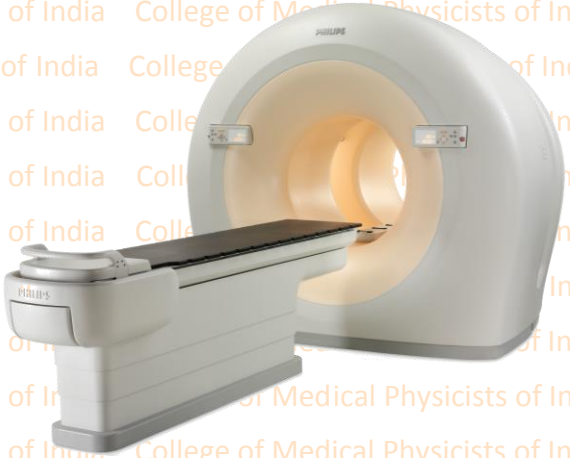
College of Medical Physics of India

Syllabus for Master's Program in Medical Physics



Outcome of the CMPI Workshop on Harmonization of Syllabus for Medical Physics held during 22nd to 23rd June 2012

Published – July 2014

Participants at the workshop:

1. Dr. Kurup, Apollo Hospital, Chennai and Chairman CMPI
2. Dr. S.D.Sharma, RP & AD, BARC, Mumbai
3. Dr.Thayalan, Rtd, Professor, BIR, MMC, Chennai
4. Dr.Deshpande, TMH, Mumbai
5. Dr. Mariadas, SGPGI, Lucknow, Secretary – Treasurer, CMPI
6. Dr. Ravikumar, KMIO, Bangalore,
7. Dr.Sathyanarayana, Rubi Hall Clinic, Pune, Registrar, CMPI
8. Dr.Lalith Agarwal, Banaras Hindu University, Varanasi
9. Dr. Sowmy Narayanan, Bangalore
10. Dr.Kaliappan, Kanchepuram,
11. Dr. Pratik Kumar, AIIMS, New Delhi
12. Dr. ArunOinam, PGI, Chandigarh
13. Dr.Srinidhi, ManipalHopsital, Manipal
14. Dr.Jeevan Ram, Bharathidasan University, Trichy
15. Dr. Dhanskodi, Bharathidasan University, Trichy
16. Mr. Bharanidharan, Anna University
17. Dr. Devakumar, CMC Vellore
18. Dr.Rabi Raja Singh, CMC, Vellore
19. Dr. Paul Ravindran, CMC Vellore,
20. Ms. Retna John, CMC Vellore.

College of Medical Physics of India

Syllabus for Training of Medical Physicists

The following are the subjects that are necessarily be taught to the candidates undergoing training in Medical Physics. Though the universities and colleges are fully entitled to develop their own syllabus for the training of Medical Physicists, the centers seeking accreditation by the CMPI should ensure that the following subjects are included in their syllabus. A workshop was conducted by the CMPI on 22nd and 23rd June 2012 to draft a syllabus that forms the common minimum requirement to conduct Medical Physic program in India. Senior Medical Physicists from Various universities and colleges in India that conduct the training program were invited for the workshop. The syllabus was made available at the CMPI website and suggestion to improve was sought from the CMPI members. The following syllabus has the comments and suggestion incorporated to the one developed at the workshop. The syllabus has been drafted for a two year M.Sc Medical Physics conducted as academic year program. The universities and colleges having semester system may appropriately divide the syllabus for the semesters. The institutions having one year diploma with intake of candidates with M.Sc in Physics may adjust the syllabus for one year duration by reducing the content of the subjects already taught in M.Sc general physics program.

The following syllabus is intended to be comprehensive in the range of subjects to be covered without being detailed. Students should possess a sound knowledge of the subjects and those of practical procedures which physicists might be called up on to undertake

First year

1. Anatomy and Physiology as applied to Medical Physics
2. **Basic Radiation Physics**
3. Mathematical Physics
4. Solid State Physics
5. Radiation Detection and Instrumentation
6. Radiation Dosimetry and Standardization
7. Physics of Radiation Oncology
8. Experiments in Basic Radiation Physics

Second Year

9. Advanced Radiation Oncology Physics
10. Radiation Biology
11. Physics of Medical Imaging
12. Radiological Safety And Protection
13. Advanced Experiments related to Radiotherapy, Radiology and Nuclear medicine.

ANATOMY AND PHYSIOLOGY AS APPLIED TO MEDICAL PHYSICS

(***Suggested number of teaching hours is 70 including tutorials and demonstrations***)

UNIT I: Skeletal system 10 hours

The skull – vertebral column, ribs and sternum, bones of upper limb, lower limb. The muscular system - superior extremities, inferior extremities, the thoracic cage, the diaphragm, abdominal region, Neck – sternocleidomastoid muscle

UNIT II: Digestive system & Circulatory system: 15 hours

Functions of mouth, tongue, teeth, esophagus, salivary glands, stomach, small intestine, large intestine, pancreas, liver, biliary System.– 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, Plasma, Anatomy of the heart, artery, vein, capillaries and their functions – Major vessels – Aorta and it branches, Superior and Inferior venae cava and their trubutaries, internal jugular vein, subclavian vein, axillary vein, femoral vein, popliteal vein, superficial veins of upper and lower limbs, Lymphatic system. Physiological properties of heart muscle, cardiac dynamics – EEG – blood pressure and its regulation.

UNIT III: Respiratory & Endocrine system: 15 hours

Anatomy of Nose, Pharynx, Bronchi - Trachea – Lungs and their functions Physical laws of respiration — oxygen transport –Physiology of Respiration – Lung Volume and capacity, control, gas exchange. Pituitary gland and its functions – functions of adrenal, thyroid, pancreas - secretion – chemistry – physiological actions, effects on removal effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action - Insulin.

