AMRITA SCHOOL OF MEDICINE
Centre for Allied Health Sciences

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CURRICULUM
Post Graduate Diploma in Medical Radiological Sciences

A Super Speciality Tertiary Care Hospital Accredited by ISO 9001-2008, NABL & NABH
SPIRITUAL PRINCIPLES IN EDUCATION

“In the gurukulas of ancient rishis, when the master spoke it was love that spoke; and at the receiving end disciple absorbed of nothing but love. Because of their love for their Master, the disciples’ hearts were like a fertile field, ready to receive the knowledge imparted by the Master. Love given and love received. Love made them open to each other. True giving and receiving take place where love is present. Real listening and ‘sraddha’ is possible only where there is love, otherwise the listener will be closed. If you are closed you will be easily dominated by anger and resentment, and nothing can enter into you”.

“Satguru Mata Amritanandamayi Devi”
Introducing AIMS

India is the second most populous nation on earth. This means that India’s health problems are the world’s health problems. And by the numbers, these problems are staggering: 41 million cases of diabetes, nearly half the world’s blind population, and 60% of the world’s incidences of heart disease. But behind the numbers are human beings, and we believe that every human being has a right to high-quality healthcare.

Since opening its doors in 1998, AIMS, our 1,200 bed tertiary care hospital in Kochi, Kerala, has provided more than 4 billion rupees worth of charitable medical care; more than 3 million patients received completely free treatment. AIMS offers sophisticated and compassionate care in a serene and beautiful atmosphere, and is recognized as one of the premier hospitals in South Asia. Our commitment to serving the poor has attracted a dedicated team of highly qualified medical professionals from around the world.

The Amrita Institute of Medical Sciences is the adjunct to the term “New Universalism” coined by the World Health Organization. This massive healthcare infrastructure with over 3,330,000 sq. ft. of built-up area spread over 125 acres of land, supports a daily patient volume of about 3000 outpatients with 95 percent inpatient occupancy. Annual patient turnover touches an incredible figure of almost 800,000 outpatients and nearly 50,000 inpatients. There are 12 super specialty departments, 45 other departments, 4500 support staff and 670 faculty members.

With extensive facilities comprising 28 modern operating theatres, 230 equipped intensive-care beds, a fully computerized and networked Hospital Information System (HIS), a fully digital radiology department, 17 NABL accredited clinical laboratories and a 24/7 telemedicine service, AIMS offers a total and comprehensive healthcare solution comparable to the best hospitals in the world. The AIMS team comprises physicians, surgeons and other healthcare professionals of the highest caliber and experience.

AIMS features one of the most advanced hospital computer networks in India. The network supports more than 2000 computers and has computerized nearly every aspect of patient care including all patient information, lab testing and radiological imaging. A PET (Positron Emitting Tomography) CT scanner, the first of its kind in the state of Kerala and which is extremely useful for early detection of cancer, has been installed in AIMS and was inaugurated in July 2009 by Dr. A. P. J. Abdul Kalam, former President of India. The most recent addition is a 3 Tesla Silent MRI, da Vinci Surgical System (a robotic surgical platform) and ROSA – Robotic Surgical Assistant.

The educational institutions of Amrita Vishwa Vidya Peetham, a University established under section 3 of UGC Act 1956, has at its Health Sciences Campus in Kochi, the Amrita School of Medicine, the Amrita Centre for Nanosciences, the Amrita School of Dentistry, the Amrita College of Nursing, and the Amrita School of Pharmacy, committed to being centres of excellence providing value-based medical education, where the highest human qualities of compassion, dedication, purity and service are instilled in the youth. Amrita School of Ayurveda is located at Amritapuri, in the district of Kollam. Amrita University strives to help all students attain the competence and character to humbly serve humanity in accordance with the highest principles and standards of the healthcare profession.
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### Part II - PGDMRS Syllabus

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I. Post Graduate Diploma in Medical Radiological Sciences (PGDMRS)

1.1 Details of the Course:

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<td>PGDMRS</td>
<td>1 year + 1 year of practical training (Internship)</td>
<td>First or high second class in M.Sc Physics or MS Engineering; Those who will be appearing in final exam are also eligible to apply;</td>
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I.2. Medium of Instruction:

English shall be the medium of instruction for all subjects of study and for examinations.

