NIT(AP)/Senate/49/2016-2017 Date : 25/07/2019

National Institute of Technology, Arunachal Pradesh
Yupia, Arunachal Pradesh – 791112

Minutes of the 19th Senate Meeting of NIT, Arunachal Pradesh held on 25/07/2019 at 02:00 pm at NIT-Arunachal Pradesh, Yupia, Papumpare

Following Members were present:-

1. Prof. (Dr.) Pinakeswar Mahanta, Director, NIT Arunachal Pradesh - Chairman
2. Prof. V. S. Moholkar, Professor, IITGuwahati - Member
3. Prof. S. N. Shome, Professor, ME, NIT AP - Member
4. Prof. Isha T.B., Professor, EE, NIT AP - Member
5. Dr. Uday Kumar Khanikar, Registrar NIT, Arunachal Pradesh - Member Secretary
6. Dr. M. Mallik, Associate Professor/CE, NIT, Arunachal Pradesh – Invitee
7. Dr. Rajen Pudur, DIC(A&E), NIT, Arunachal Pradesh – Invitee
8. Dr. K. R. Singh, Asso. DIC(A&E), NIT, Arunachal Pradesh – Invitee
9. Prof.. R.P. Sharma, Asso. Professor, NIT, Arunachal Pradesh – Invitee
10. Dr. J. Taipodia, HoD CE, NIT, Arunachal Pradesh – Invitee
11. Dr. K. Mondal, HoD/CHE, NIT, Arunachal Pradesh – Invitee
12. Dr. Anup Paul, HoD/ME, NIT, Arunachal Pradesh – Invitee
13. Dr. S. Maity, HoD/BAS, NIT, Arunachal Pradesh – Invitee
14. Dr. P. K. Hui, HoD I/C/BT, NIT, Arunachal Pradesh – Invitee
15. Dr. A. Banerjee, HoD/EE, NIT, Arunachal Pradesh – Invitee
16. Dr. K. Sambyo, HoD/CSE, NIT, Arunachal Pradesh – Invitee
17. Dr. Y. Saring, HoD/ECE, NIT, Arunachal Pradesh – Invitee
18. Dr. Vijay Kumar, I/C HoD, M&H, NIT Arunachal Pradesh – Invitee

Member not present:

1. Prof. Jumyir Basar, Associate Professor, RGU, APMember, could not attend the meeting due to pre-occupations.

Member on video conferencing:

1Prof. Ayton Bhattacharjee, Professor, NIT Meghalaya

Agenda Item: 19.1: Confirmation of the Minutes of 18th Meeting of the Senate held on 14/06/2019 and Action Taken Report:

Minutes of 18th Senate Meeting of NIT, Arunachal Pradesh were made and signed by members. As such Minutes of 18th Senate is approved & Action Taken Report is placed in ANNEXURE 19.01.

Decision:- Noted and approved.

Agenda Item: 19.02: Seeking approval for signing MoU with Royal University of Bhutan

A letter has been received from Ambassador Ruchira Koamboj, Ambassador of India to Bhutan on 3rd July 2019, and has sought the consent of NIT Arunachal Pradesh for signing Memorandum of Understanding (MoU) to strengthening academic linkages with Bhutan's only university the Royal University of Bhutan. Keeping the academic purview of Senate, this matter is placed for open discussion.

Decision:- Senate welcomed the proposal for execution of MOU. Recommended for consideration to BOG, however, participation of the students with course credit transfer and creation of super-numeric seats etc, may be considered at BOG

Agenda Item: 19.03: Ratification of first year undergraduate syllabus and postgraduate for all branch for 2019 batch approved by BoS.

New course curriculum is prepared and approved by BoS, for first year undergraduate and postgraduate Programme.

First year curriculum:-

Course Curriculum for B. Tech.

First Year

(For students admitted in 2019-20 onwards)

National Institute of Technology Arunachal Pradesh

P.O. - Yupia, Dist.–Papumpare, Arunachal Pradesh, Pin–791112
Phone No: 0360-2284801/2001582
Fax No: 0360-2284972
www.nitap.ac.in

COURSE STRUCTURE

B. Tech. 1st Year, Semester I

Sl. No	Course Code	Course Title	L	T	P	C
1	CY-101	Engineering Chemistry	3	0	0	3
2	CY-102	Engineering Chemistry Lab	0	0	2	1
3	MA-101	Engineering Mathematics I	3	1	0	4
4	ME-101	Engineering Mechanics	3	0	0	3
5	ME-102	Workshop Practice I	0	0	3	1.5
6	MH-101	Communication Skill	0	3	0	3
7	BIO-101	Bio-Science	3	0	0	3
8	MH-113	NSS/NCC	0	0	2	0
		Total Credits	12	4	7	18.5

B. Tech. 1st Year, Semester II

Sl. No	Course Code	Course Title	L	T	P	C
1	PHY-101	Engineering Physics	3	0	0	3
	PHY-102	Engineering Physics Lab	0	0	2	1
2	MA-102	Engineering Mathematics II	3	1	0	4
3	CY-108	Environmental Engineering	3	0	0	3
4	CSE-112	Introduction to Computer Programming	2	0	0	2
5	CSE-113	Introduction to Computer Programming Laboratory	0	0	4	2
6	ME-121	Engineering Drawing	1	0	3	2.5
7	MH-106	Fundamentals of Economics	3	0	0	3
8	MH-113	NSS/NCC	0	0	2	0
		Total Credits	15	1	11	20.5

Name of the Module: Engineering Chemistry
Module Code: CY 101
Semester: 1st
Credit Value: 3 [L=3, P=0, T=0]

A. Course Objectives:

a) To enable the students to acquire knowledge about chemistry and its technology, covering all important topics of research and related areas.
b) To bring adaptability to new developments in engineering chemistry and a knowledge of contemporary issues relevant to engineering
c) To understand applicability of chemistry for engineering purposes.
d) To make them apply the knowledge of fundamental chemistry for design system components or processes considering the public health and safety, and the cultural, societal, and environmental considerations.

B. Course Content

Chemical thermodynamics: the first law, work, heat, energy and enthalpy; the relation between Cp and Cv; second law: entropy, free energy and chemical potentials; chemical equilibrium; chemical kinetics: rate of reaction, elementary reaction and chain reaction; surface chemistry: liquid surface, surfactants, colloidal systems; electrochemistry: conductance of electrolytic solutions, Kohlrausch's law, transport numbers, cell EMF and its thermodynamic significance, hydrogen and quinhydrone cell.

Shapes of inorganic compounds, ligand, nomenclature, isomerism, valence bond theory, crystal field and molecular orbital theory, bond order and energy, charge transfer transition, d-d transition, John-Teller effect, magnetic properties, spectrochemical series; bioinorganic and organometallic chemistry.

Hybridization, inductive effect, resonance, hyperconjugation, carbocation, carbanion and free radicals, substitution and addition reactions, introduction to instrumental methods (IR, UV-vis, NMR and Mass).

Polymers and materials: addition and condensation polymerization, degree of polymerization, thermoplastic & thermosetting plastics, conducting polymers, composite materials, nanomaterials, nanocomposites, explosive materials, corrosion-introduction; corrosion mechanisms.

C. Text Books:

1. Organic chemistry, R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, 7th Ed., Pearson education, New Delhi, 2010.
2. Physical chemistry, P.C. Rakshit, 7th Ed., Sarat book distributors, Kolkata, 2004.
3. Inorganic chemistry: principles of structure and reactivity, J. E. Huheey, E. A. Keiter, R. L. Keiter, 4th Ed., Pearson Education, New Delhi, 2009.

D. Reference Books:

1. Engineering chemistry, B. C. Ray, S. N. Das and S. Biswas, New Central Book Agency, Kolkata, 2008.
2. Polymer science, V. R Gowariker, N. V Viswanathan and J. Sreedhar, New Agency International, Kolkata, 2012.
3. Selected topics in inorganic chemistry, W. U. Malik, G. D. Tuli and R. D. Madan, S. Chand, New Delhi, 2012.
4. Organic reaction mechanisms, V. K. Ahluwalia and R. K. Parashar, 4th Ed., Narosa publishing house, Kolkata, 2013.

E. Course Outcomes:

After studying this course, students will be able to

a) an ability to function on multidisciplinary subjects.
b) design economically, environmental friendly and new methods of synthesis nano materials.
c) apply their knowledge for protection of different metals from corrosion.
d) a knowledge of exothermic and endothermic processes.
e) categorize the materials on the basis of their properties.
f) select appropriate method of analysis and interpret its result.

Name of the Module: Engineering Chemistry Lab
Module Code: CY 102
Semester: 1st
Credit Value: 1 [L=0, P=2, T=0]

A. Course Objectives:

a) To enable the students to acquire knowledge about chemistry practical and its technological importance towards research works.
b) To bring adaptability to new developments in engineering chemistry and a knowledge of contemporary issues relevant to engineering and research.
c) To understand applicability of chemistry for engineering and research purposes.
d) To make them apply the knowledge of fundamental chemistry for design system components or processes and researches considering the public health and safety, and the cultural, societal, and environmental considerations.

B. List of Experiments:

1. Determination of the concentration of NaOH solution.
2. Standardization of $KMnO_4$ solution by Mohr's salt.
3. Estimation of hardness of water using EDTA titration.
4. Conductometric titration for
   a) Determination of the strength of a given HCl solution by titration against a standard NaOH solution.
   b) Analysis of a mixture of strong and weak acid by strong base.
5. Estimation of available chlorine in bleaching powder.
6. Determination of pH value of the solution by digital pH meter and pH paper.
7. Production of methyl ester from vegetable oil.

C. Reference Books:

1. Laboratory Mannual for Engineering and Physical Chemistry, M. V. Basaveswara Rao, Studium Press (India) PVT. Ltd. 2013.
2. Vogel's Qualitative Inorganic Analysis, Vogel Arthur Israel, Publisher: Pearson Education Limited, ISBN: 9780582218666, 0582218667

D. Course Outcomes:

After studying this course, students will be able to

a) an ability to function on research areas in multidisciplinary subjects.
b) design economically, environmental friendly and new methods of synthesis for various needful products.
c) apply their knowledge for protection of environment by controlling the experimental methods.
d) a knowledge of production of methyl ester from vegetable oil.
e) a knowledge titration for various kinds of acid-base for new experimental aspects.
f) select appropriate method of analysis and interpret its result.

Name of the Module: Engineering Mathematics- I
Module Code: MA 101
Semester: 1^{st}
Credit Value: 4[P=0, T=1, L=3]

A. Course Objectives:

The course is designed to meet with the objectives of:

a) providing high quality education in pure and applied mathematics in order to prepare students for graduate studies or professional careers in mathematical sciences and related fields,
b) imparting theoretical knowledge and to develop computing skill to the students in the area of Science and Technology,
c) providing teaching and learning to make the students competent to their calculating ability, logical ability and decision making ability,
d) giving students theoretical knowledge of Calculus, Algebra and their practical applications in the various fields of Science and Engineering,
e) apply their knowledge in modern industry or teaching, or secure acceptance in high-quality graduate programs in Mathematics and other fields such as the field of quantitative/Mathematical finance, Mathematical computing, statistics and actuarial science.

B. Course Content:

Linear Algebra: Basic concept of matrices,Determinant, Jacobi's theorem. Singular and non-Singular matrices, Inverse and its properties, Orthogonal matrix and its properties, Trace of a matrix, Rank of a matrix, System of homogeneous and non-homogeneous linear equations, Introduction to vector space (up to basis), Eigen values and Eigen vectors of a square matrix (of order 2 or 3), Cayley-Hamilton theorem and its applications.

Differential Calculus: Limit and Continuity, Higher order derivatives, Leibnitz's theorem and its application, Rolle's theorem and its application, Mean Value theorems – Lagrange & Cauchy and their application, Taylor's theorem and its application, Expansions of functions by Taylor's and Maclaurin's theorem.

Integral Calculus: Single integrals, double and triple integrals and evaluation of area and Reduction formulae both for indefinite and definite integrals, volume, Change of order of integration.

C. TextBooks

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley, 11th edition, 2010.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd edition, 2014.

D. Reference Books

1. Ross L. Finney and George B. Thomas, Calculus and Analytical Geometry (Linear Algebra), Narosa Publishing House, 6th edition 1998.

2. K. M. Hofmann and R. Kunze, Linear Algebra, Prentice hall, 2nd edition, 2015.
3. Bartle and Sherbart, Introduction to Real Analysis, Wiley 4th edition, 2014.
4. T. M. Apostol, Calculus, Vol I and II, John Wiley and Sons Ltd Wiley; 2nd edition, 2007.
5. James Stewart, Transcendental Calculus, Cengage; 2nd edition, 2014.
6. S. K. Mappa, Higher Algebra, Shrat book House, 2014.
7. S. K. Mappa, Real Analysis, Shrat book House, 7th edition, 2013.
8. Clarence Reymond Wylie and Louis C. Barrett, Advanced Engineering Mathematics, McGraw Hill, 1995.

E. Course Outcomes:

The outcomes of course are following:

1. Students will become more confident about their computing skill, logical skill and decision making skill,
2. Students will find various applications of calculus and algebra in the practical fields science and engineering,
3. Students will become more competent to analyse mathematical and statistical problems, precisely define the key terms, and draw clear and reasonable conclusions,
4. Student will be able to use mathematical and statistical techniques to solve well defined problems and present their mathematical work, both in oral and written format, to various audiences (students, mathematicians, and non-mathematicians),
5. Student will be able to understand, and construct correct mathematical and statistical proofs and use the library and electronic data-bases to locate information on mathematical problems,
6. Student will be able to explain the importance of mathematics and its techniques to solve real life problems and provide the limitations of such techniques and the validity of the results,
7. Student will be able to propose new mathematical and statistical question and suggest possible software packages and/or computer programming to find solutions to these questions.

Name of the Module: Engineering Mechanics
Module Code: ME-101
Semester: I
Credit Value: 3 {L = 3, T = 0, P = 0}

A. Course Objectives:

The course is designed to meet with the following objectives:

1. Ability to utilise scalar and vector analytical techniques for analysing forces in statically determinate structures.

2. Ability to apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems.
3. Student gets a basic idea of Centre of gravity, moment of inertia, mass moment of inertia, friction.

B. Course Content:

Forces and Moments: Force, Moment and Couple, Wrench, Equivalent force and moment, Forces in space equilibrium, FBD, general equations of equilibrium-Lami's theorem, analysis of forces in truss and frames, brief introduction to vector approach.

Friction: Introduction to dry friction, laws of friction, friction of simple machines, inclined planes, Screw jacks, clutch, and collar pivot bearing (uniform wear and uniform pressure assumptions).

Centre of gravity and moment of inertia: Centre of gravity, volume and compositebodies, Area moment of inertia and mass moment of inertia for plane figures and bodies.

Dynamics: Kinematics and Kinetics, Rectilinear motion of particles, determination of positionvelocity and acceleration under uniform rectilinear motion (uniform and non-uniform acceleratedrectilinear motion), Relative motion, construction of x-t, v-t and a-t graphs (simple problems),Projectile motion, Normal and Tangential components, Radial and Transverse components, simpleproblems, Equation of motion, D. Alembert's principle, principle of virtual work, planar kinematics and kinetics of system of particles and rigid bodies.

C. Text Books:

1. Timoshenko S. and Young D.H., "Engineering Mechanics", 5th Ed., 2017, MGH.
2. Beer and Johnston, "Vector Mechanics for Engineers: Statics and Dynamics", 10th Ed., 2012, TMGH.

D. Reference Books:

1. Meriam, J. L. and Kraige, L. G., "Engineering Mechanics, Volume 1: Statics", 8th Ed., 2017, Wiley.
2. Meriam, J. L. and Kraige, L. G., "Engineering Mechanics, Volume 2: Dynamics", 5th Ed., 2006, Wiley.
3. Shames, I. H. and Rao,G. K., "Engineering Mechanics: Statics and Dynamics'", 4thEd., 2006, Pearson.
4. Nelson A., "Engineering Mechanics: Statics and Dynamics", 1st Ed., 2017, TMGH.

E. Course Outcomes:

Upon completion of the subject, students should have the knowledge of:

1. different type of forces and how to resolve forces.
2. centre of gravity of different size, shape, and solid.
3. centre of gravity, moment of inertia, mass moment of inertia, friction.

Name of the Module: Workshop Practice-I
Module Code: ME-102
Semester: I
Credit Value: 1.5 {L = 0, T = 0, P = 3}

A. Course Objectives:

The course is designed to meet the following objectives:

1. Acquire skills in basic engineering practice.
2. Identify the hand tools and instruments.
3. Acquire measuring skills.
4. Acquire practical skills in the trades.
5. Acquire practical skills in welding, carpentry, fitting.

B. List of experiments:

1. Study of various hand tools.
2. Making various joints (carpentry, fitting, sheet metal)
3. Welding (surface preparation and welding practice)
4. CNC assembly/disassembly (lathe and milling using kit)
5. 3-D printing (assembly kit)

C. Reference Books:

1. Choudhury, S. K. H., Choudhury, A. K. H., Roy, N., "Elements of Workshop Technology" Vol-1, 2008, Media promoters & pubmishers pvt ltd.
2. Begeman, M. L. and Amstead, B. H., "Manufacturing Process"8th edition, 1987, Wiley.
3. Chapman, W. A. J. and Arnold E., "Workshop Technology, Vol. I, II & III", 5th, 4th and 3rd editions, 2001, 2005 and 1995, CRC press, Prentice Hall.

D. Course Outcomes:

Upon completion of the subject, students should have the knowledge of:

1. Workshop safety.
2. Handling workshop tools, machines.
3. Different welding types.
4. Different carpentry joints.
5. Working principle of different tools.

Module Name: **Communication Skills**
Module Code: **MH-101**
Semester: **Semester I**
Credit: 03 {L=0, T=3, P=0}

A. Objectives:

The course is designed to meet the following objectives:

1. to increase the student'sconfidence to improve and utilize the skills necessary to be competent interpersonal communicator.
2. to increase the student'slinguistic understanding of his or her own communication behaviour.
3. to increase the student's understanding of other communication behaviours.
4. to improve the student'slistening, speaking, reading and writing skills in both social and professional contexts.

B. Course Content:

Basics of Communication

Concept and meaning, Communication cycle, Objectives, Barriers to communication (linguistic and semantic, psychological, physical, mechanical, cultural), The importance of audience and purpose, Types of communication, Styles of communication, Verbal and non-verbal communication, Comparing general communication and technical communication language skills (listening, speaking, reading, writing), Transactional analysis.

Listening Skills

Listening: Types of listening, Listening to classroom lectures/talks on engineering/technology- podcasts, Differentiation of minimal pairs and accents, Listening comprehension. **Activities:** Ear drills and listening exercises.

Speaking Skills

Speaking: Introducing oneself - exchanging personal information, Dialogue building, Demo presentations, Effective oral presentation skills, Neutral accent,**Activities:** Pronunciation Drills- vowels, consonants drills, songs, rhymes, chants and tongue twister drills, repetition drills.

Reading andWriting Skills

Reading: Types of reading, Reading longer technical texts- identifying the various transitions in a text- Paragraphing.

Technical writing: Techniques to define an object, Writing instructions, Language exercises based on types of expositions (description of an object &explanation of a process), Blogs, Tweets, Online résumé, E-mails, SMS and online texting, Report writing, Describing charts and tables, Writing for media on current events, Résuméwriting, Letters, Technical report writing. **Activities:** Various reading and writing activities

C. Text Books:

1. English Language and Communication Skills for Engineers (as per AICTE Syllabus), Sanjay Kumar and Pushp Lata, New Delhi: Oxford University Press (OUP), 2018.
2. Technical Communication: Principles and Practice, Second Edition by Meenakshi Raman and Sangeeta Sharma, Oxford Publications, 2017.

D. Reference Books:

1. Communication Skills, Sanjay Kumar and Pushp Lata, Second Edition, New Delhi: Oxford University Press (OUP), 2018.
2. A Comprehensive Grammar of the English Language, Randolph Quirk, Sidney Greenbaum, Geoffrey Leech, Jan Svartvik. Pearson Education India; First edition (2010).

Programme Outcomes:

- Display competence in oral, written, and visual communication.
- Apply communication theories in various speech acts.
- Use current technology to the communication field.
- Understand the process of communication and its effect on giving and receiving information\

Name of the Module: Bio
Science Module Code: BIO-101
Credit Value: 3 [L=3, T=0, P=0]

A. Course Objectives:

The course is designed to:

1. impart knowledge on the origin of Earth and life forms on Earth, appreciating importance of biological diversity and understanding biomolecules being the main component oflife
2. understand "Cell" – the basic unit in different life forms, and structure and function of different tissue systems in plants and animals
3. impart knowledge on water relations, nutrient uptake and assimilation, and metabolism in plants
4. provide knowledge on Bioenergetics of plant cells, an introduction to DNA and genetic engineering

B. Course Content:

Origin of Life: History of earth, theories of origin of life and nature of the earliest organisms. Varieties of life: Classification, Five kingdoms, viruses (TMV, HIV, Bacteriophage), Prokaryote (Bacteria-cellstructure, nutrition, reproduction), Protista, Fungi, Plantae and Animalia.

Chemicals of life: (Biomolecules) - Carbohydrates lipids, amino acids, proteins, nucleic acids and identification of biomolecules intissues.

Cell: Cell concept, structure of prokaryotic and eukaryotic cells, plant cells and animal cells, cell membranes, cell organelles and their function, Structure and use of compound microscope.

Histology: Meristematic tissue (apical, intercalary, lateral) and their function; simple tissue (parenchyma, collenchymas, sclerenchyma); Complex tissue (xylem and phloem); Tissue systems (epidermal, ground, vascular); primary body and growth (root, stem, leaf); Secondary growth (root, stem). Animal tissues (Epithelial, connective, muscle and nervous tissues) and their functions in the body.

Transport: Plant water relationships, properties of water, diffusion, osmosis, imbibition, uptake of water by roots and theories of transport of water through xylem (ascent of water in xylem, cohesion- tension theory), apoplast and symplast theory; Transpiration-structure of leaf, opening and closing mechanisms of stomata, factors affecting transpiration and significance of transpiration.

Nutrition: Mineral Nutrition in plants, Heterotrophic nutrition in plants; Photosynthesis (Autotrophic- forms of nutrition), Chloroplast structure, two pigment systems, photosynthetic UNIT, light absorption by chlorophyll and transfer of energy, phosphorylation and electron transport system, Calvin-Benson Cycle (C3), Hatch Slack Pathway (C4), Crassulacan Acid Metabolism (CAM), factors affecting photosynthesis. Genetics: Introduction to Principles of inheritance, Discovery of DNA as genetic material, Structure and Function of DNA, DNA mutation and types, Genetic diseases, Applications of Genetic engineering.

C. Text Books:

1. Rajveer Singh Chauhan: A Text Book of Life Science Paperback, 3rd Revised 12 Aug. 2010 edition, Publisher: International Book Distributing Co
2. P. S Verma and V K Agarwal: Cell Biology Paperback – Jan 2016 edition, S. Chand *Publishing,* S. Chand and Company PVT. LTD., Ram Nagar, New Delhi
3. P.S Verma and VK.Agarwal: Genetics, 2010 edition, S. Chand *Publishing,* S. Chand and Company PVT. LTD., Ram Nagar, New Delhi
4. B. P Pandey: College Botany Volume III Paperback, 2015 edition, S. Chand *Publishing,* S. Chand and Company PVT. LTD., Ram Nagar, New Delhi

D. Reference Book:

P.S Verma and VK.Agarwal: Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, 2015 edition, S. Chand *Publishing,* S. Chand and Company PVT. LTD., Ram Nagar, New Delhi

E. LearningOutcomes:

At the end of the course, a student will be able to:

1. understand the characteristics of living organisms; appreciate the importance of diversity of life and their interaction with the environment
2. explain the interrelationship between biomolecules and the living system, and influences of biomolecules upon the structure and function of intracellular components
3. have a broad knowledge on Bioenergetics of plant cells; DNA and genetic engineering
4. understand the concept of DNA as hereditary material and harmful consequences of mutation thereby enable them to initiate a healthy lifestyle and environment

Name of the Module: Engineering Physics
Module Code: PHY 101
Semester: 2nd
Credit Value: 3 [P=0, T=0, L=3]

A. Course Objectives:

The course is designed to meet with the objectives of:

a) imparting theoretical & practical knowledge to the students in the area of engineering physics.
b) providing teaching and learning to make students acquainting with modern state-of-art of Engineering.
c) injecting the future scope and the research direction in the field of Physics with specific specialization.
d) making students competent to design & development of Engineering Physics.

B. Subject matter:

Physical Optics:

Superposition of waves, Interference: Newton's ring, Diffraction: single slit diffraction, double slit diffraction and diffraction granting, Polarization.

Electricity and Magnetism:

Coulombs law in vector form, Electric field, Gauss's law (differential and integral form), Electric potential and energy, multipole expansion of electric potential. Boundary value problem (Poisson's Eqn. and Laplace's Eqn.). Dielectric, Biot-Savart law, Ampere's law (differential and integral form), Faraday's law of electromagnetic induction, Maxwell'sfield equation in vacuum and matter.

Modern Physics and Quantum Mechanics:

Photo electric effect, Compton effect, Blackbody radiation (no derivations). Wave particle duality, two slit experiments, De-broglie's hypothesis. Heisenberg's uncertainty principle, concept of wave function and wave packet, phase velocity and group velocity, Formulation of quantum mechanics and basic postulates, physical interpretation of wave function, Schrodinger's wave equation, Steady state of Schrodinger's wave equation, One dimensional quantum problems:Free particle, particle in a box, particle in a step potential.

