual, auditory, somatosensory); Motor evoked responses	(2h)
(c)	Electrical stimulation of excitable tissues, measurement of nerve conduction velocity	(2h)
(d)	Body-fluid flow and pressure measurement: Blood, Air respiration, Cranial fluid, Urine and other basic body fluids.	(4h)
2.	***Biomedical Instrumentation***	***(14h)***
(a)	Introduction to various types of biomedical sensors. Physical sensors, Biopotential sensors, Electrodes.	(3h)
(b)	Basic amplifier circuits, Differential amplifier, Instrumentation amplifier	(2h)
(c)	Isolation and Noise reduction techniques: filtering, right leg driven circuitry	(2h)
(d)	Constant Current source circuits	(2h)
(e)	Stimulator circuits: Muscle stimulators, Nerve stimulators, Cardiac defibrillators	(2h)

(f) Hardware interfacing: Analog-digital conversion of biomedical signals, interfacing with computational hardware, communication protocols (3h)

3. ***Rehabilitation equipment*** ***(12h)***

(a) Cardiac pacemakers: External and Internal pacemakers, programmable pacemakers (2h)

(b) Hemodialysis machines: Artificial kidney, dialyzers (2h)

(c) Ventilators: types and basic circuitry, humidifiers, nebulizers, aspirators (2h)

(d) Optical rehabilitation: correction of eyesight, optical lens, contact lens, LASIK (2h)

(e) Audiological rehabilitation: Hearing aids - External and implanted devices (2h)

(f) Prosthetic joints (2h)

4. ***Patient Safety and Ethics*** ***(4h)***

(a) Risk factors, safety and management of medical equipment (2h)

(b) Ethical issues related to clinical research (2h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

i) Understand the measuring techniques of some basic biopotentials generated in the human body.
ii) Cope with the measuring techniques of different parameters related to body fluids.
iii) Have an idea about the basic blocks of biomedical instruments and be capable of designing biomedical instruments according to standard.
iv) Have an idea about converting biosignals into measurable signals and the processes involved in the conversion.
v) Gain insight on some basic rehabilitation equipment.
vi) Follow patient safety regulations.

e) Instructional Strategies

- Lectures
- Discussion
- Question Answer
- Group discussion
- Project work

f) Student Assessment

- Continuous assessment
  - Incourse exam
  - Assignments
  - Presentation
- Final written examination

g) References

1. The Biomedical Engineering handbook: Medical Devices and Systems, Third Edition by Joseph D Bronzino, CRC Press
2. Analysis and application of Analog Electronic Circuits in Biomedical Instrumentation by Robert B. Northrop, CRC Press
3. The Measurement, Instrumentation and Sensors by John G. Webster, CRC Press
4. Medical Physics and Biomedical Engineering (Medical Science Series) by B.H Brown, R.H Smallwood, D.C. Barber, and P.V Lawford, D.R Hose, Churchill Livingstone, IOP Publishing Ltd.
5. Biomedical Instrumentation: Technology and Applications by R.S. Khandpur, Tata McGraw-Hill Publishing Company Limited
6. Bioinstrumentation, by John D. Enderle, Morgan and Claypool Publishers.

BMPT 504 Medical Imaging Methods (3 credits)

a) Course Description

This course is designed to provide understanding of principles of major medical imaging methods. It also acquaints students with the application of these techniques in diagnosis of various physiological conditions. The course aims to provide a generalized overview of the medical imaging methods so that learners from diverse interdisciplinary background can participate.

b) Course Objectives

To help students to:

i) Know about the most common medical imaging methods
ii) Understand the basic principle of these medical imaging methods
iii) Understand their application in diagnosis
iv) Learn special engineering techniques that are used in different medical imaging

c) Course Contents

Contents	**Contact hours**
1. ***Introduction to medical imaging:*** The role of physics in medical imaging and the range of imaging methods.	(1h)
2. ***Ultrasound Imaging:*** Transducers, properties of ultrasound beam, interaction of the beam with the patient, acoustic impedance, scanning modes (A, B and M Scan), Doppler ultrasound and flow imaging (Color Doppler).	(10h)
3. ***X-ray imaging and X-ray CT:*** X-ray tubes and generation of X-rays, X-ray spectrum, interaction of X-rays with the patient, attenuation, image receptors, X-ray image properties, measurement noise, contrast, resolution, Mammography and Fluoroscopy. X-ray computed tomography (CT), 2-D and 3-D imaging, filtered back projection, Hounsfield Units.	(15h)
4. ***Magnetic Resonance Imaging (MRI):*** Basic concepts of MR Physics, spin polarization, resonance, relaxation, spin echoes, gradient echoes, spatial encoding using magnetic field gradients, k-space and image reconstruction, relaxation enhancement. Clinical utility of MRI. Introductory functional MRI, MR spectroscopy, chemical shift.	(10h)
5. ***Nuclear Imaging:*** Radioisotopes, radiotracers and molecular imaging, radiopharmaceuticals and their supply, scintillators, gamma cameras, resolution, sensitivity, collimators, rectilinear scanners, SPECT, PET.	(5h)
6. ***Advanced Imaging:*** Magnetoencephalography, Diffuse optical tomography, Optical coherence tomography, Elastography, Tactile imaging, Photoacoustic imaging and emerging imaging technologies.	(4h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

i) Understand the basic principle of the common medical imaging methods.

