Dr. N.G.P. ARTS AND SCIENCE COLLEGE (Autonomous)

REGULATIONS 2022-23 for Post Graduate Programme
(Outcome Based Education model with Choice Based Credit System)
M.Sc. Degree

(For the students admitted during the academic year 2022-23 and onwards)

Programme:

M.Sc. Medical Physics – Two year (2 Years of academic + 1 Year Internship)

Eligibility

The candidates who have passed B.Sc. Physics with 60% and above aggregate marks with Mathematics as one of the ancillary subjects in regular mode from a recognized university.

Admission Criteria

The admission is based on the marks secured in the entrance examination conducted by Dr.N.G.P.ASC and the marks secured in UG degree by the candidate. The entrance examination will be conducted for 100 marks in the pattern of multiple choice questions from B. Sc. Physics. (Major Subjects - 75 marks and Ancillary Subjects – 25 marks).

Programme Educational Objectives

1. The Curriculum is designed to attain the following learning goals which students shall accomplish by the time of their post graduation.
2. The aim of this programme is designed to enable a student to optimize their learning and their knowledge by implementing in medicine and biology in order to improve health care.
3. To develop new methods & techniques for the radiology and imaging and radiotherapy related science.
4. To plan radiotherapy treatment methods, delivery, verification and execution.
5. To develop radiation dosimetry and ensure radiological safety of healthcare workers, patients and public.
6. At the end of the programme the student will have an in depth knowledge in the field of Medical Physics and related sciences.

PROGRAMME OUTCOMES:

On the successful completion of the program, the following are the expected outcomes.

PO Number	PO Statement
PO1	To impart the quality of Medical Physics program focuses on the clinical application of radiation sciences in medicine. Students are trained to play a central role in developing, planning and implementing patient treatment programs.
PO2	To apply Medical Physics theories, methods and tools related to measurement of radiation dose (relative and absolute), verification of output from radiation producing machines, patient-specific treatment plans development, approval, and verification.
PO3	To provide hands-on clinical education and to prepare the graduate for the AERB board certification examination and a professional career in radiation therapy.
PO4	To develop treatment plans that provides adequate target coverage while sparing normal and critical tissues.
PO5	To demonstrate an awareness of the complexity of knowledge in medical physics as well as receptiveness to alternative interpretations, new knowledge, and alternative approaches to problem solving.

PG REGULATION (R4) (Students

Admitted in the AY 2022-23)

(OUTCOME BASED EDUCATION WITH CBCS)

Effective from the academic year 2022-23 and applicable to the students admitted to the Degree of Master of Arts/Commerce/Management/Science.

1.NOMENCLATURE

1.1 Faculty: Refers to a group of programmes concerned with a major division of knowledge. Eg. Faculty of Computer Science consists of Programmes like Computer Science, Information Technology, Computer Technology, Computer Applications etc.

1.2 Programme: Refers to the Master of Arts/Management/Commerce/Science Stream that a student has chosen for study.

1.3 Batch: Refers to the starting and completion year of a programme of study. Eg. Batch of 2022–2024 refers to students belonging to a 2-year Degree programme admitted in 2022 and completing in 2024.

1.4 Course: Refers to component of a programme. A course may be designed to involve lectures / tutorials / laboratory work / seminar / project work/ practical training / report writing / Viva voce, etc or a combination of these, to effectively meet the teaching and learning needs and the credits may be assigned suitably.

a) Core Courses A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

b) Extra Departmental Course (EDC): A course chosen generally from a related discipline/subject, with an intention to seek exposure in the discipline relating to the core domain of the student.

c) Discipline Specific Elective Course (DSE): Elective courses are offered under main discipline/ subject of study.

d) Project Work: It is considered as a special course involving application of knowledge in

problem solving/analyzing/exploring a real-life situation. The Project work will be given in lieu of a Core paper.

e) Extra credits Extra credits will be awarded to a student for achievements in co-curricular activities carried out outside the regular class hours. The guidelines for the award of extra credits are given in section two, these credits are not mandatory for completing the programme.

f) Advanced Learner Course (ALC): ALC is doing work of a higher standard than usual for students at that stage in their education. Research work / internships carried out in Universities/ Research Institutions/ Industries of repute in India or abroad for a period of 15 to 30 days.

2. STRUCTURE OF PROGRAMME

- Core Course
- Extra Departmental Course (EDC)
- Discipline Specific Elective (DSE)
- Industrial Training (IT)
- Project

3. DURATION OF THE PROGRAMME

A student is normally expected to complete the M.Sc. /M.Com. / M.A. Programme in 4 semesters. However, in any case not more than 5 consecutive semesters. Failing which the concerned BoS will identify suitable/ equivalent course.

4. REQUIREMENTS FOR COMPLETION OF A SEMESTER

Every student shall ordinarily be allowed to keep terms for the given semester in a program of his/ her enrolment, only if he/ she fulfills at least seventy five percent (75%) of the attendance taken as an average of the total number of lectures, practicals, tutorials, etc. wherein short and/or long excursions/field visits/study tours organised by the college and supervised by the faculty as envisaged in the syllabus shall be credited to his attendance. Every student shall have a minimum of 75% as an overall attendance.

5. EXAMINATIONS

The end semester examinations shall normally be conducted after completing 90 working days for each semester. The maximum marks for each theory and practical course as follows,

a) Mark distribution for Theory Courses

Continuous Internal Assessment (CIA) : 50 Marks

End Semester Exams (ESE) : 50 Marks

Total : 100 Marks

i) Distribution of Internal Marks

S.No.	Particulars	Distribution of Marks
1	CIA I (2.5 Units) (On completion of 45th working day)	15
2	Model (All 5 Units) (On completion of 85th working day)	15
3	Assignment	05
4	Attendance	05
5	Library Usage	05
6	Skill Enhancement *	05
	Total	**50**

Assignment Rubric

(Maximum -20 marks converted to 5 marks)

Criteria	4 marks	3 Marks	2 Marks	1 MArk
Language	Excellent spelling and Grammar	Good spelling and Grammar	Reasonable spelling and Grammar	Bad spelling and Grammar
Style	Outstanding style beyond usual college level	Attains College level style	Approaches College level style	Elementary form with little or no variety in sentence structure

Referencing	Good use of wide range of reference sources	Moderate use of suitable reference materials	Shows signs of plagiarism & using sources without referencing	No reference material used
Development	Main points well developed with high quality and quantity support	Main points developed with quality and quantity supporting details	Main points are present with limited details and development	Main points lack detailed development
Critical thinking/Problem solving	Advanced attempt to interpret the process, content/ analyse and solve the problem	Proficient attempt to interpret the process, content/ analyse and solve the problem	Adequate attempt to interpret the process, content/ analyse and solve the problem	Limited attempt to interpret the process, content/ analyse and solve the problem

Breakup for Attendance Marks:

S.No	Attendance Range	Marks Awarded
1	95% and Above	5
2	90% - 94%	4
3	85% - 89%	3
4	80% - 84%	2
5	75% - 79%	1

Note:

Special Cases such as NCC, NSS, Sports, Advanced Learner Course, Summer Fellowship and Medical Conditions etc. the attendance exemption may be given by principal and Mark may be awarded.

Break up for Library Marks:

S.No	Attendance Range	Marks Awarded
1	10h and above	5
2	9h– less than 10h	4
3	8h – less than 9h	3
4	7h - less than 8h	2
5	6h – less than 7h	1

Note:
In exception, the utilization of e-resources of library will be considered.

***Components for "Skill Enhancement" may include the following:**

Class Participation, Case Studies Presentation/Term paper, Field Study, Field Survey, Group Discussion, Term Paper, Presentation of Papers in Conferences, Industry Visit, Book Review, Journal Review, e-content Creation, Model Preparation & Seminar.

Components for Skill Enhancement

Any one of the following should be selected by the course coordinator

S.No.	Skill Enhancement	Description
1	Class Participation	• Engagement in class • Listening Skills • Behaviour
2	Case Study Presentation/ Term Paper	• Identification of the problem • Case Analysis • Effective Solution using creativity/imagination
3	Field Study	• Selection of Topic • Demonstration of Topic • Analysis & Conclusion
4	Field Survey	• Chosen Problem • Design and quality of survey • Analysis of survey

5	Group Discussion	• Communication skills • Subject knowledge • Attitude and way of presentation • Confidence • Listening Skill
6	Presentation of Papers in Conferences	• Sponsored • International/National • Presentation • Report Submission
7	Industry Visit	• Chosen Domain • Quality of the work • Analysis of the Report • Presentation
8	Book Review	• Content • Interpretation and Inferences of the text • Supporting Details • Presentation
9	Journal Review	• Analytical Thinking • Interpretation and Inferences • Exploring the perception if chosen genre • Presentation
10	e-content Creation	• Logo/ Tagline • Purpose • Content (Writing, designing and posting in Social Media) • Presentation
11	Model Preparation	• Theme/ Topic • Depth of background Knowledge • Creativity • Presentation
12	Seminar	• Knowledge and Content • Organization • Understanding • Presentation

ii) Distribution of External Marks

Total	**:**	**50**
Written Exam	**:**	**50**

Marks Distribution for Practical course

Total	**:**	**100**
Internal	**:**	**50**
External	**:**	**50**

i) Distribution of Internals Marks

S. No.	Particulars	Distribution of Marks
1	Experiments/Exercises	15
2	Test 1	15
3	Test 2	15
4	Observation Notebook	05
	Total	**50**

ii) Distribution of Externals Marks

S.No.	Particulars	External Marks
1	Materials and methods/ Procedures/Aim	10
2	Experiment/ Performance/ Observations/ Algorithm	10
3	Results/ Calculations/ Spotters/ Output	10
4	Inference/Discussion/ Presentation	10
5	Record	6
6	Viva- voce	4
	Total	**50**

A) Mark Distribution for Project

Total	**:**	**200**
Internal	**:**	**100**
External	**:**	**100**

i) Distribution of Internal Marks

S.No.	Particulars	Internal Marks
1	Review I	40
2	Review II	40
3	Attendance	20
	Total	**100**

ii) Distribution of External Marks

S.No	Particulars	External Marks
1	Project Work & Presentation	80
2	Viva –voce	20
	Total	**100**

Evaluation of Project Work shall be done jointly by Internal and External Examiners.

6 . Credit Transfer

a. Upon successful completion of 1 NPTEL Course (4 Credit Course) recommended by the department, during Semester I to II, a student shall be eligible to get exemption of one **4 credit course** during the 3rd or 4th semester. The proposed NPTEL course should cover content/syllabus of exempted core paper in 3rd or 4th semester.

S. No.	Course Code	Course Name	Proposed NPTEL Course	Credit
1			Option – 1 Paper title	4
			Option – 2 Paper title	
			Option – 3 Paper title	

b. Upon successful completion of **2 NPTEL Courses** (2 Credit each) recommended by the department, during Semester I to II, a student shall be eligible to get exemption of **one 4 credit course** during the 3rd or 4th semester. Out of 2 NPTEL proposed courses, **at least 1 course**

should cover content/syllabus of exempted core paper in 3rd or 4th semester.

Mandatory

The exempted core paper in the 3rd or 4th semester should be submitted by the students for approval before the end of 2nd semester

Credit transfer will be decided by equivalence committee

S. No.	Course Code	Course Name	Proposed NPTEL Course	Credit
1			Option – 1 Paper title	2
			Option – 2 Paper title	
			Option – 3 Paper title	
2			Option – 1 Paper title	2
			Option – 2 Paper title	
			Option – 3 Paper title	

NPTEL Courses to be carried out during semester I – II.					
S. No.	**Student Name**	**Class**	**Proposed NPTEL Course**		**Proposed Course for Exemption**
			Course I	Option 1- Paper Title Option 2- Paper Title Option 3- Paper Title	Any one Core Paper in 3rd or 4th Semesters
			Course II	Option 1- Paper Title Option 2- Paper Title Option 3- Paper Title	
Class Advisor			**HoD**		**Dean**

7. Internship/Industrial Training

Students must undertake industrial / institutional training for a minimum of 15 days and not exceeding 30 days during the II semester summer vacation. The students will submit the report for evaluation during III semester.

Mark Distribution for industrial / institutional training

Total : 100
Internal : 50
External : 50

i) Distribution of Internal Marks

S.No.	Particulars	Internal Marks
1	Review I	20
2	Review II	20
3	Attendance	10
	Total	**50**

ii) Distribution of External Marks

S.No	Particulars	External Marks
1	Internship /Industrial training Presentation	40
2	Viva –voce	10
	Total	**50**

Evaluation of Internship /Industrial training Presentation shall be done jointly by Internal and External Examiners.

8. Extra Credits: 10

Earning extra credit is not essential for programme completion. Student is entitled to earn extra credit for achievement in Curricular/Co-Curricular/ Extracurricular activities carried out other than the regular class hours.

A student is permitted to earn a maximum of 10 extra Credits during the programme period.
A maximum of 1 credit under each category is permissible.

Category	Credit
Self study Course	1
CA/ICSI/CMA (Foundations)	1
CA/ICSI/CMA (Inter)	1
Sports and Games	1
Publications / Conference Presentations (Oral/Poster)/Awards	1
Innovation / Incubation / Patent / Sponsored Projects / Consultancy	1
Representation in State / National level celebrations	1
Awards/Recognitions/Fellowships	1
Advanced Learner Course (ALC)*	2

Credit shall be awarded for achievements of the student during the period of study only.

GUIDELINES

Self study Course

A pass in the self study courses offered by the department.

The candidate should register the self study course offered by the department only in the III semester.

CA/ ICSI/ CMA (Foundations)

Qualifying foundation in CA/ICSI/CMA / etc.

CA/ICSI/ CMA (Inter)

Qualifying Inter in CA/ICSI/CMA / etc.

Sports and Games

The Student can earn extra credit based on their Achievement in sports in University/ State / National/ International.

Publications / Conference Presentations (Oral/Poster)

Research Publications in Journals

Oral/Poster presentation in Conference

Innovation / Incubation / Patent / Sponsored Projects / Consultancy

Development of model/ Products /Prototype /Process/App/Registration of Patents/ Copyrights/Trademarks/Sponsored Projects /Consultancy

Representation in State/ National level celebrations

State / National level celebrations such as Independence day, Republic day Parade, National Integration camp etc.

Awards/Recognitions/Fellowships

Regional/ State / National level awards/ Recognitions/Fellowships

***Advanced Learner Course (ALC):**

ALC is doing work of a higher standard than usual for students at that stage in their education.

Research work/internships carried out in Universities/ Research Institutions/ Industries of repute in India or abroad for a period of 15 to 30 days will be considered as Advanced Learners Course.

QUESTION PAPER PATTERN

CIA Test I: [1½ Hours-2.5 Units] - 25 Marks

SECTION	MARKS	DESCRIPTION	TOTAL	Remarks
Section – A	8 x 0.5= 04 Marks	MCQ	25 Marks	Marks secured will be converted To 15 mark
Section - B	3 x 2 = 06 Marks	Answer ALL Questions Either or Type ALL Questions Carry Equal Marks		
Section - C	3 x 05 = 15 Marks	Answer ALL Questions Either or Type ALL Questions Carry Equal Marks		

CIA Test II/ Model [3 Hours-5 Units] - 50 Marks

SECTION	MARKS	DESCRIPTION	TOTAL	Remarks
Section – A	10 x 1 = 10 Marks	MCQ	50 Marks	Marks secured will be converted To 15 mark
Section - B	5 x 6 = 30 Marks	Answer ALL Questions (Either or Type Questions) Each Questions Carry Equal Marks		
Section - C	1 x 10 = 10 Marks	Compulsory Question		

End Semester Examination [3 Hours-5 Units] - 50 Marks

SECTION	MARKS	DESCRIPTION	TOTAL
Section – A	10 x 1 = 10 Marks	MCQ	50 Marks
Section - B	5 x 6 = 30 Marks	Answer ALL Questions (Either or Type Questions) Each Questions Carry Equal Marks	
Section - C	1 x 10 = 10 Marks	Compulsory Question	

TOTAL CREDIT DISTRIBUTION

Courses	Credits	Total Marks		Credits	Cumulative Total
Core- Theory	4	10x100	1000	40	40
	5	2x100	200	10	10
	3	1x100	100	3	3
Core- Practical	3	3x 100	300	9	9
EDC	4	1x100	100	4	4
Elective	4	4x100	400	16	16
Medical Physics Summer Training	2	1x100	100	2	2
Project work	8	1x200	200	8	8
Total			**2400**	**92**	**92**

CURRICULUM

M.Sc. MEDICAL PHYSICS PROGRAMME

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
First Semester										
222MP2A1CA	Core	Nuclear Physics	4	1	-	3	50	50	100	4
222MP2A1CB	Core	Radiation Physics	4	1	-	3	50	50	100	4
222MP2A1CC	Core	Biomedical Electronics and Instrumentation	4	1	-	3	50	50	100	4
222MP2A1CD	Core	Radiological Anatomy, Physiology and Pathology	4	1	-	3	50	50	100	4
222MP2A1CP	Core Practical-I	Biomedical Electronics and Instrumentation Lab	-	-	6	3	50	50	100	3
222MP2A1DA	DSE-I	Solid State Physics	4	-	-	3	50	50	100	4
222MP2A1DB		Non-Ionizing Radiation in Medicine								
222MP2A1DC		Programming in C++								
Total			**20**	**4**	**6**	**-**	**-**	**-**	**600**	**23**

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Second Semester										
222MP2A2CA	Core - V	Radiation Detectors and Instrumentation	4	1	-	3	50	50	100	4
222MP2A2CB	Core - VI	Physics of Radiation Therapy	4	1	-	3	50	50	100	4
222MP2A2CC	Core - VII	Physics of Radiology Imaging	4	1	-	3	50	50	100	4
222MP2A2CP	Core Practical -II	Radiation Measuring and Monitoring Instrumentation	-	-	6	6	50	50	100	3
222MT2A2EB	EDC-I	Mathematical Physics	4	-	-	3	50	50	100	4
222MP2A2DA	DSE-II	Advanced Materials in Medicine and Healthcare	4	1	-	3	50	50	100	4
222MP2A2DB		Radiation Dosimetry and Standardization								
222MP2A2DC		Information Technology and Software Tools for Medical Physics								
		TOTAL	**20**	**4**	**6**	**-**	**-**	**-**	**600**	**23**

D. Sukumar 03/12/22

BoS Chairman/HoD
Department of Medical Physics
Dr. N. G. P. Arts and Science College
Coimbatore – 641 048

Dr.N.G.P. Arts and Science College
APPROVED

BoS- 14th	AC - 14th	GB - 19th
03.12.22	19.01.23	30.01.2023

Academic Council
Dr.V. Rajendran
CHAIRMAN
Dr.N.G.P. Arts and Science College

Dr.NGPASC
COIMBATORE | INDIA

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Third Semester										
222MP2A3CA	Core-VIII	Advanced Radiotherapy Physics	4	1	-	3	50	50	100	4
222MP2A3CB	Core-IX	Physics of Nuclear Medicine	4	1	-	3	50	50	100	4
222MP2A3CC	Core-X	Radiation Biology	4	1	-	3	50	50	100	5
222MP2A3CD	Core-XI	Brachytherapy Physics	4	1	-	3	50	50	100	4
222MP2A3CP	Core Practical-III	Treatment Planning, Radiation Dosimetry and Survey	-	-	6	6	50	50	100	3
222MP2A3DA	DSE-III	Materials for Radiation Dosimeters	4	-	-	3	50	50	100	4
222MP2A3DB		Biological Dosimetry								
222MP2A3DC		Artificial Intelligence in Healthcare								
222 MP2A3CT	Summer Training	Medical Physics Summer Training					50	50	100	2
Total			**20**	**4**	**6**	-	-	-	**700**	**26**

D. Skumar 14/06/2023
BoS Chairman/HoD
Department of Medical Physics
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Dr.NGPASC
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BoS- 15th 14.6.23 | AC- 15th 14.7.23 | GB- 20th 5.8.23

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Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Fourth Semester										
222MP2A4CA	Core-XII	Radiation Hazards, Evaluation and Control	5	1	-	3	50	50	100	5
222MP2A4CB	Core-XIII	Professional Ethics and Legal aspects	2	1	-	3	50	50	100	3
222MP2A4DA	DSE-IV	Quality Control, Acceptance Testing and Calibration of Radiation Systems	4	1	-	3	50	50	100	4
222MP2A4DB		Monte Carlo Techniques in Dosimetry								
222MP2A4DC		Advances in Medical Physics								
222MP2A4CV	Project	Project and Viva - Voce	-	-	16	-	100	100	200	8
Total			**11**	**3**	**16**				**500**	**20**
Grand Total									**2400**	**92**

Note:

- As per the Atomic Energy Regulatory Board safety code: AERB/RF-SC/MED, the candidate should undergo minimum 12 Months of internship at AERB recognized well-equipped radiation therapy department after successful completion of M.Sc. Medical Physics Programme to work as a qualified Medical Physicist in a Radiotherapy facility in India.
- The Candidates are eligible for appearing RSO examination after completion of minimum 12 Months of internship at AERB recognized well-equipped radiationtherapy department.

