Department of Biomedical Physics and Technology
Faculty of Science, University of Dhaka

Syllabus

Master of Science

Program Outline (As revised at Academic Committee meeting on 20.08.2017)

Effective from the academic session 2016-17. This syllabus will continue until changes are brought about later.

Degree: MS in Biomedical Physics & Technology

with two specializations:

i) **Biomedical Engineering**
ii) **Medical Physics**

Duration of course: One academic year.

Entry requirements:

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

Explanation: 3 Credits: 45 contact hours; 3 Credits (Laboratory): 90 contact hours

Evaluation of the courses:

Theory Courses

Serial no	Assessment Criteria	Marks %
1	Attendance	05
2	Continuous Assessment (Incourse/ Assignment/ Presentation)	35
3	Final Examination	60
	Total	100

Laboratory Course

Serial no	Assessment Criteria	Marks %
1	Attendance	05
2	Continuous Assessment	35
3	Final Examination	60
	Total	100

Thesis

Serial no	Assessment Criteria	Marks %
1	Dissertation	60
2	Oral on thesis	40
	Total	100

Degree requirements:

A student must earn 32 credits by choosing from the following courses with minimum GPA 2.5 (on a scale of 4) to get an MS degree in Biomedical Physics & Technology.

A. Mandatory courses for all students:		**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	Medical Radiation Physics	3
Sub-Total A:		**15**
B. Other Mandatory courses		
BMPT 511	Thesis	6
BMPT 512	Viva-voce	2
BMPT 513	Practical Laboratory Work	3
Sub-Total B:		11
C. Optional courses for specialization in Biomedical Engineering (6 credits to be taken)		
BMPT 521	Bioelectromagnetism and Biophotonics	3
BMPT 522	Biomedical Signal & Image Processing	3
Sub-Total C:		**6**
D. Optional courses for specialization in Medical Physics (6 credits to be taken)		
BMPT 531	Radiation Biology	3
BMPT 532	Physics of Radiation Therapy	3
Sub-Total D:		**6**
Grand TOTAL:		**32**

Syllabus details

A. Mandatory Courses

(15 credits) starts from BMPT 501

BMPT 501 Introduction to Human Anatomy and Physiology 3 credits

1. **Introduction to the human body & Homeostatsis** (2h)
   Structural levels of human body; goal & importance of physiology; Homeostasis; Major functional systems and control systems of the body.
2. **Cellular & Tissue System** (6h)
   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.
3. **Musculoskeletal System** (4h)
   Classification, characteristics, function and structure of major muscle, bones, joints and cartilages.
4. **The Skin** (2h)
   Structure of the skin, function of the skin; wound healing.
5. **Blood and Circulation System** (4h)
   Composition and function of blood, Blood Flow, Blood Pressure, The Microcirculation and the Lymphatic System: Capillary Fluid Exchange, Interstitial Fluid, and Lymph Flow.
6. **Central and Peripheral Nervous system** (8h)
   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, Limbic systems and Hypothalamus; Autonomic Nervous system; States of Brain Activity—Sleep, Brain Waves, Epilepsy and Circadian Rhythm.
7. **Special Senses** (3h)
   Organization and Functions of Vision, Hearing and Equilibrium, Smell and Tastes.
8. **Cardiovascular System** (4h)
   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.
9. **Respiratory system** (3h)
   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.
10. **Digestive system** (3h)
    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.
11. **Renal System** (3h)
    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.

12. **Endocrine and Reproduction System** (3h)
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.

Recommended Books:

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.

BMPT 502 Biophysics **3 credits**

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. (7h)
2. ***Basic Enzyme Behaviour:*** 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, colour 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 blood flow in vessels, laminar and turbulent blood flow, work done by the heart, Cardiac output & venous return. (7h)
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 manoeuvres, 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. (8h)

Recommended Books:

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**

1. Biomedical sensors and transducers (Working principle and Operations) ***[9h]***

a. Physical sensors: **(2h)**
Displacement sensors, inductance sensors, capacitive sensors, ultrasound sensors, velocity sensors, accelerometers, thermal sensors.

b. Biopotential sensors: **(2h)**
Basis of bioelectrical signal, electrical characteristics, surface electrodes, intra-cavity and intra-tissue electrodes, microelectrodes.

c. Electrochemical sensors: **(2h)**
Electrochemical sensors, Potentiometric sensors, Volta-metric sensors, Reference electrodes.

