Department of Biomedical Physics and Technology
Ph.D. and M.Phil Courses

30 March 2009

This is a multidisciplinary department taking in postgraduate students from various disciplines in science, engineering and medicine, and therefore a student taking admission into a Ph.D. or M.Phil course directly has to obtain some working background on necessary related subjects not covered by his/her previous background. These courses are designed not to make a student expert in all these subjects, but to give him/her an overview together with some fundamental concepts so that during the course of research s/he can feel the relevance of a particular topic of a particular subject and refer to an expert.

To comply with uniform requirement of the University of Dhaka Ph.D. and M.Phil. students of this department will have taught courses equivalent to 2 full units of 60 contact hours each. The present syllabus presents several half unit courses (each of 30 contact hours), and a student has to take 4 of these courses, based on his/her background and as suggested by his/her supervisor.

A combined list of the courses presently offered and their code names are given below (**BPT-PM** stands for **B**iomedical **P**hysics & **T**echnology **P**h.D. & **M**.Phil courses).

1. BPT-PM101 : Concepts of Physics
2. BPT-PM102 : Mathematics and Statistics
3. BPT-PM103 : Basic Electronics and Computers
4. BPT-PM104 : Physiology
5. BPT-PM105 : Anatomy
6. BPT-PM106 : Pathology
7. BPT-PM107 : Physics of Radiation in Health, and Imaging Devices
8. BPT-PM108 : Biomedical Instrumentation

Details of the syllabus

Course : BPT-PM101, Concepts of Physics

½ unit Full marks: 50, No. of lectures: 30

The whole syllabus uses virtually no mathematics except the minimum needed. Emphasis is on understanding of the concepts.

Item	**No. of lectures**
1. Physics and Measurement a. Units and dimensions, base and derived units, dimensional analysis b. Estimates, order of magnitude calculation c. Significant figures	(1)
2. Mechanics a. Vector & Scalar quantity b. Motion in one and two dimensions: position, displacement, velocity (including average and instantaneous velocity), speed, acceleration c. Circular motion, angular position, displacement, velocity, acceleration, torque. d. Newton's Laws of Motion, concept of mass based on 2nd law, conservation of momentum.	(3)

e. Force, friction, drag, terminal speed, impulsive force, types of forces (Gravitational, electromagnetic-weak, nuclear strong)
f. Work, energy, power, energy conservation, 'mass-energy' conservation
g. Fluid Mechanics, pressure, measuring pressure, Pascal's & Einstein's principle, viscosity, laminar flow, turbulence, equation of continuity, Bernoulli's equation, relevance to blood flow.

3. Oscillations and Waves (6)
   a. Mathematical and graphical representation of simple harmonic oscillation, mass-spring system, simple pendulum, angular simple harmonic oscillator.
   b. Wave motion, Transverse and Longitudinal waves, mathematical representation, amplitude, frequency, wavelength, velocity, intensity, energy.
   c. Types of waves: Mechanical waves in fluids and solids, sound wave, Electromagnetic wave, spectrum of sound and electromagnetic waves, their origin, speed in different media, subsonic and supersonic speeds
   d. Reflection, transmission, refractive index and velocity, standing waves in strings and air columns, natural frequency, damped oscillation (in string, bell), correspondence to that in RLC circuit.
   e. Forced oscillation & resonance in string, air column (flute, Violin box, ear canal, hall), LC circuit, piezoelectric crystals.
   f. Sound pressure levels, Hearing limits, Intensity, loudness, pitch and frequency, Doppler effect
   g. Superposition, interference and diffraction, for sound and electromagnetic waves including light
   h. Ultrasound and its characteristics, interaction with biological tissue, absorption
   i. Non-sinusoidal waves, Fourier analysis

4. Heat and Thermodynamics (3)
   a. Temperature, Heat, heat capacity, specific heat, heat of transformation.
   b. Heat and work, First and second law of thermodynamics, internal energy examples, heat transfer mechanisms, thermal resistance and thermal conductivity.
   c. Kinetic theory of gases: avogadro's number, ideal gas law, pressure, temperature, speed of molecules, evaporation, boiling.