D. Sharma 17/10/23
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DISCIPLINE SPECIFIC ELECTIVE

Students shall select the desired course of their choice in the listed electivecourse during Semesters

Semester I (Elective I)

List of Elective Courses

S. No.	Course Code	Name of the Course
1	222MP2A1DA	Solid State Physics
2	222MP2A1DB	Non-Ionizing Radiation in Medicine
3	222MP2A1DC	Programming in C++

Semester II (Elective II)

List of Elective Courses

S. No	Course Code	Name of the Course
1	222MP2A2DA	Advanced Materials in Medicine and Healthcare
2	222MP2A2DB	Radiation Dosimetry and Standardization
3	222MP2A2DC	Information Technology and Software tools for Medical Physics

Semester II (Elective III)

List of Elective Courses

S. No.	Course Code	Name of the Course
1	222MP2A3DA	Materials for Radiation Dosimeters
2	222MP2A3DB	Biological Dosimetry
3	222MP2A3DC	Artificial Intelligence in Healthcare

Semester IV (Elective IV)

List of Elective Courses

S. No	Course Code	Name of the Course
1	222MP2A4DA	Quality Control, Acceptance Testing and Calibration of Radiation Systems
2	222MP2A4DB	Monte Carlo Techniques in Dosimetry
3	222MP2A4DC	Advances in Medical Physics

EXTRA CREDIT COURSES

The following are the courses offered under self study to earn extra credits:

S. No.	Course Code	Course Name
1	222MP2ASSA	Research Methodology
2	222MP2ASSB	Cancer Biology

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1CA	NUCLEAR PHYSICS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The basic principles, theory and concepts of nuclear physics
- The concepts of particle accelerators
- The various types of natural/particle induced nuclear reactions

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain about nucleus, its energy states and radioactivity principles	K3
CO2	Classify the decay types and nuclear reactions	K2
CO3	Outline the concepts of accelerators and their medical applications	K4
CO4	Evaluate various nuclear models and nuclear reactions	K4
CO5	Analyze different types of spectroscopy with varied detectors	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2					✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1CA	NUCLEAR PHYSICS	SEMESTER I

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Nucleus 8 h

General Properties of Nuclei – Constituents of Nuclei, Nuclear Size, Nuclear Radii, Nuclear Mass – Nuclear Units - Atomic Mass Unit, Electron Volt- Binding Energy - Systematic of Binding Energy - Mass Defect, Mass Excess, Packing and Binding Fraction - Discovery of Radioactivity – Radioactive Decay- Activity, Half Life, Mean Life - Decay Constant - Radioactive Series – Radioactive Equilibrium - Secular, Transient, Non Equilibrium.

Unit II Radioactive Decay Types 10 h

Alpha Decay - Geiger-Nuttal law – Energetics and Spectrum- Beta Decay and its Energies – Origin of Continuous Beta Spectrum - Neutrino Hypothesis – Properties of Neutrino - Nuclear Isomerism- Gamma Decay – Nature of Gamma Rays- Internal Conversion – Positron Emission - Electron Capture- Nuclear Fission and it's Discovery - Energy Release in Fission - Nature of the Fission Fragments - Energy Distribution Between the Fission Fragments - Fissile and Fertile Materials - Spontaneous Fission - Source of Energy in Stars - Nuclear Reactions and its Types - Conservation Laws - Q Values - Cross Section.

Unit III Particle Accelerators 12 h

Introduction - Classification and Performance Characteristics of Accelerators - Industrial, Medical and Research Applications – Resonant Transformer – Cascade Generator - Van De Graff Generator - Cyclotron - Betatron - Syncro Cyclotron- Linear Accelerator - Microtron– Electron Syncrotron – Proton Syncrotron.

Unit IV Nuclear Models, Fission and Fusion Reactors 15 h

Shell Model, Liquid Drop Model - Fission - Energetics of Fission Process, Controlled Fission Reactions - Chain Reaction – Basics of Reactor - Gas Cooled Reactors - Advanced Gas Cooled Reactors- Pressurized Water Reactor - Boiling Water Reactor - Heavy Water Reactor - Breeder Reactor - Fusion Process - Characteristics of Fusion - Solar Fusion - Controlled Fusion Reactors - Critical Conditions - Four Factor Formula - Nuclear energy and social development.

Unit V Nuclear Electronics and Techniques 15 h

Preamplifiers – Amplifiers - Single Channel Analyzers - Counting Statistics - Energy Measurements - Spectrometer - Introduction to Spectroscopy - Definition of Energy Spectra - Measurement of an Integral Spectrum and Differential Spectrum - Energy Resolution of a Detection System - Multichannel Analyzer - Calibration of MCA - Charged Particle Spectroscopy - Energy Straggling- Time of Flight Spectrometer – Detector Telescopes - Position - Sensitive Detectors (PSD), Categories - Photonic devices, Light detection and Characterization, Optoelectronics, Vision, Displays and Imaging, Optical metrology topics.

Text Books

1 Enge. H. 1983. Introduction to Nuclear Physics, 1st Edition, Addison Wesley publisher.

2 Ghoshal. S. N. 1997. Nuclear Physics, 4th Edition, S. Chand Ltd publisher

References

1 Kenneth Krane. S, 1987, "Introductory Nuclear Physics", 3rd Edition, John Wiley and Springer publisher.

2 MuraleedharaVarier. M, 2009, "Nuclear Radiation Detection, Measurements and Analysis", 2nd edition, Narosa publisher.

3 Stefaan Tavernier, 2010, "Experimental Techniques in Nuclear and Particle Physics", 4th Edition, Springer publisher.

4 Tayal D.C, 2009,"Nuclear Physics", 2nd edition, Himalaya Publishing House.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1CB	RADIATION PHYSICS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The production and its properties of electromagnetic radiations and particulate radiations
- The broad knowledge on the Ionizing Radiation, X-ray production, and properties of X-rays
- The Interaction of Directly and indirectly ionizing radiation with matter and its effects

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Discuss about electromagnetic spectrum and particulate radiation and it's properties	K3
CO2	Outline the X-ray tube construction and safe operation of the X-ray tube and its function	K4
CO3	Evaluate the theories of atomic physics nuclear reactions uncertainity and exclusion principles to radiation physics	K4
CO4	Explain the Physics aspects of interaction of indirectly ionizing radiation with matter	K3
CO5	Summarize the interaction of directly ionizing radiation with matter and its effects inside a living object	K2

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1CB	RADIATION PHYSICS	SEMESTER I

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Ionizing Radiation 10 h

Electromagnetic Radiation and its Properties – Electromagnetic Spectrum - Radio waves, Microwaves, Infrared, Visible light, UV, X-rays and Gamma rays – Particulate Radiation – Properties of alpha, beta, neutrons and positrons – Classification of Radiation – Directly Ionizing Radiation – Electrons, Positrons, Heavy charged particles and Pions - Indirectly Ionizing Radiation – X-rays, Gamma rays and Neutrons.

Unit II X-Ray Generators 12 h

Discovery - Production - Properties of X-Rays - Characteristics and Bremmstralung - Design of Hot Cathode X-Ray Tube - Basic Requirements of Medical Diagnostic, Therapeutic and Industrial Radiographic Tubes - Rotating Anode Tubes - Hooded Anode Tubes - X-Ray Tubes for Crystallography - Rating of Tubes - Safety Devices in X-Ray Tubes : Ray Proof and Shockproof Tubes - Insulation and Cooling of X-Ray Tubes - Fixed X-ray machines, Portable X-ray machines and Mobile X-ray machines - C-Arm and Dental Unit – Maintenance of X-Ray Tube Unit.

Filament and High Voltage Transformers – High Voltage Circuits - Half-Wave and Full Wave Rectifiers - Condenser Discharge Apparatus - High Frequency Generators - Voltage Doubling Circuits - Current and Voltage Stabilizers - Control Panels - X-Ray Circuits - Image Intensifiers and Closed Circuit TV Systems – Flat Panel Technology.

Unit III Interaction of Photons with Matter 12 h

Ionization and Excitation - Attenuation - Linear Attenuation Coefficient - Mass Attenuation Coefficient - Energy Transfer and Mass Energy Absorption Coefficients - HVL – Rayleigh Scattering – Thomson Scattering - Photoelectric Effect - Compton Effect – Pair Production – Positron Annihilation - Photo disintegration - Relative Importance of Various Types of Interactions - Importance of Interaction in Tissue.

Unit IV Interaction of Charged Particles with Matter 14 h

Classical Theory of Inelastic Collisions with Atomic Electrons – Energy Loss Per Ion Pair by Primary and Secondary Ionization – Dependence of Collision Energy Losses on the Physical and Chemical State of the Absorber – Cerenkov Radiation –

Electron Absorption Process – Radiative Collision – Range Energy Relation – Continuous Slowing Down Approximation (CSDA) – Straight ahead Approximation and Detour Factors – Transmission and Depth Dependence Methods for Determination of Particle Penetration - Empirical Relations Between Range and Energy – Back Scattering.

Interaction of Heavy Charged Particles - Energy Loss by Collision – Range Energy Relation – Alpha bragg curve and Proton bragg curve – Specific Ionization – Stopping Power – Bethe Bloch Formula.

Unit V Interaction of Neutrons with Matter 12 h

Neutron Sources – Properties – Energy Classifications - Fast neutron, Slow neutron and Thermal Neutron and its interactions with matter, Neutron capture – Elastic and Inelastic Scattering Coefficients and Cross Sections – Energy Transfer and Logarithmic Energy Decrement - Nuclear Reactions –Dependence on E and Z – (n,p), (n,2n), (n,γ) and other Reactions – Neutron Activation - Radio Isotope Production.

Text Books

1 Johns. H. E and Cunningham, 1984, "The Physics of radiology", 4th Edition, Charles C Thomas Publishers.

2 E.B.Podgarsak, 1996, "Radiation Physics for Medical Physicists", 2nd Edition, Springer Verlag Publishers.

References

1 MarkolfNeimz. H, 1996, "Laser-Tissue Interactions", 3rd Edition, Springer Verlag publisher

2 Curry, T.S. Dowdey and J.E. Murry R.C, 1984, "Christensen's introduction to the Physics of diagnostic radiology", 3rd Edition, Philadelphia, Lea & Febiger publisher.

3 Podgarsak. E.B, 2005, "Radiation Oncology Physics: Handbook for Teachers and Students", IAEA, Vienna publisher.

4 Attix. F. H, 2004, "Introduction to Radiological Physics and Radiation Dosimetry", 4th Edition, Viley VCH, Verlog publisher.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1CC	BIOMEDICAL ELECTRONICS AND INSTRUMENTATION	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The knowledge in digital principles and its applications
- The application of op-amps for various mathematical applications
- The bio electric signal recording, physiological assist devices, operation theater equipments

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Manipulate the component types and connections used to build functioning electronic circuits	K3
CO2	Explain about solving problems related to number systems and Boolean algebra	K4
CO3	Construct the basic architecture of different Microprocessors	K4
CO4	Estimate the concept of various bioelectric potentials generated in human body and related equipments	K4
CO5	Evaluate human physiology and anatomy with signal processing paradigms	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1CC	BIOMEDICAL ELECTRONICS AND INSTRUMENTATION	SEMESTER I

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Basic Electronics 8 h

UniJunction Transistor (UJT) - Semi Conductor Diode - Characteristics - Voltage Regulator Circuits - LED - Bipolar Junction Transistors - CB and CE Configuration - FET - MOSFET- JFET Amplifier - Characteristics - Principle of Operation.

Op-Amp - Circuit Symbol-Ideal Op-Amp Characteristics - CMRR-Applications: Adder, Subtractor, Analog Integrator, Analog Differentiator, Voltage-to-Current Converter, Current-to-Voltage Converter and Logarithmic Amplifier.

Unit II Digital Electronics 10 h

Logic Gates - Boolean Algebra - Boolean Laws – De-Morgan's Theorem - Implementation of Logic Circuits from Truth Table – Sum-of-Products Method – Products-of-Sum Method - Combinational Circuits: Multiplexer and De-Multiplexer Circuits - BCD to Decimal Decoders - Seven Segment Decoders - Decimal to BCD Encoder.

Arithmetic Building Blocks: Half-Adder and Full-Adder - Digital Comparator - Flip Flops: RS, Clocked RS, D-Flip Flop, Edge-Triggered D Flip Flop – J K Flip Flop - Sequential Logic Circuits: Registers - Shift Registers – Applications - Counters: Ripple Counters Up, Down and Up-Down Ripple Counters - Asynchronous and Synchronous Counters - ADC and DCA.

Unit III Microprocessor 12 h

Architecture of 8-Bit Microprocessor: Intel 8085A Microprocessor, Pin Description and Internal Architecture - Operation and Control of Microprocessor: Timing and Control Unit, Op-Code Fetch Machine Cycle, Memory Read/Write Machine Cycles, I/O Read/Write Machine Cycles, Interrupt Acknowledge Machine Cycle, State Transition Diagram - Instruction Set - Assembly Language Programming - Interfacing - Interrupts - Programmable Peripheral Interface - Programmable Interval Timer- Sample 8085 Assembly Language Programmes.

Unit IV Physiological Assist Devices 15 h

Cardiac Output Measuring Techniques – Dye Dilution Method, Thermo Dilution Method, BP Method - Blood Flow Measuring Techniques: Electromagnetic Type - Ultrasound Blood Flow Meter, Automatic Counting Of RBC, WBC and Platelets. Measurement of Blood Pressure – Direct Methods and Indirect Methods -

Temperature - Respiration Rate - Heart Rate Measurement - O2, CO2 Measurements, Respiratory Volume Measurement, BMR Measurement, Plethysmography Technique, Detection of Various Physiological Parameters Using Impedance Technique - Kidney Machine – Hemodialysis Units – Peritoneal Dialysis- Lithotripsy - Various Types of Endoscopy- Ventricular Assist Devices (VADs) topic

Unit V Bioelectric Signal Recording and Clinical Equipment 15 h

Bio-Electrodes: Surface - Micro - Needle Electrodes - Equivalent Circuits of Electrodes – Biochemical and Transcutaneous - Electrodes: PH, PO2, PCO2 Bio amplifiers – Bio potential Signals and their Recording: Bio amplifiers- Carrier Amplifier, - Isolation Amplifier - Differential Amplifier - Chopper Amplifier - Instrumentation Amplifier - Bioelectric Signals (ECG, EMG, EEG, EOG & ERG) and their Characteristics - Different Types of Bio Electric Signal and Recording Electrodes - Surface Electrodes and the Deep - Seated Electrodes - Electrodes for ECG, EEG And EMG - ECG Machine - EMG Machine – 10-20 Electrodes Placement System for EEG - EEG Machine - Heart Sound and Characteristics, PCG - Biochemical Measurement Techniques: Chemical Fibro Sensors, Fluorescence Sensors - Glucose Sensor - Colorimeter, Spectro Photometer, Flame Photometer – Chromatography - Mass Spectrometer , Auto Analyzer.

Text Books

1 Santanue Chattopadhyay, 2006, "A text book of Electronics", 1st Edition, New Central Book Agency publisher. Kolkata.

2 Malvino. A. P and Leach. D. P. 1994, "Digital Principles and Applications", 5th Edition, Tata McGraw-Hill Publishing Co publisher, New Delhi.

References

1 Bhattacharya. A. B. 2007, "Electronic Principles and Applications", 2nd Edition, New Central Book Agency, Kolkata.

2 Geddes LA and Baker L.E. 1989, "Principals of AppliedBiomedical Instrumentation", 3rd Edition, John Wiley and sons, New york.

