MSc Course in Radiological Physics (New syllabus)
Department of Physics, Gauhati University &
Dr. BBCI, Guwahati, (2013-14)

MSc (Radiological Physics) course is of duration two years credit based and one year Internship. The first two years have 4 semesters, conducted jointly by the Department of Physics, Gauhati university and Dr. B Borooah Cancer Institute, Guwahati. After successful completion of two years, a student has to undergo one year compulsory Internship programme in a selected Hospital. The general structure is given below :

I Sem :

Papers	Hours per week				Marks	Credit
	Contact		H	Tot		
	(L+T)	Pract				
RP1.1 = Nuclear Physics	3+1= 4		2	6	100	6
RP1.2 = Solid state Physics, Electronics & Instrumentation	3+1= 4		2	6	100	6
RP1.3 = Anatomy & Physiology as Applied to Radiological Physics	3+1= 4		2	6	100	6
RP1.4 = Radiobiology	3+1= 4		2	6	100	6
RP1.5P = Physics Practical(Nuclear + Electronics Lab)		6+3			100	4+2
Total	25 (Contact hours)				500	30

II Sem :

Papers	Hours per week				Marks	Credit
	Contact		H	Tot		
	(L+T)	Pract				
RP2.1 = Radiation Physics	3+1= 4		2	6	100	6
RP2.2 = Mathematical Physics & Statistics	3+1= 4		2	6	100	6
RP2.3 = X & Gamma Ray Detection & Dosimetry	3+1= 4		2	6	100	6
RP2.4 = X-ray Imaging	3+1= 4		2	6	100	6
RP2.5PP = Physics Practical (Nuclear Lab)		6			50	4
RP2.5PB = Radiological Lab (at BBCI)		6			50	4

Total	28 (Contact hours)	500	32

III Sem :

Papers	Hours per week				Marks	Credit
	Contact		H	Tot		
	(L+T)	Pract				
RP3.1 = Numerical & Computational Physics	3+1= 4		2	6	100	6
RP3.2 = Standardization of radiation sources.	3+1= 4		2	6	100	6
RP3.3 = Radiation Therapy-1	3+1= 4		2	6	100	6
RP3.4 = Radiation Therapy-2	3+1= 4		2	6	100	6
RP3.5PC = Computational Lab (at Physics Dept)		6			50	4
RP3.5PB = Medical Physics Lab (at BBCI)		6			50	4
Total	28 (Contact hours)				500	32

IV Sem :

Papers	Hours per week				Marks	Credit
	Contact		H	Tot		
	(L+T)	Pract				
RP4.1 = Clinical Imaging	3+1= 4		2	6	100	6
RP4.2 = Nuclear Medicine	3+1= 4		2	6	100	6
RP4.3 = Radiation Safety:	3+1= 4		2	6	100	6
RP4.4 = Medical Management.	3+1= 4		2	6	100	6
RP4.5PB = Adv. Radiological Lab (at BBCI)		9			100	6
Total	25 (Contact hours)				500	30

Notations used : L = Lecture T = Tutorial H = Home assignment

Semesters	I	II	III	IV	V & VI	Grand Total
Credits	30	32	32	30	-	124
Marks	500	500	500	500	-	2000
Contact Hours	25	28	28	25	-	106

CLASS ROUTINE :

I Sem :

Days	Practical (10.00 – 13.00) hr		1st (13.45–14.45) hr	2nd (14.45–15.45) hr	3rd (15.45–16.45) hr
Mon	RP1.5P(Phys)	B	RP1.1	RP1.2	-
Tue	RP1.5P(Phys)	R	RP1.2	RP1.1(T)	RP1.2
Wed	RP1.5P(Phys)	E	RP1.1	RP1.2(T)	RP1.1
Thurs		A	RP1.3	RP1.4(T)	RP1.3
Fri		K	RP1.4	RP1.3(T)	RP1.4
Sat			RP1.4	RP1.3	-

Note : Monday through Wednesday, classes held at Physics Dept, GU.
Thursday through Saturday, classes held at Dr. BBCI, Guwahati.

II Sem :

Days	Practical (10.00 – 13.00) hr		1st (13.45–14.45) hr	2nd (14.45–15.45) hr	3rd (15.45–16.45) hr
Mon	RP2.5PP(Phys)	B	RP2.1	RP2.2	-
Tue	RP2.5PP(Phys)	R	RP2.2	RP2.1(T)	RP2.2
Wed	RP2.5PP(Phys)	E	RP2.1	RP2.2(T)	RP2.1
Thurs	RP2.5PB(BBCI)	A	RP2.3	RP2.4(T)	RP2.3
Fri	RP2.5PB(BBCI)	K	RP2.4	RP2.3(T)	RP2.4
Sat	RP2.5PB(BBCI)		RP2.4	RP2.3	-

Note : Monday through Wednesday, classes held at Physics Dept, GU.

Thursday through Saturday, classes held at Dr. BBCI, Guwahati.