I.3. Eligibility:

Essential qualifications for eligibility are mentioned under clause No. I.1

II. General Rules:

Admissions to the course will be governed by the conditions laid down by the University from time to time and as published in the Regulations for admissions each year.

II.1. Duration of the Course:

Duration details are mentioned under clause No.I.1 of this booklet.

Academic study hours / days will be scheduled by the Department of Radiation Oncology. Holidays and leave will be approved by Principal, Amrita School of Medicine.

Practical training (internship) wherever specified are integral part of the course and generally, need to be done in Amrita Institute of Medical Sciences, Amrita School of Medicine, Kochi itself. However Candidates may do selected parts of their practical training (internship) in other institution/s with the approval of Principal, Amrita School of Medicine.

II.2. Educational Methodology

Learning occurs by attending didactic lectures, as part of regular work, from coworkers and senior faculty, through training offered in the workplace, through reading or other forms of self-study, using materials available through work, using materials obtained through a professional association or union, using materials obtained on students’ own initiative, during working hours at no cost to the student.
II.3. Academic Calendar

FIRST YEAR (Two semesters)

Commencement of classes – August
First Semester University exam (with Practical) – February
Second Semester University exam(with practical) – July

SECOND YEAR

Practical Training (Internship) and Dissertation

Commencement of Practical Training (Internship) – August of Second Year
Project/Thesis – July of Second Year
(For the successful completion of the course the students should complete the entire tenure of the course till 31st July in the parent departments)

II.4. Discontinuation of studies

Rules for discontinuation of studies during the course period will be those decided by the Chairman /Admissions, Amrita Centre for Allied Health Sciences, and Published in the “Terms and Conditions” every year.

III. Examination Regulations:

III.1. Attendance:

Medical leave or other types of sanctioned leaves will not be counted as physical presence. Attendance will be counted from the date of commencement of the course to the last day of the final examination in each subject.

Academic study hours / days will be scheduled by the Department of Radiation Oncology. Holidays and leave will be as specified /approved by the Principal, Amrita School of Medicine.

III.2. Internal Assessment:

1. Regular periodic assessment shall be conducted throughout the course. At least one sessional examination in every theory subject and one on practical examinations should be conducted. The model examination should be of the same pattern as the University Examination. Average marks of sessional examinations and the marks obtained in assignments / oral / viva / practicals shall also be taken to calculate the internal assessment.
2. A candidate should secure a minimum of 35% marks in the internal assessment in each subject (separately in theory and practical) to be eligible to appear for the University examination.

3. Each student should maintain a logbook and record the procedures they do and the work patterns they are undergoing. It shall be based on periodical assessment, evaluation of student assignment, preparation for seminar, clinical case presentation, assessment of candidate's performance in the sessional examinations, routine clinical works, logbook and record keeping etc.

4. Day to day assessment will be given importance during internal assessment, Weightage for internal assessment shall be 20% of the total marks in each subject.

5. Sessional examination as mentioned above will be conducted and the marks secured by the students along with their attendance details shall be forwarded to the Principal

III.3. University Examinations:

- University Examination shall be conducted at the end of every Semester in the first Year.
- A candidate who satisfies the requirement of attendance, internal assessment marks, as stipulated by the University shall be eligible to appear for the University Examination.
- One academic year will be twelve months including the days of the University Examination. Year will be counted from the date of commencement of classes which will include the inauguration day.
- The minimum pass for internal assessment is 35% and for the University Examination is 45%. However the student should score a total of 50% (adding the internal and external to pass in each subject (separately for theory and practical)
- If a candidate fails in either theory or practical paper, he/she has to re-appear for both the papers (theory and practical)
- All practical examinations will be conducted as per Radiological Lab I and II
- Number of candidates for practical examination should be maximum 8 per day
- One internal examiner and one ex officio (Head, Medical Physics and Rad Safety) examiner should jointly conduct practical examination for each student during first year.
III.4. Eligibility to appear for university Examination:

A student who has secured 35% marks for Internal Assessment is qualified to appear for University Examination provided he/she satisfies percentage of attendance requirement as already mentioned in clause III.1.

III.5. Valuation of Theory – Revaluation Papers:

- Valuation work will be undertaken by the examiners in the premises of the Examination Control Division in the Health Sciences Campus.

- There is provision for Re-Valuation for any of the University examinations, should this be requested by any student. Fees for revaluation will be decided by the Principal from time to time.