3 Mathur. A. P. 2005, "Introduction to Microprocessors", 3rd Edition, Tata McGraw-Hill Publishing Co, New Delhi.

4 R. S. Khandpur. 1990, "Handbook of Biomedical Instrumentation", Tata McGraw Hill, NewDelhi.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1CD	RADIOLOGICAL ANATOMY, PHYSIOLOGY AND PATHOLOGY	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The structure and function of the organs and systems.
- The cancer prevention and public education and early detection and screening.
- The professional aspects and role of Medical Physicists.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Demonstrate the normal organization of the organ systematic levels	K3
CO2	Experiment the anatomy of human body, nomenclature, and radiographic anatomy	K4
CO3	Categorize the indications and complications of various treatment procedures	K4
CO4	Verify the site specific signs, symptoms, diagnosis and management for all types of cancer	K4
CO5	Discuss the various treatment modalities and the interpretation of clinical trials	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1CD	RADIOLOGICAL ANATOMY, PHYSIOLOGY AND PATHOLOGY	SEMESTER I

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Human Anatomy and Physiology 15 h

Introduction to Human Body - The Cells, Tissues and Organization of Body - Blood Skin - Lymphatic System - Skeletal System - Nervous System - Endocrine System - Cardiovascular - Respiratory System - Digestive System - Gastro-Intestinal - Excretory System - Reproductive System - Special Senses.

Unit II Radiographic Anatomy 9 h

Anatomy of Human Body Nomenclature - Surface Anatomy - Radiographic Anatomy - Cross Sectional Anatomy – Identify the Different Organs/Structures on Plain X-rays, CT scans and other available Imaging Modalities - Normal Anatomy and Deviation for Abnormalities.

Unit III Tumor Pathology,Cancer Screening and Treatment Modalities 18 h

Tumor Pathology and Carcinogenesis - Basic Pathological Features of Cancers and Interpretation of Clinico-Pathological Data - Benign and Malignant Disease - Methods of Spread of Malignant Disease - Staging and Grading Systems - Treatment Intent – Curative & Palliative - Cancer Prevention and Public Education- Patient Management on Treatment – Monitoring and Common Management of Side Effects – Information and Communication - Screening - Definition, Principles, Evaluating Screening Tests, Developing and Evaluating a Cancer Screening Programme - Different Kind of Screening Tests - Screening for Specific Types of Cancer - Genetic Counseling - Treatment – Essential Terms, Surgery, Radiation, Chemotherapy, Biological Therapy, Hormone Therapy, Transplantation, Targeted Therapy, Radiolabelled Immunotherapy, Gene Therapy and other Treatment Methods (Cryosurgery, Laser Therapy, Photodynamic Therapy, Hyperthermia)- Cancer Clinical Trials.

Unit IV Site Specific Signs, Symptoms, Diagnosis and Management 9 h

Head and Neck, Breast, Gynecological, Gastro-Intestinal Tract, Genito - Urinary, Lung and Thorax, Lymphomas, Leukemias & other Cancers including AIDS Related Cancers.

Unit V Professional Aspects and Role of Medical Physicists 9 h

General Patient Care - Principles of Professional Practice – Medical Terminology – Research & Professional Writing – Patient Privacy – Ethical & Cultural Issues - Legal Aspects – Confidentiality, Informed Consent, Health and Safety.

Text Books

1 Ross and Wilson, 2014, "Anatomy and Physiology in Health and Illness" by Anne Waugh, Allison Grant, 12th Edition, published by Churchill Livingstone.

2 Henry Gray, 2009, "Anatomy and physiology", 30th Edition, Philadelphia: Lea & Febiger.

References

1 Rod R. Seely, 1999, "Anatomy and Physiology", 5th edition, Mcgraw-Hill College.

2 Meschan, 1969, "Normal Radiation Anatomy", 8th edition, WB Sunders Company.

3 C. K. Warrick, 2001, "Anatomy and Physiology for Radiographers", Oxford University Press.

4 C. H. Best and N. B. Taylor, 1999, "A Test in Applied Physiology", Williams and Wilkins Company, Baltimore.

222MP2A1CP	CORE PRACTICAL BIOMEDICAL ELECTRONICS AND INSTRUMENTATION LAB	SEMESTER I

Total Credits: 2
Total Instructions Hours: 72 h

List of Experiments

S. No	
1	Zener regulated power supply and percentage of regulation.
2	Transistor characteristics- CB and CE configuration.
3	Single stage R-C coupled transistor amplifier.
4	Single stage FET amplifier- CS configuration.
5	FET characteristics.
6	OP-Amp applications - Adder and Subtractor.
7	OP-Amp applications - Differentiator and Integrator.
8	Logic gates OR, AND, NOT, NOR and NAND Gates.
9	Half adder and Full adder.
10	NAND gate as a universal gate.
11	A/D and D/A converters.
12	UJT characteristics
13	Photosensitive diodes.
14	Verification of De-morgan's theorem.
15	Construct analog to digital conversion using IC-74148

Note: 10 out of 15 experiments are mandatory

References

1 Hughes J, 2015. "Practical Electronics: Components and Techniques", 1st edition, O'Reilly Media Publisher.

2 Ian Sinclair, 1980. "Practical Electronics Handbook", 6th Edition, Elsevier Publisher.

3 Bhatt N.D, 1990, "Elementary Engineering Drawing", Charater Publishing Co.

4 Hajra Choudry S.K, 1992, " Elements of Workshop Teaching", Vol.I and II. Tata McGraw Hill Publishing Co., New Delhi.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1DA	SOLID STATE PHYSICS	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The basic principles, theory and concepts of rigid solid matter
- The Crystalline state and structure
- The Magnetic, Superconductivity and Semiconducting properties of solids

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Illustrate the various crystal structures and forces associated with it	K3
CO2	Explain the application of lattice structures heat processes associated with it	K3
CO3	Outline the theories of various metals and semiconductors and their mobility phenomena	K4
CO4	Classify different types of magnetic materials	K4
CO5	Discuss different types of superconductors and their applications	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1DA	SOLID STATE PHYSICS	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Crystal Physics 8 h

Bravais lattice - Miller Indices - Simple Crystal Structures - Crystal Diffraction - Bragg's Law - Reciprocal Lattice (Sc, Bcc, Fcc) - Laue Equations - Structure Factor - Atomic Form Factor - Types of Crystal Binding - Cohesive Energy of Ionic Crystals- Madelung Constant - Inert Gas Crystals - Vander Waal - London Equation - Metal Crystals - Hydrogen Bonded Crystals.

Unit II Lattice Dynamic 10 h

Primitive cell and Unit Cell - First Brillouin Zone - Group and Phase Velocities - Quantization of Lattice Vibrations - Phonon Momentum – Inelastic Scattering - Debye's Theory of Lattice Heat Capacity - Einstein's Model and Debye's Model of Specific Heat - Thermal Expansion - Thermal Conductivity - Umklapp Processes.

Unit III Theory of Metals And Semiconductors 10 h

Free Electrons Gas in Three Dimensions - Electronic Heat Capacity - Wiedmann-Franz Law - Hall Effect - Band Theory of Metals and Semiconductors - Bloch Theorem - Kronig-Penny Model -Semiconductors - Intrinsic Carrier Concentration - Mobility - Impurity Conductivity - Fermi Surfaces and Construction - Experimental Methods in Fermi Surface Studies - De Haas Van Alphen Effect - Application of Semiconductor in Medicine.

Unit IV Magnetic Properties of Materials 10 h

Elementary Ideas of Dia, Para and Ferro Magnetism - Quantum Theory of Paramagnetism - Rare Earth Ion - Hund's Rule - Quenching of Orbital Angular Momentum - Adiabatic Demagnetization - Quantum Theory of Ferromagnetism - Curie Point - Exchange Integral - Heisenberg's Interpretation of Weiss Field - Ferromagnetic Domains - Bloch Wall - Spin Waves - Quantization - Magnons - Thermal Excitation of Magnons - Curie Temperature and Susceptibility of Ferrimagnets - Theory of Antiferromagnetism - Neel Temperature - Application of Magnet in Medicine.

Unit V Super Conductivity 10 h

Experimental Facts - Occurrence - Effect of Magnetic Fields - Meissner Effect - Entropy and Heat Capacity - Energy Gap - Microwave and Infrared Properties - Type I and II Superconductors - Theoretical Explanation - Thermodynamics of Super Conducting Transition - Coherence Length - BCS Theory - Single Particle Tunneling - Josephson Tunneling - DC And AC Josephson Effects - High Temperature Super Conductors - SQUIDS.

Text Books

1 Kittel. C, 2005, "Introduction to Solid State Physics", 7th Edition, Wiley, New York.

2 Pillai. S. O, 2002, "Solid State Physics", 6th Edition, New Age International, New Delhi.

References

1 Blakemore. J. S, 1985, "Solid State Physics", 2nd Edition, Publisher Cambridge University.

2 Dekker. A. J, 1986, "Solid State Physics", 2nd Edition, Macmillan India, New Delhi.

3 Pillai. S. O, 2007, "Problems and Solutions in Solid State Physics", 4th Edition, New Age International, New Delhi.

4 Wahab A M, 2007, "Structure and Properties of Materials", 2nd edition, Narosa Publishing house, New Delhi, India.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1DB	NON-IONIZING RADIATION IN MEDICINE	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The non-ionizing radiations and its properties
- The interaction of non-ionizing radiations with tissues
- The applications of lasers, ultrasound, radio frequency and microwaves in medicine

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the various sources of non-ionizing radiations and its properties	K3
CO2	Discuss the interaction of optical radiations with tissues	K3
CO3	Summarize the applications of Lasers in dermatology, oncology and cell biology	K2
CO4	Explain the ultrasound production, properties and its application in medicine	K3
CO5	Describe the interaction of radiofrequency waves and microwaves with biological system	K1

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1DB	NON-IONIZING RADIATION IN MEDICINE	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Fundamentals of Non-Ionizing Radiation Physics 10 h

Electromagnetic spectrum - Different sources of non-ionizing radiation and its physical properties - Laws of photochemistry - Grothus-Draper Law and Stark-Einstein Law - Law of reciprocity - Electrical impedance and Biological impedance - Principle and theory of thermography – Applications.

Unit II Applications of Optical Radiation 10 h

Introduction to optical radiations – UV, Visible and IR sources - Lasers: Theory and mechanism - Lasers in surgery - Fluence measurement from optical sources - Optical properties of tissues – Interaction of laser radiation with tissues – Photothermal -Photochemical – Photoablation – Electromechanical effect.

Unit III Lasers in Medicine 8 h

Lasers in medicine - Applications of ultrafast pulsed lasers - Lasers in dermatology, oncology and cell biology - Lasers in blood flow measurement - Fiber optics in medicine - Hazards of lasers and their safety measures.

Unit IV Ultrasound in Medicine 10 h

Production, Properties and Propagation of ultrasonic waves – Bioacoustics - Acoustical characteristics of human body - Ultrasound in obstetrics and gynecology -Vascular System - Early pregnancy and foetal activity - Ultrasound in ophthalmology and echocardiography - Ultrasonic dosimetry - High power ultrasound in therapy.

Unit V Radio Frequency and Microwave in Medicine 10 h

Production and Properties - Interaction mechanism of RF and microwaves with biological systems: Thermal and non-thermal effects on whole body, lens and cardiovascular systems - Tissue characterization - Hyperthermia and other applications.

Text Books

1 Martellucci S. S and Chester A. N, 1985, "Laser Photobiology and Photomedicine", Plenum Press, New York.

2 Markolf H. Neimz, 1996, "Laser-Tissue Interactions", Springer Verlag, Germany.

References

1 Greening J. R, 1999, "Medical Physics", North Holland Publishing Co., New York.

2 Pratesi R and Sacchi C. A, 1980, "Lasers in Photomedicine and Photobiology", Springer Verlag, West Germany.

3 Harry Moseley Hospital Physicists' Association, 1999, "Non-ionising radiation: microwaves, ultraviolet, and laser radiation", A. Hilger, in collaboration with the Hospital Physicists' Association.

4 Malvino A.P, 2007, "Electronic principles", 7th edition, Tata McGraw Hill Publication Co. Ltd., New Delhi.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A1DC	PROGRAMING IN C++	CORE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The fundamental programming concepts and methodologies which are essential to build good C++ programs
- The fundamental programming methodologies in C++ language through laboratory experiences
- The fundamental Microsoft Visual Studio programming

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the basic concepts of C++ programs	K3
CO2	Discuss the methods of classes and objects	K3
CO3	Interpret the binary operators and types of inheritance	K3
CO4	Explain about pointers and arrays	K3
CO5	Explain about file stream classes	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

✓	Skill Development		Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A1DC	PROGRAMING IN C++	SEMESTER I

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to C++ 10 h

Key concepts of Object-Oriented Programming – Advantages – Object-Oriented Languages – Usages of C++ - I/O in C++ - C++ Declarations - Control structures - Decision making and statements: If, Else, jump, goto, break, continue, Switch case statements - Loops in C++: For, While, Do - Functions in C++ - Inline functions – Function overloading.

Unit II Classes and Objects 10 h

Declaring objects – Defining member functions – Static member variables and functions – Array of objects –Friend functions – Overloading member functions – Bit fields and classes – Constructor and destructor with static members.

Unit III Operator Overloading 10 h

Overloading unary, binary operators – Overloading friend functions – Type conversion – Inheritance: Types of Inheritance – Single, Multilevel, Multiple, Hierarchal, Hybrid, Multi path inheritance – Virtual base Classes – Abstract classes - Sample programs to implement inheritance.

Unit IV Pointers 10 h

Pointers – Declaration – Pointer to Class , Object – this pointer – Pointers to derived classes and Base classes – Arrays – Characteristics – Array of classes – Memory models – New and delete operators – Dynamic object – Binding , Polymorphism and Virtual functions - Sample programs to implement polymorphism

Unit V Files 8 h

Operations – Binary and ASCII Files – Random access operation – Templates – Exception handling - String – Declaring and Initializing string objects – String attributes – Miscellaneous functions

Text Books

1 Ashok N Kamthane, 2006, "Object-Oriented Programming with ANSI and Turbo C++", 1st Edition, published by Pearson Education.

2 Balagurusamy E, 2013, "Object-Oriented Programming With C++", 6th Edition, published by Tata Mc-Grawhill.

References

1 Maria Litvin & Gray Litvin, 1997, "C++ for you", 1st Edition published Skylight.

2 Brian W. Kernighan and Dennis M. Ritchie, 2006, "The C programming Language" Prentice-Hall.

3 Bjarne Stroustrup, "The C++ Programming language", 3rd Edition, Pearson Education.

4 HM Deitel and PJ Deitel "C++ How to Program", 7th Edition, 2010, Prentice Hall.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2CA	RADIATION DETECTORS AND INSTRUMENTATION	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The principle of radiation detection and types of detector.
- The Function of electronic equipments used to measure and count ionizing radiation
- The characteristics of radiation detection systems

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the principle of radiation detector in the measurement of high energy radiation.	K4
CO2	Apply the concept of scintillation and other detectors.	K3
CO3	Illustrate the theory behind dosimetric instruments and their applications.	K3
CO4	Distinguish the various radiation protection instruments and their uses	K4
CO5	Outline the nuclear medicine instruments	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓		✓	✓	
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2CA	RADIATION DETECTORS AND INSTRUMENTATION	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Introduction to Radiation Measurements and Gas Filled Detectors** **12 h**

Radiation- Statistical nature of radiation emission- Accuracy and Precision of measurements - Error -Types of errors- Random error and Systematic error.

Basic principle of radiation detection and detector properties - Detector types - Principle of gas filled detectors- Voltage and current characteristic of gas filled detectors -Ionization chamber, Thimble chamber, Condenser type chamber and its construction and working - Gas multiplication - Proportional counters, Geiger-Muller counters - Dead time and recovery time – Quenching - Characteristics of organic and inorganic counters – Calorimetry –Principle and application for absolute dosimetry.

Unit II **Principles of Radiation Detection Using Scintillation and Other Detectors** **14 h**

Principle of scintillation- Scintillator and its properties - Organic and Inorganic scintillator - Relationship between pulse height and energy and type of incident particle - Photomultiplier tube - Assembly of a scintillation counter and role of light pipes - Dead time of scintillation counters – Sources of background in a scintillation counter - Resolving time–Resolving power- -Liquid scintillator.

Semiconductor detectors: Diode, Metal oxide semiconductor field effect transistor (MOSFET) - Voltage current characterization -Thermoluminescence dosimeters (TLD) – Detection process - Glow curve and dose response - Common TLD materials and their characteristics – Fading-Residual TL - Annealing Process – Reuse - Optically stimulated luminescence dosimeters(OSLD).

Radiographic and Radiochromic films - Film characteristic and calibration – Radiophoto luminescent dosimeters - Neutron detectors – Nuclear track emulsions for fast neutrons – Solid state nuclear track detectors (SSNTD).

Unit III **Dosimetry Instruments** **12 h**

Secondary standard therapy level dosimeters: Farmer type, Parallel Plate and Well type chambers (Re entrant, Sealed chamber) – BF_3 Proportional Counter - Pocket dosimeters – Multipurpose dosimeters – Different types of electrometers – String electrometer - MOSFET, Vibrating condenser and Varactor bridge types – Phantom

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– Classifications (Water, Solid, Anthropomorphic phantom) - Characteristics– Radiation field analyzer (RFA) –Thermoluminescent dosimeter reader for medical applications - Calibration and maintenance of dosimeters.

Unit IV Protection Instruments **12 h**

Film Badge –Film densitometers - TLD badge and reader – Glass dosimeter readers – Digital pocket dosimeters using solid state devices and GM counters –Teletector-Survey meter - GM type and Ion chamber type – Industrial gamma radiography survey meter–Gamma area(Zone) alarm monitors.

Contamination monitors for alpha, beta and gamma radiation – Hand and foot monitors - Laundry and portal monitors - Scintillation monitors for X and gamma radiations – Neutron monitors, Tissue equivalent survey meters – Flux meter and Fluence - Dose equivalent monitors – Pocket neutron monitors -Teledose systems.

Unit V Nuclear Medicine Instruments **10 h**

Radioisotope calibrator– Thyroid uptake probe -Instruments for counting and spectrometry– Portable counting systems for alpha and beta radiation – Gamma ray spectrometers – Multichannel analyzer– Liquid scintillation counting system – RIA counters – Whole body counters – Air monitors for radioactive particulates and gases - Details of commercially available instruments and systems.

Text Books

1. Knoll. G. F, 2000. Radiation detection and measurement, 3rd Edition, John Wiley Publisher.
2. Nicholas Tsoulfanidis, 1995. Measurement and Detection of Radiation, 2nd Edition, Taylor & Francis.