5. Electricity and Magnetism (10)
   a. Charge quantization, charge conservation
   b. Electric field, field lines, electric dipole, point charge in an electric field,
   c. Flux, Gauss' Law.
   d. Electric potential energy, electric potential, electric field, equipotential surfaces and lines of force; potential due to a point charge, dipole and a group of point charges, potential of a conductor in an electric field.
   e. Sustained electric potential: Galvani's experiment and Volta's pile, Charge pump, electric cell and battery, work, energy, emf, emf's in series and parallel, Thermoelectricity (Johnson effect, Seebeck effect, Thermocouple), piezoelectric crystal, Solar cell, biological cell, electric eel, Generator of AC, Sinusoidal AC expression and parameters, capacity of battery cells and generators, internal resistance.
   f. Current and resistance: Electric current, drift speed and speed of current, current density, resistance and resistivity, conductance and conductivity, Impedance and Admittance, insulators, semiconductors, superconductors, ionic current in fluids.
   g. Ohm's law, potential and potential drop, power dissipation, series and parallel combination of resistors, ammeter, voltmeter, ohmmeter, multimeter.

h. Capacitance, charge storage and potential, energy stored, effect of dielectrics, polarization, series and parallel combination, charging and discharging a capacitor with dc step, reactance with ac, displacement current, phase considerations, use of capacitance in a medical defibrillator, Supercapacitors as power source.
i. Magnetic field, Lines of force, magnetic effect of current, magnetic dipole. Is magnetic monopole possible? Force between two parallel currents, solenoids, toroids, Helmholtz coils, motors, Hall effect.
j. Earth magnetism, Magnetism and electrons, spin & orbital magnetic moments, Diamagnetism, Paramagnetism, Ferromagnetism, Magnetic domains, Hysteresis
k. Mutual and self Inductance, Faraday's laws of induction, Lenz's law, energy storage in magnetic field, Eddy currents, effect of core material.
l. RC, LR and LC circuit with dc step and with ac: energy storage in inductor, time constant, LC oscillaton, damped oscillation, voltage and phase of ac for a resistor, capacitor and inductor, Forced oscillation and Resonance in series and parallel RLC circuit, LC oscillation
m. AC Transformers: ideal transformer, core, practical transformers, efficiency, frequency effects, laminated core, ferrite core and air core.
n. Fields in Electromagnetic waves, polarization, reflection and refraction, total internal reflection, optical fibre, polarization by reflection, RF and microwave hyperthermia.

6. Light and Optics (3)
   a. Images, mirage, plane and spherical mirrors, spherical refracting surfaces, thin lenses, images, ray tracing, optical instruments – microscope, telescope,
   b. Interference, coherence, interference from thin films, Michelson's interferometer
   c. Diffraction, edge, single slit, circular aperture, resolvability, double slit, diffraction grating, X-ray diffraction, sound diffraction

7. Modern Physics (4)
   a. Relativity, postulates, ultimate speed, relativity of time, length, velocity, new look at energy,
   b. Quantum Physics: photons, photoelectric effect, matter waves, uncertainty principle,
   c. Atomic Physics: arrangement in periodic table, emission and absorbance of light, spin and orbital angular mometum, dipole moments, magnetic resonance, Pauli exclusion principle, X-ray and X-ay spectrum, Laser.
   d. Molecules and solids: Insulators, semiconductors, conductors,
   e. Nuclear Physics: Nuclear organization, radioactivity, radioactive decay, alpha, beta and gamma decay, Radiation dosage,
   f. Nuclear energy: fission and fusion
   g. Particle Physics: Leptons, Hadrons, Quarks, Mesons, Basic forces, messenger particles, Expanding Universe, Cosmic background radiation, Dark energy, TheBig Bang

Recommended books:

1. Fundamentals of Physics by David Halliday, Robert Resnick, and Jearl Walker, Wiley
2. Physics by A F Abbott, Heinemann Educational Publishers