UNIT IV: Reproduction system & Nervous system: 10 hours

(a). Male Reproductive System – Testis, epididymis, vas deference, seminal vesicles, prostate and their functions, Male infertility. (b) Female Reproductive System: Ovaries, Fallopian Tube, Vagina, Breast, reproductive Cycle, Menstruation, Maturation, Fertilization. Brain and spinal cord - central nervous system and Autonomic Nervous system functions

UNIT V: Excretory system & Sensory system: 10 hours

Kidney and its functions, Ureter, Urinary Bladder, Urethra,– Formation and Excretion of Urine, Micturation. Skin - Eye - Ear - Nose - Tongue.. Physiology of special senses of hearing, taste, vision

UNIT VI: Radiological and surgical anatomy: 10 hours

Anatomy and physiology as applied to radio diagnosis and radiotherapy – X-ray anatomy – CT/MRI anatomy-Radiographic anatomy (including cross sectional anatomy) – identify the different organs/structures on plain x-rays, CT scans and other available imaging modalities. Normal anatomy and deviation for abnormalities,

Surface anatomy applied to RD and RT – heart, lungs, stomach, liver, spleen, kidney, external jugular vein, cephalic vein, great saphenous vein, pulsations of radial artery, posterior tibial artery, dorsalispedis artery,

BOOKS FOR REFERENCE:

1. C.H. Best and N.B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1986.
2. C.K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 1988.
3. J.R. Brobek, Physiological Basis of Medical Practice, Williams and Wilkins, London, 1995

BASIC RADIATION PHYSICS

(***Suggested number of teaching hours is 50 including tutorials and demonstrations***)

UNIT I: **NUCLEAR PHYSICS** **5 hours**

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: RADIATION QUANTITIES AND UNITS **5 hours**

Measurement of Activity – Curie – Becquerel – decay constant – half life- relationship between half life and decay constant - Exposure and absorbed dose – Roentgen, Gray - electron volt(eV), kilovolt (kV), Half value layer (HVL) as an index of penetration of radiation – linear attenuation coefficient – measurements

UNIT III: PRODUCTION OF RADIO ISOTEOPES **5 hours**

Radiation Sources – Natural and artificial radioactive sources – Large scale production of isotopes – Reactor produced isotopes – Cyclotron produced isotopes – Fission products – Telecobalt and Brachytherapy sources- Caesium sources – Gold seeds – Tantalum wire – ^{125}I sources – Beta ray applicators – Thermal and fast neutron sources – Preparation of labelled compounds and radio colloids

UNIT IV: PRODUCTION OF X-RAYS **15 hours**

Discovery and properties of x-rays –Production of x-rays –X-ray spectrum, Bremsstrahlung Spectrum, Characteristic spectrum – X-ray tube design, Cathode, space charge effect, anode, focal spot size, line focus principle, anode angle, anode heel effect, tube insert and vacuum, tube cooling- Types of x-ray tubes, gas tubes, Coolidge tube, stationary and rotating anode X ray tubes, grid controlled x-ray tube- off focal radiation

X ray generators- transformers- Transformer construction- Autotransformer-High tension transformer- Rectifiers- Filament control and kV control circuits - high voltage transformers - High voltage circuits - Half-wave and full-wave rectifiers - Condenser discharge apparatus - Three phase apparatus - Voltage doubling circuits - Current and voltage stabilisers Single & three phase generator –high and medium frequency generator- Complete X-ray circuit- exposure timers- automatic exposure control- x-ray tube ratings & heat loading- Quality and quantity of x-rays.

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.

UNIT V: INTERACTION OF RADIATION WITH MATTER 15 hours

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 reaction.

UNIT VI:BASIC RADIATION PROTECTION 5 hours

Historical development, principles of radiation protection and its units, dose equivalent limits, protective materials, types of Radiation effects - Area and personal monitoring; Gamma zone monitor, survey meter, film and TLD badges and pocket dosimeter

Books for references

1. R.D. Evans, Atomic Nucleus
2. H. E. Johns and J. R. Cunningham, The Physics of Radiology
3. Preston M.A. Physics of Nucleus
4. Lapp R.E. Nuclear Radiation Physics
5. B.L. Theraja Modern Physics
6. Slack L. Radiations from Radioactive Atoms
7. Oliver R. Radiation Physics in Radiology
8. Crouthamel C.E. Applied Gamma – ray Spectrometry

MATHEMATICAL PHYSICS

(*Suggested number of teaching hours is 60 including tutorials and demonstrations*)

UNIT 1: PROBABILITY, STATISTICS AND ERRORS 15 hours

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.

UNIT 2:COUNTING AND MEDICAL STATISTICS 10 hours

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 – Student T Test – Mann Whitney's test - 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 3:NUMERICAL METHODS 25 hours

Why numerical methods, accuracy and errors on calculations - round-off error, evaluation of formulae. Iteration for Solving $x = g(x)$, Initial Approximation and Convergence Criteria. Interpolations: Finite differences- Forward –Backward- Central differences-Newton-Gregory forward, backward interpolation Formulae for equal intervals-Missing terms-Lagrange's interpolation formula for unequal intervals-Inverse interpolations. Characteristic equation of a matrix-Cayley Hamilton theorem-Reduction of a matrix to diagonal form – Jacobi method – Sylvester's theorem

Curve fitting - Principle of least squares - Discrete Fourier Transform - Fast Fourier Transform – Applications in Medical Imaging – Random waveforms and noise. Laplace equation – Method of separation of variables

Simultaneous linear equations: Gauss elimination method - Jordan's modification. - Inverse of a matrix by Gauss - Jordan Method - Roots of nonlinear equations: Newton- Raphson method - Iterative rule -Termination criteria.

Taylor series, approximating the derivation, numerical differentiation formulas.Introduction to numerical quadrature, Trapezoidal rule, Simpson's 2/3 rule, Simpson's Three-Eighth rule.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.

UNIT 4: COMPUTATIONAL TOOLS & TECHNIQUES 10 hours

Computational packages: Overview of programming in C++, MATLAB/ Mathematics, and

STATISTICA in data analysis and graphics.

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.