C. **Text Books:**

1. A. Ghatak, "Optics" 6th Edition, Tata McGraw Hill Education India Private Limited, 2017 .
2. David J. Griffiths, "Introduction to Electrodynamics," 4th edition, Pearson Education India Learning Private Limited, 2015.
3. David J. Grifths, "Introduction to Quantum Mechanics," 2nd edition, Pearson Education, 2015.

D. Reference Books:

1. A. Beiser, S. Mahajan and S. R. Choudhury, "Concepts of Modern Physics," 7th Edition, McGraw-Hill Education, 2017.
2. F. A. Jenkins & H. E. White, "Fundamental of Optics", 4th Editions, McGraw-Hill Education, 2017.
3. K. Krane, "Modern Physics", Wiley, 2016.
4. Richard P. Feynman, Robert B. Leighton and Matthew sands, "The Feynman Lectures on Physics Vol. 1 to Vol. 3" The New Millennium Edition, 2012.

E. Course Outcomes:

Students successfully completing this module will be able to:

1. demonstrate competency and understanding of the basic concepts found in physics.
2. utilize the scientific method for formal investigation and to demonstrate competency with experimental methods that are used to discover and verify the concepts related to content knowledge.
3. engineering applications capability to understand advanced topics in engineering.
4. identify formula and solve engineering problems.
5. adequately trained to become engineers.
6. substantially prepared to take up prospective research assignments.
7. apply quantum mechanics to engineering phenomena
8. found employment in their field or related area or continue in a professional school.

Name of the Module: Engineering Physics Lab

Module Code: PHY 102
Semester: 2nd
Credit Value: 1 [P=2, T=0, L=0]

A. Course Objectives:

The course is designed to meet with the objectives of:

a) imparting theoretical & practical knowledge to the students in the area of engineering physics.
b) student will have exposure to various experimental skills which is very essential for an engineering student.
c) to gain practical knowledge by applying the experimental methods to correlate with the physics theory.
d) to develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.
e) to learn the usage of various areas of physics like optics, mechanics, electricity and magnetism systems for various measurements.
f) apply the analytical techniques and graphical analysis to the experimental data.

B. List of Experiments:

1. Determination of wavelength of light by Newton's ring method.
2. Determination of surface tension of water.
3. Determination wavelength of light by using diffraction grating.
4. Determine the refractive index of the material of prism by using spectrometer.
5. Determination of Planck's constant using photocell.
6. Verification of Stefan's radiation law.
7. Verification of Bohr's atomic orbital theory through Frank-Hertz experiment.
8. Verification of Biot-Savart's law.

C. Reference Books:

1. C. L. Arora, "Practical Physics", S. Chand Publications, 2010.
2. G. L. Squires, "Practical Physics", Cambridge University Press, 2014.

D. Course Outcomes:

Students successfully completing this module will be able to:

a) apply the various procedures and techniques for the experiments.
b) apply the mathematical concepts/equations to obtain quantitative results.
c) develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.
d) understand principle, concept, working and application of new technology and comparison of results with theoretical calculations.
e) gain knowledge of new concept in the solution of practical oriented problems and to understand more deep knowledge about the solution to theoretical problems.
f) understand measurement technology, usage of new instruments and real time applications in engineering studies.

Name of the Module: Engineering Mathematics- II
Module Code: MA 102
Semester: 2^{nd}
Credit Value: 4[P=0, T=1, L=3]

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A. Course objectives:

The course is designed to meet the following objectives:

a) imparting theoretical knowledge to the students about three and more dimensional objects in space and to improve their capability of visualizing of objects in space.
b) making student competent enough to construct a differential equation/ mathematical modeling for every real life situation with its solution.
c) giving students theoretical knowledge of vectors with the flavour of Calculus.
d) introduce the concepts of Laplace and Fourier transforms and its application to the solution of differential equations (ODE & PDE) to the students.

B. Course Content:

Vector Calculus: Surfaces, Differentiation and integration of vector functions, scalar and vector fields, Gradient, Tangents, Normal, Curvature, Directional derivative, Divergence, Curl, Line integral, Surface integral and Volume integral, Green's, Gauss' and Stokes' theorems (without proofs) and their simple applications.

Ordinary Differential Equations: Formulation of Differential equations, Equation of first order and first degree, Exact ODE, Integrating factor, Equation reducible to first order linear ODE, Fundamental Systems and General Solution of Homogeneous equation of Order Two, Wronskian, Method of Reduction of Order, Higher order linear differential equation with constant coefficients, Operator method, Euler's homogeneous equation and reduction to an equation with constant coefficients, Methods of undermined coefficients, Method of Variation of Parameters, Series solutions (Ordinary point),

Partial Differential Equations: First order partial differential equations; solutions of linear and nonlinear first order PDEs; classification of second-order PDEs; method of characteristics; boundary and initial value problems (Dirichlet and Neumann type) involving wave equation, D'Alembertmethod, heat conduction equation, Laplace's equations and solutions by method of separation of variables (Cartesian coordinates).

Laplace & Fourier transform solution of ODE by Laplace and Fourier transform.

C. Text Books :

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley, 11th edition, 2010.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd edition, 2014.

D. Reference Books:

1. Thomas and Finney, Calculus and Geometry (Linear Algebra), 9th edition, 2010.
2. S. L. Ross, Ordinary Differential Equation, Wiley and Sons Ltd., 3rd edition, 2010
3. Boyce and Richard C. Diprima, Elementary Differential Equations and Boundary value Problems, Wiley publications, 9th edition, 2009.
4. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications Inc. 2nd edition, 2013.
5. S. J. Farlow, Partial Differential Equation for Scientists and Engineers, Dover Publications, 1st edition, 1993.
6. Alan Jeffrey,Advanced Engineering Mathematics,Academic Press, 1st edition, 2001.
7. Dennis G. Zilland and Warren S. Wright, Advanced Engineering Mathematics, 4th edition, 2010.
8. Earl Coddington, Norman Levinson, Introduction to Ordinary Differential Equations McGraw Hill Education; 1st edition, 2017.

E. Course Outcomes:

Upon completion of the subject:

1. Students will have have strong visualizing capability in their mind about any object.
2. Students are so trained that they will recognize various real life situation/ problem and able to solve them by constructing a differential equation/ mathematical model.
3. Students will be able to find the Laplace and Fourier representation as transforms of functions of one variable.

Name of the Module: Environmental Engineering
Module Code: CY-108
Semester: 2nd
Credit Value: 3 [L=3, P=0, T=0]

A. Course Objectives:

a) Imparting the knowledge to the students in the area of Environmental Engineering.
b) Providing teaching and learning to make students acquainting with advanced science and technology in Environmental Science.
c) Injecting the future scope and the research direction in the discipline of Environmental Engineering.
d) Making students competent to the research and development in Environmental Engineering.

B. Course Content : *Yet to approved*

C. Text Books:

1. Environmental engineering, G. Kiely, McGraw Hill, New Delhi 2013.
2. Introduction to environmental engineering and science, G. M. Masters and W. P. Ela, PHI Learning/Pearson, New Delhi, 2015.
3. Principles of environmental science: inquiry & applications,W. P. Cunningham and M. A. Cunningham, 4th Ed., Tata McGraw Hill, New Delhi, 2011.
4. Chemistry for environmental engineering and science, C. N. Sawyer, P. L. Mccarty and G. F. Parkin, 5th Ed., Tata McGraw Hill, New Delhi, 2009.
5. Richard O. Mines, Environmental engineering: principles and practice, John Wiley & Sons, 2014.
6. Solar Energy–Principals of thermal collection and storage, S. P.Sukhatme, J. K. Nayak, 3rd Ed., Tata McGraw Hill, New Delhi, 2008.
7. Renewable Energy recources, J. Twidell and T. Weir, 2nd Ed., Taylor & Francis, London, 2006.
8. N.S. Rathore and N. L. Panwar, "Renewable Energy Sources for Sustainable Development", New India Publishing Agency, New Delhi, 2007.

D. Reference Books:

1. Environmental chemistry, A. K. De, 7th Ed., New Age, Kolkata, 2010.
2. Environmental engineering, N. N. Basak, McGraw Hill, New Delhi, 2014.
3. Environmental science: principles and practice, R. C. Das and D. K. Behera, PHI Learning, New Delhi, 2008.

E. Course Outcomes:

After studying this course, students will be able to

a) adequately train them to become Scientist, trainers and Chemical Engineers
b) be skilled both to control and maintenance in Environmental pollution, waste water treatment and other related activities in Environmental Engineering.
c) substantially prepared to take up prospective research assignments.

Name of the Module: Introduction to Computer Programming
Module Code: CS - 112
Credit Value: 2 {L = 2, T = 0, P = 0}

A. Course Objectives:

The course is designed to:

a) Introducing the basic and fundamental components of computers and programming language.
b) Teaching and training of different problems in prior of data structures course.
c) Guiding and training students to write efficient coding,
d) Guiding & training students to fragment problems into different functions or units.

B. Course Content:

Introduction: The von Neumann architecture, machine language, assembly language, high level programming languages, compiler, interpreter, loader, linker, text editors, operating systems, flowchart.

C Fundamentals: Introduction to C, Data types, Constants and variable declaration, Scope, Storage classes, Data input and output functions, Sample programs.

Operators & Expressions: Arithmetic, Relational, Logical, Bitwise operators, Conditional, Assignment, Library functions.

Decision making: Simple If statement, if-else statement, nested if else statement, Switch statement, nested switch, the operator, goto statement.

Decision making & branching: while statement, do-while statement, for statement.

Array: Declaration, Initialization and processing One-dimension array, Two-dimension array and multi dimension array and their operations.

String & pointer: String: Operation on String without using library function and using library function. Pointer: Declaration of pointer variables, accessing the variable by using pointer, pointer increment and decrement operator, pointer and array.

Functions: Basic functions, function type, function with no argument & no return value, function with no argument but return value, function with argument & return value, Storage class identifier, Call by reference, Recursive function. Pointer to function.
Structure & Union: Defining a structure, accessing of structure variable, structure and array, array within structure. Nested structure, structure & functions, Pointer & structure, unions, enum.
File management system: Advantage of using file, Open, close, read, write in the files, Operation on files.
Dynamic memory Allocation: use of malloc, calloc, realloc, free. Library functions, Implementation of Linked list and their various operations.
The pre-processor: macro statements.
Introduction to object-oriented programming.

C. Text Books:

1. Kerninghan and Ritchie, The 'C' programming language, 2nd Edition, Pearson, 2008.
2. Yashavant P. Kanetkar, Let Us C, 8th, Infinity Science Press, 2008.
3. Balaguruswamy,Programming In ANSI C, 7thEdition, Tata McGraw-Hill Education, 2017

D. Reference Books:

1. Yashavant P. Kanetkar, —Let Us C, 16th Edition, BPB Publication, 2017.
2. Zed A. Shaw, Learn C the Hard Way: Pratical Exercises on Computational Subjects You Keep Avoiding(Like C), 2015.
3. Deepali Srivastava and S.K Srivastava, C in Depth, BPB Publication, 2017.
4. Griffiths David and Dawn Griffiths,Head First C, A Brain Friendly Guide, 2012.
5. Grey Perry and Dean Miller, C Programming Absolute Beginner's Guide, 3rd Edition, 2013.

E. Program Outcomes:

At the end of the course, a student will be able to:

a) Understand the basic terminology used in computer programming.
b) Write, compile and debug programs in C language in different operating systems.
c) Design programs involving decision structures, loops and functions.
d) Use and apply the dynamics of memory by the use of pointers in engineering applications.
e) Use and apply the differences between structure oriented and function oriented programming in programming applications.

Name of the Module: Introduction to Computer Programming Laboratory
Module Code: CS - 113
Credit Value: 2 {L = 0, T = 0, P = 4}

F. Course Objectives:

The course is designed to:

e) The student will gain a thorough understanding of the fundamentals of C programming.
f) A student can code, compile and test C programs.
g) Could take Systems programming or Advanced C programming course.
h) Although this course does not deal with object-oriented programming methodology, it will assist the student build the required foundations to undertake a course in OOP..

G. Course Content:

Module 1: To write a C program in each case, to find the sum of individual digits of a positive integer, generate the first n terms of the Fibanocci sequence and generate all the prime numbers between 1 and n, where n is a value supplied by the user; to calculate the Sum =1-x 2 /2! +x4 /4!-x 6 /6!+x8 /8!-x 10/10!

Module 2: To write C programs that use both recursive and non-recursive functions, To find the factorial of a given integer and To find the GCD (greatest common divisor) of two given integers; Also, to write a C program, which takes two integer operands and one operator from the user, performs the operation and then prints the result. (Consider the operators +,-,*, /, % and use Switch Statement) and to write a C program that uses functions to perform the Addition of Two Matrices and Multiplication of Two Matrices;

Module 3: To write a C program that uses functions to perform the operations: To insert a sub-string in to a given main string from a given position; To delete n Characters from a given position in a given string; To write a C program to determine if the given string is a palindrome or not; Also to write a C program that displays the position or index in the string S where the string T begins, or – 1 if S doesn't contain T; To write a C program to count the lines, words and characters in a given text.

Module 4: To write a C program to generate Pascal's triangle and also to construct a pyramid of numbers; Also to write a C program that uses functions to perform the following operations on singly linked list: Creation, Insertion, Deletion, Traversal;

Module 5: To write C programs that implements stack (its operations) using Arrays, Pointers and that implements Queue (its operations) using Arrays, Pointers;

Module 6: To write a C program that implements the following sorting methods to sort a given list of integers in ascending order using - Bubble sort, Selection sort; Also, to write C programs that use both recursive and non-recursive functions to perform the following searching operations for a Key value in a given list of integers- Linear search, Binary search;

Module 7: To write a C program that implements the following sorting method to sort a given list of integers in ascending order- Quick sort; Also to write a C program that implements the following sorting method to sort a given list of integers in ascending order Merge sort;

H. Text Books:

4. Kerninghan and Ritchie, The 'C' programming language, 2^{nd} Edition, Pearson, 2008.
5. Yashavant P. Kanetkar, Let Us C, 8^{th}, Infinity Science Press, 2008.
6. Balaguruswamy,Programming In ANSI C, 7^{th}Edition, Tata McGraw-Hill Education, 2017

I. Reference Books:

6. Yashavant P. Kanetkar, —Let Us C, 16^{th} Edition, BPB Publication, 2017.
7. Zed A. Shaw, Learn C the Hard Way: Pratical Exercises on Computational Subjects You Keep Avoiding(Like C), 2015.
8. Deepali Srivastava and S.K Srivastava, C in Depth, BPB Publication, 2017.
9. Griffiths David and Dawn Griffiths,Head First C, A Brain Friendly Guide, 2012.
10. Grey Perry and Dean Miller, C Programming Absolute Beginner's Guide, 3^{rd} Edition, 2013.

J. Program Outcomes:

At the end of the course, a student will be able to:

f) Understand the basic terminology used in computer programming.

g) Write, compile and debug programs in C language in different operating systems.

h) Design programs involving decision structures, loops and functions.

i) Use and apply the dynamics of memory by the use of pointers in engineering applications.

j) Use and apply the differences between structure oriented and function oriented programming in programming applications.

Name of the Module: Engineering Drawing
Module Code: ME-121
Semester: II
Credit Value: 2.5 {L = 1, T = 0, P = 3}

A. Course Objectives:

The course is design to meet with the following objectives:

1. Increase ability to understand Engineering Drawing.
2. Learn to sketch and take field dimensions.
3. Learn to take data and transform it into graphic drawings.
4. Learn basic Auto Cad skills.
5. Learn basic engineering drawing formats.
6. Prepare the student for future Engineering positions.

B. Course Content:

Indian Standards: Sheet layout, type of lines and their representations, scales.

Principles of Orthographic Projection (multi view drawing): 1stand 3rdangle projection.

Projections: Points, lines, surfaces and solids.

Projection of sections and intersections of solids; Isometric projection.

C. Reference Books:

a) *Dhananjay, A. J., "Engineering Drawing", 1st Ed., 2017, TMH.*
b) *Bhatt, N.D. and Panchal, V.M., "Engineering Drawing", 43rd ed., 2014, Charotar Publishing House Pvt.Ltd.*
c) *Venugopal, K. and Prabhu,V. R., "Engineering Graphics", 15th Ed., 2018, New Age International Pvt. Ltd.*

D. Course Outcomes:

Upon completion of the subject student's ability to:

1. hand letter will improve.
2. perform basic sketching techniques will improve.
3. draw orthographic projections and sections will improve.
4. use architectural and engineering scales will increase.
5. produce engineered drawings will improve.
6. convert sketches to engineered drawings will increase.
7. cope up and become familiar with office practice and standards will increase.
8. handle and become familiar with Auto Cad two dimensional drawings will improve.
9. develop good communication skills and team work will improve.

Name of the Module: Fundamentals of Economics
Module Code: MH-106
Semester: Second semester
Credit Value 3 [P=0, T =0 L=3]

A. Objectives:

The course is design to meet the following objectives:

1. Learn the fundamentals of Engineering Economics
2. Understand and use of Economic concepts in making business decision
3. Use economic information to manage the organization
4. Use economic tools with respect to acceptance or rejection of investment proposals
5. Know the current issues relating to economic environment

B. Course content

Basics of Economics

Basic Concepts, Scope, Importance and definitions, Relevant to Managerial Economics-Factors Influencing Managerial Decision – Managerial economics and other disciplines, Relation between Science, Engineering, Technology and Economics

Demand Analysis

Managerial Decisions-Meaning of Demand- Types of Demand –Determinants of Demand – Demand Functions – Demand Elasticity – Demand Forecasting Methods – Accuracy of Forecasting

Cost concept

Costs Concepts - Accounting Cost and Economic Cost – determinants of Cost – Cost – Output Relationship – Estimation of Cost – Output Relationship, Break Even Analysis-linear approach (Simple numerical problems to be solved).

Market Structure and Product Pricing

Perfect and Imperfect Market Structures. Conditions of Perfect Competition. Price of a Product under demand and supply forces. Equilibrium Price. Pricing under Monopoly and Monopolistic Competition. Pricing under Oligopoly. Kinked Demand Curve. Discriminating Prices.

Inflation, Business cycle, National Income

Inflation- meaning, feature, Types, causes,Factors Causing Increases in Demand, Factors Causing Decrease in Supply, Impacts/ Effects of Inflation , Measures to Control Inflation. Business Cycle - Features of Business Cycle, Causes of Business Cycle, Types of Business Cycle, Theories of Business Cycle ,Impacts/Effects of Business Cycle, Measures to Control Business cycle, National Income & Current Issues- Concepts of National Income, Factors Determining Level (Size) of National Income, Methods of Measurement of National Income, Choice of Methods of National Income, Importance of Measurement of National Income, Difficulties in Measuring National Income.

C. **Text Books:**

1. Panneerselvam, R., Engineering Economics, Second Edition, New Delhi, PHI Learning Private Limited, 2013.
2. Parvin, K., Fundamentals of Engineering Economics,New Delhi, John, and Wiley, 2012.

C. Reference Books:

1. Chan S. P., Fundamentals of Engineering Economics, Fourth Edition, New York, Pearson, 2018
2. Seema, S., Economics for Engineering Students, Second Edition .I.K. International Publishing House, Delhi, 2014.
3. Joel, **D.,** Managerial Economics, Englewood Cliffs, N.J.: **Prentice-Hall, 2011**
4. Gupta, G.S., Managerial Economics, New Delhi, Tata McGraw Hill Publication, 2010.
5. Diwedi, D.N., Managerial Economics, New Delhi, Pearson Education India, 2012.
6. Varshney, S.C., Managerial Economics, New Delhi Sultan Chand & Sons, 2010

E. Programme outcomes:

1. Learn the fundamentals of Engineering Economics
2. Understand and use of Economic concepts in making business decision
3. Use economic information to manage the organization
4. Use economic tools with respect to acceptance or rejection of investment proposals
5. Know the current issues relating to economic environment

Course Curriculum for M. Tech.

in

Fluids & Thermal Engineering

(For students admitted in 2019-20 onwards)

Mechanical Engineering Department

National Institute of Technology Arunachal Pradesh

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COURSE STRUCTURE

Semester I					
Course Code	**Course Title**	**Contact Hours**			**Credit**
		L	**T**	**P**	
MA-501	Advanced Numerical Methods	3	0	0	3
ME-501	Advanced Fluid Mechanics	3	0	0	3
ME-502	Conduction and Radiation	3	0	0	3
ME-503x	Elective-I	3	0	0	3
ME-504x	Elective-II	3	0	0	3
MA-503	Computing Lab	0	0	3	1.5
ME-505	Thermo-Fluid Lab-I	0	0	3	1.5
Total		**15**	**0**	**6**	**18**

Semester II					
Course Code	**Course Title**	**Contact Hours**			**Credit**
		L	**T**	**P**	
ME-521	Computational Fluid Dynamics	3	0	0	3
ME-522	Convective Heat Transfer	3	0	0	3
ME-523	Advanced Thermodynamics	3	0	0	3
ME-524x	Elective-III	3	0	0	3
ME-525x	Elective-IV	3	0	0	3
ME-526	Thermo-Fluid Lab-II	0	0	3	1.5
ME-527	Technical writing and presentation	0	0	3	1.5
Total		**15**	**0**	**6**	**18**

Semester III					
Course Code	**Course Title**	**Contact Hours**			**Credit**
		L	**T**	**P**	
ME-601	Project phase -I	0	0	28	14
Total		**0**	**0**	**28**	**14**

Semester IV					
Course Code	**Course Title**	**Contact Hours**			**Credit**
		L	**T**	**P**	
ME-621	Project phase -II	0	0	30	15
Total		**0**	**0**	30	**15**

List of subjects offered under electives

Elective-I	Elective-II	Elective-III	Elective-IV
Refrigeration and Cryogenics (ME-503A)	Jet propulsion (ME-504A)	Experimental method (ME-524A)	Finite element analysis (ME-525A)
Gas Turbine Technology (ME-503B)	Micro and Nanoscale Energy Transport (ME-504B)	Fuels and combustion (ME-524B)	Advanced IC engine (ME-525B)
Turbomachinery (ME-503C)	Energy conversion and waste heat recovery (ME-504C)	Aerodynamics (ME-524C)	Two phase flow and heat transfer (ME-525C)
Mechatronics (ME-503D)		Heat Exchanger Design (ME-524D)	Boundary Layer Theory (ME-525D)

Semester-I

MA-501: Advanced Numerical Methods (3-0-0-3)

A. **Course Objectives:**

The course is designed to meet the objectives of:

1. introducing the basic concepts of round off error, truncation error, numerical stability and condition, Taylor polynomial approximations; to derive and apply some fundamental algorithms for solving scientific and engineering problems: roots of nonlinear equations, systems of linear equations, polynomial and spline interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations.
2. application of computer oriented numerical methods which has become an integral part of the life of all the modern engineers and scientists. The advent of powerful small computers and workstation tremendously increased the speed, power and flexibility of numerical computing.
3. injecting future scope and the research directions in the field of numerical methods.

B. **Course Content:**

Algebraic and transcendental equations- Definition and sources of errors, solutions of nonlinear equations, Bisection method, Newton's method, fixed point iterations, Regula-Falsi method, convergence analysis, Newton's method for two variables.

Solution of the system of linear equations- Gauss elimination method, Gauss Jordan method, Matrix Inversion, Operations Count, LU Factorization method, Gauss-Jacobi and Gauss-Seidel method, Successive Over Relaxation method

Initial value problems- Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Predictor-Corrector method, multistep methods and its stability analysis.

Finite difference schemes for partial differential equations- Discretization, Explicit and Implicit schemes, Consistency, Stability and Convergence, Stability analysis by matrix and Von Neumann methods, Lax's equivalence theorem, Finite difference schemes for initial and boundary value problems - FTCS, backward Euler and Crank-Nicolson schemes, ADI methods for Parabolic and Hyperbolic PDEs, Central difference schemes Elliptic PDEs

C. **Text Books:**

1. *Smith, G. D., "Numerical Solutions to Partial Differential Equations", 3rd edition, 1986, Oxford University Press.*
2. *Morton, K. W. and Mayers, D. F., "Numerical Solution of Partial Differential Equations", 2nd edition, 2005, Cambridge University Press.*
3. *Saha, S. R., "Numerical Analysis with Algorithm and Programming", 1st edition, 2016, CRC Press.*

D. **Reference Books:**

1. *Kincaid, D. and Cheney, W., "Numerical Analysis: Mathematics of Scientific Computing", 3rd edition, 2002,* AMS.
2. *Atkinson, K. E., "An Introduction to Numerical Analysis", 2nd edition, 1989, Wiley.*
3. *Conte, S. D. and Deboor, C., "Elementary Numerical Analysis - An Algorithmic Approach", 3rd edition, 1981, McGraw-Hill.*
4. *Mathews, J. H., "Numerical Methods for Mathematics Sciences and Engineering", 2nd edition, 2003, Prentice Hall of India, New Delhi.*
5. *Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical method for Scientific and Engineering Computation", 3rd edition, 1993, New Age International Pvt. Ltd.*
6. *Strikwerda, J. C., "Finite Difference Schemes and Partial Differential Equations", 2nd edition, 2004, SIAM.*
7. *Lapidus, L. and Pinder, G. F., "Numerical Solution of Partial Differential Equations in Science and Engineering", 1982, John Wiley.*

E. **Course Outcomes:**

Upon Completion of the subject:

1. students will be skilled to do Numerical Analysis, which is the study of algorithms for solving problems of continuous mathematics.
2. students will know numerical methods, algorithms and their implementation in C++for solving scientific problems.
3. students will be substantially prepared to take up prospective research assignments.