References

1. Podgarsak. E.B. 2005. Radiation Oncology Physics: Handbook for Teachers and Students, IAEA, Vienna publisher.
2. Meredith.W.J and Massey.J.B, 1972. Fundamental Physics of Radiology, 2nd Edition, John Wright and sons, UK.
3. Price W.J, 1964. Nucleus Radiation detection, 2nd Edition, McGraw-Hill, New York.
4. Kapoor. S.S. and. Ramamurthy.V, 1986. Nuclear Radiation Detectors,1st Edition, New Age International (P)Ltd.
5. https://humanhealth.iaea.org/HHW/MedicalPhysics/elearning/Nuclear_Medicine_Handbook_slides/Chapter_06._Basic_Radiation_Detectors.pdf.
6. https://depts.washington.edu/uwmip/Week_3/RadDetect08.pdf.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2CB	PHYSICS OF RADIATION THERAPY	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The Physics of radiation beam generators used in radiation therapy
- The dose distribution of therapeutic beams and its dosimetric parameters
- The various treatment techniques, the concept of treatment planning and dose calculation for external beam therapy

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Demonstrate the construction and working of various therapy beam generators	K3
CO2	Interpret the various central axis dosimetric parameters	K3
CO3	Classify the beam modifying devices and its uses	K4
CO4	Analyze the concept of treatment planning process in teletherapy	K4
CO5	Explain the characteristics of electron beam, treatment techniques and dose calculation	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	
CO4	✓		✓	✓	
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2CB	PHYSICS OF RADIATION THERAPY	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Therapy Beam Generators — 12 h

Kilovoltage therapy X-ray units – Grenz ray therapy, Contact therapy, Superficial therapy, Deep therapy and Supervoltage therapy – Spectral distribution of kV X-rays and effect of filtration -Thoraeus filter - Telecobalt units: Construction and working, Source design, Beam shutter mechanisms – Radiation field - Beam collimation, Penumbra and its types, Trimmers and Breast cones - Beam directing devices - Front and Back Pointers, Pin & arc ODI, Laser - Isocentric gantry.

Linear accelerator - Design - Principle and function of klystron and magnetron, traveling and standing waveguide, pulse modulators and auxiliary systems, Bending magnet systems, Treatment head - Electron beam, X-rays, Beam collimation, Asymmetric collimator, Multileaf collimator, Dose monitoring systems - Interlocks – Output calibration procedure - Relative merits and demerits of kV X-rays, gamma rays, MV X-rays and electron beams.

Unit II Central Axis Dosimetry Parameters — 13 h

Collimator scatter factor, Phantom scatter factor and Total scatter factor - Percentage depth dose (PDD) - Factors affecting PDD - Maynord factor - Tissue air ratio (TAR), Backscatter factor/Peakscatter factor (BSF/PSF) - Tissue phantom ratio (TPR) - Tissue maximum ratio(TMR) - Relationship between TAR and PDD and its applications – Relationship between TMR and PDD and its applications – Scatter air ratio (SAR)– Scatter maximum ratio(SMR) - Off axis ratio and field factor - Surface dose and buildup region - Isodose chart - Measurements of Isodose curves – Characteristic of isodose curves – Dosimetric data resources for treatment calculation – Concept of dose calculation for equivalent square field.

Unit III Beam Modification And Shaping Devices — 10 h

Bolus and its types – Beam spoilers -Wedge filters – Individual, Universal, motorized and dynamic wedges – Shielding blocks - Field shaping, Custom blocking -Styrofoam cutting machine -Tissue compensators – Design of compensators, 2D compensators, 3D compensators – Multileaf collimator (MLC).

Unit IV Treatment Planning In Teletherapy — 13 h

Electron contamination, Dmax, Buildup Dose, Entrance dose, Exit dose, Target volume definition and Dose prescription criteria – ICRU 29, ICRU 50, ICRU 62 and ICRU 83 -

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Treatment planning in teletherapy - Positioning/Immobilization - 2D and 3D localization techniques - Conventional simulator and CT simulator – Contrasts - Markers - Patient data acquisition – DICOM- Relative electron density - Image registration and segmentation using CT, MRI, US and PET.

SSD and SAD set ups – Extended SSD - Field arrangements – Single, Parallel opposed and Multiple fields – Corrections for tissue inhomogeneity, Contour shapes and beam obliquity– Integral dose-Arc/Rotation therapy and Clarkson technique for irregular fields – Mantle and inverted Y Fields. Conventional and Conformal radiotherapy-Gradient Index, Treatment time and Monitor unit calculations for Co-60 and Linear accelerator – SSD and SAD/Isocentric techniques - Dose prescription and normalization - Virtual simulation – Digitally reconstructed radiographs (DRR)-Beam's Eye view - Plan evaluation - DVHs – Differential and Cumulative

Unit V Electron Beam Therapy **12 h**

Energy specification - Depth dose characteristics of electron beam (Dmax, Ds, Dx, dmax, R90, R50, Rp and Bremsstrahlung Tail) - Characteristic of clinical electron beams - Collimation - Electron cutouts, Electron applicator - Determination of absorbed dose - Applicator factor - Cut out factor- Monitor unit calculations – Output factor formalisms - Planning and dose calculation effects of patient and beam geometry - Internal heterogeneities - Treatment planning techniques – Field abutment techniques – Photon and electron mixed beams – Electron arc therapy - ICRU71.

Text Books

1 Faiz Khan. M, 2014. The Physics of Radiation Therapy, 5th Edition, Wolterskluwer.

2 Podgarsak. E.B. 2005. Radiation Oncology Physics: Handbook for Teachers and Students, IAEA, Vienna publisher.

References

1 G.C.Bentel, 1992. Radiation Therapy Planning, 1st Edition, Macmillan Publishing Co., New York.

2 Faiz M. Khan, Roger A. Potish, 1998. Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore.

3 Hendee. W. R, 2004. Medical Radiation Physics, preface of 3rd Edition, Medical Publishers Inc London.

4 Bomford. C. K, kunkler. I. H, Walter and Miller's, 2002. Textbook of Radiotherapy, 6th revised edition, Churchill Livingstone.

5 https://www.slideshare.net/AminAmin/medical-linear-accelerator.

6 https://www.slideshare.net/jyotimannath/electron-beam-therapy-60129214.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2CC	PHYSICS OF RADIOLOGY IMAGING	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The fundamentals of medical imaging techniques such as, X-ray, Fluoroscopy, Mammogram, CT, MRI, and Ultra Sound.
- The methods for generating 2D and 3D images in diagnostic radiology.
- The factor influences the image quality and QA protocols for various imaging modalities.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Interpret the principle of X-ray imaging and the associated technical parameters	K3
CO2	Illustrate the concept of generating mammography and fluoroscopy images	K3
CO3	Infer the physical principle behind CT and image reconstruction algorithms	K4
CO4	Demonstrate the Physics principle of MRI and Quality assurance	K3
CO5	Explain the interaction of ultrasonic waves with tissues and various modes of image display for ultrasound.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	
CO4	✓	✓	✓	✓	✓
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2CC	PHYSICS OF RADIOLOGY IMAGING	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Principles of X-Ray Diagnosis & Imaging 14 h

Principle - Interactions of X-rays with human body - Differential transmission of x - ray beam -Spatial image formation - Visualization of spatial image - Limitations of projection imaging technique viz. superimposition of overlying structures and scatter - Application of contrast media and projections at different angles to overcome superimposition of overlying structures

Prime factors kVp, mAs and SID/SFD and its influence on Image quality - Filters and its types - Beam restrictors and its types – Scatter reduction - Grid and its types – Air gap technique - Cassettes - Intensifying screen - Absorption efficiency and conversion efficiency - Structure of x-ray film, Types of films, Characteristics of x-ray film, Film processing, Manual and Automatic film processing - Computerized radiography- Film handling and storage, influence of temperature and time, Replenisher, dark room - Safe light - Image quality, Spatial and contrast resolution, noise, geometric factors, optimal quality image, artifact - QA of diagnostic x-ray.

Different Radiography Techniques: Xeroradiography, Intra and Extra oral radiography - Orthopantomography(OPG), Dental CBCT – Bone mineral densitometer (BMD) - Conventional radiography (CR) and Digital radiography(DR).

Unit II Mammography and Fluoroscopy 14 h

Mammography: Mammographic X-ray tube design, Filter, Spectra, Compression paddle, Grids and AEC. Collimation, Filtration and HVL - Magnification – Screen film mammography – Digital mammography - Tomosynthesis- Display of digital mammography-QA.

Fluoroscopy: Conventional fluoroscopy, Cine and Fluoro mode - Dark room adaptation, Image intensifiers, Closed circuit TV systems, Flat panel detectors - Modern trends in interventional radiology – Single and Bi-plane imaging, Rotational angiography, Cardiac imaging, Real time imaging characteristics – Filtration, Continuous and pulsed fluoroscopy, High dose-rate fluoroscopy, Spot imaging, Digital Subtraction acquisition technique, Road mapping, Image

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magnification, Lastimage hold, Automatic exposure control, Automatic brightness control, Brightness gain - Image quality - Radiation dose management: Dose area product (DAP) meters, Peak skin dose, Cumulative dose and Dosimetric techniques in interventional radiology - Dose management for pediatric and pregnant patients in interventional imaging, Diagnostic reference levels and guidelines – QA and Radiation protection.

Unit III Computed Tomography **12 h**

Principle of Computed tomography - CT Equipment, System design, Gantry and Couch, X-ray tubes, Filters and Collimation, Detector array, Generations of CT-Dual energy CT - Modes of CT acquisition: Axial acquisition, Helical acquisition, Cone beam acquisition, Cardiac CT, CT angiography, CT perfusion-CT number-Image display –CT image reconstruction: Back projection, Filtered back projection, Fourier reconstruction, Cone beam reconstruction, Iterative reconstruction, Post processing tools, Volume rendering, Multiplanar reconstruction (MPR), Maximum intensity projection (MIP) - Image quality - factors influence on image quality – Contrast, Spatial resolution, Noise, Unsharpness, Magnification, Distortion and Artifacts - Quality assurance - Image artifacts, Radiation dose management: factors affecting patient dose CTDI, CTDIvol, Dose length product(DLP),Multiple scan average dose(MSAD)-QA of CT.

Unit IV Magnetic Resonance Imaging **10 h**

Basics Physics of MRI, Magnetism, Nuclear characteristics, Hydrogen characteristics, Magnetization vector, Precession, Radiofrequency and Resonance, MRI signal, Flip angle - Relaxation time: T1 relaxation time, T2 relaxation time, Comparison of T1 and T2 - MR signal localization, Gradient field, Slice selection, Phase encoding gradient, Frequency encoding gradient, Composite signal, K-space - MR imaging sequences - Spin echo sequence, T1 weighted image, T2 weighted image, Spin density weighted image, Inversion recovery, Gradient recalled echo– Specialized MR sequences, MR angiography, Perfusion imaging, Diffusion imaging, Functional imaging, MR spectroscopic imaging – MR instrument and biosafety - Image quality and artifacts - QA of MRI.

Unit V Ultrasound **10 h**

Basics of Ultrasound, Propagation of sound, interaction of Ultrasound with matter - Ultrasound transducer, Piezoelectric material, Transducer design, Transducer array - Beam properties - Near field - Far field - Side lobes - Spatial resolution - 2D, 3D and 4D Ultrasound-Data acquisition systems –ADC - Receiver, Echo display

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modes, Scan converter - Image data acquisition, Pulse echo acquisition - Ultrasound image display: Amplitude mode, Motion mode, Brightness mode - Doppler ultrasound - Ultrasound image quality - Image artifacts -Bio-effects of ultrasound-QA of ultrasound.

Text Books

1. Curry, T.S. Dowdey and J.E. Murry, R.C, 1990. Christensen's introduction to the Physics of diagnostic radiology, 4th Edition, Philadelphia, Lea & Febiger Publisher.
2. Bushberg,S.T; Seibert, J.A; Leidholt, E.M & Boone, J.M, 2011. The essential Physics of Medical imaging, 3rd Edition, Baltimore, Williams & Wilkins Publisher.

References

1. Johns. H.E. & Cunningham. J.R, 1983. The Physics of Radiology, 4th Edition, Spring field.
2. Thayalan. K, 2014. The Physics of Radiology and Imaging, 1st Edition, Jaypee Brothers Medical Publishers Private Limited.
3. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R, 2006. The Physics of Diagnostic imaging, 2nd Edition, CRC Press.
4. Farr. R. F and PJ Allisy-Roberts, 2006. Physics for Medical Imaging, 2nd Edition Saunders.
5. https://www.kau.edu.sa/Files/0008512/Files/19500_2nd_presentation_final.pdf.
6. https://www.slideshare.net/MadhukaPanagoda/radiology-medical-imaging.

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APPROVED		
BoS- 14th	AC - 14th	GB - 19th
03.12.2022	19.01.2023	30.01.2023

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222MP2A2CP	CORE PRACTICAL-II: RADIATION MEASURING AND MONITORING INSTRUMENTATION	SEMESTER II

Total Credits: 3
Total Instructions Hours: 72 h

S. No	List of Experiments
1	Statistics of radioactive counting
2	Determination of plateau and resolving time of a Geiger-Muller counter and its application in estimating the shelf ratio and activity of a beta source
3	Production and attenuation of Bremsstrahlung
4	Radiation exposure: Effect of distance, shielding and time
5	Determine the range of beta particles
6	Backscattering of beta particles
7	Absorption and backscattering of Gamma rays - Determination of HVT
8	Determination of wedge and tray factor for a standard field size of nominal energy
9	Quality assurance of a diagnostic X-ray machine
10	Leakage level measurement of a diagnostic X-ray machine
11	Radiation protection survey of diagnostic radiology installation
12	Study of Voltage-Current (V-I) characteristics of an Ion Chamber
13	Cross calibration of Ion chambers
14	Dose output measurement of high energy photon beams used in radiotherapy department using TRS-398 protocol
15	Dose output measurement of high energy electron beams used in radiotherapy department using TRS-398 protocol
16	Head leakage and collimator leakage level measurement of linear accelerator machine (IEC)

Note: Out of 16 experiments 10 are mandatory

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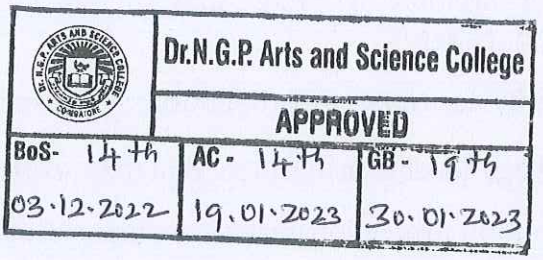
References

1. Deokar M.R, 2007." Laboratory Manual", Radiological Physics and Advisory Division, Bhabha Atomic Research Centre, Mumbai.
2. Narender Reddy J, Dr.Murty M.S.R, "Experiments with GM Counter", Nucleonix Systems Private Limited, Hyderabad.
3. Dr. Sathiyan S, 2014, "Monograph on Radiation Physics Practical's for Medical Physics Students".
4. IAEA , 2006 ,"TRS-398-Absorbed Dose Determination in External Beam Radiotherapy", 1st Edition , IAEA.



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Course Code	Course Name	Category	L	T	P	Credit
222MT2A2EB	MATHEMATICAL PHYSICS	EDC	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The basics of statistics and medical statistics
- The different types of numerical methods and solving simultaneous linear equations
- The Monte carlo method and the computational tools

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Understand the basics of statistics and radiation detection	K2
CO2	Discuss the discrete and continuous distributions	K2
CO3	Explain clinical study designs and hypothesis testing	K2
CO4	Determine the interpolations and solve the system of equations	K3
CO5	Explain the advantages of computational tools like MATLAB & STATISTICA	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability		Innovations
	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MT2A2EB	MATHEMATICAL PHYSICS	SEMESTER II

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Statistics and Errors 10 h

Definition - collection, tabulation and graphical representation of data -Basic ideas of statistical distributions - frequency distributions – measures of central tendency - arithmetic mean - median - mode - geometric mean - harmonic mean - measures of dispersion - range - quartile deviation - standard deviation - root mean square deviation - standard error and variance.

Application to radiation detection - Uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit.

Unit II Probability and Distributions 10 h

Probability - addition and multiplication laws of probability - conditional probability -random variables - discrete random variables - continuous random variables -probability density function - discrete probability density function - continuous probability distributions - moments- skewness - kurtosis -Cumulative distribution function - accuracy and precision - law of large number - Central limit theorem -Binomial distribution - Poisson distribution - Gaussian distribution - exponential distribution - additive property of normal variates - confidence limits - Bivariate distribution - correlation and Regression - Chi-Square distribution -t-distribution – F distribution.

Unit III Counting and Medical Statistics 10 h

Statistics of nuclear counting - Application of Poisson's statistics - Goodness-of-fit tests - Lexie's divergence coefficients Pearson's chi-square test and its extension - Random fluctuations Evaluation of equipment performance - Signal-to-noise ratio - Selection of operating voltage - Preset of rate meters and recorders - Efficiency and sensitivity of radiation detectors - Statistical aspects of gamma ray and beta ray counting - Special considerations in gas counting and counting with proportional counters - Statistical accuracy in double isotope technique. Sampling and sampling distributions - Confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors.

Unit IV Numerical Methods 10 h

Iteration for Solving x = g(x), Initial Approximation and Convergence Criteria. Interpolations: Finite differences - Forward –Backward-Central differences -

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Newton - Gregory forward, backward interpolation Formulae for equal intervals - Missing terms - Lagrange's interpolation formula for unequal intervals - Inverse interpolations - Curve fitting - Principle of least squares -Discrete Fourier Transform - Fast Fourier Transform - Applications – Random waveforms and noise.

Simultaneous linear equations: Gauss elimination method - Jordan's modification. - Inverse of a matrix by Gauss - Jordan Method - Roots of nonlinear equations: Newton- Raphson method - Iterative rule -Termination criteria -Taylor series - approximating the derivation - Numerical differentiation formulas - Introduction to numerical quadrature - Trapezoidal rule - Simpson's 2/3 rule - Simpson's Three-Eighth rule - Picard's method - Taylor's method -Euler's method - the modified Euler's method - Runge-Kutta method.

Unit V Monte Carlo method and Computational Tools **8 h**

Monte Carlo Method: Random numbers and their generation - Tests for randomness - Inversion random sampling technique including worked examples - Integration of simple 1-D integrals including worked examples.

Computational Tools: Overview of programming in C++, MATLAB/ MATHEMATICA , and STATISTICA in data analysis and graphics.

Text Books

1. Croxton F.E., 1959,"Elementary statistics with applications in medicine and the biological sciences", Dover publications, New York.
2. Agarwal B.L., 2015,"Basic Statistics", New Age International publishers, New Delhi.