III Sem :

Days	Practical (10.00 – 13.00) hr		1st (13.45–14.45) hr	2nd (14.45–15.45) hr	3rd (15.45–16.45) hr
Mon	RP3.5PB (BBCI)	B	RP3.3	RP3.4(T)	RP3.3
Tue	RP3.5PB(BBCI)	R	RP3.4	RP3.3(T)	RP3.4
Wed	RP3.5PB(BBCI)	E	RP3.4	RP3.3	
Thurs	RP3.5PC(Phys)	A	RP3.2	RP3.1(T)	RP3.2
Fri	RP3.5PC(Phys)	K	RP3.1	RP3.2(T)	RP3.1
Sat			RP3.1	RP3.2	

Note : Monday through Wednesday, classes held at Dr. BBCI, Guwahati.

Thursday through Saturday, classes held at Guwahati.Physics Dept, GU.

IV Sem :

Days	Practical (10.00 – 13.00) hr		1st (13.45–14.45) hr	2nd (14.45–15.45) hr	3rd (15.45–16.45) hr
Mon	RP4.5PB(BBCI)	B	RP4.3	RP4.4(T)	RP4.3
Tue	RP4.5PB(BBCI)	R	RP4.4	RP4.3(T)	RP4.4
Wed	RP4.5PB(BBCI)	E	RP4.4	RP4.3	
Thurs		A	RP4.2	RP4.1(T)	RP4.2
Fri		K	RP4.1	RP4.2(T)	RP4.1
Sat			RP4.1	RP4.2	

Note : Monday through Saturday, all the classes held at Dr. BBCI, Guwahati.

Syllabus for MSc Course in Radiological Physics
Semester-I

RP1.1 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP1.1: Nuclear Physics

A. Basic Nuclear Physics **22**

1.**Nuclear force :**Nucleon-nucleon forces – qualitative discussions on nuclear force. Brief outline of Yukawas meson theory, Nuclear stability, neutron proton ratio in stable nuclei, stability curve, odd-even rules of nuclear stability.(2 lectures)

2.**Model of Nuclear Structure :** Nuclear stability, mass parabolas – prediction of stability against beta decay, stability limits against spontaneous fission. Shell Model : Evidence of shell structure, magic numbers (3 lectures)

3.**Nuclear Reactions :** Classification, conservation principles, laboratory and cms frame of reference - energy and angle relationship for nonrelativistic cases, kinematics and Q-values, exo-ergic and endo-ergic reactions, threshold energy. (5lectures)

4.**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 (5lectures)

5. Radiation quantities and Units : Quantities to describe a radiation beam- particle flux and fluence- Photon flux and fluence- cross section- linear and mass absorption coefficient-stopping power and LET. Activity – Curie – Becquerel. Exposure and its measurements – Roentgen, Radiation absorbed Dose – Gray – Kerma- kerma rate constant- Electronic equilibrium-relationship between kerma, exposure and absorbed dose–Relative biological effectiveness- radiation weighting factors. Equivalent dose-effective dose- tissue weighting factors-ambient and directional equivalent dose and their relevance in dosimetry, tissue equivalence, dose commitment and collective dose. (7 lectures)

B. **Particle Accelerators** **8**

Need of Particle accelerators for industrial, medical and research applications – Essential components of an accelerator – Van De Graff Generator, its limitations – Pelletron, LINAC, Cyclotron – Working principle & construction – Betatron – principle of action, betatron condition.

Medical LINAC – components & configuration. Details of main beam family components of a modern Medical LINAC. Principle of particle acceleration by guided wave, Klystron and magnetron – Traveling and Standing wave acceleration – microtron – Electron synchrotron, proton synchrotron. Details of accelerator facilities in India

Books recommended :

1. K. S. Krane, Introductory Nuclear Physics, John-Wiley, New York (1987)
2. S. B. Patel, Nuclear Physics : An Introduction, Wiley-Eastern Limited, New Delhi (1991)
3. B. L. Cohen, Concepts of Nuclear Physics, Tata Mc-Graw Hill, New Delhi (1988)
4. H. S. Hans, Nuclear Physics : Experimental and Theoretical, New Age International

Publishers, New Delhi (2001)
5. The Physics of Radiation Therapy Faiz .M. Khan, Williams & Willkinds (2003).

RP1.2 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP1.2 : Solid State Physics, Electronics & Instrumentation.

A. Solid state Physics : 8

1. Crystal structure and X-ray diffraction: Crystalline and amorphous solids, Bravais lattices, scattering of X-rays by an electron, an atom and a unit cell, atomic scattering factor and structure factor, diffraction of X-rays. [Lecture: 2]

2. **Semiconductors:** Intrinsic and extrinsic semiconductors, number density, Fermi levels, Hall Effect. [L:2]

3. **Energy bands in solids:** Bloch function, Kronig Penny model, Brillouin zones, effective mass. [L:2]

4. Magnetic Properties and Superconductivity: Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism (qualitative discussions only), Superconductivity, Meissner effect, type I and type II superconductors. [Lecture:2]

Books Recommended:

1.Introduction to Solid State Physics, C. Kittel, Wiley and Sons.
2.Solid State Physics, A. J. Dekker, Macmillan Education Limited.
3.Introduction to Solid State Physics, H. P. Mayers, Taylor & Francis.
4.Elements of X-ray Diffraction, B.D.Cullity and S. R. Stock, Prentice Hall.
5.Introduction to Magnetism and Magnetic Materials, David Jiles, Chapman & Hall.