ME-501: Advanced Fluid Mechanics (3-0-0-3)

A. Course Objectives:

This course is designed

1. to introduce fundamental aspects of fluid flow behaviour.
2. to learn to develop steady state mechanical energy balance equation for fluid flow systems.
3. to estimate pressure drop in fluid flow systems and determine performance characteristics of fluid machinery.

B. Course Content:

Introduction- Review of fundamental Concepts, Eulerian and Lagrangian methods of description of fluid flow; Reynolds transport equation, basic equations of motion of fluid flow, Equation of continuity, Navier-Stokes equationsand boundary conditions; Non-dimensionalization of equations and order of magnitude analysis, Euler's equations, Bernoulli's equation, dimensionless parameters and their significance,Exact solution of incompressible Navier-Stokes equations- plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders.

Potential flows- Stream and Velocity potential function, Circulation, Irrotational vortex, Source and Sink, Vortex flow, Doublet, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag.

Boundary layer theory- D' Alemberts paradox, Prandtl's boundary layer equations, Von Karman's momentum integral equations, Blasius solution, approximate methods, transition and turbulent flows, turbulent boundary layer, instability and transition.

Compressible flow- Isentropic flow; flow with area change; normal shock waves; oblique shock wave, one and two dimensional compressible flows, compressible viscous flows, compressible boundary layers.

C. Text Books:

1. *Munson, B. R., Young, D. F., Okiish, T. H., "Fundamental of Fluid Mechanics", 6th edition, 2009, Wiley.*
2. *White, F., "Fluid Mechanics", 8th edition, 2017, TMH.*

D.Reference Books:

1. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th edition, 2003, Wiley.*
2. *Anderson, J., Modern Compressible Flow, 3rd edition, 2017, TMH.*
3. *White, F. M., "Viscous Fluid Flow", 3rd edition, 2017, McGraw-Hill Education.*
4. *Schlichting, H., "Boundary Layer Theory", 2011, Springer.*

E. Course Outcomes:

Upon Completion of the subjects: The focus of the course is to solve problems in industry. The course is intended to provide students with the following benefits:

a) Understanding the concept of fluid and the models of fluids

b) Understanding the basic physical meaning of general equations
c) Understanding the concept of stream function and potential function
d) Ability to derive the equation for viscous flow, including laminar flow and turbulent flow.
e) Ability to address such problems in engineering, and to solve the problems

ME-502: Conduction and Radiation (3-0-0-3)

A. Course Objectives:

The objectives of the course is

1. to familiarize the students with the fundamental concepts of
2. to introduce a basic study of the phenomena of conduction and radiation to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.
3. to impart knowledge related to design problem requiring the formulations of solid conduction and the technique of numerical computation.

B. Course Content:

Introduction to conduction- Recapitulation: Steady and Transient conduction; Fins, Lumped parameter and semi-infinite solid approximations, Heisler and Grober charts; 3-D conduction, isotropic, orthotropic and anisotropic solids.

Analytical methods- Mathematical formulations, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamels theorem and Greens function.

Numerical method- 2-D conduction problems without and with heat generation.

Introduction to radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Spectral and directional variations, View factors.

Enclosure with transparent medium- Enclosure analysis for diffuse-gray surfaces and non-diffuse, non-gray surfaces, net radiation method.

Enclosure with participating medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation.

C. Text Books:

- *Myers, G. E., "Analytical Methods in Conduction Heat Transfer", 1987, McGraw-Hill.*
- *Modest, M. F., "Radiative Heat transfer", 3rd edition, 2013, Academic Press.*
- *Ozisik, M. N., "Heat Conduction", 2nd edition, 1993, John Wiley & Sons.*

D. Reference Books:

1. *Vedat S. A., "Conduction Heat Transfer", 1987, Addison-Wesley.*
2. *Incropera, F. P., Dewitt, D. P., Bergman, T. L., "Introduction to Heat Transfer", 5th edition, 2006, John Wiley & Sons.*

3. *Siegel, R. and Howell, J. R., "Thermal Radiation Heat Transfer", 4th edition, 2002, Taylor & Francis.*

- **Course Outcomes:**

The course is intended to provide students with the following benefits:
1. Analyze problems involving steady state heat conduction in simple geometries.
2. Develop solutions for transient heat conduction in simple geometries.
3. Obtain numerical solutions for conduction and radiation heat transfer problems.
4. Calculate radiation heat transfer between black body surfaces.
5. Calculate radiation heat exchange between gray body surfaces.

MA-503: Computing Lab (0-0-3-1.5)

A. **Course Objectives:**

The course is designed to meet the objectives of:
1. To increase the Numerical programming skill to solve the various engineering problems,
2. To injecting future scope and the research directions in the field of numerical methods.

B. **Experiments:**
1. Solution of a system of Linear Equations: Gauss elimination, Gauss Jordan, Matrix Inversion, Jacobi, Gauss Seidel.
2. Find the Roots of Algebraic Equations: Bisection, Regula-Falsi, Newton- Raphson Methods.
3. Solution of Ordinary Differential Equations: Taylor Series, Euler's Method, Runge-Kutta (4th Order).
4. Solution of Partial Differential Equations: FTCS scheme, Crank-Nicolson Scheme, ADI scheme.

C. **Books:**
1. *Saha, S. R., "Numerical Analysis with Algorithm and Programming", 1st edition, 2016, CRC Press.*
2. *Xavier, C., "C Language and Numerical Methods", 1st edition, 1999, New Age Publisher.*
3. *Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P., "Numerical Recipes: The Art of scientific Computing", 3rd edition, 2007, Cambridge University Press.*

D. **Course Outcomes:**

Upon Completion of the subject:
1. Students will be skilled to do Numerical Analysis, which is the study of algorithms for solving problems of continuous mathematics.
2. Students will know numerical methods, algorithms and their implementation in C++for solving scientific problems.

3. Students will be substantially prepared to take up prospective research assignments

ME-505: Thermo-Fluid Lab-I (0-0-3-1.5)

A. Course Objectives:

The course is designed to meet the objectives of:

1. To introduce the student the fundamental theories and the industrial applications of fluid mechanics.
2. This laboratory supports the courses for the graduate studies.
3. This laboratory also supports the advanced research in the area of fluid mechanics.

B. Experiments:

A few experiments under this laboratory courses are:

1. Jet impact on flat and curved surfaces
2. Determination of friction factor as a function of Reynolds number in pipe flow
3. Study of the pressure distribution over smooth and rough cylinder.
4. Flow past bluff and a streamlined bodies and measurement of pressure drag.
5. Flow through converging and diverging nozzles
6. Study of the Pressure distribution over symmetric aerofoil, cambered aerofoil and thin aerofoils.
7. Shock waves and expansion patterns around a two-dimensional model in supersonic flow conditions.
8. Measurement of the velocity profile in laminar and turbulent boundary layers on rough and smooth plates.

C. Books:

1. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th edition, 2003, Wiley.*
2. *Anderson, J., Modern Compressible Flow, 3rd edition, 2017, TMH.*
3. *White, F. M., "Viscous Fluid Flow", 3rd edition, 2017, McGraw-Hill Education.*
4. *Schlichting, H., "Boundary Layer Theory", 2011, Springer.*

D. Course Outcomes:

Upon Completion of the subject:

1. Students should be capable of analysing the physical flow situation of the problem at hand.
2. Estimation of uncertainty in experiments and the so obtained results.

Semester II

ME-521: Computational Fluid Dynamics (3-0-0-3)

d) **A. Course Objectives:**

1. Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems
2. Provide the essential numerical background for solving the partial differential equations governing the fluid flow

e) **B. Course Content:**

f) **Introduction to computational fluid dynamics and principles of conservation-** Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations.

g)

h) **Classification of partial differential equations and physical behaviour-** Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations,Physical examples of elliptic, parabolic and hyperbolic partial differential equations.

i) **Approximate solutions of differential equations-** Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations, Properties of variational form, Weighted residual approach: trial function and weighting function, Requirement of trial function and weighting function, Least square method, Point Collocation method, Galerkin's method, Rayleigh-Ritz method.

j) **Fundamentals of discretization-** Discretization principles:Preprocessing,Solution,Postprocessing, Finite Element Method, 3 Finite difference method, Well posed boundary value problem,Possible types of boundary conditions, Conservativeness,Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term.

k) **Finite volume method-** Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems:Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Composite material with position dependent thermal conductivity, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions.

l) **Discretization of unsteady state problems-** 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme.

m)

n) **Finite volume discretization of 2-d unsteady state diffusion type problems-** FVM for 2-D unsteady state diffusion problems.

o) **Solution of linear algebraic equation-** Basic numerical methods, Direct method, Tri-diagonal Matrix algorithm, TDMA and other iterative methods.

p)

q) **C. Text Books:**

r) *1. Chung, T. J., "Computational Fluid Dynamics", 2nd edition, 2014, Cambridge University Press.*

s) *2. Anderson J. D. (Jr)., "Computational Fluid Dynamics: The basic with applications", 2017, McGraw Hill Education.*

t) **D. Reference Books:**

u) *1. Patankar, S. V., "Numerical Heat Transfer and Fluid Flow", 2017, CRC Press.*

v) *2. Versteeg, H. K., Malalasekera, W., "An Introduction to Computational Fluid Dynamics", 2nd edition, 2007, PHI.*

w) *3. Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Dynamics", 3RD edition, 2002, Springer.*

x)

y) **E. Course Outcomes:**

1. Understand solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly.
2. Define and setup flow problem properly within CFD context, performing solid modelling using CAD package and producing grids via meshing tool.
3. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
4. Use CFD software to model relevant engineering flow problems. Analyse the CFD results. Compare with available data, and discuss the findings.

ME-522: Convective Heat Transfer (3-0-0-3)

A. Course Objectives:

The course is design to meet with the following objectives:

1. This is one of the major courses for post graduate students which will help to understand the flow of fluids and heat transfer.
2. The focus of the course is a central theme of modern applied mathematics. Based on mathematical concepts of gradient, divergence, vorticity and tensor, the basic properties normally ascribed to fluids such as density, compressibility and dynamic viscosity will be introduced.
3. Then general equations, including continuous equation, momentum equation and energy equation are derived.
4. Therefore the course is used to model a vast range of physical phenomena and plays a vital role in science and engineering.

B. Course Content:

Introduction- Continuity, Momentum and Energy differential equations in different coordinate systems, Boundary layer Approximations/Scaling Analysis.

Laminar external flow and heat transfer- Blasius solution for flat plate, Pressure gradient flow, von Karman-Pohlhausen method for flows with pressure gradient Integral solutions for flow over an isothermal flat plate, Flat plate with constant heat flux.

Laminar internal flow and heat transfer- Fully developed forced convection in pipes with different wall boundary conditions- Hagen Poiseuille flow, Plane Poiseuille flow, and Couette flow, Graetz solution for forced convection in the thermal entrance region of ducts and channels.

Natural convection heat transfer- Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical plate with constant wall temperature and heat flux conditions.

Turbulent convection- Governing equations for averaged turbulent flow field (RANS), Eddy viscosity and eddy thermal diffusivity, Turbulence Models, Turbulent flow and heat transfer across flat plate and circular tube.

C. Text Books:

1. *Kays, W., Crawford, M. and Weigand, B., "Convective Heat and Mass Transfer", 4th edition, 2017, McGraw Hill Education.*
2. *Burmeister, C., L., "Convective Heat Transfer", 2nd edition, 1993, John Wiley and Sons.*
3. *Bejan, A., "Convection Heat Transfer", 3rd edition, 2006, John Wiley.*

D. Course Outcomes:

Upon Completion of the subjects, the students should:

1. be able to solve industry oriented problems.
2. understand the concept of fluid and the models of fluid flow and heat transfer for flow over external surfaces and duct of different cross-sections.
3. understand the basic physical meaning of general equations.
4. be able to derive the equation for viscous flow, including laminar flow and turbulent flow.

ME-523: Advanced Thermodynamics (3-0-0-3)

A. Course Objectives:

1. This subject designed to cover advanced topics on thermodynamics in detail which are usually not taught at the UG level.
2. The focus of the course is to make the students understand the practical application of the concepts of thermodynamics to practical.
3. To help the postgraduate students to deal with advanced level problems in the practical field.

C. Course Content:

Thermodynamic relations- Generalized relation for C_p, C_v, K, relations for internal energy and enthalpy, the various Tds equation, clapeyron equation, Helmhotz free energy function, Gibbs free energy function, coefficient of volumetric expansion, isothermal compressibility, differential relation for U, H, G &F-Maxwell relations.

Exergy- Introduction, definition, exergy of closed and open system, 40nalyzing40ility, exergetic efficiency, exergy analysis of systems and components, entropy generation minimization, finite time thermodynamics, thermo economics.

Non-reactive gas mixtures- introduction, basic definitions for gas mixtures, p-v-t relationship for mixtures of ideal gases, properties of mixtures of ideal gases, entropy change due to mixing, mixtures of perfect gases at different initial pressure and temperatures.

Direct energy conversion- Introduction, thermoelectric converters, thermo-ionic converters, magneto hydrodynamics generators, solar power cells plant, fuel cell hydrogen, hydrogen fuel cells, direct and indirect oxidation fuel cells, biochemeical fuel cells.

Statistical thermodynamics- Introduction to statistical thermodynamics

D. Text Books:

1. *Wylen, G. V. and Sontag, R. E., "Fundamentals of Classical Thermodynamics", 4th edition, 1994, Wiley Eastern Limited, New Delhi.*
2. *Moran, M. J. and Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 4th edition, 1999, John Wiley and Sons.*
3. *Sears, F. W. and Salinger, G. L., "Thermodynamics, Kinetic Theory and Statistical Thermodynamics", 1998, Narosa Publishing House, New Delhi.*

E. Course Outcomes:

1. The students will be able to understand clearly and will have firm grasp of the basic principles ofthermodynamics.
2. The students ability for creative thinking and a deeper understanding on thermodynamics will enhance.
3. The students will have necessary skills to bridge the gap between knowledge and the confidence to properly apply knowledge on the broad application area of thermodynamics
   covering from microscopic organisms to common household appliances, transportation vehicles, power generation systems, and even philosophy.

ME-526: Thermo-Fluid Lab-II (0-0-3-1.5)

A. Course Objectives:

The course is designed to meet the objectives of:

1. to introduce the student the fundamental theories and the industrial applications of fluid mechanics, heat transfer, I. C engine etc.
2. this laboratory supports the courses for the graduate studies.
3. this laboratory also supports the advanced research in the area of thermal and fluid mechanics.

B. Experiments:

1. Forced Convective Heat Transfer.

2. Boiling Heat Transfer
3. Measurement and Analysis of combustion parameters in I.C. engines.
4. Performance of a vapour compression refrigeration system.
5. Turbine and pump characteristics.
6. Use of softwares: COMSOL, FLUENT (ANSYS).

C. Books:

1. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th edition, 2003, Wiley.*
2. *Burmeister, C., L., "Convective Heat Transfer", 2nd edition, 1993, John Wiley and Sons.*
3. *Dossat, R. J., "Principles of Refrigeration", 4th edition, 2002, Pearson Education.*
4. *V. Ganesan, "Internal Combustion Engines", 2nd edition, Tata McGraw-Hill.*

D. Course Outcomes:

Upon Completion of the subject:

1. Students should be capable of 41nalyzing the physical heat transfer, I. C. engine problem at hand.
2. Estimation of uncertainty in experiments and the so obtained results.

ME-527: Technical writing and presentation (0-0-3-1.5)

Individual students or group of students (maximum of two) are required to choose a topic of their interest preferably from *outside the M.Tech projects* and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members including course coordinator shall assess the presentation of the seminar and award marks to the students. Each student/group shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

ELECTIVES

ME-503A: Refrigeration and Cryogenics (3-0-0-3)

A. Course Objectives:

The course is design to meet with the following objectives:

1. To enable students to select alternate new azeotrope and mixed refrigerants based on application in a various refrigeration system.
2. To enable students to analyse low temperature refrigeration systems.
3. To enable students to present design aspects of various refrigeration systems and its components.
4. To enable students to evaluate refrigeration systems to improve the performance.
5. To encourage the dissemination of information concerning low temperature processes and techniques.

B. Course Content:

Refrigeration

Introduction- Review of basic principles of refrigeration, methods of producing cold.
Air refrigeration systems- basic and practical cycles, air craft refrigeration systems, DART.
Vapour compression systems- V-C refrigeration systems- ideal and actual cycles, single and multi- stage systems, cascade systems.
Absorption refrigeration systems- properties of fluid mixtures, simple and practical cycles, NH_3-H_2O and LiBr-H_2O VAR systems.
Refrigerants- Classification, nomenclature, Desirable properties of refrigerants, replacement and selection of refrigerants.
Other refrigeration systems- steam jet, pulse-tube, hilse-tube, piezoelectric refrigeration systems.

Cryogenic

Thermodynamics of gas liquefaction- liquefaction cycles- cryogenic refrigeration systems down to milli Kelvin range. Properties of cryogenic liquids, superfluidity. properties of solids at cryogenic temperatures: mechanical, thermal, electrical and magnetic properties, superconductivity. Storage and transfer of cryogenic liquids, liquid level. Typical applications of refrigeration and cryogenics.

C. Text Books:

1. *Mukhopadhyay, M., "Fundamentals of Cryogenic Engineering", 4th edition, 2010, Prentice Hall India Learning Private Limited.*
2. *Dossat, R. J., "Principles of Refrigeration", 4th edition, 2002, Pearson Education.*

D. Reference Books:

1. *Barron, R. F., "Cryogenic Systems" 2nd edition, 1985, Oxford University Press.*
2. *Stoecker, W. F., "Refrigeration and Air Conditioning", 2nd edition, 2014, Tata McGraw-Hill.*

a) **E. Course Outcomes:**

Upon completion of the subject, students should:

1. Select appropriate new eco-friendly refrigerants according to application in various types of refrigeration systems.
2. Design and analyze low temperature refrigeration systems.
3. Design and analyze the refrigeration systems for various applications.
4. Evaluate the refrigeration systems to improve the performance.

5. Describe various methods to produce low temperature and phenomena's at cryogenic temperature.

ME-503B: Gas Turbine Technology (3-0-0-3)

A. Course Objectives:

1. This course is designed to have an advanced understanding of the theory and operation of gas turbine engines.
2. To apply thermodynamic principles to calculate parameters such as pressure and temperature in Gas Turbine Engines as used in aircraft.

B. Course Content:

Fundamentals of turbo machines- Classification, Applications, Isentropic flow, Energy transfer, Efficiency, static and Stagnation conditions, continuity equation, Euler's flow through variable cross sectional area, unsteady flow in turbo machine.

Gas dynamics- Fundamentals, thermodynamic concepts, Isentropic conditions, Mach number and Area – Velocity relation, Dynamic pressure, normal shock relations for perfect gas, supersonic flow, oblique shock waves.

Centrifugal compressors- Elements of compressor stage, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery, slip factor, Compressor performance - Stall and surge, Performance characteristics.

Axial flow compressors- Flow analysis, work and velocity triangles, Efficiencies, Thermodynamic analysis, stage pressure rise, Degree of reaction, stage loading, Free and forced vortex blades, Effect of axial velocity and incidence on velocity triangles, Performance characteristics.

Axial flow gas turbines- Work done; velocity triangles and efficiencies; thermodynamic flow analysis, degree of reaction, Free-vortex blades, Blade angles for variable degree of reaction, Matching of compressor and turbine.

C.Text Books:

1. *Breeze, P., "Gas-Turbine Power Generation", 2016, Academic Press.*
2. *Ganesan, V., "Gas Turbines", 3rd edition, 2017, Tata McGraw-Hill.*

D. Reference Books:

1. *Saravanamuttoo, "Gas Turbine Theory", 5th edition, 2006, Pearson Education.*

E. Course Outcomes:

1. Students will be able to analyze the thermodynamics of aircraft propulsion systems and gas turbines.
2. They will learn the basic principles and will be able to design them.

ME-503C: Turbomachinery (3-0-0-3)

A. Course Objectives:

1. Provide a thorough understanding of the principles and applications of turbomachinery in modern industry.
2. Provide a useful tool for designing and researching on turbomachinery instruments.

B. Course Content:

Centrifugal fans and blowers - Types- stage and design parameters-flow analysis in impeller blades-volute and diffusers, losses, characteristic curves and selection, fan drives and fan noise.

Centrifugal compressor - Construction details, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.

Axial flow compressor - Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done simple stage design problems and performance characteristics.

Axial and radial flow turbines - Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, testing and performance characteristics.

C. Text books:

1. *Yahya, S. M., "Fundamentals of Compressible Flow", 6th edition, 2018,. New Age International (P) Limited.*
2. *Stepanoff, A.J., "Turboblowers", John Wiley & Sons.*

D. Reference Books:

1. *Church, A. H., "Centrifugal pumps and blowers", 1944, John Wiley and Sons.*
2. *Dixon, S. L. and Hall, C. A., "Fluid Mechanics and Thermodynamics of turbomachinery", 7th edition, 2014, Pergamon Press.*

E. Course Outcomes:

1. The students will have basic understanding of fluid mechanics and thermodynamics in turbomachinery.
2. It will provide a general treatment of the common forms of turbomachine, covering basic fluid dynamics and thermodynamics.
3. Students will be apply the conservation equations of mass momentum, and energy in relative and absolute coordinate systems to determine the ideal mean-line performance of turbomachine elements.
4. Understand the viscous and compressible effects responsible for non-ideal performance in turbomachines.
5. Applying performance models to estimate non-ideal performance for design and analysis of turbomachine elements.
6. Understand the fluid mechanics responsible for limits of turbomachinery operability and stability, particularly, stall, surge, cavitations, and choke.
7. Appreciating the use of laboratory and testing methods, and the value of quality data in design and development.
8. Understand the basic characteristics of radial and axial pumps, compressors, turbines and fans with different kinds of working mediums.

ME-503D: Mechatronics (3-0-0-3)

A. Course Objectives:

1. Generate conceptual design for Mechatronics systems based on potential customer requirements.
2. Selection of appropriate sensors and transducers and devise an instrumentation system for collecting information about processes, control systems.
3. Design a control system for effective functioning of Mechatronics systems using digital electronics, microprocessors, microcontrollers and programmable logic controllers.
4. Selection of appropriate actuators for physical systems.
5. Analyse PD, PI and PID controllers for a given mechatronics system.
6. Develop pneumatic and hydraulic circuits.
7. Determine the performance of different Mechatronics system.

B. Course Content:

Introduction: Introduction to Mechatronics, need and applications, Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modeling, Analysis and Simulation, Man Machine Interface; , role of mechatronics in automation, manufacturing and product development.

Sensors and transducers: characteristics, classification, working principles, Development in Transducer technology, Opto-electronics Shaft encoders, strain, velocity , Acceleration, LVDT, temperature Sensors, Vision System, etc.

Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators, Microsensors, Microactuators;

Application: Case studies based on the application of mechatronics in manufacturing, Machine Diagnostics, Road vehicles and Medical Technology, bionics and avionics. Industrial robotics, types of Industrial robots, classification based on work envelope, Generations configurations and control loops, co-ordinate systems, need for robot, basic parts and functions, specifications.

C. Text Books:

1. *Bolton, W., "Mechatronics, Electronic control systems in mechanical and electrical engineering", 5th edition, 2011, Pearson Education.*
2. *Alcaiatore, G.D., Michel B. H., "Introduction to Mechatronics and Measuring Systems", 3rd edition, 2006, Mc. Graw Hill International.*
3. *Robert H. B., "The Mechatronics Handbook", 2nd edition, 2007, CRC Press.*

D. Reference Books:

1. *Stenersons, J., "Fundamentals of Programmable Logic Controllers Sensors and Communications", 3rd edition, 2004, Pearson Education.*
2. *Kuttan K. A., "Introduction to Mechatronics", 2007, Oxford University Press.*

E. Course Outcomes:

Students who successfully fulfil the course requirements will have demonstrated:

1. an ability to identify, select, and integrate mechatronic components to meet product requirements.
2. an ability to analyse PD, PI and PID controllers for a given mechatronics system.
3. an ability to develop pneumatic and hydraulic circuits.
4. an ability to design, analyze, and optimize mechatronic products.
5. an ability to determine the performance of different Mechatronics system.

ME-504A: Jet Propulsion (3-0-0-3)

A. Course Objectives:

1. This course is designed to teach the principles of jet propulsion.
2. The primary focus of the course is on the teaching of thermodynamics and Gas dynamics in aircraft engines.
3. The course will provide information that will enable the engineering analysis of ramjets and turbine engines and its separate components including inlets, nozzles, combustion chambers, compressors.

B. Course Content:

Basic theory of Jet propulsion devices and historical development. Types of various jet propulsion plants like air screw, turboprop, turbojet, Ram jet, pulse jet, rocket propulsion, etc. and their comparative study.

Performance study of various jet propulsion devices from ideal and practical consideration. Study and design considerations of main components of jet propulsion plants. Thrust augmentation devices and their thermodynamic analysis.

Combustion performance, products of combustion and their properties.

Recent advances in jet propulsion devices.

C. Text Books

1. *Flack, R. D., "Fundamentals of Jet Propulsion with Applications", 2011, Cambridge University Press.*
2. *Hill, P. and Carl, P., "Mechanics and Thermodynamics of Propulsion", 2nd edition, 2009, Pearson Education.*
3. *Mattingly, J. D., "Jet Propulsion", 2006, McGraw Hill Inc.*

D. Reference Books:

1. *Roy, B., "Aircraft Propulsion", 1st edition, Elsevier (India).*

2. *Ahmed, E. A., "Aircraft Propulsion and gas Turbine Engines", 2nd edition, 2017, CRC press.*

E. Course Outcomes:

Students successfully completing this course will get:

1. a basic understanding of thermodynamic cycles of jet engines.
2. a basic understanding of the compressible fluid flow in inlets and compressors and turbines.
3. a basic understanding of the combustion physics in combustion chambers.
4. a basic understanding of the rational behind several types of jet engines. The ability to analyze jet engines; determine propulsion efficiency and design inlets and nozzles.

