File Ref.No.82320/GA - IV - J3/2019/Admn

**UNIVERSITY OF CALICUT**

**Abstract**

General & Academic - CCSS PG Regulations 2019 - Faculty of Science- Scheme and Syllabus of M.Sc Radiation Physics Programme w.e.f 2020 Admission onwards - Incorporating Outcome Based Education - Implemented - Subject to ratification of Academic Council - Orders Issued.

**G & A - IV - J**

U.O.No. 5647/2021/Admn Dated, Calicut University.P.O, 27.05.2021

*Read:*-1) U.O.No. 9546/2019/Admn Dated,19.07.2019.
2) U.O.No. 15916/2019/Admn Dated 11.11.2019.
3) The minutes of the meeting of Board of Studies in Radiation Physics, Dated 18.05.2021.
4) Remarks of the Dean, Faculty of Science, Dated 26.05.2021.
5) Orders of the Vice Chancellor in the file of even no, Dated 27.05.2021.

ORDER

1. The scheme and syllabus of M.Sc Radiation Physics Programme under CCSS PG Regulations 2019 in the Teaching Department of the University, w.e.f 2019 admission onwards has been implemented, vide paper read (1) above, and the same has been modified, vide paper read (2) above.
2. The Board of Studies in Radiation Physics has resolved to incorpate Outcome Based Education (OBE) in the scheme and syllabus of M.Sc Radiation Physics Programme under Teaching Department of the University, in tune with the new CCSS PG Regulations 2019 with effect from 2020 Admission onwards, vide paper read (3) above.
3. The Dean, Faculty of Science, vide paper read (4) above, has approved to implement the scheme and syllabus of M.Sc Radiation Physics Programme (CCSS-PG-2019) incorporating Outcome Based Education (OBE), in the existing syllabus forwarded by Chairperson, Board of studies in Radiation Physics, in tune with the new CCSS PG Regulations 2019 with effect from 2020 Admission onwards.
4. Considering the urgency, the Vice Chancellor has accorded sanction to implement the scheme and syllabus of M.Sc Radiation Physics Programme incorporating Outcome Based Education (OBE), in tune with the new CCSS PG Regulations under Teaching Departments of the University with effect from 2020 Admission onwards, subject to ratification by the Academic Council.
5. Scheme and syllabus of M.Sc Radiation Physics Programme (CCSS) incorporating Outcome Based Education (OBE) in the existing syllabus, is therefore implemented with effect from 2020 Admission onwards under Teaching Department of the University, subject to ratification by the Academic Council.
6. Orders are issued accordingly.
7. U.O.No. 15916/2019/Admn Dated 11.11.2019, is modified to this extend. (Syllabus appended )

Ajitha P.P

Joint Registrar

To

The Head, Department of Physics
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

# SCHEME, REGULATIONS AND SYLLABUS

(Outcome Based Education)

## FOR THE COURSE

# M.Sc. RADIATION PHYSICS

**(Revised for 2020 - 2021 onwards)**

Program Code: MRPHY

## UNIVERSITY OF CALICUT

**Calicut University**
**Kerala 673635**

| Program Educational Objectives (PEOs) | |
|---|---|
| On completion of M.Sc., Radiation Physics program, the students are expected to : | |
| 1 | **Illustrate** basic application of physics in medicine and industry in the areas of radiotherapy, radiology, dosimetry, nuclear medicine, radiation protection and safety |
| 2 | **Demonstrate** different types of radiations and various interactions of radiation with matter, fundamentals of radiation dosimetry and radiobiology, diagnostic radiology, physics behind different medical imaging and therapy methods, radiation hazards and safety management, radiation safety evaluation methods and advanced techniques in the field of radiation oncology. |
| 3 | **Expertise** in design and practice of radiation facilities, dosimetry, radiation protection, radiation therapy and radiology. |
| 4 | **Developing** set up for radiation detection and nuclear instrumentation |
| 5 | **Use** and implement radiation safety measures in medical radiation installation and its research level applications. |
| 6 | **Perform** quality assurance, quality control, acceptance and commissioning procedures associated in the field of medical radiotherapy, radiology, nuclear medicine installation and medical research. |
| 7 | **Training** on practical use of various internationally accepted dosimetry and radiation safety protocol. |
| 8 | **Perform** radiotherapy treatment planning under internationally accepted protocols. |
| 9 | **Trained** in new technologies and inventions in the field of radiation dosimetry and radiotherapy. |
| 10 | **Manage** any radiation emergencies and security plan in radiation installation, such as radio therapy, radiology, nuclear medicine, and research laboratories, as per the national and international regulatory authorities. |

## Program Outcomes (POs)

After the completion of M.Sc. Radiation Physics program

1. Able to qualify Radiological Safety Officer (Medical) examination conducted by Radiological Physics and Advisory Division (RPAD) of DAE as per the regulations of the Atomic Energy Regulatory Board (AERB).
2. Designated as radiological safety officer, medical physicist, radiation dosimetrist and scientist in the developing field of radiation physics and medical physics.
3. Able to work in the field of radio-isotope production, radiation transport and management sections, R &D of radiation generating equipment and research industries.
4. Work as faculty in various institutions.
5. Contribute in international level medical conferences workshops.

## Program Specific Outcomes (PSOs)

After the completion of M.Sc. Radiation Physics program

1. Professional attitude towards medical physics and radiation physics
2. Develop a deep knowledge about their associate fields like radiation safety, radiation physics, medical physics, radiation dosimetry and scientific research.
3. Able to handle standard radiation dosimetry and detector systems, measurement protocols and calculations. Contribute in new procedure of developing radiation detectors and measurement.
4. Gain knowledge about various medical imaging techniques, its procedures and basic physics behind the process.
5. Acquire professional experience from radiation safety and radiotherapy section after the completion of their internship program. And will able to perform radiation safety programs and treatment planning procedure associated with radiotherapy unit.

6 Able to perform quality assurance, quality control test procedures that recorded with radiation installation.

7 Able to plan the design for medical radiation installation and its associated safety systems, and perform the acceptance and commissioning test procedures.

8 Trained in the nuclear medicine installation, isotope production, processing, conditioning and calibration.

9 Trained for the radiological safety officer, general working procedure and practices.

10 Trained to design and develop new techniques and methods in the field of radiation/medical physics, which are beneficial for the society.

**UNIVERSITY OF CALICUT**

SCHEME AND REGULATIONS FOR **M.Sc RADIATION PHYSICS** Programme.
(REVISED FOR 2020-21 ADMISSION)

**I. TITLE OF THE PROGRAMME:**
The program shall be called Master of Science (M.Sc.) Degree in Radiation Physics.

**II. ABOUT THE COURSE:** M.Sc. Radiation Physics course is a highly specialized multidisciplinary course in Applied Physics. The course will emphasis on the interaction of radiation with human body, application in radiotherapy and the safety measures. The course has immense job potential as highly demanded **Medical Physicists** and **Radiological Safety Officers** in Advanced Hospitals, Industrial and Research Organizations in India and abroad as well as faculty, researchers, dosimetrist etc

**III. ELIGIBILITY FOR ADMISSION:** A pass in B.Sc. Physics as core subject, with Mathematics as one of the subjects, from University of Calicut or equivalent with 60% marks in aggregate of the subjects or equivalent grade.

**IV.ADMISSION CRITERIA:** The admission is made on the basis of the performance in the entrance test of the objective type/ short answer questions of 2 hours duration with the syllabus of B.Sc. Physics of the University of Calicut

**V. DURATION OF THE COURSE: 3 years** Two years course work + One year Internship/Field training– Four semesters each of 6 months followed by internship/clinical training of 12 months - A project work is to be submitted during the period.

**VI. MEDIUM OF INSTRUCTION –** English

**VII. PROGRAMME STRUCTURE**

1. The programme shall include three types of courses, viz. Core courses, Elective courses and Audited Courses.
2. There shall be a field training/ internship for one year for those who opt for jobs as Radiological Safety Officer (RSO) and Medical Physicists. A project work is also is to be carried out during this period.
3. Total credit for the program shall be 100 (hudred). The audit courses carry a total of 4 credits and it is over and above 82. The pattern of distribution of the 82 credits is as detailed below :

   i) Total credits for the core courses (theory, practicals, Viva-voce and project) shall be 74. Out of this the total credits for comprehensive viva-voce and project work combined together shall be 10 (eight) subject to a minimum of 4 (four) credit for project work.

   ii) Total credits for Elective courses shall be 8.

**Table 1. Structure of the Programme**

| Programme Duration | M.Sc Radiation Physics |
|---|---|
| Accumulated minimum credits required for successful completion of programme | 82 |
| Minimum credits required from Core courses (including viva-voce) | 74 |
| Minimum credits required from Elective courses | 8 |
| Total number of credits to be acquired for fulfilling the profession (excluding audit course) | 100 |

5. **Audit courses**:

In addition to the above courses for the mandatory requirement of a programme there will be two compulsory courses - **Ability Enhancement Course** (AEC) &**Professional Competency Course** (PCC) each with 2 credits, and these courses are to be done within the first two semesters. The credits will not be counted for computing the overall SGPA/CGPA of the student. The concerned department shall conduct examination for these courses and shall intimate /upload the results of the same to the University on the stipulated date during the III Semester. The student has to obtain only minimum pass requirements in these two courses. The broad framework of the compulsory audited courses are given hereunder.

Audit course 1 - Presentation of seminar in the related topic is to be done

Audit course 2- developing a computer program in the specific topics in radiology is to be done.

**VIII. ATTENDANCE –** A candidate is required to put in at least 80% attendance in theory and practical subjects separately in the recognized institution approved for the same or affiliated to the University of Calicut. This has to be determined on a semester basis.

**IX. SCHEME OF CLASSES**:

Every semester will have the course distribution with appropriate number of theory and practicals. The theory subjects shall have lectures for a total duration of around 80 hours each and the practical classes will be of about 70 hours each. This works out to be about 500 hours teaching per semester including tutorial. It shall be split suitably at the rate of six days per week. The fourth semester will accommodate the project work also. The classes per day shall work out as 4 hours for theory and 3 hours for practical. Working days per week – 6.

**Failure in Semester:**

A candidate who has failed in the I semester shall be promoted to II and III semester but will not be allowed to attend the IV semester classes until he/she cleared the 1$^{st}$ semester subjects. Candidate failed in any semester will not be allowed to do the internship/fieldl training until the backlog papers are cleared.

**Discontinuation:** No discontinuation is allowed in normal basis. However if a student has to discontinue the course in any semester due to the reasons of not his/her own, and he/she has paid the fee for the semester, he/she can be re-admitted to the semester in later time, if the coordinator is fully satisfied with the reason. In such cases he/she has to complete the course work as per the regulations of the newly admitted batch he/she is re-admitted and appear for the examinations accordingly. This provision is conditional on the availability of seats and facility.

**X. PROJECT WORK (6 Credits):**

Every candidate must do a project work under an approved supervisor (approved by the Coordinator) in a topic having relevance to the application of radiation in medicine, industry, agriculture and research in the 5/6$^{th}$ semester. The project thesis should be submitted to the University. The supervisor should certify about the satisfactory completion of the project. Students must present their project work before a committee constituted by the course coordinator. Project Report must be submitted within two months from the last working day of the final semester

**XI. INTERNSHIP/ FIELD TRAINING (12 Credits):**

Total duration of the internship/clinical training will be 1 year (as prescribed by the AERB). It should be done under the supervision of a designated academic staff member of recognized institute. The supervisor must certify to the adequacy of the field training on the basis of the thesis report submitted by the candidate. The students should necessarily present at least one seminar on the basis of the field training and the record of the field training must be duly certified by the designated officer in the centre and the Course Coordinator.

(The students should pay the charges for clinical training as required by the institution).

**XII. RADIOLOGICAL SAFETY OFFICER (RSO) approval by AERB:**

The University shall initiate steps for registering for the examination for Radiological Safety Officer (Level III Medical) certification, for all candidates. The examination for the same shall be conducted by Radiological Physics and Advisory Division (RPAD) of DAE as per the regulations of the Atomic Energy Regulatory Board (AERB). Students qualifying this examination will be eligible for RSO. Candidate completing one year of clinical training are eligible for this examination. Student should attend and qualify the RSO examination at their own capacity.

**XIII. SCHEME OF EXAMINATION**:

**Theory papers**: Each paper is of three hours duration – Maximum marks 100

| | |
|---|---|
| End semester examination | 70 marks |
| Continuous valuation | 30 marks* |

**Practical Examinatio**n: Three hours duration – Maximum marks 100

| | |
|---|---|
| End semester: | 70 marks |
| Continuous evaluation: | 30 marks* |

* Continuous evaluation is based on the regular performance in attendance -4 marks, internal tests (best 2 out of 3)- 12 marks, Assignments - 8 marks, seminars - 6 marks.