References

1. Gupta S.P., 2014,"Statistical methods", Sultan Chand & Sons Educational publishers, New Delhi.
2. Dass H.K.,1988,"Advanced Engineering Mathematics", S.Chand & Company Pvt. Ltd, New Delhi.
3. Syed Naeem Ahmed, 2007,"Physics and Engineering of Radiation detection", Academic press, New york.
4. Dahlberg G, 1948,"Statistical method of Medical and Biology students", G.Allen and Unwin Limited, London.

[Note: Distribution of marks 80% Problems and 20% Theory.]

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2DA	ADVANCED MATERIALS IN MEDICINE AND HEALTHCARE	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The classification of solids and its various structure
- The material properties and their applications in medicine
- The concept of Thermography and its applications.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the different structure of crystals.	K4
CO2	Analyze the crystal structure and the properties of crystals.	K4
CO3	Demonstrate the various method of Nanoparticles synthesis and its application.	K3
CO4	Illustrate the types of biomaterial and its application in health care.	K3
CO5	Interpret the concept of Thermography and its medical application.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	
CO2	✓		✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2DA	ADVANCED MATERIALS IN MEDICINE AND HEALTHCARE	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Material Structures — 14 h

Classification of solid, Types of solids, Space lattice, Crystal structure of materials, Unit cell, Symmetries in crystals, Bravais lattice, Miller and Miller - Bravais indices, Simple cubic structure (SC), Body centered cubic, (BCC), Face centered (FCC) structure, Hexa gonal closed Paced Structure (HCP), Special cubic crystal structure: Diamond, Zinc blende structure, Nacl structure.

Unit II Material Properties — 14 h

Diffraction of X-rays, Bragg's law, Braggs's X-ray spectrometer, Determination of crystal structure: Laue's method, Powder crystal method & Rotating crystal method. Braggs's law & Crystal structures.

Properties: Mechanical properties, Electric properties, Magnetic properties, Optical properties and Chemical properties. Optical properties and its applications: Introduction, Classification of optic materials, Absorption in metals, Insulators and Semi conductors, Traps, Excitons and Color centers.

Unit III Nanomaterials & Applications — 14 h

Nanoscale, Nanotechnology, Production techniques, Sol-gel method, Co-precipitation method and Radiofrequency sputtering method - Characterization Techniques: X-ray diffraction, Spectroscopic techniques like UV-Visible, Infrared spectroscopy, Raman spectroscopy and Optical and Electron microscopy. Applications in Medicine: Targeted drug delivery, Hyperthermia, Bioimaging & Therapy biosensors, Photoablation Therapy, Carbon Nanotubes, Nanowires, Quantum dots and its properties and applications.

Unit IV Biomaterial & Applications — 10 h

Introduction, Biomechanism, Classifications of Biomaterials: Metals and Alloys and Glass and Glass Ceramics, Polymers and Composites. Applications: Uses of Biomaterial, Biomaterials in organ. Biomaterials in body system.

Unit V Thermography — 8 h

Introduction - Thermal properties of solids - Specific heat - Basic principles, Detectors & Equipment, Medical Thermography, Thermographic camera,

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Advantages of Thermography. Applications In Medicine: Detection of tumors, Mapping of blood Vessels, Investigation of bone Fracture, Placental localization, Burns and Frostbite

Text Books

1. Pillai S.O,2005, "Solid State Physics", 6th Edition, New Age International Pvt.Ltd.
2. Charles Kittel, 2013, "Introduction to Solid State Physics", 8th Edition, John Wiley.

References

1. Srivastava C.M and Srivasan.C, 1997, "Science of engineering materials", 2nd Edition, New Age International Pvt. Ltd.
2. Raghavan .V , 2019, "Material Science and Engineering : A first course", 6th Edition.PHI Learning.
3. Rajendran.V, 2017, "Materials Science", McGraw Hill Education.
4. Hossein Hosseinkhani, 2019, "Nanomaterials in Advanced Medicine," 1st Edition, Wiley-VCH.
5. https://www.slideshare.net/e_gulfam/biomaterials-36179632.
6. https://slideplayer.com/slide/13895949/.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2DB	RADIATION DOSIMETRY AND STANDARDIZATION	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The fundamental concepts of radiation dosimetry
- The dosimetric standardization of X ray, gamma ray, neutron and radionuclides.
- The basic principles of chemical dosimeters.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the radiation quantities and units	K4
CO2	Demonstrate the cavity theories and measurement of D_w by using various dosimetric protocols	K3
CO3	Classify the neutrons and understand the concept of neutron standards and dosimetry	K4
CO4	Illustrate the principles of Geiger-Muller counter and scintillating counting methods for alpha, beta and gamma emitter	K3
CO5	Interpret the concept of chemical dosimetry and its applications	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓		✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2DB	RADIATION DOSIMETRY AND STANDARDIZATION	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Radiation Quantities and Units** **12 h**

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

Unit II **Dosimetry & Standardization of X and Gamma Rays Beams** **12 h**

Dosimetry Standards: Primary and Secondary standards, Traceability, Uncertainties in measurements.

Two stage energy transfer process - Electronic equilibrium: Charged particle equilibrium (CPE), Transient charged particle equilibrium (TCPE). Cavity theories- Brag Gray, Burlin and Spencer Attix cavity theory. Free air Ionization chamber (FAIC) – Design, Measurement of exposure and limitations. Cavity ion chambers: Cylindrical, Parallel plate and spherical - Dose in free space (Dgas), Dose in medium (Dmed), Expression for sensitivity, - General definition of calibration factors – Nx, Nk, NDair, NDw - IAEA TRS-398: Dw, NDW, NDWQ, KQ, KQ QO and $TPR_{20,10}$.

Measurement of Dw for external beams from ^{60}Co teletherapy machines: Reference conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for machine Timing error, Procedure for evaluation of temperature and pressure correction.

Measurement of Dw for high-energy photon and electron beams from linear accelerators: Beam quality, Beam quality index, Beam quality correction coefficient, Cross calibration of ion chamber.

Reference conditions, Various correction factors and steps involved in absorbed

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dose to water (Dw) calculations for Telecobalt machines and Linear accelerators - Cross calibration of ion chamber.

IAEA TRS-277, AAPMTG-51, TECDOC 1274, TRS 483 and other dosimetric protocols - Calorimetric standards – Inter comparison of standards

Unit III Neutron Standards & Dosimetry 12 h

Neutron classifications, Neutron sources, Neutron quality factor - Neutron standards – Primary standards, secondary standards - Neutron yield and Fluence rate measurements - Manganese sulphate bath system - Precision long counter - Activation method - Neutron spectrometry - Threshold detectors - Scintillation detectors - Multispheres - Neutron dosimetry - Neutron survey meters - Calibration - Neutron field around medical accelerators

Unit IV Standardization Of Radionuclide 12 h

Methods of measurement of radioactivity – Defined solid angle and 4Л counting – Beta gamma coincidence counting – Standardization of beta emitters and electron capture nuclides with proportional, GM and Scintillation counters – Standardization of gamma emitters with scintillation spectrometers – Ionization chamber methods – Extrapolation chamber – Routine sample measurements – Liquid counter – Windowless counting of liquid samples – Scintillation counting methods for alpha, beta and gamma emitter – Reentrant ionization chamber methods – Methods using (n, ŕ) and (n, p) reactions – Determination of yields of neutron sources – Space integration methods – Solids state detectors.

Unit V Radiation Chemistry and Chemical Dosimetry 12 h

Definitions of free radicals and G-Values - Kinetics of radiation chemical transformations – LET and dose-rate effects – Radiation chemistry of water and aqueous solutions, Peroxy radicals, pH effects – Radiation chemistry of gases and reactions of dosimetry interest – Radiation polymerization - Effects of radiation on polymers and their applications in dosimetry – Description of irradiators from dosimetric view point – Dosimetry principles.

Chemical dosimetry – Basic principle, Definitions of optical density - Molar absorption coefficient - Beer – Lamberts law- spectrophotometry – Dose calculations – Laboratory techniques – Reagents and procedures - Requirements for an ideal chemical dosimeter – Fricke dosimeter – FBX dosimeter – Free radical dosimeter – Ceric sulphate dosimeter – Other high and low level dosimeters – Applications of chemical dosimeters in radiotherapy and industrial irradiators. Biological Dosimetry - Chromosome aberration analysis.

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Text Books

1 Attix. F. M, 1991. Introduction to Radiological Physics and Radiation Dosimetry, 1st Edition, Viley– VCH, Verlog.

2 IAEA TRS 398, 2006. Absorbed dose determination in Photon and Electron beams, updated version of TRS 277.

References

1 Govindarajan, 1992. Advanced Medical Radiation Dosimetry, 1st Edition, Prentice hall of India Pvt. Ltd., New Delhi.

2 AAPM TG 51, 2014. Absorbed dose determination for photon beams, revised version.

3 Greening J R, Green S, Charles M W, Fundamentals of Radiation Dosimetry, 3rd Edition, London: Taylor & Francis, 2010 .

4 Shaheen Dewji and Nolan E Hertel, Advanced Radiation Protection Dosimetry, CRC Press (Taylor & Francis Group), 1st Edition, 2019.

5 https://www.radccore.org/files/documents/intro%20to%20radiation%20physics%20REIMAN.pdf.

6 https://www.youtube.com/watch?v=WEQUy9apjNY&t=131s.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A2DC	INFORMATION TECHNOLOGY AND SOFTWARE TOOLS FOR MEDICAL PHYSICS	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The fundamentals of computer technology both hardware and software
- The role of information technology in radiation oncology treatment planning and management systems
- The software employed in simulation, treatment planning and quality assurance

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Illustrate the principal hardware components, system software and calculation algorithms	K3
CO2	Analyze the International standards for medical information management and communication	K4
CO3	Explain the importance of information technology in various radiotherapy techniques	K4
CO4	Demonstrate the significance of software involved in radiotherapy process	K3
CO5	Infer the use of various software in radiation treatment planning and quality assurance.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓		
CO3	✓		✓	✓	
CO4	✓	✓	✓	✓	✓
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

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222MP2A2DC	INFORMATION TECHNOLOGY AND SOFTWARE TOOLS FOR MEDICAL PHYSICS	SEMESTER II

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Fundamentals **14 h**

Basic of computer networks - Local area network (LAN), Wide area Network (WAN) - Internet - Intranet - Operating system - System hardware - System software – Algorithms - Archive and Storage - Data transactions, Backup and Retrieval models - The role of algorithms in computing - Information technology (IT) - Oncology information and networking system.

Unit II International standards **12 h**

IEC, DICOM, IHE, HIS/RIS/PACS, Vendor neutral archives (VNA) remote viewing Radiotherapy R&V systems, Navigation systems, Registration, segmentation, Imaging informatics, Programming with image, Quantitative image quality assessment

Unit III Overview of Information Technology in Radiation Oncology **14 h**

IT needs in RO - RO IT related resources, RO IT resource management – IT demands in Treatment Planning Systems (TPS), Treatment management systems (TMS), Treatment delivery systems (TDS), RO specific EMR (RO EMR) and image viewing systems, Record and Verify (R&V) systems, – IT decisions in intensity modulated radiation therapy (IMRT), Image-guided radiation therapy (IGRT), Four-dimensional radiation therapy (4DRT), Electronic medical records (EMR)

Unit IV Radiation Therapy Software **10h**

Imaging software - Simulation software - contouring software - Treatment Planning software - Dose calculation algorithm - Introduction to cloud computing in radiotherapy – Big data processing in Radiation Oncology - Machine learning in Radiation Therapy.

Unit V Software in Radiation Treatment Planning and Quality Assurance **10 h**

Brainlab-Radiosurgery software iPlan RT - Elekta XiO - Monaco – Pinnacle – Prowess panther – RayStation - Varian Eclipse - Oncentra - RADIANCE - PreciseART-

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ScandiDos - IBA myQA® Platform - Pinnacle - Leksell GammaPlan - MapCHECK– NeuroBlate applications.

Text Books

1. Issam El Naqa, Martin J. Murphy, 2022, "Machine and Deep Learning in Oncology, Medical Physics and Radiology" Springer Cham.
2. Patrick McDermott , Colin Orton ,2019, "The Physics & Technology of Radiation Therapy", 2nd edition, Medical Physics Publishing Corporation.

References

1. Jacob Van Dyk , 1999, "The Modern Technology of Radiation Oncology A Compendium for Medical Physicists and Radiation Oncologists" Medical Physics Publishing.
2. John Christopher Draper (Author , 2018, "A Text-Book of Medical Physics: For the Use of Students and Practitioners of Medicine" Forgotten Books.
3. Elizabeth Berry, 2007, "A Practical Approach to Medical Image Processing (Series in Medical Physics and Biomedical Engineering)" 1st edition, CRC Press.
4. Michael G.Herman,1999, "Computer Networking and Information systems in Radiation Oncology" Radiation Oncology information systems.
5. https://www.aapm.org/meetings/99am/pdf/2755-16806.pdf.
6. http://wwwnaweb.iaea.org/nahu/DMRP/documents/slides/Chapter_11_Computerized_treatment_planning_systems.pdf.

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Course Code	Course Name	Category	L	T	P	Credit
222MP2A3CA	ADVANCED RADIOTHERAPY PHYSICS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- To be familiar with clinical indications for conformal radiotherapy
- A general understanding of the treatment planning process.
- To understand the advanced radiation therapy techniques

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Illustrate the conformal radiotherapy techniques such as 3DCRT, IMRT and VMAT.	K2
CO2	Apply the concept of KVCT , MVCT and 4DCT in IGRT and Tomotherapy	K3
CO3	Plan and execute SRS/SRT treatment techniques	K3
CO4	Demonstrate the special techniques such as TBI, TSET, Particulate beam therapy and Intraoperative radiotherapy	K3
CO5	Illustrate the treatment planning Algorithms for dose computation	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights	-	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A3CA	ADVANCED RADIOTHERAPY PHYSICS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Conformal & Intensity Modulated Radiation therapy** 12 h

3D Conformal Radiotherapy Techniques - IMRT Principles -MLC based IMRT – step and shoot and sliding window techniques – Compensator based IMRT – Planning process – Inverse treatment planning – Immobilization for IMRT – dose verification phantoms, dosimeters, protocols and procedures – machine and patient specific QA- Volumetric modulated arc therapy (VMAT).

Unit II **Image Guided Radiotherapy and Tomotherapy** 12 h

Image Guided Radiotherapy (IGRT)- concept - imaging modality - kV cone beam computed tomography (KVCT)- MV cone beam computed tomography (MVCT)- Image registration- Plan adaptation- QA protocol and procedures - special phantom- 4DCT. Tomotherapy - Principle - Commissioning - Imaging - Planning and Dosimetry - Delivery - Plan adaptation

Unit III **Stereotactic Radiosurgery & Radiotherapy (SRS/SRT** 12 h

Cone and mMLC based X-knife – Gamma Knife -Frame and Frameless based SRS/SRT – Small Field Dosimetry (TRS-483) and planning procedures – evaluation of SRS/SRT treatment plans – QA protocols and procedures for X and Gamma knife units – patient specific QA- physical, planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and Cyber knife-based therapy

Unit IV **Special Techniques in Radiation Therapy** 12 h

Total Body Irradiation (TBI) – large Field Dosimetry – Total Skin Electron Therapy (TSET) – Electron arc treatment and dosimetry – Intraoperative Radiotherapy. Particulate beam therapy: Neutron captures therapy– Carbon ion therapy –Proton Therapy – Hadron Therapy- Flash Radiotherapy.

Unit V **IIntroduction To Treatment Planning System and Dose Calculati on Algorithm** 12 h

Scope of computers in radiation treatment planning – review of algorithms used for treatment planning computations – pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam and electron beam – factors to be incorporated in computational algorithms- plan optimization – direct aperture optimization – beamlet optimization –simulated

annealing – dose volume histograms – indices used for plan comparisons – hardware and software requirements – beam & source library generation-networking, DICOM and PACS

Text Books

1 Faiz Khan. M, 2014,"The Physics of Radiation Therapy", 5th Edition, Wolters kluwer.

2 Van Dyk. J, 1999,"The Modern Technology of Radiation Oncology", Volume-1, Medical Physics Pub Corp.

References

1 Webb. S, 2001,'"Intensity Modulated radiation therapy", 1st Edition, CRC Press.

2 Webb. S,1993,"The Physics of Three-Dimensional Radiation Therapy", 1st Edition, CRC Press.

3 Levit. S. H, Purdy. J. A, Perez. C. A and Vijayakumar. S, 2006.," Technical Basis of Radiation therapy Practical Applications",1st Edition, Springer....

4 Thomas Bortfeld, Rupert Schmidt- Ullrich, Wilfried De Neve, David E Wazer, 1993. "Image Guided Radiotherapy", 3rd Edition, Springer Berlin Heidelberg.

5 https://international.anl.gov/training/materials%5CIAEA%20Publications%5CRadiation%20Oncology%20Physics%20Handbook%5CRadiation%20Oncology%20Physics%20-%20Slides%20-%20pdf%5CChapter_15_Special_techniques.ppt.pdf.

6 https://www-pub.iaea.org/MTCD/Publications/PDF/D483_web.pdf.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3CB	PHYSICS OF NUCLEAR MEDICINE	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The properties and production of radionuclides used in nuclear medicine.
- The use of unsealed radioactive isotopes in diagnostic radiology and radiation therapy.
- The Principles of internal dosimetry and calculation of the radiation dose from internally administered radionuclide

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Outline the production of radiopharmaceuticals and its uses in diagnostic/ therapeutic Nuclear Medicine.	K2
CO2	Understand the In -vivo and In-vitro Techniques in Nuclear Medicine	K2
CO3	Demonstrate about Data acquisition and processing with various equipments, quality control of instruments and labeled agents	K3
CO4	Illustrate the treatment for thyroid disorders and palliative treatment using radioisotope.	K3
CO5	Describe Internal Dosimetry and calculation of the radiation dose from internally administered radionuclide	K2

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development		Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A3CB	PHYSICS OF NUCLEAR MEDICINE	SEMESTER III

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Radionuclide and Its production** 12 h

Introduction to nuclear medicine- unsealed Sources- production of radionuclide used in nuclear medicine- reactor based radionuclide, accelerators based radionuclide, photonuclear activation, equations for radionuclide production, radionuclide generators and their operation principles- Radiopharmaceuticals-Ideal Properties, various usages and Quality control.

Unit II **In -vivo and In-vitro Techniques** 10 h

Thyroid uptake measurements- reno gram- life span of RBC, blood volume studies etc-general concept of radionuclide- imaging and historical developments-In-vitro techniques-RIA/IRMA techniques and its principles.