ME-504B: Micro and Nanoscale Energy Transport (3-0-0-3)

A. Course Objectives:

The course is designed to meet with the following objectives:

1. Gain an understanding of the fundamental elements of solid-state physics and quantum mechanics.
2. Develop skills to derive continuum physical properties from sub-continuum principles.
3. Apply statistical and physical principles to describe energy transport in modern small-scale materials and devices.

B. Subject Matter:

Transport phenomena applied to micro-nano scale, basic heat transfer and kinetic theory, transport phenomena, photons, electrons, phonons, energy carriers, energy transport, heat transport, energy levels, statistical behavior, internal energy, waves and particles, scattering, heat generation,Quantum statistics, Bose – Einstein statistics, Fermi – Dirac statistics, Boltzmann equation, Classical laws, Fourier, Newton, Ohm, thermoelectric effect, Brownian motion, surface tension, van der Waals potential.

C. Text Books:

1. *Chen, G., "Nanoscale energy transport and conversion", 1st edition, 2005, Oxford University Press.*

2. *Sobhan, C. B. and Peterson, G. P., "Microscale and Nanoscale Heat Transfer", 1st edition, 2008, CRC press.*

3. *Zhang, Z. M., "Nano/Microscale Heat Transfer", 1st edition, 2007, McGraw-Hill.*

D. Reference Books:

1. *Tien, C. L., Majumdar, A., and Gerner, F. M., "Microscale energy Transport", Illustrated edition, 1998, Taylor & Francis.*
2. *Faghri, M., and Sunden, B., "Heat and Fluid Flow in Microscale and Nanoscale Structures", Illustarted edition, 2003, WIT Press.*

E. Course Outcomes:

Upon completion of the subject, the students should learn:

1. the recent developments in thermal science and engineering related to micro/nanoscale technologies.
2. the fundamentals of nano/microscale heat transfer and thermophysics as applied to emerging technologies, as well as methodology for solving practical problems in small dimensions and/or short time periods.
3. the microscopic descriptions and approaches in thermal science, including the equilibrium statistics, Boltzmann transport equation, and nanoscale heat conduction and radiation.

ME-504C: Energy Conversion and Waste Heat Recovery (3-0-0-3)

A. Course Objectives:

1. To impart knowledge in the domain of energy conservation
2. To bring out Energy Conservation Potential and Business opportunities across different user segments under innovative business models.
3. To inculcate knowledge and skills about assessing the energy efficiency of an entity/ establishment.
4. To understand and analyze the present and future energy demand of world and nation and techniques to exploit the available renewable energy resources such as, solar, bio-fuels, wind power, tidal and geothermal effectively.

B. Course Content:

Introduction- Introduction to energy conversion technologies, Waste Heat, Importance of Waste Heat Recovery.

Energy Economics.

In Power plant cycles- Energy Cascading, Combined Cycles, Cogenerations, Bottoming Cycle options for WHR.

In refrigeration- Vapor Absorption Refrigeration, Ejector Refrigeration.

Heat exchangers for waste heat recovery- Recuperator, Regenerator, Special Heat Exchanger Devices, Heat pipes & Vapor Chambers, Prime movers, Heat Recovery from Incinerators.

Energy conversion technologies- Thermoelectric Generators, Thermoionic conversion, Thermo-PV, MHD and others.

Energy storage techniques- Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage etc., Chemical, Thermal, electrical, magnetic and chemical storage systems.

Energy economics

C. Text Books:

1. Harlock, J. H., "Combined Heat and Power", Pergaman Press.

2. Kreith, F. and West, R. E., "Energy Efficiency", 1st edition, 1996, CRC Press.

D.Reference Books:

1. *Kays, W. M. and London, A. L., "Compact Heat Exchangers", 3rd edition, 1998, McGraw-Hill.*

E. Course Outcomes:

1. Obtain knowledge about energy conservation policy, regulations and business practices.
2. Analyse energy systems from a supply and demand perspective.
3. Recognize opportunities for enabling rational use of energy.
4. Apply knowledge of Energy Conservation Opportunities in a range of contexts.
5. Develop innovative energy efficiency solutions and demand management strategies.

ME-524A: Experimental Methods (3-0-0-3)

A. Course Objectives:

The course is design to meet with the following objectives:

1. To learn basic concept of experimental methods.
2. To learn techniques involve in measurement and its principles.
3. To familiar with different measuring instruments related to fluid flow and heat transfer.
4. To learn methods of measurement of physical quantitites and uncertainity analysis.

B. Course Content:

Introduction- Importance of measurement and experimentation, Basic issues in measurements, Signal flow diagram of measurement system.

Principles of measurement- Causes and types of errors in measurement, Error analysis and method for error estimate, Propagation of errors, Regression analysis, Calibration, Curve fitting and quality of curve fitting, zero order, first order, second order systems, Inputs and their methods of correction - broad category of methods for measuring field and derived quantities, Design of experiments, control systems, PID, LVDT, data acquisition.

Pressure measurement- Manometers, Electric pressure transducers, Bourdon tube pressure gage, Diaphragm gage.

Flow rate measurement- Positive displacement flow meters, venture, orifice, impact tube, flow nozzle, sonic nozzle, rotameter, pitot static tube, hot-wire anemometer, laser Doppler anemometer, flow visualization techniques – shadowgraph, Schlieren and interferometer.

Thermometry- Hg-in-glass thermometer, RTD, thermocouple, optical pyrometer, Effect of heat transfer on temperature measurement, errors of system/sensor interaction.

Thermal conductivity measurement- Guarded hot plate apparatus, heat flux meter.
Uncertainty analysis.

C. Text Books:

1. *Holman, J. P., "Experimental Methods for Engineers", 7th edition, 2017, McGraw Hill Education.*

2. *Beckwith, T.G., Lienhard, J. H. and Marngoni, V. R. D., "Mechanical Measurements", 6th edition, 2013, Pearson Education.*

D. Reference Books:

1. *Dally, J. W., Riley, W. F. and McConnel, K. G., "Instrumentation for Engineering Measurements", 2nd edition, 1993, John Wiley & Sons.*
2. *Doebelin, E.O. "Measurement systems, Application and Design", 2nd edition, 1990, Tata McGraw-Hill.*

E. Course Outcomes:

Upon completion of the subject, students will be able to:

7. Understand the basics of errors in measurement and its analysis.
8. Understand different mathematical and experimental techniques involved in measurement of physical quantities.

ME-524B: Fuels and Combustion (3-0-0-3)

A. Course Objectives:

1. To build up knowledge of the concepts and theories of fuel combustion.
2. To develop understanding of the basic principles and concepts of advanced fuel combustion and control process
3. To provide students with the required skills for analyzing thermal cycles.

B. Course Content:

Introduction- History of Fuels, classification, properties, Production, present scenario and consumption pattern of fuels.

Solid fossilfuel (coal)- Definitions and properties, classification, Analysis- Proximate and ultimate, composition, preparation, combustion techniques, liquefaction, Gasification.

Liquid fossil fuel(petroleum)- exploration, evaluation, Refining of Petroleum, cracking, Synthesis of Gasoline-Fischer-Tropsch process. And Bergius process, distillation, Hydrotreatment, dewaxing, deasphalting, Refining of Petroleum.

Gaseous fuels- Natural gas, LPG, Producer gas, Water gas, Hydrogen, Acetylene and Other fuel gases.

Power alcohol and biodiesel- Production of ethanol, Production of biofuels.

Combustion technology- Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame-premixed and diffusion flames, Flame Properties, Combustion devices-Burners, Furnaces, Gasifiers, IC Engines, Nuclear Reactors

C. Text Books:

1. *Turns, S., "An Introduction to Combustion: Concepts and Applications", 3rd edition, 2017, McGraw-Hill.*
2. *Sarkar, S., "Fuels and Combustion", 3rd edition, 2009, Universities Press.*
3. *Moran, M. J. and Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 4th edition, 1999, John Wiley and Sons.*

D. Reference Books:

1. *Glassman, I., "Combustion", 4th edition, Academic Press.*
2. *Griswold, J., "Fuels Combustion and Furnaces", Mc-Graw Hill.*

E.Course Outcomes:

The student will be able to

1. differentiate between various fuels
2. analyze various bio fuel.
3. understand the chemistry behind the combustion
4. understand about various combustion devices.

ME-524C: Aerodynamics (3-0-0-3)

A. Course Objectives:

1. Formulate and apply appropriate aerodynamic models to predict the forces on and performance of realistic three-dimensional configurations;
2. Assess the applicability of aerodynamic models to predict the forces on and performance of realistic three-dimensional configurations and estimate the errors resulting from their application;

B. Course Content:

Aircraft and Aerodynamic Forces and Moments, Fluids and Forces in Fluids, Kinematics of fluid motion, Velocity with specified extension and vorticity, Vorticity Distribution, Velocity without expansion and vorticity Navier - Stokes Equation, Conservation of Energy and Energy Equation, Equations of Motions, Exact Solution for Simple Problems, Non-dimensional Form of the Equations and Possible Simplifications, High Reynolds Number Approximation, Conditions fior Incompressibility, Potential Flow-Combination of Basic Solutions.

C. Text Books:

1. ***Anderson, J., "Fundamentals of Aerodynamics" 5th edition, 2011, TMH.***

D. Course Outcomes:

1. Define basic aerodynamic forces acting on an aircraft
2. Define aerodynamic devices on an aircraft
3. Explain the changes in the characteristics of compressible and incompressible flows through variable-area sections using mathematical relations.

ME-524D: Heat Exchanger Design (3-0-0-3)

A. Course Objectives:

The objective of this course is to exhibit how real components are desigend in industry following the principles outlined here.

B. Course Content:

Introduction- Types of heat exchangers, shell and tube heat exchangers, regenerators and recuperators, Temperature distribution and its implications, Parts description.

Process design of heat exchangers- Heat transfer correlations, Overall heat transfer coefficient, analysis of heat exchangers, LMTD and effectiveness method. Sizing of finned tube heat exchangers, U tube heat exchangers, Design of shell and tube heat exchangers, fouling factors, pressure drop calculations.

Stress analysis-Stress in tubes, types of failures, buckling of tubes, flow induced vibration.

Compact and plate exchanger- Types, Merits and Demerits, Design of compact heat exchangers, plate heat exchangers, performance influencing parameters, limitations.

Condensers and cooling towers- Design of surface and evaporative condensers, cooling tower, performance characteristics.

C. Text Books:

1. *Shah, R. K. and Sekulic, D. P., "Fundamentals of Heat Exchanger Design", 2012, John Wiley & Sons.*

D. Reference Books:

1. *Cengel, Y. A., "Heat transfer: A Practical Approach", 2006, McGraw Hill*
2. *Kakac, A. and Liu, H., "Heat Exchangers", 3rd edition, 2012, CRC Press.*
3. *Kays, W. M. and London, A. L., "Compact Heat Exchangers", 2016, Krieger Pub Co.*

E. Course Outcomes:

1. Analyze heat exchanger performance by using the method of log mean temperature difference.
2. Students will be able to design various heat exchanger like shell & tube heat exchanger, plate heat exchanger.

ME-525A: Finite Element Analysis (3-0-0-3)

A. Course Objectives:

1. To apply vector mechanics as a tool for problem solving
2. To Understand the need in Design for the Finite Element Method
3. To understand mechanical engineering design concepts to use the Finite Element Method software correctly and efficiently
4. To analyze a physical problem, develop experimental procedures for accurately investigating the problem, and effectively perform and document findings.
5. To understand forces associated with different parts of a machine

B. Course Content:

Overview of engineering systems- Continuous and discrete systems Energy methods: Variational principles and weighted residual techniques (least square method, collocation, sub-domain collocation, Galerkin method) for one-dimensional equation, Rayleigh-Ritz Formulation, development of bar and beam element, application to truss and frames.

Finite elements for two-dimensions- Equivalence between energy formulation and Galerkin approach, discretization concepts, choice of elements, derivation of element shape functions (Lagrangian and Hermite) in physical coordinates, Iso-parameteric mapping, numerical integration, Assembly procedure, solution techniques.

Introduction to finite element programming- Applications to problems in engineering: plane elasticity, heat conduction, potential flow and Transient problems. Computer implementation.

C. Text Books:

1. *Bathe, K. J., "Finite element procedures", 2006, Prentice Hall, Indian edition.*
2. *Fish, J. and Belytschko, T., "A first course in finite elements", 2007, Wiley, USA.*
3. *Cook, R. D., Malkus, D. A., Plesha, M. E., Witt, R. J., "Concepts and Applications of finite element analysis", 4th edition, 2002, John Wiley & Sons.*

D. Reference Books:

1. *Szabo, B. and Babuska, I., "Introduction to finite element analysis", 2011, John Wiley & Sons, UK.*
2. *Zienkiewicz, O. C. and Taylor, R. L., "The finite element method", Volume 1 & 2, 5th edition, 2000, Butterworth Heinemann, New Delhi.*

E. Course Outcomes:

Student will be able to:

1. understand the numerical methods involved in Finite Element Theory
2. understand the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation
3. understand direct and formal methods for deriving finite element equations
4. understand global, local, and natural coordinates
5. understand the formulation of one-dimensional elements (truss and beam)
6. understand the formulation of two-dimensional elements (triangle and quadrilateral continuum and shell elements)
7. understand the formulation of three-dimensional elements (tetrahedral and brick elements)

ME-525B: Advanced IC Engine (3-0-0-3)

A. Course Objectives:

1. To understand the underlying principles of operation of different IC engines and components.

2. To understand the combustion process in SI engine and CI engine and emissions formation during the combustion cycle and their treatment.
3. To provide knowledge on pollutant formation, control, alternate fuel.

B. Course Content:

Spark ignition engines- Mixture requirements, Fuel injection systems, Single point, Multipoint & Direct injection, Stages of combustion, Normal and Abnormal combustion, Knock, Factors affecting knock, Combustion chambers.

Compression ignition engines- Diesel Fuel Injection Systems, Stages of combustion, Knocking, Factors affecting knock, Direct and Indirect injection systems, Combustion chambers, Fuel Spray behaviour, Spray structure and spray penetration, Air motion, Introduction to Turbocharging.

Pollutant formation and control- Pollutant, Sources, Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter, Methods of controlling Emissions, Catalytic converters, Selective Catalytic Reduction and Particulate Traps, Methods of measurement, Emission norms and Driving cycles.

Alternative fuels- Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel, Properties, Suitability, Merits and Demerits, Engine Modifications.

Recent trends- Air assisted Combustion, Homogeneous charge compression ignition engines, Variable Geometry turbochargers, Common Rail Direct Injection Systems, Hybrid Electric Vehicles, NOx Adsorbers, Onboard Diagnostics.

C. Text Books:

1. *Ganesan, V., "Internal Combustion Engines", 4th edition, 2017, Tata McGraw-Hill.*
2. *Smith, D., "Auto Fuel Systems", 2nd edition, 1992, The Good Heart Willcox Company, Inc.*

D. Reference Books:

1. *Mathur. R.P. and Sharma, M. L., "Internal Combustion Engines", 2014, Dhanpat Rai & Sons.*
2. *Ramalingam, K. K., "Internal Combustion Engine Fundamentals", Scitech Publications.*
3. *Chowenitz, E., "Automobile Electronics", SAE Publications.*

E. Course Outcomes:

The student will be able to explain

1. design parameters like fuel-air mixtures and cycle analysis
2. gas exchange processes and motion of charge in the cylinder and its effects on combustion process in SI and CI engines and control the pollutant formation
3. flow in carburetor and Intake manifolds
4. future internal combustion engine technology

ME-525C: Two-phase Flow and Heat Transfer (3-0-0-3)

A. Course Objectives:

The course is designed to meet with the following objectives:

2. To provide a rudimentary exposure to the thermo-fluid transport phenomena in one of the simplest multiphase systems: two-phase.
3. To formulate and solve problems associated with two-phase flow phenomena.
4. Design heat transfer equipment in which phase change (boiling or condensation) takes place.

B. Course Content:

Introduction- Basic definitions; Review of one-dimensional conservation equations in single phase flows; Governing equations for homogeneous; pressure gradient components; flow patternsmaps for horizontal and vertical systems; Simplified treatment of stratified, bubbly, slug and annular flows, Pressure Drop in Two-Phase Flow, brief discussion on Critical Flow.

Basic flow models- Homogeneous flow model, pressure gradient, twophase friction factor for laminar flow and turbulent flow, two phase viscosity, modeling of two phase flow.

Boiling- Evaporation, nucleate boiling, convective boiling; bubble formation and limiting volume; boiling map; nucleation and dynamics of single bubbles, critical boiling conditions; static and dynamic instabilities;empirical correlations in two phase flow, critical heat flux and interfacial phenomena, rohsenow correlation for nucleate boiling, pool and boiling crisis.

Condensation- Types of condensation, Nusselt theory, deviations from Nusselt theory, practical equations, condensation of flowing vapors; introduction to boiling and condensation in small passages.

C. Text Books:

1. *Ghiaasiaan, S. M., "Two-Phase flow, Boiling, and Condensation", 2nd edition, 2017, Cambridge UniversityPress.*
2. *Brennen, C.E., "Fundamentals of Multiphase Flow", 1st edition, 2009, Cambridge University Press.*

D. References

1. *Collier, J. G. and Thome, J. R., "Convective Boiling and Condensation", 3rd edition, 1996, Oxford UniversityPress.*
2. *Tong, L. S. and Tang, Y. S., "Boiling Heat Transfer and Two-Phase Flow", 2nd edition, 1997, CRC Press.*

E. Course Outcomes:

Upon completion of the subject, the students should:

1. describe the most important phenomena and principles of two-phase flow in engineering applications.
2. apply the basic two-phase models and flow pattern maps to calculate the pressure drops of two-phase flow at various conditions.

3. apply the models of critical flow and flooding to analyze limiting flow of engineering processes.
4. explain the main points of boiling and condensation, heat transfer, and their enhancement methods.
5. describe the concept boiling crisis (e.g., DNB - departure from nucleate boiling, and dryout) and its modelling.

ME-525D: Boundary Layer Theory (3-0-0-3)

A. Course Objectives:

The course is design to meet with the following objectives:

1. An understanding of fluid mechanics fundamentals, including concepts of mass and momentum conservation.
2. Knowledge of laminar and turbulent boundary layer fundamentals.
3. An exposure to recent developments in fluid mechanics, with application to aerospace systems.

B. Course Content:

Introduction- A general review of basic concepts, physics and mathematical descriptions of viscous flow; BL parameters; Prandtl Laminar BL equations.

Navier-stokes equation and its application- Navier-Stokes equations and some of the exact solutions; Understand the boundary layer model and different analytic methods.

Solution to boundary layer- Flat plate at zero angle of incidence, method of exact solution Blassius solution to boundary layer problems, Approximate solutions - Vonkarman solution to boundary layer flows over the flat plate, flow with pressure gradient, flow over a cylinder, plane Couette flow, flow between parallel plates.

Thermal boundary layers- Heat transfer from heated surface. Heat transfer from cold surface, thermal boundary layer growth over the hot and cold surface, flow over the flat plate with different flow conditions with heat transfer, exact and approximate solutions to thermal boundary layer flows relation between thermal and hydrodynamic boundary layer theories, Reynolds analogy and Colburn analogy, non-dimensional numbers governing boundary layer flows.

Boundary layer control- Need of boundary layer control, causes of boundary layer separation, flow over the cylinder and aerofoil for different flow conditions leads separation, Advanced Boundary layer Theory- Similarity solutions to the BL equations (other than a flat plate); Similarity solutions to thermal BL; Energy Equation in thermal BL.

C. Text Books:

1. *Schlichting, H. and Gersten, K., Boundary Layer Theory, 8th edition, 2000, Springer.*
2. *Panton, R. L., Incompressible Flow, 3rd edition, 2006, Wiley,*

D. Reference Books:

1. *White, F., "Fluid Mechanics", 8th edition, 2017, TMH.*
2. *Munson, B. R., Young, D. F., Okiish, T. H., "Fundamental of Fluid Mechanics", 7th edition, 2012, Wiley.*

E. Course Outcomes:

Upon completion of the subject, students will have the:

1. knowledge of basic fluid dynamics.
2. knowledge of control volume analysis.
3. ability to use differential equations to understand pressure and velocity variations.
4. knowledge of dimensional analysis.
5. ability to determine "losses" in flow systems.

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Department of Electronics & Communication Engineering

M.Tech. in VLSI & Embedded Systems (2019 Onwards)

Semester - 1

Code	Subject	L	T	P	Credit
MAS XXX	Mathematics	3	0	0	3
ECE 501	Physics of Semiconductor Devices	3	0	0	3
ECE 502	Digital CMOS IC	3	0	0	3
ECE 503	Analog IC Design	3	0	0	3
ECE 504	Embedded Systems &IoT	3	0	0	3
ECE 505	VLSI Lab I	0	0	8	4
ECE 506	Embedded Systems Design Lab I	0	0	4	2
					21

Semester - 2

Code	Subject	L	T	P	Credit

ECE 521	Mixed Signal IC Design	3	0	0	3
ECE XXX	Elective I	3	0	0	3
ECE XXX	Elective II	3	0	0	3
ECE XXX	Elective III	3	0	0	3
ECE 523	VLSI Lab II	0	0	4	2
ECE 524	Embedded Systems Design Lab - II	0	0	8	4
					18

Semester - 3

Code	Subject	L	T	P	Credit
ECE 691	M-Tech Thesis Preliminary	-	-	-	10
					10

Semester - 4

Code	Subject	L	T	P	Cr
ECE 692	M-Tech Thesis Final	-	-	-	16
					16

List of Electives

Code	Subject	L	T	P	Credit
ECE 531	MEMS & Microsystem	3	0	0	3
ECE 532	Memory Design & Testing	3	0	0	3
ECE533	Embedded Systems for Industrial Automation	3	0	0	3
ECE 534	CAD for VLSI	3	0	0	3
ECE 535	RF IC Design	3	0	0	3

ECE 536	Testing &Verification	3	0	0	3
ECE 537	VLSI System Design	3	0	0	3
ECE 538	VLSI DSP Architectures	3	0	0	3
ECE 539	Pattern Recognition & Machine Learning	3	0	0	3
ECE 540	Wireless Communication	3	0	0	3

Name of the Module: Physics of Semiconductor Devices

Module Code: ECE-501

Credit Value: 3 {L = 3, T = 0, P = 0}

A. Objectives:

The course is design to meet with the objectives of:

- Imparting theoretical and practical knowledge to the students in the area of Heterostructure.
- Providing teaching and learning to make students acquainting with advanced semiconductor devices.
- Injecting the future scope and the research direction in the discipline of HBT & HEMT.

B. **Course Content**

***Semiconductor fundamentals*:** Band theory, E-k diagram, Effective mass, Density of states, Statistics, Carrier density, Degeneracy, Compensation.

***Transport*:** Ohm's law, Mobility, Boltzmann equation, Hall mobility, Diffusion, Scattering mechanisms, Hot electrons.

***Excess carriers*:** Recombination in direct gap, SRH theory, Traps, Continuity equation.

***P-N Junction theory*:** Band diagram of semiconductor P-N junction, Depletion width, Built-in potential, I-V characteristics, Varactor diode.

***Bipolar junction transistors*:** Minority carrier distribution and terminal currents, Generalized biasing, Switching, Secondary effects, Frequency limitations of transistors.

***MOS Capacitors and MOSFETs*:** Band diagram under depletion, Inversion and accumulation, Threshold voltage and its control, C-V curves, I-V characteristics, Gradual channel approximation, Charge sheet model, Pao-Sah current formulation, Subthreshold current conduction, Channel length modulation, Hot electrons.

Advanced MOSFETs: CMOS scaling, Short channel effects, Threshold voltage roll-off, DIBL, GIDL, Gate leakage current, Hot carrier injection, Punch through, Silicon-on-insulators (SOI) MOSFETs, Low Power and high speed design issues.

Heterostructures and Quantum Well Devices: Quantization and low dimensional electron gas, Influence on MOSFET characteristics, Band alignment in Si/SiGe heterostructures, High electron mobility transistors (HEMTs), Quantum Well FETs, FinFET, FDSOI.

C. Text and Reference Books:

1. B. G. Streetman and S. K. Banerjee, "Solid State Electronic Devices", 6/e, PHI Private Limited, 2011.
2. P. Bhattacharya, "Semiconductor Optoelectronic Devices", 2/e, PHI, 2009.
3. G. Massobrio and P. Antognetti, "Semiconductor Device Modeling with SPICE", 2/e, TMH, 2010.
4. C. C. Hu, "Modern Semiconductor Devices for Integrated Circuits", Pearson Education, 2010.
5. R. S. Muller and T. I. Kamins, "Device Electronics for Integrated Circuits", 3/e, Wiley India, 2009.
6. S. M. Sze and K. K. Ng, "Physics of Semiconductor Devices", 3/e, Wiley India, 2010.
7. Y. Tsividis, "Operation and Modeling of the MOS transistor", 2/e, TMH, 1999.
8. D. A. Neamen and D. Biswas, "Semiconductor Physics and Devices", 4/e, TMH, 2012.

D. Course Outcomes:

Upon completion of the subject:

- Students will be adequately trained to research on HBT & HEMT.
- Students will be skilled both theoretically and practically to use this subject for the application in wirelesscommunication, optical communication and computers.

Name of the Module: Digital CMOS IC

Module Code: ECE-502

Credit Value: 3 {L = 3, T = 0, P = 0}

***MOS transistor theory*:** Ideal I-V Characteristics, C-V Characteristics, Non-ideal I-V Effects, DC transfer characteristics.

