D.Y. PATIL EDUCATION SOCIETY KOLHAPUR

DEEMED UNIVERSITY

(Declared under section 3 of the UGC act 1956)

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COURSE CURRICULUM

M. Sc. Applied Physics (Medical)

2 Years Course

Choice Base Credit System

BL-APM-01- About the course

In recent years, along with the Physics, its application in biomedical field becomes one of the most important and forefront fields. The application of Physics to life/ medical science has opened entire new branch of Physics in biomedical applications. The branch holds the promise of many breakthroughs that may possibly change the course of future medical advances and our insight. It has been observed that properties such as electronic structure, reactivity, conductivity, melting temperature, optical properties and mechanical properties change as the particles become smaller than a critical size. This dependence of property on size allows for the engineering of nanostructures with varied properties with applications in producing stronger and lighter materials for advanced drug delivery system, tailor-made therapy in pharmaceuticals, piezoelectric materials for wound healing, magnetic materials for hyperthermia, the focused impendence spectroscopy for diagnosis, Materials for Implant Applications, Biomedical Instrumentation, Biosensors, Medical Imaging Techniques, development of multifunctional nanoparticles for cancer therapy, magnetic resonance imaging, DNA transfection, and enzyme immobilization, etc are few of the prominent thrust areas of Applied Physics in Medical applications.

Masters Program in Applied Physics (Medical) will provide students to understand the current concepts and prospect of world of Medical Instrumentation for diagnosis, Nanoscience with hands-on experience for treatment of various diseases. The course structure and the syllabi has been tailor made with the aim to enable the student acquire a holistic and inter-disciplinary view of the subjects and their inter-relationship along with the application of the knowledge gained in one course on another. This Program would prepare the students for research in application of Physics in biomedical field and also open more job opportunities in various fields.

BL-APM-02- Vision Mission and Goal

Vision: To be a world-class centre of academics and research in applied physics specifically in Medical by pursuing interdisciplinary ties for the benefit of nation and masses at large.

Mission: To promote academic growth by offering state-of-the-art postgraduate program in the field of Applied Physics specifically in Medical.

Goals:

- To develop overall excellence in student that meet international standard.
- To enable the interdisciplinary research through the Physical sciences, Medical Sciences, Chemical sciences and Engineering discipline.
- To develop state-of-art resource centre in Applied Physics (Medical) and education hub.
- To provide solutions for industry through technology transfer and contribute to social as well as country economic growth

BL-APM-03- Outcome of the program

- Students will be well versed with the concept of applied Physics which can be used in biomedical applications
- Students will learn different characterization technique involved in nanoscience
- Culture of Interdisciplinary research will be seeded through collaborations with Medical Sciences and Life sciences
- Students will get the job opportunities below:
  - Academics such as Assistant Professor (in Graduate college/University after SET/NET/Ph.D.), Lecturer in Engineering College, Polytechnic college etc.
  - They are eligible for giving the SET/NET/GATE examination based on which they can apply for Ph.D position as well as after qualifying SET/NET examination, they will be eligible for getting Assistant Professor position in Graduate college/University.
  - Students will be eligible for getting Junior Research Fellowships (JRF) on different research projects.
  - There are various permanent positions in Research and Development (R&D) sections of the Central government.
  - Along with this, there are various positions in Central government jobs after M.Sc. Physics.
  - After completion of M.Sc. Applied Physics (Medical), students will be eligible for doing further Diploma in Radiation Physics (conducted by Atomic Energy Regulatory Board). After completion of which, they are eligible to work as Medical Physicist (as well as Radiological Safety Officer) in Cancer Hospitals.
  - Students have career opportunities in electronics and manufacturing companies andStudents.
  - are eligible to pursue Higher Degree in the field of Physics.

BL-APM-04- Syllabus

Course Structure & Distribution of Credits.

M.Sc. Applied Physics (Medical) Program is Choice Based Credit System (CBCS) based and consists of total 16 theory courses and total four practical lab courses spread over 4 semesters and one research project. For first two semesters, eight theory courses and two practical lab courses will be common and compulsory to all the students. For third and fourth semesters, three theory papers and one practical lab course are compulsory to all the students. For remaining one theory paper, student can select one theory paper from groups of elective papers of these semesters.

Each theory course will be of four credits, a practical lab course will be of four credits and a project will be of eight credits. A student earns 24 (twenty four) credits per semester and total 96 (ninety six) credits in 4 semesters.

Eligibility: Graduation from Physics

The course structure is as follows,

Theory Courses

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Semester I	Mathematical Physics (MAP101) (Compulsory)	Solid State Physics (MAP102) (Compulsory)	Electronics And Instrumentation (MAP103) (Compulsory)	Classical And Quantum Mechanics (MAP104) (Compulsory)
	Paper V	**Paper VI**	**Paper VII**	**Paper VIII**
Semester II	Electrodynamics (MAP201) (Compulsory)	Nuclear Physics (MAP202) (Compulsory)	Radiation Physics & Radiation Generators (MAP203) (Compulsory)	Anatomy And Physiology (MAP204) (Compulsory)
	Paper IX	**Paper X**	**Paper XI**	**Paper XII Elective**
Semester III	Thermodynamic and Statistical Mechanics (MAP301) (Compulsory)	Experimental Techniques (MAP302) (Compulsory)	Nanoscience and Nanobiotechnology (MAP303) (Compulsory)	Biomedical Instrumentation (MAP304A) Or Radiation Detectors And Instrumentation (MAP304B)
	Paper XIII	**Paper XIV**	**Paper XV**	**Paper XVI Elective**
Semester IV	Atomic and Molecular Physics (MAP401) (Compulsory)	Materials for Implant Applications (MAP402) (Compulsory)	Bio-materials and Biosensors (MAP403) (Compulsory)	Medical and Optical Imaging Techniques (MAP404A) Or Radiation Safety (MAP404B)

Practical Lab courses

Semester-I	Lab course 1	Group A	Group B
Semester-II	Lab course 2	Group A	Group B
Semester-III	Lab course 3	Group A	Research Project
Semester-IV	Lab course 4	Group A	Research Project

Semester I

M.Sc. Applied Physics (Medical) Program for Semester-I consists of four theory courses (compulsory) and one practical laboratory course (Lab Course 1) consisting two groups of practicals (group A and group B**)** . The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours.)	Credits
(Paper I) MAP101	Mathematical Physics (Compulsory)	60	04
(Paper II) MAP102	Solid State Physics (Compulsory)	60	04
(Paper III) MAP103	Electronics And Instrumentation (Compulsory)	60	04
(Paper IV) MAP104	Classical And Quantum Mechanics (Compulsory)	60	04
	Total	**240**	**16**

Practical lab courses: 16 hours per week

Practical Lab Course 1	Practical Lab (Hours)	Credits
MAPP101 (Group A)	120	04
MAPP102 (Group B)	120	04
Total	240	08

Semester II

M.Sc. Applied Physics (Medical) Program for Semester-II consists of four theory courses (compulsory) and one practical laboratory course (Lab Course 2) consisting two groups of practicals (group A and group B**)** . The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours)	Credits
(Paper V) MAP201	Electrodynamics (Compulsory)	60	04
(Paper VI) MAP202	Nuclear Physics (Compulsory)	60	04
(Paper VII) MAP203	Radiation Physics And Radiation Generators (Compulsory)	60	04
(Paper VIII) MAP204	Anatomy And Physiology (Compulsory)	60	04
	Total	240	16

Practical lab courses: 16 hours per week

Practical Lab Course 2	Practical Lab (Hour)	Credits
MAPP201 (Group A)	120	04
MAPP202 (Group B)	120	04
Total	240	08

Semester III

M.Sc. Applied Physics (Medical) Program for Semester-III consists of four theory courses and one practical laboratory course (Lab Course 3) consisting of group of practical which are compulsory and Research Project. Out of four theory courses, three theory courses are compulsory and fourth theory course is elective (**Paper XIIA) MAP304 (A) Or (Paper XIIB) MAP304(B)**. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours.)	Credits
(Paper IX) MAP301	Thermodynamic and Statistical Physics (Compulsory)	60	04
(Paper X) MAP302	Experimental Techniques (Compulsory)	60	04
(Paper XI) MAP303	Nanoscience and Nanobiotechnology (Compulsory)	60	04
(Paper XIIA) MAP304(A) Or (Paper XIIB) MAP304(B)	Biomedical Instrumentation **Or** Radiation Detectors And Instrumentation	60	04
	Total	240	16

