Course Outline

Degree: MS in Biomedical Physics & Technology

Duration of course: 1 academic year

This syllabus will continue until changes are brought about later

Explanation: 4 Credits: 60 lectures; 2 Credits: 30 lectures

Entry requirement: BS in Physics, Applied Physics & Electronics, Electrical & Electronic Engineering, Computer Science and Related subjects

Outline:

A student has to take 32 credits by choosing from the following courses to get an M.S. degree in Biomedical Physics & Technology.

A. Mandatory courses for all students:		**Credits**
BPT-M_01.	Biophysics and Medical Radiation Physics	4
BPT-M_02.	Human Body in Health & Disease	4
BPT-M_03.	Biomedical Instrumentation	4
BPT-M_04.	Bio-electricity & Bio-impedance	2
BPT-M_05.	Medical Imaging methods	2
BPT-M_06.	Computers & Microcontrollers in Healthcare	2
Sub-Total A:		**18**

B. Optional courses (4 credits to be taken)*

(Courses to be offered depending on the number of students and availability of teachers)

BPT-M_11.	Physics for Medicine	2
BPT-M_12.	Electronics	2
BPT-M_13.	Research Methodology and Biostatistics	2
BPT-M_14.	Signal processing in Biomedical Engineering	2
BPT-M_15.	Computational techniques	2
BPT-M_16.	Biophotonics	2
Sub-Total C:		**4**

C. Other Mandatory Courses

BPT-M_21.	Practical laboratory work	4
BPT-M_22.	Dissertation	4
BPT-M_23.	Oral examination	2
Sub-Total C:		**10**
Grand TOTAL:		**32**

* For the session 2011-2012, only the courses BPT-M_13 and BPT-M_14 among the optional courses will be offered.

Syllabus Details

Syllabus details MS in Biomedical Physics & Technology

Duration of course: 1 year

This syllabus will continue until changes are brought about later

Explanation: 4 Credits: 60 lectures; 2 Credits: 30 lectures of approx. 1 hr each.

Mandatory Courses

(starts from BPT-M_01)

BPT-M_07. Biophysics, Medical Radiation Physics 4 credits

A. Biophysics (22h)

1. Neural communication - digital systems and frequency modulation; action potentials of nerves and muscles, equivalent dipole and volume conductor fields, electrical model of a nerve fibre, generation and propagation of action potential – polarisation, depolarisation and repolarisation, conduction velocity, conduction in myelinated nerve fibres, muscle contraction mechanism, muscle activity for movement, major disorders of the neuromuscular system and their effects on conduction – stroke, nerve block, demyelination, neural degeneration, muscular degeneration. (10h)
2. Sensory organs : Eye (vision)- focusing and adaptation, disorders. Ear – ear canal resonance, sound transmission and amplification through ossicles, Cochlear function, Otto Acoustic Emission, Hearing threshold in terms of Sound pressure level (SPL) and Hearing threshold level (HTL), hearing defects in terms of HTL. (5h)
3. Cardiovascular system: Pumping action of heart and blood flow cycle, arterial and venous system, distributed venous pump, blood pressure in arteries and veins; Natural pacemakers of the heart – SA node, AV node, HP-bundle; mechanism of pacemaker cells in creating oscillations, frequency override hierarchy including brain control with electronic analogy. (4h)
4. 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. (3h)

B. Medical Radiation Physics (38h)

5. Radiation decay, ionising radiations and their properties (3h)
6. Effects of ionizing radiation on biological materials, biological aspects of environmental radiation exposure. (5h)
7. Radiation detection: gas, scintillation, and solid state radiation detectors, Photomultiplier tubes, Counting statistics, Dosimetry units, Personal monitoring and Radiation protection. (5h)
8. Radiation diagnosis (Nuclear Medicine): Iodine uptake studies, radiation imaging applications, Radio-nuclides for Nuclear Medicine (radiopharmaceuticals) and their supply. (5h)
9. Radiation therapy concepts, physiological mechanisms; Tumour ablation, Internal dose delivery: Brachytherapy, Shielding considerations. (4h)
10. External dose delivery: Fractional delivery scheme (2h)
11. Radiation therapy equipment: Cobalt source, properties, housing, dose delivery, collimation & effects; LINAC, photon and electron beams; concepts on IGRT, Stereotactic radiosurgery, Gamma knife, IMRT, Proton therapy and Heavy ion theory. (7h)
12. Treatment planning, Calibration, Phantom measurements, treatment simulation, Commissioning & Quality Assurance. (6h)
13. Regulations in Radiotherapy. (1h)