B. Electronics & Instrumentation : 22

1. Electronic Devices and applications: JFET, MOS and CMOS devices, Tunnel Diode, Gunn Diode, Integrated Circuit (2 Lectures)

2. Basic amplifier principles: Pre amplifier circuits noise, linear pulse amplifier, pulse shaping, D.C. amplifier, Power amplifier, Distortion in amplifiers, Feedback amplifiers, Pulse Amplifier. Types of oscillators. Power supplies: Regulated HT and EHT supplies, RF power supplies. Single and multi channel analyzers, Voltage doubler circuits. (5 Lectures)

3. Amplifiers and Oscillators: Power amplifier design – Class B pushpull amplifier, Emitter follower, Darlington pair. Differential Amplifier, operational amplifier characteristics, Instrumentation amplifier, Differentiating and integrating circuits. Principles of filters. RC phase shift oscillator. A/D and D/A converter, Frequency to voltage converter, Digital voltmeter (Ramp type). (7 Lectures)

4. Trigger circuits, Digital electronics, Logic systems::– Multivibrator, Discriminator, Scale of two Scale of ten, Coincidence and anticoincidence circuits, Amplitude analyzer and counting rate meters, Principles of Servomechanism and control. Logic gates: Flip flops, Synchronous and asynchronous counters, Decoders and Encoders. Basics of Microprocessor and Microcontroller.(4 Lectures)

5. Transducers and Instrumentation: LVDT, A.C and D.C Tachometers, Capacitance transducers, Thermistor based thermometers, Strain gauge, Ultrasonic transducers and their electrical equivalent circuits. CRO, Phosphors, LED, LCD, and Plasma display, Seven segment, dot matrix system, Guest Host effect. (4 Lectures)

Books Recommended:

1. A.K.Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanapat Rai

and Sons, New Delhi – 1982.
2. Lal Kishore K., Electronic Devices and Circuit Analysis, B.S.Publications
3. Malvino and Leech, Digital Principles and Applications, Tata McGrow Hills (1978)
4. H.S.Kalsi, electronics Indsturmentation, Indian soceity for Technical Education
5. J.Millman and C.Halkias. Integrated Circuits, McGraw Hill, 1979.
1. J.D.Ryder, Electronics Fundamentals and Applications, Prentice Hall of India, New Delhi.
2. W.Cooper, Electronic Instrumentation and Measurement Techn., Prentice Hall of India. 1970
3. R.P.Jain, Modern Digital Electronics, Tata McGraw Hills

RP1.3 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP1.3 : Anatomy and Physiology as Applied to Radiological Physics

A. Cell Biology 10

1. Cell physiology and biochemistry- Structure of the cell- Types of cells and tissue, their structures and functions- Organic constituents of cells- Carbohydrates, fats, proteins and nucleic acids- Enzymes and their functions- Functions of mitochondria, ribosomes, golgi bodies and lysosomes- Cell metabolism- DNA as concepts of gene and gene action- Mitotic and meiotic cell division- Semi conservative DNA synthesis, Genetic variation crossing over, mutation, chromosome segregation- Heredity and its mechanisms.

B. Anatomy, Physiology and Pathology 20

Anatomy and Physiology as applied to radiodiagnosis and radiotherapy- Structure and function of organs and systems & their common diseases: Skin, Lymphatic system, Bone and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and Ear.

Anatomy of human body, nomenclature & Surface 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 & deviation for abnormalities.

Tumour pathology and carcinogenesis, common pathological features of cancers and interpretation of clinic pathological data.

Books Recommended:

1.Cell Physiology — Arthur C. Giese
2.Mustafi's Systematic Anatomy — BN Basu and M. Pan
3.Gray's Anatomy — Roger Warwick and Peter L. William
4.Gray's Anatomy — Sir Benjamin Collins
5.Human Anatomy Vol.1(Upper limb & Thorax) — B.D. Chaurasia
6.Human Anatomy vol. 2 (Lower Limb, Abdomen, & Pelvis) — B.D.Chaurasia

7.Human Anatomy Vol.3(Head, Neck, Brain) B.D.Chaurasia
8.Ross and Wilson Anatomy and Physiology in Health and Illness Allison Grant and Anne Waugh
9.Textbook of Medical Physiology Arthur C Guyton & John E. Hall
10.Essentials of Medical Physiology Anil Mahapatra
11.Textbook of Medical Physiology Indu Khurana
12.Robbins and Cotran Pathologic Basis of Disease Vinay Kumar & Others
13.Robbins Pathologic Basis of Disease Stanley L. Robbins & Others

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RP1.4 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP1.4 : Radiobiology

A. Biological effects of Radiations 25

1.Interaction of Radiation with Cells : Action of radiation on living cells – Radiolytic products of water and their interaction with biomolecule – Nucleic acids, proteins, enzymes, fats – Influence of oxygen, temperature –Cellular effects of radiation – Mitotic delay, chromosome aberrations, mutations and recombinations – Giant cell formation, cell death Recovery from radiation damage – Potentially lethal damage and sublethal damage recovery - Pathways for repair of radiation damage. Law of Bergonie and Tribondeau.

