DEPARTMENT OF MEDICAL PHYSICS

ANNA UNIVERSITY, CHENNAI

VISION

The Medical Physics course is planned in such a way that it is committed to being at the forefront of finding better diagnosis and treatments for cancer patients by way of superior clinical care and clinical trials coupled with cutting edge research in medical physics field, cancer biology and health services.

MISSION

The Mission of the medical physics program is to introduce advancement in the practice of principles of Physics for diagnosis and treatment of disease by educating students, on the concepts of radiological physics, medical imaging, radiation therapy and radiation safety aspects. The program aims to provide students with necessary foundation and confidence through rigorous teaching, hands on practice and mentored research.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.PHIL. APPLIED PHYSICS (FT)

REGULATIONS - 2019

CHOICE BASED CREDIT SYSTEM

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To teach the students about the methodologies followed to carry out research in various advanced fields of Applied Physics.
2. To train students in data acquisition using the state-of-the-art Photonics equipments and in various scientific data analytic techniques so that they can analyze their research data and interpret the results. This will be helpful in their research activities.
3. To train the students in understanding the concepts of Laser theory and its applications in medicine and industry.
4. To enrich the knowledge of the students in the aspects of radiation dosimetry, medical imaging and renewable energy in order to develop new materials & techniques for medical and energy applications.
5. To provide knowledge on Computational techniques to understand the properties of materials and the influence of atmosphere on human health and train the students to design novel materials for societal applications in the thrust areas.

II. PROGRAMME OUTCOMES (POs):

After one year of completing the M.Phil. Applied Physics course the students are expected to have the following attributes with the corresponding outcomes:

PO#	Graduate Attribute	Programme Outcome
1.	Scientific knowledge	Will develop specialist knowledge and skills in the fields of Laser Physics, Radialogical Physics, Computational Physics, and Atmospheric Physics.
2.	Practical ability	Will have the ability to pursue research in their field of interest using various data analytics tools and experimental facilities.
3.	Knowledge transfer	Will be able to evaluate and implement new technologies and in translation of research into professional practice.
4.	Modern tool usage	Will be able to develop the skills to critically evaluate and optimize the performance of advanced laser, radiation physics equipments, computational packages and procedures.
5.	Environment and sustainability	Design their experiments with environment consciousness and sustainable development.

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6.	Ethics	Practice ethical, responsible, reliable, and dependable behavior in all aspects of professional lives, and a commitment to the profession and society. They will be able to establish and maintain standard protocols of operation in dosimetry and their respective research fields.
7.	Individual and team work	Ability to become an advisor to a team of professionals including oncologists, radiologists, radiotherapists, technologists and biomedical engineers. Ability to carry out independent and group research activities and become a research supervisor.
8.	Communication	Proficiency in oral and written communication with focus on writing research papers, reports, proposals and thesis.
9.	Design/development of new materials	Students will be given opportunities to survey research literature and thereby identify current problems in their respective fields
10.	Conceiving concepts for fabrication of prototypes	To develop the concepts with proof for the fabrication of new indigenous devices for disease discrimination.
11.	Project Management	Will be able to use problem solving abilities to analyze outputs, derive inferences and provide solutions to the research team and thereby manage a research team.
12.	Life-long learning	Will be able to gain and induce lifelong learning skills, attitudes for social and personal development .

III. **PROGRAM SPECIFIC OUTCOMES (PSOs):**

By the completion of the program the student will have following Program specific outcomes.

1. Will have the ability to perform research in the fields of radiation dosimetry, medi photonics, ultrasonics, computational condensed matter physics, and environmental effects of radiation.
2. Will have the ability to derive inference on thrust areas in their respective research areas, perform experiments and computations and analyze results using various data analytics tools.
3. Can pursue a broad range of research projects.
4. Can teach medical physics courses to graduate students/Post graduate Medical students and Medical Physics students / dosimetrists.
5. To gain employment in Research and Development labs of government and private sectors.

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1. PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓		✓		✓	✓	✓	✓	✓		
II	✓	✓		✓	✓	✓		✓	✓	✓		✓
III	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓
IV	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
V	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Mapping of Course Outcome and Programme Outcome

		Course Name	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
YEAR 1	Semester1	Laser Theory & Applications	✓	✓		✓	✓	✓		✓	✓			✓
		Research Methodology and Data Analytics	✓	✓		✓	✓	✓		✓		✓	✓	✓
		Elective – I	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
		Elective – II	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	Semester 2	Project	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
		Seminar	✓	✓		✓	✓				✓	✓	✓	✓

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UNIVERSITY DEPARTMENTS

M. Phil. APPLIED PHYSICS

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5101	Laser Theory and Applications	PCC	4	0	0	4	4
2.	MY5102	Research Methodology and Data analytics	RMC	4	0	0	4	4
3.		Program Elective - I	PEC	4	0	0	4	4
4.		Program Elective - II	PEC	4	0	0	4	4
TOTAL				**16**	**0**	**0**	**16**	**16**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5211	Seminar	EEC	0	0	2	2	1
2.	MY5212	Project	EEC	0	0	32	32	16
TOTAL				**0**	**0**	**34**	**34**	**17**

TOTAL NO. OF CREDITS: 33

PROFESSIONAL CORE COURSE (PCC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5101	Laser Theory and Applications	PCC	4	0	0	4	4
TOTAL				4	0	0	4	4

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RESEARCH METHODOLOGY COURSE (RMC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5102	Research Methodology and Data analytics	RMC	4	0	0	4	4
			TOTAL	**4**	**0**	**0**	**4**	**4**

EMPLOYABILITY ENHANCEMENT COURSE

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5211	Project	EEC	0	0	32	32	16
2.	MY5212	Seminar	EEC	0	0	2	2	1
			TOTAL	**0**	**0**	**34**	**34**	**17**

PROGRAM ELECTIVES COURSE (PEC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODSPER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MY5001	Laser in Medicine	PEC	4	0	0	4	4
2.	MY5002	Biomedical Optical Spectroscopy	PEC	4	0	0	4	4
3.	MY5003	Medical Ultrasonics	PEC	4	0	0	4	4
4.	MY5004	Molecular Imaging Techniques	PEC	4	0	0	4	4
5.	MY5005	Physics of Advanced Radiation Therapy	PEC	4	0	0	4	4
6.	MY5006	Radiation Physics and Dosimetry	PEC	4	0	0	4	4
7.	MY5007	Stereotactic Radiosurgery and Stereotactic Radiotherapy	PEC	4	0	0	4	4
8.	MY5008	Three Dimensional Conformal Radiotherapy	PEC	4	0	0	4	4
9.	MY5009	Computational Condensed Matter Physics	PEC	4	0	0	4	4
10.	MY5010	Semiconductor Materials: Theory and Practice	PEC	4	0	0	4	4
11.	MY5011	Physics of the Atmosphere	PEC	4	0	0	4	4
12.	MY5012	Middle Atmosphere physics	PEC	4	0	0	4	4

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SUMMARY

	M.PHIL. APPLIED PHYSICS			
	Subject Area	Credits per Semester		Credits Total
		I	II	
1.	PCC	4	0	**04**
2.	RMC	4	0	**04**
3.	PEC	8	0	**08**
4.	EEC	0	17	**17**
	Total Credit	**16**	**17**	**33**

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MY5101 **LASER THEORY AND APPLICATIONS** **L T P C**
4 0 0 4

OBJECTIVE

- To expose the students with theoretical aspects of laser theory and its applications.
- To provide knowledge on laser theory, resonators and switching theory
- To provide knowledge on gas & liquid lasers, solid state & semiconductor lasers and their applications.