**Viva-voce:** There will be an end semester viva-voce, distributed on all papers of the semester, for all the four semester. Maximum marks for the viva voce will be 50 marks in each semester.

| | | | |
|---|---|---|---|
| **Project work: Total marks**: | | 200 | |
| Project Record: | | 100 | |
| Presentation and viva: | | 100 | |
| **Total Marks:** | | **2800** | |
| **Mark Distribution:** | Semester I-IV: | 2800 | (750+750+650+650) |

Project Report: 120*

Presentation and viva: 80*

* Project marks are for qualitative evaluation only and not to be included in consolidation. (Viva may include project work and clinical training)

Total Marks: **2800**
**Total credits 100**
**Minimum credits required to pass 82**

**Classification of results**

Minimum marks for a pass: Theory 40% (equivalent grade of C) minimum per paper and an aggregate of 50% (equivalent grade of B) - separately for theory and practical. There is no paper minimum for practicals. Evaluation of internship and project work is only for qualitative purpose only. Minimum grade required will be 50% or equivalent. Project and internship will not be accounted for grading and consolidation. University will issue certification to the effect as,

1. The candidate has successfully undertaken project work carrying 6 credits
2. The candidate has successfully completed one year internship/ clinical training carrying 12 credits

The Semester grade point Average (SGPA) and final grade(Cumulative Grade Point Average CGPA) will be calculated as follows.

$$SGPA = (C1*G1 + C2*G2 +....Cn*Gn)/(C1 + C2 +....Cn)$$

Where Ci, C2.. Cn are the credits of each paper and G1,G2 ..Gn are the grade scored in the respective papers. Same procedure will be followed for CGPA for the entire course work.

Presently the Following mark based grade will be followed

| Mark range (in %) | Grade point | Letter grade | Class |
|---|---|---|---|
| 80 - 100 | 8.0-10.0 | O | Outstanding |
| 70 - 79 | 7.0-7.9 | A+ | Excellent |
| 60 - 69 | 6.0-6.9 | A | Very Good |
| 55-59 | 5.5 – 5.9 | B + | Good |
| 50 - 54 | 5.0-5.4 | B | Average<br>(SGPA pass minimum) |
| 40 – 49 | 4.0-4.9 | C | F in CGPA)<br>(Paper pass minimum) |
| < 40 | < 4.0 | F | F in paper |

| | | | |
|---|---|---|---|
| Course incomplete | | I | Course incomplete |
| * Fractional percentages should to be rounded off to the next whole number) | | | |

**XIII. Award of the Certificate:**
M.Sc Radiation Physics Degree certificate will be awarded to the successful candidates only after successful completion of the course as detailed above. However those who are not interested in Medical Physicists/RSO they can be issued certificates for four semester M.Sc course without undergoing field training/internship and project work.

**XIV. SEMESTER VISE BREAKE-UP OF COURSE CONTENT:**

| | | |
|---|---|---|
| **SEMESTER I:** | | **21 credits** |
| RPH1C01 | Mathematical Methods in Physics | 4 credits |
| RPH1C02 | Classical Mechanics | 2 credits |
| RPH1C03 | Basic Electronics | 4 credits |
| RPH1C04 | Introductory Nuclear Physics | 4 credits |
| RPH1C05. | Basics of Electrodynamics | 2 credits |
| RPH1C06 | Interaction of Radiations with Matter | 2 credits |
| RPH1C07 | Electronics Practical | 2 credits |
| RPH1C08 | Comprehensive semester viva voce | 1 credit |
| RPH1A01 | Audit course 1-Ability enhancement- Presentation skill | 2 credits* |

| | | |
|---|---|---|
| **SEMESTER II** | | **21 credits** |
| RPH2C09 | Quantum mechanics | 4 credits |
| RPH2C10 | Anatomy, Physiology and Radiobiolgy | 4 credits |
| RPH2C11 | Radiation Detection, Measurement and Instruments | 4 credits |
| RPH2C12 | Numerical Techniques and Computer programming | 2 credits |
| RPH2C13 | Radiation Physics Fundamental | 2 credits |
| RPH2C14 | Practicals in Computer applications | 2 credits |
| RPH2C15 | Practicals in Instrumentation in Radiology | 2 credits |
| RPH2C16 | Comprehensive viva voce | 1 credit |
| RPH2A02 | Audit course 2-Professional competency course- | 2 credits* |

| | | |
|---|---|---|
| **SEMESTER III** | | **21 credits** |
| RPH3C17 | Radiation Hazards safety, evaluation and control | 4 credits |
| RPH3C18 | Physics of Medical Imaging | 4 credits |
| RPH3C19 | Physics of radiotherapy | 4 credits |
| RPH3C20 | Nuclear Medicine | 4 credits |
| RPH3C21 | Practicals in Radiation Detection and Measuring Instruments | 2 credits |
| RPH3C22 | Practicals in Medical Imaging | 2 credits |

| | | |
|---|---|---|
| RPH3C23 | Comprehensive viva voce | 1 credit |
| **SEMESTER IV:** | | **19 credits** |
| RPH4C24 | Quality assurance, acceptance testing and Commissioning of Radiation systems | 4 credits |
| RPH4E25A | Radiotherapy Treatment Planning | 4 credits |
| RPH4E25B | Industrial and research applications of radiation | 4 credits |
| RPH4E26A | Modern trends in Radiology and Radiotherapy | 4 credits |
| RPH4E26B | Recent developments in industrial applications of radiations | 4 credits |
| RPH4C27 | Practicals in Radiotherapy | 2 credits |
| RPH4C28 | Practicals in Radiotherapy Planning and Dosimetry | 2 credits |
| RPH4C29 | Practicals in Q/A and calibration of radiological equipments | 2 credits |
| RPH4C30 | Comprehensive viva voce | 1 credit |
| **SEMESTER V & VI** | | **18 credits** |
| RPH5E31 | Project work | 6 credits |
| RPH6E32 | Field training | 12 credits |
| **Total credits** | | **100** |

*__Credits for the Audit Courses will not be counted for computing SGPA or CGPA. Students have to obtain only pass minimum requirements for the audit course.__

# M.Sc. RADIATION PHYSICS (MRPHY) SYLLABUS

The syllabus gives an outline of the topics to be covered during the course. However the course being one of Applied Physics having relevance to many fields like medical imaging, radiotherapy, use of radioactive nuclides etc. recent developments should be adequately taken care of in the teaching program with greater emphasis to the applied nature of the subjects.

## SEMESTER I

**RPH1C01: MATHEMATICAL METHODS IN PHYSICS 4 CREDITS**

| **Course Objectives:** |
| --- |
| • To introduce different coordinate systems and vector calculus.<br>• To introduce the basics of tensors<br>• To get familiar with matrix operations, eigen value calculation, orthogonality condition etc<br>• To prepare the students to solve higher order differential equations<br>• To teach the use of different special functions in solving physical problems<br>• To provide an understanding of Integral Transform |
| **Expected course outcomes:** |
| • Solve problems in different coordinate systems<br>• Do the basic mathematical operations on vectors and tensors<br>• Use matrix operations to solve the vibration modes of molecules.<br>• Solve higher first order differential equation using different methods.<br>• Use mathematical functions and integral transforms to solve the problems of theoretical physics<br>• Develop mathematical skills to solve problems in electrodynamics and other fields of theoretical physics |

1. **Vectors and Tensors:** Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular,

cylindrical and spherical polar coordinates, Laplacian operator, Laplace's equation – application to electrostatic field and wave equations, Vector integration,Definition of Tensors, Contraction, Direct products, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, irreducible tensors
**(14 hours)**

2. **Matrices :** Basic properties of matrices (Review only), Orthogonal matrices, Direction Cosines,Orthogonality Conditions,Euler angles,Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Eigen Vectors, Eigen values,Normal Matrices,Normal Modes Of Vibration-Example $CO_2$ molecule. **(16 hours)**
3. **Second Order Differential Equations:** Partial differential equations in Physics, Separation of variables, Singular points, Ordinary series solution, Frobenius method, A second solution, Self-adjoint differential equation, eigen functions and values, Boundary conditions, Hermitian operators, their properties, Schmidt orthogonalization, Completeness of functions **(18 hours)**
4. **Special functions :** Gamma function, Beta function, Delta function, Dirac delta function, Bessel functions of the first and second kinds, Generating function, Recurrence relation, Orthogonality, Neumann function, Spherical Bessel function, Legendre polynomials, Generating function, Recurrence relation, Rodrigues' formula, Orthogonality, Associated Legendre polynomials, Spherical harmonics, Hermite polynomials, Laguerre polynomials **(20 hours)**
5. **Fourier Series :** General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Fourier integral, Fourier transform, Properties, Inverse transform, Transform of the derivative, Convolution theorem, Laplace transform (**12 hours)**

**Textbook :**

1. G.B.Arfken and H.J.Weber: "Mathematical Methods for Physicists Ed.6, 2001, Academic Press

**Reference books :**


1. J.Mathews and R.Walker : "Mathematical Methods for Physics"( Benjamin, New York)
2. L.I.Pipes and L.R.Harvill : "Applied Mathematics for Engineers and Physicists (3rd Edition)" (McGraw Hill)
3. Erwin Kreyzig : "Advanced Engineering Mathematics - 8th edition" (Wiley)
4. M. Greenberg : "Advanced Engineering Mathematics – 2nd edition " (Pearson India 2002)
5. A.W.Joshi, Matrix and Tensors (John Wiley, New York)


**RPH1C02: CLASSICAL MECHANICS** **2 CREDITS**

| **Course Objectives:** |
| --- |
| • Introduce the concept of Lagrangian and Hamiltonian mechanics<br>• To explain two- body central problems, and equivalent one -body problem<br>• To explain canonical transformation and Poisson brackets<br>• To explain the method of Hamilton Jacobi Formulation and action angle variable techniques |

| Expected course outcomes: |
|---|
| • Apply Lagrangian and Hamiltonian formulation to solve physical systems<br>• Solve Kepler problem and scattering in a central force field<br>• Solve the problems of generating function, canonical transformation & Poisson brackets<br>• Apply Hamilton Jacobi formulation and action angle variable techniques on physical systems |

**1.Lagrangian and Hamiltonian Formulation**: Preliminary ideas about Constraints and Generalized coordinates, D'Alemberts principle and Lagrange's equation, Velocity dependent potentials, Simple applications of Lagrangian formulation,Hamilton's Principle, Conservation theorems and symmetries, Lagrange's equation from Hamilton's principle, Two- body central problems, Equivalent one -body and one dimensional problem, Kepler problem, Inverse square law of force, Laplace-Lenz vector, Scattering in a central force field, Transformation to lab coordinates. Exercises **(18 hours)**

2.**Hamiltonian Formulations:** Legendre Transformation and Hamilton's equations, Cyclic co-ordinates and conservation theorems, Principle of least action, Canonical transformations and examples, Infinitesimal canonical transformations, Poisson brackets and other canonical invariants, Equation of motion in Poisson bracket form, Angular momentum Poisson brackets, Hamilton-Jacobi equation, Hamilton's principal and characteristic function, H-J equation for the linear harmonic oscillator, Separation of variables, Action-angle variables, H-J formulation of the Kepler problem, H-J equation and the Schrödinger equation. **(19 hours)**

Books for study: Goldstein, Classical Mechanics, 3rd Edition. Addison Weley

References:

1. V.B.Bhatia : "Classical Mechanics" (Narosa Publications, 1997)
2. N.C.Rana and P.S.Joag : "Classical Mechanics" (Tata McGraw Hill, 2011)
3. R.G.Takwale and P.S.Puranik : "Introduction to Classical Mechanics" (Tata McGraw Hill, 1978 )
4. Atam P. Arya : "Introduction to Classical Mechanics, " ( 2nd Edition, Addison Wesley, 1998)

**RPH1C03. BASIC ELECTRONICS 4 CREDITS**

| Course Objectives: |
|---|
| • To give the fundamental concepts of amplifiers and transistors.<br>• To teach different types of microwave and photonic devices<br>• To understand the working of Op-amp IC and its applications<br>• To give fundamental knowledge on different types of arithmetic circuits, Flip-flops, and Counters.<br>• To introduce the architecture of 8085 microprocessor and microcontrollers |
| **Expected course outcomes:** |
| • Able to use FET and amplifiers in electronics circuits |

- Able to use microwave and photonic devices
- Design electronic circuits using Op-amp IC for different applications
- Use flip-flops and counters for data storage and counting in CPU.
- Do programming and designing of microprocessor based circuits

**1. Transistor Amplifier :**BJT: Biasing and ac models, voltage amplifiers, power amplifiers (EP 11:3 – 11-5), emitter follower , differential amplifier, FET: h-parameters, FET small signal model, biasing the FET, analysis of common source and common drain amplifiers and the high frequency response, FET as VVR and its applications. MOSFET: circuit symbol and equations, small signal model Digital MOSFET circuits. **(16 hours)**

**Texts:** 1.Electronic principles, Malvino 6th Edition, Tata McGrows Hills India 2.Integrated Electronics, Millman and Halkias, Tata McGrows Hills India

**2. Microwave and Photonic Devices**: Tunnel diode, Transferred electron devices, Negative differential resistance and devise operation, Radiative transitions and optical absorption, Light emitting diodes (LED) –Visible and IR, Semiconductor lasers - materials, operation (population inversion, carrier and optical confinement, optical cavity and feedback, threshold current density),Photo-detectors, Photoconductor (Light dependent resistor- LDR) and photodiode, p-n junction solar cells - short circuit current, fill factor and efficiency ( **12 hours)**

**Books for study:**1. S. M. Sze, "Semiconductor Devices- Physics and Technology", John Wiley &Sons.

**3. Operational Amplifier:** Dual input differential amplifier DC and AC analysis, Op-Amp, block diagram representation, analysis of a typical Op-Amp equivalent circuit ideal Op-Amp characteristics, equivalent circuit, open loop configurations, Op-Amp parameters input offset voltage & current, input bias current, output offset voltage, CMRR , Op-Amp with negative feedback: voltage series feedback amplifier: gain, input & output impedances , Frequency response, compensating networks **(14 hours)**

**Text:** Op-Amps and Linear Integrated Circuits: 3rd Edition, R. A. Gayakwad, PHI

**4. OPAMP Applications:** Summing, scaling and averaging amplifiers , Analog integrator and differentiator Electronic analog computation, Active filters: Butterworth filters (low & high orders), Low pass, High pass, band pass (wide & narrow band) and band reject filters , Oscillators: Phase shift,Wein bridge, Quadrature oscillators, Square, triangular and saw-tooth wave generators , comparators, zero crossing detectors, Schmitt trigger **(12 hours)**

**Texts**: 1. Op-Amps and Linear Integrated Circuits: 3rd Edition, R. A. Gayakwad, PHI
2. Integrated Electronics, Millman and Halkias, TMH India.