Unit III **Emission Tomography Techniques** 12 h

Radionuclide imaging: other techniques and instruments- the rectilinear scanner and its operational principles- basic principles and design of the anger Camera / scintillation camera- system components, detector system and electronics- different types of collimators- design and performance characteristic of the parallel hole, converging, diverging and pin hole collimator- image display and recording systems- digital image processing systems- scanning camera- limitation of the detector system and electronics.

Different imaging techniques: basic principles- two dimensional imaging techniques-Three Dimensional imaging techniques –Basic principles and problems- focal plane tomography-Emission computed tomography-Single Photon Emission Computed Tomography-Positron Emission Tomography-Image reconstruction techniques -Back projection and Fourier based techniques- iterative reconstruction method and their drawbacks-attenuation correction, scatter correction, resolution correction, other requirements or sources of error- Image quality parameters: spatial resolution, factor affecting spatial resolution, methods of evaluation of spatial resolution, contrast, noise- NEMA protocols followed for quality assurance / quality control of imaging instruments

Unit IV **Applied Positron Emission Tomography Imaging** 12 h

Principles of PET, PET instrumentations- annihilation coincidence detection- PET detector scanner design- data acquisition for PET- data corrections and quantitative aspect of PET-working of medical cyclotron- radioisotopes produced and their characteristic- treatment of thyrotoxicosis - thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment-radiation synovectomy and the isotopes used.

Unit V Internal Radiation Dosimetry **14 h**

Different compartmental model- single compartmental model- two compartmental model with back transference- two compartmental model without back transference-classical methods of dose evaluation: beta particle dosimetry- equilibrium dose rate equation, beta dose calculation specific gamma ray constant- gamma ray dosimetry-geometrical factor calculation- dosimetry of low energy electromagnetic radiation- MIRD technique for dose calculations- Basic producer - cumulative activity, equilibrium dose constant, absorbed fraction, specific absorbed fraction, dose reciprocity theorem, mean dose per unit cumulative activity and problems related to the dose calculations- limitation of MIRD technique.

Text Books

1 J.Herbert and D.A.Rocha, 1984. "Text Book of Nuclear Medicine, Vol. 2 and 6, Lea and Febiger Co., Philadelphia.

2 Webb. S, 1990. The Physics of Medical Imaging, 2nd Edition, Medical Science Series, Adam Hilgers Publications, Bristol.

References

1 Blahd. W. H, 1980. Nuclear medicine, 1stedition, McGraw Hill Co., New Delhi..

2 Wagner. W. N, 1995. Principles of Nuclear Medicine, 2nd Edition, W. B. Saunders Co., London.

3 Pant. G. S, 2003. Advances in diagnostic Medical Physics, 3rd Edition, Mumbai : Himalaya Pub. House..

4 Ramesh Chandra, 2011, " Nuclear Medicine Physics: The Basics, 7th Edition, Lippincott Williams and Wilkins, Newyork.

5 https://humanhealth.iaea.org/HHW/MedicalPhysics/e-learning/Nuclear_Medicine_Handbook_slides/Chapter_04._Radionuclide_Production.pdf

6 https://depts.washington.edu/uwmip/Week_3/RadDetect08.pdf.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3CC	RADIATION BIOLOGY	CORE	4	1	-	5

PREAMBLE

This course has been designed for students to learn and understand

- The Structure, Composition and function of the cells, tissue and organism.
- The interaction of radiation with cells and effects of radiation.
- The physical and biological factors influencing the biological effects of radiation with cells.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Describe the structures and biological functions of cells, tissues, and organisms.	K2
CO2	Illustrate different interactions of radiation on living cells and its biological damage.	K3
CO3	Interpret the biological basis 5Rs of fractionated radiotherapy	K3
CO4	Demonstrate the relationship between LET, RBE and OER.	K3
CO5	Analyze the effects of radiation and factors influencing radiation effect.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A3CC	RADIATION BIOLOGY	SEMESTER III

Total Credits: 5

Total Instruction Hours: 60 h

Syllabus

Unit I Cell Biology **12 h**

Cell physiology and biochemistry – structures of the cell - types of cells and tissue, their structures and functions - organic constituents of cells – carbohydrates, fats, proteins and nucleic acids – enzymes and their functions – functions of mitochondria, ribosomes, golgi bodies and lysosomes – cell metabolism – DNA as concepts of gene and gene action – mitotic and meiotic cell division – semi conservative DNA synthesis, genetic variation crossing over, mutation, chromosome segregation – heredity and its mechanisms.

Unit II Interaction of Radiation With Cells **12 h**

Action of radiation on living cells – radiolytic products of water and their interaction with biomolecule – nucleic acids, proteins, enzymes, fats – influence of oxygen, temperature – cellular effects of radiation – mitotic delay, chromosome aberrations, mutations and recombinations – giant cell formation, cell death recovery from radiation damage – potentially lethal damage and sublethal damage recovery - pathways for repair of radiation damage- Law of Bergonie and Tribondeau.

Repair misrepair hypothesis – dual action hypothesis – modification of radiation damage – LET, RBE, dose rate, dose fractionation – oxygen and other chemical sensitizers – anoxic, hypoxic, base analogs, folic acid, and energy metabolism inhibitors – hyperthermic sensitization – radio-protective agents.

Unit III Biological Basis of Radiotherapy **10 h**

Physical and biological factors affecting cell survival, tumor regrowth and normal tissue response – non-conventional fractionation scheme and 5R's of fractionated radiotherapy repair, repopulation, redistribution, reoxygenation and radiosensitivity in the cell cycle – high LET radiation therapy.

Unit IV Radiobiological Models **12 h**

Cell population kinetic models- survival curve parameters – model for radiation action – target theory – multihit, multitarget –time dose fractionation – basis for dose fractionation in beam therapy – concepts for nominal standard dose (NSD)- Roentgen equivalent therapy (RET) – time dose fractionation (TDF) factors and cumulative radiation effects (CRE) – gap correction, linear and linear Quadratic models- TCP and NTCP evaluation.

Unit V Biological Effects of Radiation 14 h

Somatic effects of radiation – physical factors influencing somatic effects – dependence on dose, dose rate, type and energy of radiation, temperature, anoxia - acute radiation syndrome– LD50 dose, LD50,30 LD50,60 – effects of radiation on skin and blood forming organs- digestive track – sterility and cataract formation – effects of chronic exposure to radiation – induction of leukemia – radiation carcinogenesis – risk of carcinogenesis – animal and human data – shortening of life span – in-utero exposure – genetic effects of radiation-Radiation effects on Embryo and fetus – factors affecting frequency of radiation induced mutations – dose-effects relationship – first generation effects – effects due to mutation of recessive characteristics – genetic burden – prevalence of hereditary diseases and defects – spontaneous mutation rate – concept of doubling dose and genetic risk estimate

Text Books

1 J Hall. E. J, 1987. Radiobiology for Radiologists, 2nd Edition, J.B. Lippincott Co., Philadelphia..

2 Godden Steel, 2002. Principles of radiobiology, 3rd Edition, CRC Press.

References

1 Perez & Bradys, 2008. Principles and practice of radiation oncology,5th Edition, Lippincott Williams and Willins..

2 Tubiana M, Dutreix. J,1990. Introduction of Radiobiology,1st Edition, Taylor & Francis.

3 IAEA TRS 42, 2010. Radiation Biology: A Handbook for Teachers and Students, Vienna, Austria..

4 Kuppusamy Thayalan, 2017. Handbook of Radiobiology, Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi, India.

5 http://www.naweb.iaea.org/nahu/dmrp/documents/slides/chapter_14_basic_radiobiology.pdf.

6 https://www.utoledo.edu/med/depts/radther/pdf/Lecture%202%20-%20Survey%20Radiobiology%20handouts.pdf.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3CD	BRACHYTHERAPY PHYSICS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The Basics of Brachytherapy and its classification and various techniques based on dose rate, treatment time and placement of radioactive source.
- The production and construction of radionuclides and its physical properties.
- Brachytherapy dosimetry, treatment planning, advanced brachytherapy techniques and quality assurance procedures.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Summarize the physical properties and construction of brachytherapy sealed sources used in brachytherapy treatment.	K2
CO2	Describe the dosimetry procedures and various quality assurance tests in brachytherapy	K3
CO3	Demonstrate the basics of brachytherapy and its classification	K3
CO4	Illustrate the treatment planning for various techniques. To understand the ICRU recommendations.	K3
CO5	Interpret about the advanced brachytherapy techniques	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A3CD	BRACHYTHERAPY PHYSICS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Basics of Brachytherapy 12 h

Definition and classification of brachytherapy based on Dose rate considerations - low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR) and classification of brachytherapy techniques, Surface mould, Intracavitary, Interstitial and Intraluminal techniques. Applicators used in Brachytherapy - temporary and permanent implants. AAPM and IEC requirements for remote afterloading HDR Brachytherapy equipment..

Unit II Radionuclides and Their Properties 12 h

Introduction- Requirement for brachytherapy sources – Production and construction of sealed sources Radium(needles), Cobalt-60(HDR and LDR), Cesium-137(LDR), Gold-198(LDR seeds), Iridium-192(HDR and LDR), Iodine-125(LDR seeds), Cesium-131(LDR seeds), Californium-252 and other commonly used brachytherapy sources.

Unit III Dosimetry and Quality assurance 14 h

Source specification – Concept of exposure rate constant, reference air kermarate(RAKR), apparent activity, air kerma strength(AKS), primary standard, water calorimetry, NK factor for Iridium-192 HDR calibration, room scatter correction-Stochholm system, Manchester system-,Paris system-point and line source dosimetry formalisms, Sievert integrals-TG43/TG43U1 formalisms, IAEA TECDOC 1274 and ICRU 72 recommendations. -AAPM TG 60 protocol for intravascular Brachytherapy -Image Guided adaptive Brachytherapy, commissioning, imaging, planning and dosimetry, delivery, plan adaptation, QA protocol and procedures.

Unit IV Treatment Planning 12 h

Brachytherapy treatment planning, CT/MR based brachytherapy planning - forward and inverse planning - DICOM image import / export from OT - record & verification.

Scope of computers in radiation treatment planning –Applicator reconstruction, Montecarlo based algorithms - Optimization techniques -geometric optimization (GO) and volume optimization (VO) -Intracavitary & Interstitial HDR brachytherapy- ICRU 38 & ICRU 89 -ICRU 58 Recommendations.

Unit V Advanced Techniques In Brachytherapy 10 h

Accelerated partial breast irradiation using balloon catheter –Intraoperative Brachytherapy (IORT)- Ocular brachytherapy using photon and beta sources. Intravascular brachytherapy - classification - sources - Integrated Brachytherapy Unit (IBU) -Electronic Brachytherapy–Intensity Modulated Brachytherapy(IMBT).

Text Books

1. D. Baltas, 2007, The Physics of Modern Brachytherapy for oncology, Taylor and Francis, London,Uk...
2. FaizM. Khan, 2015, The Physics of Radiation Therapy, 5th Edition Lippincott Williams and Wilkins, U.S.A.

References

1. E.B.Podgorsak, 2016, Radiation Physics for Medical Physicists, 3rd Edition 2Springer.
2. E.B.Podgorsak, 2005, Radiation Oncology Physics: A Handbook for Teachers and Students, IAEA.
3. Phillip. Devlin, 2010, Brachytherapy: Applications and Techniques , Ist Edition Lippincott Williams and Wilkins U.S.A.
4. Faiz M. Khan, Roger A. Potish, 1998, Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore..
5. http://www-naweb.iaea.org/nahu/dmrp/documents/slides/chapter_13_ brachytherapy. pdf
6. https://indico.ictp.it/event/a14234/session/8/contribution/54/material/slides/0.pdf.

222MP2A3CP	CORE PRACTICAL-III: TREATMENT PLANNING, RADIATION DOSIMETRY AND SURVEY	SEMESTER III

Total Credits: 3
Total Instructions Hours: 72 h

S. No	List of Experiments
1	Determination of Percentage Depth Dose (PDD) for Photon and electron Beams
2	Determination of radiation field flatness, symmetry, beam quality index and penumbra of external photon and electron beam.
3	Verification of mechanical and radiation alignment of a linear accelerator machine.
4	Periodic quality assurance of High Dose Rate (HDR) remote after loader Brachytherapy unit
5	AKS/RAKR measurement of HDR Brachytherapy sources using well type and cylindrical ionization chamber
6	Familiarization with treatment planning procedure using a computerized radiotherapy treatment planning system.
7	3DCRT Planning techniques in cancer of uterine cervix, Head and Neck, Oesophagus
8	Pre-treatment Patient specific QA for IMRT
9	Room lay out Planning and Radiation protection survey of Medical Linear Accelerator unit and verifying the adequacy of shielding on safety point of view
10	Room lay out Planning and Radiation protection survey of Brachytherapy unit.
11	Manual Treatment Planning of Two, Three and Four fields.
12	Autoradiography test for Brachytherapy source in Remote afterloader unit
13	Comparison of manual treatment planning and computerized treatment planning irregular fields (Using Clarkson's method.).
14	Quality Assurance of Multileaf Collimator.
15	Quality assurance (QA) test procedures of Teletherapy machines
16	Determination of Couch Transmission Factor for a standard Treatment setup.

References

1. Deokar M.R, 2007." Laboratory Manual", Radiological Physics and Advisory Division, Bhabha Atomic Research Centre, Mumbai.
2. Narender Reddy J, Dr.Murty M.S.R, "Experiments with GM Counter", Nucleonix Systems Private Limited, Hyderabad.
3. Dr. Sathiyan S, 2014, "Monograph on Radiation Physics Practical's for Medical Physics Students".
4. IAEA , 2006 ,"TRS-398-Absorbed Dose Determination in External Beam Radiotherapy", 1st Edition , IAEA.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3DA	MATERIALS FOR RADIATION DOSIMETERS	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- To provide fundamental concepts of radiation dosimeters based on the electronic band structure concepts.
- To make students understand different types of dosimeters and their respective applications.
- To provide an overview on various synthesis techniques and to give detailed understanding in working principles of current dosimeter materials

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Demonstrate the fundamental knowledge on the working principle of dosimeters	K3
CO2	Distinguish the different types of dosimeters and their applications	K2
CO3	Illustrate the different synthesis techniques and their influence on the properties of dosimeters	K3
CO4	Interpret the structure-property relationships of dosimeter materials	K3
CO5	Infer the properties required for various materials used in medical applications.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓		✓	✓	

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A3DA	MATERIALS FOR RADIATION DOSIMETERS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Energy Band Structure in Solids **10 h**

Electrons in periodic potential, Origin of energy bands in solids, classification of solids as metals , insulators and semiconductors on the basis of the band picture, Origin of the energy gap (qualitative discussions). Bloch's theorem in one dimension, nearly free electron approximation - formation of energy bands and gaps - Brillouin zone, concept of effective mass and holes, Density of states for electrons in band.

Unit II Fundamentals of Dosimetry Defects in Solids **10 h**

Defects in Crystals: Point defects, line defects and planner (stacking) faults. The observation of imperfections in crystals. Colourcentres, F-centre and aggregate centres in Semiconductors. Types of Impurities – Substitutional impurities, Donors and acceptors, Isoelectronic impurities, vacancies, Defect complexes – Interstitial defect and anti-site defects. Mobility and conductivity – Characterizing defects: Hall-effect measurement.

Unit III Types of Dosimeters **10 h**

Thermoluminescence Dosimeters – Optically Stimulated Luminescence (OSL) Dosimeters – Principles and materials used – Absorption and Emission Wavelengths – OSL measuring technology - Compound semiconductor dosimeters – GaAs detectors – HgI2 detectors - CdTe dosimeters - Role of impurities: Zn-doped CdTe detectors – Other novel dosimeter materials Neutron detectors..

Unit IV Material Synthesis Techniques **10 h**

Powder synthesis method; hydrothermal synthesis of ceramic oxide powders, chemical methods. –Classification of crystal growth methods Nucleation –Melt Growth techniques - Bridgman method – Czochralski crystal pulling method –- Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods – Vapour phase crystallization in a closed system – Gas flow crystallization

Unit V Medical Applications of Dosimeters **8 h**

Radiation dosimeters – pMOS and direct ion storage (DIS) dosimeters - In-vivo dosimetery– Materials and methods – Thermoluminescent (TL) materials:

CaSO4:Dy, and LiF:Mg, Cu, P,- Characteristics of TL - Spintronic Neutron detectors for enhanced signal-to-noise ratio – Effect of different synthetic techniques on radiation detection. Measurement techniques of doses– Radiopharmaceuticals and semiconductors used in nuclear medicine

Text Books

1. Neil W Ashcroft and N. David Mermin, 2014. Solid State Physics, India edition IE, Thomsom books, Reprint.
2. Khalil Arshak and Olga Korostynska, 2017. Advanced Materials and Techniques for Radiation Dosimetry, Artech House Publishers.

References

1. S.W.S. McKeever, 1995. Thermoluminescence Dosimetry Materials: Properties and Uses, Ramtrans Publishing.
2. S. O. Pillai, 2005. Solid State Physics, 6th Edition, New age International Pvt Ltd.
3. Frank Herbert Attix, 2007. Introduction to Radiological Physics and Radiation Dosimetry, John Wiley & Sons.
4. Charles Kittel, 2013. Introduction to Solid State Physics, 8th Edition, John Wiley.
5. https://inis.iaea.org/collection/NCLCollectionStore/_Public/45/026/45026289.pdf.
6. https://acadpubl.eu/hub/2018-119-12/articles/2/489.pdf.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3DB	BIOLOGICAL DOSIMETRY	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The biomarkers used for biological dosimetry
- The protocol to perform dosimetry using lymphocytes and various techniques
- The emergencies and new developments in Biodosimetry

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Describe about the biomarkers used for biological dosimetry	K2
CO2	Understand the protocol to perform dosimetry using lymphocytes	K2
CO3	Illustrate the basics of various techniques available to perform biological dosimetry.	K3
CO4	Understand the importance cell survival based analysis to measure the biological effects of radiation.	K2
CO5	Interpret the procedures need to be followed while handling biological samples.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A3DB	BIOLOGICAL DOSIMETRY	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Biomarkers **10 h**

Cytogenetic biomarkers- Biomarkers for nucleotide pool damage and DNA damage- Biomarkers for germ line inherited mutations and variants- Biomarkers for induced mutations- Biomarkers for transcriptional and translational changes- Others- Safety of laboratory staff.