Books for References

1. Hoffman, Numerical Methods for Engineers and scientists – 2nd Edition
2. Revised and expanded,.
3. A.C. Bajpai, I.M. Calus and J.A. Fairley Numerical methods for
4. engineers and scientists – a student's course book, John Wiley & sons
5. Band W. Introduction to Mathematical Physics
6. Croxton – elementary statistics
7. Dahlberg G. Statistical Method of medical & biology students
8. Krasnor m.L. Ordinary differential equation

SOLID STATE PHYSICS

(*Suggested number of teaching hours is 40 including tutorials and demonstrations*)

I. SOLID STATE PHYSICS

UNIT I: Crystal Physics **5 hours**

Types of lattices - Miller indices - simple crystal structures - Crystal diffraction - Bragg's law - Reciprocal lattice (sc, bcc, fcc) - Laue equations - Structure factor - Atomic form factor - Types of crystal binding - Cohesive energy of ionic crystals - Madelung constant - Inert gas crystals - Vander Waal - Landon equation - Metal crystals - Hydrogen bonded crystals.

UNIT II: Lattice dynamics **7 hours**

Monoatomic lattices - Lattice with two atoms per primitive cell - First Brillouin zone - Group and phase velocities - Quantization of lattice vibrations - Phonon momentum - Inelastic scattering by phonons - Debye's theory of lattice heat capacity - Einstein's model and Debye's model of specific heat - thermal expansion - Thermal conductivity - Umklapp processes.

UNIT III: Theory of metals and semiconductors **8 hours**

Free electrons gas in three dimensions - Electronic heat capacity - Wiedmann-Franz law - Hall effect - Band theory of metals and semiconductors - Bloch theorem - Kronig-Penny model - Semiconductors - Intrinsic carrier concentration - Mobility - Impurity conductivity - Fermi surfaces and construction - Experimental methods in Fermi surface studies - de Haas Van Alphen effect.

UNIT IV: Magnetism **10 hours**

Elementary ideas of dia, para and ferro magnetism - quantum theory of paramagnetism - Rare earth ion - Hund's rule - Quenching of orbital angular momentum - Adiabatic demagnetization - Quantum theory of ferromagnetism - Curie point - Exchange integral - Heisenberg's interpretation of Weiss field - ferromagnetic domains - Bloch Wall - Spin waves - Quantization - Magnons - thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of antiferromagnetism - Neel temperature. M.Sc. Physics : Syllabus (CBCS) 24

UNIT V: Super conductivity **10 hours**

Experimental facts-occurrence - Effect of magnetic fields - Meissner effect - Entropy and heat capacity - Energy gap - Microwave and infrared properties - Type I and II superconductors - theoretical explanation - thermodynamics of super conducting transition - London equation - Coherence length - BCS Theory - single particle Tunneling - Josephson tunneling - DC and AC Josephson effects - High temperature super conductors - SQUIDS.

Books for Reference

1. C. Kittel, 1996, Introduction to Solid State Physics, 7th Edition, Wiley, New York.
2. M. Ali Omar, 1974, Elementary Solid State Physics-Principles and Applications, Addison-Wesley, London.
3. H.P. Myers, 1998, Introductory Solid State Physics, 2nd Edition, Viva Book, New Delhi.
4. S.O. Pillai, 1997, Solid State Physics, New Age International, New Delhi.

5. N.W. Aschroft and N.D. Mermin, Solid State Physics, Rhinehart and Winton, New York.
6. J.S. Blakemore, 1974, Solid State Physics, 2nd Edition, W.B. Saunder, Philadelphia.
7. A.J. Dekker, Solid State Physics, Macmillan India, New Delhi.
8. H.M. Rosenburg, 1993, The Solid State, 3rd Edition, Oxford University Press, Oxford.
9. S.O. Pillai, 1994, Problems and Solutions in Solid State Physics, New Age International, New Delhi.
10. S.L. Altmann, Band Theory of Metals, Pergamon, Oxford.
11. M.A. Wahab, 1999, Solid State Physics, Structure and Properties of Materials, Narosa, New Delhi.
12. J.M. Ziman, 1971, Principles of the Theory of Solids, Cambridge University Press, London.

RADIATION DETECTION AND INSTRUMENTATION

(*Suggested number of teaching hours is 65 including tutorials and demonstrations*)

UNIT I: APPLIED ELECTRONICS 10 hours

Semiconductor diodes - JFET – MOSFET – Thyristors- SCR &Triac- characteristics and ratings- power control using thyristorspower-IGBT- switch mode DC power suppliesIntegrated Circuits - Operational amplifiers(OPAM) and their characteristics - Differential Amplifier - Operational amplifier systems – OPAMApplicatons -Addition, subtraction, Integration and Differentiation – Active amplifiers - Pulse Amplifiers - Decoders and Encoders - Power supplies - Regulated power supplies using IC's - DC-DC converter and RF power supplies – Switching mode power supplies – AC regulators - Instrumentation amplifier - V to I and I to V converter - Op-amp circuits using diodes - Sample and Hold circuits - Log and Antilog amplifiers - Multiplier and Divider - Electronic analog Computation - Schimitt Trigger - Astable, MonostableMultivibrator - Triangular wave generators - Sine wave generators - Rc Active filters

Noise in electronics due to ionising radiation, radiation damage; radiation hardening techniques in manufacture and in application

UNIT II: Opto electronic devices 5 hours

Light sources and Displays - Light emitting diodes - Surface emitting LED - Edge Emitting LED - Seven segment display - LDR - Diode lasers - Photo detectors - Basic parameters - Photo diodes - p-i-n Photo diode - Solar cells - Photo transistors - IR and UV detectors

UNIT III: Digital Electronics, Microprocessors & Micro Controllers 10 hours

Binary adders- Decoder & encoder- multiplexer & de-multiplexer- JK flip flop- shift registers- Ripple counter- synchronous counter- A/D and D/A converters- Introduction to microprocessors , architecture, families, examples of manufacturer specific features. Programming, input and output, timers and interrupts - interfacing memory & I/O devices- Memory address space and data organization- segment registers and memory segmentation generating a memory address- I/O address space- Addressing modes- comparison of 8086 and 8088- Basic 8086/8088 configuration- Minimum mode- maximum mode.Introduction to microcontrollers- comparison with microprocessors- study of microcontroller(MC 51 family)- Architecture, instruction set, addressing modes and its programming.