BPT-M_08. Human Body in Health & Disease **4 credits**

1. Introduction to the human body: structural levels of human body; the internal environment and homeostasis. (1h)
2. Introduction to the chemistry of life (I): atoms, molecules and compounds; important biological molecules. (2h)
3. Introduction to the chemistry of life (II): Movements of substances within the body; body fluids. (1h)
4. Human Cell: Plasma membrane, organelles, cell division, mutation (2h)
5. Human Cell: Transport of substances across biological membranes (3h)
6. Cell surface specialization and junctional complexes. (1h)
7. Epithelial tissue: Definition, Classification, Components, Characters, Distribution and function. (2h)
8. Nervous tissue: Definition, Classification, Components, Characters, Distribution and function. (3h)
9. Connective tissue and Muscular tissue: Definition, classification, components, Characters, Distribution and function. (2h)
10. Disorders of cells and tissues (I): Introduction to the pathophysiology and cellular adaptation concept, concepts of etiology and pathogenesis, morphology and functional changes of tissues (2h)
11. Disorders of cells and tissues (II): Basic concepts of cellular injury and adaptation, inflammation, infract and shock, thrombosis and embolism. (2h)
12. Disorders of cells and tissues (III): Neoplasm and tumours; characteristic feature of benign and malignant tumours, grading straging of malignant tumours; precancerous conditions, various methods of diagnosis of cancer. (3h)
13. Skeletal system: Bonesand cartilage, types, characteristics; location, function; joints. (2h)
14. Mascular System: Classification, characteristics, function and structure. (1h)
15. Blood: Composition, Plasma protein, Formed elements of blood. (3h)
16. Cardiovascular System: Component, parts, heart and blood vessels, General, Portal and Regional circulation, lymphatic drainage. Physiology of cardiac muscle. Conductive system of heart. Cardiac cycles, ECG, Cardiac output and venous return, Blood pressure and its regulation, physics of blood flow and pressure. (4h)
17. Respiratory system: Respiratory apparatus, Pulmonary ventilation, Mechanism of respiration, Lung function tests, Gaseous exchange, oxy-haemoglobin and carbon-di-oxide dissociation curve; Regulation of respiration, Hypoxia. (5h)
18. Urinary System: General outline of Uro-Genital Component parts, situation, structure, Physiology of kidneys. Mechanism of urine formation kidney function tests, Oedema and pulmonary fluid, the special fluid system of the body. (4h)
19. Digestive system: Introduction, A general outline of its different parts with their functions. Digestive glands and associated organs; Transport of food, Digestive juices- composition, secretion function; Bile, Structure and function of liver; Liver function tests. (4h)
20. Nervous system: A general outline of organization, Neurons, Nerve, Fibers, Synapse, Neuro transmitters, Sensory system of the body motor system of the body; Sensory and motor pathways of spinal cord; Function of cerebellum, Basal ganglia and Hypothalamus; Physiology of Autonomic Nervous system. (6h)
21. Special Senses: Optics of Visions, Physiology; Errors of refraction; Accommodation and light reflex, auditory pathway; Physiology of smell and taste. (2h)
22. Endocrinology and Reproduction: Types, general mechanism of action, function and secretion of hormone; Clinical importance of endocrine system; Physiology of pregnancy. (3h)
23. The skin: Structure of the skin, function of the skin; wound healing. (1h)