Course : BPT-PM102, Mathematics and Statistics

½ unit, Full marks: 50, No. of lectures: 30

Item	No. of lectures

A. Mathematics

1. Coordinate Geometry. Coordinate systems, angles, solid angles. (1)
2. Differentiation and integration. Limits, derivatives, differentials, partial derivatives, total differentials and chain rule, integration. (2)
3. Exponentials and logarithms. The exponential function, logarithms, natural logarithms, changing the base of a logarithm, presence of logarithmic behaviour in nature (2)
4. Series and the Taylor expansion. Sequences and series, convergence of infinite series, the Taylor series expansion, the binomial theorem, Applications. (2)
5. Vectors. Vectors, Cartesian components, multiplication of vectors. Applications in Medical Physics. (1)
6. Complex numbers. Imaginary and complex numbers, Argand diagram, Euler's formula. Application of complex numbers in electrical networks, phasors. (2)
7. The Fourier transform. A non-mathematical description, Fourier series, The Fourier transform, Delta functions. (2)
8. Convolution and deconvolution. Convolution, Deconvolution - basic idea (1)
9. Sampling and aliasing. The Sampling theorem, Aliasing, application in computerized data acquisition (1)
10. Differential equations. Classification, First order equations, Second order equations. Examples in Biophysics (1)
11. Directional derivatives. The directional derivative. The Del operator. (1)

B. Statistics

12. Descriptive statistics: Populations and samples, Distributions, means, standard deviation and variance. (2)
13. Probability, Sampling and error theory (standard error of mean). (2)
14. Proportions and the binomial distribution. (1)
15. Poisson statistics. (1)
16. Statistical models and null hypothesis, the normal distribution, tests of hypothesis: t-test, chi-squared, contingency tables. (3)
17. Correlation and regression analysis, Analysis of variance. (2)
18. Non-parametric statistics. (1)
19. Direct calculation of probabilities (1)
20. Common fallacies. (1)

Recommended books:

1. Engineering Mathematics, by K S Stroud and Dexter J Booth, Palgrave [ISBN 0-333-91939-4]
2. Essentials of Engineering Mathematics, by Alan Jeffrey, Chapman & hall [ISBN 0-412-39680-7]
3. Introductore Statistics, by Ronald Wannacott and Thomas H Wannacott, John Wiley & Sons.
4. Principle of Medical Statistics, by Austin Bradford and I D Hill, Edward Arnold (AL)

Couurse : BPT-PM103, Basic Electronics and Computers

½ unit, Full marks: 50, No. of lectures: 30

The whole syllabus uses virtually no mathematics except the minimum needed. Emphasis is on understanding of the concepts, mostly through graphical means.

Item **No. of lectures**

1. Basic and simple electronic devices (5)

Conductor (Metal), Semiconductor and Insulator, Electronics vs. Electricity, Thermistor, Photoresistor (LDR),Vacuum diode, use in rectification of ac, Semiconductor Diode: p-n junction, forward/reverse bias, I-V curve, application in reverse voltage protection or auto polarity (using bridge) of dc equipment, application in instant emergency power supplies, use in half wave & full wave rectification of sinusoidal ac, capacitor smoothing, Diode breakdown, PIV rating, Zener diode, use in voltage stabilization, Ge and Si diodes, LED, white LED, Photodiode & Solar Cell, Liquid crystal display.

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2. Bipolar Junction Transistor (BJT) (3)

npn & pnp configurations, transistor action ; alpha & beta, CE characteristics, load line & operating points, transistor as a switch. CE amplifier, active region for linear amplification, Q-point, graphical analysis. Transistor biasing: fixed bias, collector feedback and voltage dividers bias, Emitter feedback for bias stabilization, bypass capacitor. Photo-transistor

3. Field Effect Transistors (FET) (1)

n & p-channel MOSFET and JFET basic operation, Application to utilise high gate resistance

4. Equivalent Models and Circuits (2)

Constant Voltage and Constant Current sources, Thevenin's and Norton's equivalent circuits, Two-port network equivalent circuits, voltage gain, input and output resistances, requirements for a voltage amplifier, requirement for voltage and power transfer between cascaded stages.

5. Operational Amplifier with ideal analysis (4)

Basic concepts, differential input-single ended output scheme, open loop differential gain, Common mode gain, Common Mode Rejection Ratio. Equivalent circuit. Ideal op-amp approximations. Comparator, Negative feedback for stability, Non-inverting amp, gain and input output resistances, application in high impedance voltmeter. Current to voltage converter, application in current meter, Inverting amplifier, gain and input output resistances, Adder, Subtractor, Instrumentation amplifier, application in Bioelectrical measurements.