ii) Understand the diagnosis of several physiological conditions using different medical imaging methods.
iii) Apply these concepts in developing novel diagnosis techniques using the medical imaging methods.

e) Instructional Strategies

- Lectures
- Discussion
- Question Answer
- Group discussion
- Project work

f) Student Assessment

- Continuous assessment
  - Incourse exam
  - Assignments
  - Presentation
- Final written examination

g) References

1. Radiologic Science for Technologists by S C Bushong.
2. The Essential Physics of Medical Imaging by J T Bushberg, J A Seibert, E M. Leidholdt Jr, J M Boone.
3. Medical Physics and Biomedical Engineering by B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose.
4. Medical Physics by J R Cameron.

BMPT 505 Research Methodology in Biomedical Physics (3 credits)

a) Course Description

The course is designed to familiarize the students with the traditional as well as recent advances in the research methodology with the focus on identification and critical evaluation of real-life problems in the field of biomedical engineering and medical physics.

b) Course Objectives

To help students to:

i) Understand the advantages and the limitations of most common research strategies in biomedical research.
ii) Identify of the problem area.
iii) Organize of a survey, trial, investigation etc.
iv) Design and develop of new systems for obtaining quantitative information.
v) Design a research protocol.
vi) Understand ethical and administrative aspects of research.
vii) Analyze information and interpret results.

c) Course Contents

Contents	**Contact hours**
1. ***Planning and Execution of Research:*** Planning, Research Study Designs, Ethical Issues of Research, Hypothesis Development and Measurements, Collecting Data and its Management.	(15h)
2. ***Biostatistical Applications in Research:*** Sampling Issues in Research, Assessment of Risk, Analyzing Observations: Statistical Significance, Estimating Confidence, Interval, Central tendencies, Correlation and Regression; Presenting Observations.	(20h)
3. ***Concluding the Research:*** The Basis for Drawing Conclusions, Sources of Error in Studies, Scientifically Writing the Thesis/Report/ article: Literature review, referencing, plagiarism.	(10h)

d) Learning Outcomes

After completion of the course students will be able to:

i) Understand the basic research principles.
ii) Identify and develop research problems.
iii) Design research strategies.
iv) Evaluate scientific articles.
v) Write scientific papers.

e) Instructional Strategies

- Lectures
- Question Answer
- Group work on different experimental designs
- Presentation of own study design
- Analyses of scientific papers on statistical approaches

f) Student Assessment

- Continuous assessment
  - Incourse exam
  - Assignments
  - Presentation
- Final written examination

g) References

1. Biomedical Research Methodology by Das Ranjan, Das PN. Jaypee Brothers Publishers. ISBN: 9350900149, 9789350900147.

B. OTHER CORE COURSES

(10 credits for thesis group, 8 credits for non-thesis group)

Starts from *BMPT 511*

BMPT 511 Viva-voce (2 credits)

a) Course Description

This course is designed for students to have a clear conception about the various topics covered in the courses of the program. The course is based on an oral session for which the students are expected to have good communication skills and clear subject knowledge.

b) Course Objectives

To help students to:

i) Achieve a clear conceptual view about the topics covered in the courses.
ii) Achieve and enhance the quality of oral communication.

c) Course Contents

All the courses covered in the program.

d) Learning Outcomes

After completion of the course students will be able to:

i) Critically think and answer questions simultaneously.
ii) Communicate verbally with confidence.

e) Instructional Strategies

- Lectures
- Seminars
- Field visit
- Laboratory work
- Hands-on practice
- Presentation

f) Student Assessment

An individual viva-voce examination will be held after the course final examination by the Examination Committee.

BMPT 512 Biomedical Measurement Laboratory (2 credits)

a) Course Description

This course is designed for students to get hands on experience on measuring various physiological signals. Students get a detailed understanding on physiological phenomenon of signals biological constraints in consideration. Various biological signals are observed using training modules and their characteristics analysed with theoretical values.

b) Course Objectives

To help students to:

i) Achieve hands-on experience of designing biomedical circuitry.
ii) Monitor and interpret measured physiological signals.
iii) Analyse the observed biosignals with theoretical values.

c) Course Contents

Experiments based on the theories covered in BMPT 502, BMPT 503, BMPT 521, BMPT 522 and BMPT 531.

d) Learning Outcomes

After completion of the course students will:

i) Understand the measuring techniques of some basic biopotentials generated in the human body
ii) Cope with the measuring techniques of different parameters related to body fluids.
iii) Have an idea about the basic blocks of biomedical instruments.
iv) Have a hands-on experience about the typical signals generated in the human body.

e) Instructional Strategies

- Lectures
- Demonstration
- Simulation
- Hands-on practice

f) Student Assessment

- Continuous assessment
  - Lab performance
  - Lab report
  - Viva
- Final Exam

g) References

1. *The Biomedical Engineering handbook: Medical Devices and Systems*, Third Edition by Joseph D Bronzino.

2. *Analysis and application of Analog Electronic Circuits in Biomedical Instrumentation* by Robert B. Northrop.
3. *Bioinstrumentation,* by John D. Enderle.