Unit II Lymphocyte based Biodosimetry **10 h**

Phases of biological dosimetry: Sample collection phase, Sample processing phase, Data analysis phase- Radiation Induced Chromosomal Alterations: Radiation induced DNA lesions - Chromosome type aberrations- Unstable aberrations- Stable aberrations- Premature chromosome condensation (PCC).

Unit III Techniques and Dose Estimation in Biodosimetry 8 h

Micronuclei (MN) assay-Protocols advantage and disadvantages - Dicentric Chromosome Aberration (DCA) assay- Protocols, Advantage and disadvantages - Fluorescence In Situ Hybridization (FISH) technique- Comet assay- Polymerization Chain Reaction (PCR) - Flow cytometry- Western blot- Enzyme-linked immunosorbent assay (ELISA) - DNA Microarray technology

Unit IV Dose Estimation **10 h**

Cell survival curves – Multi-target single hit model, Linear quadratic Model - Production of an in vitro dose response curve - General Considerations, Physical Considerations, Statistical Considerations - Dose calculation in biological dosimetry - Choice of curves - Number of cells to be analysed - Uncertainty on dose estimates- Dose Assessment - Acute whole body exposure, low dose overexposure cases, Partial body exposure, After delayed blood sampling, After protracted and fractionated exposure

Unit V Emergencies and New Developments in Biodosimetry **10 h**

Automation of chromosomal assays - Automated Sample Processing, Automated Image Analysis, Laboratory Information Management System (LIMS) – Investigation of radiation accidents - Chernobyl, The Istanbul accident - Mass Casualty Events - Potential Radiation Exposure, Historical Experience, Role of Biological Dosimetry - Existing Mass Casualty Strategies.

Text Books

1. C. S. Sureka and C. Armpilia 2017, "Text book on –Radiation biology for Medical Physicists‖", CRC Taylor & Francis Group, USA.
2. IAEA, 2011, "Cytogenetic Dosimetry: Applications in Preparedness for and Response to Radiation Emergencies", IAEA.

References

1. IAEA, 2001, "Cytogenetic Analysis for Radiation Dose Assessment" - A Manual (TRS-405), IAEA.
2. E.B. Podgorsak, 2005, "Radiation Oncology Physics: A Handbook for Teachers and Students", IAEA..
3. Alok Dhawan, Diana Anderson, 2016, "The Comet Assay in Toxicology: 2nd Edition, Royal Society of Chemistry.
4. Wolfgang G. Eisert, Mortimer L. Mendelsohn, 1984, Biological Dosimetry Cytometric Approaches to Mammalian Systems, Springer Berlin, Heidelberg.
5. https://www-pub.iaea.org/MTCD/publications/PDF/eprmedt/Day_2/Day_2-8. pps.
6. https://www.nasa.gov/centers/johnson/pdf/514216main_MD-01_Biodosimetry_methods.pdf.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A3DC	ARTIFICIAL NTELLIGENCE IN HEALTH CARE	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The artificial intelligence, specifically computational models of intelligence
- The machine learning models and their applications in medicine and healthcare.
- The performance of specific models as applied to biomedical problems, and justify their use and limitations

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Interpret the concept of artificial intelligence, specifically computational models of intelligence	K3
CO2	Analyze about machine learning and expert systems.	K4
CO3	Illustrate the application of artificial intelligence in healthcare.	K3
CO4	Summarize the application of artificial intelligence in diagnostic radiology and radiation oncology.	K2
CO5	Apply the tools and technologies and its implementation in healthcare sector and social issues.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights		Gender Sensitization
✓	Social Awareness/ Environment		Constitutional Rights/ Human Values/ Ethics

222MP2A3DC	ARTIFICIAL INTELLIGENCE IN HEALTH CARE	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Artificial Intelligence **10 h**

Concept of Artificial Intelligence - Artificial Intelligence Problems – Topics of Artificial Intelligence – Timelines of Artificial Intelligence – Production Systems – State space representation – Branches of Artificial Intelligence – Applications of Artificial Intelligence. Learning: Types of Learning – Machine Learning – Intelligent Agents.

Unit II Supervised and Unsupervised Learning and Expert Systems **10 h**

Supervised Learning: Support Vector Machines – Inductive Logic Programming – Case based reasoning – ensemble Classifiers – Nearest Neighborhood – Fuzzy Network. Unsupervised Learning: Expectation Maximization – Self Organization Maps – Adaptive Resonance Theory. Expert Systems: Characteristics – Development – Applications of Expert Systems

Unit III Applications of Artificial Intelligence in Healthcare **10 h**

Artificial Intelligence and Human Intelligence, Artificial Intelligence in Healthcare Sector - Artificial Intelligence in Preventive Healthcare - Artificial Intelligence in Radiology - Artificial Intelligence in Pathology - Artificial Intelligence in Surgery - Artificial Intelligence in Anesthesiology - Artificial Intelligence in Psychiatry - Artificial Intelligence in Cardiology - Artificial Intelligence in Pharmacy - Artificial Intelligence in Dermatology - Artificial Intelligence in Dentistry - Artificial Intelligence in Orthopedics - Artificial Intelligence in Ophthalmology.

Unit IV Artificial Intelligence in Oncology and Radiation Oncology 10 h

Role in screening - Role in diagnosing; emphasis on radiology - Role in prognostication - AI in radiation oncology: Image acquisition - Tumor and organs at risk segmentation - Image registration – AI in Radiation Treatment planning - Radiation delivery methods

Unit V Implementation and Evaluation **8 h**

Tools and Technologies for implementing AI methods - Model evaluation and performance metrics, cross-validation, model interpretability. Ethical, Legal, and Social Issues of AI in medicine and healthcare Challenges of Artificial Intelligence - Advantages and Disadvantages

Text Books

1 Arvin Agah, 2013. Medical Applications of Artificial Intelligence, 1st Edition, CRC Press.

2 Adam Bohr, Kaveh Memarzadeh, 2020. Artificial Intelligence in Healthcare, 1st Edition, Academic Press.

References

1 Bernard Nordlinger, Cédric Villani , Daniela Rus, 2020. Healthcare and Artificial Intelligence, 1st Edition, Springer.

2 Vinod Chandra S S, Anand Hareendran S (2014), Artificial Intelligence and Machine Learning, PHI...

3 Rajit Rattan, Tejinder Kataria, 2019. Artificial intelligence in oncology, its scope and future prospects with specific reference to radiation oncology, Review Published by the British Institute of Radiology.

4 Arjun Panesar, 2019. Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes, 1st Edition, Apress..

5 .https://www.sciencedirect.com/science/article/abs/pii/S0167814018302895

6 https://www.sciencedirect.com/science/article/abs/pii/S1939865420300084.

222MP2ASSA	RESEARCH METHODOLOGY	SEMESTER III

Total Credits: 1

Syllabus

Unit I Introduction to Research Methodology

Introduction- Meaning of Research - objectives of Research -Motivation of Research-Types of Research – Research approaches – Significance of Research - Research and scientific methods – Research Process– Criteria of good Research – Problems encountered by Researchers – Literature review.

Unit II Research Formulation

Defining a research problem -Selecting the Research problem–Necessity of defining the problem–Technique involved in designing problem-Research Design Formulation of Research design – Need for Research design – Features of a good design – Important concepts related to Research design. Different research designs– Basic principles of experimental designs.

Unit III Sampling Design

Census and sample survey –Implication of sample design- Steps involved sampling design – Criteria of selecting a sampling procedure- Characteristics of good sample design- different types of sample design-random sample from an infinite universe-complex random sampling designs.

Unit IV Statistical Techniques and Tools

Introduction of statistics – Functions – Limitations – Measures of central tendency - Arithmetic mean – Median – Mode – Standard deviation – Co-efficient of variation (Discrete serious and continuous serious) – Correlation - Regression – Multiple Regression. Sampling distribution – Standard error – Concept of point and interval estimation – Level of significance – Degree of freedom – Analysis of variance – One way and two way classified data – 'F'-test.

Unit V Interpretation and Report Writing

Meaning and Technique of interpretation – Techniques of interpretation- Precautions in interpretation – Significance of report writing – Different steps in writing a report – Layout of a Research report. Types of report – Mechanics of writing a research report – Precautions for writing a research report. Steps involved in writing a a good report- concept of bibliography and reference

Text Books

1 Kothari. C.R, 2004,"Research Methodology (Methods and Techniques)", 2nd Edition, New Age International Publishers.

2 Gupta, S., 2001,"Research Methodology and Statistical Techniques, Deep and Deep", New Delhi.

References

1 Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. "An introduction to Research Methodology", RBSA Publishers..

2 Mukul Gupta, Deepa Gupta, 2011. "Research Methodology, PHI Learning Private Ltd"., New Delhi.

3 Gupta. S.C and Kapoor. V.K, 2014. "Fundamental of Mathematical statistics", 10th Edition, Sultan Chand & Sons, Delhi.

4 Gupta S.P, 2014, "Statistical methods", 44th Edition, Sultan Chand & Sons Educational publishers, New Delhi.

222MP2ASSB	CANCER BIOLOGY	SEMESTER III

Total Credits: 1

Syllabus

Unit I Biology of Cancer: The Basics

Definition of Cancer, Tumors - Benign and Malignant, Nomenclature – Macroscopic and Microscopic features of neoplasm, Hallmarks of Cancer, Classification of Human Cancer, Common Symptoms, Molecular-Growth Signal Autonomy, Evasion of Growth Inhibitory Signals, Evasion of Apoptosis (Programmed Cell Death), Unlimited Replicative Potential, Angiogenesis (Formation of New Blood Vessels), Invasion and Metastasis, Molecular Basis of Cancer -Cancer Genes (Oncogenes and Tumour Suppressor Genes), Carcinogenesis – A Multistep Process, Evidences for Multistage Models of Carcinogenesis.

Cancer Metabolism: Altered Metabolism in Cancer Cells, Energetic of Cell Proliferation, Genetic Events Important for Cancer Influence Metabolism, Targeting Caner Metabolism

Unit II Classification of Cancer and Risk Factors

Cancer Classification – TNM Classification - Purpose, Types of Staging, TNM System, Stage Grouping, Other Factors That Can Affect the Stage, Other classification System – FIGO Classification, Special staining tumors – ERPR, Molecular Classification of Cancer

Cancer Risk Factors: Theories of Carcinogenesis, Oncogenes and Antioncogene - Physical, Biological, Chemical -Exogenous and Endogenous Carcinogens, Metabolism of Chemical Carcinogens, DNA Adduct Formation, Biological - DNA Viruses and RNA Viruses, Genetic Syndromes, Life Style Factors.

Unit III Cell Cycle Apoptosis and Tumor genesis

Cell cycle - Alterations in Pathways Affecting Growth and Proliferation, Mutations Neutralizing Stress Responses, Mutations Causing Genetics and Genomic Instability, Cell Cycle and Cancer Therapy; Apoptosis - Molecular Mechanisms (Intrinsic and Extrinsic Pathway), p53 and Apoptosis, Apoptosis and Cancer, Apoptotic Pathways and Cancer Therapy, Autophagy (Mechanism, Autophagy in Tumourigenesis, Autophagy Modulation for Cancer Treatment), Necrosis.

Unit IV Pathophysiology of Cancer

Invasion and Metastasis: Evaluation and Pathogenesis of Metastasis, An Integrated Model of Metastasis, Tools of Cell Migration – Tumour Invasion, Cell Adhesion,

Integrins and Proteases, Intravasation, Transport, Extravasation, Metastatic Colonization, Organ Selectivity of Metastasis, Metalloproteinase's Inhibitors (MPIS).

Etiology of Cancer – Physical, Chemical, Biological, hormonal, Hereditary and Immunity – Systemic effects of Neoplasia – Cancer Pattern-incidence in India – Cancer markers for oral cancer – prostate cancer – head and neck – colorectal – cervical, lungs – breast – gastrointestinal cancer – Alpha fetoproteins – carcino-embryonic antigens – leukemia. Cancer Screening and Treatment Modalities

Unit V Cancer Screening and Treatment Modalities

Screening - Definition, Principles, Evaluating Screening Tests, Developing and evaluating a Cancer Screening Programme, Different Kind of Screening Tests, Screening for Specific Types of Cancer, Genetic Counseling. Treatment-Essential Terms, Surgery, Radiation, Chemotherapy, Biological Therapy, Hormone Therapy, Transplantation, Targeted Therapies, Radiolabeled Immunotherapy, Gene Therapy, Other Treatment Methods (Cryosurgery, Laser Therapy, Photodynamic Therapy, Hyperthermia), Cancer Clinical Trials.

Treatment intent – Curative and Palliative, Cancer Prevention and Public education – Patient Management on treatment – side effects related to radiation dose and chemotherapeutic drug.

Text Books

1 Robert A. Weinberg, 2012, " The Biology of Cancer", Garland Science.

2 Robin Hesketh, 2013, " Introduction to Cancer Biology", Cambridge University Press..

References

1 Vincent T. Devita, Jr., Theodore S. Lawrence, Steven A. Rosenberg, 2011, "Cancer: Principles and Practice of Oncology", 9th Edition, Lippincott Williams and Wilkins.

2 Francesco Pezzella, Mahvash Tavassoli, David J. Kerr, 2019, " Oxford Textbook of Cancer Biology", Oxford University Press.

3 Arthur B. Pardee, Gary S. Stein, 2008, "The Biology and Treatment of Cancer: Understanding Cancer", John Wiley & Sons, Inc.

4 Franks L.M, Teich.N.M, 1997, "Introduction to the Cellular and Molecular Biology of Cancer" 3rd edition, Oxford University Press.

222MP2A3CT	MEDICAL PHYSICS SUMMER TRAINING	SEMESTER III

Total Credits: 2

PREAMBLE

This course has been designed for students to learn and understand

- The clinical work carried out in Radiation Oncology, Radiology and Nuclear Medicine Departments.
- The duties and responsibilities of a Medical Physicist and Radiological Safety Officer (RSO).
- The Radiation safety instruments used to ensure safety of Patient, Radiation worker and Public.

Content

Students must undertake field training for 30 days during their II semester summer vacation to observe the clinical works carried out in Radiation Oncology, Radiology and Nuclear Medicine Department of AERB recognized Hospitals/ Research Institutes under the guidance and supervision of Medical Physicist and class advisor. The students will submit the report for evaluation during III semester.

The stages in Field Training Report Work are given below:

- A guide will be allotted by the Department to each student.
- The Student has to maintain the work diary.
- The training should be pursued in the department allotted by the hospital.
- Student should prepare a Training Report at the end of field training and it has to be certified and approved by the guide. (The Report should be in the Standard Format).
- The training should be carried out individually and personally by the student.
- The Field Training Report should demonstrate the learning of the students.
- The training certificate copy must be enclosed in the Report.
- The training report should be submitted to the department with enclosed copy of training certificate

Based on the performance marks will be awarded as follows:

Internal Marks	External Marks (Report & Viva - voce)	Total Marks
50	50	100

Internal Marks Distribution:

The internal mark will be awarded based on the field training report

The guide will give the marks for internal marks as per the norms stated below:

Review	- 20 Marks
Report	- 20 Marks
Attendance	- 10 Marks
Total	- 50 Marks

External Marks Distribution:

Presentation and Viva-voce Examination:

The evaluation for the report will be done as per the norms given below:

Presentation	- 40 Marks
Viva-Voce Examination	- 10 Marks
Total	- 50 Marks

D. Sakumar 14/6/2023

BoS Chairman/HoD
Department of Medical Physics
Dr. N. G. P. Arts and Science College
Coimbatore – 641 048

Dr.N.G.P. Arts and Science C...
APPROVED

BoS	AC	GB
15th	15th	20th
14.6.23	14.7.23	5.8.23

Academic Council
CHAIRMAN
Dr.N.G.P. Arts and Science College

Course Code	Course Name	Category	L	T	P	Credit
222MP2A4CA	RADIATION HAZARDS, EVALUATION AND CONTROL	CORE	5	1	-	5

PREAMBLE

This course has been designed for students to learn and understand

- The basic concepts of radiation protection standard system.
- The monitoring and protection principle of internal and external radiation hazards.
- Radiation safety codes for transport and waste disposal of radioisotopes and radiation emergencies and its management

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain the hazards of radiation and its protection system.	K3
CO2	Illustrate the monitoring and protection principle of internal and external radiation exposure	K3
CO3	Interpret the types of installations and Safety requirements on radiation sources and equipment	K3
CO4	Discuss about the radioactive waste disposal and transport of radioactive material.	K2
CO5	Explain the radiation safety legislation, radiation emergencies and medical management	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights	-	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A4CA	RADIATION HAZARDS, EVALUATION AND CONTROL	SEMESTER IV

Total Credits: 5

Total Instruction Hours: 72 h

Syllabus

Unit I **Radiation Protection Standards** **15 h**

Radiation dose to individuals from natural radioactivity in the environment and manmade sources-basic concepts of radiation protection standards - historical background - International Commission on Radiological protection and its recommendations - ICRP 60 and 103 - The system of radiological protection - justification of practice, optimization of protection and individual dose limits - potential exposures, dose and constraints - system of protection for intervention - categories of exposures - occupational, Public and medical exposures - permissible levels for neutron flux - factors governing internal exposure - radionuclide concentrations in air and water - ALI, DAC and contamination levels.

Unit II **Principles of Monitoring and Protection** **14 h**

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

Unit III **Safety in the Medical Uses of Radiation** **15 h**

Planning and shielding calculations of medical radiation installation - general considerations - design of diagnostic, deep therapy, telegamma, accelerators and installations, brachytherapy facilities, SPECT, PET/CT and medical cyclotron in the nuclear medicine department and medical radioisotope laboratories-evaluation of radiation hazards in medical diagnostic therapeutic installations - radiation monitoring procedures - protective measures to reduce radiation exposure to staff and patients - radiation hazards in brachytherapy department and teletherapy departments and radioisotope laboratories - particle accelerators protective equipment - handling of patients - radiation safety during sources transfer operations special safety features in accelerators, reactors

Unit IV **Radioactive Waste Disposable and Transport of Radioisotope** **15 h**

Radioactive waste – sources of radioactive waste – classification of waste – treatment techniques for solid, liquid and gaseous effluents – concept of delay tank and various Waste disposal Methods used in nuclear medicine. permissible limits for disposal of waste– sampling techniques for air, water and solids – geological, hydrological and meteorological parameters – ecological considerations- disposal of radioactive wastes – general methods of disposal- transportation of radioactive substances – historical background – general packing requirements – transports documents – labeling and marking of packages – regulations applicable for different modes of transport – transports by post –transport emergencies – special requirements for transport of large radioactive sources and fissile materials– exemptions from regulations – shipments approval – shipment exclusive use– transports under special arrangement – consignors and carriers responsibilities.