6. Frequency Response (3)

General voltage gain and phase response considerations of RC low pass and high pass filters (graphical), cut-off frequency, decibel (dB) voltage gain, Bode Plots, rolling off slope in dB /decades and dB/octave. Frequency response of a transistor amplifier, 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, frequency response requirements of a few bioelectrical signals to minimize distortion.

7. DC stabilised power supply (2)

Series Voltage regulation with feedback using transistor and op-amp, IC regulators (positive and negative, fixed and variable), Switched Mode power supply concepts.

8. Oscillator and Pulse generator circuits (2)

Positive feedback and oscillations. Phase shift and Wien Bridge oscillator circuits. Relaxation Oscillators: BJT astable multivibrator, pulse generation using Timer IC.

9. Digital Electronics - an Overview (2)

Analogue and Digital world, advantages in error free communication and processing, representation of binary values using transistors. Number systems: Decimal, Binary and Hexadecimal and their conversion, Codes: BCD & ASCII , Binary logic: NOT, OR AND, Exclusive OR, NOR, NAND, basic ideas on electronic implementation, truth tables and symbols.

10. Digital Computers (1)

Basic computer operation with examples, Instruction words - op code & operand, requirement of memory, Block diagram showing CPU, memory & input/output devices.

11. Building Blocks, hardware (2)

FF-memory element, multi-bit memory, Decoder, Encoder, Multiplexer, Demultiplexer, Binary adder, typical Arithmetic Logic Unit (ALU). Data Bus, transfer of data, internal memory in a Computer & Terminology (ROM, RAM, EPROM, etc.), external permanent memory.

12. Software (1)

Interface of hardware and software, machine language and high level languages. Interactive and Compiled languages, examples, Source code and Executable code concepts.

13. Computer Interfacing & Data acquisition (1)

Basic concepts on digital data acquisition using a computer. A/D conversion of analogue static data, sampling of time-varying data, Nyquist criterion, aliasing.

14. Radio (1)

Basic concepts on types of AM & FM modulation and radio transmission. Fundamentals of Demodulation, Diode detection.

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.

Course : BPT-PM104, Physiology

½ unit Full marks: 50, No. of lectures: 30

01. Introduction: - Homeostasis, Membranes transport, Membrane and action potential. Muscle contraction. Cellular receptors. (3)

02. Blood: - Composition, Plasma protein, Formed elements of blood. (3)

03. Cardiovascular System: - Physiology of cardiac muscle. Conductive system of heart. Cardiac cycles, ECG, Cardiac out put and venous return, Blood pressure and its regulation physics of blood, blood flow and pressure. (4)

04. 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. (4)

05. Renal physiology and body fluid:- Physiology of kidneys. Mechanism of urine formation kidney function tests. Body fluid types, compartments, measurement, compositions. Body matter and mater balance oedima and pulmonary fluid, the special fluid system of the body. (4)

06. Alimentary system: - Introduction, Transport of food, Digestive juices-composition, secretion function. Bile, Structure and function of liver. Liver function tests. (3)

07. Nervous system:- Organization, Neurons, Nerve, Fibbers, Synapse, Neuro transmitters, Sensory system of the body motor system of the body. Sensory and motor pathways of spiral cord. Function of cerebellum, Basal ganglia and Hypothalamus. Physiology of Autonomic Nervous system. (5)

08. Special Senses:- Optics of Visions, Physiology. Errors of retraction. Accommodation and light ratlines- and auditory pathway. Physiology as smell and taste. (2)

09. Endocrinology and Reproduction:- Types, general mechanism of action, function and secretion of hormone. Physiology of pregnancy, foetus and neonate. (2)

Course : BPT-PM105, Anatomy

½ unit Full marks: 50, No. of lectures: 30

General Anatomy:-8

1. Introduction of Anatomy:- Definition, subdivisions of Anatomy and its importance in the study of medicine, implications subdivisions of Anatomy with their Anatomical terminology and Anatomical planes and position. (1)

2. Skeletal system:- Bones and cartilage's- Their types, characters situations, functions and Joints. (1)

3. Muscular System:- Classification, characteristic, function and structure. (1)

4. Circulatory system:- Component, parts, heart and blood vessels, General, Portal and Regional circulation, lymphatic drainage. (1)