Practical lab courses (2): 16 hours per week

Practical Lab Course 3	Practical Lab (Hours)	Credits
MAPP301 (Practical)	120	04
MAPP302 Research Project	120	04
Total	240	08

Semester IV

M.Sc. Applied Physics (Medical) Program for Semester-III consists of four theory courses and one practical laboratory course (Lab Course 4) consisting of group of practical which are compulsory and Research Project. Out of four theory courses, three theory courses are compulsory and fourth theory course is elective **(Paper XVIA) MAP404 (A) or (Paper XVIB) MAP404 (B)**. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours.)	Credits
(Paper XIII) MAP401	Atomic and Molecular Physics (Compulsory)	60	04
(Paper XIV) MAP402	Materials for Implant Applications (Compulsory)	60	04
(Paper XV) MAP403	Bio-materials and Biosensors (Compulsory)	60	04
(Paper XVIA) MAP404 (A) or (Paper XVIB) MAP404 (B)	Medical and Optical Imaging Techniques Or Radiation Safety	60	04
	Total	**240**	**16**

Practical lab courses (2):16 hours per week

Practical Lab Course 4	Practical Lab (Hours)	Credits
MAPP401 (Practical)	120	04
MAPP402 Research Project	120	04
Total	**240**	**08**

M.Sc. Applied Physics (Medical) (Theory Courses)

Semester –I

Paper I: MAP101: Mathematical Physics (60 hours, 4 credits)

UNIT I: VECTOR SPACES AND MATRICES AND DIFFERENTIAL EQUATIONS (15 h)

Vector spaces and subspaces, linear dependence and independence, basis and dimensions, linear operators, matrices, inverse, orthogonal and unitary matrices, independent elements of a matrix, eigenvalues and eigenvectors, diagonalization, complete orthonormal sets of functions second order linear ODEs with variable coefficients, solution by series expansion.

UNIT II: SPECIAL FUNCTIONS OF DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (15 h)

Legendre, bessel, hermite and lagaurre equations, physical applications, generating functions, recursion relations, laplace transform, first and second shifting theorems, inverse LT by partial fractions, LT of derivative and integral of function, fourier series, FS or arbitrary period, half wave expansions, partial sums, fourier integral and transforms, FT of delta function

UNIT III: PROBABILITY, STATISTICS AND ERRORS (15 h)

Probability: addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data. basic ideas of statistical distributions, frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis, application to radiation detection: uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit. binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution, additive property of normal variates, confidence limits, bivariate distribution, correlation and regression, chi-Square distribution, t-distribution, F-distribution. Statistics of nuclear counting: Application of Poisson's statistics - goodness-of-fit tests -Lexie's divergence coefficients, Pearson's chi-square test and its extension, random fluctuations, evaluation of equipment performance, Signal-to-noise ratio, selection of operating voltage, preset of rate meters and recorders, efficiency and sensitivity of radiation detectors, statistical aspects of gamma ray and beta ray counting, special considerations in gas counting and counting with proportional counters, statistical accuracy in double isotope technique, sampling and sampling distributions, confidence intervals, clinical study designs and clinical trials, hypothesis testing and errors, regression analysis.

UNIT IV: NUMERICAL METHODS, COMPUTATIONAL TOOLS & TECHNIQUES (15 h)

Need for numerical methods, accuracy and errors on calculations - round-off error, evaluation of formulae, iteration for Solving x = g(x), initial approximation and convergence criteria, Newton-Raphson Method. Taylor series, approximating the derivation, numerical differentiation formulas, introduction to numerical quadrature, Trapezoidal rule, Simpson's 1/3rule, Simpson's 3/8rule, Boole rule, Weddle rule, initial value problems, Picard's method, Taylor's method, Euler's method, the modified Euler's method, Runge-Kutta method, Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

Computational packages: Overview of programming in C++, MATLAB, Origin and SPSS in data analysis and graphics.

BOOKS FOR STUDY AND REFERENCE:

1. Pipes L.A. & L.R. Harvil, Applied Mathematics for Engineers and Physicists (3rd Edition), Mc Graw-Hill Book Co., New York, 1970.
2. Mary.L.Boas, Mathematical methods in the Physical Sciences (2nd edition), John Wiley & Sons., New York, 1983.
3. E. Butkov, Mathematical Physics, Addison Wesley, New York, 1973.
4. E. Walpole, R.M. Myers, S.L. Myers, K. Ye, "Probability & Statistics for Engineers and Scientists (9th edition)", Pearson Education, 2012.
5. SathyaPrakash, Mathematical Physics, Sultan Chand & Co., New Delhi, 2004.
6. M.K. Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing co., Madras, 1994.
7. G. Arfken and H.H. Weber, Mathematical Methods for Physicists (4th edition), Prism Books, Bangalore, 1995.

Paper II: MAP102: Solid State Physics (60 hours, 4 credits)

UNIT I: CRYSTAL STRUCTURE (15 h)

Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, fcc. and bcc, lattices, Laue and Bragg equations. determination of crystal structure with X-rays.

Different types of bonding- ionic, covalent, metallic, van-der Waals and hydrogen. band theory of solids, periodic potential and Bloch theorem, energy band structure.

UNIT II: STRUCTURE OF SOLIDS AND DIELECTRIC AND MAGNETIC PROPERTIES OF MATERIALS (15 h)

Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals: Phenomenology and implication.

Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization, molecular field in a dielectric; Clausius-Mosotti relation, dia, para and ferro-magnetic properties of solids, Langevin's theory of diamagnetism and paramagnetism, quantum theory of paramagnetism, Curie's law, ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.

UNIT III: LATTICE VIBRATIONS (15 h)

Elastic and atomic force constants; dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals. Einstein's and Debye's theories of specific heats of solids.

Lattice vacancies, diffusion, colour centres: F centres, other centres in alkali halides.

UNIT IV: SUPERCONDUCTIVITY AND LUMINESCENCE IN SOLIDS (15 h)

Introduction (Kamerlingh - Onnes experiment), effect of magnetic field, type-I and type-II superconductors, Isotope effect, Meissner effect, BCS pairing mechanisms, Ideas about High-Tc superconductors

Types of Luminescence, Fluorescence and phosphorescence, Thermo luminescence, Electroluminescence, LASER.

BOOKS FOR STUDY AND REFERENCE:

1. C. Kittel, Introduction to Solid State Physics (8th edition), John Wiley and Sons, New York, 2004.
2. M. A. Omar, Elementary Solid State Physics: Principles and Applications, Addison-Wesley Publishing Company, Inc, USA, 1975.
3. A. J. Dekker, Solid State Physics, Macmillan India, 2000
4. S. O. Pillai, Solid State Physics, New Age International, India, 2006.
5. J. P. Srivastava, Elements of Solid State Physics, Prentice Hall India Pvt., Limited, India, 2004.
6. R.J. Elliot and A.F. Gibson, An Introduction to Solid State Physics and Applications, McMillan, London, 1928.
7. D.W. Snoke, Solid State Physics: Essential Concepts, Person Education, 2009.

Paper III: MAP103: Electronics and Instrumentation (60 hours, 4 credits)

UNIT I: SEMICONDUCTOR DEVICES (15 h)

Characteristic curves and physics of p-n junction; Schottky, tunnel and MOS diodes; bipolar junction transistors(BJT), junction field effect transistor (JFET), metal oxide semiconductor field effect transistor (MOSFET), uni-junction transistor (UJT) and silicon controlled rectifier (SCR), optoelectronic devices (photo-diode, solar cell, LED, LCD and photo transistors) diffusion of impurities in Si, growth of oxide.

Op-amp: introduction, input modes and op-amps with negative feedback, open-loop response - mathematical operations, analog simulation, OTAs, CFOAs, active filters,

UNIT II: ANALOG ELECTRONICS (15 h)

Oscillators- principles, types, frequency stability, response, the phase shift oscillator, Wein bridge oscillator, oscillator with RC feedback circuits (RC and LC) , relaxation oscillators, linear and nonlinear oscillators, 555 timer as an oscillator, IC voltage regulators, evolution of ICs, CCDs, multi-vibrators, classification, selection of a transducer, strain gauge, displacement transducer (capacitive, inductive, differential transformer, photo electric and piezoelectric transducers), strain flow measurements, thermistor and thermo couple based thermometers for measuring temperature.