UNIT IV:PRINCIPLES OF RADIATION DETECTION 10 hours

Principles of Radiation Detection and measurement – Basic Principles of radiation detection – Gas filled detectors – ionization chambers – Theory and design – construction of condenser type chambers 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 –Thermolumenescent 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 V:RADIATION MEASURING & MONITORING INSTRUMENTS 15 hours

Dosimeters based on condenser chambers - Pocket chambers - Dosimeters based on current measurement - Different types of electrometers - MOSFET, Vibrating condenser and Varactor 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 - 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.

UNIT VI : IN VIVO DOSIMETRY 5 hours

In-vivo dosimetry – importance – requirements – methods – Thermoumicentdosimetry (TLD) – diodes - MOSFET - Optically stimulated Luminescence dosimeters – calibration methods for invivodosimetry – practical consideration during in-vivo dosimetry- applications – TBI –TSET – intra-cavitary measurements.

UNIT VII: INTERNAL RADIATION DOSIMETRY 10 hours

Difference Compartmental Model; Single Compartmental Model, Two Compartmental Model with Back Transference, Two Compartmental Model without Back Transference. Classical Methods of Dose Evaluation; Beta particle Dosimetry; Equilibrium Dose Rate Equation, Beta Dose calculation, Specific Gamma Ray constant, Gamma Ray Dosimetry, Geometrical Factor calculation, Dosimetry of Low Energy Electromagnetic Radiation. MIRD Technique for Dose calculations; Basic procedure and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit cumulative Activity and Problems related to the Dose Calculations. Limitation of MIRD technique.

Books for Reference

1. YU-Cheng Liu & Glenn A Gibson , "Microprocessor system, Architecture Programming & Design.
2. Bre, "The Intel Microprocessors –" PHI
3. Douglas V Hall ,"Microprocesors & Interfacing" – TMH
4. Avtar Singh, "IBM PC/8088 assembly Language Programming"
5. Scott MacKeinz "The 8051 Microcontroller, 3/E" Prentice Hall Inc.
6. H. E. Johns and J. R. Cunningham, The Physics of Radiology
7. Jacob Van Dyk , The Modern Technology of Radiation Oncology
8. Ramesh Chandra, Nuclear Medicine Physics 5th edition , Lea & Febiger, Philadelphia
9. Antonto Fernando Goncalves Rocha and John Charles Harbet, Text book of Nuclear Medicine: Basic science
10. Patil J.Early.M.A. Razzak and D.Bruces Sodee Text book of Nuclear Medicine Technology,The C.V. Mosby Company
11. A.L. Baert and K.Sartor, Diagnostic Nuclear Medicine, 2nd edition, springer
12. 5. Gopal B.Saha, Fundamental of Nuclear Pahrmacy 5th edition, spinger

RADIATION DOSIMETRY AND STANDARDIZATION

(*Suggested number of teaching hours is 60 including tutorials and demonstrations*)

UNIT I: RADIATION QUANTITIES AND UNITS 10 hours

Radiation quantities and units - Radiometry - Particle flux and fluence - Energy flux and fluence - Cross section - Linear and mass attenuation coefficients - Mass energy transfer and mass energy absorption coefficients - Stopping power - LET - Radiation chemical yield - W value - Dosimetry - Energy imparted -Absorbed dose- Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose - Concepts of collective dose - KERMA-CEMA - Exposure - Air kerma rate constant - Charged particle equilibrium (CPE) - Relationship between kerma, absorbed dose and exposure under CPE - Dose equivalent - Ambient and directional dose equivalents [(H*(d) and H'(d)] - individual dose equivalent penetrating Hp(d) - Individual dose equivalent superficial Hs(d).

UNIT II: DOSIMETRY& STANDARDISATION OF X AND GAMMA RAYS BEAMS 20 hours

Standards – Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/Exposure.Limitations of FAIC.Bragg-Gray cavity theory, Mathematical expression describing Bragg-Gray principle and its derivation.Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of D_{gas}, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General Definition of calibration factor – Nx, N_K, $N_{D,air}$, $N_{D,W}$. IAEA TRS277: various steps to arrive at the expression for Dw starting from Nx. TRS398: $N_{D,W,Q}$, $K_{Q,Q0}$, K_Q, Derivation of an expression for $K_{Q,Q0}$, Calorimetric standards – Inter-comparison of standards. TG 51 and other dosimetry protocols

Measurement of Dw from Cobalt-60 teletherapy machines - Reference conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for Machine timing error, procedure for evaluation of Temperature and pressure correction. Thermometers and barometer.Measurement of temperature and pressure.Saturation correction - derivation of expression for charge collection efficiency of an ion chamber based on Mie theory - Parallel plate, cylindrical and spherical ion chambers, k_{sat}.Two voltage method for continuous and pulsed beams, polarity correction.

Measurement of Dw for high-energy photon beams from Linear Accelerators: Beam quality index, beam quality correction co-efficient, Cross calibration using intermediate beam quality. Quality Audit programmes in Reference and Non-Reference conditions.

Standardization of brachytherapy sources – Apparent activity – Reference Air Kerma Rate – Air Kerma strength Standards for HDR Ir-192 and Co-60 sources – standardization of I-125 and beta sources – IAEATECDOC 1274 – room scatter correction.Calibration of protection level instruments and monitors.

UNIT III: NEUTRON STANDARDS AND DOSIMETRY 10 hours

Neutron Classification, Neutron Sources, Neutron standards – primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method.Neutron spectrometry, threshold detectors, scintillation detectors &multispheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators.

UNIT IV: STANDARDIZATION OF RADIONUCLIDES 10 hours

Methods of measurement of radioactivity – Defined solid angle and 4π counting – Beta gamma coincidence counting – standardization of Beta emitters and electron capture nuclides with proportional, GM and Scintillation counters – standardization of gamma emitters with scintillation spectrometers – Ionization chamber methods – Extrapolation chamber – Routine sample measurements – Liquid counter – Windowless counting of liquid samples – scintillation counting methods of alpha, beta and gamma emitter – Re-entrant ionization chamber methods – methods using (n, γ) and (n,p) reactions – Determination of yield of neutron sources – Space integration methods – Solid state detectors.