***Electrical wire models*:** The ideal wire, The lumped model, The lumped RC model and The distributed RCline.

***The CMOS inverter*:**The static CMOS inverter, The static behaviour- Switching threshold, Noise margin, The dynamic behaviour- Computing capacitances, Propagation delay, Power, Energy and Energy Delay - Dynamic, Static and Short circuit, Technology scaling and its impact.

***CMOS fabrication and layout*:** Fabrication process, Layout design rules - stick diagram, Technology related CAD issues, Manufacturing issues, Custom to semicustom and structured array design approaches, Cell based design methodology, Array based implementation approaches.

***Designing CMOS combinational logic gates*:** Static CMOS design - complimentary CMOS, Ratioed logic and pass transistor logic, Dynamic CMOS design - dynamic logic, speed and power dissipation, Signal integrity issues, Designing logic for reduced supply voltages.

***Designing sequential logic circuits*:** Timing metrics, Static latches and registers - bistability principle, Multiplexer based latches, Master-Slave edge triggered register, Low voltage static latches, Dynamic latches and registers, Pipelining, Synchronous design- Timing basics, Sources of skew and jitter, Clock distribution approaches.

***Interconnects*:** Capacitive parasitics – crosstalk, capacitance and performance in CMOS, Resistive parasitics – resistance and reliability, Electromigration and RC delay, Inductive parasitics, Reduced swing circuits.

***Arithmetic and logic circuits*:** Adder circuits – carry look-ahead adder, Carry select adder, Multipliers; Barrel shifters, General purpose functional blocks and ALU design.

***Low power circuits*:** Leakage in CMOS nanometric technologies, Modelling for designing in deep submicron technologies, Low power dynamic logic circuits, Circuit techniques for dynamic power reduction, Circuit techniques for leakage reduction,adiabatic and clock powered circuits.

Text and reference Books:

1. J.M. Rabaey, A. Chandrakasan and B. Nikolic, "Digital Integrated Circuits- A Design Perspective", 2/e, PHI, 2003
2. S.M. Kang and Y. Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", 3/d, McGraw Hill, 2003
3. J. P. Uyemura, "Introduction to VLSI Circuits and Systems", Springer, 2014
4. David A. Hodges, Horace G. Jackson and R. A. Saleh, "Analysis and Design of Digital Integrated Circuits in Deep Submicron Technologies", 3/e, McGraw-Hill, 2003.

Name of the Module: Analog IC Design
Module Code: ECE-503
Credit Value: 3 {L = 3, T = 0, P = 0}

F. Course Objectives:

The course is designed to meet with the objectives of:

To develop both a solid foundation and methods of analyzing circuits by inspection so that the audience learns the approximations to be made in circuits and the subsequent error to be expected in individual approximation.

G. Course Content:

Review of MOS transistor: MOSFET structure, MOS I-V characteristics, Second order effects,

MOS device models;**Single stage amplifiers:** Common source, Source follower, Common gate,

Cascode; **Analog CMOS sub-circuits:** MOS switch, Current sink and sources, Current mirrors,

Current and voltage references.

Differential amplifiers: Single ended and differential, Basic differential pair; Common mode response, Gilbert cell;**Frequency response of amplifiers:** Miller effect,Common source stage, Source followers, Common gate, Cascode stage, Differential pair.

Noise: Characteristics, types and representation, Noise in single stage and differential amplifiers;**Feedback:** Properties of feedback circuits, Types, Feedback topologies, Effect of loading;

Oscillators: General Consideration, Ring oscillators; LC oscillators, Voltage Controlled Oscillators.

Operational amplifiers: Basic concepts, Performance parameters, One stage Op-amp, Two stage Op-amp, Gain boosting, Slew rate, Power supply rejection ratio, Stability and frequency compensation; **High performance CMOS Op-amps**: Micropower Op-amps, Low noise Op-amps, Low voltage Op-amps;**Comparators:** Characterization, Two stage open loop comparator, Other open loop comparators, Improving the performance of open loop comparators.

H. TextBooks

1. B. Razavi, "Design of Analog CMOS Integrated Circuits", 2/e, McGraw Hill, 2017.
2. Gray, Hurst, Lewis and Meyer, "Analysis and Design of Analog Integrated Circuits", 5/e, Wiley, 2009.
3. Adel Sedra and Kenneth C. Smith, "Microelectronic Circuits", 7/e, Oxford University Press, 2017.
4. P. E. Allen and D. R. Holberg, "CMOS Analog Circuit Design", 3/e, Oxford University Press, 2017.

I. Reference Books

1. R. Jacob Baker, Harry W. Li and David E. Boyce, "CMOS: Circuit Design, Layout, and Simulation", 1/e,Wiley, 2009.
2. T. C. Carusone, D. Johns and K. Martin, "Analog Integrated Circuit Design", 2/e, Wiley, 2013.
3. Recent Literature in Analog IC Design.

J. Course Outcomes:

The outcomes of course are the following:

1. To draw the equivalent circuit of MOS based analog circuits for a given specification
2. To evaluate performance metrics for a given specification and equivalent circuit
3. To analyze the frequency response of different amplifiers using equivalent model

Name of the Module: Embedded Systems & IoT
Module Code: ECE-504
Credit Value: 3 {L = 3, T = 0, P = 0}

K. Course Objectives:

The course is designed to:

- understand the requirement of embedded system and IoT
- Provide a basic approach to problem solving related to embedded system and IoT.
- understand the operation of 8051 and PIC
- introduce ARM processor family, Raspberry Pi and Arduino processor
- understand the concept of reconfigurable processor
- understand the concept of RTOS
- develop a clear understanding of the IoT
- Analyze various types of embedded system.

L. Course Content

Review of Embedded system: Requirements of embedded system, Hardware software co-design, architecture, challenges and design issues in embedded systems.

Review:of8051 and PIC, design consideration and applications.

Advance Microcontroller:ARM- Introduction to ARM processor and ARM processor family,

architecture and advance functionality of ARM and programming techniques, exception handling, case

study, Raspberry Pi-Architecture and advance functionality of the latest Raspberry Pi, programming

techniques, exception handling, case study.

Advanced Arduino processor:Architecture and advanced functionality of the Arduino and Intel Galileo, programming techniques, exception handling, case study.

FPGA based embedded system:Programmable interconnect; partitioning and placement routing resources, delays, Dynamic architecture using FPGAs, reconfigurable systems, arbiter design, application case studies.

RTOS: Tasks, process and threads, Multi-processing and multi-tasking, Task scheduling, Inter process communication, message passing, interrupt driven input and output – non-maskable interrupt, software interrupt. Threads – single, multi-thread concept; multitasking sequential circuit, task synchronization techniques. Handling of interrupts in RTOS and timing analysis.

***Application*:**Implementation of advance embedded controller for actuator and sensor interfacing, high end application in the field of robotics.

***IoT*:** Introduction to IoT Platform, Data management, Artificial intelligence application in IoT, cloud computing, IoT Security, IoT device energy level issues. Interfacing a sensor and Appliances control through server; Design challenges.

M. Text and Reference Books:

a) Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C",2/e, Pearson, 2007.
b) Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi, "AVR Microcontroller and Embedded Systems", 1/e, Pearson, 2012.
c) Andrew Robinson and Mike Cook, "Raspberry Pi Projects", 1/e, Wiley, 2014.
d) Arockia Bazil Raj, "FPGA-Based Embedded System Developer's Guide", 1/e, CRC Press, 2018.
e) Cuno Pfister, Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud (Make: Projects)", 1/e, Shroff,2011.

Name of the Module: VLSI Lab I
Module Code: ECE-505
Credit Value: 4 {L = 0, T = 0, P = 4}

List of Experiments

1. Standard Cell design of static CMOS based inverter, buffer, NAND gate and NOR gate for equal rise, fall time around a load of 1Pf.
2. Standard Cell design of conventional Master-Slave configured D Latch and D Flip-Flop.
3. Standard Cell design of Transmission-Gate (TG), TG based Multiplexer and De-multiplexer for equal rise, fall time around a load of 1Pf.
4. Standard Cell design of 1 bit digital comparator, priority Encoder/Decoder and Adder/Subtractor around a load of 1Pf.
5. Design & Analysis of a ring oscillator and VCO.
6. Design of a 4 bit memory (comprising of bit cell and row/column decoder).

Name of the Module: Embedded Systems Design Lab I
Module Code: ECE-506
Credit Value: 2 {L = 0, T = 0, P = 4}

List of Experiments

1. To study Proteus design suit, Arduino and Galileo:Blinking LED, Driving RGB LED, Driving multiple LEDs, Driving relays using push button, Driving a motor using timer and interrupt, Reading a sensor data and store in memory and resend to a target port.
   2 links 2 DoF joint controller design-
   I. Planning
   II. Algorithm development
   III. Simulation
   IV. Implementation and verification

2. To study Experiments using Raspberry Pi:Python tutorial and practices, IoT Smart garage door opener using Raspberry Pi, Real Time Face Recognition using Raspberry Pi and Opencv.
3. FPGA based embedded system design:Simulation and Implementation, Writing a basic software application to access peripherals devices, adding a timer and interrupt controller generate periodic events, Arbiter design for sensors and actuators interfacing-
   I. Planning
   II. Algorithm development
   III. Simulation
   IV. Implementation and verification

Name of the Module: Mixed Signal IC Design
Module Code: ECE-521
Credit Value: 3 {L = 3, T = 0, P = 0}

***Switched capacitor circuits*:** Switched capacitor amplifiers, Switched capacitor integrators, z domain models of two phase switched capacitor circuits, 1st and 2nd order switched capacitor circuits, Switched capacitor filters.

***Analog filter design*:** Bilinear transfer functions and frequency, cascade design with 1st order circuits, The biquad circuit, Butterworth lowpass filters, Butterworth bandpass filters, The Chebyshev response, Frequency transformations, Highpass and band elimination filters, Ladder design, Leapfrog simulation of ladders.

Phase locked loops: Revision of VCOs,Simple PLL, Charge pump PLLs, Nonideal effects in PLLs; Delay locked loops, Applications.

***Data converter fundamentals*:** Ideal D/A converters, Ideal A/D converter; Serial and Flash D/A converters and A/D converters, Medium and High Speed converters, Over-sampling converters, Performance limitations, Design consideration.

Text and Reference Books:

1. B. Razavi, "Design of Analog CMOS Integrated Circuits", 2/e, McGraw Hill, 2017.
2. Gray, Hurst, Lewis and Meyer, "Analysis and Design of Analog Integrated Circuits", 5/e, Wiley, 2009.
3. Adel Sedra and Kenneth C. Smith, "Microelectronic Circuits", 7/e, Oxford University Press, 2017.
4. R. Jacob Baker, Harry W. Li and David E. Boyce, "CMOS: Circuit Design, Layout, and Simulation", 1/e,Wiley, 2009.
5. T. C. Carusone, D. Johns and K. Martin, "Analog Integrated Circuit Design", 2/e, Wiley, 2013.
6. Phillip E. Allen and Douglas R. Holberg, "CMOS Analog Circuit Design", 3/e, Oxford University Press, 2013.

Name of the Module: VLSI Lab II
Module Code: ECE-521
Credit Value: 2 {L = 0, T = 0, P = 4}

List of Experiments

1. Characterization of NMOS & PMOS Transistor (both DC and AC) and Analysis of current equation.
2. Standard Cell design of a Common Source / Common Gate / Common Drain Amplifier for different loads (like 50fF, 500fF and 1pF).
3. Standard Cell design of a Single stage Cascode Amplifier for different loads (like 50fF, 500fF
   and 1pF).
4. Standard Cell design of a Current Mirror along with Differential Pair for different loads (like 50fF, 500fF and 1pF).
5. Design of a single and two-stage Op-Amp with different loads (like 50fF, 500fF and 1pF).
6. Design and Analysis of an ideal PLL circuit.

Name of the Module: Embedded Systems Design Lab II
Module Code: ECE-521
Credit Value: 4 {L = 0, T = 0, P = 8}

List of Experiments

1. To study distributed embedded system using Proteus design suit.
2. Robot multiple link joint controller for industrial automation.
3. ARM based embedded system design using μKeil simulator and implementation using ARM
   .
4. Demonstrate ARM Cortex-M Programming using μKeil and debugging using Unilink LED pattern design using input/output ports.
5. To study timing analysis using logic analyzer for automatic material handling system.
6. To study the embedded security for embedded system.
7. To study embedded system development techniques using Matlab.
8. To study embedded system development techniques using Labview.

List of Electives

Name of the Module: MEMS & Microsystem
Module Code: ECE-531
Credit Value: 3 {L = 3, T = 0, P = 0}

Overview of MEMS and Microsystems: Introduction, Evolution of MEMS, Microfabrication, Typical MEMS, Microsystems products and their applications, Introduction to smart materials and systems.

Working principles of MEMS and Microsystems: Introduction to microsensors and microactuators, Electrical and mechanical concepts in MEMS, Sensing techniques for MEMS piezoresistive, Piezoelectric, Capacitive and Optical sensing methods, Piezoresistive sensor materials, piezoelectric materials, Applications for tactile, flow, inertia and pressure sensors, Microactuation techniques for MEMS: Actuation methods using thermal forces, piezoelectric crystals and electrostatic forces, Examples of MEMS based microsensors and microactuators.

Microsystems materials: Substrates and wafers, active substrate materials, Gallium Arsenide, Quartz, piezoelectric crystals.

Fabrication processes: Silicon wafer processing, Thin film deposition, Photolithography, Diffusion, Ion Implantation, Oxidation, Chemical Vapor Deposition, Physical vapor deposition – Sputtering, Deposition by Epitaxy, Etching Techniques, packaging materials.

Micromachining processes: Bulk Micromachining and Surface Micromachining, the LIGA Process, other moulding techniques, Introduction to soft lithography and thick film processing, Overview of polymers in MEMS, MEMS for RF Applications.

Electronic circuits for MEMS and Microsystems Semiconductor devices: Interface electronics for MEMS, Overview of Diodes, BJT, MOSFET, CMOS, Electronic amplifiers, Operational amplifiers, Differential amplifiers, Wheatstone Bridge circuits for measurement of resistance and analog to digital converters for MEMS and Microsystems, Signal conditioning for Microsystems devices,Differential charge measurement, switched capacitor circuits for capacitance measurement, Control and Microsystems, Smart sensors and MEMS, MEMS Simulators.

Text and Reference Books:

1. T. R. Hsu, "MEMS and Microsystems Design and Manufacture", 1/e, Tata McGraw-Hill, 2017.
2. S. D. Senturia, "Microsystem Design", 1/e, Springer, 2003.
3. M. J. Madou, "Fundamentals of Microfabrication: The Science of Miniaturization", 2/e, CRC Press, 2018.
4. C. Liu, "Foundations of MEMS", Pearson, 2011.
5. N. Maluf, "An Introduction to Microelectromechanical SystemsEngineering", 2/e, Artech House, 2000.
6. J. W. Gardner, "Microsensors: Principles and Applications", Wiley, 1994.

Name of the Module: Memory Design & Testing
Module Code: ECE-532
Credit Value: 3 {L = 3, T = 0, P = 0}

***Static RAM*:** Cell design – CMOS NAND and NOR memory cells, Read/Write operation, SRAM cell

layout, Address decoders – Row and column decoders, Sense amplifiers.

Memory array organization: Memory address and address decoders, row and column decoders, access time management, sense amplifiers, Single and multiport memories, Cache memories.

***Dynamic RAM*:** Three-transistor cell, one-transistor cell, external characteristics of dynamic RAM

***Read-only Memories (ROM)*:** Review of basic MOS physics – Threshold voltage and its control, EPROM, EEPROM, Flash memory, FRAMs; MOS ROM Cell arrays.

***Content Addressable Memories*:** BCAM, TCAM.

***Advanced Topics*:** Magnetic memory cells - Giant Magneto-resistance phenomenon, MRAM, ReRAM, spintronics.

Memory Modeling and testing faults in SRAMs: Open, short, bridge fault, Delay faults. Functional fault modeling and testing of SRAMs, Test for single cell and two port SRAMs, Marching Tests, Fault diagnosis & Repair algorithms, Built – in self test and design for testability of RAMs, Built in self repair architecture, Trend in embedded memory testing.

Text and Reference Books:

1. J.M. Rabaey, A. Chandrakasan and B. Nikolic, "Digital Integrated Circuits- A Design Perspective", 2/e, PHI, 2003.
2. R. Jacob Baker, Harry W. Li, David E. Boyce, "CMOS: Circuit Design, Layout, and Simulation", 2/e,Pearson, 2016.
3. A. K. Sharma, "Semiconductor Memories: Technology, Testing and Reliability", Wiley-Blackwell, 2002.
4. C. Hu, "Nonvolatile Semiconductor Memories: Technologies, Design and Applications", 1/e, IEEE, 1991.
5. K. Itoh, "VLSI Memory Chip Design", Springer, 2001.
6. G. Sun, "Exploring Memory Hierarchy Design with Emerging Memory Technologies", Springer, 2013.
7. C. Shin, "Variation Aware Advanced CMOS Devices and SRAM", 1/e, Springer, 2016.

Name of the Module: Embedded Systems for Industrial Automation
Module Code: ECE-533
Credit Value: 3 {L = 3, T = 0, P = 0}

Introduction: Embedded systems, Applications in industrial automation, Networked systems design. ***System modeling***: System specification, Hardware/software: partitioning problem, Cost estimation, Co-design, System specification and modeling.

RTOS: Task scheduling, Handling of interrupts and timing analysis.

Drives controller for industrial automation: Pneumatic drives, Hydraulic drives, Mechanical drives, electrical drive d.c. Servo motors, a.c., Servo motors features, Stepper motor, Applications and comparison of drives.

End effectors controllers for Industrial Automation:Mechanical grippers, Magnetic grippers, Vacuum grippers,Two fingered and three fingered grippers,Internal grippers and external grippers.

Sensors for Industrial Automation:Sensors for motion, vision, sonar, Joint movement etc. commonly used in industrial automation.

Design Consideration for Embedded Circuit: I/O interfacing with different drives, sensors using different advanced microcontroller.

Basics of Automation: Co-ordinate systems, Work envelope, Pitch, Yaw, Roll, Joint notations, Forward kinematics, Inverse kinematics of manipulators controller for two, Three degrees of freedom.

Embedded Controller Design Implementation: Optimization and implementation techniques using suitable embedded controller (Raspberry PI, Arduino, etc.) and FPGA.

Text and Reference Books:

1. Myke Predko, "Programming and Customizing the 8051 Microcontroller", McGraw-Hill International, 1999.
2. J. W. Stewart and J. J. Mistovich, "The 8051Microcontroller: Hardware, Software and Interfacing", 2/e, 1998.
3. M. P. Groover, M. Weiss and R. Nagel, "Industrial Robotics – Technology, Programming and Applications", McGraw-Hill, 1987.
4. K.S. Fu, C. S. George Lee and Ralph Gonzalez., "Robotics Control, Sensing, Vision and Intelligence", McGraw, 1987.
5. Yoram Koren, "Robotics for Engineers", McGraw-Hill,1985.

Name of the Module: CAD for VLSI
Module Code: ECE-534
Credit Value: 3 {L = 3, T = 0, P = 0}

Matrices: Linear dependence of vectors, Solution of linear equations, Bases of vector spaces, orthogonality, Complementary orthogonal spaces and solution spaces of linear equations.

Graphs: Representation of graphs using matrices, Paths, Connectedness, Circuits, Cutsets, Trees, Fundamentals circuit and cutset matrices, Voltage and current spaces of a directed graph and their complementary orthogonality.

***Algorithms and data structures*:** Efficient representation of graphs, Elementary graph algorithms involving BFS and DFS trees, Such as finding connected and 2-connected components of a graph, The minimum spanning tree, Shortest path between a pair of vertices in a graph.

Algorithms for VLSI physical design, Synthesis, Circuit simulation and digital design automation.

Algorithms for design automation using FPGA/CPLD, Fault tolerant systems, VLSI testing.

Text and Reference Books:

1. K. Hoffman and R.A. Kunze, "Linear Algebra", Prentice Hall, 1986.
2. N. Balabanian and T.A. Bickart, "Linear Network Theory; Analysis, Properties, Design and Synthesis", Matrix Publishers, Inc., 1981.
3. T. H. Cormen, C. E. Leiserson and R.L. Rivest, "Introduction to Algorithms", MIT press and McGraw Hill,1990.
4. N. Shervani, "Algorithms for VLSI Physical Design Automation", 3/e, Kluwer Academic Publishers, 1998
5. W. J. McCalla, "Fundamentals of Computer-Aided Circuit Simulation", Kluwer Academic Publishers, 1987
6. G. De Micheli, "Synthesis and Optimization of Digital Circuits", Tata McGraw Hill, 2003.
7. S. H. Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 1999.

Name of the Module: RF IC Design
Module Code: ECE-535
Credit Value: 3 {L = 3, T = 0, P = 0}

***Introduction*:** Basics of RF systems, Review of circuit theory- impedance concept, reflection and maximum power transfer.

***Tuned Circuits*:** Series and parallel RLC networks, Q-factor, matching

***RF IC components*:** Resistance, capacitance and inductance, skin effect; Review of MOS transistor.

***Transmission Lines*:** The wave equation and its solutions, reflections, lossy transmission lines, Smith chart and its use.

***RF Amplifiers*:** Amplifier topologies, bandwidth estimation, rise-time, delay and bandwidth, Shunt-series amplifiers, Cascaded amplifiers.

Power amplifiers: Class A, B, AB and C amplifiers, Switching power amplifiers, RF power amplifier design examples.

Noise: Signal and noise, Noise sources – thermal noise, flicker noise; noise figure, Intrinsic MOS noise parameters, Power match vs noise match, Low noise amplifier concept.

Oscillators: Oscillator topologies, RF Resonators, Negative resistance oscillators.

Mixers: Multiplier based mixers, large signal performance, Design examples.

Phase Locked Loops: Linearized PLL Models; Phase detectors, charge pumps, loop filters; CMOS VCO, PLL Design examples.

Frequency Synthesis: Frequency dividers and multipliers, Frequency synthesizer examples.

Radio architectures: GSM, CDMA and UMTS system architectures.

Text and Reference Books:

1. Thomas H. Lee,"The Design of CMOS Radio Frequency Integrated Circuits", 2/e, Cambridge University Press,2004.
2. Behzad Razavi,"RF Microelectronics", 2/e, Pearson,2013.

Name of the Module: Test & Verification
Module Code: ECE-536
Credit Value: 3 {L = 3, T = 0, P = 0}

Course introduction, VLSI design flow, Need of pre-silicon verification and post-silicon validation and debug, VLSI testing needs and challenges, Test challenges, Yield, and Defects, Faults and fault models, Yield and fault equivalence.

Combinational equivalence checking, BDD operations and SAT, Logic simulation, Fault simulation, Deductive and concurrent fault simulation, Combinational equivalence checking, Automatic test pattern generation (ATPG): algebraic method.

D algorithm, PODEM, PODEM, FAN, Sequential equivalence checking, Sequential ATPG, Sequential equivalence checking, Sequential equivalence checking, Scan design, Sequential equivalence checking.

Model checking, Issues in san design, Random access scan, Random access scan, Basics of model checking,Partial scan, LTL,LTL & CTL.

Text and Reference Books:

1. M. L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital Memory and Mixed Signal VLSI Circuits", Springer, 2009.
2. H. Fujiwara, "Logic Testing and Design for Testability", MIT Press, 1985.
3. M. Abramovici, M. Breuer, and A. Friedman, "Digital System Testing and Testable Design", 1/e, Jaico Publishing House, 2001.
4. M. Huth and M. Ryan, "Logic in Computer Science- Modelling and Reasoning about Systems", 2/e, Cambridge Univ. Press, 2005.
5. T. Kropf, "Introduction to Formal Hardware Verification", 1/e, Springer, 2010.

Name of the Module: VLSI System Design
Module Code: ECE-537
Credit Value: 3 {L = 3, T = 0, P = 0}

***Basics of system hardware design*:** Hierarchical design using top-down and bottom-up methodology, System partitioning techniques, Interfacing between system components.

***Programmable Logic Devices*:** FPGA, CPLD, PLA, PAL.

***Design Phases*:** Design, Testing, Fabrication, Packaging, Abstraction and their Types.

Computer Aided Designs: Modeling &simulation, VLSI design flow, ASIC design flow.

***Designing basic building blocks*:** Digital systems design using conventional components such as gates, flip flops, PALs, and FPGAs etc.

Synchronous and Asynchronous Circuits: Concept of finite state machine (FSM), Moor and Mealy machines, synchronous FSM Design, State diagram, State assignment, Derivation of next state and Output expressions, Arithmetic logic design, Designing multi data path ALU, Algorithmic state machine. ***Memories*:** Introduction to different types of memories, Single and multiple port memories.

Introduction to GALS (Globally Asynchronous Locally Synchronous).

Introduction to Network on Chip.

Introduction to FIFO and designing fast FIFOs.

***Clocks*:** Static timing analysis; Handling multiple clock domains, Global and local clock distribution, Case studies involving system designing using CAD tools around soft-core processors and other peripherals (I/O, Memories etc.).

Processor Design*:** Von Neumann architecture, Harvard architecture, Modified Harvard architecture. ***Datapath and Control: Enhancing performance with pipelining, Exploiting memory hierarchy.

Case studies using Intel X86 family of Advanced Microprocessors: Programming model for x86 family. ***8086 Microprocessor Architecture***: Addressing modes, Instruction set, Assembly language programming; Stacks, Micros, Interrupts, Interrupt service routines, 8086 system bus structure.

***I/O Programming*. *Multiprocessor Configurations*:** Coprocessors.

Memory and I/O Interfacing: Parallel and serial communication interface, D/A and A/D interface, Timers.