UNIT III: DIGITAL ELECTRONICS (15 h)

Introductory digital concepts, overview of logic functions , fixed function integrated circuits, programmable logic devices , digital integrated circuits, NAND and NOR gates building block, X-OR gate, simple combinational circuits, half and full address, functions of combinational logic, flip flops and related devices, counters, shift registers, memory and storage (ROM, RAM and EPROM), microprocessor and microcontroller basics (Intel 8085).

UNIT IV: ELECTRONICS FOR NUCLEAR DEVICES (15 h)

Preamplifier, AC-DC converter , Pulse shaper, Isolator, High range gamma survey meter circuit, scintillation dose rate meter, scintillator photodiode X-ray detector, pocket monitor, general purpose contamination monitor, discriminator single channel analyzer, linear gate, time to amplitude converter.

BOOKS FOR STUDY AND REFERENCE:

1. S. M. Sze, K.K. Ng, Physics of semiconductor devices (3rd edition), Wiley-Interscience, New York, 1969.
2. P. Horowitz and W. Hill, "The art of electronics', (2nd edition), Cambridge university press, Cambridge, 1995.
3. A.P. Malvino, "Electronic principles', (6th edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi, 1999.
4. T.L. Floyd, Electronic devices', (6th edition), Pearson Education Inc., New Delhi, 2003
5. R.F. Coughlin and F.F. Driscoll, 'Operational amplifiers and linear integrated circuits', (6th edition), Pearson Education Inc., New Delhi, 2001.
6. M. Lakshmanan and K. Murali, Chaos, 'Chaos in nonlinear Oscillators', World Scientific, Singapore, 1996.
7. T. L. Floyd, Digital Fundamentals, (8th edition), pearson education Inc., New Delhi, 2003.
8. S. Brown and Z. Vranesic, 'Fundamentals of digital logic with Verilog design', Tata McGraw Hill Publ Co. Ltd., New Delhi, 2003.
9. H. Skalsi, "Electronic instrumentation (2nd edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi, 2004.

Paper IV: MAP104 Classical and Quantum Mechanics (60 hours, 4 credits)

UNIT I: CENTRAL FORCE PROBLEM AND HAMILTONIAN FORMULATIO (15 h)

Two body problem, the equation of motion and first integral, equation of orbit, Kepler's laws, Kepler's problem, general analysis of orbits, stability of orbits, artificial satellites, Rutherford scattering: differential scattering cross section, Rutherford Formulae for scattering.

Hamilton's principle, Hamiltonian, generalized momentum, constant of motion, Hamilton's canonical equations of motion, deduction of canonical equations from Variational principle.

UNIT II: APPLICATIONS OF HAMILTONIAN EQUATIONS OF MOTION, CANONICAL TRANSFORMATIONS AND HAMILTONS - JACOBI THEORY (15 h)

Applications of Hamilton's equations of motion. principle of least action, proof of principle of least action.

Generating functions, illustrations of canonical transformations, condition for transformation to be canonical, examples. Poisson's brackets, Poisson's theorem, properties of Poisson's Brackets, Hamilton's canonical equations in terms of Poisson's brackets, Hamilton's-Jacobi theory, solution of harmonic oscillator problem by HJ Method, problems.

UNIT III: FUNDAMENTAL CONCEPTS AND FORMALISM (15 h)

Need for Quantum mechanics, revision; inadequacy of classical mechanics; Sequential Stern-Gerlach experiment, analogy with polarization of light, Ket and Bra spaces and inner products, operators, the associative axiom base kets and matrix representations, measurements, observables and the uncertainty relations, change of basis, position, momentum and translation; wave function in position and momentum space.

Time evolution and Schrödinger equation; the Schrödinger versus the Heisenberg picture, simple Harmonic oscillation, Schrödinger wave equation,

UNIT IV: QUANTUM DYNAMICS (15 h)

One-dimensional problems, wells and barriers; Harmonic oscillator by Schrödinger equation and by operator method. Uncertainty relation of x and p, states with minimum uncertainty product; General formalism of wave mechanics; Commutation relations.

Rotations and angular momentum commutation relations, spin ½ systems and finite rotations; SO(3), SU(2) and Euler rotations, eigenvalues and eigenstates of angular momentum, orbital angular momentum, addition of angular moment.

BOOKS FOR STUDY AND REFERENCE:

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics (3rd edition), Addison Wesley, Cambridge, 1980.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
3. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Education, New Delhi, 1999.
4. S. L. Gupta, V. Kumar and R. C. Sharma, Classical Mechanics, Pragati Prakashan Meerut, 2000 .
5. A. Ghatak, S. Lokanathan, Quantum Mechanics: Theory and Applications, Kluwer Academic Publishers, London, 2004.

6. J. J. Sakurai, Modem Quantum Mechanics, Addison Wesley Publication Company Inc.USA, 1933.
7. L. I. Schiff, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1949.
8. M. Mathews, K. Venkatesan, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1978.

Semester –II

Paper V: **MAP201: Electrodynamics** (60 hours, 4 credits)

UNIT I: MAXWELL'S EQUATIONS AND E.M. WAVES (15 h)

Review of four-vector and lorentz transformation in four-dimentional space, electromagnetic field tensor in four dimensions and Maxwell's equations: microscopic and macroscopic forms (revision), conservation of the bound charge and current densities, E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Rectangular and circular waveguides, hybrid modes, concept of LP modes.

UNIT II: TIME –DEPENDENT POTENTIALS AND FIELDS (15 h)

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard –Wiechert Potentials, Fields due to a charge in the arbitrary motion.

UNIT III: RADIATION FROM ACCELERATED CHARGES AND RADIATION REACTION (15 h)

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and synchrotron radiations, Power radiated by point charge: Larmour's formula, angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments), radiation reaction: criteria for validity, Abraham–Lorentz formula, physical basis of radiation reaction, self force.

UNIT IV: FORMULATION OF COVARIANT ELECTRODYNAMICS (15 h)

Contravariant and co-variant four-vectors and their products, tensors of rank two and their differentiation, co-variant form of Maxwell's equations: four–potential and four current, E.M. field tensor: its curl and divergence.

BOOKS FOR STUDY AND REFERENCE:

1. D.J. Griffiths, Introduction to Electrodynamics (3rd edition), Prentice Hall, New Jersey, 1999.
2. J.R. Reitz, F.J. Milford & R.W. Christy, Foundation of E.M. Theory (3rd edition), Addison Wesley, New Jersey, 1979.
3. J.D. Jackson, Classical Electrodynamics (3rd edition), Wiley Eastern, New York, 1975.
4. S.P. Puri, Classical Electrodynamics, Tata McGraw Hill Education, New Delhi,1990.

Paper VI: MAP202: Nuclear Physics (60 hours, 4 credits)

UNIT I: BULK PROPERTIES OF NUCLEI (15 h)

Nuclear mass, charge, size, binding energy, spin and magnetic moment, Isobars, isotopes and isotones; mass spectrometer (Bainbridge), Spin and parity.

Nature of forces between nucleons, nuclear stability and nuclear binding.

UNIT II: NUCLEAR STRUCTURE AND UNSTABLE NUCLEI (15 h)

The liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples).

(a) Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. (b) Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. (c)Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).

UNIT III: NUCLEAR REACTIONS (15 h)

Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment.

Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.

UNIT IV: ELEMENTARY PARTICLES (15 h)

(a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. (b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.

BOOKS FOR STUDY AND REFERENCE:

1. W.N. Cottingham and D. A. Greenwood, An Introduction to Nuclear Physics, Cambridge University Press, 1986.
2. B. L. Cohen, Concepts of Nuclear Physcics, Tata McGraw Hill Education, New Delhi, 1971.

3. S. N. Ghoshal, Atomic and Nuclear Physics, S. Chand, New Delhi, 1997.
4. S. B. Patel, Nuclear Physics: An Introduction, New Age International, New Delhi, 1991.
5. E. Segre, Nuclei and Particles (2nd edition), W.A. Benjamin Inc., 1977.
6. J.S. Lilley, Nuclear Physics: Principles and applications (1st edition), John Willey and Sons (Asia) Pvt. Ltd., 2001.
7. J. Basdevant, J. Rich and M. Spiro, Fundamentals in Nuclear Physics: from Nuclear Structure to Cosmology, Springer-Verlag New York, 2005.
8. A. Seiden, Particle Physics: A Comprehensive Introduction, Persian Education, 2004.