- Application for revaluation should be submitted to the office of the Principal, within 10 days from the date of declaration of the result, along with the fees as decided by the Principal.

III.6. Supplementary Examinations:

Main University examinations may be followed by a supplementary examination which will normally be held within four to six months from the date of completion of the main examination.

As stipulated under clause No. III.2, Internal Assessment, HOD will hold an internal examination three to four weeks prior to the date of the University Examination. Marks secured in the said examination or the ones secured in the internal examination held prior to the earlier University Examination whichever is more only will be taken for the purpose of internal assessment. HODs will send such details to the Principal ten days prior to the date of commencement of University examination.

Students who have not passed / cleared all or any subjects in the first semester University examination will be permitted to attend the second semester classes and also eligible to appear for second semester university examination along with first semester supplementary examination.

Same attendance and internal marks of the main examination will be considered for the supplementary examination, unless the HOD furnish fresh internal marks and attendance after conducting fresh examination.
Students of supplementary batches are expected to prepare themselves for the University Examinations. No extra coaching is expected to be provided by the Institution. In case at any time the Institution has to provide extra coaching, students will be required to pay fees as fixed by the Principal for the said coaching.

III.7. Rules regarding carry-over subjects:

A candidate will be permitted to continue the rest of the course even if he/she has failed in the first semester university examinations.

A candidate must have passed in all subjects to become eligible to undergo compulsory practical training (internship) of one year. For the candidates who have not passed all the subjects the duration of the final year shall be extended until they become eligible to undergo compulsory practical training (internship).

IV. Criteria for Pass in University Examination - Regulations:

IV.1. Eligibility criteria for pass in University Examination:

In each of the subjects, a candidate must obtain 50% in aggregate for a pass and the details are as follows:

- A separate minimum of 35% for Internal Assessment
- 45% in Theory & 35% in Oral / Viva
- A separate minimum of 50% in aggregate for Practicals / Clinics (University Examinations)
- Overall 50% is the minimum pass in subject aggregate (University Theory + Viva / Oral + Practicals + Internal Assessment)

IV.2. Evaluation and Grades:

1. Minimum mark for pass shall be 50% in each of the theory and practical papers separately (including internal assessment) in all subjects.

2. A candidate who passes the examination in all subjects with an aggregate of 50% marks and above and less than 65% shall be declared to have passed the examination in the second class.

3. A candidate who passes the examination in all subjects in the first attempt obtaining not less than 65% of the aggregate marks for all the three years shall be declared to have passed the examination with First Class.

4. A candidate who secures an aggregate of 75% or above marks is awarded distinction. A candidate who secures not less than 75% marks in any subject will be deemed to have passed the subject with distinction in that subject provided he / she passes the whole examination in the first attempt.

5. A candidate who takes more than one attempt in any subject and pass subsequently shall be ranked only in pass class.
6. A Candidate passing the entire course is placed in Second class / First class / Distinction based on the cumulative percentage of the aggregate marks of all the subjects in the Ist & IInd semester university examinations

7. Rank in the examination: - Aggregate marks of all the semester examinations will be considered for awarding rank for the PGDMRS Course.

V. Practical Training (Internship) and Project Dissertation:

V.1. Eligibility for Practical Training (Internship) - Regulations:

Practical training (Internship) is a part of the curriculum (see clause No.1); students will have to do the practical training (Internship) in Amrita Institute of Medical Sciences itself. A candidate must have passed in all subjects to become eligible to undergo compulsory practical training (Internship) of one year. For the candidates who have not passed all the subjects the duration of the final year shall be extended until they become eligible to undergo compulsory practical training (Internship).

“Practical training (Internship) has to be done continuously for a period provided in the syllabus except in extra ordinary circumstances where subject to the approval of the Principal the same may be done in not more than two parts with an interruption not exceeding six months. In any case Practical training (internship) shall be completed within 18 months from the date of acquiring eligibility to the practical training (internship).