Keyboard/display controller: Interrupt controller, DMA controller.

Hardware of 186, 286, 386, 486 & Pentium processors.

Text Books:

1. M. Morris Mano, "Digital Logic & Computer Design", 1/e, Pearson, 2016.
2. D. A. Patterson and J. L. Hennessy, "Computer Organization and Design: The Hardware/Software Interface", 2/e, Morgan Kaufmann Publishers Inc., 1998.
3. J. Rabaey, A. Chandrakasan and B. Nikolic, "Digital Integrated Circuits - A Design Perspective", 2/e, Pearson Education, 2011.

Name of the Module: VLSI DSP Architectures
Module Code: ECE-538
Credit Value: 3 {L = 3, T = 0, P = 0}

***Introduction to digital signal processing systems*:** Typical DSP algorithms, DSP application demands and scaled CMOS technologies, Representations of DSP algorithms.

***Iteration bound*:** Data flow graph representation, Loop bound and iteration bound, Algorithms for computing iteration bound, Iteration bound of multirate data flow graphs.

Pipelining and parallel processing: Pipelining of FIR digital filters, Parallel processing, Pipelining and parallel processing for low power.

Retiming: Definition and properties, Solving system of equalities, Retiming techniques.

Unfolding: Algorithm for unfolding, Properties of unfolding, Critical path, Unfolding and retiming, Applications.

Folding: Folding transformation, Register minimization techniques, Register minimization in folded architectures, Folding of multirate systems.

Systolic architecture design: Systolic array design methodology, FIR systolic arrays, Selection of scheduling vector, Systolic design for space representations containing delays.

Fast convolution: Cook Toom, Winograd and Iterated algorithm, Cyclic Convolution.

Algorithmic strength reduction in filters and transforms: Parallel FIR filters, DCT and inverse DCT, Parallel architectures for rank order filters.

Pipelined and parallel recursive and adaptive filters: Pipeline interleaving in digital filters, Pipelining in 1storder IIR digital filters, Pipelining in high order IIR digital filters, Parallel processing for IIR filters, Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.

Scaling and round off noise: State variable description of digital filters,Scaling androundoff noise computation, Roundoff noise in pipelined IIR filters, Roundoff noise computation using state variable description.

Digital Lattice Filter Structures: Digital basic lattice filters, Derivation of one multiplier, Normalized, Scaled normalized lattice filter, Roundoff noise calculation, Pipelining of lattice IIR digital filter.

Bit Level Arithmetic Architectures: Parallel multipliers, Bit serial multipliers, Bit serial filter design,Distributed arithmetic.

Redundant Arithmetic: Subexpression elimination, Multiple constant multiplication, Additive and multiplicative number splitting.

Text and References Books

1. K. K. Parhi, “VLSI Digital Signal Processing and Systems, Design and Implementation”, John Wiley, 1999.

2. U. Meyer Baese, "Digital Signal Processing with FPGA", 3/e, Springer, 2007.
3. S. Ramachandran, "Digital VLSI Systems Design", Springer 2007
4. K. Madisetti, "VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis", IEEE Press 1995.

Name of the Module: Pattern Recognition & Machine Learning
Module Code: ECE-539
Credit Value: 3 {L = 3, T = 0, P = 0}

Introduction: Problem framing, feature selection, Dimensionality reduction using PCA and other methods.

Discriminative classifiers: LDA, Multi-layer perceptron, Backpropagation, SVM.

Unsupervised learning: Clustering, Vector quantization, Kohonen map, EM algorithm, ***Generative models***: Definition and characteristics, probabilistic graphical models, density estimation in learning.

Combining classifiers: Advantages, Boosting, Hierarchical classifiers and issues, Selected special topics such as manifold learning and case studies.

Text and Reference Books:

1. S. Marsland, "Machine Learning: An Algorithmic Perspective", 2/e, Chapman & Hall/CRC, 2014.
2. R. O. Duda, P. E. Hart and D. G. Stork, "Pattern Classification", 2/e., Wiley, 2007.
3. C. M. Bishop, "Pattern Recognition and Machine Learning(Information Science and Statistics)", 1/e, Springer, 2006.
4. I. H. Witten, "Data Mining: Practical Machine Learning Tools And Techniques", 3/e, Elsevier, 2014.

Name of the Module: Wireless Communication
Module Code: ECE-540
Credit Value: 3 {L = 3, T = 0, P = 0}

Overview of current wireless systems and standards;

Wireless channel models: path loss and shadowing models; statistical fading models; narrowband and wideband fading models; MIMO channels.

Diversity in wireless communications - Non-coherent and coherent reception; error probability for uncoded transmission; realization of diversity: time diversity; frequency diversity: DSSS and OFDM; receiver diversity: SC, EGC and MRC; transmit diversity: space-time codes;

Information theory for wireless communications- Capacity of fading channels: ergodic capacity and outage capacity; high versus low SNR regime; waterfilling algorithm; capacity of MIMO channels;

Multiuser wireless communications: multiple access: FDMA, TDMA, CDMA and SDMA schemes; interference management: power control; multiuser diversity, multiuser MIMO systems.

Texts & Reference Books:

1. A. J. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.
2. D. Tse and P. Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.
3. A. Molisch, *Wireless Communications*, John Wiley & Sons, 2005.
4. S. Haykin and M. Moher, *Modern Wireless Communications*, Pearson Education, 2005.
5. T. S. Rappaport, *Wireless Communications*, Prentice Hall, 1996.
6. G. L. Stuber, *Principles of Mobile Communications*, Kluwer, 1996.
7. T. Cover and J. Thomas, *Elements of Information Theory*, John Wiley & Sons, 1991.

Course Curriculum for M. Sc.

in

Applied Physics

(For students admitted in 2019-20 onwards)

National Institute of Technology
Arunachal Pradesh

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Course Structure and Syllabus for M.Sc. in Applied Physics

Semester-I

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH401	Mathematical Methods-I	3	0	0	3	3
2	APH402	Classical Mechanics	3	0	0	3	3
3	APH403	Quantum Mechanics-I	3	0	0	3	3
4	APH404	Statistical Mechanics	3	0	0	3	3
5	APH405	Electrodynamics-I	3	0	0	3	3
6	APH 406	Physics Lab-I	0	0	4	4	2
		Total	15	0	6	19	17

Semester-II

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH407	Mathematical Methods-II	3	0	0	3	3
2	APH408	Condensed Matter Physics	3	0	0	3	3
3	APH409	Quantum Mechanics-II	3	0	0	3	3
4	APH410	Electrodynamics-II	3	0	0	3	3
5	APH411	Numerical Methods and Programming	3	0	2	5	4
6	APH412	Physics Lab-II	0	0	4	4	2
		Total	15	0	4	21	18

Semester-III

Sl.	Subject	Subject	L	T	P	Hours/Week	Credit

No.	Code						
1	APH501	Semiconductors Physics and Devices	3	0	0	3	3
2	APH502	Nuclear and Particle Physics	3	0	0	3	3
3	APH503	Advance Electronics and Communications	3	0	0	3	3
4	APH504	Atomic and Molecular Physics	3	0	0	3	3
5	APH505	Advanced Atmospheric Physics	3	0	0	3	3
6	APH506	Physics Lab-III	0	0	4	4	2
		Total	15	0	8	19	17

Semester-IV

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH507	Project Work and Viva	0	0	20	20	10
2	APH508	Seminar Course	0	0	2	2	1
3	APH509	Elective-I	3	0	0	3	3
		Total	6	0	10	25	14

List of Electives:

1. Nano Science and Technology
2. Bio-Electronics
3. Advanced Characterization Techniques
4. General Theory of Relativity
5. Group Theory and its Applications
6. Graph Theory

N.B: More electives may be added as per the expertise of new faculty joining the department.

Semester-I

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH401	Mathematical Methods-I	3	0	0	3	3
2	APH402	Classical Mechanics	3	0	0	3	3
3	APH403	Quantum Mechanics-I	3	0	0	3	3
4	APH404	Statistical Mechanics	3	0	0	3	3
5	APH405	Electrodynamics-I	3	0	0	3	3
6	APH 406	Physics Lab-I	0	0	4	4	2
		Total	15	0	6	19	17

Name of the Module: Mathematical Methods-I
Module Code: APH 401
Semester: 1st
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

N. Course Objectives:

The course is designed to meet with the objective of:

1. The main objective of this course is to provide basic tools of mathematics which will behelpful to understand the various branches of physics and engineering.
2. Mathematical Techniques are required for theoretical physicists and even forExperimentalists.
3. The subject will meet the challenge of theoretical physicists faced.

O. **Subject Contents:**

Review of vector analysis: Curl, gradient and divergences, Stoke's theorem, Gauss divergence theorem.

Linear Algebra: Vector Spaces, subspaces, linear independence, spans, basis, dimensions, linear transformations, image and kernel, rank and nullity, change of basis, similarity transformation, inner product spaces, orthonormal sets, Gram-Schmidt procedure, dual space, eigenvalues and eigenvectors, Hilbert space.

Ordinary Differential equations:

First and Second order equations with constant coefficients, series solution-Frobenius method, Sturm-Liouville equations; Special functions: Legendre, Hermite, Laguerre and Bessel functions.

Partial Differential equations:

Laplace equation, method of separation of variables in Cartesian, Spherical and Cylindrical coordinates, Green's function and its applications, Helmholtz equation.

Integral transformations: Laplace and Fourier transformations and applications to differential equations.

P. TextBooks:

1. G. B. Arfken, H.J.Weber and F.E. Harris, "Mathematical Methods for Physicists", 7e, Academic Press(2012)
2. T. Lawson, "Linear Algebra", John Wiley & Sons (1996).
3. E.A. Coddington, "Introduction to Ordinary Differential Equations", Prentice Hall of India (1989)

Q. Reference Books:

1. S. Andrilli&D.Hecker, "Elementary Linear Algebra", Academic Press (2006)
2. S. Lang, "Introduction to Linear Algebra", 2e, Springer (2012)
3. M.L.Boas, "Mathematical Methods in Physical Sciences", John Wiley & Sons (2005)
4. P. Dennery& A. Krzywicki, "Mathematics for Physicists", Dover Publications (1996)
5. I. Sneddon, "Elements of Partial Differential Equations", Tata McGraw Hill,(2013)

R. Program Outcomes:

After completion of this subject:

1. Students will demonstrate competence with a wide variety of mathematical tools andtechniques.
2. Students will demonstrate the ability to assess the accuracy, implications and limitationsof their mathematical results.
3. Students will master the basic elements of complex mathematical analysis, including theintegral theorems; obtain the residues of a complex function and to use the residuetheorem to evaluate definite integrals.

Name of the Module: Classical Mechanics
Module Code: APH 402
Semester: 1st
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

The course is designed to meet with the objective of:

1. To introduce students to classical mechanics and its applications
2. To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics.
3. To develop skills in formulating and solving physics problems.
4. To develop self-discipline and work habits necessary to succeed in research or higher learning in the real world.

B. Subject Contents:

Lagrangian dynamics: Mechanics of a system of particles: in vector form. Conservation laws, Degrees of freedom, generalised coordinates and velocities.Lagrange's equations, applications, variational calculus and least action principle.

Hamiltonian dynamics: Generalised momenta, Legendre transformations, Hamilton's equations of motion, cyclic coordinates and conservation theorems, canonical transformations, poisson brackets, Hamilton-Jacobi theory, Action Angle variables

Central force problem: Equation of motion, orbits, Virial theorem, Kepler problem, Scattering in a central potential, Rutherford formula, scattering cross section.Rigid body motion: Orthogonal transformations, Euler angles and Euler's theorem for motion of a rigid body, Coriolis effect, angular momentum and kinetic energy, inertia tensor, Euler's motion, heavy symmetric top.

Small oscillations: Eigenvalue problems, frequencies of free vibrations and normal mode, forced vibrations and effect of dissipative forces

Special relativity: Inertial frames. Principle and postulate of relativity.Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Four- vector notation. Energy-momentum four-vector for a particle.Relativistic invariance of physical laws.

C. Text Books:

1. H. Goldstein," Classical Mechanics", 2e, Narosa Pub. House (1989).
2. W. Greiner, "Classical Mechanics", Springer-Verlag (2003)

D. Reference Books:

1. L. Landau and E. Lifshitz, "Nechanic", Oxford (1981).
2. F. Scheck, "Mechanics", Springer (1994).
3. D. Rindler, "Special Theory of Relativity", Oxford University Press (1982).

E. Course Outcomes:

1. After completion of the subject:
   1. Students will learn sufficient analytical techniques to solve many complicated physicsproblems in a more effective manner.
2. Students will learn the limitation of Newtonian methods and how it was replaced by moreadvanced method provided by Lagrange, Hamiltonian and many others.
3. They will also learn some techniques which will help them to understand the quantum physics in a smooth ways.

Name of the Module: Quantum Mechanics-I
Module Code: APH 403
Semester: 1st
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Course Objectives

The course is designed to meet with the objective of:

1. To learn the limitations of classical physics and how quantum physics successful explain thoselimitations and agree with experimental results.
2. To learn basics rules of quantum mechanics and how to solve physical problems throughquantum mechanics technique.
3. To develop skills in formulating and solving physics problems.
4. To develop self-discipline and work habits necessary to succeed in research or higher learningin the real world.

B. Subject Contents:

Introduction to Quantum Mechanics: Basic principles of quantum mechanics, Wave-particle duality, group velocity and phase velocity, uncertainty principle, wave packets, concept of probability and probability current density, position and momentum representations wavefunctions Schrodinger equation, operators, expectation values, eigenvalues and eigenfunctions

Linear vector spaces: Bra and ket vectors. Completeness, orthonormality, basis sets. Change of basis. Eigenstates and eigenvalues

One dimensional potential problems: Particle in a box, potential barriers, tunnelling, Linear harmonic oscillator: wavefunction approach and operator approach.

Three dimensional problem: Particle in a potential box and potential barrier in Cartesian coordinates

Angular momentum Algebra: Orbital and spin angular momentum operators. Commutator algebra of angular momentum operators (orbital and spin), Eigenfunctions and Eigenvalues of angular momentum operators, matrix representations of angular momentum operators, Pauil sigma matrixes, addition of angular momenta, Clebsch-Gordon coefficients.The hydrogen atom and its energy eigenvalues.Charged particle in a uniform constant magnetic field, energy eigenvalues and eigenfunctions.

Central potential problem: Radial and harmonic wave function, hydrogen atom.

C. Text Books:

1. E. Merzbacher, "Quantum Mechanics", 2e, Wiley International Edition (1970).
2. P. W. Mathews and K. Venkatesan, "A Textbook of Quantum Mechanics", Tata McGraw Hill (1995).

D. Reference Books:

1. J.J. Sakurai, "Modern Quantum Mechanics", Benjamin Cummings (1985).
2. David J. Griffiths,"Introduction of Quantum Mechanics", Pearson Education; 2010
3. B. H. Bransden and C. J. Joachain, "Introduction to Quantum Mechanics", Longman (1993).
4. L. I. Schiff, "Quantum Mechanics", Tata Mcgraw-Hill (1968).

E. Course Outcomes

After completion of the subject:

1. Students will learn the kinds of experimental results which are incompatible with classical physics and require a new development of quantum theory.
2. Students will learn how a single wave function gives all the information of physical variables like momentum, energy, angular momentum by operator and Schrodinger wavemechanics.
3. Students will learn the role of uncertainty in quantum physics and use the commutationrelations of operators to determine whether or not two physical variables can be measured simultaneously.
4. Students will learn the method of separation variables to solve problems in 3D and spherical polar coordinates and will the occurrence of degeneracy in atomic structure.
5. Students will learn some matrix technique to solve physical problems.

Name of the Module: Statistical Mechanics

Module Code: APH404
Semester: 2nd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. The course is designed to meet with the objective of:
   1. The main objective of this subject is to develop an understanding of statistical nature ofthermodynamics.
2. To provide basic theory of statistical mechanics and to apply this theory wide variety ofphysical phenomena.
3. To provide basic tools for theoretical physicists or mathematicians for their study of many-body systems or more complicated system.

B. Subject Contents:

Review of thermodynamics: Law of thermodynamics, entropy, potentials

Statistical thermodynamics: Macrostates, microstates and accessible microstates, fundamental postulate of equilibrium statistical mechanics, connection between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox

Ensemble Theory: Phase space, Liouville's theorem, microcanonical ensemble, examples, quantum states and phase space.

Canonical Ensemble: partition function, free energy, energy fluctuation, calculation of thermodynamic quantities, Classical ideal gas equation, Maxwell-Boltzmann distribution, equipartition theorem, Paramagnetism, Langevin and Brillouin functions, Curie's law

Grand Canonical Ensemble: Equilibrium, grand partition function, density and energy fluctuation, correspondence with other ensembles, examples

Quantum statistics: Quantum mechanical ensemble theory, density matrix, statistics of various ensembles, examples, systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, Pauli's exclusion principle, fermions

Theory of Simple Gasses: Ideal gas in different quantum mechanical ensembles. Systems of monoatomic, diatomic and polyatomic molecules

Ideal Bose gas: Degeneracy. Blackbody radiation.Bose-Einstein condensation, Einstein model of lattice vibrations, phonons, Debye's theory of the specific heat of crystals, Helium-II, Phase diagrams, phase equilibria and phase transitions

Ideal Fermi Gas: Free electron gas, Pauli paramagnetism, Landau diamagnetism, Dehass van Alphen effect, thermionic and photoelectric emissions, white dwarfs

Interacting systems: Cluster expansion, Virial expansion, Mean-fjeld theory of liquid-gas transition (Van der Waals model) and ferromagnet-paramagnet transition (Weiss' molecular field theory). Heisenberg exchange interaction and the origin of ferromagnetism. Elementary ideas on Ising and Heisenberg models of ferromagnetism

C. Text books

1. R. K. Pathria, "Statistical Mechanics", Elsevier (2002).
2. K. Huang, "Statistical Mechanics", John Wiley Asia (2002).

D. Reference Books:

1. F. Reif, "Fundamentals of Statistical and Thermal Physics", International Student Edition, McGraw-Hill (1988).
2. L. D. Landau and E.M. Lifshitz, Statistical Physics (Part I &1I), 3e, Pergamon Press (1989).

E. Course Outcomes:

After completion of the subject:

1. Students will learn the qualitatively and quantitatively the concept of phase transition,scaling.
2. Students will learn the qualitatively and quantitatively the concept of cooperativephenomena in disorder and equilibrium systems.
3. Students will able to compute various thermodynamic properties of idealized simpleclassical and quantum mechanical systems using standard techniques, such as thepartition function and the grand partition function.
4. Students will be able to model new physical situations using the methods exemplified inthe course.
5. Students have gained insights into more advanced methods which touch upon modern research.

Name of the Module: Electrodynamics-I
Module Code: APH405
Semester: 1st
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

The course is designed to meet with the objective of:

1. To enhance students' understanding of the fundamental laws of electrodynamics.

2. To develop the mathematical tools for Electrical and Electronics Engineering and physicists needed for doctoral-level research.

3. To develop professional habits of problem solving and research needed for success in a doctoral program.

B. Subject Contents:

Electrostatics: Continuous charge distribution, delta function, field and potential, Poisson and Laplace equations, Dirichlet and Neumann boundary conditions and uniqueness theorems, Electrostatic potential energy.

Boundary value problems: Solution of Laplace and Poisson equation in 2 & 3 dimensions, Method of images, separation of variables in Cartesian, spherical and cylindrical coordinate systems, applications; Green function formalism: Green function for the sphere, expansion of Green function in spherical coordinates; Multipole expansion.

Dielectrics: Polarization, bound charges, susceptibility, energy and force, boundary conditions, boundary value problems for dielectrics.

Magnetostatics: Biot-Savert's Law, Ampere's Law (differential and integral form), vector potential, magnetic field, moments, force and energy of localized current distributions, boundary conditions, boundary value problems.

Electrodynamics: Electromotive force, Ohm's law, faraday's law, self and mutual inductance, energy in magnetic field, Maxwell's equations, Gauge transformations, energy and momentum conservation and Poynting's theorem.

Electromagnetic waves: wave equation, propagation of electromagnetic waves in non-conducting medium, reflection and refraction at dielectric interface, total internal reflection, Goos-Hänchen shift, Brewster's angle, complex refractive index.

C. Text Book:

1. J. D. Jackson, "Classical Electrodynamics, John Wiley (Asia) (1999).
2. D. J. Grifiths, "introduction to Electrodynamics", 4th edition, Pearson (2012).

D. Reference Books:

1. L. D. Landau and E. M. Lifshitz, "Electrodynamics of continuous Media", Butterworth Heimrmann (1995)
2. J. R. Reitz and F. J. Millford, "Foundation of Electromagnetic Theory", Narosa (1986)
3. W. Greiner, "Classical Electrodynamics", Springer (1998)

E. Course Outcomes:

After completion of the subject:

1. Students will learn the deeper meaning of the Maxwellian field equations and account fortheir symmetry and transformation properties, domain of validity, and limitations.

2. Students will learn how to formulate and solve electromagnetic problems with the help

ofelectrodynamics potentials and super potentials, and make a detailed account for gaugetransformations and their use.
3. They will master the technique of deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions.
4. They will calculate the electromagnetic radiation from radiating systems (aerials, localised charge and current distributions) at rest.
5. They will formulate and solve electrodynamic problems in relativistically covariant formin four-dimensional space-time.

Name of the Module: Physics Lab-I
Module Code: APH 406
Semester: 1st
Credit Value: 2[P=4, T=0, L=0]
Module Leader:

A. Course Objectives:

1. The main objective of this subject is to verify experimentally various laws of opticalphenomena.

B. Subject Matter:

1. Determination of wavelength of light by Newton's ring method
2. Verification of Brewster's law.
3. Diffraction Experiment: Single Slit, Double Slit and grating
4. Michelson-Moerly interferometer
5. Fabry-parot interferometer experiment.

C. Text books:

1. R. A. Dunlop, "Experimental Physics", Oxford University Press(1988)
2. A. C. Melissionos, "Experiments in Modern Physics", Academic Press(1996)

D. Course Outcomes:

1. Students will learn that practical results are not always agreed with theoretical value.
2. They will able to learn the source of error of their experiments and how to minimize theseerrors.

Semester-II

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH407	Mathematical Methods-II	3	0	0	3	3
2	APH408	Condensed Matter Physics	3	0	0	3	3
3	APH409	Quantum Mechanics-II	3	0	0	3	3
4	APH410	Electrodynamics-II	3	0	0	3	3
5	APH411	Numerical Methods	3	0	2	5	4
6	APH412	Physics Lab-II	0	0	4	4	2
		Total	**15**	**0**	**4**	**21**	**18**

Name of the Module: Mathematical Methods-II
Module Code: APH-407
Semester: 2nd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. Group theory is one of the building blocks of modern algebra. Objective of this course is to introduce students to basic concepts of group theory and examples of groups and their properties.
2. The main objectives of this course are to introduce the basics of graphs, their properties and applications, to apply graph theory based tools in solving practical problems.

B. Subject Contents:

Tensors: inner and outer products, contraction, symmetric and antisymmetric tensors, metric tensor, covariant and contravariant derivatives

Complex Analysis: Functions, derivatives, Cauchy-Riemann conditions, analytic and harmonic functions, contour integrals, Cauchy-Goursat Theorem Cauchy integral formula; Series: convergence, Taylor series, Laurent series, singularities, residue theorem, applications of residue theorem, conformal mapping and application

Group Theory: Groups, subgroups, conjugacy classes, cosets, invariant subgroups, factor groups, kernels, continuous groups, Lie groups, generators, SO(2) and SO(3),SU(2), crystallographic point groups.

C. Text Books:

1. G.B.Arfken, H.J.Weber and F.E. Harris, "Mathematical Methods for Physicists", 7e, Academic Press (2012).
2. J. Brown and R.V.Churchill, "Complex Variables and Applications", McGraw-Hill, 8th Edition (2008).
3. A.W.Joshi, "Elements of Group Theory", New Age Int. (2008).

D. Reference Books:

1. A.W.Joshi, "Matrices and Tensors in Physics", 3e, New Age Int. (2005)
2. M.L.Boas, "Mathematical Methods in Physical Sciences", John Wiley & Sons (2005).
3. M. Hamermesh, "Group Theory and Its Applications to Physical Problems", Dover (1989)

E. Course Outcomes:

1. On completion of the course, the student should acquire basic knowledge of some advanced topics in Mathematical Physics, such as the elements of functional analysis, the elements of algebra and group theory and the elements of differential geometry.
2. The student should be able to solve problems within these topics and describe their significance in modern physics.

Name of the Module: Condensed Matter Physics
Module Code: APH408
Semester: 1st
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. This module will teach you the fundamental physics behind different materials we commonly see in the world around us.
2. What gives materials their properties and what are the different models to explain these properties.
3. The module will demonstrate the link between microscopic structure and bulk properties in a variety of systems in hard and soft condensed matter.
4. This class will describe the applications of hard and soft condensed matter, teaching students how materials are used in a variety of applications and modern technologies.

B. Subject Contents:

Crystallography: Elementary concepts of point and space group and its relevance to crystal structure. Interaction of X-rays with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques.

Defects in Crystals: Point defects, line defects and planer (stacking) faults. Role of defects in crystal growth. The observation of imperfections in crystals, X-ray and electron microscopic techniques.

Lattice Dynamics: Vibration of atoms in one dimensional crystal lattice, quantisation of lattice vibrations, acoustic and optical modes, dispersion relation, density of states, specific heat.

Electronic Properties of Solids: Free electrontheory of metals,Band theory: Tight-bonding model, Metal, Semiconductor and Insulators. Fermi surface, de Hass-van Alphen effect,

Semiconductor Physics: Charge carrier density in intrinsic semiconductors,Direct and Indirect band gap Semiconductors, doping of semiconductors, carrier densities in doped semiconductors, conductivity of semiconductors, Hall effect (Classical and Quantum), photo conductivity and optical absorption, Diffusion.