Paper VII: MAP203: Radiation Physics And Radiation Generators (60 hours, 4 credits)

UNIT I: RADIOACTIVITY (15 h)

Radioactivity, general properties of alpha, beta and gamma rays, laws of radioactivity, laws of successive transformations, natural radioactive series, radioactive equilibrium, alpha ray spectra, beta ray spectra, theory of beta decay, gamma emission, electron capture, internal conversion, nuclear isomerism, artificial radioactivity, nuclear cross sections, elementary ideas of fission and reactors, fusion.

UNIT II: PARTICLE ACCELERATORS (15 h)

Particle accelerators for industrial, medical and research applications: the resonant transformer, Cascade generator, Van De Graff Generator, Pelletron, Cyclotron, Betatron, Synchro-Cyclotron linear accelerator, Klystron and magnetron, travelling and standing wave acceleration, Microtron, electron synchrotron, proton synchrotron, details of accelerator facilities in India.

UNIT III: X-RAY GENERATORS (15 h)

Discovery, production, properties of X-rays, characteristics and continuous spectra, design of hot cathode X-ray tube, basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes, rotating anode tubes, hooded anode tubes, industrial X-ray tubes, X-ray tubes for crystallography, rating of tubes, safety devices in X-ray tubes, ray proof and shockproof tubes, insulation and cooling of X-ray tubes, mobile and dental units, faults in X-ray tubes, limitations on loading, electric accessories for X-ray tubes, filament and high voltage transformers, high voltage circuits, half-wave and full-wave rectifiers, condenser discharge apparatus, three phase apparatus, voltage doubling circuits, current and voltage stabilizers, automatic exposure control, automatic brightness control, measuring instruments: Measurement of kV and mA, timers, control panels, complete X-ray circuit, image intensifiers and closed circuit TV systems, modern trends.

UNIT IV: INTERACTION OF RADIATION WITH MATTER (ORIENTED TOWARDS RADIOLOGY)

(15 h)

Interaction of electromagnetic radiation with matter, exponential attenuation, Thomson scattering, photoelectric and Compton process and energy absorption, pair production, attenuation and mass energy absorption coefficients, relative importance of various processes. interaction of charged particles with matter, classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, dependence of collision energy losses on the physical and chemical state of the absorber, Cerenkov radiation, electron absorption process, scattering excitation and ionization, radiative collision, Bremmstrahlung: range energy relation, continuous slowing down approximation (CSDA), straight ahead approximation and detour factors, transmission and depth dependence methods for determination of particle penetration, empirical relations between range and energy, back scattering, passage of heavy charged particles through matter, energy loss by collision, range energy relation, Bragg curve, specific ionization, stopping power, Bethe Bloch Formula, interaction of neutrons with matter, scattering, capture, neutron induced nuclear reactions.

BOOKS FOR STUDY AND REFERENCE:

1. E.B. Podgorsak, Radiation Oncology Physics, IAEA Publication, Austria, 2005.
2. F. M. Khan, The Physics of Radiation Therapy (3rd edition), LIPPINCOTT WILLIAMS & WILKINS, USA, 2003.
3. H. E. Jones, J. R. Cunnighum, Physics of Radiology (4th edition), Charles C Thimas, USA, 1983.
4. W. J. Meredith & J. B. Massey, Fundamental Physics of Radiology (3rd edition), John Wright & Sons Ltd. 1977 .
5. W. R. Handee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003

Paper VIII: MAP204: Anatomy and Physiology (60 hours, 4 credits)

UNIT I: DEFINITIONS **(15 h)**

Applications, History: cells, structure and functions, sex cells, early development, the tissues, the systems, skin, cartilage and bone, bacteria, inflammation, injection, ulceration, neoplasm, bones, the skeleton, joints, the skeletal system, the skull, vertebral column, thorax etc., the muscular system, the thoracic cage, the mediastinum, the diaphragm the abdominal cavity and abdominal regions, anatomy of the heart.

UNIT II: DIGESTIVE SYSTEM (15 h)

Functions of mouth, tongue, teeth, esophagus, stomach, small intestine, large intestine, digestion and assimilation of carbohydrates, fats and proteins, gastric juice, pancreatic juice, function of liver and spleen, blood and circulatory system, blood and its composition, RBC and WBC, blood grouping, coagulation of blood, artery, vein, capillaries and heart structure and functions: Physiological properties of heart muscle, cardiac dynamics: EEG, blood pressure and its regulation.

UNIT III: RESPIRATORY, REPRODUCTION AND EXCRETORY SYSTEMS (15 h)

Physical laws of respiration: trachea, lungs and its functions, oxygen transport, nervous regulation of respiration, hormonal control over reproduction, kidney and its functions, water and electrolyte metabolism.

UNIT IV: ENDOCRINE SYSTEM AND NERVOUS SYSTEM (15 h)

Pituitary glands and its functions: functions of adrenal, thyroid etc, secretion chemistry, physiological actions, effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action.

Brain and spinal cord: its functions, central nervous system and autonomic nervous system functions, physiology of special senses of hearing, taste vision etc.

BOOKS FOR STUDY AND REFERENCE:

1. C. H. Best and N. B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1999.
2. C. K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 2001.
3. J. R. Brobek, Physiological Basis of Medical Practice, Williams and Wilkins, London, 1995.

Semester –III

Paper IX: MAP301: Thermodynamics and Statistical Mechanics (60 hours, 4 credits)

UNIT I: STATISTICAL MECHANICS AND THERMODYNAMICS (15 h)

Basic concepts: phase space, ensemble, a priori probability, Liouville's theorem (revision). fluctuations of physical quantities, statistical equilibrium, thermodynamics: thermodynamic laws and functions, Entropy, free energy, internal energy, Enthalpy (definitions), contact between statistics and thermodynamics, Entropy in terms of microstates, change in entropy with volume and temperature.

UNIT II: STATISTICAL ENSEMBLES THEORY (15 h)

Micro canonical Ensemble, microcanonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution. canonical Ensemble: canonical distribution, partition function, calculation of free energy of an ideal gas, thermodynamic functions, energy fluctuations, grand canonical ensemble: grand canonical distribution, thermodynamic functions, number and energy fluctuations.

UNIT III: FORMULATION OF QUANTUM STATISTICS (15 h)

Distinction between MB, BE and FD distributions, Quantum distribution functions: Boson and Fermion gas and their Boltzmann limit, partition function, ideal Bose gas, Bose Einstein condensation, phonon gas, liquid He4: second sound, ideal Fermi gas: Weakly and strongly degenerate, Electron gas: free electron theory of metals, Pauli paramagnetism

UNIT IV: PHASE TRANSITIONS AND CRITICAL PHENOMENON (15 h)

Phase transitions, conditions for phase equilibrium, first order phase transition: Clausius-Clayperon equation, second order phase transition, the critical indices

BOOKS FOR STUDY AND REFERENCE:

1. S.K. Sinha, Statistical Mechanics: Theory and Applications, Tata McGraw-Hill Education, New Delhi, 1990.
2. B. B. Laud, Fundamentals of Statistical mechanics, New Age International Publishers (2nd edition) New Delhi, 1998.
3. R. K. Pathria, Statistical Mechanics, Pergamon press, 1972.
4. F. Reif, Statistical and Thermal Physics, Tata McGraw-Hill Education, 1965.
5. L. D. Landau, E. M. Lifshitz, Statistical Physics (2nd edition), Pergamon press/ Addison-Wesley, (1958).

Paper X: MAP302: Experimental Techniques (60 hours, 4 credits)

UNIT I: VACUUM TECHNIQUES (15 h)

Production of low pressures: rotary, diffusion, and sputter ion pumps; measurement of low pressure: McLeod, Pirani, thermocouple & Penning gauges; leak detection: simple methods of LD, palladium barrier and halogen leak detectors.

UNIT II: LOW TEMPERATURE AND MICROSCOPY TECHNIQUES (15 h)

Production of low temperatures: adiabatic cooling, the Joule-Kelvin expansion, adiabatic demagnetization, 3 He cryostat, the dilution refrigerator, principle of Pomerunchuk cooling, principle of nuclear demagnetization; measurement of low temperatures,

Optical microscopy, scanning electron microscopy, electron microprobe analysis, low energy electron diffraction.