5. Digestive system: A general outline of its different parts with their function. Digestive glands and associated organs. (1)

6. Respiratory system: A general out line of its different parts and function. (1)

7. Nervous system:- A general outline of functional mechanism. (1)

8. Uro-Genital and Endocrine system:- General outline of Uro-Genital Component parts, situation, structure, Function and clinical importance of Endocrine system. (1)

Regional Anatomy:-12

01 Thorax:- Thoracic wall, thoracic cavity, pleura and mediastinum. Heart with pericardium. Lung, trachea and bronchus. The diaphragm. (1)

02 Superior extremity:- Pectoral region, Axilla. Scapular region. Front of the arm and forearms palm. Back of the arm and forearm dorsum of the hand. (2)

03 Abdomen:- Wall of the Abdomen. Stomach, Duodenum, pancreas and spleen. Small and large intestine. Liver, gall bladder, kidney, urinary bladder. Rectum and Anal canal. (3)

04 Interior Extremity:- Gluteal region, thigh, leg, foot. (2)

05 Head, Neck and Brain, Eyeball:- Scalp, face, orbit, thyroid gland, month, tongue, nose and ear, Neck. Cerebrum, spinal card, and visual apparatus including the eyeball. (2)

Cell biology and Histology:-5

01. Human cell: Basic organizations, Constituents, nucleus and chromosomes, cell cycle and cell division, cell membrane, organelles and inclusions. (1)

02. Cell surface specialization and junctional complexes. (1)

03. Epithelial tissue:- Definition, Classification, Components, Characters, Distribution and function. (1)

04. Nervous tissue: Definition, Classification, Components, Characters, Distribution and function. (1)

05. Connective tissue and Muscular tissue:- Definition, classification, components, Characters, Distribution and function. (1)

Surface Anatomy: 3

01 Abdomen:- Locate, demonstrate on the surface of the body the different anatomical points and important organs. (1)

02 Thorax:- Locate and count ribs. Demonstrate on the surface of the body important anatomical points and structures. (1)

03 Superior extremity, inferior extremity and head, neck:- Demonstrate on the surface of the body important anatomical points and structures. (1)

Radiography Anatomy:-2

01. Identification and location of normal structures by: Radiography, Ultrasonography and tomography. (2)

Course : BPT-PM106, Pathology

½ unit Full marks: 50, No. of lectures: 30

General Pathology:- 14

01 Introduction to Pathology and Cellular adaptation: - Definitions, Pathogenesis, morphology and functional changes of tissues. Different types of Cellular adaptations. (1)

02 Cell Injury:- Reversible and irreversible injury, cellular swelling and fatty change, necrosis and its types, Gangrene. (2)

03 Acute inflammation:- Definition, vascular changes, exudate formation, types, features of acute inflammation. (1)

04 Chronic inflammation and healing:- Definition, Features, Granular formation, Definition of Healing, repair, regeneration. Factors influencing healing. (2)

05 Oedema Hyperaemia and congestion:- Definition of oedema, pathogenesis. Cardiac, hepatic, Renal and Pulmonary oedema. Definition of hyperemia and congestion. (3)

06. Infarct and shock:- Define infarction pathogenesis and morphological charges of in infarction. Definition of Shock, Types of shock. (1)

07. Thrombosis and Embolism:- Definition of Thrombosis and thrombus, Pathogenesis, morphology and fate of thrombus. Definition of embolism and its types and fates. (1)

08. Neoplasia:- Definition, Classification, Characteristic features of benign and malignant tumours. Grading and staging of malignant tumours. Precancerous conditions. Various methods for diagnosis of cancer. (3)

Systemic Pathology:- 12

1. Cardiovascular system:- Vascular diseases, athelosclerosis. Ischemic and rheumatic heart disease, Hypertension. (2)
2. Respiratory System:- Pneumonia, Tuberculosis, Lung abscess. Bronchitis, Bronchial asthma, Common tumours. (2)
3. Gastrointestinal tract:- Ulcer, carcinoma and inflammation of oral cavity, esophagus, stomach and intestine. Hepatitis, cirrhosis of liver and diseases of gall bladder. (2)
4. Urogenital system:- Nephrolithiasis, tumors of kidney and urinary, bladder. Tumors prostate, Diseases of uterus and ovary. (2)
5. Diseases of Breast and skin:- Inflammatory disease, Fibrocystic disease and turners of breast. Tumours of skin. (2)
6. Nervous system and disease of Eye and ENT:- Meningitis, encephalitis and tumours of nervous system. Tumours of Eye and ENT. (2)