BPT-M_09. Biomedical Instrumentation **4 credits**

A. Sensors & transducers(23h)

1. Temperature sensors: thermocouple, resistance thermometer, thermistor, diodes, fibre optic temperature sensors. (3 h)
2. Light sensors: photoconductors (LDR), photodiodes, phototransistors; spectral response, CCD and CCD cameras. (3 h)
3. Sound sensors: microphone – carbon, electromagnetic, piezoelectric, ferroelectric (condenser type); earphones and speakers, stethoscope; frequency response and resonance considerations, impedance considerations. (4 h)
4. Position, Displacement, velocity and acceleration transducers, angular motion transducers. (4 h)
5. Flow and velocity sensors for liquids and gases, electromagnetic flowmeter, ultrasound Doppler velocity sensors. (4 h)
6. Transducers to measure Strain, Pressure, Viscosity, Moisture (3 h)
7. Selective membrane sensors - pH sensor. (2 h)

B. Diagnostic instrumentation and measurements(37h)

1. Temperature measurement and monitoring: Mercury clinical maximum recording thermometer, electronic thermometer, Infrared Radiation measurement (2h)
2. Blood pressure measurement: Indirect (non-invasive: basis, Sphygmomanometer, mercury & electronic), Direct (invasive) (2h)
3. Plethysmography: Optical (1h)
4. Respiratory measurements: spirometry equipment, measurement of spirometric functions and analysis, Electrical impedance measurement. (3h)
5. Haemodialysis: introductory concepts (1h)
6. Bioelectrical measurements: Surface and needle Electrodes, electrode-equivalent circuits, Noise & CMRR considerations, Instrumentation amplifier, Virtual Instrumentation. (4h)
7. Electrocardiography: Twelve lead configuration and front end network, Gain and frequency response considerations, Frank Lead system, Vectorcardiography (3h)
8. EMG equipment and measurement (1h)
9. EEG equipment and measurement (1h)
10. Evoked response measurement, signal averaging, artificial stimulation of nerves, Sensory & Motor Nerve conduction velocity measurement, Visual & Audio evoked responses (SVR, BSER), Otoacoustic Emission (OEM) (5h)
11. Patient monitoring systems (1h)
12. Telemedicine basic concepts (1h)
13. Ultrasound Doppler techniques: blood velocity measurement – non-directional and directional, Foetal monitoring. (3h)
14. Audiological measurements: pure tone audiometry, Bone conduction (2h)
15. Patient Safety and regulatory issues. (1h)

C. Therapy and Rehabilitation:

1. In cardiac disorders: Defibrillator, Pacemaker (1h)
2. Hearing aids, Hearing aid fitting (1h)
3. Physiotherapy instruments: Infra-red heating, RF diathermy, Ultrasound therapy, Muscle & Nerve stimulators. (2h)

D. In -Vitro Measurements:

1. Colorimeter, Spectrophotometer, Conductometer, pH-meter (2h)

Books Recommended:

1. Medical Physics by John R. Cameron, John Wiley & Sons, Inc.
2. 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
3. Biomedical Instrumentation: Technology and Applications by R. S. Khandpur, McGraw-Hill
4. Biomedical Transducers and Instruments by Tatsuo Togawa, Toshiyo Tamura, and P.A. Öberg, CRC Press Inc

BPT-M_10. Bio-electricity & Bio-impedance 2 credits

A. Bioelectricity (12h)

1. History of Bioelectricity (1h)
2. Origin of Bioelectricity, Semi-permeable membranes and ion channels, charge separation by membranes, charge pumps, action potential, nerve and muscle action potentials. (2h)
3. Modelling of Bioelectric Signals; dipole fields in a volume conductor; Theory of Bioelectric Measurements: Lead Field Equations, Ideal Lead Fields. (3h)
4. Polarisation of water and electrolytes, response of medium to ionic charges; cell polarisation at microscopic level, Charge shielding, Debye length. (1h)
5. Dielectrics, Effect of external electric fields, effects on polar and non-polar molecules, concepts of polarisation and permittivity, effects on capacitance, effects of dc and ac excitation. (2h)
6. Electrical model and properties of cells in the body, cell membrane, intracellular and extracellular fluid, effect of external electric fields with dc and ac of different frequencies, various dispersion ranges. (3h)