BMPT 513 Thesis (6 credits)

a) Course Description

This course is designed to help learners develop research skills in the fields of medical physics and biomedical engineering. Emphasis have been given to understand a real life problem, conceptualization, testing, analysis and scientific report writing.

b) Course Objectives

i) Familiarize students with different medical physics and biomedical engineering real life problem solving.
ii) Expose students how to plan, organize and conduct research.

c) Course Contents

i) Development of a Research Proposal.
ii) Literature Review.
iii) Designing the relevant research methodology.
iv) Testing/ Survey.
v) Result Analysis.
vi) Dissertation.
vii) Final Defense.

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Identify research problem and perform research activities.
ii) Present the findings scientifically.
iii) Write scientific dissertation.

e) Instructional Strategies

- Brainstorming
- Discussion
- Hands-on learning
- Laboratory Work/ Simulations
- Field visit/ Survey
- Direct Supervision

f) Student Assessment

- **Thesis Proposal:** After 10 weeks from the start, each student of thesis groups will submit a three to five page thesis proposal (signed by his/ her supervisor) and present her/his proposal, which will be evaluated by the internal members of the examination committee and all supervisors. Proposal will be evaluated as ‘Satisfactory/Not satisfactory’. In case of “Not satisfactory” performance, the examination committee may give the student a second opportunity for proposal presentation. Students with

“Not-Satisfactory” performance after the second chance will be transferred to the non-thesis group.

- **Pre-defense**: Each student will have to present his/her research work and outcome (signed by respective supervisor) in front of internal members of examination committee. They will evaluate a thesis as: ‘Accepted/ Accepted with corrections/ Rejected’ after consultation of respective supervisor.
- **Oral on thesis:** Oral examination of the MS thesis students will be conducted by the members of Examination Committee consisting of three internal and one external examiners and approved by the Academic Council of the University. Supervisor of a student will be requested to be present at the time of the presentation. He/she may participate in discussion but not in evaluation.
- **Dissertation:** Dissertation will be evaluated as per existing rules of the university by two external examiners from outside the Department.

g) References

1. Research Methods for Postgraduates (3rd Ed.). Tony Greenfield and Sue Greener (Editors). 2016. Wiley and Sons Ltd. Print ISBN: 9781118341469, Online ISBN: 9781118763025. DOI: 10.1002/9781118763025.

BMPT 514 Biomedical Instrumentation Laboratory (2 credits)

a) Course Description

This course is designed for students to get hands on experience on designing circuits for measuring various physiological signals. Students get hands-on experience of building each circuit block from scratch using ICs and components.

b) Course Objectives

To help students to:

i) Achieve hands-on experience of designing and building biomedical circuitry.
ii) Troubleshoot the circuitries to eliminate artefacts.

c) Course Contents

Experiments based on the theories covered in BMPT 502, BMPT 503, BMPT 521 and BMPT 522.

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Understand the building techniques of biomedical measurement circuits.
ii) Compare the raw signals with the processed signals from the modules.
iii) Have the idea of artefacts occurring in biomedical measurements.
iv) Optimize circuits by tuning parameters and comparing outcomes with processed modular outcomes.

e) Instructional Strategies

- Lectures
- Demonstration
- Simulation
- Hands-on practice

f) Student Assessment

- Continuous assessment
    - Lab performance
    - Lab report
    - Viva
- Final Exam

g) References

1. *The Biomedical Engineering handbook: Medical Devices and Systems*, Third Edition by Joseph D Bronzino.
2. *Analysis and application of Analog Electronic Circuits in Biomedical Instrumentation* by Robert B. Northrop.
3. *Bioinstrumentation*, by John D. Enderle.

BMPT 515 Seminar Presentation (2 credits)

a) Course Description

The course is designed to introduce the students with the recent trends in the field of biomedical engineering and medical physics.

b) Course Objectives

To help students to:

i) Find out recent trends in research.
ii) Critically assess scientific write-ups in the relevant field.
iii) Process and present the findings in front of an audience.
iv) Develop presentation skill and audience handling capacity.

c) Course Contents

i) Assessing Research Articles.
ii) Information processing.
iii) Presentation.

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Critically evaluate scientific writings.
ii) Summarize key information.
iii) Present in front of an audience with confidence.

e) Instructional Strategies

- Discussion
- Field visit/ Survey
- Group work on scientific articles
- Audio-visual Presentation

f) Student Assessment

- Examination committee will assign topics to individual student for seminar presentation.
- Students will attend seminars in the department round the year.
- Each student will have to present TWO seminar presentations over an academic year.
- Examination committee will evaluate the individual student performances in the seminars.

g) References

1. Clear and Concise Communications for Scientists and Engineers by James G. Speight. CRC Press. ISBN: 978-1439854792.
2. Speaking about Science: A Manual for Creating Clear Presentations by Scott Morgan. Cambridge University Press. ISBN: 978-0521683456.