V.2. Practical training and Project Dissertation during Practical training (Internship):

1. Quality Assurance in Radiation Oncology; Equipment calibration and Quality Assurance, Commissioning and acceptance testing of Radiation oncology equipments.
2. Clinical Dosimetry Service including Treatment Planning in Radiation Oncology: EBRT & Brachytherapy.
3. Quality Assurance in Diagnostic Imaging and Nuclear Medicine
4. Hospital wide Radiation Safety: Safety Evaluations, Radiation Surveys and Monitoring in Diagnostic Imaging, Nuclear Medicine, Cardiac Cath Lab and Other Imaging areas, and the Dental School Radiology; Radiation Safety In-Service to the various user departments.
5. Commissioning and acceptance testing of radio diagnostic Equipment
6. Project & Dissertation

Students will have to submit a dissertation to the university by the end of second year to be eligible for the practical training (internship) completion certificate. The
practical training (internship) certificate is required for submission to AERB for eLO-RA registration as Radiation Professionals (RP), and for RSO examination. Only after successful completion of the project dissertation, will the candidate be eligible to receive the practical training (internship) certificate.

**V.3. Attendance and leave details during Practical training (Internship):**

The Practical training (Internship) hours / day will be scheduled by the Department of Radiation Oncology. Holidays and leave will be as specified/approved by the Principal, Amrita School of Medicine.

**VI. General considerations and teaching / learning approach:**

There must be enough experience to be provided for self learning. The methods and techniques that would ensure this must become a part of teaching-learning process.

Proper records of the work should be maintained which will form the basis for the students assessment and should be available to any agency who is required to do statutory inspection of the school of the course.
Part II
Syllabus: PGDMRS
MAIN OBJECTIVES OF THE COURSE

The student should be able to achieve the following.

- Be knowledgeable in the physical aspects of the application of radiation for the diagnosis and treatment of diseases using radiation
- Be able to independently provide routine clinical physics services in:
  - Radiation Oncology: External Beam Radiation Therapy, Brachytherapy and Open sources of radiation; Quality Assurance and Radiation Safety
  - Diagnostic Radiology and Nuclear Medical Imaging: Physical Principles, Quality Assurance and Radiation Safety
- Provide advice and services in Radiation Safety in all applications of radiation in medicine
- Fulfill the role of, and be qualified as Radiation Safety Officer Level-III as declared by the Atomic Energy Regulatory Board (AERB)
- Be knowledgeable enough to teach the Physical Aspects of Radiation Applications in Medicine, including Radiation Safety and Regulatory Compliance in Radiation Applications
- Be able to function in the role of a resource person in equipment selection, installations planning and design, acceptance testing and commissioning of medical radiological facilities including Radiation Therapy and diagnostic X-ray imaging facilities
- Be able to do independent research and development in the techniques and application of radiation in medicine
- Be eligible for further advancing their knowledge and expertise in Medical Radiological Physics by pursuing a Ph.D program in Medical Radiological Sciences
SYLLABUS

2. PAPER - I: Radiological Physics: 42 Lectures

1.1 Nuclear Physics 10 Lectures


1.2 Particle Accelerators 10 Lectures

Particle accelerators for medical, research and industrial, applications - The Resonant transformer - Cascade generator - Van De Graff Generator - Pelletron - Cyclotron - Betatron - Synchro-Cyclotron-Linear Accelerator - Klystron and magnetron - Travelling and Standing Wave Acceleration - Microtron - Electron Synchrotron-Proton synchrotron. Details of accelerator facilities in India.

1.3 X-ray Generators 10 Lectures


1.4 Interaction of Radiation with Matter (oriented towards Radiology) 12 Lectures

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 - Radioactive collision - Bremsstrahlung - 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.


3. PAPER – II: RADIATION DETECTORS AND INSTRUMENTATION: 40 Lectures

2.1 Medical Electronics 5 Lectures

Semiconductor diodes - JFET – MOSFET – Integrated Circuits - Operational amplifiers (OPAM) and their characteristics - Differential Amplifier - Operational amplifier systems - OPAM Applicatons -Addition, subtraction, Integration and Differentiation - Active amplifiers - Pulse Amplifiers - Decoders and Encoders - Microprocessors and associated peripherals - Power supplies - Regulated power supplies using IC’s - DC-DC converter and RF power supplies - Switching mode power supplies - AC regulators.

2.2 Principles of Radiation Detection 18 Lectures

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 - Thermoluminescent Dosimeters (TLD) - Optically stimulated Luminescence dosimeters (OSLD) - Radioluminescent dosimeters - Neutron Detectors - Nuclear track emulsions for fast neutrons - Solid State Nuclear track (SSNTD) detectors - Calorimeters - New Developments.