**5. Digital Electronics:** Arithmetic circuits: adder, adder/subtracter, ALU, RS, JK and JK MS flip-flops, Registers: types of registers, SISO & 7491, SIPO &74164, PIPO, 74198, applications of shift registers. Counters:asynchronous counter & 7493A, decoding gates, synchronous counters, 7490A, decade counters . D/A-A/D converters , Memory & memory addressing

**<u>Microprocessors and Microcontrollers</u>:** Microprocessor, architecture of 8085: Bus organization, Registers, memory, block diagram of 4 bit register, memory map, tri-state buffer , 8085 functional pin diagram, control & status signals, microprocessor communication and bus timing (memory read/write operations), address data de-multiplexing , microcontrollers, architectural overview and block diagram of microcontrollers , functional pin diagram of Atmega16 microcontroller. **(16 hours)**

**Texts:** **1.** Digital Principles and Applications: 6th Edition, Leach, Malvino and Saha, (Tata McGraw Hill).
2.Microprocessor Architecture and Programming and Application, Ramesh S. Gaonkar, (New Age Publishers.)
3. The 8051 Microcontroller: 2Ed, Kenneth J. Ayala, Thomson, (Delmar)
4. Atmega16 microcontroller data sheet available (from Atmel website.)

**General references:**

1. Electronic devices and circuit theory, Robert L. Boylstead & L. Nashelsky – Pearson Education.
2. Electronic devices, 5th Edition, Floyd, Pearson Education.
3. Electronic Devices and Circuits, Alen Motorshed, Prentice-Hall of India Pvt.Ltd
4. Microelectronic Circuits: Analysis & Design, M. H. Rashid, PWS Publishing
5. Linear Integrated circuits, D. R. Choudhuri, S. Jain, (New Age International)
6. Fundamentals of Microprocessors and Microcomputers, 2nd Edition, B.Ram, Dhanapathi Rai & Sons.
7. Embedded C Programming and the Atmel AVR, Barnett, O'cull, Cox, Cengate Learning.

## RPH1C04. INTRODUCTORY NUCLEAR PHYSICS 4 CREDITS

| **Course Objectives:** |
| --- |
| • To review the basics of nuclear properties.<br>• To learn the two nucleon systems and nucleon-nucleon scattering and its underlying principles.<br>• To learn different mechanism for nuclear decay.<br>• To understand different nuclear models and nuclear reactions<br>• To teach the physics of nuclear reactor |
| **Expected course outcomes:** |
| • Able to explain the basics of nucleus and nuclear properties.<br>• Explain the two nucleon system and nucleon-nucleon scattering.<br>• Able to interpret different decay mechanisms<br>• Apply selection rules to find the allowed beta decay transitions<br>• Calculate the cross section for nuclear reactions<br>• Apply principles of physics in nuclear reactor |

1. **Nuclear Forces:** Four basic forces - Gravitational, Electromagnetic, Weak and Strong - Relative strengths, Properties of the nucleus, size, binding energy, angular momentum**,** The deuteron and two-nucleon scattering experimental data, Simple theory of the deuteron structure, Low energy n-p scattering, characteristics of nuclear forces, Spin dependence, Tensor force, Scattering cross sections, Partial waves, Phase shift, Singlet and triplet potentials, Effective range theory, p-p scattering. **(14 hours)**

2. **Nuclear Decay:** Basics of alpha decay and theory of alpha emission. Beta decay, Energetics of beta decay, Fermi theory of beta decay, Comparative half-life, Allowed and forbidden transitions, Selection rules, Parity violation in beta decay. Neutrino. Energetics of Gamma Decay, Multipole moments, Decay rate, Angular momentum and parity selection rules, Internal conversion, Lifetimes. **(18 hours)**

3. **Nuclear Models, Fission and Fusion:** Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadruple moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula, Energetics of Fission process, Controlled Fission reactions. Fusion process, Characteristics of fusion, solar fusion, Controlled fusion reactors. Critical conditions, four factor formula **(16 hours)**

4. **Nuclear reactions:** Nuclear Reactions, Energetics of nuclear reactions, conservation laws, scattering and reaction cross- sections, theoretical calculation, measurement of cross-section, Nuclear reaction models-compound nucleus reactions, Direct reactions, resonance reactons, statistical theory, optical potential, heavy ion reactions. **(16 hours)**

5. **Reactor Physics:** Interaction of neutrons with mater, Nuclear Fission, Neutron Chain Reacting Systems, Criticality, Multiplication Factor, Neutron balance conditions for cryticality, Conversion and Breeding, Types of nuclear reactors, Reactor Power, Fuel Burnup, Neutron transport in reactors, Neutron current density, Equation of Condinuity, Fricks law, Diffusion Equation, Neutron moderation, Leathergy, Multiscattered neutrons, Fermi Age theory, Age equation, Solusions to the age equation, Elastic moderation time, Slowing down kernals, Neutron absorption with moderation and fission, Weak absorption, Resonance escape, Thermal neutron spectra, Reactor Power, Criticality for reactor geometries. **(16 hours)**

**Books for study**

1. H.Enge: Introduction to Nuclear Physics" (Addison Wesley)
2. John. R. Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley, USA

**Reference:**

1. H.S.Hans: Nuclear Physics – Experimental & theoretical (New Age International 2001)
2. Kenneth S Krance, Introductory nuclear physics, (Wiley india, 2012)
3. S.B.Patel, An introduction to nulcear Physics, (New Age International)
4. George I. Bell and Samuel Glasstone, Nuclear Reactor Theoy, Van Nostrand Reinhold Company, USA

**RPH1C05. BASICS OF ELECTRODYNAMICS 2 CREDITS**

| **Course Objectives:** |
| --- |
| • To review electrostatics and magnetostatics in matter.<br>• To explain various techniques for solving the boundary value problems<br>• To understand basic principles of transmission lines, waveguides and cavity resonators<br>• To explain electromagnetic radiations |
| **Expected course outcomes:** |
| • Update fundamental knowledge of electricity and magnetism<br>• Do potential formulations using gauge transformations<br>• Develop an insight on electromagnetic transmission along the transmission lines, wave guides and cavity resonators<br>• Able to explain electromagnetic effect and power radiation of a moving electric point charge |

**1. Electrodynamics:** Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor. **(14 hours)**

**2. Transmission lines, Wave guides and cavity resonators**: Transverse electromagnetic waves along a parallel plate transmission line, General transmission line equations, Wave characteristics on finite transmission lines, General wave behavior along uniform guiding structures, Rectangular wave guides, Cavity resonators **(10 hours)**

**3. Electromagnetic Radiation:** Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction **(16 hours)**

Text:

1. David K. Cheng : " Field and Wave Electromagnetics" (Addisson Wesley)

Reference books:

1. J.D.Jackson: "Classical Electrodynamics" (3rd Ed.) (Wiley,1999)
2. David Griffiths: "Introductory Electrodynamics" (Prentice Hall of India, 1989)
3. Podgorsak, Ervin B: "Radiation Physics for Medical Physicists" (Springer, 2010)
4. Helmut Wiedemann: "Particle Accelerator Physics" (3rd Ed.)(Springer, 2007)

**RPH1C06. INTERACTION OF RADIATIONS WITH MATTER 2 CREDITS**

| **Course Objectives:** |
| --- |
| • To learn different mechanisms for the Interaction of electromagnetic radiation with matter<br>• To explain the theory of collision of charged particles with matter, radioactive collisions<br>• To understand different mechanisms for the interaction of neutrons with matter |
| **Expected course outcomes:** |
| • Calculate the energy deposited by the electromagnetic radiations in matter and its effects.<br>• Able to calculate the energy deposited by the charged particle in matter and its effects.<br>• Able to calculate energy loss and diffusion of neutrons in materials |

1. **Interaction of electromagnetic radiation with matter (14 hours)**

Thomson scattering - Photoelectric absorption – Angular distribution of photoelectrons –Compton effect, Compton process – Klein Nishina cross-section – Scattering coefficients – angular distribution of Compton electrons – Pair production – Annihilation radiation, electrons – energy momentum conservation, Photo nuclear reactions,– Attenuation – Linear, mass attenuation coefficients- Total absorption coefficients. Absorption and scattering coefficients and cross sections.

2. **Interaction of electrons and heavy charged particles with Matter (16 hours)**

Classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, Cerenkov radiation, Electron, Absorption, Scattering, Excitation and Ionization. Values of w in different media, radioactive collision– Radiation energy loss (bremsstrahlung)– Range of beta particles, Range straggling, absorption of beta particles and back scattering, self absorption . Interaction of heavy charged particles with matter –Energy loss by collision, maximum energy loss in a single collision, range energy relation- Bragg curve, specific ionization, Bethe-Bloch formula for collision, stopping power and radiation stopping power

3. **Interaction of Neutrons with Matter (10 hours)**

Neutron capture Neutron sources, properties, energy classification, Elastic and inelastic scattering coefficients and cross sections– Energy transfer and logarithmic energy decrement, Inelastic scattering, Nuclear reaction, Dependence on E and Z, (n, p), (n, 2n), (n, f) and other reaction, Neutron activation, Radio- isotope production. Familiarization of standard data libraries

**STANDARD BOOKS FOR STUDY**


1. E.B Podgorsak : "Radiation Physics for Medical Physicists". Springer, USA

2. F.H.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.

**REFERENCES**

1. R.D Evans : "The Atomic Nucleus" (Tata -McGraw Hill Publishing Company)
2. G.F.Knoll : "Nuclear Radiation Detectors" (Willy international, New york)
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
5. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
6. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981.
7. F.M Khan : "Physics of Radiation Therapy"- Fourth Edition
8. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.

PRACTICALS:-

**RPH1C07. ELECTRONICS PRACTICALS (70 Hours) 2 CREDITS**

( Minimum 12 expts. are to be carried out)

| **Course Objectives:** |
| --- |
| • To attain hands on training for measuring, value of passive and active components<br>• Demonstrate design, construction and testing of basic electronics circuits |
| **Expected course outcomes:** |
| • Able to measure the values of active and passive electronic components<br>• Able to design, construct and test the electronic circuits |

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 – Measurement of Ripple
5. Characteristics of a regulated power pack using 2N3055
6. DC voltage regulator using OPAMP
7. Feedback amplifier
8. Construction of an oscillator
9. Multivibrator- Monostable and astable
10. Low pass and high pass filter -first and second order
11. OPAMP circuits – Inverting and non inverting amplifiers
12. Integrator and differentiator circuit using OPAMP
13. Simple D/A converter – Ladder type
14. Coincidence and anti-coincidence timed circuits
15. Pulse shaping circuits
16. Microprocessor experiments (Addition, subtraction, division and multiplication – 8 bit using 8085)

**RPH1C08 Comprehensive semester viva voce** **1 credit**
**RPH1A01 Audit course 1-Ability enhancement- Presentation skill** **2 credits**

## SEMESTER II

## RPH2C09. QUANTUM MECHANICS 4 CREDITS

| **Course Objectives:** |
|---|
| • Make aware about the basic formulations in quantum mechanics and the different types of representations of state and operators that are very useful in studying the subject deeply.<br>• Familiarization of Hermitian operators, their eigenvalues and eigenvectors and also the various commutation and uncertainty relations.<br>• Familiarization of unitary transformations, Dirac delta function, matrix representation of operators and their applications.<br>• Introduce angular momentum operator and their representation in spherical coordinates and addition of angular momenta<br>• Insight to classical and quantum mechanical approach for Scattering from low energy to high energy. |
| **Expected course outcomes:** |
| • Able to do practical aspects of complex vectors and kets<br>• Interpret the results of experiments in terms of quantum theory<br>• Apply the postulates of quantum mechanics to specific physical situations<br>• Calculate the probabilities of measurement outcomes and the future state of a system from its initial state and its Hamiltonian<br>• Able to explain the quantum scattering. |

**1.Formulation of Quantum Mechanics**: Vector spaces, The Hilbert space,Dimensions and basis, Operators and properties, Representation of vectors and operators,Commutator, Functions of operators, Eigen values and eigen vectors, Matrix representation of bras, kets and operators, Coordinate and momentum representations and their connection, The fundamental postulates Probability density, Superposition principle, Observables and operators, The uncertainty principle **(16 Hours)**

**2. Quantum Dynamics** : The equation of motion, Schrödinger, Heisenberg and the Interaction pictures of time development, The linear harmonic oscillator in the Schroedinger and Heisenberg pictures, Hydrogen atom problem **(24 hours)**

**3. Theory of Angular Momentum**: Angular momentum operators, Matrix representation of angular momentum operators, Pauli spin matrices, Orbital angular momentum, The hydrogen atom, Addition of angular momenta, Clebsh-Gordon coefficients, Simple examples **(12 hours)**