Repair misrepair hypothesis – Dual action hypothesis – Modification of radiation damage – LET,RBE, dose rate, dose fractionation – Oxygen and other chemical sensitizers – Anoxic, hypoxic, base analogs, folic acid, and energy metabolism inhibitors – Hyperthermic sensitization

2. Somatic effects of radiation – Physical factors influencing somatic effects – Dependence on dose, dose rate, type and energy of radiation, temperature, anoxia,- Acute radiation sickness – LD 50 dose – Effect of radiation on skin and blood forming organs, digestive tract – Sterility and cataract formation – effect of chronic exposure to radiation Induction of leukaemia – Radiation carcinogenesis – animal and human data – Shortening of life span – In-utero exposure – Genetic effects of radiation – Factors affecting frequency of radiation induced mutations – Dose-effect Relationship – first generation effects – Effects due to mutation of recessive characteristics – Genetic burden Prevalance of hereditary diseases and defects – Spontaneous mutationrate – Concept of doubling dose and genetic risk estimate.

B. Biological Basis of Radiotherapy 05

- Physical and biological factors affecting cell survival, tumour regrowth and normal tissue response – Non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle – High LET radiation therapy. Radio-protective agents.

Books Recommended:

1. E.J.Hall, Radiobiology for Radiologists Eric J Hall & Amato j. Giaccia

2. S.P.Yarmonenko, Radiology of Humans and animals, MIR,Publishers, Moscow, 1990.
3.The Chemical Basis of Radiation Biology C. Von Sonntag
4.Biological Effects of Radiation J.E. Coggle
5. Radiobiological concepts in Radiotherapy D. Bhattacharjee & B.B.Singh

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RP1.5P Total marks : 80+20 (Internal)
Total Credits : 6 (9 Practical hours)

Paper RP1.5P : Physics Practical

1. Nuclear Physics Lab – Minimum expts. to be carried out : 5.

1.GM counter – determination of plateau characteristics and study counting statistics.
2.GM counter – Range of beta particles by Feather Analysis and determination of end point energy.
3.GM counter - Backscattering of beta particles and determination of unknown thickness.
4.GM counter – To determine the dead time using single source.
5.GM counter - To determine the efficiency using a γ-ray source.
6.GM counter - Verify the Inverse Square Law for Gamma rays
7.GM counter - Estimating the shelf-ratio and activity of a beta source.

2. Electronics Lab – Minimum expts. to be carried out : 5

1. Measurement of L, C and R by Universal bridge
2. Series resonance and Q of a coil
3. Two stage RC coupled amplifier – frequency response
4. Construction of a voltage multiplier
5. Characteristics of a regulated power pack
6. DC voltage regulator using transistors
7. Feedback amplifier
8. Construction of an oscillator
9. OPAMP circuits – Inverting and non inverting amplifiers
10. Integrator and differentiator circuit using OPAMP
11. Pulse shaping circuits

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Syllabus for MSc Course in Radiological Physics
Semester-II

RP2.1 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP2.1

Radiation Physics :

1. Interaction of Radiation with Matter **10**

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 process. Interaction of charged particles with matter-Classical theory of inelastic collision 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- Cerencov radiation- Electron absorption process- Scattering excitation and ionization- Radiative collision- Bremmstrahlung- Range energy relation- Continuous slowing down approximation (CSDA)- Straight head approximation and detour factors- transmission and depth dependence methods for determination of particle penetration- empi0rical 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.

2. Principles of Radiation Detection **15**

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 film- Thermoluminescent dosimeter (TLD)- Optically stimulated Luminescence dosimeter (OSLD)- Radiophotoluminescent dosimeter- Neutron detectors- Nuclear track emulsions for fast neutrons- Solid state Nuclear track (SSNTD) detectors- Calorimeters- New Development.

3. Non-ionizing Radiation Physics 5

Electromagnetic spectrum- Different sources of Non Ionising radiation-Radiofrequency, Microwaves, Infrared, Visible and Ultra violet radiation production, physical properties and their interaction with tissues- Electrical Impedance and Biological Impedance - Principle and theory of thermography – applications-Laser: theory and mechanism- interaction of laser radiation with tissues – photothermal -photochemical – photoablation – electro mechanical effect- Lasers in dermatology, oncology and cell biology.