C. ELECTIVE COURSES FOR SPECIALIZATION

(9 Credits, at least 6 credits from intended specialization branch)

BMPT 52x: BME Specialization
BMPT 53x: MP Specialization

BME Specialization Courses

BMPT 521 Bioelectromagnetism and Biophotonics (3 credits)

a) Course Description

This course is designed to help learners comprehend the concepts of inherent properties, like electrical, magnetic and optical properties of the human body. Emphasis have been given to the different aspects, effects of external and internal stimulations to the human body, modelling and developing various applications due to the changes of these properties.

b) Course Objectives

i) Orientate students to different aspects of Bioelectromagnetism and Biophotonics.
ii) Introduce students to different bioelectrical, biomagnetic and bio-optical properties.
iii) Familiarize students with different bioelectrical, biomagnetic measurement and modelling techniques.
iv) Expose students to different applications related to Bioelectromagnetism and Biophotonics.

c) Course Contents

	Content	Contact hours
a.	***Bioelectricity***	***(15h)***
1.	Origin of Bioelectricity: Semi-permeable membranes and ion channels and pumps, Membrane potential, Nernst equation, Nerve and muscle action potentials, Synapses, The Hodgkin–Huxley Membrane Model.	(5h)
2.	Electrical model and properties of cells in the body, cell membrane, intracellular and extracellular fluid; Dielectrics, polarization, DC and AC polarization, relaxation, complex permittivity and conductivity, effect of external electric fields with dc and ac of different frequencies, various dispersion ranges.	(3h)
3.	Bioelectric Measurements & Modelling: Modelling volume conductor and volume source, Theory of Bioelectric Measurements, Lead field equations, Reciprocal lead field, Sensitivity field, Electroencephalography (EEG), Electrocardiography (ECG).	(5h)
4.	Bioelectric Stimulations: Functional Electric Stimulation, Cardiac Pacing and Defibrillation, Electrotherapy, Electro-surgery.	(2h)
b.	***Bioimpedance***	***(12h)***

1. Theory of measurement of Bioimpedance: electrodes, electrode-electrolyte interface; two, three and four electrode measurements; isocurrent and isopotentials, sensitivity distribution, negative sensitivity; Bioimpedance at different frequencies, dc and ac models; Electrical equivalent circuit, Cole model, complex impedance, Cole-Cole plot; concepts of Finite Element Method for numerical solutions; Practical measurement of Bioimpedance: Basic electronic circuitry, Multi-frequency measurements, Clinical applications of Bioimpedance. (5h)
2. Physiological effects of dc and ac on body tissues, leakage current, safety issues in measurements. (2h)
3. Impedance Plethysmography & Impedance Tomography: Electrical Impedance Tomography (EIT), Focused Impedance Method (FIM), Pigeon Hole Imaging (PHI). (5h)

c. Biomagnetism ***(7h)***

1. Biomagnetic field, Nature of the biomagnetic sources. (1h)
2. Biomagnetic Measurements: Reciprocity Theorem For Magnetic Fields, Magnetic Dipole Moment, Lead Fields, Synthesization Of Lead Fields, Magnetoencephalography (MEG), Magnetocardiography (MCG) (4h)
3. Biomagnetic Stimulation: Coil Design, Field Distribution, Activation of Tissues, Applications. (2h)

d. Biophotonics ***(11h)***

1. Fundamental optical properties of tissue, Light-Tissue Interactions and Photobiology. (3h)
2. Biophotonic diagnosis and therapy: basic concepts. (3h)
3. LASERs in medicine: Principles of LASER, LASER Tweezer and LASER scissors, Application of LASER in medicine. (3h)
4. Bioimaging: Basic Principles and Techniques, Optical Coherence Tomography (OCT). (2h)

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Understand different concepts of bioelectromagnetism and biophotonics.
ii) Solve analytical problems.
iii) Evaluate multifaceted applications in biomedical engineering.

e) Instructional Strategies

- Lecture-demonstration
- Question-answer
- Case Study
- Participatory teaching approach

f) Student Assessment

- Continuous Assessment
    - Assignment

    - Presentations
    - Incourse Examinations
- Final Examination

g) References

1. J. Malmivuo and R. Plonsey Bioelectromagnetism, Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, 1995.
2. Webster JG (ed) Measurement, Instrumentation, and Sensors Handbook, CRC – IEEE Press, Boca Raton, FL. ISSN: 1523-3014.
3. Introduction to Biophotonics, Paras N. Prasad Wiley (2003).
4. Journal papers, Articles and write-ups on demand.

BMPT 522 Biomedical Signal and Image Processing (3 credits)

a) Course Description

The course is broadly divided in two parts: (i) signal processing and (ii) image processing. It is designed to provide understanding of application of various signal processing techniques in biomedical engineering. The application of these techniques on several biomedical signals is discussed with several case studies. The second part of the course is designed to provide understanding of some basic image processing techniques on medical images. The basic principle of these techniques is discussed with their applications in biomedical engineering. Along with these, special emphasis is given on image reconstruction which is immensely important for understanding Computed Tomography (CT).