UNIT I LASER THEORY **12**

Absorption - Spontaneous and stimulated emission - Einstein's coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems.

UNIT II RESONATORS AND SWITCHING THEORY **12**

Resonant cavity - Fox and Li - Boyd and Gorden's theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

UNIT III GAS AND LIQUID LASERS **12**

He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers-organic dyes - Pulsed and CW dye lasers - Threshold conditions - Pumping configurations.

UNIT IV SOLID STATE AND SEMICONDUCTOR LASERS **12**

Ruby, Nd : YAG, Nd : Glass, Ti-sapphire, Alexandrite, lasers - Semiconductor lasers - Homo junction - Hetro junction - Quantum well laser.

UNIT V APPLICATIONS **12**

Speckle, speckle interferometry - Holography - Holographic interferometry - Material processing - Surface treatment – welding - drilling - Laser ranging - Laser Doppler Velocimetry - Pollution monitoring - Medical applications.

TOTAL: 60 PERIODS

OUTCOME

Employ students with the basic knowledge about

- lasers for material characterization,
- Speckle interferometry and Holography
- Different types of gas and Liquid lasers
- Solid and semiconductor lasers and their types
- medical applications at their fundamental frequency and higher harmonic

TEXT BOOKS

1. Thyagarajan. K &AjoyGhatak, "Laser fundamentals and applications", Springer, 2010.
2. William T. Silfvast, " Laser Fundamentals ", Cambridge University Press, 1999.
3. Oshea, Callen and Rhcdes, "An Introduction to Lasers and their Applications", Addison Wesley, 1985.
4. MarkolfNeimz, "Laser Tissue interactions", Springer science & Business media, 2004.

REFERENCES

1. Hector J Rabal, Roberto A Braga Jr., "Dynamic Laser Speckle and applications", CRC Press, 2009.
2. Fotakis. C, Papazoglou. T &Kalpouzos. C, "Optics and Lasers in Biomedicine and Culture", Springer, 2000.
3. Guy A Catone, Charles C Alling, "Laser Applications in Oral and Maxillofacial Surgery", W.B. Saunders, 1997.
4. Hariharan, "Optical Holography", Academic Press, New York, 1983.

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MY5102 RESEARCH METHODOLOGY AND DATA ANALYTICS L T P C
4 0 0 4

OBJECTIVES

- To expose the students in different methodologies of research
- To expertise the students in mathematical and advanced statistical methods.
- To familiarize the students in advanced computing tools such as neural network and fuzzy logic.
- To train the students to handle the graphical and simulation software.

UNIT I RESEARCH METHODOLOGY 12

Introduction - Defining research problem - Objectives and types of research: Motivation and objectives – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Literature review –Search Engine for Journal search -Frameworks - Research questions and hypotheses - Multimethod research. Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review –Identifying gap areas from literature review - Development of working hypothesis, Research design and methods, Plagiarism.

UNIT II MATHEMATICAL ANALYSIS 12

Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Hypothesis-testing - Generalization and Interpretation.-Sampling distributions - Characteristics of good estimators - Maximum Likelihood Estimation - Interval estimates for mean, variance and proportions. Type I and Type II errors - Tests based on Normal, t, χ^2 and F distributions for testing of mean, variance and proportions. Method of Least Squares –Regression Techniques; Normal, Partial and Multiple Correlations.

UNIT III ADVANCED STATISTICAL METHODS 12

Analysis of Variance - One-way and two-way Classifications - Completely Randomized Design - Randomized Block Design - Latin Square Design. Multivariate analysis - Mean Vector and Covariance Matrices - Partitioning of Covariance Matrices - Combination of Random Variables for Mean Vector and Covariance Matrix - Multivariate, Normal Density and its Properties - Principal Components: Population principal components - Principal components from standardized variables.

UNIT IV NEURAL NETWORK & FUZZY LOGIC 12

Introduction of Neural Network- Artificial Neuron - Activation Functions, Neural Network Architecture: Single Layer and Multilayer Feed Forward Networks, Recurrent Networks. Various Learning Techniques; Perception - Back Propagation Networks- Effect of Learning Rule Co-Efficient; Fuzzy logic - Basic Concepts, Fuzzy and Crisp Sets, Properties of Fuzzy Sets, Fuzzy and Crisp Relations, Fuzzy to Crisp Conversion. Membership Functions, Fuzzy If Then Rules, Fuzzy Implications: Fuzzification and De-fuzzification, Applications of NN and FL in medicine.

UNIT V GRAPHICAL AND SIMULATION SOFTWARE 12

Introduction to SPSS, Origin Pro and Matlab –Implementation of statistical methods using SPSS- 2D, 3D plotting using Origin Pro - Statistical analysis using Origin Pro: Fourier Transform, Filtering, Correlation and Regression. Matlab: data types and variables – operators – flow control – functions – input-output – array manipulation –Executing Matlab programs – Visualizaion of 2D, 3D data matrix - plotting – overview of simulink environment.

TOTAL: 60 PERIODS

OUTCOME

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

- Understand the methodology of research, hypothesis and plagiarism concepts.
- Know about how to execute research and understand mathematical analysis.
- Gain knowledge to apply advanced statistical methods in research.
- Get aware about advanced computing tools such as neural network and fuzzy logic.
- Handle the graphical and simulation software.

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TEXT BOOKS

1. Research Methodology: Methods And Techniques, (Paperback) – New Age International publishers, New Delhi, 2019.
2. S. S. Shastry. Introductory methods of numerical analysis. Fifth Edition, PHI Learning Pvt Ltd, New Delhi, 2012.
3. Andy Field, "Discovering Statistics using IBM SPSS Statistics", (Paperback), SAGE Publications Lt., Fourth edition, 1900.
4. Siman Haykin, —Neural Networks and Learning Methods, Third Edition, Prentice Hall of India, 2008.
5. Rudra Pratap, Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers, First Edition, Oxford University Press, 2009.

REFERENCES

1. John Kuada, Research Methodology: A Project Guide for University Students, Samfundslitteratur Publisher, 2012.
2. Peter Westfall, Kevin S. S. Henning , Understanding Advanced Statistical Methods(Chapman & Hall/CRC Texts in Statistical Science), CRC Press, 2013.
3. Giuseppe Ciaburro, MATLAB for Machine Learning, Packt Publishing Ltd, 2017.
4. Stormy Attaway, Matlab: A Practical Introduction to Programming and Problem Solving *MATLAB: A Practical Introduction to Programming and Problem Solving*, Stormy Attaway, Elsevier, 2011.