Books recommended :

1 **Books**. K. S. Krane, Introductory Nuclear Physics, John-Wiley, New York (1987)

2. S. B. Patel, Nuclear Physics : An Introduction, Wiley-Eastern Limited, New Delhi (1991)
3. B. L. Cohen, Concepts of Nuclear Physics, Tata Mc-Graw Hill, New Delhi (1988)
4. H. S. Hans, Nuclear Physics : Experimental and Theoretical, New Age International Publishers, New Delhi (2001)
5. The Physics of Radiation Therapy Faiz .M. Khan, Williams & Willkinds (2003).

RP2.2 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP2.2 : Mathematical Physics & Statistics

A. Mathematical Physics

1.A Differential equations and special functions (No. Of lectures 15)

(a) Introduction:

Ordinary and partial differential equations, linear and non linear equations with physical examples, their areas of applications.

(b) Series solutions and polynomials:

Singularities of adifferential equation, series solution – Frobenius method. Legendre, Hermite, Laguerre and Bessel differential equations and associated polynomials. Orthogonality properties of Legendre and Hermite polynomials.

(c) Partial Differential equations:

Physical examples of partial differential equation, method of variable separation, solutions for one dimensional vibration equation, Laplace equation and Poisson's equation.

(d) Special functions and Fourier analysis:

Gamma and beta function, Dirac delta function and Green's function; Fourier series and applications, Fourier transform.

Books recommended :

B. Probability, Statistics and Errors & Counting and Medical Statics 15

Probability – addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data (2 lectures)

Basic ideas of statistical distributions, frequency distributions, averages or measures of central tendency, arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis. (2 lectures)

Application to radiation detection – uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit (2 lectures)

Binomial distribution, Poisson distribution, Gaussian distribution and their properties. Sampling and Sampling distributions – confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis. (4 lectures)

Statistics of nuclear counting – Application of Poisson's statistics – Goodness-of-fit tests- Lexie's divergence co-efficients 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.(5 lectures)

Books recommended :

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RP2.3 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP2.3 : X & Gamma-ray detection & Dosimetry

A. X-Ray Generators 10

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 tube – X-ray tube for crystallography – Rating of tubes – Safety devices in X – ray tubes- Rayproof 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 – Filaments 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 – Measurements of kV and mA – timers – control panels – Complete X-ray circuit – Image intensifiers and closed circuit TV systems – Modern trends.

B. Radiation Detection Techniques and Radiation measuring and Monitoring Dosimeters 10

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 system- Brachytherapy dosimeters- Thermo luminescent 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, gamma radiation- Head 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 particulars and gases. Details of commercially available instruments and system.

C. Dosimetry and Standardisation of X and Gamma ray beam 10

Standards- Primary and Secondary Standars, 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 theory, Mathematical Expression describing Bragg-gray principle and its derivation. Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium(TCPE), Concept of Dgas, Cavity ion chambers. Derivation of an expression for sensitivity of a cavity ion chamber . General definition of calibration factor –Nx, Nk, Nd, air ,Nd,w. IAEA TRS277. Various steps to arrive at the ezpression for Dw starting from Nx. TRS398: N D.W.Q: N D.W: KQ,Q0:KQ, Derivation of an expression for KQ,Q0.

Calorimetric standars-Intercomparison of standard Measurement of Dw for External beams from 60Co 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; Thermometer and pressure gauges. 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, Ksat, two voltage method for continuous and pulsed beams, polarity correction . Measurement of Dw for high –energy photon beams from the linear accelerators. Beam quality, Beam quality index, Beam quality correction coefficient, cross calibration , Measurement of Dw for energy Electron beams from the linear accelerators: Beam quality, Beam quality index, Beam quality correction coefficient, cross calibration using intermediate beam quality. Quality Audit Programs in Reference and Non-Reference conditions.

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

Books Recommended:

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RP2.4 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP2.4 : X-ray Imaging.

A. Principle of X-Ray diagnosis and conventional Imaging 20

Physical principle of diagnostic radiology: Interactions of X-rays with human body, differential transmission of X-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique viz. superimposition of overlying structures and scatter, application of contrast media and projections at different angles to overcome superimposition of overlying structures

Radiography techniques: Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection and slices selected for imaging, objective of radio-diagnosis, patient dose vs image quality

Filters: inherent and added filters purpose of added filters, beryllium filter, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolinium, molybdenum).

Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, contrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders & collimators), grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique.

Intensifying screens: function of intensifying screens, screen function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare earth screens.

Radiographic Film: Components of radiographic film, physical principle of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.) QA of film developer.

Image Quality: Image quality parameters, sources of un-sharpness, reduction of un-sharpness, factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution (point spread function (PSF), line spread function (LSF), edge spread function (ESF), modulation transfer function (MTF)), focal spot size evaluation.

QA of conventional diagnostic X-ray equipment: Purpose of QA, QA protocols, QA test methods for performance evaluation of X-ray diagnostic equipment.