b) Course Objectives

To help students to:

i) Recall some basic concepts of signals and systems
ii) Learn to design digital filters (both FIR and IIR)
iii) Understand the basic principle of adaptive filtering and their applications
iv) Use different signal processing techniques to learn filtering common artefacts in biomedical signals
v) Understand use of different signal processing techniques and algorithms to extract significant features from biomedical signals and derive measurements from these features
vi) Understand basic image processing techniques and learn their use in medical imaging
vii) Learn basic principle and application of image reconstruction

c) Course Contents

Content	**Contact hours**
Signal Processing	**(30h)**
1. ***Introduction:*** Nature of biomedical signals, Overview of signals and systems, Correlation, Convolution, Discrete time signals and systems, Analysis of linear time-invariant systems	(2h)
2. ***Z-transform:*** The z-transform, properties of z-transform, Rational z-transform, Analysis of linear time-invariant systems in the z-domain.	(3h)
3. ***Frequency Analysis:*** Frequency analysis, Properties of the Fourier transforms, Frequency domain characteristics of linear time invariant systems.	(3h)
4. ***Discrete Fourier Transform:*** Frequency domain sampling: the Discrete Fourier Transform, Properties of the DFT, Frequency analysis of signals using DFT, FFT algorithms.	(2h)
5. ***Digital filter Design:*** FIR and IIR structures, FIR filter design using window method, optimal method, frequency sampling method. IIR filter design using impulse invariant method, bilinear z-transform, approximation of derivatives.	(6h)
6. ***Adaptive filtering:*** Necessity of adaptive filters, adaptive filters as noise canceller, Basic Wiener filter theory, Wiener-Hopf equation, LMS algorithm.	(4h)

7. ***Filtering of Artifacts in Biomedical Signals*:** Random, structured and physiological noise. Stationary and non-stationary process, Synchronized averaging, Moving averaging (MA) process, Removal of artifacts in biomedical signals. (6h)
8. ***Event detection:*** Derivative based detection of QRS complex, The Pan-Tompkins algorithm, Identification of heart sounds, Correlation analysis of EEG rhythms. (4h)

Image Processing (15h)

1. ***Introduction:*** Digital image fundamentals, Pixels, Relationship between neighboring pixels, Image size. (2h)
2. ***Intensity Transformation & Spatial Filtering:*** Histogram processing and equalization, smoothing spatial filters: Linear and nonlinear. Application in Medical Imaging. (2h)
3. ***Image Reconstruction:*** Importance and application in Computed Tomography (CT), Image reconstruction from projections, Radon transform, Fourier-Slice theorem, Filtered back projection, Iterative reconstruction. (6h)
4. ***Image segmentation:*** Intensity segmentation, Edge detection, Region growing, Application in Medical Imaging. (3h)
5. ***Image registration:*** Methods for image registration, Biomedical application: combining anatomical and functional imaging (2h)

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Design digital filters (FIR and IIR).
ii) Understand the basic principle of adaptive filtering.
iii) Apply signal processing techniques to filter artefacts from biomedical signals.
iv) Apply signal processing techniques to detect, extract and analyze significant features from biomedical signals.
v) Apply basic image processing techniques in biomedical imaging.
vi) Understand the concept and application of image reconstruction in computed tomography.

e) Instructional Strategies

- Lectures
- Discussion
- Question Answer
- Group discussion
- Project work

f) Student Assessment

- Continuous assessment
  - Incourse exam
  - Assignments
  - Presentation
- Final Examination

g) References

1. Digital Signal Processing by J G Proakis and D G Manolakis
2. Digital Signal Processing: A Practical Approach by E C Ifeachor and B W Jervis
3. Adaptive Filters by Simon Haykin
4. Biomedical Signal Analysis by R M Rangayyan
5. Medical Physics and Biomedical Engineering by B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose
6. Digital Image Processing by R C Gonzalez and R E Woods
7. Advanced Biomedical Image Analysis by M A Haidekker

BMPT 523 Biomedical Control System (3 credits)

a) Course Description

The goal of this course is to prepare students for a clear concept about control system designing of the biomedical engineering devices. Modelling a system regarding mathematical aspect as well as electromechanical environment needs a deep concept about control system. Since biomedical devices are fully concerned with our physiological behaviour and its control, this subject merges the concept of engineering control system and physiological control system to provide the students a sufficient knowledge regarding the mechanism of Physiological Control System.

b) Course Objectives

i) To understand various concepts and laws to analyze a variety of dynamic systems.
ii) To familiarize with the key strategies that the body uses to regulate its function.
iii) To comprehend control system theory as applied to human physiology.
iv) To apply linear control theory to model and analyze biological systems.