MY5001 LASER IN MEDICINE L T P C
4 0 0 4

OBJECTIVE

- To provide knowledge on the basics of Laser
- To teach the students in detail about the Laser Tissue Interaction
- Designed to teach the photobiological effects and its applications in diagnosis and therapy.

UNIT I LASERS AND ITS BEAM CHARACTERISTICS 12

Lasers – New Light source- Principles of Laser Action _ Einstein coefficients –Beam Characteristics as Applied to Medicine – Classification of Lasers- CO_2 Laser – Ar Ion Laser- Nd-YAG Laser- Diode Laser – Dye Laser – Excimer Laser -Ti: Sapphire Laser – Radiometry

UNIT II LASER TISSUE INTERACTION MECHANISM 12

Interaction of Light with Molecule - Photophysical process - Photobiological Process - Optical Absorption and Scattering by biological systems - different types of interactions - Thermal - Photochemical (one photon and multiphoton) - Photo ablative Process-Electro Mechanical Effect

UNIT III OPTICAL DIAGNOSIS 12

Optical properties of tissues (normal and tumor) - experimental methods to determine the reflectance, transmittance, absorption and emission properties of tissues. Fluorophores -Electronic Absorption- Emission -DiffuseReflectance – RAMAN Spectroscopy &Imaging of Cells and Tissues – Confocal Fluorescence microscope -Principles of OCT

UNIT IV SURGICAL APPLICATIONSOFLASERS 12

Heat Generation and Effect in tissues - sterilization - hemostasis - cancer surgery - liver surgery - stomach surgery - gynecological surgery - urological surgery - cardiac surgery- lasers in Ophthalmology – Dermatology and Dentistry – cosmetic surgery**.**

UNIT V THERAPEUTIC APPLICATIONS LASERS AND HAZARDS 12

Photodynamic Therapy (PDT)– Basic principles- Mechanism -Photosensitizers for PDT - Laser Sources- Dosimetry- NanoPDT- -Biosimulation- Low Level Laser Therapy-Basic laser safety – eye hazards – skin hazards – electrical hazards – fire and flood hazards – laser safety classes.

TOTAL: 60 PERIODS

OUTCOME

On completion, students will be able to use

- Different lasers of optoelectronic devices for different diagnostic and therapeutic applications.
- Identify Tissue Optical properties
- Basic principle of Photodynamic Therapy
- lasers in Ophthalmology, Dermatology ,Dentistry,Cosmetic surgery
- Laser and Its Safety in Medicine

TEXTBOOKS

1. Markolf H. Neimz, Laser-Tissue Interactions, Springer Verlag, Germany,1996.
2. Paras N Prasad, Introduction to Biophotonics , Wiley Interscience, 2003
3. R. Pratesi and C. A. Sacchi, Lasers in Photomedicine and Photobiology, Springer Verlag, West Germany,1980.

REFERENCES

1. S. S. Martellucci and A. N. Chester, Laser Photobiology and Photomedicine, Plenum Press, New York,1985
2. Ronald W. Waynant, Lasers in Medicine, CRC Press,2010.
3. J. A. S. Carruth and A. L. McKenzie, Medical Lasers, Adam Hilger Ltd.,Bristol,1992.
4. D.R. Vij, K. Mahesh, Medical applications of lasers, Springer,2002.

MY5002 BIOMEDICAL OPTICAL SPECTROSCOPY L T P C
4 0 0 4

OBJECTIVE

- Designed to provide the knowledge for use of different laser spectroscopic methods in bioanalysis.
- To study about the propagation of Light in Turbid Media
- To learn about various optical sources and detectors

UNIT I TISSUE OPTICS 12

Structure of cells and tissues – light-matter interaction: absorption, scattering, reflection, refraction, luminescence, interference, polarization; their physical models and mechanisms. Specific features of living tissues from the point of optics. Relations of scattering and absorption in tissues -different interaction of lasers with tissues – Thickness and optical properties of appropriate skin layers - Skin pigments (melanin, bilirubin, carotene, hemoglobin) and their spectra - Composition of blood. Spectral properties of erythrocytes, thrombocytes and bloodplasma Differences between oxygenated and deoxygenated hemoglobinabsorption spectra.

UNIT II LIGHT PROPOGATION IN TURBIDMEDIA 12

Models of light propagation in tissues and the parameters used absorption and scattering coefficients, anisotropy, penetration depth, transport parameters; their connection with diffuse reflectance (remission). Time-resolved remittance models. Modeling of anisotropy, isotropic and layered tissue structures. Experimental studies of light propagation in tissues; tissue phantoms in experiments

UNIT III OPTOELECTRONIC DEVICES 12

Conventional UV- Visible - IR sources - LED – principles of Lasers – super luminescence diode – Optical detectors – characteristics – diodes – PMT – CCD – Streak camera - fibers – coupler – intensity and phase modulated fibersensors.

UNIT IV OPTICAL SPECTROSCOPY IN MEDICINE 12

Optical characteristics of biomolecules from the point of spectroscopy – principles of UV – Visible absorption – IR and FTIR absorption – Raman and Fluorescence spectroscopy – application with regard to characterization of biomolecules – blood oxygen, glucose measurements, monitoring drug concentration, cancer diagnosis.

UNIT V OPTICAL IMAGING OF CELLS AND TISSUES 12

Transillumination – fluorescence and Raman microscopy – fluorescence life time imaging – FRET imaging - principles of OCT – confocal lasers scanning microscopy – application of multiphoton techniques – Optical tweezers - laser safety procedures.

TOTAL: 60 PERIODS

OUTCOME

- The student can able to design different laser spectrometers
- Students can able to understand about the devices used for spectroscopic analysis and imaging of cells and tissues.
- Students will learn about FTIR, Raman and Fluorescentce spectroscopy techniques
- Students will understand about Confocal and FRET imaging
- Will learn about the application of multiphoton techniques

TEXTBOOKS

1. Markolf H Niemz, Laser-Tissue Interactions Fundamentals and Applications, Springer- Verlag Berlin Heidelberg New York,1996.
2. Paras N Prasad, Introduction to Biophotonics , Wiley Interscience, 2003.
3. A.J.Welch, M. Van Germet, Optical Thermal Responseof Laser-IrradiatedTissue, Plenum press, NY,1995.

REFERENCES

1. Joseph R Lakowitz, Principles of Fluorescence spectroscopy,Plenum press, NY,2002.
2. William W .Parson, Modern Optical Spectroscopy: W ithExercises and Examples from Biophysics and Biochemistry, Springer, 2009.
3. Nikolai V. Tkachenko, Optical Spectroscopy: Methods and Instrumentations, Elsevier,2006.