4.B Digital X-Ray Imaging and Computed Tomography 10

Xero radiography, mammography, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (principle only), orthopan tomography (OPG), Computed Tomography (CT) QA of CT equipment

References:

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RP2.5PP Total marks : 40+10 (Internal)
Total Credits : 4 (6 Practical hours)

Paper 2.5PP : Physics Practical

Nuclear Physics Lab –

1. GM counter - To determine the half life of Radioactive Isotop I^{116}.
2. Alpha spectrometer with MCA - To create the rough vaccum in a given small stainless steel chamber and find out the resolution of an SSB detector using ^{241}Am α-source.
3. To study the complete spectrum of different gamma sources and to locate the corresponding photo peak, compton edge etc., and draw calibration curve using Single channel Gamma spectrometer with NaI(Tl) scintillation detector.
4. To find the resolution R for different energies and hence to draw logR vs. logE curve. using Single channel Gamma spectrometer with NaI(Tl) scintillation detector.
5. To determine the average diameter of α-particle tracks in SSNTD.

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RP2.5PB Total marks : 40+10 (Internal)
Total Credits : 4 (6 Practical hours)

Paper 2.5PB : Radiological Practical

Syllabus for MSc Course in Radiological Physics
Semester-III

RP3.1 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP3.1 : Numerical & Computational Physics

A. Numerical Methods 20

1. Introduction

Representation of integers and real numbers in computers, floating point arithmetic, sources of errors i.e. roundoff and truncation errors1. Solution of Nonlinear Equations (1 lecture)

2. Solution of Nonlinear Equations Isolations of roots of simple equations, general methods for solving transcendental equations i.e. solution by bisection, Newton-Raphson method (with graphical analogy) and its advantage and disadvantage (2 lectures)

3. Solution of Linear System Ax = b

Gauss elimination and Gauss-Jordan elimination (2 lectures)

4. Interpolation and curve fitting

Polynomial interpolation by Lagrange's method Construction of Newton-Gregory forward difference and backward difference tables. Estimation of errors in these methods, Least square curve fitting. (3 lectures)

5. Numerical integration

Numerical integration as quadrature (area under the curve), integration through Lagrange's polynomial interpolation (i.e. Newton-Cotes formulae : trapezoidal and Simpson's rule), simple applications with composite trapezoidal and Simpson's rule, Gaussian quadrature. (4 lectures)

6. Solution of differential equations

Method to solve first order linear differential equations (i.e. initial value problem) by Euler's method and its limitations with a discussion on its accuracy, introduction to second order accurate method such as second order Runge-Kutta method and its comparison with Euler's method. (3 lectures)

7. Monte Carlo Method

Monte Carlo Random variables, 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 sample 1-D integral including worked examples. (5 lectures)

B. Computational tools and Techniques 10

Introduction to the FORTRAN / C programming languages with an emphasis to FORTRAN 90/95 and structured programming, constants and variables, variable declaration, expressions, I/O statements, assignment statements, control statements, Arrays / subscripted variables, use of library functions, subroutines and functions. Handling characters and strings, Functions and voids, Structures, Pointers [in C]. File operations. (5 lectures)

Computational packages: Overview of programming in C++, MALTAB/Mathematica and STATISTICA in data analysis and graphics. (5 lectures)

Books :

1.V. Rajaraman, Computer Programming in FORTRAN 90 and 95 (Prentice-Hall of India, New Delhi, 1997).
2.S. J. Chapman, Introduction to FORTRAN 90/95 (McGraw-Hill Book Co., Singapore, 1998).
3.M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation (New Age International, New Delhi, 1993).
4.J. H. Mathews, Numerical Methods for Mathematics, Science and Engineering (Prentice-Hall of India, New Delhi, 1998).

RP3.2 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP3.2 : Standardization of radiation sources

A. Neutron Standards & Dosimetry 10

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.

2.B. Standardizing of Radionuclides 8

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 chambers methods –Extrapolation chamber- Routine sample measurements – Liquid counter – Windowless counting of liquid samples- scintillation counting methods for alpha , beta and gamma emitters- Reentrant ionization chamber methods –Methods using (n, gamma) and (n,p) reactions- determination of yield of neutron sources –Space integration methods – Solid state detectors

2.C. Radiation Chemistry and Chemical Dosimetry 12

Definitions of free radicals and G- value-Kinetics of radiation chemical transformations- LET and dose- rate effects- Radiation Chemistry of water and aqueous solutions, proxy 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-Description of irradiators from Dosimetric viewpoint- Dosimetry principles – Definitions of optical density, molar absorption coefficient , 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 dosimeter- Applications of chemical dosimeter in Radiotherapy and industrial irradiators

Books recommended :

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RP3.3 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP3.3 : Radiation Therapy-1

A. Beam Therapy 20

Description of low KV therapy x- ray units- spectral distribution of kv x-rays and effect of filtration- thoraeus filter – output calibration procedure.

Construction and working of telecobalt units – source design – beam collimation and penumbra- trimmers and breast cones. Design and working of medical electron linear accelerator – beam collimation-asymmetric collimator – multileaf collimator – dose monitoring – electron contamination. Output calibration of 60Co gamma rays, high energy x-rays and electron beams using IAEA TRS398, AAPM TG 51 and other Dosimetry protocols. Relative merits and demerits of kv x-rays, gamma rays ,MV x- rays and electron beams. Radiotherapy simulator and its applications. CT and virtual simulations.