UNIT III: ATOMIC ABSORPTION SPECTROMETRY (15 h)

Fundamentals: principle, basic equipment, operation, monochromator action, modulation; apparatus: double beam instrument, radiation sources, aspiration and atomization; interferences, control of AAS parameters, reciprocal sensitivity and detection limit; techniques of measurement routine procedure, matrix matching method, and method of additions.

UNIT IV: X-RAY FLUORESCENCE SPECTROMETRY AND MÖSSBAUER SPECTROSCOPY (15 h)

Introduction to wavelength-dispersive X-ray fluorescence spectrometry (WDXRF) and energy-dispersive X-ray fluorescence spectrometry (EDXRF), dispersive systems, detectors, instruments, matrix effects, XRF with synchrotron radiation. Elementary theory of recoil free emission and resonant absorption of gamma rays, Mössbauer experiment, hyperfine interactions: chemical isomer shift, magnetic dipole hf splitting, and electric quadrupole hf splitting; line broadening.

BOOKS FOR STUDY AND REFERENCE:

1. J.Yarwood, High vacuum techniques, Chapman & Hall, 1967.
2. A.Roth, Vacuum technology, North-Holland Publishing Company, Amsterdam, 1982.
3. G.K.White, Experimental techniques in low temperature physics, Oxford, 1968.
4. L.C. Jackson, Low temperature physics, Methuen & Co. Ltd., 1962
5. O.V.Lounasmaa, Experimental principles & methods below 1K, Academic press, New York, 1974
6. R.E.Smallman & K.H.G.Ashbee, Modern metallography, Peramon press, Oxford
7. D.K.Bowen & C.R.Hall, Microscopy of materials, the MacMillan press Ltd., London, 1975.

Paper XI: MAP303: Nanoscience and Nanobiotechnology (60 hours, 4 credits)

UNIT I: FUNDAMENTALS OF MICRO FABRICATION (15 h)

Photolithography, deposition, and selective etching, Thin Film Growth and deposition, diffusion and dopants, atomic layer epitaxy, soft lithography. Self assembled organized systems: dendrimers, liposomes, vesicles, supramolecular complexes, Langmuir Blodgett films, atomic force microscopy (AFM)

UNIT II: MICRO FLUIDIC PATTERNING AND BIOPOLYMER PATTERNING (15 h)

Micro fluidic processes: fundamentals of laminar fluids, micro fluidic processes: the role of micro-scale fluid dynamics in Bio MEMS, Neuro MEMS - microelectrodes and neuronal interfaces, Microstereolithography.

UNIT III: NANOFABRICATION AND NANO-BIOTECHNOLOGY (15 h)

Molecular engineering and Quantum dots, nanoscale structures as biological tags and as functional interfaces with biological systems, nanoparticles and microorganisms, nanomaterials in bone substitutes and dentistry, nanoparticles in food and cosmetic applications, drug delivery and its applications.

UNIT IV: NANOBIOSENSORS (15 h)

Biochips and analytical devices, biosensors, nanomedicine, nanobiosensor, nanofluidics, manocrystals in biological detection, electro-chemical DNA sensors, Integrated nanoliter systems. clean rooms practice and environmental issues; applications

BOOKS FOR STUDY AND REFERENCE:

1. M. Koch, A. Evans, A. Brunnschweiler, Micro fluidic Technology and Applications (Micro technologies and Microsystems Series**)**, CRC Press, London, 2001.
2. Niemeyor, christober M. Mirkin, Nanobiotechnology: concepts, applications and perspectives, Kluwer publications, USA, 2004.
3. R.A. Freitas Jr , Nanomedicine , Freitas Jr.Kluwer publications, USA, 1998.
4. R. Coombs, D. W. Robinson, Nanotechnology in medicine and the biosciences, Gordon and Breach Publishers, 1996.
5. E. J. Koprowski, G. Koprowski, Nanotechnology in medicine: Emerging applications, Tata McGraw Hill Education, New Delhi 2011.
6. T. Vo-Dinh, Nanotechnology in Biology and Medicine: Methods, Devices, and Applications, CRC Press, 2007
7. G. A. Silva, Nanotechnology for biology and medicine, Springer, 2012

Paper XIIA: MAP304 (A): Biomedical Instrumentation (60 hours, 4 credits)

UNIT I: BIOPOTENTIAL ELECTRODES AND TRANSDUCERS (15 h)

Cell structure, nature of cancer cells, transport of ions through cell membrane, resting and action potential, half cell potential, bioelectric potential, design and components of medical instruments, electrodes, surface, needle, depth electrodes, electrical circuits.

UNIT II: BIOELECTRIC SIGNAL RECORDING AND PHYSIOLOGICAL ASSIST DEVICES (15 h)

Introduction, characterstics of recording systems, Electrodcardiography (ECG), Electroencephalograph (EEG), Electromyograph (EMG), Electroneurograph (ENG), recoring units.

Cardiac pacemakers, natural and artificial pacemakers, pacemaker batteries, defibrillator, A. C./D. C. synchronized defibrillator, stimulators, bladder stimulators, Heart lung machine, various types of oxygenators, kidney machine, hemodialysing units, peritoneal dialysis.

UNIT III: CLINICAL AND OPERATION THEATER EQUIPMENTS (15 h)

Flame Photometer, Spectroflurometer, pH meters, Audiometer, endoscopes, Electromagnetic and laser blood flow meters, ventilators, diathermy units, ultrasonic, microwave and short wave diathermy, types and their applications, surgical diathermy.

UNIT IV: BIOTELEMETRY AND SAFETY INSTRUMENTATION (15 h)

Principles of a biotelemetry system: radiotelemetry with subcarrier, multiple channel telemetry systems, problems in implant telemetry, uses of biotelemetry, physiological effects of 50Hz current, microshock and macroshock, electrical accidents in hospitals, devices to protect against electrical hazards.

BOOKS FOR STUDY AND REFERENCE:

1. M. Arumugam, Biomedical Instrumentation, Anuradha Publishing Co., Kumbakkonam, Tamilnadu, 2004.
2. Jacobson and Webster, Medicine and clinical Engineering, Prentice Hall of India, New Delhi, 1979.
3. R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill Education, New Delhi 1990.
4. Richad Aston, Principles of Biomedical Instrumentation and measurement, Merrill Publishing Co., London, 1990.
5. M. D. Weiss, Biomedical instrumentation, Chilton Book Co., 1973
6. L. Cromwell, F.J. Weibell, E. A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice-Hall, 1980

Paper XIIB: MAP304 (B): Radiation Detectors and Instrumentation (60 hours, 4 credits)

UNIT I: MEDICAL ELECTRONICS (15 h)

Semiconductor diodes, JFET, MOSFET, integrated Circuits, operational amplifiers (OPAM) and their characteristics, differential amplifier, operational amplifier systems, OPAM applicatons -addition, subtraction, integration and differentiation, active amplifiers, pulse amplifiers, decoders and encoders,microprocessors and associated peripherals, power supplies - regulated power supplies using IC's - DC-DC converter and RF power supplies, switching mode power supplies, AC regulators.

UNIT II: PRINCIPLES OF RADIATION DETECTION (15 h)

Principles of radiation detection and measurement, basic principles of radiation detection, gas filled detectors, ionisation chambers, theory and design, construction of condenser typechambers and thimble chambers, gas multiplication, proportional and GM counters, characteristics of organic and inorganic counters, dead time and recovery time, scintillation

detectors, semiconductor detectors, chemical systems, radiographic and radiochromic films, thermoluminescent dosimeters (TLD), optically stimulated luminescence dosimeters (OSLD), radiophotoluminescent dosimeters, neutron detectors, nuclear track emulsions for fast neutrons, solid state nuclear track (SSNTD) detectors, calorimeters, new developments.

UNIT III: RADIATION MEASURING & MONITORING INSTRUMENTS I (15 h)

Dosimeters based on condenser chambers, pocket chambers, dosimeters based on current measurement, different types of electrometers, MOSFET, vibrating condenser andvaractor bridge types, secondary standard therapy level dosimeters, farmer dosimeters radiation field analyser (RFA), radioisotope calibrator, multipurpose dosimeter, water-phantom dosimetry systems, brachytherapy dosimeters, thermoluminescent dosimeter readers for medical applications, calibration and maintenance of dosimeters. instruments for personnel monitoring, TLD badge readers, PM film densitometers, glass dosimeter readers, digital pocket dosimeters using solid state devices and GM counters.