MY5003 MEDICAL ULTRASONICS L T P C 4 0 0 4

OBJECTIVE

- To learn the interaction mechanism and production methodology of ultrasound.
- To learn about the tissue interaction mechanism and scanning methods
- To stusy about the various applications of Ultrasound

UNIT I ULTRASOUND PRODUCTION AND ITS CHARACTERISTICS 12

Basic ultrasound- frequency- speed- wavelength-power amplitude- acoustic impedance matching–beam width- reflection –refraction –scattering –attenuation- production and propagation- transducer- types – piezo electric –magnetostriction- ferro electric crystals- efficiency-transducer mounting – probe and its types

UNIT II SCANNING METHODS 12

A, B, M-mode, system design-real time scanning –dynamic focus, compound scanning- resolution- axial, lateral- factors affecting image quality. 3-D, 4-D Applications to Ophthal – Obstertrics and Gynaecology.

UNIT III DOPPLER METHODS 12

Double doppler shift-single beam doppler- continuous wave & pulsed wave doppler – high pulse repetition frequency doppler- directivity and spectral analysis- duplex scanning – color & power doppler – blood flow measurements — cardiovascular applications- ultrasound guided biopsy – tissue doppler mapping.

UNIT IV APPLICATIONS OF ULTRASOUND 12

Cavitation – types of cavitation – commercial ultrasound contract agent – molecular imaging –cases of sonoporation-drug carriees – therapeutic gases – cell death – high intensity focus ultrasound

UNIT V DOSIMETRY, SAFETY AND BIO-EFFECTS 12

Intensity- exposure time – spatial power & pressure measurement – mechanism of possible ultrasound induced biological effects- dose reduction techniques.

TOTAL: 60 PERIODS

OUTCOME

Students will Gain knowledge about

- Ultrasound & its safety level and importance of optimum scanning methodology.
- A scan and B scan
- Double Doppler effect
- Various applications of Ultrasound in medicine
- Ultrasound dosimetry and its safety

REFERENCES

1. Michel Postema, " Fundamentals of Medical Ultrasonic", Spon press, 2011.
2. Hill. C R, Bamber. J C, Ter Haar. G R, " Physical principles of Medical Ultrasonic", John Wiley & Sons, publishing, 2004.
3. David J Cheeke N, “Fundamental and Applications of Ultrasonic waves ", CRC Press, 2002.
4. Lerski R.A. (Ed), “Practical Ultrasound”, IRL Press, Oxford, 1988
5. Woodcock J.P., “Ultrasonics”, Adam Hilger Ltd., U.K., 1979
6. Hylton b.Meire, John, Basic Ultrasound , Wiley & Sons, 1995.
7. Robert T.Beyer and Stephen V. Letcher, “Physical Ultrasonics”, Academic Press London, 1969.

MY5004 MOLECULAR IMAGING TECHNIQUES L T P C

4 0 0 4

OBJECTIVES:

- To enrich the knowledge about microscopes.
- To educate the types of microscopes, their resolution, image contrast and depth of investigation.
- To study the basic principles of Microscopes.

UNIT I OPTICAL MICROSCOPY 12

Optical microscopy- Use of polarized light microscopy – Phase contrast microcopy – Interference Microscopy – hot stage microscopy - surface morphology – confocal microscopy – florescence microscopy.

UNIT II SCANNING ELECTRON MICROSCOPY 12

Basic design of the scanning electron microscopy – types of electron source - Modes of operation– Backscattered electrons – secondary electrons- typical forms of contrast– Resolution and contrast – enhancement – Specimen Preparation - applications of SEM.

UNIT III TRANSMISSION ELECTRON MICROSCOPY 12

Basic principles - Modes of operation – Specimen preparation – Diffraction in imperfect crystals – Dislocations – precipitates – Structure of Grain boundaries and interfaces- HRTEM use in nanostructures – SAED – FFT pattens.

UNIT IV ATOMIC FORCE MICROSCOPY 12

Basic concepts-Interaction force - AFM tip on nanometer scale structures- force curves, measurements and manipulations-feed back control-different modes of operation –contact, non contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-Shear force Microscopy-Lateral Force Microscopy-Magnetic Force microscopy.

UNIT V SCANNING TUNNELING MICROSCOPY 12

Principle- Instrumentation- importance of STM for nanostructures – surface and molecular manipulation using STM -3D map of electronic structure.

TOTAL: 60 PERIODS

OUTCOME:

- Can use various microscopes to characterize the materials to study the surface properties
- Can differentiate various microscopic techniques
- Will learn about the electron sources used in microscopy
- Will learn about the 3-D mapping
- identify the dislocations of crystals using microscopy

REFERENCES

1. Goldstein. J, Newbury. D. E, Joy. D.C, and Lym. C.E., “Scanning Electron Microscopy and X-ray Microanalysis”, 2003.
2. Flegler. S.L, Heckman. J.W and Klomparens. K.L, “Scanning and Transmission Electron Microscopy: A Introduction”, WH Freeman & Co, 1993.
3. Goodhew. P.J, Humphreys. J, Beanland. R, “Electron Microscopy and Analysis”, 2001.
4. Haynes. R, Woodruff. D.P and Talchar. T.A, “Optical Microscopy of Materials”, Cambridge University press, 1986.
5. Brain Herman and John J Lemasters – “Optical Microscopy”. Emerging methods and Applications -1993, Academic Press.
6. Grey Haustad, "Atomic force Microscopy understanding Basic Modes & Advanced Applications", Wiley, 2012.

MY5005 PHYSICS OF ADVANCED RADIATION THERAPY L T P C
4 0 0 4

OBJECTIVES

- To provide knowledge based and practical skills training to support the implementation of advanced Radiotherapy techniques in India.
- To study about Modern Radiotherapy Techniques
- To study about Image guidance in Radiation therapy

UNIT I CONFORMAL RADIOTHERAPY WITH MULTI LEAF COLLIMATOR 12

MLC - different categories –commercial MLC systems — MLC acceptance testing, commissioning and safety assessment - Quality Assurance of MLCs - Leaf position detection – recent developments in MLC.

UNIT II INTENSITY MODULATION RADIATION THERAPY 12

IMRT –Different methods – physical optimization –– Target and critical structure definitions for IMRT – Static MLC IMRT, Dynamic MLC IMRT–potential problems with IMRT– Commissioning and QA for IMRT treatment planning – patient specific quality assurance– IMRT delivery system quality assurance.

UNIT III IMAGE GUIDED RADIATION THERAPY 12

Imaging techniques for guidance in Radiation therapy – clinical procedures in employing imaging technologies – Methods to manage respiratory gating - Effect of motion on the total dose distribution – 4D computed tomography imaging and treatment planning - Gated Radiation Delivery- IGRT QA protocol.