4. Symmetry and Conservation Laws : Space-time symmetries, Space translation and conservation of linear momentum, Time translation and conservation of energy, Space rotation and conservation of angular momentum, Space inversion and time reversal, Identical particles, Construction of symmetric and anti symmetric wave functions, Slater determinant, Pauli exclusion principle, Bosons and Fermions, Spin wave functions for two electrons, The ground state of He atom, Scattering of identical particles **(12 hours)**

**5. Scattering** : Classical approach for Scattering in a central force field- alpha scattering, Transformation to lab coordinates. Quantum mechanical approach -Scattering cross section and scattering amplitude, Low energy scattering by a central potential, The method of partial waves, Phase shifts, Optical theorem, Convergence of partial wave series, Scattering by a rigid sphere, Scattering by a square well potential, High energy scattering, Scattering integral equation and Born approximation **(14 hours)**

**Books for study**: N.Zettili, Quantum Mechanics – Concepts and applications (John Wiley&Sons, 2004)

**Reference books**:

1. V.K.Thankappan: "Quantum Mechanics" (Wiley Eastern)
2. L.I. Schiff: "Quantum Mechanics" (McGraw Hill)
3. P.M.Mathews and K.Venkatesan : "A Textbook of Quantum Mechanics" (TataMG Hill)
4. J.J.Sakurai : "Modern Quantum Mechanics" (Addison Wesley)
5. A.Ghatak and S.Lokanathan : "Quantum Mechanics" (Macmillan)

**RPH2C10. ANATOMY, PHYSIOLOGY AND RADIOBIOLGY 4 CREDITS**

| **Course Objectives:** |
|---|
| • To familiarize the action of ionizing radiation in living matter<br>• Analyze Radiation biology<br>• Able to understand the cell biology and kinetics<br>• Understand the radio-biology of cancer and normal tissue toxicity<br>• To understand dose response in living cells |
| **Expected course outcomes:** |
| • Able to explain the basic anatomy & physiology of human body and its importance in radiotherapy and radiology.<br>• Able to explain the clinical and treatment aspects of oncology.<br>• To explain the effect of radiation in living beings at various levels.<br>• To explain the radio-biological effectiveness<br>• Explain different parameters of biological damage |

1. **Basic Anatomy** : Introduction to the Human Body, Skeletal System, Muscular System, Nervous Tissue, Central Nervous System, Peripheral and Autonomic Nervous Systems, Cardiovascular System, Lymphatic System and Body Immunity, Respiratory System, Digestive System, Urinary System, Water and Electrolyte Balance, Reproductive System, Xray anatomy, CT/MRI anatomy surface anatomy applied to RD and RT **(16 hours)**

2. **Clinical Aspects of Radiation Oncology:** Biology of cancer and tumor, catagories of disease, treatment modalites-Radiation therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy & radionuclide therapy, Benign and malignant disease, Methods of spread of malignant disease, Treatment intent, Curative & Palliative **(12 hours)**

**3. Radiation Chemistry and Cell Kinetics:** Elements of cell biology, Action of ionizing radiation on living cells –Direct and indirect actions, effects at Molecular level, Radiation Chemistry, Stochastic Nature Of Energy Transfers CellularLevels, Reactions Of The Products of Water Radiolysis, G Value, Expression Of Yield In Radiation Chemistry, Products Of Radiolysis, Fricke Dosimeter Direct And Indirect Action, Recombination, Restitution and Repair, DNA Structure And Radiation Damage, Theories And Models For Cell Survival, Clonogenic Survival, Biological Survival Curves, Development Of The Target Theory Model, MultitargetSingleHit Survival, Molecular Models For Cell Death, Molecular Theory Of Radiation Action, Survival Curve And Its Significance, Significance Of Shoulder On The Survival Curve, Repair Of Sublethal Damage, Repair Of Potentially Lethal Damage. **(18 hours)**

4. **Radiobiological Concepts:** Linear energy transfer and its effect, Tumor lethal dose, tissue tolerance dose and therapeutic ratio, Radiobiological effectiveness (RBE), Oxygen effect, Oxygen enhancement ratio(OER), Five R's of Radiobiology, TCP/NTCP Time dose fraction(TDF) basis for dose fractionation in radiotherapy Concept of nominal standard dose (NSD), Linear Quadratic models, AlphaBeta concepts. BED, Rate equations Sensitizers and Protectors, Reduction of side effects. Somatic effects of radiation –Acute radiation sickness –LD50 dose –Effect of radiation on skin –Blood changes –Sterility –Cataract formation –Effects of chronic exposure to radiation. Doubling dose and its effect on genitic equilibrium, Tissue structure and radiation effect, Radiation effect on fetus, Fractionation and its effect, effect on different systems dependence on dose and dose rate, tolerance limits for various systems, acute radiation syndrome, effects of low level irradiation, effects relevant to women, fetus and children **(22 hours)**

5. **Modifiers and Dose limits**: Modification Of The Radiation Response, Role of Water Temperature And Radiation Damage, Oxygen Effect, Modification of The Radiation Response, Hypoxia And Radiosensitivity in Tumor Cells, Late Effects of Radiation on Normal Tissues, Nonstochastic/ Deterministic Effects Stochastic Effects, Fractionation and protraction of exposure in the modification of late radiation injury, Stochastic Effects Radiation Carcinogenesis, Biological Modifiers, Cell Kinetics, Cell Cycle Control Mechanisms, RTOGs, IMAMI and CONTEC recommendations **(14 hours)**

Books for study

1. Radiobiology- Hand book for teachers and students, TC-42, IAEA,2010

Reference:
1. Delmar's "Fundamentals of Anatomy & Physiology", Thomson LearningUSA, 2001
2. A LANGE medical book "Basic Radiology" 2nd Edition, The McGrawHill2011
3. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.
4. EJ Hall and Amato J Glaccia, " Radiobiology for the Radiologist", 7th Edn., Lippincott Williams &Wikins, USA
5. IAEA, AERB , NCRP PUBLICATIONS ON DOSE LIMITS.

**RPH2C11. RADIATION DETECTION, MEASUREMENT AND INSTRUMENTS**
**4 CREDITS**

| **Course Objectives:** |
| --- |
| • To understand the theory and techniques of gas filled and scintillation detectors<br>• Learn the different type of semiconductor detectors, thermo luminescent dosimetry and its applications in Radiotherapy.<br>• To understand the principle of various neutron detectors<br>• Understanding of the principles of signal processing and nuclear instruments.<br>• Explain the errors and its analysis in nuclear data acquisition |
| **Expected course outcomes:** |
| • Able to use gas filled and scintillation detectors for radiation detection<br>• Able to use different type of detectors for dosimetry.<br>• Able to measure neutron dose<br>• Able to design and setup radiation measurement systems<br>• To evaluate the uncertainties in the measured nuclear data. |

**1. Gas filled , Scintillation Detectors:** Relationship Between Voltage and Charge Collected -characteristic curve, Different Types of Gas-Filled Detectors, Ionization Chambers, Proportional Counters, Geiger-Muiller Counters, Gas-Flow Counters, Rate Meters Scintillation detectors, Inorganic (Crystal) Scintillators , Organic Scintillators , Gaseous Scintillators , The Relationship Between Pulse Height and Energy and Type of Incident Particle , The Photomultiplier Tube, Assembly of a Scintillation Counter and the Role of Light Pipes, Dead Time of Scintillation Counters, Sources of Background in a Scintillation Counter, Resolving time and resolving power of detectors. **(14 hours)**

**2. Semiconductor, Thermo luminescent Dosimetry Miscellaneous Detectors::** Different Types of Semiconductor Detectors - Surface-Barrier Detectors - Diffused-Junction Detectors - Silicon Lithium-Drifted [Si(Li)] Detectors - Germanium Lithium-Drifted [Ge(Li)] Detectors - germanium (Ge) Detectors -CdTe and HgI Detectors - Radiation Damage to Semiconductor Detectors , Detector Telescopes (E-dE Detectors), Position-Sensitive Detectors. Thermo luminescent dosimetry; process and properties, photon energy dependence, fading, residual TL and annealing for reuse, repeated read out of TLDs, TL- instrumentation, beta, gamma extremity dosimetry, ultra thin TLDs, graphite/boron carbide mixed TLDs, glow curve analysis, -common TLD materials, their characteristics, energy dependence and method of use. Chemical dosimetery, Organic and inorganic systems, Fricke dosimeter, FBX dosimeter, Free radical dosimeter – Ceric sulphate dosimeter, Other high and low level dosimeters, Applications in Radiotherapy and industrial irradiators, Glass dosimetry, Calorimetry, Instruments of personal monitoring, films, digital pocket dosimeters ,Radiation survey meter, Contamination monitors ,gamma ray spectrometer, whole body monitor etc. , Thermal and fast neutron survey meters **(20 hours)**

**3. Neutron Detectors, Spectroscopy:** The BF3 Counter, 6Li- Counters, 3He proportional counter, Fission Chambers, Neutron Detection by Foil Activation (Activation counter), Detection of Fast Neutrons using Threshold Activation Reactions (Threshold Detector), The Time-of-Flight Method, Bubble chambers, Sources of Radiation, Irradiation of the Sample, Counting of the Sample, Analysis of the Results, Advantages and Disadvantages of the Activation Analysis Method ,Measurement of neutron flux -Activation and absorption methods, CR -39 films, SSNTD, Albedo Dosimeter, Manganese Bath, Precision long Counter. **(16 hours)**

**4. Nuclear Instrumentation:** NIM Concept, High-Voltage Power Supply, Preamplifier, Amplifier, Oscilloscope, -Differentiating Circuit- Integrating Circuit- Delay Lines- Pulse Shaping- Timing- Coincidence -Anti coincidence Measurements, Pulse-Shape Discrimination, Discriminator- Single-Channel Analyzer (SCA). energy measurements, introduction to spectroscopy: Definition of Energy Spectra, Measurement of an Integral Spectrum and Differential Spectrum, Energy Resolution of a Detection System, Multichannel Analyzer (MCA) -calibration, Timer, Analog-to-Digital Converters (ADC). Time of flight spectrometer, charged particle spectroscopy, Measurement of energy straggling, **(16 hours)**

**5. Counting Statistics and error analysis:** Characterization of data, Statistical models- binomial - poisson -normal distributions, Application of statistical models -checkout for consistency -precision of single measurement, Error propagation- sum -difference - multiplication- division -mean value of combination, Optimization of counting experiments, Limits of detectability, Distribution of time intervals -successive events - time to next event -scaled event -Error analysis- Accidental and systematic errors, error distribution and error function, error in numerical computations and propagation of errors, applications in calibration of instruments, standards in overall error estimation, applications to evaluation of noise in amplifier system, examples of medical statistics for follow up studies **(14 hours)**

**BOOKS FOR STUDY**

1. Nicholas Tsoulfanidis - Measurement and Detection of Radiation, second edition
2. G.F.Knoll, Radiation detection and measurements, 3rd edn, John Wiley, New York

**AND REFERENCES**

1. W.E. Burcham & M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. Mcknlay, A.F., Bristol, Adam Hilger , Thermoluninescense Dosimetry-Medical Physics Handbook 5,,CRC Press, USA
3. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
4. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series Adam Hilger Ltd., USA

**RPH2C12. NUMERICAL TECHNIQUES AND COMPUTER PROGRAMMING**
**2 CREDITS**

| **Course Objectives:** |
|---|
| • To introduce the numerical methods, for obtaining solutions to mathematical problems in physics.<br>• To familiarize elements of error analysis using Romberg's method.<br>• Familiarization of interpolation methods<br>• Learn the eigen value problems, solution of matrix problems using programming techniques<br>• Familiarization of C programming |
| **Expected course outcomes:** |
| • Able to find numerical solution of algebraic equations using different methods<br>• To perform various application and interpolation methods and finite difference concepts.<br>• Able to develop an algorithm that implies efficient calculations and implement it in a programming language.<br>• Able to execute programs and its visulisation.<br>• Able to develop specific computer programs to solve practical problems using C programming. |

1. **Roots of transcendental equations**: Location theorem, Bisection (half interval) method- Method of false position (Regula Falsi), Graphical Method, Newton-Raphson method, Geometric significance, inherent error, convergence of Newton Raphson method, Special procedure for Algebraic equations, Iteration Method, Geometry and convergence of iteration process. **(10 hours)**

2. **Interpolation and curve fitting** : Errors in polynomial interpolation, Detection of errors, Linear interpolation, Interpolating polynomials, Lagrange interpolating polynomial, Difference calculus, Detection of errors, Newton forward and backward difference formulae, Least squares curve fitting( linear and nonlinear), **(9 hours)**

3. **Numerical integration and Ordinary differential equations** : Numerical differentiation, Maximum and minimum value, Numerical integration, Trapezoidal and Simpson’s methods, Newton Cote’s method, Gauss quadrature, Solution of ordinary differential equations – Euler’s Maclaurin method, Runge-Kutta methods, **(9 hours.)**

4. **Determinants and matrices:** Evaluation of numerical determinants, Cramer's rule, Successive elimination of unknowns-division by leading co-efficients, Gauss method,solution by inversion of matrices:Solution of equation by matrix methods, Systems soluble by Iteration and condition for convergence. The Eigenvalue problem-Eigen values of asymmetric tridiagonal matrix-Householder's method-QR method, Enough Exercises **(12 hours)**