UNIT IV: RADIATION MEASURING & MONITORING INSTRUMENTS II (15 h)

Teletector, industrial gamma radiography survey meter, gamma area (Zone) alarm monitors, contamination monitors for alpha, beta and gamma radiation, hand and foot monitors, laundry and portal monitors, scintillation monitors for X and gamma radiations, neutron monitors, tissue equivalent survey meters, flux meter and dose equivalent monitors, pocket neutron monitors, teledose systems. instruments for counting and spectrometry, portable counting systems for alpha and beta radiation, gamma ray spectrometers,multichannel analyser, liquid scintillation counting system, RIA counters, whole body counters, air monitors for radioactive particulates and gases. details of commercially available instruments and systems.

BOOKS FOR STUDY AND REFERENCE:

1. W.J. Price, Nuclear Radiation Detection (2nd edition), McGraw-Hill, New York, 1964
2. B.I Stepanor., Theory Of Luminescence (1st edition). Print ISSN,1968
3. Glenn F Knoll. Radiation Detection & Measurement(4th edition),John Wiley & Sons, august-2010
4. Albert Paul Malvino, Electronics Principles.McGraw-Hill Higher Education; 7th edition, May 1, 2006
5. Robert L. Boylestad, Electronics Devices and Circuit Theory, Prentice Hall,6th edition 1996
6. Paul-Horowitz, Art of Electronics(3rd edition), Cambridge University Press, April 9, 2015
7. R.A Greiner, Semiconductor Devices & Application (1st edition), McGraw-Hill Inc.,US, December 1961
8. R.H. Crawford,MOSFET in Circut Design (1st edition),McGraw-Hill Education ,1967

Semester –IV

Paper XIII: MAP401: **Atomic and Nuclear Physics** (60 hours, 4 credits)

UNIT I: THE ATOM MODEL FOR TWO VALENCE ELECTRONS (15 h)

Coupling Schemes: l-l coupling, s-s coupling, LS or Russell, Saunder's coupling, the Pauli exclusion principle, Coupling schemes for two electrons, Tau-factors for LS coupling, Lande interval rule, jj-coupling, branching rules, selection rules.

UNIT II: ZEEMAN EFFECT, PASCHEN-BACK EFFECT AND STARK EFFECT (15 h)

The magnetic moment of the atom, Zeeman effect for two-electrons, intensity rules for Zeeman effect, Paschen-Back effect for two electrons, Stark effect of hydrogen, weak field Stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure.

UNIT III: MICROWAVE SPECTROSCOPY (15 h)

Classification of molecules: linear, symmetric tops, spherical tops, asymmetric tops; rotational spectra: the rigid diatomic molecule, the non-rigid rotator, spectrum of a nonrigid rotator, chemical analysis by microwave spectroscopy, techniques and instrumentation of microwave spectroscopy.

UNIT IV: INFRA-RED SPECTROSCOPY (15 h)

The energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating-rotator, analysis by infra-red spectroscopy, techniques and instrumentation of infra-red spectroscopy.

BOOKS FOR STUDY AND REFERENCE:

1) H.E. White, Introduction to Atomic Spectra, Tata McGraw Hill Education, New Delhi, 1934.
2) C.N. Banwell, Fundamentals of Molecular Spectroscopy (3rd edition), Tata MacGraw Hill Education, New Delhi, 1983.
3) G. Herzberg, Spectra of Diatomic Molecules, Vol. I, N.J.D. van Nostrand, 1950.
4) B.P. Straughan and S. Walker, Spectroscopy, Vol. I, II and III, Chapman and Hall, 1976.
5) G.M. Barrow, Introduction to Molecular Spectroscopy, Tata MacGraw Hill Education, 1962.
6) J.M. Brown, Molecular Spectroscopy, Oxford University Press, 1998.

Paper XIV: MAP402: Materials for Implant Applications (60 hours, 4 credits)

UNIT I: BIOLOGICAL PERFORMANCE OF MATERIALS AND CHARACTERIZATION TECHNIQUES (15 h)

Biofunctionality and biocompatibility, material response, deformation and failure, friction and wear, Host response, Inflammatory process, capsule formation, coagulation and

hemolysis, approach to thromboresistant material development, chemical and foreign body carcinogenesis, electron microscopic methods: SEM, TEM, spectroscopic methods: IR, visible, UV and X-ray methods, differential thermal analysis, differential thermogravimetric analysis, NDT methods.

UNIT II: CLASSES OF MATERIALS USED IN MEDICINE (15 h)

Metals and alloys; stainless steel, cobalt based alloys, titanium based materials, ceramics, bioinert ceramics, carbon, alumina, zircona and titania, bioactive ceramics, bioactive glass and glass ceramics, calcium phosphate ceramics, polymers, grouting materials, PMMA bone cement, articulating component, UHMWPE, composites, matrix and filter components, surface properties and bulk mechanical properties.

UNIT III: OPHTHALMOLOGIC APPLICATIONS AND DRUG DELIVERY SYSTEMS (15 h)

Materials for ophthalmology, contact lens and intraocular lens materials, corneal implants, implants for Glaucoma, implants for retinal detachment surgery, drug delivery systems, diffusion controlled-water penetration controlled, chemically controlled-regulated systems, sutures materials, categories and characteristics.

UNIT IV: CARDIOVASCULAR MATERIALS, ARTIFICIAL ORTHOPEADIC AND DENTAL MATERIAL (15 h)

Artificial organs, cardiovascular materials, cardiac prosthesis, vascular graft materials, cardiac pacemakers, cardiac assist devices, extra carporial artificial organs, dialysis, heamofiltration, apheresis, lung substitues and assists.

Materials for bone and joint replacement, dental metals and alloys, ceramic, bioinert, bioactive ceramics, polymers, dental restorative materials, dental amalgams, burn dressing, principles of wound coverage and healing, nanobiomaterials.

BOOKS FOR STUDY AND REFERENCE:

1. B. D.Ratner, A,S. Hoffman, Biomaterials Science “An Introduction to Material in Medicine” (3rd edition), Elsevier Academic Press, Oxford, UK, 2013.
2. J. Black, Biological Performance of materials, Fundamentals of Biocompatibility, Marcel Dekker Inc., New York, 1992.
3. D. F. Williams (editor), Material Science and Technology - A comprehensive treatment, Vol. 14, Medical and Dental Materials, VCH Publishers Inc., New York, 1992.
4. Sujatha.V..Bhat, Biomaterials (2nd edition) Alpha Science International Ltd., 2005.
5. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishers, New Delhi, 1986.
6. A. Bandhyopadhya, S. Bose, Characterization of Biomaterials, Newnes, 2013.

Paper XV: **MAP402: Biomaterials and Biosensors** (60 hours, 4 credits)

UNIT I: BIOSENSOR TRANSDUCERS (15 h)

Electrochemical transducers (amperometric, potentiometric, conductimetric), semiconductor transducers (ISFET, ENFET), optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR), thermal transducers; piezoelectric and acoustic-wave transducers-limitations & problems to be addressed: an overview of performance and applications.

UNIT II: BIOSENSOR FABRICATION AND TYPES OF BIOSENSORS (15 h)

Methods for biosensors fabrication, self-assembled monolayers, screen printing photolithography, soft lithography, micro contact printing, deposition and selective etching, thin film growth and deposition, MEMS, engineering concept

Catalytic biosensors, mono-enzyme electrodes-bi-enzyme electrodes, enzyme sequence electrodes and enzyme competition electrodes, affinity based biosensors, inhibition based biosensors, cell based biosensors, biochips and biosensor arrays, Problems and limitations.

UNIT III: DETECTION IN BIOSENSORS/ BIORECOGNITION SYSTEM (15 h)

Enzymes, oligonucleotides and nucleic acids, lipids (Langmuir-Blodgett bilayers, phospholipids, liposomes), membrane receptors and transporters, microbial metabolism, tissue and organelles (animal and plant tissue), cell culture.

Immunoreceptors, chemoreceptors, Limitations.