UNIT V: RADIATION CHEMISTRY AND CHEMICAL DOSIMETRY 10 hours

Definition of free radicals and G-value – Kinetics of radiation chemical transformations – LET and dose-rate effects – Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects – Radiation chemistry of gases and reactions of dosimetry interest – Radiation polymerization, effects of radiation on polymers and their applications in dosimetry – Formation of free radicals in solids and their applications in dosimetry — Dosimetry principles – Definitions of optical density, molar absorption co-efficient, Beer-Lambert's law, Spectrophotometry – Dose calculations – Laboratory techniques – Reagents and procedures – Requirements for an ideal chemical dosimeter – Fricke dosimeter – FBX dosimeter – Free radical dosimeter – Ceric sulphate dosimeter – Other high and low level dosimeters – Applications of chemical dosimeters in Radiotherapy.

Books for Reference

1. IAEA TRS 374, Calibration of dosimeters used in Radiation Therapy
2. F.H. Attix. Introduction to Radiological Physics and Radiation dosimetry, Viley-VCH, Verlog, 2004
3. H.E. Johns and Cunningham, The Physics of radiology
4. Jacob Van Dyk The Modern Technology of Radiation Oncology

PHYSICS OF RADIATION ONCOLOGY

Suggested number of teaching hours is 60 including tutorials and demonstrations.

Unit I. Kilo-Voltage Machines **10 hours**

Principles of superficial therapy and orthovoltage x-ray production, superficial therapy machine, Orthovoltage therapy machine, Beam collimation and treatment distances (SSD), Comparison with diagnostic x-ray machine and tube cooling methods.

Unit II. Megavoltage Machines **10 hours**

Telecobalt machines, ,Construction and working of telecobalt units - source design - shutter mechanisms, beam collimation – penumbra trimmers, beam modifiers and timer errors - trimmers and breast cones. Design and working of medical electron linear accelerators - beam collimation - asymmetric collimator - multileaf collimator - types - dose monitoring - electron contamination - Basic components, RF power generation and accelerating guides, magnetron – klystron- Electron beam transport, linac treatment head, target and filters, dose monitoring- Production of clinical electron beam, beam collimation and types of collimators, Treatment couch, lasers and electronic portal imaging devices, Betatron and Medical Microtron.

Unit III.Treatment Simulation& Planning **15 hours**

Radiotherapy simulator and its applications, SIM CT, CT Simulator and virtual simulations – positioning laser - Networking in Radiotherapy - Record & verification (R&V).

Factors for treatment planning: Central axis dosimetry parameters - Tissue air ratio (TAR) Back scatter/ Peak scatter factor (BSF/PSF) - Percentage depth doses (PDD) - Tissue phantom ratio (TPR) - Tissue maximum ratio (TMR) - Collimator, phantom and total scatter factors- Relationship between these factors and their application - SAR, SMR, Off axis ratio. Build-up region and surface dose.Tissue equivalent phantoms. Beam data acquisition - Radiation filed analyzer (RFA). Description and measurement of isodose curves/charts.Dosimetry data resources.

Beam modifying and shaping devices – physical wedge filters - universal, motorized and dynamic wedges- shielding blocks and compensators. Treatment planning in teletherapy – target volume definition and dose prescription criteria- ICRU 50 and 62 - SSD and SAD set ups - two and three dimensional localization techniques - contouring - simulation of treatment techniques - field arrangements - corrections for tissue inhomogeneity, contour shapes and beam obliquity -determination of dose distribution –

integral dose. Arc/ rotation therapy and Clarkson technique for irregular fields - Conventional and conformal adiotherapy.Treatment time and Monitor unit calculations. Treatment planning techniques – beam matching methods for adjacent photon beams.

Clinical electron beams - energy specification - electron energy selection for patient treatment - depth dose characteristics (Ds, Dx, R100, R90, R50, R etc.) – therapeutic range - beam flatness and symmetry - penumbra - isodose plots - monitor unit calculations - output factor formalisms - effect of air gap on beam dosimetry - effective SSD - beam matching for adjacent electron beams and photon-electron beams

Unit IV.Brachytherapy **15 hours**

Definition and classification of brachytherapy techniques - surface mould, intracavitary, interstitial and intraluminal techniques. Requirement for brachytherapy sources – Radiation sources used in Brachytherapy – their physical properties and production of Radio isotopes used in brachytherapy. Description of radium and radium substitutes - 137Cs, 60Co, 192Ir, 125I and other commonly used brachytherapy sources. Paterson Parker and Manchester Dosage systems.Gynecologicalbrachytherapy -ICRU 38 and 58.

Specification and calibration of brachytherapy sources - RAKR and AKS - IAEATECDOC 1274 and ICRU 72 recommendations. Point and line source dosimetry formalisms - Sievert Integral - AAPM TG-43/43U1 and other dosimetry formalisms.

After-loading techniques - Advantages and disadvantages of manual and remote after-loading techniques.AAPM and IEC requirements for remote after-loading brachytherapy equipment. Acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment. Dose rate considerations and classification of brachytherapy techniques - Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR - Remote after-loading machines, LDR and HDR machines, Ir -192 & Co-60 HDR Units, Brachytherapy Treatment planning system, Networking between Planning system and Remote after-loading Units, X-ray Brachytherapy.

ISO requirements and QA of brachytherapy sources.Integrated brachytherapy unit.Brachytherapy treatment planning - CT/MR based brachytherapy planning - forward and inverse planning - DICOM image import / export from OT - Record & verification.

Unit V. Quality Assurance in Radiotherapy **10 Hours**

Acceptance Testing and Quality assurance in radiation therapy – quality assurance protocols for telecobalt, medical linear accelerator including multi leaf collimators and radiotherapy simulators - IEC requirements - Portal and in-vivo dosimetry. Electronic portal imaging devices - Dialy, weekly and annual QA for teletherapy - Brachytherapy - Simulator - CT simulator machines

Books for Reference

1. Jacob Van Dyk The Modern Technology of Radiation Oncology
2. Faiz M.Khan, The Physics of Radiation Therapy, 4th edition
3. H.E. Johns and Cunningham, The Physics of radiology
4. Faiz M.Khan, Roger A. Potish, treatment Planning in radiation Oncology
5. Walter and Miller's Textbook of Radiotherapy by C.K.Bomford, I.H.kunkler

ADVANCED RADIATION ONCOLOGY PHYSICS

Suggested number of teaching hours is 60 including tutorials and demonstrations.