5. **C Programming fundamentals (to be taught as a part of practicals)** : Constants and variables, Data types, Type declaration of variables, Symbolic constants, Arithmetic operators, Increment and decrement operators, Conditional operator, Bitwise operators, Hierarchy, Arithmetic expressions, Logical operators and expressions, Assignment operators, Arithmetical and assignment statements, Mathematical functions, Input/output statements, Formatted I/O, Relational operators, Decision making and branching, Go to, if, if…else, switch statements, Looping, While, do and for, Arrays, Handling characters and strings, Functions and voids, Structures, Pointers(elementary ideas only), File operations (defining, opening, reading, writing, updating and closing of files (**20hours)**

**Books for study**:

1. S.S.Shastry : “Introductory methods of **N**umerical analysis” (Prentice Hall of India,1983)
2. E.Balaguruswamy : “Programming in ANSI C” (Tata-McGraw Hill, 1992)

**Reference Books** :

1. V. Rajaraman : “Programming in C”, PHI
2. J.H. Rice : Numerical methods-software and analysis (McGraw Hill, 1983)
3. J.B. Scarborough: Numerical mathematical analysis (Oxford and IBH, 6th Edn)

**RPH2C13. RADIATON PHYSICS FUNDAMENTAL 2 CREDITS**

| **Course Objectives:** |
|---|
| • To familiarize various radiation quantities and units used in radiation dosimetry.<br>• Understand standardization of radiation dosimetry equipments |
| **Expected course outcomes:** |
| • To evaluate radiation exposure and radiation dose.<br>• To explain the parameters of radiation dosimetry<br>• To explain the functioning of primary and secondary standards for dose measurements and standardization of X ray, electrons and gamma ray beams. |

1. **Radiation Quantities and Units:** Radiation quantities and units – Radiometry , Particle flux and fluence, Energy flux and fluence, Cross section, Mass energy transfer and mass absorption coefficients, LET - Radiation chemical yield – W value – Dosimetry – Energy imparted –Absorbed dose- Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose, Concepts of collective dose – KERMA- CEMA, XEMA, TERMA, 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). **(20 hours)**

2. **Standards and Measurement of Ionizing Radiation:** Standards – Primary and Secondary Standards, Traceability, Uncertainly in measurement. Bragg-gray principle and air wall chamber, Standardization of X-ray, electrons and gamma ray beams: Determination of exposure and air kerma, conditions for the realization of exposure, ionization chamber for low, medium and high energy x-rays and gamma rays, determination of absorbed dose, -Bragg Gray theory and its validity, Burlin's theory for measurement for radiation quantities, design of free air chambers(FAIC), thimble chamber, chamber calibration, Electrometers, Parallel plate chambers, Ion collection, Polarity effect, Measurement of exposure, Radiation absorbed Dose, Kerma, Relation between Dose, Kerma and exposure. Calculation of Absorbed Dose from Exposure. Effective point of measurement. Calibration of secondary standards-Calibration factors-Concepts of protocols **(20 hours)**

**BOOKS FOR STUDY**


1. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
2. ICRU Report No. 85, Journal of ICRU Vol. 11 No1.(2011) Oxford University Press
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980


**REFERENCES**


1. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
2. W.R.Hendee, Medical Radiation Physics, Year Book – Medical Publishers Inc. London, 1981.
3. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
4. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981


**RPH2C14- PRACTICALS IN COMPUTER APPLICATIONS 2 CREDITS**

Minimum experiments to be carried out - 12. **(70 Hours)**

| **Course Objectives:** |
|---|
| • Enhance the ability to solve problem using C programming. |

| |
|---|
| • Learn the importance of numerical methods of solving differential equations.<br>• Study curve fitting techniques using principle of least square fitting.<br>• Confirm basic quantum mechanical ideas using C programming |
| **Expected course outcomes:** |
| • Demonstrate the basic quantum mechanical concepts using C programming.<br>• Apply numerical methods to solve differential equations.<br>• Implement numerical integration techniques and illustrate it with the help of C programming.<br>• Analyze different curve fitting methods and study error estimation.<br>• Develop Problem solving skills. |

1. Solution of quadratic equation
2. Curve fitting methods- Least squares, chi square,
3. Error estimation in curve fitting with - in Gausian, exponential, polynomial
4. Numerical interpolation
5. Numerical Integration(Simpson's method)
6. Numerical solution of first order differential equation by Runge_Kutta method
   Simulation (BASIC / C)
7. Quantum mechanical particle in a box
8. Bouncing ball
9. Phase space plots for damped and undamped oscillator
10. Transmission coefficient for a potential barrier
11. Evaluation of pi (p) using montecarlo
12. Simulation detector response
13. Alpha scattering
14. Attenuation of radiations
15. Dose evaluation using stopping power table

**RPH2C15. PRACTICALS IN INSTRUMENTATION IN RADIOLOGY** (70 Hours)
**2 CREDITS**
(Minimum 12 expts. to be carried out )

| **Course Objectives:** |
|---|
| • Demonstrate the functioning of GM counter and its uses<br>• Demonstrate the working of Scintillation counter, SSNTD, Solid state detector and determination of energy of radiations.<br>• Demonstration of radioactivity measurement and calibration of radiation equipments<br>• Measurement of absorption coefficients of materials and attenuation coefficients of radiations |
| **Expected course outcomes:** |
| • Able to use GM counter for radiation measurement.<br>• Able to use Scintillation counter, SSNTD and Solid state detectors<br>• Calibration of radiation equipment<br>• Measure the linear and mass attenuation coefficients for gamma rays. |

1. GM counter – characteristics – plateau and variation of pulse height with applied voltage and resolving time
2. GM counter – Statistics of counting
3. GM counter – Inverse square law properties
4. Gamma ray spectroscopy using NaI(Tl) -characteristics – plateau and variation of pulse height with applied voltage
5. Scintillation spectrometer – Calibration and determination of unknown energy
6. Measurement of linear and mass attenuation coefficients for a gamma ray beam using GM counter
7. Measurement of range of Beta rays (1) in air (2) in material like aluminum and calculation of absorption coefficients- GM counter – Feather Analysis – end point energy
8. Absorption of Gamma rays from different isotopes -energy and Z dependence
9. Alpha spectroscopy using solid state detectors- determination of energy
10. Experiments with solid state nuclear track detector(SSNTD)
11. Resolution of Scintillation counter at various energies
12. Resolution of Ge/Si detector at various energies
13. Gamma Spectrometer - Compton scattering- angle -energy relation
14. Determination of half life of a short lived isotope
15. Characteristics of a flow type proportional counter
16. Measurement of radioactivity using an isotope calibrator
17. Measurements using radiation monitor

**RPH2C16 Comprehensive viva voce 1 credit**
**RPH2A02 Audit course 2-Professional competency course- 2 credits**

## SEMESTER III

**RPH3C17. RADIATION HAZARD, SAFETY, EVALUATION AND CONTROL 4 CREDITS**

| **Course Objectives:** |
|---|
| • To learn different radiation hazards and basic principles of time, distance and shielding<br>• Learn about different kinds of radioactive packages and its transport<br>• Study on methods of radioactive waste disposal<br>• Understand administrative and legislative aspects of radiation protection.<br>• Learn on radiation facility designing. |
| **Expected course outcomes:** |
| • Able to observe the different radiation hazards, in vivo dosimetry, classification of different RIA laboratories and effect of time, distance and shielding and its calculation |

against different types of radiations.
- Able to handle different types of radioactive packages, classification of packages, labeling of radioactive packages for transport, transport index calculations.
- Trained on different methods using radioactive waste management, disposal of radioactive waste, emergency preparedness of handling of radioactive waste.
- Able to assess legal compliance of radiation protection of national and international regulatory authorities, role of AERB and atomic energy act.
- Able to design and implement room layout and wall thickness calculations of different radiation facilities like diagnostic x ray, radiotherapy and nuclear medicine.

**1. Radiation Hazard :** Radiation Hazard- external, internal hazard, Radiation Hazard Evaluation by Calculation and measurement. Calculation of specific gamma constant. RHM, RMM, Area monitoring, personal monitoring Internal Hazard Evaluation by Calculation and measurement – inhalation, ingestion, and Absorption, Physical Decay, Biological Decay. Bioassay, Whole Body counter. Internal Radiation hazard Evaluation and Control, contamination on work surfaces, person and samples – Internal radiation hazards – Radio toxicity of different radio nuclides and the classifications of laboratories – General requirements of class A, class B and class C laboratories – Basic Principles for control of contamination, -Methods of decontamination.

Effects of distance, time and shielding – Shielding calculations, Alpha, Beta, Neutron Shielding, Shielding thickness calculation, Narrow Beam/ good geometry, Broad beam geometry, HVT, TVT , relation between TVT and HVT **(18 hours)**

**2. Transport of Radioactive Material:** Introduction, Regulatory aspects, Objective of the regulations, Radioactive Material, Special form Radioactive Material, A1, A2 values, Determination of A1/ A2 values of radionuclides, Contamination, Exclusive Use, Low specific activity material, Surface Contaminated object, Shipment under special arrangement, Package- Excepted package, Industrial (IP-1, IP-2, IP-3) package, Type A package, Type B package, type B(U) /(M), Type C package. Contents limit for package, General requirements for all types of packages, Additional requirements for packages transported by Air, Requirements for Type A , B(U), B(M), C packages, Test Procedures: Test for special form radioactive material, Tests for different types of packages- Type A, Type B(U),B(M) and Type C. Approval and Administrative Requirements, Contamination level for packages, Categories of packages, Transport Index, Radiation level on Surface, Marking , Labeling and Placarding. Consignor's Responsibility, Emergency Response Requirements on transport accidents. **(16 hours)**

**3. Radiation waste Disposal:** Disposal of radioactive wastes,Sources of radioactive waste, Classification of wastes, Permissible levels and authorization, Disposal of liquid wastes, Treatment techniques, for solid, liquid and gaseous effluents, permissible limits for disposal of wastes, Sampling technique for water, air and solid, ecological considerations, general methods of disposal, management of radioactive waste in hospital and research establishments, Meteorological parameters. Emergency preparedness, emergency handling, graded approach, site emergency. Safe custody of sources- procedures for issue for applications - methods of eventual disposal. **(14 hours)**

**4. Administrative and legislative aspects of radiation protection:** Aims of Radiological Protection, need for protection, System of Radiological Protection, - Justification, Optimization, Dose Limit,Types Of Radiation Exposure- Fetus Dose, Radiation trainee Dose limit, external and internal exposure, additive risk model and multiplicative risk model, risk coefficients, Emergency/ Interventions, ICRP and AERB recommendations, Atomic Energy Act, Radiation Protection Rules (RPR). Applicable Safety Codes, Standards, Guides and Manuals. Regulatory Control – Licensing, Inspection And Enforcement. Responsibilities of Employers, Licensees, Radiological Safety Officers And Radiation Workers **(16 hours)**

**5. Safety Concern on Therapy/Diagnostic/Brachytherpay Room Planning:** Shielding materials, Site selection, Area requirements, Parameters used for shielding calculations, Use factor, work load, Occupancy Factor, TVT, HVT, Radiation dose- Permissible limits, Calculation of Shielding thickness for the walls and ceiling- primary wall, secondary wall, Maze wall and its importance, Width of Primary barrier, Calculation of secondary thickness, scattered radiation, leakage radiation, Radiation at Door level. Neutron dose shielding in high energy Linac. Workload of x-ray machine, Shielding calculation for diagnostic X-ray rooms, Dose due to primary, leakage, scattered radiations, Lead lining of the Door. Brachytherapy Room calculation for Manual after loading, Remote After loading and HDR. **(16 hours)**

**STANDARD BOOKS FOR STUDY AND REFERENCES**


1. NCRP, ICRP, ICRU, IAEA, AERB Publications.
2. S.P.Yaremonenko, “Radiobiology of Humans and Animals”, MIR Publishers, Moscow, 1988.
3. R.F. Mold “Radiation Protection in Hospitals” Adam Hilger Ltd. Bristol, 1985.
4. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey &Sons, Inc. New York, 1981.
5. Herman Cember. “Introduction to Health Physics”


**RPH3C18. PHYSICS OF MEDICAL IMAGING 4 CREDITS**

| **Course Objectives:** |
|---|
| • Study on x-ray production and its physics, different types of x-ray tube and x-ray generators.<br>• Learn about different image receptor systems like screen film radiography.<br>• Trained on Computed tomography and applications.<br>• Study on basic principles of ultrasound.<br>• Understand nuclear magnetic resonance and MRI |
| **Expected course outcomes:** |
| • Able to explain x-ray production and its physics, different types of x-ray tubes and x-ray generators.<br>• Able to handle different image receptor systems like screen film radiography, latent image formation, film processing, dark room and film characteristics. |

- Trained on basic principles of CT scan and its instrumentation, generations of CT, various image reconstruction methods, artifacts in CT, principles of fluoroscopy and its working, special radiographic technique like micro radiography, auto radiography, flash radiography and industrial radiography.
- Able to explain ultra sound production, application in medical imaging, different types of ultra sound transducers and different scanning modes.
- Understand the principles of nuclear magnetic resonance imaging and its physics, MR hardware, different coil system, different types of magnet using in MRI, quenching, T1 and T2 relaxation time, pulse sequences using in MR imaging, MR artifacts, safety and bio effects.