UNIT IV: BIOSENSORS FOR MEDICAL APPLICATIONS (15 h)

Biorecognition elements and transduction technology, biorecognition elements, transduction technology, biosensors for diabetes applications, glucose as diabetes biomarker, biosensors for glucose measuring, biosensors for cardiovascular diseases applications, cardiovascular disease biomarkers, biosensors in cardiovascular disease, biosensors for cancer applications, cancer biomarkers, biosensors in cancer diseases

BOOKS FOR STUDY AND REFERENCE:

1. T. Togawa, T. Tamura, P. A. Oberg, Biomedical Transducers and Instruments, CRC Press, New York, 1997.
2. J. Kline, Handbook of Bio Medical Engineering, Academic press Inc., Sandiego, Oxford University Press, 2004.
3. G. K. Knoff, A. S. Bassi, Smart Biosensor Technology, CRC Press, 2006.
4. J.Janata, Principles of Chemical Sensors, Plenum Press, 1989.
5. F. Schellr, F. Schubert, J. Fedrowitz, Frontiers in Biosensors, Birkhauser Verlag, 1995.
6. F. Ligler, C. Rowe Taitt, Optical Biosensors: Present & Future. Elsevier, 2002.
7. Pier Andrea Serra, Biosensors for Health, Environment and Biosecurity, Intech, 2011.

Paper XVIA: MAP404(A): Medical and Optical Imaging Techniques (60 hours, 4 credits)

UNIT I: ADVANCED X-RAY IMAGING SYSTEMS (15 h)

Bremsstralung, characteristic line spectrum, factors affecting the x-ray spectrum, attenuation of heterogeneous and homogenous x-rays, attenuation coefficients, attenuation mechanisms, radiographic image quality, factors affecting image quality, focal spot, heel effect, filters, grids, intensifying screens, X-ray film, diagnostic applications of X-rays, skeletal system, soft tissues, the chest, mobile and dental X-ray machine, mammography, CT**:** Basic principle, generation of CT, Helical CT, single slice and multi slice CT scan system, image reconstruction, CT artifacts

UNIT II: MAGNETIC RESONANCE IMAGING (15 h)

Basic principles, spin, processing , relaxation time, free induction decay, T1, T2 proton density weighted image, pulse sequences, basic and advance pulse sequences, MR instrumentation, image formation, localization of the signal, factors influencing signal intensity, contrast and resolution, types of magnets, super conductors, RF transmitters, RF receivers, Gradiant coils, RF shielding, MR Spectroscopy, FMRI, MR artifacts, safety aspects in MRI.

UNIT III: DIAGNOSTIC ULTRASOUND (15 h)

Ultrasonic waves, beam characteristics, attenuation of ultrasound, specific acoustic impedance, reflection at body interfaces, coupling medium, interaction ultrasound with tissues, A scan, B scan and M mode-real time scanners, image clarity, resolution: axial and lateral resolution, artifacts, pulse echo imaging, obsterics abdominal investigations, Echo cardiograph (UCG), the Doppler effect-Doppler shift continuous wave Doppler system-pulsed wave Doppler systems, duplex scanning, display devices for ultrasonic imaging.

UNIT IV: RADIOISOTOPES IN DIAGNOSIS AND THERMOGRAPHY AND OTHER IMAGING TECHNIQUES (15 h)

Production of artificial radio nuclides, radio pharmaceuticals, radio nuclides imaging, selection of radioisotopes, image quality, radionuclides, specific activity and effective halflife, scintillators, gamma camera, radioactive tracers, static and dynamic imaging uptake for cardiac, renal, respiratory disorders, dilution analysis and its applications positron emission computed tomography(PET), SPECT(elementary ideas), density measurements, image reconstruction

Physics of thermography, infrared detectors, thermographic equipments, quantitative medical thermography, pyroelectric video camera, applications of thermography, fluorescence imaging, fluorescence life-time imaging, electrical impedance tomography (EIT), electrical source imaging (ESI), magnetic source imaging (MSI).

BOOKS FOR STUDY AND REFERENCE:

1. T. S. Curry, Physics of Diagnostic Radiology (4th Edition), Lippincott Williams & Wilkins, 1990.
2. Jerrold T Bushberg, The Essential Physics for Medical Imaging (2nd edition), Lippincott Williams & Wilkins 2002.
3. J. A. Pope, Medical Physics: Imaging, Heinemann Publishers, 2012
4. MRI – Perry Sprawls – Medical Physics Publishing, Madison, Wisconsin-2000
5. Advances in Diagnositc Medical Physics, Himalaya Publishing House-2006.
6. Diagnositc Ultrasound applied to OBG, Sabbahaga, Maryland, 1980.
7. F. A. Mettler,M.J. Guibertau, Essentials of Nuclear Medicine Imaging, Saunders, 2005.
8. Molecular Imaging FRET Microscopy and Spectroscopy Edited by Ammasi Periasamy and Richard N Day, Oxford Press 2005

Paper XVIB: MAP404 (B): Radiation Safety (60 hours, 4 credits)

UNIT I: RADIATION PROTECTION STANDARDS AND PRINCIPLES OF MONITORING (15 h)

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. basic concepts of radiation protection standards - historical background - international commission on radiological protection and its recommendations – The system of radiological protection – justification of practice, optimisation of protection and individual dose limits – adiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – concepts of collective dose-potential exposures, dose and dose constraints – system of protection for intervention - categories of exposures – occupational, public and medical exposures - permissible levels for neutron flux - factors governing internal exposure - radionuclide concentrations in air and water - ALI, DAC and contamination levels.

evaluation of external radiation hazards - effects of distance, time and shielding – shielding calculations - personnel and area monitoring - internal radiation hazards – radio toxicity of different radionuclides and the classification of laboratories – control of contamination – bioassay and air monitoring – chemical protection – radiation accidents – disaster monitoring.

UNIT II: SAFETY IN THE MEDICAL, INDUSTRIAL, AGRICULTURAL AND RESEARCH USES OF RADIATION (15 h)

Planning of medical radiation installations – general considerations – design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories.Evaluation of radiation hazards in medical diagnostic therapeutic installations – radiation monitoring procedures - protective measures to reduce radiation exposure to staff and patients - radiation hazards in brachytherapy departments and

teletherapy departments and radioisotope laboratories - particle accelerators protective equipment - handling of patients waste disposal facilities - radiation safety during source transfer operations special safety features in accelerators, reactors.
Use of ionising radiation in irradiator, industrial radiography, nucleonic gauging, well logging and research such as medical research, industrial research and agricultural research.

UNIT III: RADIOACTIVE WASTE DISPOSAL AND TRANSPORT OF RADIOISOTOPES (15 h)

Radioactive wastes – sources of radioactive wastes - classification of waste – treatment techniques for solid, liquid and gaseous effluents – permissible limits for disposal of waste - sampling techniques for air, water and solids – geological, hydrological and meteorological parameters – ecological considerations.Disposal of radioactive wastes - general methods of disposal - management of radioactive waste in medical, industrial, agricultural and research establishments.
transportation of radioactive substances - historical background - general packing requirements - transport documents - labeling and marking of packages – regulations applicable for different modes of transport - transport by post - transport emergencies - special requirements for transport of large radioactive sources and fissile materials - exemptions from regulations – shipment approval – shipment under exclusive use – transport under special arrangement – consignor's and carrier's responsibilities.

UNIT IV: LEGISLATION, RADIATION EMERGENCIES AND THEIR MEDICAL MANAGEMENT (15 h)

Physical protection of sources - safety and security of sources during storage, use, transport and disposal – security provisions: administrative and technical – security threat and graded approach in security provision national legislation – regulatory framework – atomic energy act – atomic energy (radiation protection) rules – applicable safety codes, standards, guides and manuals – regulatory control – licensing, inspection and enforcement – responsibilities of employers, licensees, radiological safety officers and radiation workers – national inventories of radiation sources – import, export procedures
Radiation accidents and emergencies in the use of radiation sources and equipment in industry and medicine - radiographic cameras and teletherapy units - loading and unloading of sources - loss of radiation sources and their tracing - typical accident cases. radiation injuries, their treatment and medical management - case histories.