2.3 Radiation Measuring & Monitoring Instruments 17 Lectures

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 - Multi-
purpose dosimeter - Water phantom dosimetry systems - Brachytherapy dosimeters - Thermoluminescent dosimeter readers for medical applications - Calibration and maintenance of dosimeters.


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.

4. Paper - III: Radiation Dosimetry and Standardization: 55 Lectures

3.1 Radiation Quantities and Units 6 Lectures

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 - Kerma - 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)

3.2 Radiation Sources 5 Lectures

Radiation sources - Natural and artificial radioactive sources - Large scale production of isotopes - Reactor produced isotopes - Cyclotron produced isotopes - Fission products - industrial uses - Telecobalt and Brachy Caesium sources - Gold seeds - Tantalum wire - 125I Sources - Beta ray applicators - Thermal and fast neutron sources - Preparation of tracers and labelled compounds - Preparation of radio colloids.

3.3 Dosimetry & Standardization of X and Gamma Rays Beams 15 Lectures

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 theory, Mathematical expression describing Bragg-Gray principle and its derivation. Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of $D_{\text{gas}}$, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor - $N_X$, $N_K$, $N_{D,\text{air}}$, $N_{D,W}$. IAEA TRS277: Various steps to arrive at the expression for $D_W$ starting from $N_X$. TRS398: $N_{D,W}$, $Q : N_{D,W}$ : $K_{Q,0}$ : $K_Q$, Derivation of an expression for $K_{Q,0}$. Calorimetric standards - Intercomparison of standard


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

3.4 Neutron Standards & Dosimetry 9 Lectures


3.5 Standardization of Radionuclides 8 Lectures

Methods of measurement of radioactivity - Defined solid angle and $4\pi$ 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 for alpha, beta and gamma emitter - Reentrant ionization chamber methods - Methods using $(n, \gamma)$ and
(n, p) reactions - Determination of yield of neutron sources - Space integration methods - Solid state detectors.

3.6 Radiation Chemistry and Chemical Dosimetry 12 Lectures

Definitions 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 polymerisation, 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 view point - 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 dosimeters - Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

5. PAPER - IV: RADIATION BIOLOGY: 56 Lectures

4.1 Cell Biology 6 Lectures

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.

4.2 Anatomy, Physiology and Pathology 10 Lectures

Anatomy and physiology as applied to radiodiagnosis and radiotherapy - Structure & 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 clinico-pathological data

4.3 Interaction of Radiation with Cells 6 Lectures


4.4 Biological Effects of Radiation 9 Lectures


4.5 Clinical Aspects of Medical Imaging & Radiation Oncology 15 Lectures

Radiation Therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy & Radionuclide therapy, Benign and malignant disease, Methods of spread of malignant disease, Staging and grading systems, Treatment intent - Curative & 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 & 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.

4.6 Biological Basis of Radiotherapy 5 Lectures

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.

4.7 Time Dose Fractionation 5 Lectures

Time dose fractionation - Basis 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 and Linear Quadratic models.


5.1 Beam Therapy 30 Lectures

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 accelerators - beam collimation - asymmetric collimator - multileaf collimator - dose monitoring - electron contamination. Output calibration of $^{60}$Co gamma rays, high energy x-rays and electron beams using IAEA TRS 398, 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 filed analyzer (RFA). Description and measurement of isodose curves/charts. Dosimetry data resources.

Clinical electron beams - energy specification - electron energy selection for patient treatment - depth dose characteristics ($D_s$, $D_x$, $R_{100}$, $R_{90}$, $R_{50}$, $R_p$ 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.


5.2 Brachytherapy 12 Lectures

Definition and classification of brachytherapy techniques - surface mould, intracavitary, interstitial and intraluminal techniques. Requirement for brachytherapy sources - Description of radium and radium substitutes - $^{137}\text{Cs}$, $^{60}\text{Co}$, $^{192}\text{Ir}$, $^{125}\text{I}$ 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.


5.3 Computers in Treatment Planning 12 Lectures

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 calcu-

5.4 Special and Advanced Techniques of Radiotherapy 12 Lectures

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 radiosurgery/radiotherapy (SRS/SRT) - cone and mMLC based X-Knife - Gamma Knife - 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 - Patient 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 e.g. Rapid Arc). 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.