c) Course Contents

Content	Contact hours
1. Introduction to biomedical control systems: Fundamental Concepts of Systems Analysis, Physiological Control Systems, Differences Between Engineering and Physiological Control Systems.	(3h)
2. Mathematical Modeling of physiological systems: Generalized System Properties, Linear Models of Physiological Systems, Conversions Between Electrical and Mechanical Analogs, Distributed-Parameter Versus Lumped-Parameter Models, Linear Systems and the Superposition Principle, Zero-Input and Zero-State Solutions of ODEs, Laplace Transforms and Transfer Functions, The Impulse Response and Linear Convolution, State-Space Analysis.	(9h)
3. Static Analysis of Physiological Systems: Open-Loop Versus Closed-Loop Systems, Determination of the Steady-State Operating Point, Example of static analysis: regulation of Cardiac Output, Closed-Loop Analysis: Heart and Systemic Circulation Combined, Regulation of Glucose Insulin, Chemical Regulation of Ventilation.	(3h)
4. Time-Domain Analysis of Linear Control Systems: Linearized Respiratory Mechanics: Open-Loop Versus Closed-Loop, Open-Loop Versus Closed-Loop Transient Responses: First-Order Model, Impulse Response, Step Response, Open-Loop Versus Closed-Loop Transient Responses: Second-Order Model, Impulse Responses, Descriptors of Impulse and Step Responses, Open-Loop Versus Closed-Loop Dynamics: Other Considerations.	(3h)
5. Frequency-Domain Analysis of Linear Control Systems: Steady-State Responses to Sinusoidal Inputs, Graphical Representations of Frequency Response, Estimation of Frequency Response from Input–Output Data, Frequency Response of a Model of Circulatory Control.	(3h)
6. Stability Analysis, Linear Approaches: Stability and Transient Response, Root Locus Plots, Routh–Hurwitz Stability Criterion, Nyquist Criterion for Stability, Relative Stability, Stability Analysis of the Pupillary Light Reflex, Model of Cheyne–Stokes Breathing.	(4h)

7. ***Digital Simulation of Continuous-Time Systems:*** Preliminary Considerations: Sampling and the Z-Transform, Methods for Continuous-Time to Discrete-Time Conversion, Sampling, Digital Simulation: Stability and Performance Considerations, Physiological Application: The Integral Pulse Frequency Modulation Model. (4h)
8. ***Model Identification and Parameter Estimation:*** Basic Problems in Physiological System Analysis, Nonparametric and Parametric Identification Methods, Problems in Parameter Estimation: Identifiability and Input Design, Identification of Closed-Loop Systems: "Opening the Loop", Identification Under Closed-Loop Conditions, Identification of Physiological Systems Using Basis Functions. (6h)
9. ***Estimation and Control of Time-Varying Systems:*** Modeling Time-Varying Systems: Key Concepts, Estimation of Models with Time-Varying Parameters, Estimation of Time-Varying Physiological Models, Adaptive Control of Physiological Systems, (4h)
10. ***Nonlinear Analysis of Physiological Control Systems:*** Nonlinear Versus Linear Closed-Loop Systems, Phase-Plane Analysis, Nonlinear Oscillators, The Describing Function Method, Models of Neuronal Dynamics, Nonparametric Identification of Nonlinear Systems (3h)
11. ***Complex Dynamics in Physiological Control Systems:*** Spontaneous Variability, Nonlinear Control Systems with Delayed Feedback, Coupled Nonlinear Oscillators: Model of Circadian Rhythms, Time-Varying Physiological Closed-Loop Systems: Sleep Apnea Model, Propagation of System Noise in Feedback Loops. (3h)

d) Learning Outcomes

After successful completion of the course students will be able to:

i) Apply various concepts and laws to analyze a variety of dynamic systems.
ii) Understand the key strategies that the body uses to regulate its function.
iii) Develop an understanding for control system theory as applied to human physiology.
iv) Apply linear control theory to model and analyze biological systems.

e) Instructional Strategies

- Lectures
- Discussion
- Question Answer
- Group discussion
- Project work

f) Student Assessment

- Continuous assessment
  - Incourse exam
  - Assignments
  - Presentation
- Final written examination

g) References

1. *Physiological Control Systems: Analysis, Simulation, and Estimation*, M.C.K. Khoo IEEE Engineering in Medicine and Biology Society, Wiley & Sons, ISBN 0-7803-3408-6.
2. *Automatic Control System in Biomedical Engineering*, J. Fernández de Cañete, C. Galindo, J. Barbancho, A. Luque, Springer, ISBN - 978-3-319-75716-2.
3. Modern Control Systems, R.C. Dorf and R.H. Bishop, 12th Edition, Prentice Hall.

MP Specialization Courses

BMPT 531 Medical Radiation Physics (3 credits)

a) Course Description:

This course examines the basic theory and practice of Radiation and Health Physics. This course is designed to help students to acquaint with the principles of radiation physics including radioactivity, ionizing radiation, interaction of radiation with matter, and their effects on living tissue. This course also focuses on radiation dosimetry, nuclear medicine, radiation therapy equipment, and radiation protection.

b) Course Objectives:

To help students to

i. Learn the basic theory and practice of radiation physics, understand the interaction of ionizing radiation with matter and to understand the biological effects of radiation.
ii. Acquaint them with the radiation detectors, dosimetry principles and measurement units.
iii. Learn the principles of nuclear medicine and its application in diagnosis and therapy.
iv. Gain knowledge that professionals working in *medical physics* need to master for efficient and safe dealings with ionizing radiation.