B. Bioimpedance (18h)

7. Theory of measurement of Bioimpedance: electrodes, electrode-electrolyte interface; dc and ac models; two, three and four electrode measurements; isocurrent and isopotentials, sensitivity distribution, negative sensitivity; infinite and bound mediums, concepts of Finite Element Method for numerical solutions. (4h)
8. Physiological effects of dc and ac on body tissues, safety issues in measurements. (1h)
9. Bioimpedance at different frequencies, Electrical equivalent circuit, Cole model, complex impedance, complex permittivity, Cole-Cole plot. (2h)
10. Practical measurement of Bioimpedance: Basic electronic circuitry, noise considerations and sensitivity, Multi-frequency measurements; Applications. (2h)
11. Electrical Impedance Tomography (EIT): basics for 2D EIT, 3D effects, Applications of 2D EIT, present status towards 3D EIT. (2h)
12. Focused Impedance Method (FIM): 8, 6 and 4 electrode methods; equipotential models, phantom studies and numerical sensitivity distributions; Instrumentation, Multifrequency instrumentation basics, Applications. (4h)
13. Pigeon Hole Imaging (PHI): Two versions as extensions of 6 and 4 electrode FIM, basic concepts and measurement schemes. (1h)
14. Potential applications of Electrical Impedance Measurement techniques. (2h)

Recommended Books:

1. J. Malmivuo and R. Plonsey Bioelectromagnetism, Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, 1995, ISBN: 0-19-505823-2
2. S. Grimnes and O.G. Martinsen, Bioimpedance and Bioelectricity Basics, Academic Press, 2000, ISBN: 0-19-505823-2
3. J.G.Webster, Electrical Impedance Tomography. Adam Hilger, 1990

BPT-M_11. Medical Imaging methods — 2 credits

1. **Introduction to medical imaging** (1h)

The role of Physics in medical imaging and the range of imaging methods.

2. Ultrasound Imaging (4h)

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.

3. X-ray imaging and X-ray CT (6h)

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.

4. Image mathematics and introductory image processing (4h)

Digital image representation, Fourier reconstruction methods, iterative reconstruction, modulation transfer functions, 2D convolution, image filtering and noise reduction, image segmentation, image registration, Visualization software.

5. Nuclear Medicine Imaging: Positron emission tomography (PET) and single photon emission computed tomography (SPECT) (5h)

Radioisotopes, radiotracers and molecular imaging, scintillators, gamma cameras, resolution, sensitivity, collimators, coincidence, PET-CT and SPECT-CT, tracer kinetic modelling,

6. Magnetic Resonance Imaging (MRI) (7h)

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, MRI scanner hardware, diagnostic utility and clinical MRI, functional MRI, MR spectroscopy, chemical shift.

7. Other imaging modalities in medical research (3h)

Magnetoencephalography, electrical impedance tomography, electroencephalography, high frequency ultrasound, diffuse optical tomography, optical coherence tomography.

BPT-M_12. Computers & Microcontrollers in Healthcare — 2 Credits

A. Computers (14h)

1. Basic computer system organization: Block diagram showing CPU, memory & input/output devices, Internal and external memory, Volatile and non-volatile memory, large volume data

storage. (2h)

2. Internal block diagram of CPU explaining the basic functioning of a computer, concept of program (software), where hardware meets software in a computer. (2h)
3. Buses & registers, program counter, Timing and control section, Instruction register, Program Counter, Memory Address register, Accumulator. (2h)
4. Simple program example, Program execution, Computer operating cycles: Instruction & Execution cycles, Synchronising and controlling of operations. (2h)
5. Programming language types-machine language, Assembly language and high level languages, Interpreter and Compiled program, Executable Files and Source code. (2h)
6. Input/Output: Handshaking: Examples of I/O, Process instruments control, Keyboard entry/Display, Parallel - serial interface , the UART, Asynchronus serial data communication. (2h)
7. Computer Interfacing & Data acquisition. (2h)