7. PAPER - VI: IMAGING Science: 60 Lectures

6.1 Principles of X-ray Diagnosis & Conventional Imaging 12 Lectures

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, objectives 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, sensitometric 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

6.2 Digital X-Ray Imaging and Computed Tomography 10 Lectures

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

6.3 Nuclear Medicine & Internal Dosimetry 20 Lectures

Physics of Nuclear Medicine (12 Lectures)

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, Life Span of RBC etc. General concept of Radionuclide Imaging and Historical developments.


In-vitro Technique: RIA/IRMA techniques and its principles.

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

Treatment of 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 during the installation of SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

Internal Dosimetry (8 Lectures)


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.

6.4 Magnetic Resonance Imaging (MRI) 6 Lectures

Magnetic Resonance image - proton density, relaxation time T1 & 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.

6.5 Ultrasound Imaging 4 Lectures

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

8. PAPER – VII: Health Physics and RADIATION SAFETY

7.1 Radiation Protection standards 7 Lectures

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

7.2 Principles of Monitoring and Protection 6 Lectures

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

7.3 Safety in the Medical Uses of Radiation 15 Lectures

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 and therapeutic installations - Radiation monitoring procedures - Protective measures to reduce radiation exposure to staff and patients - Radiation hazards in brachytherapy departments and teletherapy departments and radioisotope laboratories - Particle accelerators - Protective equipment - Handling of patients - Waste disposal facilities - Radiation safety during source transfer operations - Special safety features in accelerators, reactors.

7.4 Radioactive Waste Disposal 4 Lectures

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.

7.5 Transport of Radioisotopes 4 Lectures

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

7.6 Legislation 5 Lectures

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


7.7 Radiation Emergencies and their Medical Management 5 Lectures

Radiation accidents and emergencies in the use of radiation sources and equipment in industry and medicine - Radiographic cameras and teletherapy units - Loading and unloading of sources - Loss of radiation sources and their tracing - Typical accident cases. Radiation injuries, their treatment and medical management - Case histories.
9 PRACTICALS: Radiological Lab I and Radiological Lab II:

1. Production and attenuation of bremsstrahlung.
2. Calibration of survey instruments and pocket dosimeters.
3. Calibration of a therapy level dosimeter.
5. Calibration of a OSL personnel monitoring badge and dose evaluation.
7. Evaluation of characteristics of a radiographic image.
8. Dose output measurement of photon (\(^{60}\)Co gamma rays and high energy x-rays) beams used in radiotherapy treatment.
11. AKS/RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionization chambers.
12. In-phantom dosimetry of a brachytherapy source.
13. Familiarization with treatment planning procedure using a computerized radiotherapy treatment planning system.
14. Survey of a radioisotope laboratory and monitoring of surface and air contamination.
15. Absorption and backscattering of gamma rays - Determination of HVT; “good geometry”; “poor geometry”.
17. Radiation protection survey of diagnostic radiology installations.
18. CT-Diagnostic Suite Shielding Calculation
19. Dose Estimates From Diagnostic Imaging Procedures (a) Fetal dose calculations
(b) Pediatric dose issues (c) Risk estimates
20. Evaluation of Imaging System Performance
   (a) MTF
   (b) ROC
   (c) Figures of Merit
21. Ultrasound
   (a) Imaging principles
   (b) QC
(c) Measurement of intensity, power

22. Magnetic Resonance Imaging

(a) Imaging principles

(b) Basic pulse sequences and common imaging options

(c) Radio frequency and gradient coil design and specifications

(d) Siting and safety

(e) Acceptance testing, QC, and accreditation

23. Mo-Tc Radionuclide Generator

(a) Elution and assay

(b) Quality control

24. Radioisotope Calibrator

(a) Quality control: Constancy, linearity, accuracy

(b) Wipe testing of sealed radiation sources

25. Scintillation Camera (Anger Type)

   (a) Quality control: Flood field uniformity and spatial resolution; use of asymmetric windows for evaluating field uniformity and a crystal hydration

   (b) Effect of pulse height analyzer window size on contrast and spatial resolution

   (c) Measurement of resolving time

   (d) Measurement of intrinsic, extrinsic, and extrinsic in scatter spatial resolution and calculation of modulation transfer functions