d. Optical sensors: **(2h)**
Photodetectors, optical fibers, general principles of optical sensing, applications

e. Advanced biological sensors **(1h)**

2. <u>Biomedical Instrumentation</u> ***[13h]***

a. Basic biomedical amplifier requirements **(1h)**

b. Bio-amplification Circuits: **(2h)**
Differential amplifier, Instrumentation amplifier, Common mode rejection ratio (CMRR), constant current source

c. Isolation of amplifier and patent safety: **(2h)**
Surge protection, Input guarding, dynamic range and recovery,

d. Noise in biomedical amplifiers: **(1h)**
source of noise, noise cancellation techniques

e. Optical instrumentations: **(2h)**
Endoscope, Biomedical lasers, Scanning Electron Microscope

f. Rehabilitation instruments: **(3h)**
i. Cardiac disorder: Pacemakers, Defibrillators
ii. Hearing disorder: Hearing aids, Cochlear implants
iii. Physiotherapy: Muscle and nerve stimulators, ultrasound therapy, infrared heating, microwave diathermy

g. Diagnostic instruments: **(2h)**
Overview of the instruments for x-ray, echocardiography, MRI, computed tomography.

3. Bio-physical measurements ***[16h]***

a. Biopotential measurements: **(4h)**
Electrocardiography (ECG): Basics of heart, origin of signal, measuring techniques
Electromyography (EMG): Basics of muscle, origin of signal, measuring techniques
Electroencephalography (EEG): Basics of brain, origin of signal, measuring techniques
Electrooculography (EOG): Basics of eye, origin of signal, measuring techniques

b. Evoked response measurements: **(3h)**
i. Sensory evoked response: visual evoked response, auditory evoked response, somatosensory evoked response
ii. Motor evoked response
iii. Nerve conduction velocities: Sensory nerve conduction velocity, Motor nerve conduction velocity, Supramaximal stimulation, Stimulation artifact.

c. Fluid and velocity measurements: **(4h)**
i. Long term sampling methods: vascular unloading principle, Occlusive cuff mechanics, Method of Korotkoff, Oscillometry, Derivative oscillometry.
ii. Pulse dynamic methods: R-wave unloading technique, continuous vascular unloading, pulse sensing, arterial tonometry, flexible diaphragm tonometry.
iii. Non-invasive arterial mechanics.
iv. Blood velocity measurement: Ultrasound doppler blood velocity technique.
v. Blood flow measurement: Electromagnetic blood flow technique.
vi. Optical plethysmography, pulse oximetry.

d. Respiration measurements: **(3h)**
i. Lung volumes, Pulmonary function tests, Dynamic tests, Pneumotachograph, Nitrogen-washout method, physiologic dead space
ii. Ventilators: Types of ventilators, modes of ventilation, breath control delivery

e. Biochemical measurements: **(2h)**
i. Measurement of blood glucose
ii. Measurement of blood hemoglobin

4. Instrument interfacing and communication protocols: ***[5h]***

a. Interfacing: **(3h)**
i. A/D and D/A converters, DMA controllers, Overview of microcontrollers
ii. Memory architectures and memory interfacing
iii. BUS interfacing
iv. I/O hardware interfacing: interfacing with sensors and actuators

b. Communication protocols: **(2h)**
i. Serial communications
ii. USB communications
iii. Bluetooth communications
iv. Wi-Fi communications.

5. Patient Safety and Ethics ***[2h]***

a. Risk factors, safety and management of medical equipment: **(1h)**
i. Definition
ii. History
iii. Application
iv. Case study

b. Ethical issues related to clinical research: **(1h)**
i. Ethical issues in feasibility studies
ii. Ethical issues in emergency use
iii. Ethical issues in treatment use
iv. The safe medical devices act

Recommended Books:

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.
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

BMPT 504 Medical Imaging Methods — 3 credits

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. Artificial productions of radio-nuclides for Nuclear Medicine. (7h)
6. **Advanced Imaging:** Magnetoencephalography, Diffuse optical tomography, Optical coherence tomography, Elastography, Tactile imaging, Photoacoustic imaging (2h)

Recommended Books

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 Medical Radiation Physics 3 credits

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 charged particles with matter –Specific ionization, Linear energy transfer range.[2h]
3. 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]
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, ionization chamber, 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- haemotalogical 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 attenuation coefficients, ALARA concept, Occupational, public exposure and annual limits, Personal and environmental dosimetry, Shielding calculation, Radiation protection during transportation of radioactive materials, Radioactive waste disposal. [7h]
9. Radiation therapy concepts, physiological mechanisms; Tumour ablation, Internal dose delivery: Brachytherapy, External dose delivery: linear accelerator, Tele-isotope units, Beam collimators, Fractional delivery scheme. [7h]

Books recommended:

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.
3. Frank H. Attix , Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons.