UNIT I: COMPUTERS IN TREATMENT PLANNING 10 Hours

3D Treatment planning system, Digitizer, Image transfer, calibration of CT numbers - DICOM and DICOMRT, Radiotherapy Networking, Treatment planning networking.Hardware and software requirements - beam & source library generation. Networking, DICOM and PACS.Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEATRS 430 and other protocols.

Scope of computers in radiation treatment planning - Review of algorithms used for treatment planning computations - Pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam, and brachytherapy - Factors to be incorporated in computational algorithms. Plan optimization - direct aperture optimization - beamlet optimization - simulated annealing - dose volume histograms - Indices used for plan comparisons

Unit II: ADVANCED RADIOTHERAPY TECHNIQUES 15 hours

Three dimensional conformal Radiotherapy (3D CRT) – beam shaping – conformal blocks – use of multi leaf collimator - imaging requirement - Intensity modulated Radiotherapy (IMRT) – principle – types of IMRT – step and shoot – sliding windo - dynamic IMRT – tomotherapy – helical tomotherapy – volumetric treatment (RapidARc , VMAT)– advantages and dosimetric issues – plan evaluation techniques – DVH – dose painting. Image guided Radiotherapy – techniques – in room CT – OBI and MV CT & MV-kV cone beam CT – Gated Radiotherapy – 4 D CT and 4 D Treatment – Deep Inspiration Breath Hold technique - 4D vero radiotherapy - commissioning of advanced treatment techniques – end to end phantom test. Adaptive Radiotherapy

Stereotactic Radiosurgery /radiotherapy (SRS/SRT) – Stereotactic localization – imaging for Radiosurgery – angiographic localization – BRW frame - Gamma Knife Radiosurgery – linac based Radiosurgery - cone and mMLC based Radiosurgery –- Stereotactic Radiotherapy – Re-locatable GTC / BrainLab frames - immobilization devices for SRS/SRT - dosimetry and planning procedures - Evaluation of SRS/SRT treatment plans – Pre treatmentQA for Radiosurgery – Winston – Lutz test - protocols and procedures for X- and Gamma Knife units - Cyber Knife based Stereotactic Radiosurgery - Physical, planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT)

UNIT III: SPECIAL TECHNIQUES OF RADIOTHERAPY 15 hours

Special techniques in radiation therapy - Total body irradiation (TBI) - large field dosimetry - total Skin electron therapy (TSET) - electron arc treatment and dosimetry – Intraoperative Radiation Therapy (IORT) – Physical and clinical requirements for IORT – IORT with Orhtovoltage x-ray – Electron beams- HDR units- Born Neutron Capture Therapy. Brachytherapy treatment for Prostate cancer.Permanent prostate implant with seeds - Ocular brachytherapy using photon and beta sources. Intravascular brachytherapy - classification - sources - dosimetry procedures - AAPM TG 60 protocol. Electronic brachytherapy

Unit IV: HEAVY PARTICLE THERAPY 10 hours

Relative merits of electron, neutron, x-ray and gamma ray beams - Neutron capture therapy - Heavy ion therapy.-Production of Heavy Ion Particles: Ion source, Accelerators, Cyclotrons and Synchrotrons. Beam Transport: Vacuum tubes, Dipoles, Quadrapoles, Steering coils and beam profile monitors .Beam Delivery: Double scattering, single scattering, uniform scanning/wobbler method and Pencil beam (spot scanning), Spread out Bragg peak, Range modulation, Fixed and super-conducting gantry

Radiobiology of Protons and Carbon ions: RBE and LET, Clinical advantages of heavy ion therapy over photon therapy. Quality assurance checks and Radiation shielding design for heavy ion facility.

Unit V: QUALITY ASSURANCE IN RADIATION THERAPY 10 hours

Accessories and tools used for QA tests in Radiotherapy. Optical and radiation field congruence, isocenter verification – start shot- Winston and Lutz test for SRS – patient specific quality assurance for IMRT and Rapid Arc – methods & equipment– film dosimetry – 2D array portal dosimetry. Quality assurance of Image guidance system – CT – kV - MV cone beam CT -

Books for Reference

1. Jacob Van Dyk The Modern Technology of Radiation Oncology
2. Faiz M.Khan, The Physics of Radiation Therapy, 4th edition
3. H.E. Johns and Cunningham, The Physics of radiology
4. Faiz M.Khan, Roger A. Potish, treatment Planning in radiation Oncology
5. Walter and Miller's Textbook of Radiotherapy by C.K.Bomford, I.H.kunkler
6. S.Webb, The physics of three dimensional radiation therapy
7. 2. S.webb, The Physics of Conformal radiotherapy
8. Thomas Bortfeld, Rupert Schmidt- Ullrich, Wilfried De Neve, David E

9. Wazer. Image Guided IMRT Springer Berlin Heidelberg, 2006

10. 3. S.Webb, Intensity Modulated radiation therapy

RADIATION BIOLOGY

(*Suggested number of teaching hours is 50 including tutorials and demonstrations*)

UNIT I: CELL BIOLOGY **10hours**

Cell Physiology and Biochemistry - Structures of the cell - Types of cells and tissues, their structures and functions - organic constituents of cells - carbohydrates, fats, proteins and nucleic acids - functions of mitochondria, ribosome, Golgi bodies and lysosomes - cell metabolism - DNA as a concepts of Gene and Gene actions - Mitotic and Meiotic cell divisions - semi-conservative DNA Synthesis, genetic variation crossing over, mutation, chromosome segregation- hereditary and its mechanisms.

UNIT II : INTERACTIONS OF RADIATION WITH TISSUE 10 **hours**

Survival curve - Shape of survival curves- mechanism of cell killing-DNA target, Bystander effect- mitotic and apoptotic death: autophagic cell death.