c) Course Contents

	Contents	Contact hours
1.	Atomic and nuclear structure, Electromagnetic Radiation, Electromagnetic spectrum, Ionizing radiation, Radioactive decay, modes of radioactive decay, Activity, half-life, decay constant, radioactive equilibrium.	(4h)
2.	***Interaction of radiation with matter:*** Bremsstrahlung, characteristic x-rays, Annihilation, Photoelectric effect, Compton Scattering, Pair production, Attenuation, Interaction of neutron with matter and their clinical significance.	(4h)
3.	***Interaction of charged particles with matter***: Specific ionization, Linear energy transfer range	(2h)
4.	***Radiation dose units and quantities:*** Particle flux and fluence, energy flux, fluence cross-section, Exposure, Kerma, stopping power, LET, Absorbed dose, Dose equivalent, Effective dose.	(5h)
5.	***Radiation detection:*** properties of dosimeters, gas filled detectors, film, luminescence and semiconductor dosimetry, scintillation, Photomultiplier tubes, Radiation monitoring instrument, Cavity theories, stopping power ratio, calibration and standardization.	(8h)
6.	***Biological Effects of Radiation***	(2h)
7.	***Nuclear Medicine:*** Radio-nuclides for Nuclear Medicine (radiopharmaceuticals) and their supply, Isotope generators, Radionuclides administration, Non imaging examples- hematological measurements, glomerular filtration rate, thyroid uptake; Radionuclide imaging- bone, brain, dynamic renal function, myocardial perfusion, Radionuclide therapy.	(6h)
8.	***Radiation protection:*** Sources of radiation, exponential attenuation, half-value layer (HVL), inverse square law, tenth-value layer (TVL), Linear and mass	(7h)

attenuation coefficients, ALARA concept, Occupational, public exposure and annual limits, Personal and environmental dosimetry, Shielding calculation, Radioactive transport and waste management. Radiation accidents, Radiation injuries, radiological emergency response and medical management.

9. Radiation therapy concepts, physiological mechanisms: Tumor ablation, Internal dose delivery, Brachytherapy, External dose delivery; linear accelerator, Tele-isotope units, Beam collimators, Fractional delivery scheme. (7h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Demonstrate a knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter.
- Classify radiation and radioactivity, its properties, units of measure, dosimetry measurement concepts and methods.
- Distinguish between direct and indirect effect of radiation on cells, identify the biological effects of radiation and its application for radiation safety and for radiation treatment.
- Understand the ICRP’s conceptual framework and international recommendations in radiation protection and safe use of radiation source in medicine.
- Understand the physical basis of the use of radiation in treatment and explain the concept of external and internal beam radiotherapy.

e) Instructional Strategies

- Lecture
- Discussion
- Seminar
- Demonstration

f) Student Assessment

- Continuous Assessment
  - Quiz
  - Assignment
  - Presentations
  - Problem Solving
- Final written examination

g) References:

1. PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), Springer, New York, USA (2010).
2. CEMBER, HERMAN, AND JOHNSON, THOMAS, Introduction to Health Physics. McGraw-Hill Medical, New York, USA (2008).
3. Faiz M. Khan, John P. Gibbons, The Physics of Radiation Therapy, 5th Edition, Lippincott Williams and Wilkins.
4. Frank H. Attix , Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons.

BMPT 532 Radiation Biology (3 credits)

a) Course Description:

Knowledge of the radiobiology of normal tissues and tumors is essential for radiotherapy treatment planning. This course deals with the principles of radiation biology: factors that modify radiation response; linear energy transfer; relative biological effectiveness; tissue radio sensitivity; time-dose and fractionation; radiobiological modeling.

b) Course Objectives:

To help students to

(a) Understand the spatial scales and time-sequence of the important physical, chemical and biological events and processes underlying the formation of lethal and non-lethal genetic damage, cell death, and cancer. Understand the biological basis for radiotherapy in cancer treatment.

(b) Understand how physical (e.g., oxygen and particle linear energy transfer) and biological processes (e.g., repair and cell division) modify molecular and cellular responses to ionizing radiation and influence the collective response of cancerous and normal tissue.

(c) Apply radiobiological principles and models to fractionated radiation therapy.

c) Course Contents

	Content	Contact Hours
1.	Basic cell physiology and function, Physiological mechanisms for defects, repair, maintenance, and growth.	(4h)
2.	***Ionizing radiations and their properties:*** Effects of ionizing radiation on biological materials: from molecular interactions, through sub-cellular and cellular levels of organization, with special relevance to oncology, oxygen effect, Cell Cycle (LET, OER, SF, RBE), Sensitizers to Radiation-induced damage.	(6h)
3.	***Somatic effects of radiation:*** Physical factors influencing somatic effects, Dependence on dose, dose rate, type of energy of radiation, temperature, anoxia; Acute radiation sickness, Effect of chronic exposure to radiation, Radiation carcinogenesis, Risk of carcinogenesis, In-utero exposure; Genetic effects of radiation: Factors affecting frequency of radiation induced mutations; Aspects of environmental radiation exposure, stochastic & deterministic effects of radiation.	(8h)
4.	***Biological basis of radiotherapy:*** Physical and biological factors affecting cell survival, tumor re-growth and normal tissue response, non-conventional fractionation scheme and their effect of re-oxygenation, repair, redistribution in the cell cycle, High LET radiation therapy, Cell survival curve, Dose-response curve.	(7h)
5.	Time dose fractionation, basis for dose fractionation in beam therapy, concept of nominal standard dose (NSD), Roentgen equivalent therapy (RET), Time dose fractionation (TDF) factors and cumulative radiation effects (CRE), Gap correction, Tumor vs. normal tissue radiobiology, radiation hormesis.	(7h)