**1. X-Ray Production, X-Ray Tubes and Generators:** Discovery of X-rays, Production and properties of x-rays ,X-ray tubes, X-ray tube insert, tube housing, filtration and collimation, X-ray generator -function and components, -circuit design, Timers in radiography. Factors affecting x-ray emission Power rating and heat loading x-ray exposure rating charts. Nature of Cooling, Safety devices in X-ray tubes, Mammograph**y -** X-ray tube design, X-ray generator and phototimer system, compression scattered radiation and magnification, screen-film cassettes and film processing, Ancillary procedures, radiation dosimetry. **(16 hours)**

**2. Screen-Film Radiography and Film Processing:** Basic geometric principles of radiographic image, Latent image, screen-film system, construction and Characteristics, optical density, contrast, speed and latitude, Types of films, intensifying screens – construction and action, Types of screens-rare earth, Fluoroscopic, Film exposure, Radiographic grids. Film processing, Automatic Film Processing, artifacts, Processor QA, Contrast and dose in radiography, scattered radiation in projection Radiography, reduction of patient dose, patient dose measurement, dose level for diagnostic procedures, methods to reduce patient dose. **I**mage Quality **–**Unsharpness, Spatial resolution, Contrast**,** contrast agents, Image Noise, Image distortion and artifacts, detective quantity efficiency, sampling and aliasing in digital images, contrast-detail curves

**(16 hours)**

**3. Computed Tomography and Other X-ray techniques:** Basic principles, Historical development, Detectors and detector arrays , Details of acquisition, Reconstruction algorithms, Radon Transform, Back Projection, Filtered Back projection, Iterative Reconstruction, ML-EM, Digital image display, scan motions, x-ray sources, collimation, X-ray detectors, viewing system, Radiation Dose, Image quality, Artifacts, Fluoroscopy, image intensification, Digital fluoroscopy, Automatic Brightness Control, Cine fluorography, Xeroradiography-. Digital Radiography- Thermography-Basic principles, scanning techniques, radiation dose to patients, Radiography of welds-casting and forgings, Microradiography, Autoradiography, Flash radiography, X-ray diffraction analysis. **(16 hours)**

**4. Ultrasound:** Basic principles, Characteristics of sound, nature and production of ultrasound, interaction of ultrasound with matter, Transducers and their design, Piezoelectric effect, frequency response of transducers, various types of transducers, Ultrasound beam properties, Image data acquisition, Dynamic range, Different scan modes-A,B,M modes, Two-Dimensional image display and storage Real time scanning, Principles of Gray-scale imaging, significance of gain and gain compensation, pulse rate and its significance, Resolution and frequency, depth and frequency, Image quality, artifacts, Doppler techniques and principles of colour Doppler , System performance and QA, Acoustic power and biological effect of ultrasound **(16 hours)**

**5. Nuclear Magnetic Resonance (NMR) and MRI:** Magnetization properties, Generation and detection of magnetic resonance signals, Interaction of nuclei with a static magnetic field, Rotation and precession, Interaction of nuclei with radiofrequency wave, induction of a magnetic resonance signal in a coil, Quantum mechanical interpretation, Bulk magnetization, relaxation processes:T1 and T2, Relaxation times (T1 and T2) quality assurance, acceptance testing and commissioning of radiation system for biologic materials. Pulse sequences, spin echo, Inversion recovery, Gradient recalled echo, signal from flow, perfusion and diffusion contrast, Magnetization transfer contrast, Principles of MRI, Localization of MR signal, k-space data acquisition and image reconstruction, 3d Fourier transform image acquisition, image characteristics, angiography and magnetization transfer contrast, artifacts, instrumentation, safety and bioeffets. **(16 hours)**

**STANDARD BOOKS FOR STUDY AND REFERENCES**

1. Diagnostic radiology for teachers and students, IAEA Publication, *Pub1564*
2. N. Smith and A. Webb , Introduction to Medical Imaging Physics, Engineering and Clinical Applications 2011,Cambridge University Press
3. W.J. Meredith and J.B. Massey "Fundamental Physics of Radiology" John Wright and Sons, UK, 1989
4. Christensen 'Physics of Diagnostic Radiology' Lea and Febiger – Philadelphia (1990).
5. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981
6. P. Sprawls, Magnetic Resonance Imaging: Principles, Methods and Techniques, Medical Physics Publishing, Madison (2000)

**RPH3C19. PHYSICS OF RADIOTHERAPY 4 CREDITS**

| **Course Objectives:** |
| --- |
| • Study basic therapy physics used for radiation therapy.<br>• Learn in depth about the various dosimetric parameters.<br>• Attain experience in radiotherapy treatment planning.<br>• Study on electron beam therapy.<br>• Knowledge on brachytherapy. |
| **Expected course outcomes:** |
| • Able to explain electromagnetic spectrum, radioactive decay, physics of x-ray production, various clinical radiation generators and external beam therapy machines.<br>• Acquired knowledge in different dosimetric parameters using for radiotherapy |

calculations like PDD, TAR, TMR etc.., and various beam modifying devices.

- Able to implement different radiotherapy planning techniques.
- Able to explain interactions of electron with matter, electron depth dose curves and profiles for various energies and electron beam therapy planning.
- Able to handle different radioactive sources using in brachytherapy and its characteristics, source strength verification using different protocols, different dosimetric systems and various kinds of brachytherapy.

**Unit 1: Basic Therapy Physics:** Electromagnetic Radiation, Nuclear Transformation, Decay Process, Radioactive Equilibrium, Modes of Radioactive Decay, Nuclear Reactions, Activation of Nuclides, Nuclear reactors, physics of X-ray Production-Bremsstrahlung, Characteristic, X-ray Spectra, Clinical Radiation generators- Kilovoltage units, Grenz Ray, Superficial therapy, Deep therapy, Megavoltage, Vande Graff, Medical linear accelerators and its components, Magnetron, Klystron, Betatron, Microtron, Cyclotron, Co-60 teletherapy unit, Source description, Source Housing, Penumbra, Heavy particle beam, **(16 hours)**

**Unit 2: Dose Distribution and Dosimetric Calculations:** Phantom, Depth Dose Distribution, PDD, factors effecting PDD, Mayneord factor, TAR, Dose Calculation, SAR, TPR, Collimator factor(Output factor) , Phantom scatter factor, TMR, Accelerator calculations- SSD technique and SAD technique. SPR, SMR, Isodose chart, Measurements of Isodose curves, Parameters of Isodose curves, Wedges Filters, Combination of Radiation fields, Parallel opposed Field, Integral Dose, Multiple Fields, Isocentric, Rotation Therapy, Wedged field technique, Wedge Angle, ICRU 23/ 60 target volumes, ICRU reference Points. **(16 hours)**

**Unit 3: Treatment Planning**

Acquisition of patient data, Body Contours, Localization of Internal Structures, Treatment simulation, Treatment Verification, Electronic Portal Imaging, Correction for contour irregularities, Corrections for Tissue Inhomgenities, Absorbed Dose within Inhomogenities, Tissue Compensators, 2D Compensators, 3D Compensators, Patient positioning, XYZ isocenter Setup. Field Blocking, Custom Blocking, Multi Leaf Collimators, Skin Dose, Separation of Adjacent Fields, Guidelines for field matching. **(16 hours)**

**Unit 4: Electron therapy:** Electron Interaction, Rate of energy loss, Electron Scattering, Depth- Dose Curve, Absorbed Dose determination, Use of Films, Solid Phantoms, Central Axis Depth- Dose Curves, Isodose Carves, Field Flatness and symmetry, Electron source, X-ray Contamination, Choice of Energy- Treatment Planning, Use of bolus, External shielding, Total Skin Irradiation, Large Field Techniques, Treatment Planning Algorithms - Fermi-eyes principle, **(12 hours)**

**Unit 5:Brachytherapy: Radiative** Sources in Brachytherapy, criteria for source selection Use of Radium and radiumsubstitutes, Co-60, Ta-82 ,Cs-137 Ir-192, I-125 and Au-198, specification of source strength-activity,exposure rate equivalent mass of radium, apparent activity,airkerma strength, Calibration of exposure rate constants- open air measurements,well type ion chamber, calculation of dose distribution-sievert integral-effect of inverse square law absorbed dose in tissue, TG-43, isodose curves,Systems of Implant dosimetry-peterson parker system,quimbi system,paris system,computer system Computer Dosimetry-localization of sources, implantation techniques- surface mould, interstitial, Intracavity,-Dose specification : Cancer of Uterine Cervix-Manchester system Dose rate considerations and classification of brachytherapy techniques — Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR), Afterloading techniques Advantages and disadvantages of manual and remote afterloading techniques- temporary and permanent implants **(20 hours)**

**STANDARD BOOK FOR STUDY**

Radiotherapy handbook for teachers and students, IAEA publication

**REFERENCES**


1. F.M. Khan " Physics of Radiation Therapy" 2010- Fourth edition.
2. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
3. F.M. Khan " Physics of Radiation Therapy" 2010- Third edition
4. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
5. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc London, 1981.
6. R.F.Mould, "Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
7. S.C.Klevenhagen "Physics of Electron Beam Therapy" Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
8. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book, ADAM Hildre, 1981


**RPH3C20. NUCLEAR MEDICINE 4 CREDITS**

| **Course Objectives:** |
|---|
| • Study basics of nuclear medicine.<br>• Deep knowledge on production of radio nuclides and various detectors using in nuclear medicine.<br>• Study on in vivo and in vitro techniques.<br>• Study various emission tomographic methods.<br>• Acquire knowledge on quality control programme in nuclear medicine equipments and room designing. |
| **Expected course outcomes:** |
| • Able to explain on different radionuclides using in nuclear medicine and their characteristics, radioacitivity decay, half life and counting statistics.<br>• Able to explain different methods of production of unsealed radionuclides, their decay schemes, radio pharmaceuticals and different detectors using in nuclear |

medicine.

- Deep knowledge in in-vitro and in-vivo studies, various uptake systems and different scintigraphic techniques.
- Able to handle different emission tomographic systems and its working principles.
- Have expertise on quality control programmes of various equipments using in nuclear medicine, radio immune assay, various categories of nuclear medicine laboratories, radiation safety and protection in nuclear medicine facility, details of delay tank and therapeutic applications in nuclear medicine.

**1: Introduction to Nuclear Medicine:**Nuclides and Radioactive Processes, Nuclides and Their Classification, Nuclear Structure and Excited States of a Nuclide, Radionuclide and Stability of Nuclides, Radioactive Processes and Conservation Laws, Radioactivity: Law of Decay, Calculation of the Mass of a Radioactive sample, Specific Activity, Problems on Radioactive Decay, Average Life, Biological Half-Life, Effective Half-Life, Statistics of Radioactive Decay , Mean, Standard Deviation, Random error, Systematic error, Accuracy, Variance, Poisson distribution, standard deviation, probable error, resolving time and loss of counts, sample counting procedures. **(16 hours)**

**2: Production Of Radio Nuclides and Detectors used:** Use of unsealed sources in diagnosis and treatment, details of radionuclide including decay schemes, method of preparation, storage and handling, nature of pharmaceutical preparations. Isotopes, Selection of Isotopes, career free, Radiopharmaceuticals , Production of Radionuclide, Radionuclide generator. Instruments used in radiation detection and measurement in nuclear medicine, GM systems, liquid scintillators, solid scintillators, and electronic circuits for a scintillation detector, single and multi channel anlysers, Pulse height spectroscopy. In Vitro radiation detection-Well type NaI(Tl) Scintillation detectors, 4π β-γ coincidence counting , Routine sample measurements with radioisotopes – re-entrant chamber methods, Liquid counters – Window-less counting of liquid samples ,statistics of isotopes counting, **(16 hours)**

**3: In vitro- In vivo Procedures:** Uptake studies, thyroid uptake, details of instruments used, method of uptake measurement, determination of plasma volume using a well counter, time dependence studies like life of erythrocytes, Studies with radioactive tracers, uses of isotopes like C14, P32, Cr51, Co57, Co58,Ga67, Tc99m, I123, I131, Xe133, 111In, Au198, Tl 201. uses of whole body counters, – Circulation studies with Na-24 iron physical principles of isotopes, dilution analysis, multiple compartment system, measurement of circulation time, renal, liver, lung, cerebral function studies, In-vitro procedures, RIA kit, Treatment of thyrotoxicosis, thyroid cancer with Iodine, use of phosphorus -32 for therapy, Treatment of Polythaemia Vera and leukemia with P-32, patient doses. Use of colloidal gold and chromic phosphate in the treatment of malignant effusions – Calculation of treatment doses. **(16 hours)**

**4: Emission Tomography:** Imaging using radio nuclides, rectilinear scanner, the Anger Camera – Principles of construction, use and maintenance. Different types of Collimators. Basic principles and Problems, Focal plane

Tomography, Emission Computed Tomography, Single Photon Emission Computed Tomography. Various Image Reconstruction Techniques SPECT, Positron emission tomography (PET), principles of PET imaging, clinical applications. Working of Medical Cyclotron, Radioisotopes produced and their characteristic. **(16 hours)**

**5: QA of Nuclear Medicine equipments, Room Design and Safety concern**

QA in the preparation of radio- pharmaceuticals, QA in imaging, flood phantom. QA of Gamma Camera- Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency. Handling of radioactive materials, radiation units, permissible radiation exposures, ALARA, radiation protection measures, nuclear medicine special laboratory procedures. Planning of nuclear laboratories for diagnostic and therapeutic procedures- Categories of Nuclear Medicine laboratories (category 1, 2, 3, 4), Equipments and accessories, Staff requirements, shielding requirements in diagnostic and therapy nuclear medicine laboratories. Delay tank system. Site planning for cyclotron – PET/CT facility. **(16 hours)**

**STANDARD BOOKS FOR STUDY AND REFERENCES**


1. Nuclear Medicine handbook for teachers and students, IAEA Publications
2. W.H.Blahd, “Nuclear Medicine”, McGraw Hill Co., New Delhi, 1980.
3. H.N.Wagner, “Principles of Nuclear Medicine”, W.B.Saunders Co, London, 1970.
4. Herbert (John) & D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.
5. Ramesh Chandra, “ Nuclear Medicine Physics- The Basics Nuclear Medicine Physics: The Basics, 6th Edition” ©2004
6. 6. Safety Report Series No. 40 “ Applying Radiation Safety Standards in Nuclear Medicine “ – IAEA
7. “ Nuclear Medicine Resources Manual” INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2006


**RPH3C21 – PRACTICALS IN RADIATION DETECTION AND MEASURING INSTRUMENTS ( Minimum 12 expts. to be carried out) (70 HOURS) 2 CREDITS**

| **Course Objectives:** |
|---|
| For acquiring hands on training in instruments using for radiation detection and measurements |
| **Expected course outcomes:** |
| Practical measurements and familiarization of different radiation instruments using for radiation detection and measurement using GM detector, SCA and MCA, liquid scintillation detector. Measurements of HVT and TVT. |

1. Efficiency of G.M. Counter
2. Efficiency of NaI(Tl) and semiconductor detectors
3. Measurement of exposure time of X-ray units using spinning top.