Action of radiation on living cells – Direct action, indirect action, radiolysis of water- Free radical interaction with bio molecules including DNA – Effect of oxygen and temperature: hyperthermia – radiation effects on cell: cell cycle- DNA strand breaks-chromosome aberrations and repair- Classification of radiation damage: Potentially lethal damage and sub lethal damage; recovery - Pathways for repair of radiation damage –dose and dose rate effect and fractionation. Other dose modifying agents: LET,RBE, radio sensitizers and radio protectors. Applications of above agents in radiotherapy.

UNIT III : BIOLOGICAL EFFECTS OF RADIATION 10 **hours**

Somatic effects of radiation – deterministic effects and stochastic effects- effect of dose, dose rate, radiation type and energy - acute radiation syndrome: cerebro-vascular, gastrointestinal and hematopoietic and associated symptoms. Chronic radiation exposure effects- radiation carcinogenesis - genetic effects of radiation- mutation, chromosomal changes, multi factorial - Genetic effects on humans and genetic risk estimate.

UNIT IV:TIME, DOSE AND FRACTIONATION IN RADIOTHERAPY 5 hours

Four R's of radiobiology- dose response relation for elate and early responding tissues, Fractionation size and overall treatment time: hyper fractionation, accelerated treatment, hypo fractionation - Calculation of effective doses in radiotherapy using LQ models.

UNIT V: **CLINICAL ASPECTS OF RADIATION ONCOLOGY** **15 hours**

Radiation Therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy and Radionuclide Therapy, Benign and malignant disease, Methods of spread of malignant disease,

staging and grading systems, Treatment intent – Curative and Palliative, Cancer prevention and public education and Early detection & Screening.

Site specific signs, symptoms, diagnosis and management: Head and Neck ,Breast, Gynaecological, Gastro-Intestinal tract, Genito-Urinary, Lung and Thorax, Lymphomas &Leukemias& Other cancers including AIDS related Cancers.

Patient management on treatment – side effects related to radiation and dose – Acute & Late – monitoring and common management of side effects – information and communication.
Professional aspects and role of medical Physicists: General patient care – Principles of professional practice – Medical terminology – Research & Professional writing – patient privacy – Ethical and cultural issues. Legal aspects – Confidentiality, informed consent, Health and safety.

Books for Refernce

1. Meschan. Normal Radiation Anatomy
2. Hollinshead W.H. text Book of Anatomy
3. Eric J. Hall, Amato J. Giaccia, Radiobiology for the Radiologist
4. Hutton An Introduction to Medical Terminology for Health Care
5. Murat Beyzadeoglu, Gokhan Ozyigit, Cüneyt Ebruli, Basic Radiation Oncology
6. Michael Joiner and Albert Van der Kogel, Basic Clinical Radiobiology

PHYSICS OF MEDICAL IMAGING

(*Suggested number of teaching hours is 75 including tutorials and demonstrations*)

UNIT I: SCREEN & FILM RADIOGRAPHY 7hours

Primary radiological image- contrast agents- Grids, grid ratio, types of grid, oscillating grid, air gap techniques- cassettes- intensifying screen, Characteristics of screens, absorption efficiency and conversion efficiency - structure of x-ray film, types of films, manual processing - film handling and storage, characteristics of x-ray film, film processing, influence of temperature and time, replenisher, dark room, Automatic film processor- Image quality, contrast resolution, noise, geometric factors, optimal quality image, artefact, beam limiting devices, filtration. Quality assurance in film processor, Laser Cameras – wet and dry processing

UNIT II: DIGITAL RADIOGRAPHY 10 hours

Analog and digital representation of data-- Computed Radiography- phosphors in imaging plate, phosphor reader, image quality- Charge coupled device – digital radiography systems, indirect and direct flat panel systems, phosphor materials, - Image quality assessmentModalityworklist, DICOM, Data compression, radiological information system, data encryption, firewalls, storage requirements, disaster recovery and security. Computer Networks: basic principle, local area network, large network and network linking, telecommunication network. PACS and Teleradiology: digital images to network for image and data transfer-storage, PACS-security and reliability; quality control.

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UNIT III : MAMMOGRAPHY AND FLUOROSCOPY 10 hours

Mammography: mammographic X-ray tube design, x-ray generator and AEC. Compression paddle, grid, collimation, filtration and HVL- Magnification-Screen film cassettes and film Processing- Digital Mammography- Radiation dosimetry- quality Assurance.

Fluoroscopy: conventional fluoroscopy, dark room adaptation, image intensifiers, closed circuit TV systems, flat panel detectors. Modern trends in interventional Radiology-Bi-plane imaging, rotational angiography, cardiac imaging, real time imaging characteristics – filtration, continuous and pulsed fluoroscopy, high dose rate fluoroscopy, spot imaging, Digital Subtraction acquisition technique, road mapping, image magnification, last image hold, automatic exposure control, automatic brightness control, brightness gain- image quality- Radiation dose management: dose area product (DAP) meters, peak skin dose, cummulative dose and dosimetric techniques in interventional radiology. Dose management for pediatric and pregnant patients in interventional imaging, Diagnostic Reference levels and guidelines.

UNIT IV: COMPUTED TOMOGRAPHY 8hours

Computed tomography scanning principle- CT number, image display- CT equipment, system design, Gantry geometry, x ray tubes, filters and collimation, Detector array – Generation of CT- Modes of CT acquisition, Axial acquisition, Helical acquisition, Cone beam acquisition, Cardiac CT, CT angiography, CT perfusion- CT image reconstruction, back projection, Filtered back projection, Fourier reconstruction, cone beam reconstruction, Iterative reconstruction, postprocesing tools, volume rendering, SSD, MPR, MIP- Image quality, Spatial resolution, Noise and factors influencing them, Quality assurance - Image artefacts, Radiation dose management: factors affecting patient dose CTDI, CTDIvol, dose length product (DLP), multiple scan average dose (MSAD).