Hematology:- 4

01. Anaemia:- Definition, Megaloblastic and iron deficiency anaemia. Haemolytic anaemia. (2)

02. Hemorrhagic Disorder:- Classification, Leukaemia Myeloproliferative disorders. (2)

Course: BPT-PM107, Physics of Radiation in Health, and Imaging Devices

½ unit, Full marks: 50 No. of lectures: 30

The whole syllabus uses virtually no mathematics except the minimum needed. Emphasis is on understanding of the concepts, mostly through graphical means.

Item	No. of lectures

1. Radioactive decay, interactions of the different types of radiation with matter; (2)
2. Methods of radiation detection, radiation detectors, (2)
3. Biological effects of radiation exposure, Chemical changes, Change in molecular level. (2)
4. Radiation protection: Principle, Basic radiation protection criteria, exposure of individuals in the general public, Allowable limit of intake, rules for operation of a radiation laboratory, external radiation protection, and internal radiation protection. (3)
5. Radiation imaging technologies: X-rays, CT scanner, positron emission tomography (PET), Gamma camera, single photon emission computed tomography (SPECT) (5)
6. Radiation therapy: Principle of radiation therapy, implementing radiation therapy treatment planning, evaluation, and delivery, Simulator, teletherapy, Co-60 unit, Linac. (5)
7. Ultrasound imaging: nature and properties of Ultrasound, A, B and M Scan (3)
8. Magnetic Resonance Imaging (MRI): Nuclear magnetic resonance, Imaging basics (3)
9. Electrical localization and Imaging: Tetrapolar Impedance Measurement (TPIM), Focused Impedance Method (FIM) – 6 electrode and 4 electrode, Pigeon Hole Imaging (PHI) and Electrical Impedance Tomography (EIT) (5)

Course : BPT-PM108, Biomedical Instrumentation

½ unit, Full marks: 50, No. of lectures: 30

The whole syllabus uses virtually no mathematics except the minimum needed. Emphasis is on understanding of the concepts. Imaging techniques are covered in another course (Physics of Radiation in Health and Imaging Techniques)

Item	No. of lectures

A. Diagnostic:

1. Temperature measurement and monitoring: Mercury clinical maximum recording thermometer, electronic thermometer, Infrared Radiation measurement, Infrared Camera (2)
2. Blood pressure measurement: Indirect (non-invasive: basis, Sphygmomanometer, mercury & electronic), Direct (invasive) (2)
3. Respiratory measurements: different types of Flow sensors, Spirometric functions, measurement and analysis. (2)
4. Plethysmography: Optical, Electrical Impedance (1)

5. Electrocardiography: Electrodes, Electronic amplifiers (source impedance, gain, frequency response), Twelve lead configuration and measurement (2)
6. Computers in medicine: data acquisition, storage and analysis, Patient monitoring systems, Telemedicine. (2)
7. Ultrasound doppler techniques: blood velocity measurement, Foetal monitoring. (2)
8. Audiological measurements: pure tone audiometry, Bone conduction (1)
9. Electro-physiological measurements: electrodes and contacts, amplifiers, EEG, voluntary EMG, Evoked responses, Motor & Sensory Nerve conduction velocity measurement, Signal averaging, Visual & Audio evoked responses (SVR, BSER), Otto-Acoustic Emission (6)

B. Therapy and Rehabilitation:

1. Defibrillator, Pacemaker (2)
2. Physiotherapy instruments: Infra-red heating, RF diathermy, Ultrasound therapy, Muscle & Nerve stimulators. (2)
3. Hearing aids, Hearing aid fitting (1)
4. Vision correction (1)
5. Functional Electrical Stimulation (FES) (1)
6. Prosthesis: hand, leg, Cochlear implant. (1)

C. In -Vitro Measurements:

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

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