4. Study of dependence of exposure on factors like kV, mA, time and distance.
5. Measurement of HVL and TVT of an X-ray beam
6. Energy dependence of HVT and TVT of an Xray beam
7. Liquid scintillation counter
8. Use of a large volume ion chamber for monitoring
9. Thermo luminescent dosimeter
10. Measurement of contamination level and methods of decontamination.
11. Auto radiography of discrete sources
12. Contamination monitoring of discrete sources
13. Use of isotope calibrator
14. Film dosimetry
15. Fricke dosimetry

**RPH3C22 -PRACTICALS IN MEDICAL IMAGING**
**Minimum 12 expts. to be carried . (70 Hours) 2 CREDITS**

| Course Objectives: |
| --- |
| • Practical demonstration of equipment using in medical imaging |
| **Expected course outcomes:** |
| • Practical measurements and understanding of different aspects of instruments used in medical imaging. |

1. Standard procedures for processing of an exposed film
2. Study of safe light and light proof nature of dark room
3. Study of speed of an intensifying screen
4. Latitude of a film screen combination
5. Testing of collimator and field congruence
6. Measurements of KVp, mAS for an X-ray unit
7. Study of radiation level around an X-ray tube head
8. Working of automatic processing systems
9. Patient dose measurements in diagnostic radiology
10. Study of effectiveness of filters
11. Preparation of processing chemicals
12. Use of a sensitometer
13. Measurement of point-spread function
14. Measurement of edge-spread function
15. Measurement of Line-spread function

**RPH3C23 Comprehensive viva voce** **1 Credit**

## SEMESTER IV

### RPH4C24. QUALITY ASSURANCE, ACCEPTANCE TESTING AND COMMISSIONING OF RADIATION SYSTEMS 4 CREDITS

| **Course Objectives:** |
|---|
| • Study the importance of QA and different protocol systems.<br>• Attain knowledge on different QA protocols.<br>• Attain experience on different QA tests in diagnostic radiology<br>• Study various QA test for treatment planning system.<br>• Attain knowledge on commissioning and decommissioning procedures of radiotherapy machines. |
| **Expected course outcomes:** |
| • Knowledge on the importance of QA and its importance in radiation therapy, familiarization of different QA programme.<br>• Able to explain different QA protocols for radiotherapy like TRS, TG and various QA tests in radiotherapy.<br>• Implement various QA test in diagnostic radiology machines as per IAEA and AERB protocols.<br>• Able to handle TG-53 and TRS-430 protocols for TPS and its implementation.<br>• Trained on commissioning and acceptance of various radiotherapy machines and procedures for decommissioning . |

**1: Need for Quality Assurance:** Need for quality assurance, Goals of QA, Physics Staffing, Personnel Requirements for Clinical Radiation Therapy, Roles and Responsibilities**.** Documentation And Quality Assurance, Definition Of Terms - Quality Control, Quality Assurance, advantages of a Code of Practice based on standards of absorbed dose to water, Expression of uncertainties, The International Measurement System, The IAEA/WHO network of SSDLs, Standards of absorbed dose to water, **(14 hours)**

**2: Dosimetric Protocols and QA for Radiation Therapy:** Different Protocols For Dosimetry- TRS 277, TRS-398, TG51, TG-43 *ND,W*-BASED FORMALISM, Correction For The Radiation Quality Of The Beam, *Kq,Qo* Ionization Chambers, Phantoms, Calibration Of Ionization Chambers, Determination Of Absorbed Dose To Water, Electric check, Mechanical Checks, Dosimetric Checks, Protection Checks for Co- 60 and Linacs, - field size, alignment of radiation and optical fields, safety system and warning lights, symmetry and parallelism of collimation jaws, energy stability, Daily Checks in C0 60 and LINAC. Brachy therapy – QA of sources, Leakage and Contamination, Source Strength Verification, Uniformity of Activity, QC of Applicator, Dwell Position Verification, QC of treatment Unit, Radiation Safety, HDR Source Transport, Type A package, Source Transfer Process and safety Concern in HDR. **(16 hours)**

**3: Quality Assurance tests in Diagnostic Radiology:** Details of medical diagnostic X-ray equipment and manufacturer, Mechanical Characteristics and Display Indicators, QA tests for diagnostic X-ray machine, Air kerma rate at table top, Resolution of the imaging system, Radiation leakage levels from X-Ray tube housing & Collimator at 1m from the focus, Radiation protection survey. Darkroom QC , Intensifying Screen Cleaning Procedure, Darkroom Integrity or Fog Test, Mechanical tests for CT - Alignment of table to gantry, Gantry tilt, Positioning of the patient support, patient positioning accuracy, Collimation test, Accuracy of kV, mA Irradiation Time (t), Reproducibility, Radiation Dose test, Noise, Mean CT number and Uniformity, Low contrast resolution, Calibration methods, duration of dose delivery, documentation of physical parameters, quality indices, Magnetic resonance imaging (MRI), Phantom materials, resonance frequency, signal to noise ratio, image uniformity, spatial linearity, high contract spatial resolution, slice thickness, slice position separation, image artifacts, **(18 hours)**

**4: Quality Assurance tests for TPS:** AAPM Task Group 53 Quality Assurance for Clinical Radiotherapy Treatment Planning (1998) and IAEA Technical Report Series No. 430 Commissioning and Quality Assurance of Computerized Treatment Planning Systems for Radiation Treatment of Cancer (2005). Digitizer Accuracy, Image Acquisition and Display, Hard copy Output Accuracy, Monitor Unit Check – Open and Wedge Fields, Isodose Checks, Clinical Isodose/Monitor Unit Check, Electron Monitor Unit and PDD Check, Operating Consistency of IMRT Dose Optimization Software, HDR Treatment Planning QA, Prostate Seed Treatment Planning QA **(14 hours)**

**5: Commissioning, Acceptance tests and Decommissioning Procedures:** Acceptance / QA tests for Co-60 Teletherapy, Medical linear Accelerators and Brachytherapy, Mechanical Tests, Electrical Tests, Photon Beam Characteristics, Electron Beam Characteristic, Dose Monitoring System, Treatment table, Radiation Leakage, Protection Survey, essential Equipments for Commission and Decommission. Decommissioning Process for Radioactive Sources, Depleted Uranium, Medical Linacs Brachytherpay , Equipments required, Pocket dosimeters and others , Transport of Sources, Survey for Contamination. **(18 hours)**

**STANDARD BOOKS FOR STUDY**

1. NCRP, ICRP, ICRU, IAEA, AERB Publications on QA.
2. TRS-398, TRS 277, TRS 430 IAEA Technical Series
3. TG 51, TG 21, TG 43, TG 53 AAPM Task Group
4. Treatment Planning in Radiation Oncology, Faiz M.Khan Roger A.Potish

**RPH4E25A: RADIOTHERAPY TREATMENT PLANNING 4 CREDITS**

| **Course Objectives:** |
|---|
| • Study on combined dose distribution.<br>• Attain experience in manual and computerized treatment planning methods<br>• Study on electron beam therapy.<br>• Study various treatment planning techniques for different tumors.<br>• Attain knowledge on brachytherapy |
| **Expected course outcomes:** |
| • Able to assess combined dose distribution, different treatment volumes using for treatment planning purpose.<br>• Trained in different manual and computerized planning methods, various steps of contouring and planning, image fusion.<br>• Deep knowledge in treatment planning and dose calculations of electron beam therapy.<br>• Able to explain different treatment planning techniques for various types of cancers.<br>• Trained in clinical application of brachytherapy, various applicators are used, ICRU and RTOG guidelines and different dosimetric systems. |

**1. Dosimetric Parameters, Dose Distribution and Scatter Analysis**

Target Volume Definition and Dose Prescription Criteria (ICRU 50, ICRU 62 and ICRU 83), Gross tumor volume (GTV),Clinical target volume (CTV), Planning target volume (PTV) etc Dose prescription point, isodose line, or isodose surface, Photon Beams: Dose Modeling and Treatment Planning , Single-field dose distribution, Parameters influencing isodose curves and isodose surfaces, Combination of fields, Wedged and angled fields, Corrections for SSD, missing tissue, and inhomogeneities, Dose specification and normalization. **(14 hours)**

**2. Manual and Computerized Treatment Planning Methods**

Photon Beams: Treatment Planning, Acquisition of isodose data, Computer hardware Common algorithms: Convolution, superposition, pencil beam, Dimensionality (2D, 2.5D, and 3D treatment plans), Non-coplanar plans, Treatment planning with asymmetric collimators, Treatment planning with wedges (hard, dynamic, and virtual), Treatment planning with multileaf collimators (MLCs), Compensator design, 3-D treatment planning, Inverse planning objectives and techniques. Optimization methods, Treatment planning with Monte Carlo techniques, Biological modifiers/optimization, Clinical Photon Beams: Patient Application, Patient data acquisition, Contours, Contouring Images from CR, CT, MRI, US, PET, Fusion Techniques Conventional simulator techniques, Positioning/immobilization, Use of contrast, markers, Image parameters/optimization, Block cutting, Compensators, Bolus, CT-simulator techniques, Scout view images, Virtual simulation Digitally reconstructed radiographs (DRRs), CT number and (electron) density relation and calibration, Special considerations, Skin dose, Field matching, Integral dose, Dose-volume histograms (DVHs): Differential and integral **(18 hours)**

**3. Electron Beam Therapy-Treatment Planning and Dose Calculation**

Effects of patient and beam geometry - Air gap, Beam obliquity, Irregular patient surface, Internal heterogeneities: bone, fat, lung, air, Dose algorithms, Analytical algorithms (e.g., Fermi-Eyges based pencil beam), Monte Carlo algorithms, Clinical commissioning, Quality assurance of treatment plans, Treatment planning techniques- Energy and field size selection, Bolus: Constant thickness and shape, Collimation: Inserts, skin, internal, Field abutment techniques Photon-electron mixed beams, Special electron treatment techniques, Total skin irradiation, Total limb irradiation, Electron arc therapy, Intraoperative electron therapy, Total scalp irradiation, Craniospinal irradiation, Conformal therapy **(16 hours)**

**4. Techniques of Radiotherapy Planning for all The Malignancies in The Body**

Concept of therapeutic ratio, TCP, NTCP, organs at risk, TD50/5 table and doses, Individual organ tolerances, Patient care before and during radiotherapy Indications and RT techniques for tumors Skin, Head and Neck, Oral cavity, Pharynx, CNS, Thyroid, Lung, Breast, lymphomas, Esophagus and stomach, Pancreas and liver, Rectum, Anus, Prostate, pediatric tumors, Indications for systemic irradiation, Curative /Palliative RT, Nodular treatment, Dose-fractionation, Hypo and hyper, Accelerated radiotherapy, Concomitant radiotherapy and chemotherapy, Concomitant radiotherapy and hypoxic sensitizers, Gaps in treatment delivery, Inter-fractional motion, **(16 hours)**

**5. Brachytherpay- Treatment Planning and Dose Calculation**

Purposes of Brachytherapy Treatment Planning, Prescription points for vaginal cylinder, T&O, esophagus, endobronchial , and bile duct treatments, Treatment site, disease, prescribed doses, isodose line /prescription points, isotopes, applicators used , Contrast, markers, skin wires,Target and critical organs , Applicator insertion ,T&O implants ,total source strength and exposure time (or dose), Seeds-alone vs. boost prostate implants, indexer lengths , Catheter numbering in interstitial implants, Use of spacers, ICRU Report 58 Quantities, RTOG 95-17 , Accelerated Partial Breast Brachytherapy, Differential DVH for Optimized Plan, Simplified analytical solutions(unfiltered line source Sievers integral), Use of classical implant systems(Manchester, Quimby, Paris) for interstitial implants **(16 hours)**

**STANDARD BOOKS FOR STUDY AND REFERENCES**


1. Faiz M.Khan, Treatment Planning in Radiation Oncology, LWW publication, 2nd ed.
2. S.C.Klevenhagen "Physics of Electron Beam Therapy" Medical Physics Hand Book
   Series No.6 Adam Hilger Ltd, Bristol, 1981.
3. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. "Practical Radiotherapy Planning" Fourth Edition- 2009
4. R.F.Mould, "Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.