B. Microcontrollers (16h)

1. Introduction: Number systems and arithmetic (review), Binary, 2's complement, add, subtract, divide & multiply; Machine model (PIC and Atmel AVR) (2h)
2. Assembly language programming (using PIC): Addressing modes: Access to data, Data sizes, Indirection, Implementation of stacks; Register Set & properties; Instruction Set; Introduction to assembly/linking/simulation process; Modular programming: Use of subroutines - hardware stack, storage allocation; Simple program examples: Searching, sorting and arithmetic operations. (4h)
3. On-chip Peripherals: I/O Ports; Programmable Timer; Interrupts; Serial Peripheral Interfaces; USB Interface; A/D Conversion and sampling, aliasing; Design and interface examples; Writing to EEPROM (4h)
4. C Programming for Embedded Systems (using Atmel AVR): C Compilation & Linking; Program & data organization; Parameter Passing & stack frames; Using C to access hardware; Software building blocks - queues, tables, strings, state machines etc. (4h)
5. Expansion Methods: Memory interfacing and timing diagrams; Memory decoding & buffering. (2h)

OPTIONAL COURSES

(starts from BPT-M_11)

BPT-M_11. Physics in Medicine 2 Credits

1. Mechanics: Motion in one and two dimensions; Circular motion; Newton's Laws of Motion; Force, friction, types of forces; Work, energy, power, energy conservation, 'mass-energy' conservation; Fluid Mechanics, relevance to blood flow. (4h)
2. Oscillations and Waves: Simple harmonic oscillation, mass-spring system, simple pendulum; Wave motion, Transverse and Longitudinal waves; Mechanical and Electromagnetic waves, wave spectrum; standing waves, natural frequency, damped oscillation, RLC circuit model; Forced oscillation & resonance; LC circuit model, Superposition, interference and diffraction; Fourier analysis. (5h)
3. Heat and Thermodynamics: Temperature, Heat, heat capacity, specific heat, heat of transformation; Heat and work, First and second law of thermodynamics, internal energy, heat transfer, thermal conductivity; Kinetic theory of gases. (3h)
4. Electricity and Magnetism: Electric field, point charge in an electric field, dipole, Gauss' Law; electric potential, equipotential surfaces and lines; potential of a conductor in an electric field; electric cell, emf; AC Generator, Sinusoidal AC; internal resistance; Electric current, insulators, semiconductors, conductors and superconductors; ionic current in fluids; Ohm's law, power dissipation, series and parallel combination of resistors; ammeter, voltmeter, ohmmeter; Magnetic field, Electromagnetism, magnetic dipole; spin & orbital magnetic moments, Diamagnetism, Paramagnetism, Ferromagnetism, Magnetic domains; Mutual and self Inductance, Faraday's laws of induction; Electrical elements: resistor, capacitor, inductor and their functions; RC, LR and LC circuit with dc step and with ac: energy storage in capacitor and inductor, time constant, damped oscillation, phase, Resonance in series and parallel RLC circuit, LC oscillation; AC Transformers. (9h)
5. Light and Optics: Fields in Electromagnetic waves; reflection and refraction, total internal reflection, plane and spherical mirrors, thin lenses, optical instruments – microscope, telescope; polarization, Interference and Diffraction, diffraction grating. (3h)
6. Sound Wave: Speed of sound waves, Travelling sound waves, Interference, Intensity and sound level, Doppler effect. (2h)
7. Modern Physics: Relativity basics, Quantum Physics basics; Atomic Physics, emission and absorption spectra, spin and orbital angular mometum, dipole moments, magnetic resonance, Pauli exclusion principle, X-ray and X-ay spectrum, Laser and its application in medicine; Nuclear Physics basics; Particle Physics basics. (4h)

Recommended books:

1. Fundamentals of Physics by David Halliday, Robert Resnick, and Jearl Walker, Wiley

BPT-M_12. Electronics 2 Credits

1. Basic electronic devices: Thermistor, Photoresistor (LDR), Semiconductor Diode, Zener diode, LED, Photodiode & Solar Cell, Bipolar Junction Transistor (BJT), Field Effect Transistors (FET), Phototransistor. (5h)