Unit V **Radiation Safety Legislation and Radiation Emergencies and Their Medical Management** **13 h**

Atomic Energy Act-1962, RPR-2004 and applicable safety codes- radiation accidents and emergencies in the use of radiation sources and equipment industry and medicine - radiographic cameras and teletherapy units – loading and unloading of sources – loss of radiation sources and their tracing – typical accidents cases, radiation injuries, their treatment and medical management – case histories- eLORA

Text Books

1. Alan Martin, 1998. "Radiation Protection" 3rd Edition, published by Champman & Hall.
2. Thayalan. K, 2010. "Textbook of Radiological protection" 1st Edition, published by Jaypee Brothers..

References

1. Shapiro J. 1994. "Radiation Protection" 3rd Edition, Harvard University Press.
2. Govinda Rajan K.N, 2018, "Radiation Safety in Radiation Oncology" 1st Edition, CRC Press.
3. Herman Cember, 2008. "Introduction to Health Physics", 4th Edition, McGraw-Hill Medical.
4. AERB Radiation Protection Rules 2004, ICRP 1990 Recommendations and ICRP 2007 Recommendations..
5. https://www.slideshare.net/deenesh1110/radiation-safety-and-hazards-control .
6. https://www.slideshare.net/libinscaria/radiation-emergency.

Course Code	Course Name	Category	L	T	P	Credit
222MP2A4CB	PROFESSIONAL ETHICS AND LEGAL ASPECTS	CORE	2	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The Fundamental principles of ethics in healthcare.
- The ethics in medical physics practice and its implementations in radiology, nuclear medicine and radiotherapy
- The Legal aspects in radiation Oncology

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Demonstrate the principles of medical ethics	K2
CO2	Build the knowledge of professional ethics in Medical Physics	K3
CO3	Solve the clinical dilemmas through ethical principles	K3
CO4	Distinguish the roles of international, national, and institutional ethical committees.	K4
CO5	Interpret the roles and responsibilities of medical physicists, the legal issues and aspects of radiation oncology	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓		✓		✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	-	Entrepreneurial Development
✓	Employability	-	Innovations
-	Intellectual Property Rights	✓	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A4CB	PROFESSIONAL ETHICS AND LEGAL ASPECTS	SEMESTER IV

Total Credits: 3

Total Instruction Hours: 36 h

Syllabus

Unit I **Introduction** 7 h

Fundamental Principles of Ethics in Healthcare - Value Systems in Medical Ethics and Guiding Principles - Beneficence and Non-Maleficence - Autonomy and Dignity – Justice - Prudence and Precaution - Honesty and Transparency - Accountability and Liability- Inclusiveness.

Unit II **Ethics in Medical Physics Practice** 7 h

Workplace Ethics - Scientific Integrity - Medical Ethics - Education in Professional Ethics for Medical Physicists-Ethical values in medical radiological protection - Ethics of clinical research - Cancer clinical trials - Ethics of publication and plagiarism – Professionalism.

Unit III **Ethical Dilemmas, Ethical Principles and Solutions** 7 h

Ethical Dilemma - Diagnostic Radiology – Nuclear Medicine – Radiation Therapy – Radiation Safety and Protection - Professional Matters - Reviewing Practice from an Ethical Perspective - Evaluation method of ethical values of scenarios.

Unit IV **Practical Implementation of Biomedical Ethics** 8 h

Professional oaths and codes of ethics - Role of international, national and institutional ethics committees - Clinical practice developments - Patient's Rights - General ethical issues - Ethical review procedures - Informed consent, incapacity, shared decision-making - financial influences, Patient-centred care - Privacy, confidentiality, and stewardship of health information.

Unit V **Legal Aspects in Radiation Oncology** 7 h

Special aspects of medical use of radiation - Roles and Responsibilities of Clinically Qualified Medical Physicists -Legal issues in Medical Practice - Roles and responsibilities of EC.

Text Books

1 IAEA, 2023 "Guidelines on Professional Ethics for Medical Physicists" TCS-78, IAEA ,Vienna.

2 ICMR, 2018, "Handbook on National Ethical Guidelines for Biomedical and Health Research involving Human Participants", ICMR, New Delhi.

References

1 Jim Malone, Friedo Zolzer, Gastron Meskens, Christina Skourou, 2019, " Ethics of Radiation Protection in Medicine", CRC Press..

2 ICMR, 2019, "ICMR Policy Research Integrity and Publication Ethics", ICMR, New Delhi.

3 ACR,2018, "Guide to Professional Practice of Clinal Medical Physics, ACR Raston VA..

4 AAPM,2019, Task Group -109..

5 https://www.youtube.com/watch?v=XFH1317xHHc.

6 https://www.slideshare.net/drmdyunus/ethics-for-medical-student

Course Code	Course Name	Category	L	T	P	Credit
222MP2A4DA	QUALITY CONTROL, ACCEPTANCE TESTING AND CALIBRATION OF RADIATION SYSTEMS	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The quality assurance program for diagnostic radiology and radiation therapy equipments.
- The quality assurance procedures for Treatment planning systems.
- The Acceptance, Commissioning and Decommissioning procedures for radioactive source and equipment.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Importance of the quality assurance program	K2
CO2	Discuss the Dosimetric protocols and quality assurance tests for radiation therapy.	K2
CO3	Explain the quality assurance test for various types of diagnostic equipments.	K3
CO4	Interpret the Acceptance and commissioning test for TPS.	K3
CO5	Illustrate the Commissioning and Decommissioning procedures for radioactive source and equipment.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights	-	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A4DA	QUALITY CONTROL, ACCEPTANCE TESTING AND CALIBRATION OF RADIATION SYSTEMS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Quality Assurance **11 h**

Purpose for quality assurance, Goals of QA, Personnel Requirements for Clinical Radiation Therapy, Roles and Responsibilities of Medical Physicists. 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 network of SSDLs, Standards of absorbed dose to water.

Unit II Dosimetric Protocols and QA for Radiation Therapy **13 h**

Different Protocols For Dosimetry - TRS 277, TRS-398, TG 51 and TG-43, Correction for the Radiation Quality Of The Beam (Kqqo), Ionization Chambers, Phantoms and Calibration of Ionization Chambers.

Co-60: Mechanical Checks, Electrical checks, Radiation Checks, Radiation Protection survey, Linear Accelerator: Photon beam characteristics, Electron beam Characteristics, Dose monitoring system, Treatment table, Leakage radiation measurements, Survey of installation.

Brachytherapy – Machine Tests, QC of Applicator, QA of sources, Leakage and Contamination, Source Strength Verification, Uniformity and Symmetry, Dwell Position Verification, QC of treatment Unit, Radiation Safety, HDR Source Transport, Type A package, Source Transfer Process and safety Concern in HDR.

Unit III Quality Assurance tests in Diagnostic Radiology **13 h**

QA tests for diagnostic X-ray machine: Purpose of QA tests, test procedures, Congruence of optical and radiation fields, Central beam alignment, Focal spot size, Exposure time, Applied tube potential, Total filtration, Linearity of timer, Linearity of mA, Consistence of radiation output, Radiation leakage through tube housing exposure rate at table top, Resolution of the imaging system, Radiation protection survey, Intensifying Screen Cleaning Procedure, Darkroom Integrity or Fog Test.

Computed Tomography (CT) Unit: Tools required for QA tests of CT equipment, Categories of QA tests – Mechanical Tests- Alignment of table to gantry, Gantry tilt, Tests for high frequency generators, Radiation Dose test (CTDI) , Image Quality Parameters, Radiation leakage tests and Radiation protection survey.

Quality assurance tests of Mammography Unit, 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.

Unit IV Quality Assurance tests for TPS **12 h**

Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols. Digitizer Accuracy, Image Acquisition and Display, Hardcopy 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.

Unit V Acceptance tests, Commissioning, and Decommissioning Procedures **11 h**

Acceptance tests for Medical linear Accelerators and Remote Afterloader Brachytherapy. Commissioning: Linear accelerator – Central axis depth dose tables, Isodose curves, Monitor unit calculations, Multileaf collimators (MLC), Treatment Planning computer system, Essential Equipments for Commission and Decommission. Decommissioning Process for Radioactive Sources, Medical Linacs and Brachytherapy.

Text Books

1. Faiz M. Khan, 2015, The Physics of Radiation Therapy", 5th Edition Lippincott Williams and Wilkins, U.S.A.
2. Thayalan. K, 2010., "Textbook of Radiological protection" 1st Edition, published by Jaypee Brothers.

References

1. Podgarsak. E.B. 2005. Radiation Oncology Physics: Handbook for Teachers and Students, IAEA, Vienna publisher.
2. IAEA TRS-398,277."Absorbed Dose Determination in External Beam Radiotherapy An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water and Air". Vienna, Austria.
3. IAEA TRS-430, 2004, "Commissioning and Quality Assurance of Computerized planning systems for radiation treatment of Cancer", Vienna, Austria.
4. TG 51, TG 21, TG 43, TG 53 AAPM Task Group.
5. https://wwwnaweb.iaea.org/nahu/DMRP/documents/slides/Chapter_11_Computerized_treatment_planning_systems.pdf
6. http://wwwnaweb.iaea.org/nahu/dmrp/documents/slides/chapter_10_acceptance_testing_and_commissioning.pdf

Course Code	Course Name	Category	L	T	P	Credit
222MP2A4DB	MONTE CARLO TECHNIQUES IN DOSIMETRY	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The modeling of ionizing and non-ionizing radiation transport.
- The role of Monte Carlo in dosimetry more accurately.
- The evaluation of dosimetry using statistical approach and different computer codes used for dosimetry.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Explain various Monte Carlo techniques in solving various mathematical and physical problems.	K3
CO2	Apply the knowledge to use Monte Carlo code to design the source and evaluate the dosimetric parameters.	K3
CO3	Interpret and evaluate the results of statistical nature using Monte Carlo technique for electron transport.	K3
CO4	Demonstrate the theory of the Monte Carlo simulation for ionizing and non-ionizing radiation	K3
CO5	Develop a mathematical model of tumor in tissue by understanding the Fick's law.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights	-	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A4DB	MONTE CARLO TECHNIQUES IN DOSIMETRY	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Elements of Monte-Carlo Technique** **12 h**

Generation of random numbers - uniformity - auto correlation coefficient - time of generation period. Solving simple integrals using Monte Carlo techniques - different Monte Carlo techniques - sampling from distribution - cosine - exponential - Gaussian distribution. Monte Carlo means, variances and standard deviation - precision and accuracy - the central limit theorem - variance of the variance - variance reduction techniques - particle weight - exponential biasingforced collision - weight window - Russian roulette. Geometry description - Boolean operators-intersections - unions – complement..

Unit II **Monte-Carlo Techniques for Photon and Neutron Transport** **12 h**

Simulating the physical processes - difference between charged and uncharged particle transport - Neutron transport in tissue 1-D problem - Photon transport - Cross section for Photon/Neutron transport - Structure of a general purpose computer code - Tallies - flux to dose conversion factors.

Unit III **Monte-Carlo Techniques for Electron Transport** **12 h**

Interaction of electron with matter - continuous slowing down model - condensed random walk method –class I and class II model - electron transport - flow chart - discrete & continuous energy loss - energy loss in a thin slab of water - step size - energy straggling - tally/scoring.

Unit IV **Monte-Carlo Modeling of Light Transport in Tissues** **12 h**

Introduction - sampling random variables - rules of photon propagation : conventions, launching the photon, photon step size moving a photon - photon absorption - terminating a photon - scattering a photon - multilayered and complex tissues. Data analysis: Basic idea - conversion techniques. Varieties of sources : distributing photons at launch and convolution of impulse response.

Unit V **Diffusion Theory of Light Transport in Tissue** **12 h**

Introduction - Ficks' law - energy conversion and the diffusion equation - boundary conditions. Diffusion approximation in transport theory - transport equation - diffusion theory derived from the transport equation - phase functions. Diffusion

theory in simple geometries: planar, spherical and cylindrical geometry. Diffusion approximation in three dimensions - finite beam profiles - green's function - diffuse radiant fluence rates for finite beams.

Text Books

1. K.P.N. Murthy, Monte Carlo Basics, Indian Society for Radiation Physics, India, 2000.
2. Judith F. Briesmeister, 1997,"A General Monte Carlo N-Particle Transport Code, Report No. LA- 12625-M version 4B", Web Address. http://www.Xdiv.alnl.gov/XTM/Xtm1/world1/docs/mcnpanual/pdf/mcnp4b_man.pdf

References

1. Rogers D. W.O and Bielajew A. F, 1990,"Monte Carlo Techniques of Electron and Photon transport for Radiation Dosimetry", The Dosimetry Radiation by Attix,Vol- 3, Academic Press, London,.
2. Berger M. J, 1965," Monte Carlo Calculation of the penetration and diffusion of fast charged particles", Computational Physics, Vol. 2,
3. Nelson, W.R, Hirayama, H., & Rogers, D. W.O, 1985," EGS4 code system (No. SLAC-265)", Stanford Linear Accelerator Center, Menlo Park, CA (USA).
4. Frank Verhaegen, 2013,"Monte Carlo Techniques in Radiation Therapy", CRC Press.
5. https://cds.cern.ch/record/932011?ln=en
6. https://www.youtube.com/watch?v=_iSoU1Ycl3g

Course Code	Course Name	Category	L	T	P	Credit
222MP2A4DC	ADVANCES IN MEDICAL PHYSICS	DSE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The difference between conventional dosimetry and Nanodosimetry and to analyse its various applications.
- The importance of Monte Carlo techniques in advanced dosimetry
- The importance of Artificial Intelligence in Medical Physics.

COURSE OUTCOMES

On the successful completion of the course, students will be able to

CO Number	CO Statement	Knowledge Level
CO1	Outline the possibility to measure radiation at DNA level and the importance of replacing of conventional dosimetric quantities with nanodosimetric quantities.	K2
CO2	Illustrate the basics of Micro dosimetry and Nano dosimetry and importance of Nanodosimetry in Oncology.	K3
CO3	Infer the importance of Monte Carlo techniques in advanced dosimetry.	K3
CO4	Explain the significance of AI in Medical Imaging and Radiotherapy	K3
CO5	Apply their Medical Physics knowledge towards Industry 4.0/5.0.	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE FOCUSES ON

✓	Skill Development	✓	Entrepreneurial Development
✓	Employability	✓	Innovations
✓	Intellectual Property Rights	-	Gender Sensitization
✓	Social Awareness/ Environment	✓	Constitutional Rights/ Human Values/ Ethics

222MP2A4DC	ADVANCES IN MEDICAL PHYSICS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I **Microdosimetry** **12 h**

Microdosimetric quantities - Solid state based microdosimetric techniques - Gas based Microdosimetry- Biological effects of Microdosimetry, Evaluation of Monte Carlo techniques for Microdosimetry, Microdosimetry in targeted radionuclide therapy and radiotherapy - Cellular dosimetry of targeted Radionuclide's, Microdosimetry of radon progeny, Dose–response relationship, Micro and Nanodosimetric calculations, Relationship of absorbed dose, Specific energy and track structures.

Unit II **Nanodosimetry and its Applications** **12 h**

Definition- Nanodosimetric quantities - charge counting Nanodosimetry: Electron based Nanodosimetry and ion based nanodosimetry- History- evaluation of positive ion detector for nanodosimetry, Biological effects of nanodosimetry, - structure- optimization- current scenario - Future developments- Radiation detector- Radiation protection- Radiation biology- Radiation protection- Gamma spectrometry- Gas sensor- Oncology.

Unit III **Artificial Intelligence in Medical Imaging** **12 h**

Applying Artificial Intelligence (AI) in Medical Imaging: Computer Aided Detection (CAD), Principles of Computer Aided Image Analysis in Medical Imaging, Machine Learning (ML), and Deep Learning (DL), Content- Based Image Retrieval (CBIR), Radiomics and Radiogenomics- AI in various Medical Imaging Modalities: Limitations of Human Observers, Computer Vision (CV) and AI, Detection of micro calcifications and breast masses, Present Status and Future Directions.

Unit IV **Artificial Intelligence in Ultrasound and Nuclear Medicine** **12h**

AI in Medical Ultrasound: DL Architectures, Applications of DL in Medical US Image Analysis, Future Perspectives- AI in Nuclear Medicine Imaging: Define a Radiomics Diagnostic Algorithm, Applications of AI in Nuclear Medicine, Future Scenarios- Salient features of AI in Medical Imaging: Opportunities and Applications, Challenges, Pitfalls Guidelines for Success, Regulatory and Ethical Issues.

Unit V Artificial Intelligence (AI) in Radiotherapy (RT) 12 h

Importance of AI in Radiotherapy - AI Tools for Automated Treatment Planning (ATP): Present ATP Techniques, AI Challenges in ATP - AI in Intensity Modulated Radiotherapy (IMRT), AI for Auto-segmentation of OAR in IMRT, Future Directions - AI in Brachytherapy: AI in Radiotherapy Quality Assurance(QA), QA of ML Algorithms in Radiotherapy, Challenges Associated with AI for Quality Assurance in RT, Future Directions to Improve AI based Quality Assurance in RT-AI in Radiation Biology- AI in Radiation Protection/Safety: Problems Associated with AI based systems for Radiation Protection, Benefits and Future Directions. Radiomics in Radiotherapy- Challenges for Medical Physicists - AI Considerations for RT Curriculum Development

Text Books

1 Palmans, H., et.al 2015," Future development of biologically relevant dosimetry", The British journal of radiology,20140392.

2 Reid F. T, Gilmer V, Clifton D. F, 2018, "Artificial intelligence in radiation oncology: A specialty-wide disruptive transformation Radiotherapy and Oncology" 129, 421–426, Elsevier.

References

1 Grosswendt B, 2004, "Recent advances of nanodosimetry", Radiation Protection Dosimetry, Vol. 110, Nos 1-4, pp. 789-799,

2 Lia M, Silvia D, Loredana C., 2019, "Artificial Intelligence in Medical Imaging: From theory to Clinical Practice", USA, CRC Taylor & Francis Group.

3 Dudley T. Goodhead, 1982, "An Assessment of the Role of Microdosimetry in Radiobiology", Radiation Research; Vol. 91, No. 1, pp. 45-76.

4 Dan Nguyen, Lei Xing, Steve Jiang, 2019, "Artificial Intelligence in Radiation Therapy" First International Workshop, AIRT 2019, Held in Conjunction with MICCAI, Shenzhen, China,

5 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8966218

6 https://www.youtube.com/watch?v=6YUt5VIBWQg

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