UNIT IV VOLUMETRIC MODULATED ARC THERAPY 12

Introduction to VMAT - Machine Commissioning and Quality Assurance-Dosimetric Aspects-Treatment Planning- Comparison of VMAT treatment plans with conventional IMRT Planning - Patient Specific Quality Assurance -Electronic Portal Imaging Device –its clinical applications including QA tool in machine and patient specific quality assurance and gamma index analysis.

UNIT V PARTICLE BEAM THERAPY 12

Proton beam therapy- Physics of proton beams- Equipment for proton beam therapy- configurations of proton delivery systems- treatment planning in particle therapy- Heavy ion therapy-Carbon ion therapy-Neutron therapy-Boron Neutron Capture Therapy.

TOTAL: 60 PERIODS

OUTCOMES

- Can learn about MLC in conformal therapy
- Can practice Arc therapy
- Can learn about proton beam therapy
- Can practice IMRT and IGRT
- To practice, all aspects of clinical medical physics with safe, accurate and effective delivery of Radiotherapy treatment

REFERENCES

1. Steve Webb, “The Physics of Three–Dimensional Radiotherapy”, Institute of Physics Publishing, 2002.
2. Faiz M Khan and Roger A Potish, “Treatment Planning in Radiation Oncology”, Lippincott Williams and Wilkins, 2011.
3. Faiz M Khan, “The Physics of Radiation Therapy”, Lippincott Williams & Wilkins, 2014.
4. Jatinder R Palta and T. Rockwell Mackie, “Intensity Modulation Radiation Therapy”, Medical Physics publishing, 2003.
5. Arthur Boyer, Ph.D.,Peter Biggs, Ph.D., James Galvin, D.Sc., Eric Klein, M.Sc., Thomas LoSasso, Ph.D., Daniel Low, Ph.D., Katherine Mah, M.Sc., Cedric Yu, D.Sc., “ AAPM Report No. 72, Basic Applications of Multileaf collimators”, AAPM, USA,2001.
6. Paul J. Keall Virginia ,Gig S. Mageras , James M. Balter, Richard S. Emery , Kenneth M. Forster , Steve B. Jiang, Jeffrey M. Kapatoes , Hideo D. Kubo , Daniel A. Low , Martin J. Murphy ,Brad R. Murray , Chester R. Ramsey , Marcel B. van Herk, S. Sastry Vedam, John W. Wong , Ellen Yorke, “AAPM Report No:91, Management of Respiratory motion in radiation oncology”, AAPM, USA, 2006.
7. Thomas F. DeLaney, Hanne M. Kooy, “Proton and charged particle radiotherapy”, Lippincott Williams & Wilkins, 2008.
8. Soren M. Bentzen, Minesh P. Mehta, Paul M. Harari, Wolfgang Tomé, “Radition Oncology Advances”, Springer, 2008.

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MY5006	RADIATION PHYSICS AND DOSIMETRY	L T P C 4 0 0 4

OBJECTIVES

- Designed to teach the students about the basic radiation physics
- To study about various radiation quantities and Units
- To study about instruments used to detect and measure radiation.

UNIT I ATOMIC STRUCTURE 12

Structure of matter - Atomic structure- Building up the models- schematic description of the atomic structure - nucleus - peripheral electrons/shells- Binding energies in atoms and molecules - energy and matter - binding energies in atoms and molecules - perturbation of binding energies - excitation - ionization- nuclear forces and nuclear energy levels -Abundance of stable nuclei as a function of the number of protons and neutrons - influence of N/Z on stablility.

UNIT II NUCLEAR TRANSFORMATION 12

Quantification of Radioactivity - activity: quantity and unit - General properties of alpha, beta and gamma rays- Radioactive transformations associated with strong interactions- associated with the electrostatic force and associated with the weak interaction and artificial radioactivity - radioactive disintegration and decay - Laws of radioactivity - half life of a radioactive nuclide - specific activity - equilibrium with radioactive daughter products- laws of successive transformations - natural radioactive series.

UNIT III INTERACTION OF RADIATION WITH MATTER 12

Interaction of electromagnetic radiation with matter-thomson scattering - photoelectric and compton process and energy absorption - pair production - attenuation and mass energy absorption coefficients - relative importance of various processes. - HVL - TVL - Interction of charged particle with matter- collision losses - cerenkow radiation - radiative losses - - Bremmstrahlung - interaction of neutron with matter.

UNIT IV RADIATION QUANTITIES AND UNITS 12

Measurement of Activity - cuire - Becquerel - decay constant - half life - relationship beteween half life and decay constant - exposure and absorbed dose - Roentgen - Gray - electron volt (eV) - Half value layer as an index of penetration of radiation - linear and mass attenuation coefficients - KERMA - CEMA - Radiation Protection and its units - linear energy transfer (LET) - stomping power.

UNIT V PRINCIPLES OF RADIATION DETECTION AND DOSIMETERS 12

Introduction - Properties of dosimeters - theory of gas filled detector - Ionization chamber - proportional counter -GM counter - dead time and recovery time - quenching - scintillation detector- semiconductior detector - Radiogrphic and radiochromic - Thermoluminescent dosimeters (TLD) - optically stimulated dosimeters (OSLD)- Gel dosimetry.

TOTAL: 60 PERIODS

OUTCOMES

- Students will learn about the basics about atoms and its structure
- Students will be able to understand about radiation and their interaction with matter,
- Different types of radiation quantities with their units
- Students will be able to learn about the principles of radiation detectors
- Different types of Radiation detection system

REFERENCES

1. Radiation oncology Physics: Hand book for teachers and students, E.B.Podgorsak, IAEA Publicationss, 2005.
2. Hand book of Radiotherapy Physics - Theory and practice, P.Mayles, A.Nahum and JC Rosenwald, CRC Press, Taylor and Francis Group, LLC - 2007.
3. The Physics of Radiation Therapy , Khan F.M., Lippincott Williams and Wilkins, 2014.

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MY5007 STEREOTACTIC RADIOSURGERY AND STEROTACTIC RADIOTHERAPHY L T P C
4 0 0 4

OBJECTIVES

- To provide the knowledge on principle of gamma knife and linac based Radiosurgery and Radiotherapy
- To study about the structure and function of brain
- To study bout the QA of SRS and SRT

UNIT I STEREOTACTIC RADIOSURGERY AND STEREOTACTIC RADIOTHERAPY 12

Radiosurgery and Stereotactic Radiotherapy-Gamma Knife and Linac based Radiosurgery-Methods of immobilization, localization devices and potential for frameless stereotaxy - Treatment Planning Imaging and Evaluation - Treatment Delivery.

UNIT II CLINICAL INDICATIONS 12

Structure and Functioning of the brain. Clinical implications and malformations - AV AOVM, glioma, meningioma, acoustic schwanoma, pituitary adenoma and others.

UNIT III LINAC BASED RADIOSURGERY 12

Physical principles involved in the design of current linear Accelerators-Design and Characteristics - Modifications to the normal acclearators for Radiosurgery- MLC - Dosimetry of various collimators-3D calculation algorithms for non-coplanar fields-Quality assurance checks for radiosurgery-Image fusion in treatment planning and treatment evaluation.