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. Relation between TAR and PDD and its applications- Relation between TMR and PDD and its applications. SAR, SMR, Off axis ratio and field factor. Build-up region and surface dose . Tissue equivalent phantoms, Radiation field analyzer (RFA). Description and measurement of isodose curves/charts. Dosimetry data resources.

Beam modifying and shaping devices- 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 – single, parallel opposed and multiple fields – corrections for tissue in homogeneity, contour shapes and beam obliquity – integral dose. Arc/ rotation therapy and Clarkson technique for irregular fields – mantle and inverted Y fields. Conventional and conformal radiotherapy. Treatment time and monitor unit calculations.

Clinical electron beams- energy specification – electron energy selection for patient treatment. Depth dose characteristics (Ds, Dx, R100, R90, R50, Rp etc.) – beam flatness and symmetry - penumbra – isodose plots – monitor unit calculations – output factor formalisms- effect of air gap on beam Dosimetry – effective SSD.

Particulate beam therapy – Relative merits of electron, neutron, x- ray and gamma ray beams – neutron capture therapy- Heavy ion therapy.

Quality Assurance in radiation therapy – precision and accuracy in clinical Dosimetry- quality assurance protocols for telecobalt, medical linear accelerator and radiotherapy simulators- IEC requirements –

acceptance, commissioning and quality control of telecobalt, medical linear accelerator and radiotherapy simulators. Portal and in-vivo Dosimetry. Electronic portal imaging devices.

3.B Brachytherapy 10

Definition and classification of Brachytherapy techniques – surface mould , intracavitary, interstitial and intraluminal techniques. Requirement for Brachytherapy sources – description of radium and radium substitutes – 137Cs, 60Co, 192Ir, 125I and other commonly used Brachytherapy sources. Dose rate considerations and classification of Brachytherapy techniques- low dose rate (LDR), high dose rate(HDR) and pulsed dose rate(PDR). Paterson parker and Manchester dosage systems. ICRU 38 and 58 protocols. Specification and calibration of Brachytherapy sources – RAKR and AKS –IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line source Dosimetry formalisms – Sievert integral – AAPM TG-43/43U1 and other dosimetry formalisms.

Afterloading techniques – advantages and disadvantages of manual and remote afterloading techniques. AAPM and IEC requirements for remote afterloading Brachytherapy equipment. Acceptance, commissioning and quality assurance of remote after loading Brachytherapy equipment. ISO requirements and QA of Brachytherapy sources. Integrated Brachytherapy unit.

Brachytherapy treatment planning –CT/MR based Brachytherapy planning – forward and inverse planning – DICOM mage import / export from OT – Record & verification. Brachytherapy treatment for prostate cancer. Ocular Brachytherapy using photon and beta sources. Intravascular Brachytherapy – classification – sources- Dosimetry procedures- AAPM TG 60 protocol. Electronic Brachytherapy.(Axxent Mammosite, etc.)

Books Recommended:

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RP3.4 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP3.4 : Radiation Therapy-2

A Time Dose Fractionation 10

Time dose fractionation – basics for dose fractionation in beam therapy – concepts for nominal – standard dose(NSD), Roentgen equivalent therapy(RET) – time dose fractionation (TDF) factors and cumulative radiation effects(CRE) – gap correction, linear Quadratic models.

4.B. special and advanced Techniques of radiotherapy 20

Special techniques in radiation therapy- Total body irradiation (TBI) - large field Dosimetry – total skin electron therapy (TSET) – electron arc treatment and Dosimetry – intraoperative radiotherapy. Stereotactic radio surgery /radiotherapy (SRS/SRT)- cone and mMLC based X-Knife- gmma knife units- immobilization devices for SRS/SRT – Dosimetry and planning procedures- evaluation of SRS/SRT treatment plans-QA protocols and procedures for X- and Gamma Knife units- patients specific QA. Physical planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy.

Intensity modulated radiation therapy (IMRT) – principles- MLC based IMRT – Step and shoot and Sliding window techniques – compensator based IMRT – planning process – inverse treatment planning – immobilization for IMRT – dose verification phantoms ,dosimeters, protocols and procedures – machine and patient specific QA. Intensity Modulated Arc therapy (IMAT). Image guided Radiotherapy (IGRT) - concept , imaging modality, kV cone beam CT(KVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and Procedures – special phantom,4DCT. Tomotherapy – principle- commissioning – imaging – planning and Dosimetry – delivery – plan adaptation- QA protocol and procedures.

References:

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RP3.5PC Total marks : 40+10 (Internal)
Total Credits : 4 (6 Practical hours)

Paper 3.5PC : Computational Physics Practical

Computer Lab –

1. Sample Fortran Programmes :
2. Solution of quadratic equation
3. Least squares fitting
4. Numerical interpolation
5. Numerical Integration(Simpson's method)
6. Numerical solution of first order differential equation by Runge_Kutta method
7. Monte Carlo Simulation programs using random numbers.