6.	Radiobiological Models, Linear and Linear quadratic models.	(4h)
7.	Tumor Control Probability (TCP), Normal Tissue Complication Probability (NTCP), biologically equivalent dose (BED), Equivalent Uniform Dose (EUD), Normal and tumor cell therapeutic ratio.	(5h)
8.	Image based anatomy relevant to Radiotherapy (especially on CT images used in treatment planning), relevant physiology and pathology. Correlation of anatomical structures.	(4h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Understand the radiobiological effects at molecular and cell level.
- Differentiate between cell survival curves of varying LET radiations, hypoxic and aerated cells as well as cell cycle phases.
- Describe the biological factors affecting radiation response.
- Evaluate the radio sensitivity of tissue and organs.
- Identify the acute and late effects of radiation on living tissue. Describe the effects of whole body radiation.
- Describe the purpose and construction of dose-response relationship curves.
- Assess the biological effects of radiotherapy on tumors, high-risk organs and normal tissue, and justifying the choice of fractionation pattern.
- Understand and apply radiobiological models.
- Definition of margins, target volumes and high-risk organs.

e) Instructional Strategies

- Lecture
- Discussion
- Seminar
- Demonstration

f) Student Assessment

- Continuous Assessment
    - Quiz
    - Assignment
    - Presentations
    - Problem Solving
- Final written examination

g) Recommended Books:

1. Eric Hall and Amato J. Giaccia Radiobiology for the radiologist, Lippincottt Williams & Wilkins; Seventh edition (June 14, 2011) 7th Edition.
2. Radiation Biology: A Handbook for Teachers and Students, IAEA, 2010.
3. C. S. Sureka, Christina Armpilia, Radiation Biology for Medical Physicists, CRC Press.

BMPT 533 Physics of Radiation Therapy (3 Credits)

a) Course Description:

Radiation therapy involves the therapeutic use of controlled doses of radiation for cancer treatment in hospitals. This course is designed to give students an understanding of the radiobiological basis for radiotherapy, radiation dosimetry, dose calibration protocols, equipment used in radiotherapy, treatment planning, dose calculation, and radiotherapy treatment techniques.

b) Course Objectives:

To help students to

(a) Understand the fundamental principles underlying radiation therapy physics.
(b) Learn the operations of radiotherapy equipment, dose calculations for photon and electron beams.
(c) Learn different methods of internal and external beam radiotherapy.
(d) Understand the basics of treatment planning, simulation and QA aspects of radiotherapy.

c) Course Contents

	Content	Contact hours
1.	Overview of clinical radiotherapy.	(2h)
2.	Radiation sources, Radiation therapy equipment (accelerators, cobalt 60, cyclotrons, kV generators), Therapeutic X-ray (production, properties, beam quality, machines).	(5h)
3.	Inverse square law, penetration, treatment parameters, Central Axis and Off –axis doses, Percent Depth Dose, Iso-dose distributions, tissue compensation, Beam modifiers – for photons and for electrons, Heterogeneity corrections.	(5h)
4.	Dosimetry in Radiotherapy procedures: dose calculations for photon and electron beams, Calibration. Absorbed dose.	(4h)
5.	Basic treatment planning, Simulation, virtual simulation, DRR's, image registration, Patient setup, including positioning and immobilization.	(3h)
6.	ICRU Reports 50, 62 and 83, Basic electron radiation therapy, Kilovoltage radiotherapy.	(2h)
7.	Dose calculation algorithms and heterogeneity corrections.	(3h)
8.	Brachytherapy- HDR/LDR, Equipment, Treatment Planning.	(3h)
9.	Small-field radiotherapy equipment and techniques (Stereotactic Radiotherapy and Radiosurgery, Stereotactic Body Radiotherapy, IMRT, VMAT, Cyberknife, Gammaknife).	(4h)
10.	Therapy using Protons, Neutrons and heavy ions (brief introduction)	(3h)
11.	Image guidance and verification in radiotherapy (Cone beam CT, ultrasound, Portal imaging, in-vivo dosimetry, image registration)	(3h)
12.	Image display and dose volume histograms.	(2h)

13. Optimization. Record and verify (RV) systems, Data acquisition and entry, Machine data. Beam data and entry, Patient data. Treatment Simulation, Phantom measurements, Treatment time and Monitor Unit calculation. (4h)
14. Acceptance testing and commissioning, Quality management of radiotherapy. (2h)

d) Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Learn the principles underlying radiation therapy physics.
- Describe the working principle of radiotherapy equipment.
- Explain the treatment principles and techniques in radiotherapy.
- Understand the criteria and tools for assessing dose distribution.
- Apply the recommendations and guidelines for treatment planning.
- understand quality control, procedures and documentation of planning and treatment
- analyse and critically assess volumes and margins in radiotherapy

e) Instructional Strategies

- Lecture
- Discussion
- Seminar
- Demonstration

f) Student Assessment

- Continuous Assessment
    - Quiz
    - Assignment
    - Presentations
    - Problem Solving
- Final written examination

g) Recommended Books:

1. E.B. Podgorsak, Radiation Oncology Physics: A Handbook for Teachers and Students, IAEA 2005.
2. Faiz M. Khan, John P. Gibbons, the Physics of Radiation Therapy, 5th Edition, Lippincott Williams and Wilkins.