B. OTHER MANDATORY COURSES

(11 credits) Starts from BMPT 511

BMPT 511 Thesis	**6 credits**
Thesis should be submitted according to the university guideline.	
BMPT 512 Viva-voce	**2 credits**
An oral examination will be held based on all theory courses.	
BMPT 513 Practical Laboratory Work	**3 credits**

Laboratory experiments based on theory courses.

C. FOR SPECIALIZATION IN BIOMEDICAL ENGINEERING

OPTIONAL COURSES (6 credits) Starts from BMPT 521

BMPT 521 Bioelectromagnetism and Biophotonics **3 credits**

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)***

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)

Physiological effects of dc and ac on body tissues, leakage current, safety issues in measurements. (2h)

Impedance Plethysmography & Impedance Tomography: Electrical Impedance Tomography (EIT), Focused Impedance Method (FIM), Pigeon Hole Imaging (PHI). (5h)

C. Biomagnetism ***(7h)***

Biomagnetic field, Nature of the biomagnetic sources. (1h)

Biomagnetic Measurements: Reciprocity Theorem For Magnetic Fields, Magnetic Dipole Moment, Lead Fields, Synthesization Of Lead Fields, Magnetoencephalography (MEG), Magnetocardiography (MCG) (4h)

Biomagnetic Stimulation: Coil Design, Field Distribution, Activation of Tissues, Applications. (2h)

D. Biophotonics ***(11h)***

Fundamental optical properties of tissue, Light-Tissue Interactions and Photobiology. (3h)

Biophotonic diagnosis and therapy: basic concepts. (3h)

LASERs in medicine: Principles of LASER, LASER Tweezer and LASER scissors, Application of LASER in medicine. (3h)

Bioimaging: Basic Principles and Techniques, Optical Coherence Tomography (OCT). (2h)

Recommended Books:

1. J. Malmivuo and R. Plonsey Bioelectromagnetism, Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, 1995.
2. S. Grimnes and O.G. Martinsen, Bioimpedance and Bioelectricity Basics, Academic Press, 2000.
3. Introduction to Biophotonics, Paras N. Prasad Wiley (2003).

BMPT 522 Biomedical Signal and Image Processing — 3 credits

A. 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)

B. 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)

Recommended Books:

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

D. FOR SPECIALIZATION IN MEDICAL PHYSICS

OPTIONAL COURSES (6 credits) Starts from BMPT 531

BMPT 531 Radiation Biology 3 credits

1. Basic cell physiology and function, Physiological mechanisms for defects, repair, maintenance, and growth.
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.
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.
4. Biological basis of radiotherapy: Physical and biological factors affecting cell survival, tumour 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.
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.
6. Radiobiological Models, Linear and Linear quadratic models.
7. Tumour Control Probability (TCP), Normal Tissue Complication Probability (NTCP), biologically equivalent dose (BED), Equivalent Uniform Dose (EUD), Normal and tumour cell therapeutic ratio.
8. Image based anatomy relevant to Radiotherapy (especially on CT images used in treatment planning), relevant physiology and pathology. Correlation of anatomical structures.
9. Radiation accidents, Radiation injuries, radiological emergency response and medical management.

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 532 Physics of Radiation Therapy **3 Credits**

1. Overview of clinical radiotherapy.
2. Radiation sources, Radiation therapy equipment (accelerators, cobalt 60, cyclotrons, kV generators), Therapeutic X-ray (production, properties, beam quality, machines).
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.
4. Dosimetry in Radiotherapy procedures: dose calculations for photon and electron beams, Calibration. Absorbed dose.
5. Basic treatment planning, Simulation, virtual simulation, DRR's, image registration, Patient setup, including positioning and immobilization.
6. ICRU Reports 50, 62 and 83, Basic electron radiation therapy, Kilovoltage radiotherapy.
7. Dose calculation algorithms and heterogeneity corrections.
8. Brachytherapy- HDR/LDR, Equipment, Treatment Planning.
9. Small-field radiotherapy equipment and techniques (Stereotactic Radiotherapy and Radiosurgery, Stereotactic Body Radiotherapy, IMRT, VMAT, Cyberknife, Gammaknife).
10. Therapy using Protons, Neutrons and heavy ions (brief introduction)
11. Image guidance and verification in radiotherapy (Cone beam CT, ultrasound, Portal imaging, in-vivo dosimetry, image registration)
12. Image display and dose volume histograms.
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.
14. Acceptance testing and commissioning, Quality management of radiotherapy.

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.