UNIT V: NUCLEAR IMAGING 15 hours

Review of Radioactivity and nuclear transformation-Production of Radioisotopes, cyclotron, Medical cyclotron, cyclotron produced radionuclides, Radiopharmaceuticals- radionuclide generators- Gamma camera – Scintillation detector, Pulse height analyser, Pulse height spectrum- image display, Types of collimators-single photon emission computed tomography SPECT- Positron emission tomography(PET) principle, Positron emitters, coincidence detection-PET/CT scanner, data acquisition, attenuation correction, image display-Radiation dose -recent developments.-Performance-Design factors determining performance- Effects of scatter and attenuation on projection images-Protocols followed for Quality Assurance / Quality control of imaging instruments. In-vitro techniques: RIA / IRMA Techniques and its principles

UNIT VI :ULTRA SOUND IMAGING 5 hours

Basics of ultrasound, propagation of sound, interaction of ultrasound with matter-Ultrasound transducer, piezoelectric material, transducer design, transducer array- Beam properties- near field-far field-side lobes-spatial resolution. Image data acquisition- data acquisition systems, ADC-receiver, Echo display modes, scan converter. Image data acquisition, pulse echo acquisition- ultrasound image display, amplitude mode, Motion mode, brightness mode- Doppler ultrasound, Ultrasound image quality- image artifacts- Bioeffects of ultrasound

UNIT VII: MAGNETIC RESONANCE IMAGING (MRI) 10 hours

Basics physics of MRI, magnetism, nuclear characteristics, hydrogen characteristics, magnetization vector, precession, radiofrequency and resonance, MRI signal, flip angle-Relaxation time, T1 relation time, T2 relaxation time, Comparison of T1 and T2- MR signal localization, gradient field, slice selection, phase encoding gradient, frequency encoding gradient, composite signal, K-space- MR imaging sequences, spin echo sequence, T1 weighted image, T2 weighted image, spin density weighted image, inversion recovery, gradient recalled echo – specialized MR sequences, MR angiography, perfusion imaging, diffusion imaging, functional imaging, MR spectroscopic imaging – MR instrument and bio safety, Image quality

and artifacts

UNIT VIII: IMAGE QUALITY AND QUALITY ASSURANCE 10 hours

Digital verses analog processes, analog to digital conversion; reconstruction techniques: image fusion and registration, gray scale processing, frequency processing, sampling and quantisation, aliasing, Nyquist limit, window and level, Digital image Processing - contrast verses spatial resolution in digital imaging. Display characteristics and viewing conditions for monitors (CRT, LCD and other display systems).

Image Quality parameters: Sources of un-sharpness, reduction of un-sharpness, factors influencing radiographic contrast, resolution (spatial, contrast and temporal), factors influencing resolution, evaluation of resolution (Point spread function (PSF), Line spread function (LSF), Edge spread function (ESF), Modulation transfer function (MTF), full width at half maximum (FWHM), Noise: quantum mottle, electronic noise and other sources of noise; Detective quantum efficiency (DQE); SNR, contrast to noise ratio (CNR).

QA of conventional diagnostic x-ray equipment: purpose of QA, QA Protocols, QA Test methods for performance evaluation of diagnostic equipments - Collimator congruence test; accuracy of kVp; HVL, accuracy of mAs; consistency of output; accuracy of mA; Focal Spot size evaluation, radiation safety survey conventional and interventional radiographic systems, phantom test in digital radiography. QA in CT. Other related quality assurance as per the guidelines of the AERB as part of the regulation. QA in mammography using phantoms. Performance testing and quality assurance in ultrasound and MRI using accredited phantoms,

Books for Reference

1. W.J. Meredith & J.B. Massey Fundamental Physics of Radiology
2. Curry,T.S. Dowdey,J.E. Murry,R.C,(1990), Christensen's introduction to the Physics of diagnostic radiology, 4th edition, Philadelphia,Lea & Febiger
3. Bushberg,S.T; Seibert,J.A; Leidholt,E.M & Boone,J.M.(1994), The essential Physics of Medical imaging, Baltimore, Williams & Wilkins
4. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R. The Physics of Diagnostic imaging
5. Johns,H.E.& Cunningham,J.R, The Physics of radiology, 4th edition
6. Hendee,W.R. & Ritenour,R.(1993) Medical Imaging Physics, 3rd edition
7. Dendy,P.P. & Heaton,B. Physics for diagnostic radiology, 2nd edition
8. E.Seeram, X-ray imaging equipment, An introduction
9. Hashemi,R.H. Bradley, W.G;& Lisanti C.J. MRI the basics
10. RF Farr and PJ Allisy-Roberts Physics for Medical Imaging

11. Sprawls,P; Magnetic resonance imaging principles, methods and techniques
12. Chesney,D.N. & Chesney,M.O. X-ray equipment for student radiographers
13. Chesney,D.N. & Chesney,M.O. Radiographic imaging

RADIOLOGICAL SAFETY AND PROTECTION

(*Suggested number of teaching hours is 65 including tutorials and demonstrations*)

UNIT I:RADIATION PROTECTION STANDARDS 10hours

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 – Radiation 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

UNIT II:PRINCIPLES OF MONITORING AND PROTECTION 5 hours

Evaluation of external radiation hazards - Effects of distance, time and shielding – 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

UNIT III: SAFETY IN THE MEDICAL USES OF RADIATION 20hours

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**,** Use of ionising radiation in medical research

UNIT IV: RADIOACTIVE WASTE DISPOSAL 5 hours

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 and research establishments.

UNIT V:TRANSPORT OF RADIOISOTOPES **5 hours**

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 VI:LEGISLATION **5 hours**

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

UNIT VII:RADIATION EMERGENCIES AND THEIR MEDICAL MANAGEMENT
5 hours

Radiation accidents and emergencies in the use of radiation sources and equipment in ~~and~~ medicine 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 Reference

1. Herman Cember. Introduction to Health Physics
2. Atomic Energy Act 1962
3. AERB Radiation Protection Rules 2004
4. ICRP 1990 Recommendation
5. ICRP 2007 Recommendation
6. IAEA Basic safety standards 115, 1997
7. Shapiro T. radiation Protection
8. Mckenzie. Radiation Protection in radiotherapy
9. Mawson C.A. management of Radioactive wastes