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RP3.5PB Total marks : 40+10 (Internal)
Total Credits : 4 (6 Practical hours)

Paper 3.5PB : Radiological Practical

Medical Physics Lab

Syllabus for MSc Course in Radiological Physics
Semester-IV

RP4.1 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP4.1 : Clinical Imaging

A. Clinical Aspects of Imaging and Radiotherapy **15**

B. Magnetic Resonance and Ultrasound Imaging: **15**

Magnetic Resonance Image – Proton density, Relaxation time T1 and T2 images - image characteristics- MRI system components – magnets, magnetic fields, gradients, magnetic field shielding, radio frequency systems, computer functions – imaging process,- image artifacts – MRI safety

Interaction of sound waves with body tissues, production of ultrasound – transducers – acoustic coupling – image formation – modes of image display – color Doppler.

Books :

RP4.2 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP4.2 : Nuclear Medicine

A. Nuclear Medicine and Internal Dosimetry **30**

1. Physics of Nuclear Medicine **20**

Introduction to Nuclear Medicine, Unsealed Sources, Production of Radionuclide used in Nuclear Medicine: Reactor based Radionuclides, Accelerator based Radionuclides, Photonuclear Activation, Equations for Radionuclide Production, Radionuclide |Generators and their operation principles. Various usages of Radiopharmaceuticals .
In-vivo Non imaging procedures: Thyroid Uptake Measurements, Renogram, Life Span of RBC, Blood Volume studies, etc. General concept of Radionuclide Imaging and Historical Developments.
Radionuclide Imaging: Other techniques and Instruments: The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera/ Scintillation Camera: System components. Detector System and Electronics, Different types of Collimators, Design and performance Characteristics of

the Converging, Diverging and Pin hole collimator, Image Display and Recording Systems, Digital Image Processing Systems, Scanning Camera , Limitation of the Detector System and Electronics.

Different Imaging Techniques: Basic Principles, Two dimensional imaging techniques, Three dimensional imaging techniques – Basic Principles and problem, Focal Plane Tomography, Emission Computed Tomography, Single photon emission computed tomography, Positron Emission Tomography. Various image reconstruction techniques during image formation such s back projection and Fourier based techniques, Iterative Reconstruction method and their drawbacks. Attenuation correction , Scatter Correction, Resolution Correction, Other requirements or Sources of Error.

Image quality parameters: Spatial Resolution, Factor affecting Spatial Resolution, Methods of Evaluation of Spatial Resolution, Contrast, Noise. NEMA protocols followed for quality assurance / quality control of imaging instruments.

In – vitro Technique: RIA/IRMA techniques and its principles:

Physics of PET and Cyclotron: Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector and Scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes produced and their characteristics.

Treatment Thyrotoxicosis, Thyroid cancer with I – 131, use of P-32 and Y-90 for palliative treatment, Radiation Synovectomy and the isotopes used., Concept of Delay Tank and various Waste Disposal Methods used in Nuclear Medicine.

Planning and Shielding Calculations using the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

2. Internal Dosimetry: 10

Internal Radiation Dosimetry: Different 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 calculation. Limitation of MIRD technique.

Books recommended :

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RP4.3 Total marks : 80+20 (Internal)
Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP4.3 : Radiation Safety

A. Radiation Protection Standards: **7**

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards – Historical background – International Commission Radiological Protection and its recommendations – The system of Radiological Protection – Justification of Practice, Optimization 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

Principles of Monitoring and Protection: **5**

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.

B. <u>Safety in the Medical , Industrial, Agricultural and Research uses of Radiation.</u>

Safety in the Medical Uses of Radiation: **15**

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 accelerator protective equipment – Handling of patients – Waste disposal facilities – Radiation safety during source transfer operations special safety features in accelerators, reactors.

Safety in Industrial, Agricultural and Research uses of Radiation: **3**

Use of ionizing radiation in irradiator, industrial radiography, nucleonic gauging, well logging and research such as medical research, industrial research, industrial research and agricultural research.

Books Recommended:

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RP4.4 Total marks : 80+20 (Internal)

Total Lectures : 30. Total Credits : 6 (3L+1T+2H)

Paper RP4.4 : Medical management

A. Computers in Treatment Planning **12**

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 beams, 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 – Hardware and software requirements – beam & source library generation. Networking, DICOM and PACS. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

B. (i) Radioactive Waste Disposal & Transport.

Radioactive Waste Disposal: **4**

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.

Transport of Radioisotopes: **4**

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.

(ii) Legislation, Radiation Emergencies and their Medical Management.

Legislation: **5**

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 Emergencies and their Medical Management: **5**

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 inujuries, their treatment and medical management – Case histories.

References:

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RP4.5PB Total marks : 80+20 (Internal)
Total Credits : 6 (9 Practical hours)

Paper 4.5PB : Adv Radiological Physics Lab