2. Equivalent Models and Circuits: Constant Voltage and Constant Current sources, Thevenin's and Norton's equivalent circuits, Two-port network equivalent circuits, voltage gain, input and output resistances, voltage and power amplifiers, cascaded stages. (4h)
3. Bipolar Junction Transistor (BJT) circuits: Load line & operating points, transistor as a switch; CE amplifier, Q-point, graphical analysis; Transistor biasing. (3h)
4. Operational Amplifier with ideal analysis: Differential scheme and dc amplification; open loop differential gain, Common mode gain, Equivalent circuit; Ideal op-amp approximations, Comparator, Negative feedback, Non-inverting amp, Current to voltage converter, Inverting amplifier, Instrumentation amplifier, CMRR, application in Bioelectrical measurements. (5h)
5. Frequency Response: Voltage gain and phase response of RC low pass and high pass filters (graphical), cut-off frequency, decibel (dB) voltage gain, Bode Plots, rolling off slope, Identification of low pass and high pass elements in CE amplifier. Frequency response of an op-amp – open loop and closed loop, gain-bandwidth product. Multistage frequency effects, Active higher order filters. (5h)
6. DC stabilised power supply: Series Voltage regulation, IC regulators, Switched Mode power supply concepts. (2h)
7. Oscillator and Pulse generator circuits: Positive feedback and oscillation, Wien Bridge oscillator, Relaxation Oscillators: BJT astable multivibrator, using Timer IC. (3h)
8. Digital Electronics - an Overview: Analogue and Digital world, Number systems and Codes, Binary logic; basic ideas on electronic implementation. (3h)

Recommended Books:

1. Malvino, A.P. Electronic Principles, Tata McGraw Hill
2. Boylestad, R. and Nashelsky, L. Electronic Devices and Circuit Theory. Prentice-Hall of India.
3. Brophy, J.J: Basic Electronics for Scientists, McGraw-Hill.

BPT-M_13. Research Methodology and Biostatistics 2 Credits

1. Descriptive statistics: Populations and samples, Distributions, means, standard deviation and variance. (4h)
2. Probability, Sampling and error theory (standard error of mean). (4h)
3. Proportions and the binomial distribution. (2h)
4. Poisson statistics (2h)
5. Statistical models and null hypothesis, the normal distribution, tests of hypothesis: t-test, chi-squared, contingency tables. (6h)
6. Correlation and regression analysis, Analysis of variance. (4h)
7. Non-parametric statistics. (2h)
8. Direct calculation of probabilities (3h)
9. Clinical Statitistics: Clinical trials, treatment success, ROC curve, Sensitivity and Specificity (3h)

Recommended Books:

1. Introductory Statistics, by Ronald Wannacott and Thomas H Wannacott, John Wiley & Sons.
2. Principle of Medical Statistics, by Austin Bradford and I D Hill, Edward Arnold (AL)

BPT-M_14. Signal processing in Biomedical Engineering 2 credits

1. Introduction: Signals, Systems and Signal Processing, Classification of Signals, Analog-to-Digital and Digital-to-Analog Conversion. (4h)
2. Discrete Time Signals and Systems: Discrete Time Signals, Discrete Time Systems, Analysis of Discrete Time Linear Time-Invariant Systems, Discrete Time Systems Described by Difference Equations, Correlation of Discrete-Time Signals. (4h)
3. Laplace Transform: Definition, Properties and Theorem, S-domain equivalent circuits and impedances, applications, Laplace transform to Z-transform (3h)
4. The Z-Transform: The z-transform, properties of z-Transform, Rational z-Transform, Inversion of z-transform, One-sided z-transform, Analysis of Linear Time-Invariant Systems in the z-Domain. (4h)
5. Frequency Analysis of Signals and Systems: Frequency Analysis of Discrete-Time Signals, Properties of the Fourier Transform for Discrete Time Signals, Frequency Domain Characteristics of Linear Time Invariant Systems. (4h)
6. Discrete Fourier Transform: Frequency Domain Sampling: The Discrete Fourier Transform, Properties of the DFT, Frequency Analysis of Signals Using DFT. (3h)
7. Fast Fourier Transform: FFT Algorithms, Application of FFT Algorithms, Quantization Effects in the Computation of the DFT. (3h)
8. Digital Filter Design: Structures of FIR and IIR Filters, Design of FIR filters using: windows method, Frequency Sampling Method, Chebyshev Approximation Method, Design of IIR Filters: Impulse Variance, Bilinear Transform, Approximation of Derivatives. (5h)

Recommended Books:

1. Digital Signal Processing – Principles, Algorithms and Applications, JG Proakis and DG Manolakis.
2. Digital Signal Processing, Ifeachor and Jervis.
3. Digital Signal Processing, Thomas J Cavicchi.
4. Adaptive Filters, Simon Haykin.