**RPH4E25B: INDUSTRIAL AND RESEARCH APPLICATIONS OF RADIATIONS**

| **Course Objectives:** |
|---|
| • Study various application of radiation in industries and research. |
| **Expected course outcomes:** |
| • Knowledge on industrial applications of x ray and gamma radiography.<br>• Able to explain different industrial uses of radiation.<br>• Deep knowledge in auto radiograph.<br>• Trained for the application of radiation in oceanography. |

**UNIT 1.** Industrial application of radiation: Principles of industrial radiography with x ray and gamma ray, radiographic exposure devices, photographic film technique, radiographic contrast, definition and sensitivity, intensifying screens and pentameters,

**UNIT 2.** Principle and measurement of thickness and level in different application, density and moisture hydrogen in hydrocarbons, well logging, composition analysis.
Principe of operation of consumer products using radiation sources fire detector, baggage inspection systems, static eliminator, luminous paints and gas mantles.

**UNIT 3.** Industrial radiation processing, gamma chambers, radiation sterilization, irradiation of food and medical products. Ion exchange techniques – Physical basis of separation – Cation and anion exchangers – Removal of impurities of interfering substance – Concentration of trace constituents – Applications.

**UNIT 4 :**Autoradiography – General considerations – Laboratory requirements – Types of photographic emulsions used – Contact and stripping film methods – Interpretation of results – Chromatography – Partition, paper and gas chromatographic methods – Mounting of samples – Suitable Solvents – Quantitative aspects – Applications.

**UNIT 5.** Attenuation of beta particles and electrons in paper manufacturing. Multielement analysis, thin layer activation, smoke detectors, mineral processing, coastal engineering, flow rate measurement, - gas, liquid, river flow- erosion studies-use of Cesium-, ground water management, Oceanography, effect of high energy radiation on polymers, Accelerator mass Spectroscopy.

STANDARD BOOKD FOR STUDY

1. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
2. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
3. U.B.Thripathi Quality assurance of Radiation therapy equipment and practice – lecture note
4. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
5. NCRP, ICRP, ICRU, IAEA, AERB Publications

**RPH4E26A: MODERN TRENDS IN RADIOLOGY AND RADIOTHERAPY**
**4 CREDITS**

| **Course Objectives:** |
|---|
| • Study on imaging in radiotherapy<br>• Attain knowledge in treatment planning and different alogorithams.<br>• Study on conformal radiotherapy and multi leaf collimator<br>• Study on latest updates in conformal radiotherapy.<br>• Obtain knowledge on advances in brachytherapy |
| **Expected course outcomes:** |
| • Knowledge on imaging in radiotherapy and their applications, different image fusion techniques.<br>• Have expertise in hardware and softwares of TPS, various algorithms.<br>• Deep knowledge in conformal therapy and multi leaf collimator system.<br>• Able to handle advanced conformal therapy like IMRT, VMAT, SRS, SRT and gating<br>• Knowledge in advances in brachytherapy. |

**1: Imaging in Radiotherapy**

Recent advances in Diagnostic Radiology, Digital Radiography, Digitally Subtracted Radio Graph (DRR), Xero Radiography, Mammography, New Generation Of CT-Scanners and Their Applications – CVCT, Spiral CT, CBCT, 4DCT Etc , Image Reconstruction, CT Simulation and Simulator CT, MRI and PET Imaging, Image Fusion In Radiotherapy, Portal Imaging With Gas Filled And Solid State Detectors, KV and MV Imaging. **(16 hours)**

**Unit 2: Introduction to Treatment planning system and Dose Calculation algorithm**

Treatment Planning System (TPS), Computers In Radiotherapy, Hard Ware and Software Requirements, Development Of 3D TPS, Physics Of Treatment Planning and Various Steps In Treatment Planning Dose Calculation Algorithms- Correction Based and Model Based Algorithms, Convolution, Super Position and Montecarlo Methods, PBC, AAA And Collapsed Cone Algorithms and Dose Calculation. QA of Treatment Planning System. Gamma verification and CAP for TPS **(16 hours)**

**Unit 3: Multileaf collimators and Conformal Radiotherapy :** Physical and Clinical Aspects of Multileaf Collimators, Quality Assurance for Multi Leaf Collimators, Dose Volume Specifications In Radiotherapy, Concepts Of GTV, CTV, ITV and PTV, ICRU-50 And ICRU-62 Guidelines, Beams Eye View, Planning Optimization Methods, Plan Evaluation, Dose Volume Histogram, DMLC, MMLC, QA Of 3DCRT Plans **(14 hours)**

**Unit 4: Advancements in Conformal Radiotherapy:** Intensity Modulated Radiotherapy (IMRT)-Physical and Clinical Aspects, Treatment Planning, Optimization and Delivery Methods, Quality Assurance Of IMRT- Machine Specific And Patient Specific QA in IMRT. Gamma Analysis. Concept of energy modulated therapy, Image Guided Radiotherapy (IGRT)-Physical and Clinical Aspects, Gated IGRT, Technical Requirements for IGRT. Volumetric Arc Therapy-Physical and Clinical Aspects and Quality Assurance. Tomotherapy, Particle Beam-Proton, Neutron and Heavy Ion Therapy and Adaptive Radiotherapy,Stereotactic Radio Surgery(SRS) and Stereotactic Radiotherapy ( SRT)- Cranial and Extra Cranial Surgery Systems-Gamma Knife , X-Knife and Cyber knife Systems, Clinical Applications Of Cranial and Extra Cranial Radio Surgery, Concept Of SBRT-Stereotactic Body Radiotherapy. **(18 hours)**

**Unit 5: Advancements in Brachytherapy:** CT Based 3D Planning Systems In Brachytherapy, Use Of New Radionuclides in Brachytherapy, LDR, HDR and PDR Systems, Intra-Operative Radiotherapy, Intraluminal Radiotherapy, Prostate Implants and Ultra Sounded Guided Implants, Perineal Templates, Iodine Seeds For Prostate Cancer, Intra Vascular Brachytherapy, Dose Prescription and Plan Evaluation In Brachytherapy, QA In Brachytherapy. **(16 hours)**

**REFERENCES:**


1. James A Purdy, Walter H. Grant , 3D Conformal and Intensity Modulated Radiation Therapy- Physics and Clinical Applications" ( Perez Publisher)
2. S. Webb, Contemporary IMRT Developing Physics and Clinical Implementation", 9780750310048 - Book Depository
3. New Technologies in Radiation Oncology, W. Schlegel, T. Bortfeld, A.L. Grosu, LLW
4. "The Physics of Conformal Therapy - Advances in Technology" by S.Webb
5. A Practial Guide to CT simulation", by Lowrence Coy
6. The Physics of Medical Imaging, S.Webb, Medical Science Series, Adam Hilger, Bristol, 1984.
7. Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine"Habib Zaidi, George Sgouros- IOP, Institute of Physics Publishing, Bristol and Philadelphia


**RPH4E26B: RECENT DEVELOPMENTS IN INDUSTRIAL APPLICATIONS OF RADIATIONS (70 hours) 4 Credits**

| **Course Objectives:** |
| --- |
| • Study on radio isotope tracers<br>• Attain knowledge about activation analysis. |

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|---|
| • Study on isotope based nucleonic gauges.<br>• Study on planning of isotope labs for industrial purposes and specific applications |
| **Expected course outcomes:** |
| • Knowledge on isotope trace studies like flow rate, diffusion and vapor pressure measurements, nutrition uptake studies.<br>• Able to explain wear and tear studies, activation method studies using activation analysis and food and drugs sterilization.<br>• Deep knowledge in different nucleaonic gauges studies using isotopes.<br>• Expertise in planning of isotopes labs for agriculture and research, food and drug irradiation room.<br>• Trained in application like leakage test, oil gas mining, smoke detection and forensic and security test. |

**UNIT 1:** Radioisotope tracer applications – Measurement of flow rate – Determination of phosphorous and sulphur content in shell – Diffusion and vapour pressure measurements – Detection of animal and plant diseases by tracer methods – Study of photosynthesis and uptake of nutrients – Silt movement studies – Go-devil detection – Control of catalyst flow rate –

**UNIT 2:** Activation analysis – Wear and tear studies – Chemical analysis by activation methods – Induction of polymerization, halogenation and oxidation by radiation – Luminous dial painting – Static eliminators – Sterilization of foods and drugs – Preservation of foods, drugs, and vegetables – Radiation induced genetic changes and crop improvement – Specialized applications of radioisotopes in industry and the life sciences.

**UNIT 3:** Radioisotope gauges – Use of transmission gauges for measurement of thickness, density and composition – Level indicators – Use of back scatter gauges for measurements of the thicknesses of coatings etc. – Bremsstrahlung gauges – Neutron and gamma scatterings gauges. Details about current suppliers and procedures for procurement of sources

**UNIT 4:** Planning of radioisotope laboratories for agricultural and research institutions – Design of gamma gardens for agriculture, Desing of gamma chamber, Irradiation hall, control hall, hot room- planning and management, post irradiation storing, Food irradiation: Room desing- management and storing, testing and verification, Blood irradiation: Room design- management and storing, testing and verification

**UNIT5:** Specific Application: Leakage test, oil gas mining, smoke detection, application of AM-241 and Cf-252. Thickness measurement, container, transmission pipes, valve test, forensic and security test, DNA testing, pest control, defense applications, air traffic and marine safety.

**STANDARD BOOKS FOR STUDY**

1. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
2. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
3. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
4. NCRP, ICRP, ICRU, IAEA, AERB Publications

**RPH4C27: PRACTICALS IN RADIOTHERAPY (Minimum 12 expts.) (70 Hours)**
**2 CREDITS**

| **Course Objectives:** |
|---|
| • Practical demonstration of different parameters using in radiotherapy |
| **Expected course outcomes:** |
| • Measurements of different radiation instruments using in radiotherapy. |

1. Calibration of a cobalt therapy unit
2. Acceptance testing of a cobalt therapy unit
3. Measurement of central axis percent depth dose
4. Measurement of TAR and BSF
5. Measurement of TPR and TMR
6. Use of a large volume ion chamber as an isotope calibrator
7. Penumbra trimmers
8. Plotting of combined isodose curves for parallel pair fields with various IFDs
9. Plotting of combined isodose curves for parallel pair fields for various energies photon beams
10. Combined isodose curves for oblique fields
11. Wedge fields planning
12. Dosimetry of brachytherapy / Conventional
13. Orthogonal films and calculations
14. Use of optical densitometer for field profile determination
15. Invivo dosimetry

**RPH4C28: PRACTICALS IN RADIOTHERAPY PLANNING AND DOSIMETRY**
**Minimum expts. to be carried out 12. (70 Hours) 2 CREDITS**

| **Course Objectives:** |
| --- |
| • Practical demonstration of radiotherapy planning and calculation for radiation delivery. |
| **Expected course outcomes:** |
| • Practical measurements of different dosimetric parameters and its validation. |

1. Planning and dosimetry for single field photon irradiation
2. Planning and dosimetry for multiple fields
3. Planning of a three field isocentric treatment
4. Use of TAR and TPR in practical situations
5. Study of advantages of longer SSD using isodose curves in parallel pair irradiation
6. Dosimetry for rotational treatment
7. Dosimetry for four field isocentric irradiation
8. Determination of critical organ doses in typical multi field techniques
9. Measurement of entrance and exit doses and evaluation
10. Exit dose measurement and evaluation of deep tissues in homogeneities
11. Dosimetry for a case of irradiation of maxillary antrum
12. Use of computerized treatment planning system
13. Preparation of a surface applicator and its dosimetry
14. Dosimetry of irregular fields
15. Dosimetry of a linear arrangement of brachytherapy sources
16. Dosimetry for single plane and double plane implants
17. Dosimetry for a cylindrical mould

**RPH4C29: PRACTICALS IN Q/A AND CALIBRATION OF RADIOLOGICAL EQUIPMENTS (Minimum expts. to be carried out 12). (70 Hours) 2 CREDITS**

| **Course Objectives:** |
| --- |
| • Practical familiarization of different QA of radiological equipments. |
| **Expected course outcomes:** |
| • Practical measurements of different QA tests of all radiological equipment. |

1. Calibration of radiation monitor
2. Calibration of a survey meter using a standard source
3. Q.A testing of a simple diagnostic X-ray unit I
4. Q.A testing of a simple diagnostic X-ray unit II
5. Q.A testing of brachytherapy systems
6. Q.A testing of C.T units
7. Q.A testing of telecoblat therapy units
8. Routine testing of a Linac system
9. Room planning of a radiotherapy installation

10. Radiation monitoring around a teletherapy installation
11. Study of the effectiveness of protective systems in diagnostic radiology
12. Study of the effectiveness of shielding blocks in radiotherapy
13. Tracing a missing source
14. Management of emergencies in a cobalt therapy unit
15. Management of emergencies in a brachytherapy unit

**RPH4C30: Comprehensive viva voce** **1 credit**

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**Syllabus Revised by**
PG Board of Studies, Radiation Physics
University of Calicut.

Sd/-
**Chairperson, BoS, Radiation Physics**