BOOKS FOR STUDY AND REFERENCE:

1. Herman Cember. Introduction to Health Physics (4th edition) McGraw-Hill Professional Publishing New York, USA, 2009
2. United States. Congress. Joint Committee on Atomic Energy Atomic Energy Act 1962, Washington, Govt. Print. Off., 1962.
3. AERB Radiation Protection Rules 2004.
4. ICRP 1990 Recommendations.
5. ICRP 2007 Recommendations.
6. IAEA Basic Safety Standards 115, 1997.
7. Shapiro J. Radiation Protection, Harvard University Press,1990
8. Mckenzie. Radiation Protection in Radiotherapy, Institute of Physical Sciences in Medicine, 1986

PRACTICAL LAB. COURSE 1

SEM-I

MAPP101 (Lab-I : Group A)

1) Write a C program to find the roots of quadratic equations.
2) C program for addition, subtraction and multiplication, division of two numbers.
3) Present your data by using MS-Office excel.
    a. Pie chart
    b. Polygon
    c. Histogram
    d. Scatter diagram
4) Present your data using Origin software.
    a. Pie diagram
    b. Scatter diagram
    c. Polygon
    d. Histogram
4) To verify Simpsons and trapezoidal rule.
5) Determination of crystal structure by X-ray diffraction (XRD) technique.
6) Simple measurement of the band gap in Silicon and Germanium.
7) To study the seven crystal structure (Bravais lattices).
8) To determine the resistivity of semiconductors by Four probe Method.
9) Determination of the size of lycopodium particles using XRD pattern.
10) To determine crystal structure of the material of thin film from given XRD pattern

    a. FCC b.BCC c.HCP

SEM-I

MAPP102 (Lab-I; Group-B)

1) To study the stair case ramp generator.
2) To find the Ripple factor and regulation of a Full-wave Rectifier with and without filter.
3) To obtain the load regulation and ripple factor of a half- wave rectifier.
   a. with Filter b. without Filter
4) To study astable multitvibrator with variable duty cycle using IC-555.
5) To construct a Zener diode voltage regulator and measure its line and load regulation.
6) To observe the characteristics of UJT and calculate the intrinsic stand of ratio (¦).
7) Laboratory Experiments Manual for 8085 Microprocessor
   a. Write 8085 assembly language program for addition of two 8-bit numbers and sum is 8 bit.
   b. Write 8085 assembly language program for addition of two16-bit numbers and sum is 16 bit.
8) To verify De-Morgan's theorem using logic gates.
9) To verify the characteristic tables of D-type, R-S (Reset -Set) type T type and J-K type Flip-Flops.
10) To plot B-H curve in ferromagnetic material.
11) To study photoelectric effect and calculate Planck's constant using five different colored LEDs and photoelectric cell.
12) Measure the ratio of the electron charge-to-mass (e/m) by studying the electron trajectories in a uniform magnetic field.

PRACTICAL LAB COURSE 2

SEM II

MAPP201 (Lab-II; Group-A)

1) Construction and study of mode properties of planer wave guides.
2) To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
3) Measurement of inductance using impedance at different frequency.
4) To study the Hall effect and to find out Hall coefficient and determine carrier concentration.
5) To determine the absolute activity of an alpha source.
6) To determine the absolute activity of americium source using Radlab software.
7) To determine the Decay ratio of 230-Th alpha source.
8) To measure the Percentage Energy resolution of NaI (TL) detector for C-60 source and 137-Cs.

9) Gamma spectroscopy and linear attenuation coefficient of the (Al) using gamma radiation having energy (661.65 KeV).
10) To determine the thermal neutron flux distribution for Am-Be source and source strength for same source with BF_3 counter.
11) Study of absorption of alpha and bêta rays.
12) Study of statistics in radioactive measurement.

MAPP202 (Lab-II; Group-B)

1) To study the operating plateau of the Geiger Muller tube.
2) To study natural radioactivity series and its application in medical field.
3) Study of bones (Skeleton system).
4) To determine total WBC count in human blood.
5) To determine percentage distribution of different types of WBC's in stained film.
6) To determine total RBC count.
7) Determination of Blood group.
8) To determine Bleeding time and coagulation time.
9) Estimation of Hemoglobin content of Blood.

PRACTICAL LAB COURSE 3

SEM-III

MAPP301 (Practical)

1) Range of beta particles.
2) Study the voltage-current characteristics of GM Tube.
3) To study the absorption of beta and gamma radiation.
4) Verification of inverse square law
5) Synthesis of nanoparticles using combustion method
6) Synthesis of nanoparticles using reflux method
7) Thin film synthesis using SILAR method
8) Thin film synthesis using spin coating method
9) Measurement of hydrodynamic diameter using DLS technique
10) Study of induction heating characteristics of magnetic nanoparticles and calculation of SAR

MAPP302: Research project

PRACTICAL LAB COURSE 4

SEM-IV

MAPP401 (Practical)

1) Back scattering of beta particles.
2) Determination of plateau and resolving time of a GM counter and its application in estimating the self-ratio and activity of a beta source.
3) To verify the Inverse Square Law by using GM Tube.
4) Production attenuation of bremmstrahlung radiation.
5) Synthesis of nanoparticles using hydrothermal method
6) Synthesis of nanoparticles using co-precipitation
7) Thin film synthesis using chemical bath deposition
8) Thin film synthesis using Electrodeposition method
9) Study of FTIR spectroscopy for materials characterization
10) Study of UV-Vis spectrophotometer for materials characterization

MAPP 402: Research project

BL-APM-05- Evaluation System

The candidate shall be awarded the degree of **Master of Science in Applied Physics (Medical)** after completing the course and meeting all the evaluation criteria.

A. Scheme of Examination and Passing

1. This course will have 20 % Term Work (TW)/ Internal Assessment (IA) and 80% external (University written examination of 3 hours duration for each course paper and practical examination of 3 hours duration for each practical). All external examinations will be held at the end of each semester and will be conducted by the University as per the existing norms.
2. Term work/ Internal assessment- IA (20%) and University examination (80%) - shall have separate heads of passing (i.e. 8 Marks for passing in IA and 32 Marks for passing in University examination). For Theory courses, internal assessment shall carry 20 marks and semester-end examination shall carry 80 marks for each theory course.
3. To pass, a student has to obtain minimum grade point E, and above separately in the IA and external examination.
4. The University (external) examination for Theory and Practical shall be conducted at the end of each Semester.
5. The candidates shall appear for the external examination of 4 Theory courses each carrying 80 marks of 3 hours duration and 2 practical courses each carrying 100 marks at the end of each semester.

6. The candidate shall prepare and submit for the practical examination a certified journal based on the practical course carried out under the guidance of a faculty member with minimum number of experiments as specified in the syllabus for each group.
7. In order to appear for the examination, 80% attendance of the candidate is mandatory.
8. The candidate shall prepare the dissertation based on the Research Project for the fulfillment of Master's Degree.

B. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester based credit an d grading system.

C. Standard point scale for grading:

Grade	Marks	Grade Points
O	70 & above	7
A	60-69.99	6
B	55-59.99	5
C	50-54.99	4
D	45-49.99	3
E	40-44.99	2
F(Fail)	39.99 & below	1

Grade Point Average (GPA) calculation:

1. GPA is calculated at the end of each semester after grades have been processed and after any grade have been updated or changed. Individual assignments/quizzes/surprise tests/unit tests/tutorials/project/seminars etc. as prescribed by University are all based on the same criteria as given above. The teacher should convert his marking into the Quality-Points and Letter-Grade.
2. Performance of a student in a semester is indicated by a number called Semester Grade Point Average (SGPA). It is the weighted average of the grade points obtained in all the

$$SGPA = \frac{\sum_{i=1} C_i p_i}{\sum_{i=1} C_i}$$

C_i = The number of credits earned in the i^{th} course of a semester.

p_i = Grade point earned in the i^{th} course

i = 1,2,....n represents number of courses for which the student is registered.

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subjects registered by the students during the semester.

3. The Final remark will be decided on the basis of Cumulative Grade Point Average (CGPA) which is weighted average of the grade point obtained in all the semesters regis tered by the 1 earner.

$$CGPA = \frac{\sum_{j=1} C_j p_j}{\sum_{j=1} C_j}$$

C_j = The number of credits earned in the j^{th} course upto the semester.for whic h the CGPA is calculated

p_j = Grade point earned in the j^{th} course*

j = 1,2,....n represents number of courses for which the student is registered upto the semester for which the CGPA is calculated.

* : A letter Grade lower than E in a subject shall not be taken into consideration for the calculation of CGPA

The CGPA is rounded upto the two decimal places.