UNIT IV QUALITY ASSURANCE 12

Scope of Computers in Radiation Treatment planning-Factors to be incorporated in computational algorithms- Cost effectiveness of Treatment Planning System -Hardware and Software requirements Periodic software and hardware Q.A checks - Installation and Quality Acceptance of TPS and Linac accessories for Radiosurgery.

UNIT V RADIOBIOLOGY OF SRS AND SRT 12

Physical and Biological factors affecting cell survival-tumor re-growth and normal tissue response-Non conventional fractionation scheme and their effect of re-oxygenation, repair redistribution in the cell cycle - High LET radiation therapy - TDF- LQ Model-Radiobiology of Radiosurgery - Radiobiology of fractionated Stereotactic Radiotherapy.

TOTAL: 60 PERIODS

OUTCOMES

- Will learn about the LINAC based and Gamma knife based SRS and SRT
- Will learn about the functioning of brain their implications and Malformations
- Gain knowledge about 4-R in radiotherapy
- Can practice dosimetry of LINAC and Gammaknife
- Can perform quality assurance in Linac and Gamma-knife and treat patient with respect of Radiobiological effect

REFERENCES

1. Stanley.H.Benedict, David.V.Schlesinger, Brain.D.Kavanagh, “Stereotactic Body Radiosurgery and Stereotactic Body Radiationtherapy” CRC Press – Taylor & Frames group, 2014.
2. Joe Y. Chang, Peter Balter and Ritsuko Komaki, “Image Guided Radiotherapy of lung cancer”, Informa Healthcare, 2007.
3. Lawrance S.Chin, Ph.D, William F.Regine MD, “Principles and Practice of Stereotactic Radiosurgery”, Springer-2005.
4. Brain.D.Kavanagh, Robert D.Timmerman, “Stereotactic Body radiation therapy”, Lippincott Williams & Wilkim, 2005.
5. Steve Webb, “Physics of 3D Radiation Therapy”, Institute of Physics Publishing, 2002.

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6. Mauch & Loffier, “Radiation Oncology Technology and Biology”, W.B.Saunders Company, 1994.
7. Gordon Steel, “Basic Clinical Radiobiology”, Edward Arnold Publishers, 1993.
8. Ahiuwalia, “Tomographic methods in nuclear medicine: physical principles, instruments and clinical applications”, Boca Raton, 1989.

MY5008 THREE DIMENSIONAL CONFORMAL RADIOTHERAPY L T P C
4 0 0 4

OBJECTIVES

- To expose the students with basic concepts of conformal radiotherapy.
- To impart knowledge on three dimensional radiation therapy
- To learn about treatment planning, treatment optimization, conformal therapy with multileaf collimators, treatment machine features for conformal therapy, imaging for conformal radiotherapy planning.

UNIT I 3D RADIATION THERAPY TREATMENT PLANNING 12

Conformal radiotherapy treatment planning-Registration of two image datasets for 3D treatment planning –Summary and the NCI study of 3D therapy planning – Stages of Treatment Planning Dosimetry-Beam data Acquisition, Dosimetry with special detectors, data analysis and Input into 3D planning system – Dose verification with Phantom measurements.

UNIT II TREATMENT OPTIMIZATION 12

General Considerations –The case of circularly- symmetric dose distribution –Primitive blocked rotation therapy. Methods for 2D and 3D optimization – Evaluation of Plans-Dose Volume Histograms.

UNIT III CONFORMAL THERAPY WITH MULTI LEAF COLLIMATORS 12

Brahme’s theory of orientation – Optimization of Beam Profiles, Dynamic Wedge of Linac Wedges with MLC’s. Linac’s with Independent Collimators – Instrumentation – Radiation Detectors-ion chamber, Diode, Film, TLD - Electronic Portal Imaging Devices.

UNIT IV MACHINE FEATURES FOR CONFORMAL THERAPY 12

Machine for conformal therapy with different radioactive isotopes –Tracking Units- tracking LINAC with MLC and CT combination –Universal Wedge-Dynamic Wedge- Wedges with MLC’s-Linear Accelerators with asymmetric collimators –Two Dimensional tissue Compensators.

UNIT V IMAGING FOR CONFORMAL RADIOTHERAPY PLANNING 12

Principles of imaging by computed tomography – Signal/Noise ratio considerations - Physical factors affecting Image Quality – Parallel Beam and Fan beam systems – Magnetic Resonance Imaging-NMR theory – Relaxation times. Image reconstruction techniques – Ultrasound Imaging – Single photon emission Computed tomography (SPECT) – PET CT – CT Simulator.

TOTAL: 60 PERIODS

OUTCOMES

- Prepare 3D and IMRT treatment plans
- Analyze and discuss treatment plans for special cases
- Can identify to use various wedges for various treatment
- Quantify the 3D planning for various sites
- Can practice Imaging in Conformal therapy

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REFERENCES

1. Ashton Acton. Q, Ph.D, "Advances in conformal radiotherapy research and application", Scholarly edition, 2013.
2. Pdogorsak. E B, "Radiation Physics for Medical Physicist", Springer – Verlag Berlin Heidelber 2006.
3. Steve Webb, "Physics of 3D Radiation Therapy", Institute of Physics Publishing, 2002.
4. Peckharn, Pinedo & Veronesi, "Oxford textbook of Oncology- Vol.I" ,Oxford Medical Publications, 1995.
5. Griffiths, Short, "Radiotherapy-Principles and Practice", Churchill Livingstone Publications, 1994.
6. Gunnila G. Bentel, "Radiation Therapy Planning", Macmillan Publishing Company, 1992.
7. Steve Webb, "The Physics of Conformal Radiotherapy", Institute of Physics publishers, 1977.

MY5009 COMPUTATIONAL CONDENSED MATTER PHYSICS L T P C
4 0 0 4

OBJECTIVES

- To provide fundamental knowledge on different computational methods
- To give theoretical background on solids and their properties
- To give knowledge on properties of materials relevant for medical physics

UNIT I MANY ELECTRON SYSTEMS 12

Theoretical Background – Basic equations for interacting electrons and nuclei – Coulomb interaction in condensed matter – Statistical mechanics and the density matrix – Independent electron approximation – Exchange and correlation – Perturbation theory. Periodic solids: Structure of crystals – Reciprocal lattice – Brillouin zones – Density of States- Formation of bands.

UNIT II UNIFORM ELECTRON GAS 12

Central field approximation - Thomas Fermi model and its application - Hartree and Hartree Fock approximations - hydrogen molecule - Heitler London model - hybridization. – The correlation energy and hole – Binding in sp-bonded metals – Excitations and dielectric functions- Thomas – Fermi-Dirac approximation: Example of a functional

UNIT III DENSITY FUNCTIONAL THEORY 12

The Hohenberg-Kohn Theorems – Explanation of a functional – Extensions of Hohenberg-Kohn theorems – Difficulties in proceeding from the density – The Kohn-Sham ansatz – Meaning of eigen values – exchange, correlation hole – Local Density Approximation (LDA), Generalized-Gradient Approximation (GGA), Hybrid functionals.