Magnetism: Diamagnetism, Paramagnetism, Ferro, Antiferro and Ferri Magnetism

Superconductivity: Basic phenomena, excitations and energy gap, magnetic properties of type-I and type-II superconductors, London equations, Cooper pairs, coherence, Josephson effect, BCS theory, Ginzburg-Landau theory, Ginzburg-Landau- Abrikosov theory of Type II superconductors, introduction to high-temperature superconductors.

Quantum Hall Effect: Integer quantum Hall effect, Introduction to fractional QHE.

Soft condensed Matter: Definition, forces, energies and time scales, Phase transition in soft matter, Radial distribution function, thermodynamic functions in terms of Radial distribution functions and description of liquids; Colloids, Polymers, Gels, Liquid Crystals; Soft matter in nature.

C. Text Books:

1. C. Kittel, "Introduction to Solid State Physics", John Willy, 1996.
2. H. P. Myers, "Introduction to Solid State Physics", Viva-Books, 1998.

D. Reference Books:

1. S. O. Kasap,"Principles of electronic materials and devices", McGraw Hill Company, Inc., 2006.
2. Petr Semenovič Kireev, "Semiconductor Physics", 2e,Mir, 1978.

3. Mohammad Abdul Wahab, "Solid State Physics-Structure and Properties of Materials"; Alpha Science International, 2005.
4. M. Tinkham, "Introduction to Superconductivity",Courier Corporation, 2004
5. P. K. Mishra,"Physics of Condensed Matter", Academic Press, 2012.
6. Richard A.L. Jones, "Soft Condensed Matter"; Oxford University Press; 2002

E. Course Outcomes:

1. Student will be able to understand how different kinds of matter are described mathematically and how material properties can be predicted based on microscopic structure.
2. Students will learn the importance of different materials in a variety of applications and will be able to explain how many technological devices function.

Name of the Module: Quantum Mechanics-II
Module Code: APH409
Semester: 2nd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objective:

1. To impart knowledge of advanced quantum mechanics for solving relevant physical problems.
2. Apply scientific reasoning skills to model natural, physical, social, and aesthetic phenomena using multiple modes of inquiry.

B. Subject Contents:

Time independent Perturbation theory: Nondegenerate and degenerate cases, Examples: Zeeman and stark effects, induced electric dipole moment of Hydrogen atom, real hydrogen atom, spin-orbit coupling, hyperfine interaction, Helium atom, exclusion principle, exchange interaction.

Other Approximation Solutions: Variational method, WKB approximation, applications of WKB.

Time-dependent perturbation theory: Sinusoidal perturbation, transition probabilities, Sudden and adiabatic approximations, Fermi golden rule

Quantum theory of scattering: - cross sections, partial wave analysis, phase shifts, optical theorem. Schrodinger s equation as an integral equation, Green s function, Born'sapproximation, Coulomb scattering

Relativistic wave equations: Klein-Gordon and Dirac equations, covariant form of Dirac equation, bilinear covariants, discrete symmetries of Dirac equation. Fine structure of Hydrogen atom. Interaction picture, S-matrix, T- matrix. Introduction to second quantization, quantization of free fields.

C. Text Books:

1. E. Merzbacher, "Quantum Mechanics", 2e, Wiley International Edition (1970).
2. S. Gasiorowicz, "Quantum Physics", Kohn Wiley (Asia) (2000).
3. J.J. Sakurai, "Modern Quantum Mechanics", Benjamin Cummings (1985).

D. Reference Books:

1. P.M. Mathews and K. Venkatesan, "A Textbook of Quantum Mechanics", Tata McGraw-Hill (1977).
2. Michael E. Peskin, Daniel V. Schroeder, "An Introduction To Quantum Field Theory, Student Economy Edition", Avalon Publishing, 2015
3. James D. Bjorken, Sidney David Drell, "Relativistic Quantum Mechanics", McGraw-Hill(1998)

E. Course Outcomes:

Students will have achieved the ability to:

1. Students will develop to use quantum theory to model natural and physical phenomena in materials science, chemistry and nanotechnology.
2. explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation
3. describe second quantization and related concepts.
4. explain the formalism of relativistic quantum field theory.
5. draw and explain Feynman graphs for different interactions

Name of the Module: Electrodynamics-II
Module Code: APH 410
Semester: 1st
Credit Value: 3[P=0, T=0, L=3]

Module Leader:

A. Course Objectives:

1. Understanding of various consequences and applications of Maxwell's electromagnetic theory, and in particular of various properties of electromagnetic waves and their propagation.
2. Solving of problems in the field.

B. Subject Contents:

Electromagnetic waves in conducting medium: Reflection and transmission, frequency dependence of permittivity, permeability and conductivity, electrons in conductors and plasma, wave guides: waves between parallel conductors, TE and TM waves, Rectangular and Cylindrical wave guides.

Radiations: Moving charges, Lienard-Wiechert potential, accelerated charges, angular distribution of radiations, distribution of frequency and energy, Thomson's scattering, Bremsstrahlung in Coulomb collisions.

Radiating Systems and Multipole Fields: Electric dipole fields and radiations, quadrupole fields, multipole expansion, energy, angular momentum, multipole radiations, Scattering: Scattering at long wavelengths, perturbation theory, Rayleigh scattering, diffraction theory-Kirchhoff's integral and applications.

Special Theory of Relativity: Lorentz transformations and its consequences, conservation laws, mass energy relation, relativistic momentum and energy, relativistic force, Relativistic Electrodynamics: Covariant formalism of Maxwell's equations, transformation laws and their physical significance, relativistic generalization of larmor's formula, relativistic formulation of radiation by single moving charge.

C. Text Books:

1. J. D. Jackson, "Classical Electrodynamics, John Wiley (Asia) (1999).
2. R. Resnick, "Introduction to Special Relativity", John Wiley (Asia) (1999)

D. Reference Books:

1. E. C. Jordan and K. G. Balmain, "Electromagnetic Waves and Radiating Systems", Prentice Hall (1995)
2. J. Schwinger et al, "Classical Electrodynamics", Persesus Books (1998)
3. G. S. Smith, "Clasical Electromagnetic Radiation", Cambridge (1997)
4. W. Greiner, "Classical Electrodynamics", Springer (1998)

E. Course Outcomes:

Students will learn:

1. concepts and properties of electric and magnetic fields in vacuum and matter.

concepts and properties of electromagnetic wave propagation and emission

Name of the Module: Numerical Methods and Programming
Module Code: APH411
Semester: 2nd
Credit Value: 4[P=2, T=0, L=3]
Module Leader:

A. Course Objective:

1. To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
2. To solve problems in the field of Applied Mathematics, Theoretical Physics and Engineering which requires computing of numerical results using certain raw data.
3. To solve complex mathematical problems using only simple arithmetic operations. The approach involves formulation of mathematical models of physical situations that can be solved with arithmetic operations.
4. To deal with various topics like finding roots of equations, solving systems of linear algebraic equations, interpolation and regression analysis, numerical integration & differentiation, solution of differential equation, boundary value problems, solution of matrix problems.
5. To facilitate numerical computing.

B. Subject Contents:

Programming Language: Introduction to personal computers and operating systems (DOS/Windows and Linux), Algorithms, flow charts, constants, variables, expressions, conditional statements, loops, arrays, logical expressions, control statements, functions, structures, pointers, bit operation, files in C/Fortan. Solving simple problems using C.Fortan programming Language.

Errors in computation: Overflow and underflow; Approximation in numerical computation; Truncation and round off errors; Propagation and control of round off errors; Chopping and rounding off errors; Pitfalls (hazards) in numerical computations (ill conditioned and well conditioned problems)

Interpolation: Lagrange's Interpolation, Newton's forward & backward Interpolation Formula, Extrapolation, Newton's Divided Difference Formula.

Numerical Differentiation and Integration: Use of Newton's forward and backward interpolation formula only and corresponding error statement. Trapezoidal formula (composite); Simson's 1/3 and 3/8 formula (composite)

Solutions of nonlinear equations: Bisection method, Newton's method, fixed point iterations, convergence analysis, Secant method, Regula-Falsi methods, Newton's method for non-linear systems

Solution of the system of Linear equations: Gauss elimination method, Matrix Inversion, Operations Count, LU Factorization Method (Crouts Method), Gauss-Jordan Method, Gauss-Jacobi and Gauss-Seidel Method

Initial value problems: Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Shooting method, Predictor-Corrector method, multistep methods and stability.

List of Practical:

1. Assignments on Numerical solution of a system of Linear Equations: Gauss elimination,
Gauss Jordan, Matrix Inversion, Jacobi, Gauss Seidel.
2. Assignments on Solution of Algebraic Equations: Bisection, Secant, Regula-Falsi, Newton- Raphson Methods.
3. Assignments on Ordinary Differential Equations: Taylor Series, Eulers Method, Runge-
Kutta (4th Order).

C. Text Books:

1. D. Kincaid and W. Cheney, "Numerical Analysis: Mathematics of ScientificComputing", 3e, AMS, 2002.
2. K. E. Atkinson, "An Introduction to Numerical Analysis", Wiley, 1989.

D. References Books:

1. John H. Mathews, "Numerical Methods for Mathematics Sciences and Engineering",2e. Prentice Hall of India, New Delhi 2003.
2. M.K.Jain, S.R.K. Iyengar and R.K. Jain, "Numerical method for Scientific and Engineering Computation", New Age International Pvt. Ltd. 3e, 1993.
3. G. D. Smith, "Numerical Solutions to Partial Differential Equations", Oxford University Press, 3e., 1986.
4. J. C. Strikwerda, "Finite Difference Schemes and Partial Differential Equations", SIAM, 2004.
5. L. Lapidus and G. F. Pinder, "Numerical Solution of Partial DifferentialEquations in Science and Engineering", John Wiley, 1982.
6. K. W. Morton and D. F. Mayers, "Numerical Solution of Partial DifferentialEquations",Cambridge University Press, 2e, 2005.
7. S. D. Conte and C. de Boor, "Elementary Numerical Analysis - An Algorithmic Approach", McGraw-Hill, 1981.
8. C. Xavier, "C Language and Numerical Methods", New Age, 2003.

E. Course Outcomes:

1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
2. Apply numerical methods to obtain approximate solutions to mathematical problems.
3. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
4. Analyse and evaluate the accuracy of common numerical methods.
5. Implement numerical methods in Matlab/C.
6. Write efficient, well-documented Matlab/C code and present numerical results in an informative way.

Name of the Module: Physics Lab-II
Module Code: APH412
Semester: 2nd
Credit Value: 2[P=4, T=0, L=0]
Module Leader:

A. Course Objective:

1. The main objective of this subject is to verify experimentally various modern physicsphenomena.

B. Subject Matter:

1. Measurement of Rydberg constant
2. Franck-Hertz experiment
3. Kerr's effect Experiment
4. Zeeman effect experiment
5. Dielectric constant experiment
6. Na D lines experiment
7. Helmholtz coil experiment
8. Biot-savart law experiment
9. Faraday effect experiment

C. Reference books:

1. R. A. Dunlop, Experimental Physics, Oxford University Press(1988)
2. A. C. Melissionos, Experiments in Modern Physics, Academic Press(1996)

D. Course Outcomes

1. Students will learn that practical results are not always agreed with theoretical value.

2. They will able to learn the source of error of their experiments and how to minimizethese errors.

Semester-III

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH501	Semiconductors Physics and Devices	3	0	0	3	3
2	APH502	Nuclear and Particle Physics	3	0	0	3	3
3	APH503	Advance Electronics and Communications	3	0	0	3	3
4	APH504	Atomic and Molecular Physics	3	0	0	3	3
5	APH505	Advanced Atmospheric Physics	3	0	0	3	3
6	APH506	Physics Lab-III	0	0	4	4	2
		Total	15	0	8	19	17

Name of the Module: Semiconductors Physics and Devices
Module Code: APH 501
Semester: 2nd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

The course is designed to meet with the objectives of:

1. To know different kinds of semiconductors that are changing the way we live i.e. in our cell phones, in our optical-fiber communications systems, in our CD and DVD players, and soon in our home and office lights.

2. Imparting theoretical knowledge and to develop computing skills to the students in the area of semiconductor science and technology

B. Subject Contents:

Review of Semiconductor Physics, Properties, and Devices: Band structure, Electrons, holes, and Phonons; Occupation Statistics; Phonon Dispersion in Semiconductors, Scattering of Carriers, Carrier Transport, Some Effects Related to Energy Bands: Avalanche Breakdown, Zener Breakdown, Density of States and related considerations, Limiting and operational velocities of transport, Tunneling Effects.

Transport Across Junctions: Metal–Semiconductor Junctions, Heterojunctions, Ohmic Contacts, p–n Junctions, Metal–Semiconductor Field Effect Transistors- Analytic Quasi-Static Models, Constant Mobility with Saturated Velocity Model, Accumulation–Depletion of Carriers, Sub-Threshold and Substrate Injection Effects, Sidegating Effects, Injection and Conduction Effects, Bulk-dominated Behavior, Surface-dominated Behavior.

Insulator and Heterostructure Field Effect Transistors: Heterostructures, Strained Heterostructures, Band Discontinuities, Band Bending and Sub-band Formation, Channel Control in HFETs, Quasi-Static MISFET Theory Using Boltzmann Approximation, Quasi-Static HFET Theory Using Analytic Approximation, Quasi-Static Equivalent Circuit Refinements, Small-Signal Analysis, Transient Analysis, Hot Carrier Injection Effects.

Heterostructure Bipolar Transistors: Quasi-Static Analysis, Implications of Heterostructures and Alloy Grading, High Current Considerations of the Base–Collector Junction, Generation and Recombination Effects, Small-Signal Analysis, Small-Signal Effects of Alloy Grading, Transit Time Resonance Effects, Transient Analysis; Hot Carrier and Tunneling Structures- Quantum-Mechanical Reflections, Hot Carrier Structures, Resonant and Sequential Tunneling, Resonant Tunneling Transistors with Coupled Barrier Tunneling.

C. Text Books:

1. Sandip Tiwari, "Compound Semiconductor Device Physics", Academic Press, 1992.
2. Ben G. Streetman, Sanjay Banerjee, "Solid State Electronic Devices",6e, Pearson Prentice Hall,2010

D. Reference Books:

1. S. M. Sze and Kwok K. Ng, "Physics of Semiconductor Devices", John Wiley& Sons,2007.

2. S. O. Kasap, "Principles of Electronic Materials and Devices", 3e, TATA McGrow Hill(2007)

E. Course Outcomes:

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

1. Describe the properties of materials and Application of semiconductor electronics
2. Apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices.
3. Demonstrate the switching and amplification Application of the semiconductor devices.
4. Demonstrate the control Applications using semiconductor devices.
5. Identify the fabrication methods of integrated circuits.
6. Classify and describe the semiconductor devices for special Applications.

Name of the Module: Nuclear and Particle Physics
Module Code: APH502
Semester: 3rd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. Student gets acquainted with basic laws of nuclear and particle physics.
2. Capability of elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement results.

B. Subject Contents:

Nuclear properties: General properties: radius, mass, binding energy , nucleon separation energy, angular momentum, parity , electromagnetic moments, excited states.

Nuclear models: liquid drop model, semi - empirical mass formula, mass parabolas, beta stability line, collective rotations and vibrations. magic numbers, independent particle shell model, ground state spins.

Nuclear reactions: energetics, conservation laws, classification of nuclear reactions, fusion and fission.

Radioactive decay: radioactive decay law, production and decay of radioactivity, radioactive dating. Alpha decay: Gamow theory and branching ratios. Beta decay: energetics, angular momentum and parity selection rules, Elementary ideas of Fermi theory. Fermi and Gamow - Teller transition probabilities, Kurie plot and mass of a neutrino, Gamma decay: energetics, Mossbauer effect, angular momentum and parity selection rules.

Detectors and Accelerators: detection of nuclear radiations, interaction of radiation with matter, gas - filled ionization detectors, semiconductor detectors, solid state scintillation counters. Modern Accelerators, synchrotrons, linear accelerators.

Elementary particle Physics: fundamental particles and forces, quantum numbers, mesons and Yukawa's hypothesis, pions, CPT theorem, strange mesons and baryons, symmetries and conservation law, Gell-Mann Nishijima relation, quark model, coloured quarks and gluons, quark dynamics,Standard Model

C. Text Books:

1. K. S. Krane, "Introductory Nuclear Physics", John Wiley (1988)
2. R. R. Roy and B. P. Nigam, "Nuclear Physics: Theory and Experiment", New Age (1967).

D. Reference Books:

1. M. A. Preston and R. K. Bhaduri, "Structure of the nucleus", Addison-Wesley (1975).
2. I. S. Hughes, "Elementary Particles", Cambridge (1991).
3. F. Halzen and A. D. Martin, Quarks and Leptons:AN INTRODUCTORY COURSE IN MODERN PARTICLE PHYSICS, John Wiley & Sons, 2008.
4. D. Perkins, "Introduction to High Energy Physics", Cambridge University Press; 4e (2000).

E. Course Outcomes:

On completion of the course, the student should be able to:

1. explain the different forms of radioactivity and account for their occurrence
2. master relativistic kinematics for computations of the outcome of various reactions and decay processes
3. describe the astrophysical processes leading to nuclear synthesis
4. account for the fission and fusion processes
5. explain effects of radiation in biological matter
6. classify elementary particles according to their quantum numbers and draw simple reaction diagrams
7. classify different kinds of reactions between elementary particles
8. master the use of invariant mass for kinematical computations

Name of the Module: Advance Electronics and Communications
Module Code: APH 503
Semester: 3rd
Credit Value: 3[P=0, T=0, L=3]

Module Leader:

A. Course Objectives:

The course is designed to meet with the objectives of:

1. To introduce the student about OPAMP, Optical Fiber, μWave propagation, Detectors and its structures and functions.
2. To study different circuits used in communication
3. To study different transmission & reception systems

B. Subject Contents:

Operational Amplifier : Basic operational Amplifier, Inverting & Non inverting OP-AMP, Common Mode Rejection Ratio (CMRR), Summing Amplifier, Voltage follower, Current to voltage, Voltage to current converter, Integrator, Differentiator, Log – Antilog Amplifier, Circuit type of OP-AMP 741, Operational Amplifier parameters, Effects of offset, Frequency response and Stability, Comparators, Discriminators, sample & hold circuits, Zero crossing detector, Precision rectifier, Waveform generators, OP-AMP as astable, Monostable and bistable Multivibrater, Regenerative comparator (Schmitt trigger), IC-555 timer.

Power Amplifier & power supply:

Class A, Second Harmonics Distortion, Higher Order HarmonicsGeneration Transformer-Coupled Audio Power Amplifiers, Efficiency,Push-Pull Amplifier, Class B, Class AB. Regulated Power Supply –Series Voltage Regulator Design, Short Circuit and Overload Protections,DC Coupled Power amplifiers, Voltage Regulator Ics.SMPS.

Analog To Digital And Digital To Analog Converters:

Digital To Analog Conversion, R-2r Ladder Type Dac, Weighted Resistor Type Dac, Analog To Digital Conversion, Counter Type A/D Converter, Tracking Type A/D Converter, Flash-Type A/D Converter, Dual Slope Type A/D Converter, Successive Approximation Type Adc.

Microwave production and Microwave Communications: Limitation of conventional electronic devices at UHF, Microwave frequencies, Principle of velocity modulation. Reflex klystron. Theory and uses of cavity magnetron, PIN & GUNN diode, Detection of microwave, measurement of power, Advantages and disadvantages of Microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading ,sowlles, detectors, components, antennas used in microwave communication system.

Digital and Optical Communication: Digital signal processing, Image processing (Basic ideas only), Pulse Modulation systems, Pulse Amplitude Modulation, Pulse Width Modulation, Pulse position modulation, Pulse code modulation, Delta modulation

Frequency division multiplexing (FDM), Basic idea of digital telemetry. Principle of optical communication, Different modes of propagation of E. M. Wave through optical fibre. Optical Fibre connectors,

C. Text Books:

1. Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers and linear Integrated Circuits", 2e,Prentice-Hall, 1982.
2. V. Rajaraman,"Introduction to digital Computer Design", 2e, Prentice Hall, 1995.
3. D. L. Schilling *et. al.*"Electronics circuits Discrete and Integrated", 3e, Tata Mcgraw Hill,2008

D. Reference Books

1. D. Chaudhary Royand S. B. Jain: " Linear Integrated Circuits" New Age Int.(P) Ltd.,2004
2. Taub and Schiling, "Principles of Communication systems" Tata Mcgraw-Hill Publishing Company Limited, 1991
3. Simon Haykin, "Communication Systems",4e,John Wiley & Sons Inc.,1994

E. Course Outcomes:

After successful completion of the course student will be able to

1. Use of different modulation and demodulation techniques used in analog communication
2. Identify and solve basic communication problems
3. Analyze transmitter and receiver circuits
4. Compare and contrast design issues, advantages, disadvantages and limitations of analog communication systems

Name of the Module: Atomic and Molecular Physics
Module Code: APH 504
Semester: 3rd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1.Objective of this course is to learn atomic, molecular and spin resonance spectroscopy

B. Subject Contents:

Review of one electron and two electron atoms: Schrodinger equation, para and ortho states, Pauli Exclusion principle, excited states, Auger effect, Resonance,Spectra of alkali atoms, vector atom model, LS and jj couplings, normal and anomalous Zeeman effect, Stark effect. Symmetric and anti-symmetric wave functions, Slater determinants, constant field approximation, Hartree-Fock method, Molecular structure: General nature,Born-Oppenheimer approximation. Fine structure of spectral lines, spectra of diatomic molecules, polyatomic molecules. Raman Spectroscopy, Nuclear spin and hyperfine structure ,magnetic resonance, ESR and MNR spectra, lasers, interaction of laser with atoms

Laser: Laser and its applications (introductory). General Physical principles behind amplification : Spontaneous emission. Stimulated effects.Lasing action Role of feedback (cavity).Comparison with blackbody radiation. Cavity design :Caussian beam in spherical mirror cavity, longitudinal and transverse modes. Losses and Q-factor

Different Laser Systems : Gas Lasers, solid state, free electron, liquid state and excimer lasers. Operation principle and design specifics.Output characteristics.Modelocking, relaxation oscillations and Q-switching. Single mode laser theory: (a) Rate equation, (b) Semiclassical theories. Ideas about line-widths.

C. Text Books:

1. B. H. Bransden and C. J. Joachain, "Physics of Atoms and Molecules", Longman (1996)
2. H. E. White, "Introduction to Atomic Spectra", Tata McGraw Hill (1934)
3. A. E. Seigman, "Lasers", Oxford (1986)

D. Reference Books:

1. C. N. Banwell and E. M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw Hill (1994)
2. O. Svelto, "Principles of Laser", Plenum Press, (1982)
3. W. T. Silfvast, "Laser and Fundamentals", Cambridge (1996)

E. Course Outcomes:

Students will have achieved the ability to:

1. describe the atomic spectra of one and two valance electron atoms.
2. explain the change in behaviour of atoms in external applied electric and magnetic field.
3. explain rotational, vibrational, electronic and Raman spectra of molecules.
4. Describe electron spin and nuclear magnetic resonance spectroscopy and their applications.

Name of the Module: Advanced Atmospheric Physics

Module Code: APH 505
Semester: 3rd
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. Students can demonstrate familiarity with microphysical principles and how they determine the structures of the atmosphere and clouds.
2. Students can demonstrate the ability to apply principles of cloud microphysics and atmospheric chemistry to the solution of atmospheric problems.

B. Subject Contents:

Introduction:

Atmospheric Organization and Issues, Cloud Types and Properties, the Hydrological Cycle, Thermodynamics Review

Atmospheric transport and transformations:

Atmospheric Constituents, Principles of Interaction, Formation of New Substances.

Cloud development: Thermodynamic Drivers, Cloud Macrophysics, Supersaturation development
Cloud microphysics: Phase Nucleation, Growth of Cloud Particles, Precipitation.

Interaction of emr with atmosphere and earth's surface:

EMR – atmospheric scattering, Raleigh scattering, Mie scattering, non-selective scattering – atmospheric absorption – atmospheric windows, refraction – interaction of EMR earth"s surface – reflection – transmission – spectral signature – Reflectance characteristics of Earth's cover type: Vegetation, water, soil – Interaction of microwave with atmosphere and Earth's surface – Radar operating principle – radar equation – Definitions: Incidence angle, look angle, depression angle, Azimuth angle – Spatial resolution in radar – Synthetic aperture – radar.Remote Sensing system, Platforms and sensors. Geometric aspects of imagery , Image visualization and enhancement ,Visual interpretation of Remote Sensing Images ,Image and tables arithmetic , Vegetation indexes , Digital image classification , Radiometric and atmospheric corrections

C. Text Books:

1. M.K. Yau, R R Rogers,"A Short Course in Cloud Physics", 3e,Elsevier, 1996.

2. Fletcher, Neville H. Fletcher, "The Physics of Rainclouds"Cambridge University Press, 2011.
3. Peter V. Hobbs, Peter Victor Hobbs,"Basic Physical Chemistry for the Atmospheric Sciences"Cambridge University Press, 2000.
4. George Joseph, "Fundamentals of Remote Sensing", Universities press (India) Private Limited, Hyderabad, 2005.

D. Reference Books:

1. Dennis Lamb, Johannes Verlinde, "Physics and Chemistry of Clouds"Cambridge University Press, 2011.
2. Daniel J. Jacob, "Introduction to Atmospheric Chemistry"Princeton University Press, 1999.