   (e) Measurement of multiple window spatial registration errors

   (f) Quantitation of flood field uniformity
26. Single Photon Emission Computed Tomography (SPECT)
(a) Quality control: Center-of-rotation calibration and high count floods
(b) Comparison of planar and tomography spatial resolution
(c) Measurement of field uniformity, RMS (root mean square) noise, accuracy of attenuation correction, and contrast

27. Positron Emission Tomography (PET)
(a) Quality control
(b) Measurement of signal to noise ratio, RMS noise, and contrast

28. Absorbed Dose Determinations
(a) Calibrate a linac photon beam using both TG-21, TG-51 and TRS 277, TRS 398 protocols
(b) Calibrate a cobalt-60 beam, both isocentrically and for SSD geometry
(c) Calibrate an electron beam, beginning with energy determination, using both TG-21, TG-51 and TRS 277, TRS 398 protocols
(d) Perform two clinical TLD measurements, including requisite calibrations
(e) Use film dosimetry to measure electron depth doses and to measure the flatness and symmetry of an electron beam

29. Photon Beams: Basic Dose Descriptors
(a) Defining GTV, CTV, PTV
(b) Perform direct PDD and TMR measurements. Calculate TMRs from the PDD data and compare to measurements
(c) Calculate treatment times/MUs for several clinical cases
(d) Measure linac output factors
(e) Calculate SARs (or SMRs) from TMR data
(f) Calculate three cases of irregular fields (the Clarkson method), including one mantle field, both manually and by computer.

(g) Calculate a rotational beam average TMR manually and by computer.

30. Photon Beams: Dose Modeling, External Beams, and IMRT

31. Brachytherapy: In addition to clinical participation, perform cervix and planar implant calculations manually and by computer, both for LDR and HDR

32. Electron Beam Therapy

(a) Regularly Participate in the clinical patient treatment activities, including simulation, block cutting, treatment planning, and treatment delivery. Participate in chart rounds and patient follow-up.

(b) Beam modeling for external beam therapy.

10. PAPER – Internal: RADI OLOGI CAL MATHEMATI CS: 48 Lectures

I-1 Probability, Statistics and Errors 12 Lectures

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.

I-2 Counting and Medical Statistics 6 Lectures

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.

I-3 Numerical Methods 20 Lectures

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, Newton-Raphson Method. Taylor series, approximating the derivative, numerical differentiation formulas. Introduction to numerical quadrature, Trapezoidal rule, Simpson’s rule, Simpson’s Three-Eighth rule, Boole rule, Weddle rule. Initial value problems, Picard’s method, Taylor’s method, Euler’s method, the modified Euler’s method, Runge-Kutta method

Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

I-4 Computational Tools & Techniques 10 Lectures

Computational packages: Overview of programming in C++, MATLAB/ Mathematica, and STATISTICA in data analysis and graphics.
### 11. SCHEME OF UNIVERSITY EXAMINATIONS: First Year

<table>
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<tr>
<th>No</th>
<th>Subject Name</th>
<th>Max. Marks</th>
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<tr>
<td>1</td>
<td>Paper I: Radiological Physics</td>
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<td>Paper II: Radiation Detection and Instrumentation,</td>
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<td>Paper III: Radiation Dosimetry and Standardization</td>
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<td>Practical: Radiological Lab I</td>
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<td>5</td>
<td>Internal Assessment</td>
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<td><strong>Second Semester</strong></td>
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<td>6</td>
<td>Paper IV: Radiation Biology</td>
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<td>Paper V: Physics of Radiation Therapy</td>
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<td>8</td>
<td>Paper VI: Imaging Science (Radiology &amp; Nuclear Medicine)</td>
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<td>Paper VII: Health Physics &amp; Radiation Safety</td>
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<td>Practical: Radiological Lab II</td>
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12. PATTERN OF QUESTION PAPERS

All the question papers shall be of standard type. Each theory paper will be of 3 hours duration and shall consist of ten questions carrying equal marks with a maximum of 100 marks. Theory paper in all subjects will consist of ten questions of 10 marks each or two 5 mark sub questions in a ten mark main question.

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<tr>
<td>Principal's Office : 0484-2858131/4008131</td>
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<tr>
<td>Academic Office : 0484-2858373/4008373</td>
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<tr>
<td>Amrita Centre for Allied Health Sciences : 0484-2858845</td>
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<td>Programme Co-ordinator : +91 7034028118, Oncall: 6976</td>
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