UNIT IV METHODS OF BAND STRUCTURE CALCULATION 12

The tight-binding method - Linear Combination of Atomic Orbitals - General features of tight-binding levels - Wannier functions - muffin-tin potentials - augmented plane wave method – Pseudopotential methods – Examples – Application of different methods – Advantage of each method.

UNIT V BAND CALCULATIONS FOR MEDICAL PHYSICS 12

Prediction of materials for dosimetry – Understanding their electronic band structure – Semiconductor – Donor and acceptor levels – Role of impurities on electrical conductivity – Band structure of semiconductor dosimeters – Difference in bands of Thermoluminescent and Optically Stimulated dosimeters.

TOTAL: 60 PERIODS

OUTCOMES

Upon completion of this course, the students will be able to:

- Understand the theoretical background of solids and their electronic band formation
- Appreciate different approximations in theories like density functional theory
- Appreciate different approximations in theories like density functional theory
- Get a fundamental understanding on the electronic and optical properties of materials
- Apply their understanding while handling dosimeters and imaging techniques.

REFERENCES

1. Richard M.Martin. Electronic structure Basic theory and prtical methods. Cambridge University press, 2016.
2. N.W. Ashcroft and N.D.Mermin, Solid State Physics. Saunders, 2004.
3. H.L.Skriver, The LMTO method. Springier, Berlin, 1984.
4. G.C.Fletcher. Electron theory of solids. North Holland Pub. Co. 1980.
5. Density Functional Theory – D. S. Sholl and J.A. Steckel, Wiley, 2009.
6. A Primer in Density Functional Theory – C. Fiolhais, F. Nogueira, and M. Marques, Springer, 2016.
7. Advanced Materials and Techniques for Radiation Dosimetry, Khalil Arshak and Olga Korostynska, Artech House Publishers, 2017.

MY5010 SEMICONDUCTOR MATERIALS: THEORY AND PRACTICE

L	T	P	C
4	0	0	4

OBJECTIVES

- To provide fundamental understanding on physics of semiconductors
- To give theoretical background on solids and their properties
- To give knowledge on properties of materials relevant for medical physics

UNIT I CRYSTAL STRUCTURE AND BONDING 12

Crystalline solids - Crystal systems - Bravais lattices –Coordination number – Packing factors – Cubic, hexagonal, diamond structure, Sodium Chloride Structure – Miller Indices - Visualization of crystal types and lattice planes using Crystal structure plotting tools – Interplanar spacing – Directions. Types of bonding - Madelung constants – cohesive energy.

UNIT II FREE ELECTRON THEORY AND ENERGY BANDS 12

Drude theory – Wiedemann-Franz Law and Lorentz number –Quantum state and degeneracy – density of states - free electron statistics (Fermi-Dirac), Bloch's theorem – Kronig-Penney model-Construction of Brillouin Zones-Effective mass of electron-nearly free electron model – Tight binding approximation - classification into metals, insulators and semiconductors – Plotting Electronic bands and density of states using simple band structure codes – Understanding their origin.

UNIT III PHYSICS OF SEMICONDUCTORS 12

Semiconductors – direct and indirect gaps – Electron and holes - carrier statistics (intrinsic and extrinsic) – law of mass action– electrical conductivity and its temperature variation – Element and compound (III - V and II – VI) semiconductors: Examples. Types of defects – Influence of defects on electrical properties.

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UNIT IV OPTICAL PROPERTIES 12

Optical absorption in insulators, semiconductors and metals – band to band absorption – luminescence – photoconductivity- Injection luminescence and Light emitting diodes - LED materials - superluminescent LED materials – Optically Stimulated Luminescence - Their application in dosimeters.

UNIT V SPECTROSCOPY: THEORY AND EXPERIMENTS 12

Lattice Dynamics – Origin of vibrational spectra – Theory of Infra-red and Raman Spectroscopy – Semiconductor materials used in various parts of spectrometers: sources, emitter and detector – Prediction of UV-Visible and FTIR spectra for some materials using density functional theory method - Their Experimental verification using FTIR and UV-Vis spectrometers – Understanding origin of these spectra using band structure methods.

TOTAL: 60 PERIODS

OUTCOMES

Upon completion of this course, the students will be able to:

- Understand the theoretical background of solids and their electronic band formation
- Appreciate different types of crystal structure, bonding, structure-property relationships
- Classify materials based their electronic band structure
- Obtain a fundamental understanding on the optical properties of materials
- Apply their understanding while handling dosimeters and imaging techniques.

REFERENCES

1. M.A.Wahab. Solid State Physics: Structure and Properties of Materials. Narosa Book Distributors Pvt. Ltd., 2009.
2. Charles Kittel. Introduction to Solid State Physics. Wiley, 2013.
3. M.Ali Omar. Elementary Solid State Physics. Pearson Education, 2002.
4. N.W.Ashcroft and N.D.Mermin. Solid State Physics, Cengage Learning, 2003.
5. A.J Dekker. Solid State Physics. Macmillan India, 2000.
6. C.N. Banwell and E.M. McCash Fundamental of Molecular Spectroscopy – McGraw Hill, 2017.

MY5011 PHYSICS OF THE ATMOSPHERE L T P C
4 0 0 4

OBJECTIVES

- õ Gain knowledge about atmosphere, weather and climate
- õ Understand the physical concepts such as radiation, thermodynamics and motion evolved in the fluid system.
- õ Explore different measurement techniques used in atmosphere probing.
- õ Reveal the importance of General circulation models (GCMs) and how simulations of the atmospheric circulation and its characteristics are performed.

UNIT I THE EARTH'S ATMOSPHERE 12

Introduction to Earth's Atmosphere - Atmospheric Composition: Primary gases- Green House gases - Aerosols - Mass of the Atmosphere- Atmospheric Layers: Troposphere - Stratosphere - Mesosphere- Thermosphere, Exosphere and Magnetosphere. Vertical Structure of Atmosphere: Temperature, Pressure and wind velocity. Winds

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UNIT II ATMOSPHERIC RADIATION 12

Radiation -Radiation spectrum - Black body radiation and laws of radiation: Planck's Function, Wien's Displacement Law- Stefan Boltzmann law- Kirchhoff's law- Solar Radiation-Atmospheric scattering, absorption and emission - Sun -earth relation- Surface Receipt of Solar radiation and its effects. Terrestrial Infrared Radiation and Greenhouse effect - global warming

UNIT III ATMOSPHERIC THERMODYNAMICS 12

Gas Laws- Laws of thermodynamics, Potential Temperature, Pseudo- adiabatic Process, Equivalent Temperature, Equivalent Potential Temperature, Claussius – Clapeyron Equation, Thermodynamic Diagrams and it's uses: LCL, LFC, Precipitable Water Vapor, CAPE and CINE, Hydrostatic Equation and its application, Stability and Instability of Atmosphere, Precipitation and Cloud Formation.