E. Course Outcomes:

On completion of the course, the student should be able to:

1. apply thermodynamics on dry and humid air
2. determine if the atmosphere is stable or unstable from a vertical temperature profile
3. describe how precipitation is created
4. explain how motion (wind) is created in the atmosphere

Name of the Module: Physics Lab-III
Module Code: APH 506
Semester: 3^{rd}
Credit Value: 2[P=4, T=0, L=0]
Module Leader:

A. Objectives:

The purpose of this lab course is to provide students with hands-on experiments that give them the opportunity to:

1. observe and make measurements on simple electrical systems.
2. practice performing quantitative analysis of those measurements in order to discover or confirm relationships among the variables involved.
3. make predictions about similar systems and make measurements to check those predictions.

B. List of Experiments:

1. To design and fabricate a phase shift oscillator for the given frequency and to study the output using Op-Amp. 741/ 324 / 325
2. Determination of the Young's modulus of a beam by four-point bending.
3. To determine the velocity of sound in (a) dry air, and (b) rods by Kundt's tube method

4. Calculate the difference in wavelength between atomic transition lines and Zeeman lines using Zeeman effect set-up
5. To find out the magneto-resistance of the semiconductor sample as a function of magnetic field and to plot the graph between magnetic field vs. potential developed using magneto-resistance set-up.
6. To plot the gain – bandwidth relation for a negative feedback amplifier using IC 741.
7. To find out the Curie temperature of the given ferromagnetic material (BaTiO3) using Curie temperature kit
8. Microwave experiment
9. Fiber Optics communication:Numerical Aperture of Single and Multi mode fibres
10. Laser characteristics
11. Photoconductivity measurements

C. References:

1. P. B. Zabar and A. P. Malvino, Basic Electronics: a text-lab manual, Tata McGraw Hill (1983)
2. D.P. Leach, Experiments in Digital Principles, McGraw Hill (1986)
3. R. S. Gaonkar, Microprocessor Architecture; Programming and Applications with the 8085, Penram India(1999)

D. Outcomes:

By the end of this lab practice, student will be able to:

1. Identify quantitative and qualitative variables in an experimental investigation,
2. Design procedures and carry them out to measure quantitative variables systematically,
3. Graph and analyze those measurements via linearizationand regression techniques

Semester-IV

Sl. No.	Subject Code	Subject	L	T	P	Hours/Week	Credit
1	APH507	Project Work and Viva	0	0	20	20	10
2	APH508	Seminar Course	0	0	2	2	1
3	APH509X	Elective-I	3	0	0	3	3
		Total	6	0	10	16	14

Name of the Module: **Project Work and Viva**
Module Code: APH- 507
Semester: 4th
Credit Value: 5[P=10, T=0, L=0]
Module Leader:

Students will be able to decide their Research Project in any of the following fields:

A. Electronic- Devices & Material Development
B. Photovoltaics/ Optoelectronics
C. Device Simulation: Solar Cell and OLED
D. Theoretical Modelling
E. Others (depending on the availability of guide)

Each research project will be written up as a thesis and should be submitted in four copies.

List of Electives:

1. Nano Science and Technology
2. Bio-Electronics
3. Advanced Characterization Techniques
4. General Theory of Relativity
5. Group Theory and its Applications
6. Graph Theory

Name of the Module: Nano Science and Technology
Module Code: APH509A
Semester: 4th
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. The purpose of this course is to introduce the students to the concept of nanotechnology and also provide an overview about the wide

applications of nanotechnology in various technological fields.

2. To understand the importance of nanotechnology.
3. To apply nanotechnology in the field of energy systems.
4. To appreciate the role of nanotechnology in electronics.
5. To emphasize the importance of nanotechnology in healthcare.

B. Subject Matter:

Properties of individual Nanoparticles: Magic numbers, Theoretical modeling of nanoparticles,Geometric structure, Electronic structures, relativity, fluctuations, magic clusters, Bulk to nano-struction Semiconducting

Nanoparticles: Optical properties, photofragmentation, Coulombic explosion. Carbon nanostructures Carbon molecules: Nature of the carbon Bond,New carbon structures Small Carbon Clusters, Discovery of C60, Structure of C60 and its crystal, Alkali doped C60 ,Larger and Smaller Fullerenes, Other Bucky balls, Carbon Nanotubes Fabrication, Structure, Electricalproperties, Vibrationalproperties, Mechanical properties

Applications of carbon nanotubes: Field emission and shielding, computers,Fuel cells, Chemical Sensors,Catalysis, Mechanical Renforcement.

Bulk Nanostructured materials: Solid Disordered Nanostructures: Methods of synthesis, Failure mechanism of Conventional GrainSized Materials, Mechanical properties, Nanostructured Multilayers, Electrical properties, Other properties, Metal Nanocluster Composite Glasses, Porous Silicon

Nanostructured Crystals: Natural Nanocrystals, Computational Prediction of Cluster Lattices, Arrays of nanoparticles in Zeolites, Crystals of Metal Nanoparticles, Nanoparticle Lattices in Colloidal suspensions, Photonic Crystals Nanostructured Ferromagnetism: Basics of ferromagnetism, Effect of bulk Nanostructuring of magnetic properties, Dynamics ofnanomagnets, Nanopore Containment of magnetic properties, Nanocarbonferromagnets, Giant and colossal Magneto resistance, Ferro fluids.

Optical and vibrational spectroscopy: Infrared frequency range: Spectroscopy of semiconductors; Excitons , Infrared surface spectroscopy, Raman spectroscopy, Brillouin spectroscopy, Luminescence: Photoluminescence, Surface states, thermo luminescence nanostructures in Zeolite Cages.

Quantum wells ,Wires and Dots : Preparation of quantum nanostructures ,size and Dimensionally effects: Size effects, Conduction electron and dimensionality, Fermi gas and density of states, potential Applied Physics 2 years M.Sc Syllabus For Admission Batch 2016-17 wells, partial confinement Properties dependent on

Density of states, Excitons, Single electron tunneling,
Applications: infrared detectors, Quantum Dot Lasers, Superconductivity.

C. Text Books:

1. Ping Sheng, Zikang Tang,"Nano Science and Technology: Novel Structures and Phenomena" CRC Press, 2003.
2. William A. Goddard III, Donald Brenner, Sergey Edward Lyshevski, Gerald J Iafrate, "Handbook of Nanoscience, Engineering, and Technology" 3e,CRC Press, 2012.
3. Chris Binns, "Introduction to Nanoscience and Nanotechnology" Vol.6.Wiley, 2010.

D. Reference Books:

1. Charles P. Poole, Jr., Frank J. Owens, "Introduction to Nanotechnology" John Wiley & Sons, 2003
2. Chattopadhyay, Chattopadhyay K. K., banerjee A. N. "Introduction To Nanoscience And Nenotechnology" PHI Learning Pvt. Ltd., 2009

E. Course outcomes:

On successful completion of this course, students should have the skills and knowledge to:

1. Explain the fundamental principles of nanotechnology and their application to biomedical engineering.
2. Apply engineering and physics concepts to the nano-scale and non-continuum domain.
3. Identify and compare state-of-the-art nanofabrication methods and perform a critical analysis of the research literature.
4. Design processing conditions to engineer functional nanomaterials.
5. Evaluate current constraints, such as regulatory, ethical, political, social and economical, encountered when solving problems in living systems.
6. Apply and transfer interdisciplinary systems engineering approaches to the field of bioand nanotechnology projects.
7. Discuss and evaluate state-of-the-art characterization methods for nanomaterials, and determine nanomaterial safety and handling methods required during characterization.

Name of the Module: Bio-Electronics
Module Code: APH 509B
Semester: 4th
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

1. Basic concepts analog and digital electronics and it application to bioengineering.

2. The course will provide the background to design electronic instrumentation to assess physiological and molecular functions, from bioelectrical measurements to spectroscopic detection.

B. Subject matter:

Introduction: Structure, properties and functions of biopolymers, Thermodynamics and kinetics processes of molecular self-organization, Neurobiophysics: excitation and propagation of nerve signals, sensory centres.

Membrain: Introduction, Water shortages and need for membrane technology composition, Classification of membranes, Membrane processes, Principle of membrane filtration,Microfiltration membranes: introduction to frontal and cross flow filtration, development of knowledge and understanding of solid liquid separations and cake filtration, general membrane equations and adaptation to cake filtration, calculation of cake properties, time of filtration, bed depth and process optimisation, case studies,

Biomechanics: Introduction, Human Motion:Linear and Angular Motion, Discrete and Continuous Motion, Planes of Motion, Axes of Rotation, Body Segment Anatomical Terminology, Body Segment Motion Terminology, Biomechanical Model, Real World Applications,molecularbases of contractility and mobility, biostatics.

Biosensors: technology and applications, Evolution processes in living matter. Biosensors as Precursors of Bioelectronics, Functionalization of Sensing Substrates, Biochip, Nanosensors-Miniaturization of Biosensors, Nanomaterial Based Biosensors. Electron Transfer of Biomolecules, Nanoparticle Biomaterial Hybrid Systems for Sensing and Electronic Devices, Effect of Biosensor in biological and physicochemical techniques. DNA Templated Electronics, Sequence –specific molecular lithography, Single Biomolecule Manipulation for Bioelectronics, DNA as a semiconductor.

C. Text Books

1. Claudio Nicolini, "Nanobiotechnology&Nanobiosciences" Pan Stanford Publishing Pte. Ltd, 2009
2. Jain, K. K, "Nanobiotechnology in molecular diagnostics: current techniques and applications", Taylor & Francis, 2005.
3. W. Hoppe "Biophysics", Springer-Verlag, 1983.
4. A. Grosberg "Giant Molecules", Academic Press,1997

D. Reference Books

1. N. Hilal, M. Khayet and C. J. Wright "Membrane Modification: Technology and Applications" CRC Press, 2012
2. M. Khayet and T. Matsuura "Membrane Distillation: Principles and Applications"
Elsevier, 2011
3. Kao, J. C. "Real-World Biomechanics", 3e, Electronic Book, 2013.
4. Gordon Robertson, Graham Caldwell, Joseph Hamill, Gary Kamen, Saunders Whittlesey, "Research Methods in Biomechanics", 2e, Human Kinetics,2013

F. Course Outcomes:

By the end of this course, students will be able to:

1. To understand the basic concepts of solid state physics applied to semiconductors.
2. To learn how to design circuits with operational amplifier for biomedical applications.
3. To understand the implementation of digital algebra using logic circuits.
4. To learn how an analog signal can be converted i into a digital one.

Name of the Module: Advanced Characterization Techniques
Module Code: APH 509 C
Semester: 4th
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Course Objectives:

The objectives of the course are :

1. the latest Fabrication Technologies and their relation with material structuring and properties.
2. the most advanced imaging instruments for investigating the modern material at the highest topographic resolution.
3. the common used analytical tools for characterizing modern materials at highest sensitivity
4. the latest advancement in spectroscopy for getting structural and elemental analysis of Material

B. Subject Matter:

Growth of crystalline materials:

nucleation and crystallization, Czochralski and floating zone growth of Si, LEC and Bridgemann growth of compound semiconductors, Epitaxial growth- LPE, MBE, MOVPE and MBE.

Deposition of thin films:

physical vapour deposition-evaporation, sputtering, laser processing, plasma and ion beam processing, chemical vapour deposition-CVD,LPCVD,PECVD. Solution growth- hydrothermal, co-precipitation, Sol-gel technique, Vapor-liquid-solid (VLS) growth, spray pyrolysis, Dip print coating, Growth of quantum sized structures.

Electron beam instruments:

Transmission electron and scanning electron microscopes, Auger electron spectroscope, x-ray spectrometers, electron microprobe, electron spectrometers. Interpretation of different information: selected area and convergent beam electron diffraction patterns. Analysis of micrographs in TEM, SEM and HRTEM: theories of diffraction contrast in TEM, analysis of images in TEM and SEM. Interpretation of analytical data: EDS, WDS, Auger, EELS, ESCA, SIMS.

Optical Spectroscopy:

Atomic absorption spectroscopy, infrared spectroscopy and Raman spectroscopy, Photoluminescence; scanning Tunneling and Atomic Force Microscopy;

NMR: Principles and applications; Electrical Characterization: I-V, C-V, Hall effect, Low and high temperature effect.

Structural Characterization:

classification of techniques for characterization, micro and nano structure of solids. Introduction to X-ray and electron beam analysis of materials. Properties of x-rays: continuous and characteristics x-rays, absorption, filter, production and detection of x-ray, Diffraction of x-rays, Experimental methods in x-ray analysis,Applications.

Electron-specimen interactions:

scattered electron, X-rays, Auger electrons, electron beam induced currents, cathodoluminescence.

C. Text Books:

1. Klaus-Werner Benz, Wolfgang Neumann, "Introduction to Crystal Growth andCharacterization" Wiley & Sons, 2014.
2. Yang Leng, "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods" Wiley and Sons,2008.
3. Sam Zhang, Lin Li, Ashok Kumar, "Materials Characterization Techniques", CRC Press,2008

D. Reference Books:

1. VitalyShchukin, Nikolai N. Ledentsov, Dieter Bimberg, "Epitaxy of Nanostructures",1e, Springer,2004

2. Tom Kuech, "Handbook of Crystal Growth: Thin Films and Epitaxy", Elsevier,2015
3. Rohit P. Prasankumar, Antoinette J. Taylor, "Optical Techniques for Solid-State Materials Characterization", CRC Press,2012

E. Course Outcomes:

After completion of the couse, students will able to learn:

1. apply appropriate characterization techniques for microstructure examination at different magnification level and use them to understand the microstructure of various materials
2. choose and appropriate electron microscopy techniques to investigate microstructure of materials at high resolution
3. determine crystal structure of specimen and estimate its crystallite size and stress
4. use appropriate spectroscopic technique to measure vibrational / electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
5. apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen.

Name of the Module: General Theory of Relativity
Module Code: APH 509 D
Semester: 4^{th}
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. **Course Objectives:**
   1. To learn basic mathematical tools of space-time.
   2. To learn basic tools for astronomy and cosmology.

B. **Subject Matter:**

Mathematical background\manifolds , tensor fields , connection and curvature ; priniciple of equivalence and general covariance, geodesics and geodesic deviation, action principle , Einstein s equation , solutions- black holes (Schwarzschild, Reissner Nordstrom , Kerr) , Penrose diagrams , gravitational waves and cosmology (FRW models and some observational cosmology) , initial value problem , causal structure and singularities , black hole thermodynamics , brief introduction to problems of quantising gravity

C. Text Books:

1. Steven Weinberg,"Gravitational and Cosmology principle and applications of general theory of relativity" ,Wiley Student edition, 2008
2. Robert M. Wald,"General Relativity",University of Chicago Press, 2010

D. **Reference Books:**

1. J. B. Hartle,"Gravity An Introduction to Einstein's General Relativity", Pearson Education, 2003.
2. Bernard Schutz,"A First Course in General Relativity", Cambridge University Press, 2009.

E. **Course Outcomes:**

A successful student should be able to:

1. demonstrate a detailed physical and mathematical understanding of a variety of systems and processes in a range of advanced topics in physics;
2. apply the concepts and theories of a range of advanced topics in physics;
3. demonstrate specialized analytical skills and techniques necessary to carry out advanced calculations in a range of advanced topics in physics;
4. approach and solve new problems in a range of advanced topics in physics;
5. demonstrate an understanding of the close relationship between scientific research and the development of new knowledge in a global context;

Name of the Module: Group theory and its Applications
Module Code: APH 509 E
Semester: 4th
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. **Course Objective:**

1. To obtain proficiency in the study of symmetries of physical systems, and the use of groups to classify and quantify natural phenomenon.

B. **Subject Matter:**

Review of the representations of finite groups; Unitary and Irreducible representations; Introduction to Lie groups; Examples from the rotation group and SU(2); The representation theory of compact Lie groups; Lie algebra; Simple and semisimple Lie algebras; Invariant operators and labeling of irreducible representations; Spinor and Vector representations of Lorentz group; The Clebsch-Gordan problem; Wigner-Eckart theorem. Cartan classification of compact simple Lie Algebras-Generators; Cartansubalgebra Roots; Cartan matrix; A_r, B_r, C_r, D_r and Exceptional root systems and Dynkin diagrams; Representations of compact simple Lie algebras; Weights and Multiplicities; Weyl group, Finite Coxeter groups, Crystallograpic groups. Baryons and mesons; Quark model, SU(3) symmetry; The Gell-Mann matrices of SU(3); Fundamental and adjoint representations; Young tableaux; Meson and baryon octets and baryon decuplet.

C. **Text Books:**

1. HowardGeorgi, "Lie Algebra in Particle Physics" 2e, Hachette UK, 1999
2. Robert Gilmore, "Lie groups Lie Algebra and some of their Applications" Courier Corporation, 2012.

D. Reference Books:

1. Jean-Pierre Serre, "Lie Algebras and Lie Groups: 1964 Lectures given at Harvard University" 2e, Springer, 2009
2. Willi-Hans Steeb, Igor Tanski, Yorick Hardy, "Problems and Solutions for Groups, Lie Groups, Lie Algebras with Applications" World Scientific Publishing Company, 2012.

E. Course Outcomes:

1. To obtain proficiency in the study of symmetries of physical systems, and the use of groups to classify and quantify natural phenomenon.
2. decide whether a given group is cyclic, and given a finite cyclic group, find a generator for a subgroup of a given order.
3. Verify group properties in particular examples.

Name of the Module: Graph Theory
Module Code: APH509 F
Semester: 4th
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Course Objectives

1. To understand and apply the fundamental concepts in graph theory
2. To apply graph theory based tools in solving practical problems
3. To improve the proof writing skills.

B. Subject Matter:

Isomorphism, incidence and adjacency matrices, Sperner lemma, Trees, Cayley formula, connector problem, connectivity, constructing reliable communication network, Euler tours, Hamilton cycle, Chinese postman and traveling salesman problems, matchings and coverings, perfect matchings, edge colouring, Vizing Theorem, time table problem, Independent sets, Ramsey theorem, Turan theorem, Schur theorem, vertex colouring, Brook theorem, Hajos conjecture, chromatic polynomials, storage problem, planarity, dual graphs, Euler formula, Kuratowski theorem, five colour theorem, history of four colour theorem, nonhamiltonian planar graphs, planarity algorithm, directed graphs, job sequencing, one way road system, ranking participants in tournaments.

C. Text Books:

1. B.West,"Introduction to Graph Theory" Prentice-Hall of India/Pearson, 2009
2. J. M. Aldous. "Graphs and Applications" Springer, LPE, 2007

D. Reference Books:

1. J.A.Bondy and U.S.R.Murty,"Graph Theory and Applications (Freely downloadable from Bondy's website; Google-Bondy)

2. Gary Chartrand, Ping Zhang, "A First Course in Graph Theory", Courier Corporation, 2012.

E. Course Outcomes:

1. The students will be able to apply principles and concepts of graph theory in practical situations.

Decision:- Senate approved the new syllabus for M.Tech (VLSI), M.Tech(Fluids & Thermal Engineering) and M.Sc (Applied Physics) for 2019 batch, and Senate advised HoDs of EE, and CSE to use existing syllabus for M.Tech (REEM), M.Tech (CSE) for time being till new syllabus is not approved.

Agenda Item: 19.04: Ratification of approval given to Ph.D. scholar Mr. Pritam Bhattarcharjee for internship at Intel India.

Mr. Pritam Bhattacharjee Ph.D. Scholar in ECE department has been selected for internship for one year in Intel India, since the Intel Internship is a venture under the SMDP-C2SD (Special Manpower Development Program for Chips to System Design) which is his research work he has been allowed to participate in the internship program,

Decision:- Approved

Agenda Item: 19.05:Seeking approval for Ph.D. courses for July-Dec 2019 session

As per 17th Senate agenda item 17.08 Ph.D. seats were advertised and candidates admitted in the 2019 session, Ph.D. courses has to be prepared for approval, hence few PhD subject courses are given by HoDs for approval these are:

Decision:- Senate advised departments to use subjects already approved for Ph.D. (PH-001 to PH-069) and existing PG subjects, any new syllabus should be pass through respective BoS. Following are the subject from PG which can be taken for Ph.D. subjects in this semester.

1	Wireless Communication	PHD078	3
2	Pattern Recognition & Machine Learning	PHD079	3
3	Graph Theory	PHD084	3
4	Linear Algebra	PHD085	3

5	Numerical Methods	PHD086	3
6	Embedded Systems & IoT	PHD087	3
7	Advanced Fluid Mechanics	PHD088	3
8	Conduction and Radiation	PHD089	3
9	Energy Conversion and Waste Heat Recovery	PHD090	3

Agenda Item: 19.06. Seeking approval for engagement of UG students for final project from 7th semester.

It is propose that the undergraduate students should be engaged / allowed final year project in the commencement of their 7th semester all branches.

Decision:- Senate noted.

Agenda Item: 19.07: Seeking approval for modification of UG and PG (M.Tech & M.Sc) ordinances

Modifications of Ordinances for UG and PG (M.Tech & M.Sc.) is been done for 2019 batch, and placed for approval.

Decision:- Senate advised Dean (Academic) to constitute a committee comprising of experts from other institutes of similar kind and do modification in ordinances for UG and PG and place in the forthcoming Senate meeting.

Agenda Item: 19.08: Ratification of approval given for supervisor changed from Prof. P. K. Bandyopadhayay (Resigned) to Dr. Sahadav Roy, Assistant Professor ECE

PhD scholar Mr. Md Faysal Kabir (Roll No.Ph.D (ECE)/2017/01) was un the supervision of Prof. P. K. Bandyopadhayay Associate Professor department of Electronics and Communication, and since Prof. Bandyopadhayay has resigned from institute, the PhD supervisor has been changed after letter from Scholar and approval from competent authority, and new supervisor of Md Kabir is Dr. Sahadev Roy, it is place in senate for reporting/ratification.

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Decision:- Approved

Agenda Item: 19.09:Rafication of approvals given for RAC expert member and Ph.D. thesis submitted.

Since January 2019 16 (sixteen) RAC (Research Advisory Committee) subject experts have been approved, and 6 (Six) Ph.D. scholars have submitted Ph.D. thesisthese are:

Details of RAC Experts Approved

Sl. No.	Name of PS	Name of Supervisor	Name of Subject Expert	Date of Approved
1.	Mr. Tathagata Adhikary	Dr. Saikat Kr. Jana	Dr. Chandan Tamuly, CSIR-NEIST, Itanagar	27.06.19
2.	Mr. Debanjan Sarkar	Dr. Sanjeev Kr. Metya	Dr. Fazal Talukdar, NIT Silchar	13.02.19
3.	Mr. Raushan Krishanan	Dr. Dipak Sen	Prof. Rahul Dev Mishra, NIT Silchar	31.01.19
4.	Mr. Pritam Bhattacharjee	Dr. T. D. Das	Dr. Gaurav Trivedi, IIT GUwahati	13.02.19
5.	Mr. Suraj Kr. Saw	Dr. Alak Majumder	Dr. Roy P. Paily, IIT Guwahati	10.01.19

6.	Mr. Parashjyoti Borah	Dr. Deepak Gupta	Dr. V. Vijaya Saradhi, IIT Guwahati	15.05.19
7.	Mr. Umesh Gupta	Dr. Deepak Gupta	Dr. Sanasam Ranbir Singh, IIT Guwahati	27.03.19
8.	Mr. Achyuth Sarkar	Dr. S. K. Chakraborty	Dr. Bubu Bhuyan, NEHU	14.02.19
8.	Ms. Lucindia Dupak	Dr. Subhasish Banerjee	Prof. Utpal Bhattacharjee, RGU	16.05.19
9.	Mr. Priyaranjan Biswal	Dr. P. K. Mohanty	Prof. S. K. Dwivedy, IIT Guwahati	04.02.19
10.	Mr. Papul Changmai	Dr. S. K. Metya	Dr. Ghanshyam Singh	06.02.19
11.	Mr. Tana Baida	Dr. Rajen Pudur	Dr. A. K. Singh	14.05.19
12.	Mr. Sanjit Ningthoujam	Dr. S. K. Chakraborty	Dr. Nityananda Sarma, Tezpur University	14.05.19
13.	Mr. Samiul Islam Hazarika	Dr. A. K. Atta	Dr. S. S. Bag, IIT Guwahati	14.05.19
14.	Ms. Mayuri Kundu	Dr. S. K. Chakraborty	Dr. Maushumi Barooah, Assam Engg. College	19.02.19
15.	Ms. L Chanu	Dr. Rajen Pudur	Prof. Sarsing Gao	14.05.19
16.	Mr. M. Chitrasen	Dr. Rajen Pudur	Prof. Sarsing Gao	14.05.19

List of Ph. D. thesis submitted

Sl. No.	Name of PS	Name of Supervisor	Department	Submission Date
1.	Mr. Bholanath Dolai	Dr. A. K. Atta	BAS	08.05.19
2.	Mr. Saikat Ghosh	Dr. N. K. Pramanik	BAS	29.05.19
3.	Mr. Sandip Kr. Mandal	Dr. Dipak Sen	ME	15.05.19
4.	Ms. Moumita Das	Dr. R. S. Goswami	CSE	29.05.19
5.	Mr. Sanjib Kalita	Dr. S. Mukhopadhyay	ECE	29.05.19
6.	Mr. Indrajit Kumar	Prof. M. K. Shome	M&H	16.07.19

Decision: -Noted & Approved.

Agenda Item: 19.09: Nomination of new for BOG member under NIT Act 2007.

A letter is received from Registrar for nomination of new member for BoG because Prof. M.K. Shome has been a member of BoG since 26th Oct' 2014.

Decision:- Senate nominates Prof. R.P. Sharma, Associate Professor, departments, of Mathematic for BOG member.

Meeting was ended with vote of thanks from Chairman

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