BPT-M_15. Computational Techniques 2 Credits

1. Basics: Linear Systems (Gaussian elimination, LU decomposition, iterative methods), Nonlinear Systems (Newton method, conjugate gradient methods, globally convergent methods), Partial differential equations (separation of variables, Green's function, finite element method), Optimization and Inverse Problems (Least square criteria, regularization methods) (5h)
2. Numerical techniques: differentiation, integration, extrapolation, interpolation, convolution, splining FFTs, smoothing of curves (6h)
3. Finite Difference Method (FDM) and Finite Element Method (FEM), Application in Biomedical Physics (4h)
4. Use of MATLAB for different applications in Biomedical Physics & Technology (6h)
5. Use of Comsol Multiphysics package for solving Biomedical Physics problems (5h)
6. Computational techniques in Radiotherapy treatment planning (4h)

BPT-M_16. Biophotonics **2 Credits**

1. Definition of biophotonis: its scope and application, the electromagnetic spectrum, infrared, visible, ultraviolet light and X-ray. (1h)

2. Optical properties of tissue: fundamental optical properties of tissue- refraction, scattering, absorption, light transport in various tissues, multiple scattering, preliminaries to radiation transport, time resolved propagation light pulses, tissue properties, refractive indices, scattering and absorption properties. (3h)

3. Optical microscopy: principles, magnification, resolving power, phase-contrast microscopy: principle, positive and negative phase contrast and applications in medicine. (2h)

4. Light-tissue interactions: light interaction with a strongly scattering tissue, continuous wave light, short light pulses, temperature rise and tissue damage, optothermal and photoacoustic effects, fluorescence. (3h)

5. Biophotonic instrumentation: instrumentation for absorption (spectrophotometer), scattering and emission, excitation light sources- high-pressure arc lamp, LED, lasers, optical filters, polarizers, solid-state detectors (CCD and CMOS), optical fibers and waveguides, principles of optical fibers, single-mode and multimode fibers, fiber scopes (endoscopes), gastrocamera, laproscopic surgery, thermal imaging: principles of thermal imagers and applications in medicine and diagnostics. (8h)

6. Lasers in medicine: principles of laser devices, concept of inversion, optical pumping, laser cavity, laser threshold, special properties of laser beams, laser-tissue welding, specific laser types: carbon dioxide, argon, Nd:YAG, dye, diode lasers, application of laser in medicine: surgery, dermatology, ophthalmology, otolaryngology, laser angioplasty, laser safety. (6h)

7. Biophotonic therapy: photo sensitizers, mechanism of photodynamic action, clinical applications cancer treatment. (3h)

8. Biophotonic diagnostics: (a) Infrared and Fluorescence spectroscopy, (b) Raman spectroscopy (c) Flow cytometry (d) optical coherence imaging (OCT), principles of OCT and applications. (4h)

Recommended Books:

1. Biomedical Photomics Handbook, T.Yo-Dinh(ed.), CRC Press (2003)
2. Biophotonics, Lorenzo Pavesi, Philippe M. Fauchet (ed.) Springer (2008)
3. Introduction to Biophotonics, Paras N. Prasad Wiley (2003)

C. Other Mandatory Courses

(starts from BPT-M_21)

BPT-M_21. Practical laboratory work **4 Credits**

A. Circuit design and breadboard implementation

1. Optical Heart beat monitor
2. ECG amplifier and measurement
3. EMG amplifier and measurement
4. Nerve Stimulator
5. Galvanic skin resistance measurement
6. Electrode Impedance Measurement
7. Conductometer

B. Physiological measurement

8. Blood Pressure
9. SpO_2
10. Respiration (Spirometry)
11. 12 lead ECG
12. Heart Sound and analysis
13. Electroencephalography (EEG)
14. Nerve Conduction

C. Computer Interfacing & Microcontroller applications

15. Interfacing through printer port
16. Interfacing through USB port using a microcontroller
17. ADC and DAC

BPT-M_22. Dissertation (topic with consultation) **4 Credits**

BPT-M_23. Oral examination **2 credits**