UNIT IV ATMOSPHERIC DYNAMICS 12

Equation of motion in spherical coordinates, Coriolis force, Geostrophic Flow, Inertial Flow, Cyclostrophic Flow and Gradient Flow. Perturbation Theory, Wave motion in atmosphere: sound waves, Gravity waves, Inertial Waves, Rossby waves. Momentum and energy transports by waves in the horizontal and the vertical. Atmospheric Kelvin and Mixed Rossby Gravity Waves.

UNIT V ATMOSPHERIC MEASUREMENTS AND NUMERICAL WEATHER PREDICTION 12

Surface and upper air measurements- balloons, GPS radiosonde; Ground based remote sensing observations: LIDARS, Ionosonde, Radars and Use of Radars in atmospheric and meteorological investigation - Introduction to Numerical Weather Prediction (NWP) -Physical parameterization - Initialization and Data Assimilation- Advanced assimilation methods.

TOTAL: 60 PERIODS

OUTCOMES

The students will able to

- Gain knowledge about the physics of the atmosphere, weather and climate
- Understand the physical concepts such as radiation, thermodynamics and motion evolved in the fluid system.
- The students can understand the wave generation in a fluid medium.
- Acquire different measurement techniques used in atmosphere probing.
- Understand the importance of numerical simulation in weather forecasting.

TEXTBOOKS

1. C. Donald Ahrens, Essentials of Meteorology- An invitation to the atmosphere, 6 edition, Cengage Learning, 2011
2. Roger G. Barry and Richard J. Chorley, Atmosphere, weather and Climate, 8th Edition, Routledge is an imprint of the Taylor & Francis Group, 2004
3. James R. Holton , Gregory J Hakim , An Introduction to Dynamic Meteorology, Volume 88 (International Geophysics) 5th Edition, Academic Press, 2012.
4. Chandrasekar A., Basics Of Atmospheric Science, PHI Learning Pvt. Ltd., 2010
5. K. Mohanakumar, Stratosphere Troposphere Interactions: An Introduction, Springer Science & Business Media, 2008

REFERENCES

1. John M. Wallace, Peter V. Hobbs, Atmospheric Science, Second Edition: An Introductory Survey (International Geophysics) 2nd Edition, Academic Press, 2006.
2. David G. Andrews, An Introduction to Atmospheric Physics, 2nd Edition, Cambridge University Press, 2010
3. John Houghton, The Physics of Atmospheres, Cambridge University Press, 2002
4. Murry L. Salby, Physics of the Atmosphere and Climate, Cambridge University Press, 2012

MY5012 **MIDDLE ATMOSPHERE PHYSICS** **L T P C**
4 0 0 4

OBJECTIVE

- This course provides a broad knowledge on the Physics of middle atmosphere
- To gain the knowledge about physical interaction between waves and winds.
- To understand the impact of interaction between waves and winds.
- To know the application of Radar Technology in atmospheric probing.

UNIT I STRUCTURE AND COMPOSITION OF THE MIDDLE ATMOSPHERE 12

Static structure of the middle atmosphere - zonal mean temperature and wind distribution - composition of the middle atmosphere- Absorption of solar radiation by gases- Photochemistry of Ozone - Radiative equilibrium temperature distribution- Climatology of the middle atmosphere, wind and temperature distribution- Solar impact on middle atmosphere, Lower atmosphere and middle atmosphere interaction.

UNIT II WAVE - MEAN FLOW INTERACTION 12

Introduction, Beta plane Approximation and Quasi geostrophic theory - Atmospheric waves and its classification - Atmospheric tides, Free traveling planetary waves, forced planetary waves, gravity waves and equatorial waves. Transformed Eulerian Mean equations - Generalized Eliassen Palm theorem- Charney Drazin non acceleration theorem

UNIT III EXTRA-TROPICAL CIRCULATION AND SUDDEN STRATOSPHERIC WARMING 12

Models of the middle atmosphere - Inclusion of wave forcing effects- Winter Polar Stratosphere - Stratospheric Sudden warming (SSW) and its Types - Observed features of sudden warmings - Theoretical modeling of Sudden warmings :Matsuno's model-wave - wave interaction. SSW in northern and southern hemisphere - Stratospheric Ozone depletion and Antarctic Ozone hole

UNIT IV EQUATORIAL CIRCULATIONS AND TRACER TRANSPORT 12

Equatorial Quasi Biennial Oscillation (QBO) and its structure -Holton Lindzen theory of QBO - Semi Annual Oscillation and its structure - Transport Processes in the Stratosphere and Troposphere: QBO and Brewer Dobson Circulation, atmospheric waves and tracer transport, wave influence on mean circulation - Meridional circulation in Stratosphere and mesosphere

UNIT V RADAR TECHNOLOGY IN MIDDLE ATMOSPHERE 12

Radar and its operating principle - Middle atmosphere radars: MST, MF or partial reflection, LF, Meteor Wind, and ST Radars - momentum flux studies -Tropospheric temperature measurements - Precipitation and humidity measurement using ST radar, Convection studies with MST radars, radar in mesospheric studies.

TOTAL: 60 PERIODS

OUTCOME

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

- Gain information about the mechanics and dynamics in any fluid medium
- Gain knowledge about the structure and dynamics of middle atmosphere
- Understand the physical interaction between waves and winds.
- Know the impact of interaction between waves and winds.
- Understand the application of Radar Technology in atmospheric probing.

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TEXTBOOKS

1. James R. Holton , Gregory J Hakim , An Introduction to Dynamic Meteorology, Volume 88 (International Geophysics) 5th Edition, Academic Press, 2012.
2. David G. Andrews , Conway B. Leovy, James R. Holton, Middle Atmosphere Dynamics, Volume 40 (International Geophysics) 1st Edition, Publisher: Academic Press; 1 edition 1987.
3. Roger G. Barry and Richard J. Chorley, Atmosphere, weather and Climate, 8th Edition, Routledge is an imprint of the Taylor & Francis Group, 2004.
4. K. Mohanakumar, Stratosphere Troposphere Interactions: An Introduction, Springer Science & Business Media, 2008.
5. C. Donald Ahrens, Essentials of Meteorology- An invitation to the atmosphere, 6 edition, Cengage Learning, 2011.

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1. John M. Wallace, Peter V. Hobbs, Atmospheric Science, Second Edition: An Introductory Survey (International Geophysics) 2nd Edition, Academic Press, 2006.
2. Geoffrey K. Vallis, Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation, Cambridge University Press, 2006.
3. Mankin Mak, Atmospheric Dynamics, Cambridge University Press, 2011.
4. Murry L. Salby, Physics of the Atmosphere and Climate, Cambridge University Press, 2012.
5. David G. Andrews, An Introduction to Atmospheric Physics, 2nd Edition, Cambridge University Press, 2010.